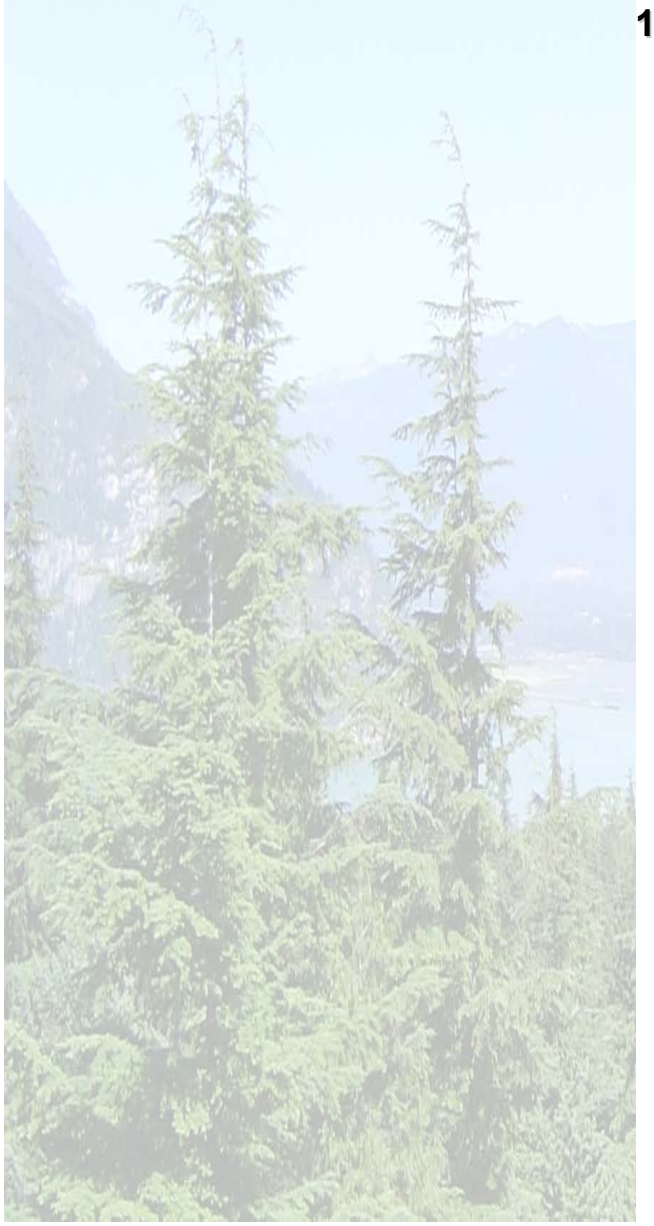
Ministry of Water, Land & Air Protection

LOWER MAINLAND REGION

Ambient Air Quality Monitoring Report
Whistler, British Columbia
PM_{10} & Ozone
1997-2001



ENVIRONMENTAL QUALITY

Ambient Air Quality Monitoring Report
Whistler, British Columbia
PM_{10} & Ozone
1997-2001

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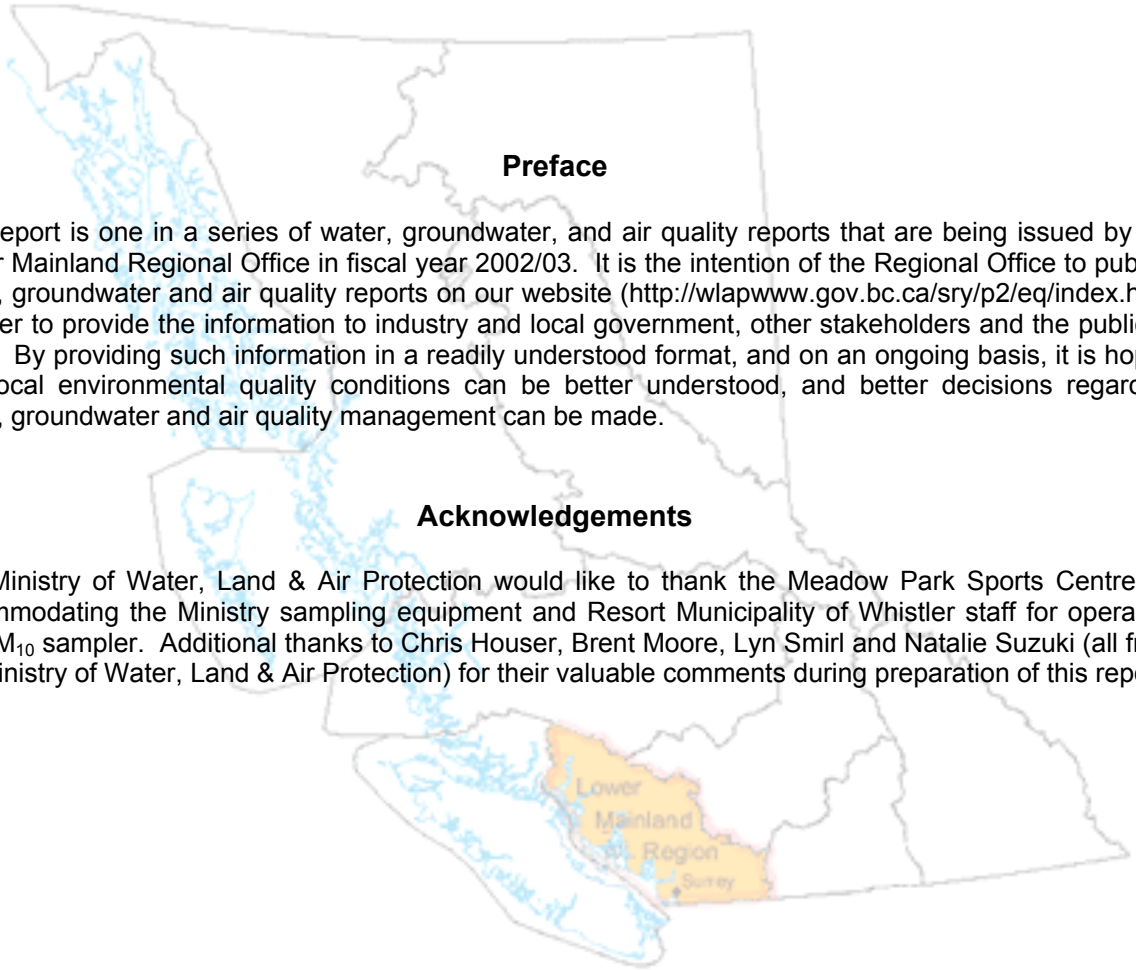

Preface

This report is one in a series of water, groundwater, and air quality reports that are being issued by the Lower Mainland Regional Office in fiscal year 2002/03. It is the intention of the Regional Office to publish water, groundwater and air quality reports on our website (http://wlapwww.gov.bc.ca/sry/p2/eq/index.htm) in order to provide the information to industry and local government, other stakeholders and the public at large. By providing such information in a readily understood format, and on an ongoing basis, it is hoped that local environmental quality conditions can be better understood, and better decisions regarding water, groundwater and air quality management can be made.

Acknowledgements

The Ministry of Water, Land & Air Protection would like to thank the Meadow Park Sports Centre for accommodating the Ministry sampling equipment and Resort Municipality of Whistler staff for operating the PM_{10} sampler. Additional thanks to Chris Houser, Brent Moore, Lyn Smirl and Natalie Suzuki (all from the Ministry of Water, Land & Air Protection) for their valuable comments during preparation of this report.

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1.0 INTRODUCTION

The Resort Municipality of Whistler (Whistler) is located approximately 120 kilometres north of the City of Vancouver, B.C. (Figure 1.0, left inset) in the Sea-to-Sky (STS) corridor. The STS corridor extends approximately 150 kilometres from the Howe Sound entrance at the Strait of Georgia (Vancouver, B.C.) to the confluence of the Pemberton and Lillooet valleys at Pemberton, B.C. The corridor traverses the Coastal Mountain Range and encompasses a coastal fjord (Howe Sound), steep valleys, glaciated terrain, coniferous forest, and river valleys. Scenic vistas are among the corridors greatest attributes and, as such, the corridor is extensively utilized for recreation, tourism and backcountry activities.

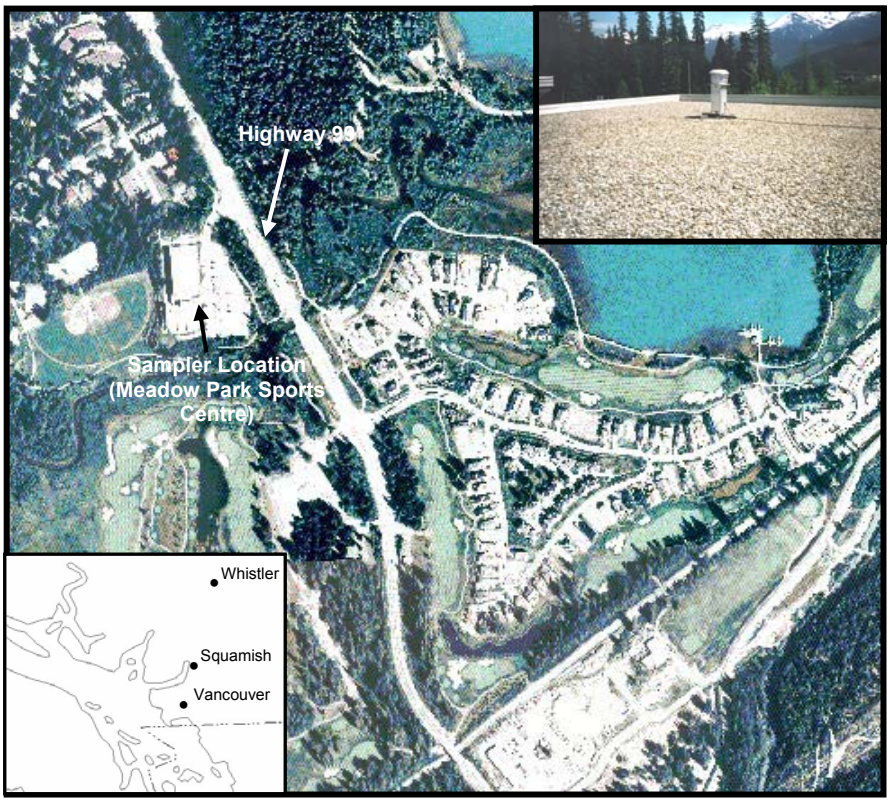

FIGURE 1.0. Location of the Whistler PM_{10} and ozone samplers. Left inset is Whistler location map. Right inset is photograph of the PM_{10} sampler on the roof of the Meadow Park Sports Centre.

Whistler was incorporated in 1975 and encompasses approximately 126 square kilometres. Data indicates a 2001 Whistler population of 9965 with the Accommodation, Food, and Beverage Services; Retail Trade; and Construction industries employing the most people in Whistler.[1] Whistler is recognized as a year-round destination resort; between 1994 and 1998, over 2 million people visited Whistler annually with an average of 13,000 visitors per day during the summer and 16,500 visitors per day during the winter. Summer and winter peak visitor numbers typically occur during the months of August and March, respectively.[2]

Whistler has undergone rapid development in recent years. For example, between 1996 and 2000 the permanent population of Whistler increased over 25 percent, with construction values totalling

[1] **BC Stats. 2001**. Community Facts: Whistler Resort Municipality. http://www.bcstats.gov.bc.ca/data/dd/facsheet/cf294.pdf

[2] **Tourism Whistler. 2001.** http://www.whistler.travel.bc.ca

approximately $550 million over the same period. Over the next 5 years construction values are anticipated to total $300 million with even greater expansion should Vancouver-Whistler host the 2010 Winter Olympics.

Concurrent with rapid expansion is an increase in potential for impacts to air quality through activities such as land clearing, construction, home heating, commercial/industrial activity, transportation etc. Reductions in air quality increases the risk of negative impacts to human health and the environment which, in turn, may impact the recreational and tourism-based economy of the region.

2.0 AIR QUALITY

Two air pollutants known to have significant impacts on human health are particulate matter under 10 microns in diameter (PM_{10}) and ground-level ozone (ozone). PM_{10} and ground-level ozone have been monitored in the STS airshed[3] and have been measured at levels known to potentially impact on human health.

2.1 PM_{10}

PM_{10}, also referred to as "inhalable particulate matter", occurs both naturally and anthropogenically[4]. Natural sources include windblown soil, pollen, spores and marine aerosols; anthropogenic sources include industrial processing, transportation (i.e. diesel exhaust particulate, road dust), and wood smoke from home heating. PM_{10} has been identified as the most important ambient air pollutant in British Columbia with studies suggesting an association between increased ambient PM_{10} concentrations and negative health effects, including mortality. Particulate matter greater than 10μm is generally not of concern, as these larger particles collect in the nose and throat and are subsequently eliminated from the body via sneezing, coughing, nose blowing or digestion. PM_{10} eludes such defence mechanisms and penetrates into the lungs, thus posing a threat to human health. Generally, the smaller the inhaled particle, the deeper it can be drawn into the lung; therefore, it is the finer fraction of PM_{10} that deposits deepest in the lung. This finer fraction of PM_{10} is referred to as "fine particulate matter" and consists of particulate matter having an aerodynamic diameter of less than 2.5μm ($PM_{2.5}$). Health impacts associated with PM_{10} (and thus $PM_{2.5}$) include irritation of the respiratory tract, aggravation of existing respiratory conditions (i.e. bronchial asthma, pulmonary emphysema), and contribution to the development of chronic bronchitis. Studies also suggest there is an increased risk of mortality with increasing concentrations of ambient PM_{10}.[5] A threshold PM_{10} concentration for which impacts to human health do not occur has not been determined.[6]

2.2 Ozone

Ozone is a colourless, reactive gas that occurs naturally in the atmosphere. In the upper atmosphere, (stratosphere) ozone is critical to life on earth as it protects biological systems from the damaging wavelengths of solar ultraviolet radiation. However, the physical and chemical properties that make ozone a critical component of the upper atmosphere are undesirable in high concentrations at ground level. Ozone is a powerful oxidant and it is significant to note that the powerful oxidizing properties of

[3] airshed - the mass of air contained within a definite boundary (usually defined by topography).

[4] anthropogenic - caused or produced by humans

[5] **Vedal, S. 1995.** Health effects of inhalable particles: implications for British Columbia. Prepared for the Air Resources Branch of the Ministry of Environment, Lands and Parks. Victoria, B.C.

[6] **Canadian Environmental Protection Act/Federal Provincial Working Group on Air Quality Objectives and Guidelines. 1998.** National Ambient Air Quality Objectives for Particulate Matter. Part 1 - Science Assessment Document: Executive Summary. Minister of Public Works and Government Services, Ottawa, Ont.

ozone have been put to use in the treatment of wastes, sterilization of equipment, bleaching of products, and purification of water.

Elevated ground-level ozone concentrations negatively impact on human health, vegetation, and property. Health impacts associated with ozone include irritation of the respiratory tract, aggravation of existing respiratory conditions (i.e. asthma, bronchitis, pulmonary emphysema), and eye irritation. A threshold ozone concentration for which impacts to human health do not occur has not been identified and studies indicate a continuum of effects through all ambient levels of ozone. Elevated levels of ozone also negatively impact on vegetation by damaging leaf surfaces, which increases susceptibility to pests and disease, and impairs food production. Ozone also damages materials such as rubber, textile fibres, paints, and dyes.[7,8,9,10]

Ground-level ozone is formed by a series of complex chemical reactions involving precursor pollutants (i.e. oxides of nitrogen, volatile organic compounds) in the presence ultraviolet light (sunlight) and heat. Oxides of nitrogen (NOx is normally used to represent nitrogen oxide and nitrogen dioxide) emissions are primarily associated with the combustion of fossil fuels, with the transportation sector representing the largest source of NOx emissions in British Columbia.[9] Volatile organic compound emissions are associated with incomplete combustion of fuel, evaporation of fuels/solvents/paints, and vegetation. In British Columbia, natural sources (i.e. vegetation) have been identified as the largest contributors of volatile organic compounds (VOCs); monoterpenes and isoprenes are VOCs commonly found in the oils responsible for plant fragrance and are notable VOCs involved in ozone formation[8].

Elevated concentrations of ground-level ozone typically occur downwind from sources of the precursor pollutants, and generally occur during the warmer months of the year when light intensity and duration is greatest.[8,9] In Canada, the period of May to September is often referred to as the "ozone season".

3.0 AIR QUALITY OBJECTIVES

The *Provincial Ambient Air Quality Objectives* define ambient air concentrations intended to be protective of human health and the environment. Objective concentrations have been developed for common atmospheric pollutants such as sulphur dioxide, nitrogen dioxide, and ozone, and are generally referred to as Level A, Level B, or Level C. The Provincial Level A, B, and C Objectives generally correspond to the *National Ambient Air Quality Objectives*[11] of 'maximum desirable', 'maximum acceptable', and 'maximum tolerable' concentrations, respectively. The **maximum desirable** concentration is intended to provide long-term protection. The **maximum acceptable** concentration is intended to provide adequate protection to soil, water, vegetation, animals, visibility, personal comfort and well-being. The **maximum tolerable** concentration indicates concentrations requiring prompt appropriate action to protect the general health of the population.

The Canadian Environmental Protection Act Federal/Provincial Working Group on Air Quality Objectives and Guidelines (Federal/Provincial Working Group) also develops air quality objectives to protect people

[7] **Friedman, R.M., Milford, J.B., Rapoport, R.D. and Szabo, N.B. 1989.** Catching Our Breath: Next Steps for Reducing Urban Ozone U.S. Congress, Office of Technology Assessment, Washington, D.C.

[8] **Canadian Environmental Protection Act/Federal Provincial Working Group on Air Quality Objectives and Guidelines. 1999.** National Ambient Air Quality Objectives for Ground-Level Ozone. Summary - Science Assessment Document. Health Canada and Environment Canada.

[9] **Ministry of Environment, Lands and Parks. 1998.** Air Quality Report for British Columbia: Ground-level Ozone Concentrations 1986-1997. Victoria, B.C.

[10] **Lutgens F.K. and E.J. Tarbuck. 1995.** The atmosphere: an introduction to meteorology. Prentice-Hall. Englewood Cliffs, N.J.

[11] **Health Canada. 2001.** National Air Quality Objectives. http://www.hc-sc.gc.ca/hecs-sesc/air_quality/naaqo.htm

and the environment from adverse effects associated with airborne pollutants[8]. The Federal/Provincial Working Group develops "Reference Levels" which are defined as levels, above which, there are demonstrated effects on human health and/or the environment.

For purposes of this report, Federal and Provincial Objective Levels and Federal Reference Levels are collectively referred to as "Ambient Air Quality Objectives".

As previously noted, threshold PM_{10} and ozone concentrations for which impacts to human health do not occur have not been determined; accordingly, impacts to human health and the environment may be occurring at concentrations below the Ambient Air Quality Objectives established for these particular pollutants.

3.1 PM_{10}

Based on a review of epidemiological studies, the Federal/Provincial Working Group recommends a 24-hour "Reference Level" of 25 micrograms per cubic metre ($\mu g/m^3$) for PM_{10}. The Provincial Ambient Air Quality 24-hour PM_{10} Objective is 50 micrograms $\mu g/m^3$.

Sampling results from the Whistler PM_{10} sampling program were compared to the Federal/Provincial Working Group 24-hour PM_{10} Reference Level of $25\mu g/m^3$ and the Provincial Ambient Air Quality 24-hour PM_{10} Objective of $50\mu g/m^3$.

3.2 Ozone

Provincial Ambient Air Quality Objectives do not currently exist for ozone; therefore, the Federal National Air Quality Ozone Objectives were adopted for this report. Federal National Air Quality Ozone Objectives exist for averaging periods of 1-hour, 24-hours and 1-year. The Whistler ozone sampling results were compared to the 1-hour Federal "Maximum Desirable", "Maximum Acceptable", and "Maximum Tolerable" Ozone Objectives of 100, 160, and $300\mu g/m^3$, respectively. A complete year of ozone data was not collected in Whistler thus precluding comparison to the 1-year Objective. Results were not compared to the 24-hour Ozone Objectives as literature suggests a 24-hour averaging period is inappropriate for ozone due to strong diurnal patterns in ozone formation, year-to-year variability in ozone at different locations, and high background ozone levels in some locations.[9,10] A recent discussion paper[12] on air quality objectives in British Columbia suggests that 1-hour, 8-hour and 1-year averaging periods be used for ozone objectives to more accurately reflect ozone exposure and thus be more protective of human health.

3.3 Canada Wide Standards

In 2000, the Canadian Council of Ministers of the Environment (CCME) developed Canada-Wide Standards (CWS) for Particulate Matter (PM) and ozone. The CWS levels are intended to reduce risks to human health and protect the environment while recognizing constraints (i.e. feasibility, cost) of reducing pollutant emissions. The federal, provincial (except Quebec) and territorial governments were signatory to a commitment to achieve the CWS for PM and ground-level ozone by 2010.

The CWS ozone standard is 65 parts per billion (approximately $130\mu g/m^3$) averaged over an 8-hour period; achievement of the CWS ozone standard is based on the 4th highest daily 8-hour measurement, averaged over 3 consecutive years.[13] As 3 years of ozone data have not yet been collected in Whistler, achievement of the CWS cannot be assessed until 2005.

[12] **Caton, R.B. and D.V. Bates. 2002.** Updating BC provincial air quality objectives - an options discussion paper. Prepared for the Ministry of Water, Land & Air Protection. 22 p + app.

[13] **Particulate Matter and Ozone Canada-wide Standards.** http://www.ccme.ca/assets/pdf/pm_ozone_backgrounder_e.pdf

A CWS standard has only been developed for $PM_{2.5}$ thus precluding comparison of Whistler PM_{10} data with CWS levels. A CWS standard was only developed for $PM_{2.5}$ as it is this fraction of PM_{10} that represents the greatest risk to human health (discussed in Section 2.1).

4.0 PREVIOUS STUDIES

4.1 PM_{10}

Prior to WLAP commencing a long-term PM_{10} sampling program in 1997, PM_{10} sampling in the Whistler area was limited to short-term studies.

In 1990, Whistler commissioned an air quality study[14] to determine ambient concentrations of contaminants associated with wood smoke from residential wood burning appliances. Parameters studied included polyaromatic hydrocarbons, total suspended particulate, and PM_{10}. Between March 1991 and March 1992, 33 PM_{10} samples were collected. The 24-hour PM_{10} concentration ranged between 0.6 and 63$\mu g/m^3$ with a mean 24-hour PM_{10} concentration of 15 $\mu g/m^3$. Two of the samples exceeded the Provincial Ambient Air Quality PM_{10} Objective of 50$\mu g/m^3$.

In 1994, B.C. Environment (now WLAP) undertook a short-term ambient PM_{10} sampling study[15] to quantify ambient PM_{10} concentrations during the winter months when residential heating (i.e. wood burning) was likely at its maximum. Between November 1994 and February 1995, 14 PM_{10} samples were collected. The 24-hour PM_{10} values ranged between 2 and 22$\mu g/m^3$ with a mean 24-hour PM_{10} concentration of 9.6$\mu g/m^3$. None of the samples exceeded the Provincial Ambient Air Quality 24-hour PM_{10} Objective.

4.2 Ground-Level Ozone

Prior to commencement of this ground-level ozone monitoring program, ozone monitoring had not be undertaken in Whistler in the past. However, ozone has been monitored in the communities of Pemberton and Squamish which are located approximately 30 kilometres north and 60 kilometres south, respectively, of Whistler.

Between February 1985 and May 1986, B.C. Environment collected 9982 hours of ground-level ozone sampling data in Pemberton, B.C. In that time, the Federal 1-hour "Maximum Desirable" Ozone Objective was exceeded 56 times between June and August 1995.

Between July 1995 and December 2000, WLAP collected 44,591 hours of ground-level ozone sampling data in Squamish, B.C. In that time, the Federal 1-hour "Maximum Desirable" and "Maximum Acceptable" Ozone Objectives were exceeded 189 and 6 times, respectively, with exceedances limited to the period of April to September. All 6 exceedances of the "Maximum Acceptable" Ozone Objective occurred in July 1998 and resulted in the issuance of an air quality advisory which instructed residents with existing respiratory ailments to consider reducing physical exertion and minimize outdoor activity.

[14] **Bovar Environmental Services (Western Research). 1993.** Air quality investigation, Whistler, B.C.: Woodsmoke from residential woodburning appliances. Prepared for The Resort Municipality of Whistler. 42 p + app.

[15] **B.C. Environment. 1993**. The Resort Municipality of Whistler Inhalable Particulate (PM10) Study 1994/95. Surrey, B.C.

5.0 SAMPLING PROGRAM

5.1 Program Objective

With rapid expansion in Whistler and the STS corridor and air quality data indicating elevated levels of PM_{10} and ground-level ozone occur in the STS corridor, WLAP commenced ambient PM_{10} and ground-level ozone sampling in Whistler, B.C. The objectives of the sampling program were:

- to quantify ambient PM_{10} and ground-level ozone for comparison to Ambient Air Quality Objectives, and
- to collect data for assessment of trends in ambient PM_{10} and ground-level ozone in the Whistler area.

This report summarizes the results of PM_{10} sampling (August 1997 to December 2001) and ground-level ozone sampling (April to December 2001) in Whistler, B.C.

5.2 Sampler Setup and Operation

5.2.1 PM_{10}

PM_{10} sampling commenced August 02, 1997. For the Whistler PM_{10} sampling program, a Sierra-Anderson Hi-Vol PM_{10} sampler was set up on the roof of the Meadow Park Sports Centre (civic address 8107 Camino Drive) in Whistler, B.C. The co-ordinates of the sampler are N 50°08'38.4" and W 122°57'39.9". The Meadow Park Sports Centre location was chosen as it allows for representative air samples of the area to be obtained, while providing a secure location requisite for a long-term monitoring program. The sampler is operated according to the National Air Pollution Surveillance (NAPS) network 6-day sampling cycle (i.e. sampling every 6th day) which allows for each day of the week to be equally sampled over the duration of a long-term monitoring program. On the designated sample date, the HiVol sampler runs continuously for 24-hours (midnight to midnight). When sampling, the HiVol draws air at a rate of approximately 1.13 cubic metres per minute (m^3/min) through the circular "head" portion of the sampler. The circular intake allows for air to be sampled in all directions from the sampler. Sampled air passes through a size selective inlet and PM_{10} is collected on a pre-weighed 8 x 10 inch teflon-coated glass fibre filter. The used sample filter is sent to a laboratory for conditioning and analysis with PM_{10} results reported in $\mu g/m^3$.

Representatives from the Resort Municipality of Whistler have been operating the Hi-Vol sampler on behalf of WLAP. WLAP is responsible for maintenance and calibration of the sampler, as well as the operating costs associated with running the sampler (i.e. sample filters, laboratory analysis etc.). The Meadow Park Sports Centre provides the power to run the sampler.

5.2.2 Ozone

Ozone sampling commenced April 24, 2001. For the Whistler Ozone sampling program, a TECO Model 49 UV Photometric Ozone Analyzer was setup at the Meadow Park Sports Centre. The analyzer and datalogger were installed in the facility maintenance room with the sampler air intake located on the roof of the building approximately 10 metres west of the previously described HiVol PM_{10} sampler. The air intake is approximately 1.5 metres above the roof.

The TECO Model 49 analyzer operates continuously (i.e. 24 hours a day, 365 days a year) and samples air at a rate of approximately 0.001 m^3/min (1.0 Litre per minute). The concentration of ozone in a sample stream is determined by measuring the amount of ultraviolet light, at a wavelength of 254 nanometres, that is absorbed in the air sample stream. The amount of light absorption is proportional to

the amount of ozone present in the air sample. The analyzer reports the ozone concentration in parts per billion (ppb). Sampling data from the ozone analyzer is stored on a datalogger and transferred to the provincial monitoring network database in Victoria, B.C. (via modem). Sampling data is reviewed and validated before being archived to the provincial database. Archived data are reported in micrograms per cubic metre ($\mu g/m^3$).

WLAP is responsible for maintenance and calibration of the ozone analyzer. The Whistler Meadow Park Sports Centre provides the phone line for data transfer and the power to run the analyzer and datalogger.

5.3 Data Capture

Data capture refers to the amount of data available within the sampling period and is a reflection of how representative the samples are for a given sampling period. Data capture is expressed as a percentage of the total number of samples that could have been obtained in the sampling period.

The WLAP State of the Environment Reporting Office (SERO) reviews data collected by various ministry programs in disciplines such as wildlife, groundwater, species-at-risk, air quality, and domestic waste. The SERO prepares comprehensive public reports on environmental conditions and trends within the province.[16] For data from a NAPS 6-day PM_{10} sampling schedule to be utilized by SERO, data capture must exceed 75 percent for 11 months of the reporting year. Since commencement of the PM_{10} sampling program in 1997, obtaining valid PM_{10} samples has been problematic and the particulate sampling program has yet to achieve the data capture requirement. The sampling program was suspended on 3 occasions for a total of 17 months and was again suspended in March 2002. For continuous gas analyzers (i.e. the Whistler ozone analyzer) data capture must exceed 75 percent for the reporting period. Ozone sampling met the data capture requirement in 2001.

6.0 RESULTS AND DISCUSSION

PM_{10} sampling results are depicted graphically in Figures 2.0 through 5.0 for 1997/1998, 1999, 2000 and 2001, respectively, with data provided in Appendices A, B, C and D, respectively. Ozone sampling results for 2001 are depicted graphically in Figure 6.0.

As noted in Section 2.3, PM_{10} data capture requirements have not been achieved since commencement of the PM_{10} sampling program. While 137 valid PM_{10} samples have been obtained since August 1997, it is important to note that the resulting data set is not temporally representative of ambient PM_{10} concentrations in Whistler. For example, over the duration of the sampling program (i.e. August 1997-December 2001) the month of January was sampled twice while the months of August, September, October and November were sampled four times. Because Whistler PM_{10} data collected to date is not fully representative, the assessment of PM_{10} trends, and the calculation of annual summary statistics (i.e. arithmetic mean, 95-Percentile concentration) is precluded. Therefore, assessment of PM_{10} data collected to date is limited to comparison with the Ambient Air Quality Objectives.

As ozone sampling in Whistler has only occurred for 8 months, the assessment of ozone trends and the calculation of annual summary statistics (i.e. arithmetic mean, 95-Percentile concentration) is precluded. Therefore, an assessment of the ozone data collected to date is limited to a comparison with the Ambient Air Quality Objectives. Comparison to the CWS ozone standard requires 3 years of data thus precluding comparison of Whistler ozone data to the CWS standard until 2005.

[16] **State of the Environment Reporting Home Page.** http://wlapwww.gov.bc.ca/soerpt/index.html

6.1 PM_{10}

6.1.1 1997 and 1998

Between August 1997 and January 1998, 22 valid samples were collected out of a possible 36. Results of 1997 and 1998 PM_{10} sampling are depicted graphically in Figure 2.0.

None of the 1997 and 1998 samples exceeded the Provincial Ambient Air Quality Objectives.

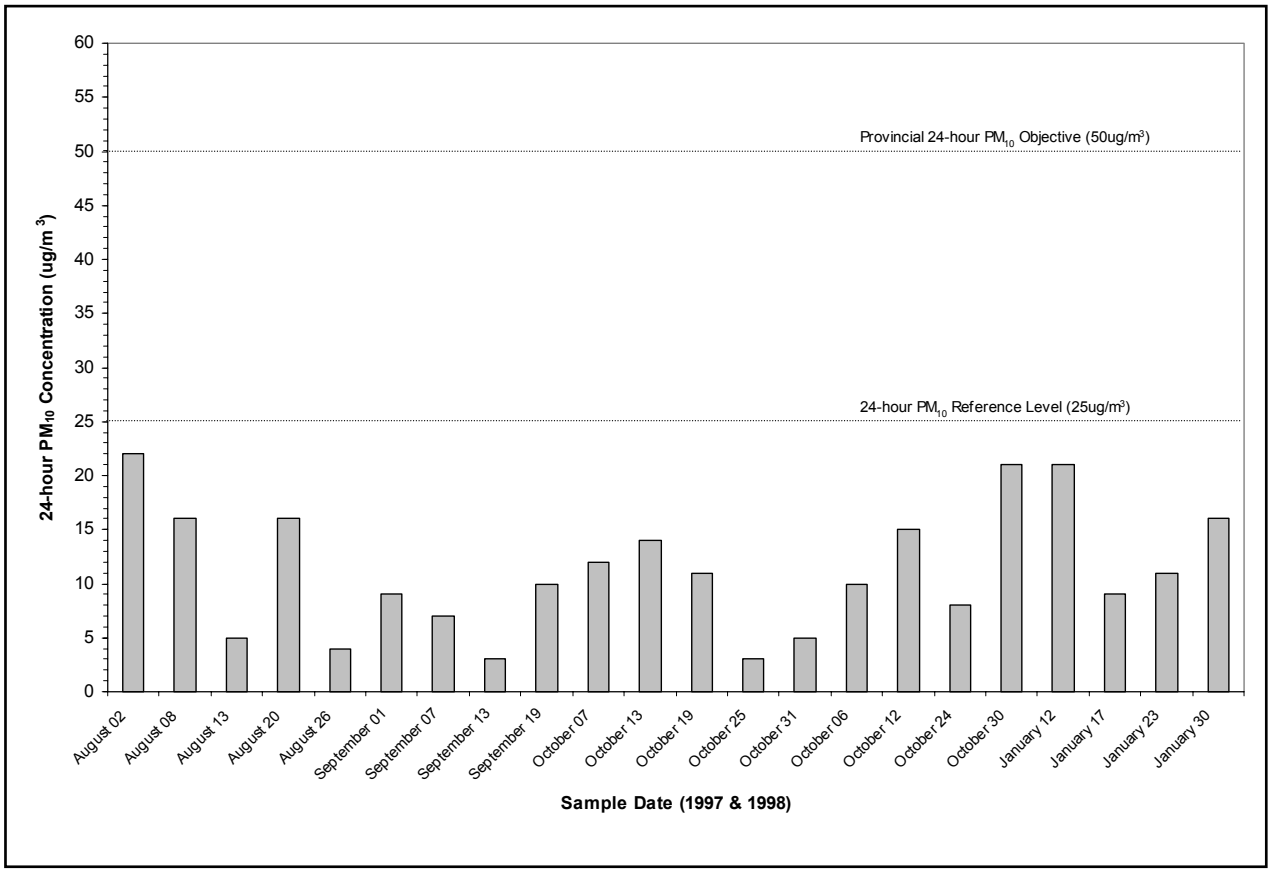

FIGURE 2.0 24-hour PM_{10} concentrations at Meadow Park Sports Centre, Whistler, B.C. between August 1997 and January 1998.

6.1.2 1999

Between March and December 1999, 40 valid samples were collected out of a possible 49. Results of 1999 PM_{10} sampling are depicted graphically in Figure 3.0.

Eight of the 40 samples collected in 1999 exceeded the 24-hour Reference Level of 25μg/m^3 with one of the samples exceeding the 24-hour Provincial Ambient Air Quality Objective of 50μg/m^3. The above-noted exceedances occurred on March 19th (27μg/m^3), March 31st (33μg/m^3), August 22nd (36μg/m^3), August 28th (36μg/m^3), September 15th (54μg/m^3), September 21st (44μg/m^3), September 27th (30μg/m^3) and November 2nd (28μg/m^3).

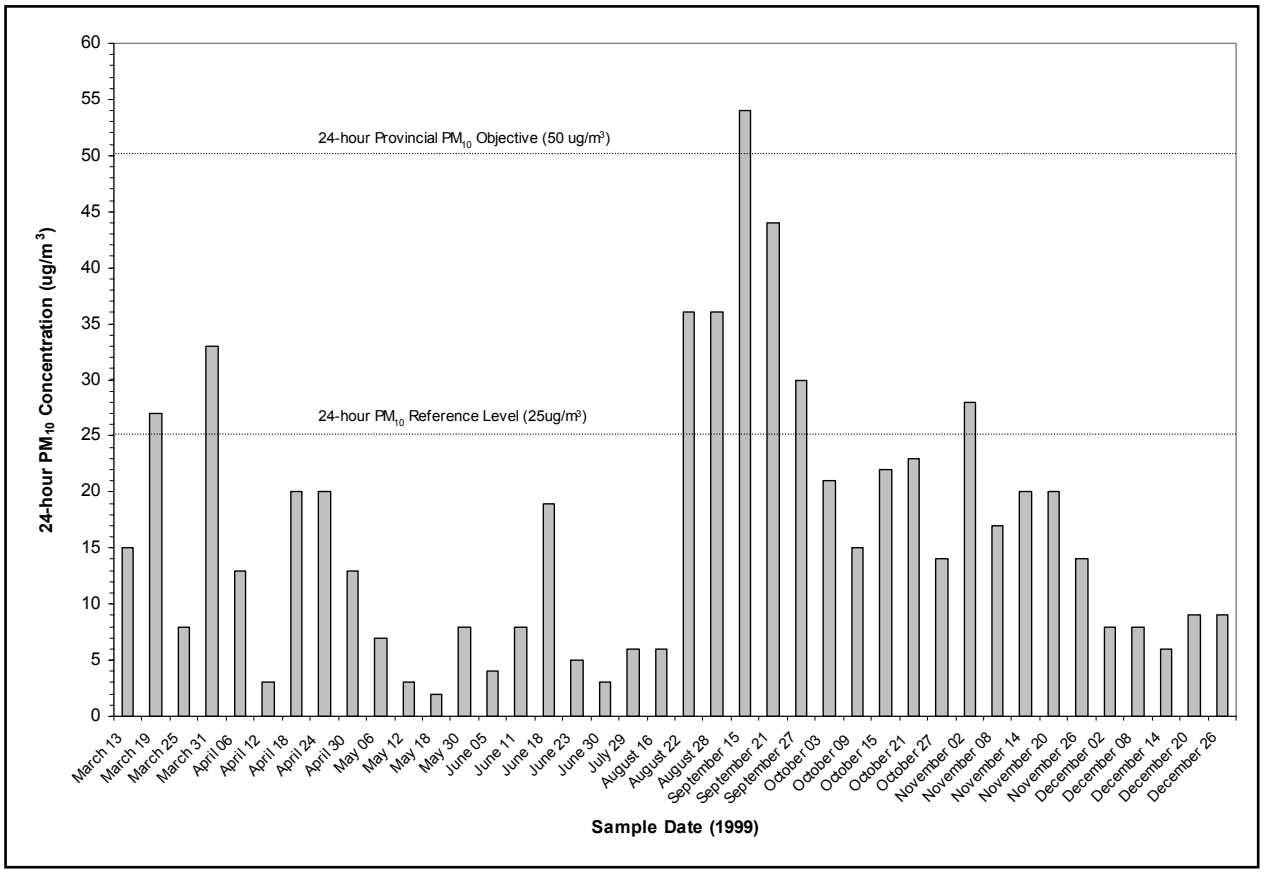

FIGURE 3.0 24-hour PM_{10} concentrations at Meadow Park Sports Centre, Whistler, B.C. between March and December 1999.

6.1.3 2000

Between January and December 2000, 53 valid samples were collected out of a possible 57. Results of 2000 PM_{10} sampling are depicted graphically in Figure 4.0.

Three of the 2000 samples exceeded the 24-hour Reference Level of 25μg/m^3. The above-noted exceedances occurred on March 7th (39μg/m^3), March 25th (28μg/m^3) and March 31st (31μg/m^3).

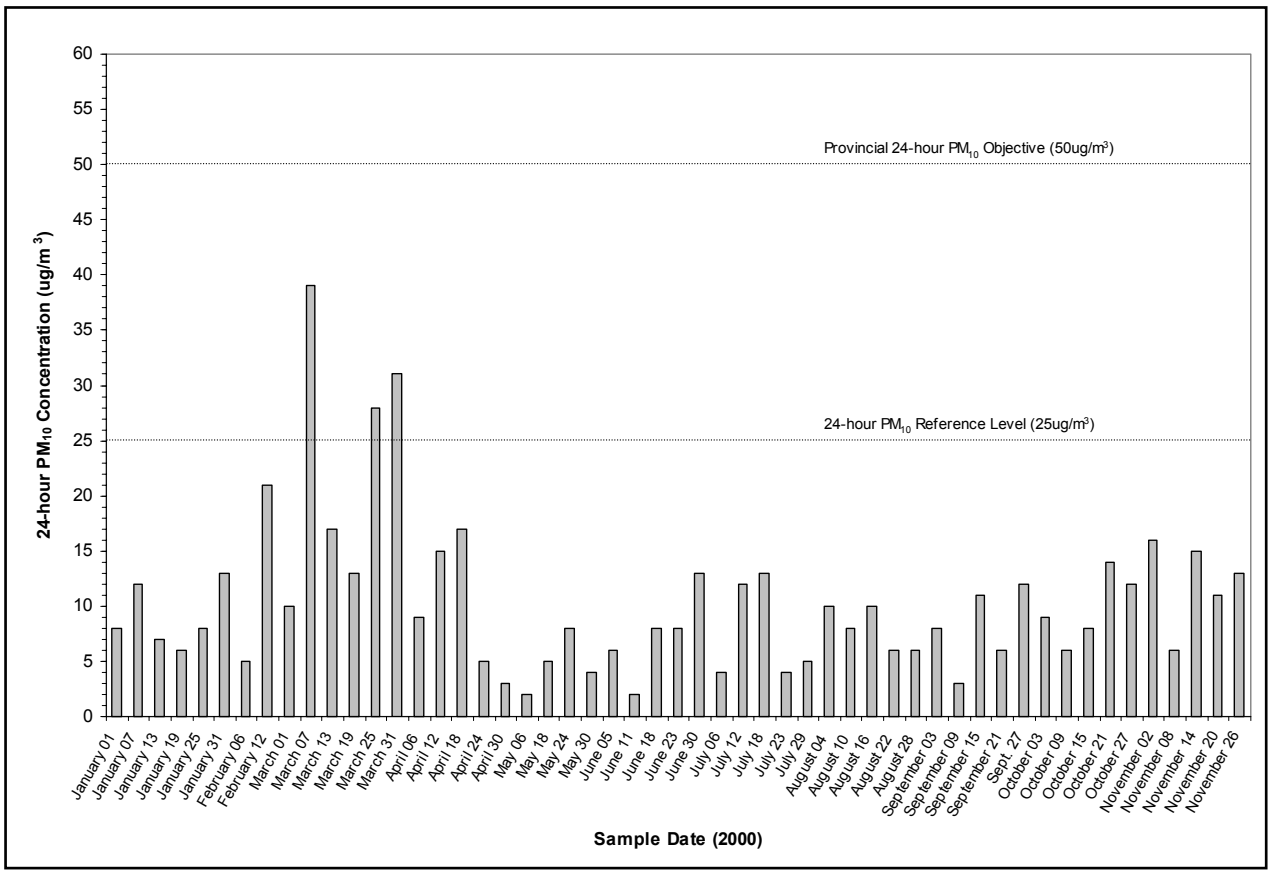

FIGURE 4.0 24-hour PM_{10} concentrations at Whistler Meadow Park Sports Centre between January and November 2000.

6.1.4 2001

Between April and December 2001, 22 valid samples were collected out of a possible 42. Results of 2001 PM_{10} sampling are depicted graphically in Figure 5.0.

None of the 2001 samples exceeded the Ambient Air Quality Objectives.

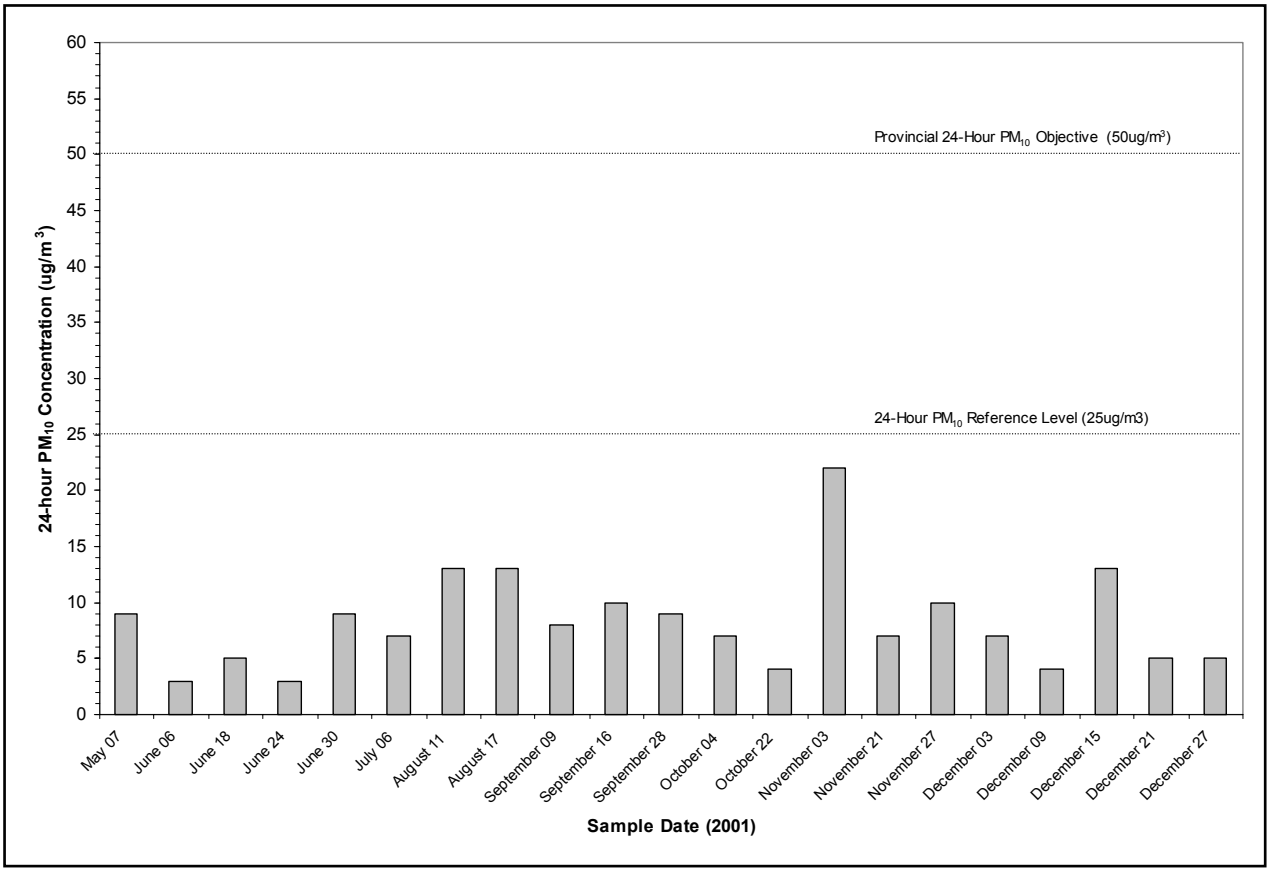

FIGURE 5.0 24-hour PM_{10} concentrations at the Whistler Meadow Park Sports Centre between May and December 2001.

6.2 Ozone

6.2.1 2001

The Whistler ozone sampling program commenced April 24, 2001. A total of 5776 hours of valid sampling data were obtained between April 24 and December 31, 2001. A monthly summary of the sampling program is provided in Table 1.0 with results of 2001 ozone sampling depicted graphically in Figure 6.0.

The Federal 1-hour "Maximum Desirable" Ozone Objective was exceeded 55 times over a period of 12 days in the above-noted sampling period. Air Quality Objective exceedances represent approximately 1

percent of the total hours sampled. Details of exceedances are provided in Table 2.0. The Federal 1-hour "Maximum Acceptable" Ozone Objective was not exceeded during 2001 sampling.

**TABLE 1.0 SUMMARY OF OZONE SAMPLING, WHISTLER, B.C.
APRIL - DECEMBER 2001**

Month	Hours of Data	Hourly Minimum	Hourly Maximum	Hourly Average	1-Hour Ozone Objective Exceedances					
					Maximum Desirable (100 µg/m^3)		Maximum Acceptable (160 µg/m^3)		Maximum Tolerable (300 µg/m^3)	
					No. of Hours	%	No. of Hours	%	No. of Hours	%
April 2001	143	0	99.8	50.6	0	0.00	0	0.00	0	0.00
May 2001	714	0	121.7	55.8	32	4.50	0	0.00	0	0.00
June 2001	690	0	109.7	44.3	5	0.70	0	0.00	0	0.00
July 2001	714	0	107.7	44.1	7	1.00	0	0.00	0	0.00
August 2001	712	0	115.7	30.2	11	1.50	0	0.00	0	0.00
September 2001	691	0	87.8	25.7	0	0.00	0	0.00	0	0.00
October 2001	714	0	83.8	28.4	0	0.00	0	0.00	0	0.00
November 2001	691	0	71.8	22.2	0	0.00	0	0.00	0	0.00
December 2001	707	0	81.8	30.4	0	0.00	0	0.00	0	0.00
April-Dec. 2001	**5776**	**0**	**121.7**	**36.9**	**55**	**0.95**	**0**	**0.00**	**0**	**0.00**

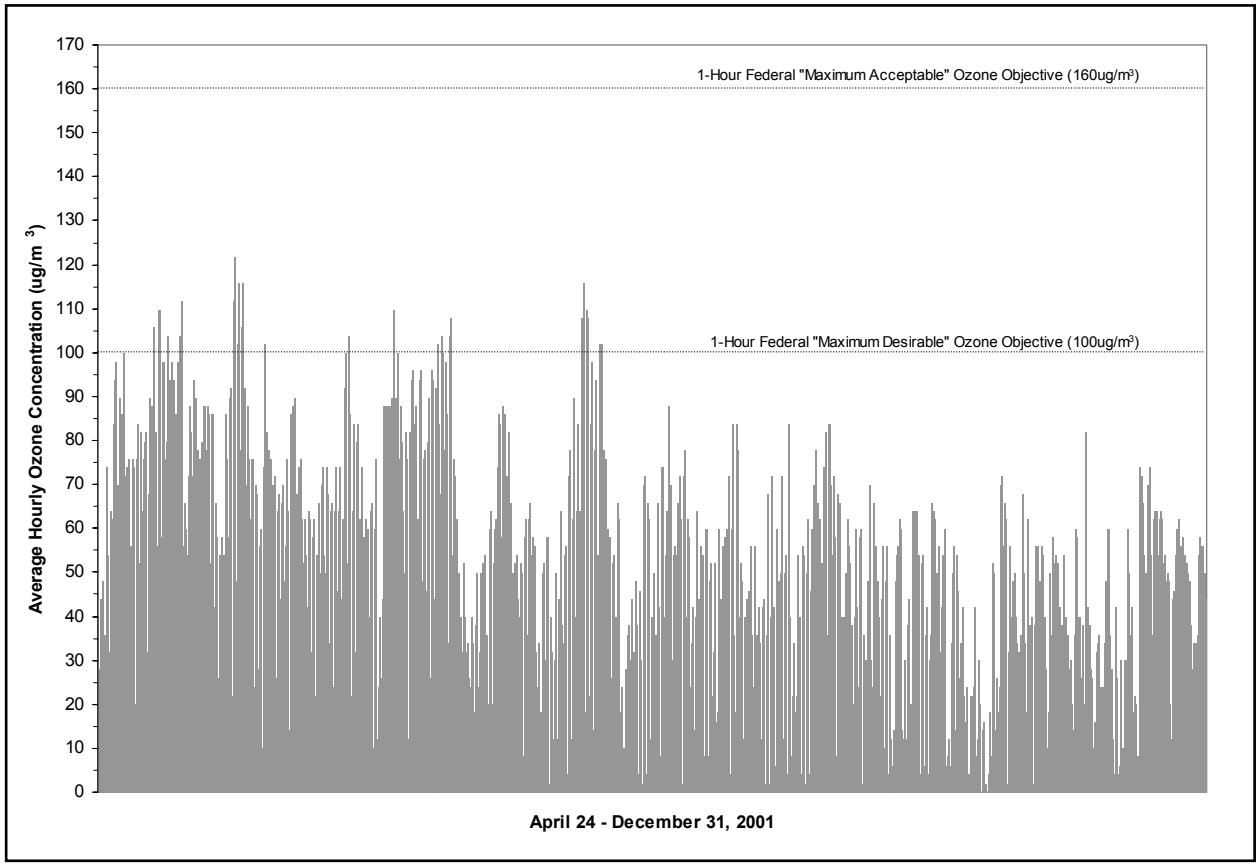

FIGURE 6.0 Average hourly ozone concentrations at Whistler Meadow Park Sports Centre between April 24, 2001 (1800 hrs PST) and December 31, 2001 (2400 hrs PST).

TABLE 2.0 EXCEEDANCES OF THE FEDERAL 1-HOUR "MAXIMUM DESIRABLE" OZONE OBJECTIVE (100µg/m^3), WHISTLER, B.C. APRIL - DECEMBER 2001

Date	Averaging Hour (PST)	Ozone (µg/m^3)	Date	Averaging Hour (PST)	Ozone (µg/m^3)
May 07	1200-1300	101.8	June 01	1000-1100	101.8
	1300-1400	105.8			
May 08	1000-1100	101.8	June 20	1300-1400	103.8
	1100-1200	109.7		1400-1500	101.8
	1200-1300	107.7			
	1300-1400	107.7	June 30	1700-1800	105.8
	1400-1500	105.8		1800-1900	109.7
	1500-1600	109.7			
	1600-1700	105.8	July 10	1700-1800	101.8
	1700-1800	103.8			
May 10	1200-1300	103.8	July 11	1600-1700	103.8
	1700-1800	103.8		1700-1800	103.8
May 13	1200-1300	103.8	July 13	1000-1100	103.8
	1300-1400	111.7		1500-1600	101.8
	1400-1500	111.7		1600-1700	107.7
	1500-1600	101.8		1700-1800	107.7
May 25	1300-1400	111.7	August 12	1500-1600	107.7
	1500-1600	121.7		1600-1700	115.7
	1600-1700	113.7		1700-1800	109.7
	1700-1800	111.7			
May 26	1200-1300	101.8	August 13	1100-1200	101.8
	1300-1400	101.8		1200-1300	109.7
	1600-1700	115.7		1300-1400	105.8
	1700-1800	115.7		1400-1500	103.8
	1800-1900	113.7		1500-1600	105.8
	1900-2000	101.8		1600-1700	107.7
May 27	1000-1100	105.8	August 16	1500-1600	101.8
	1100-1200	115.7			
	1200-1300	109.7			
	1300-1400	115.7		1700-1800	101.8
	1400-1500	115.7			
	1500-1600	105.8			

As previously noted, ozone is formed by a series of complex chemical reactions involving precursor pollutants in the presence ultraviolet light (sunlight) and heat; accordingly, elevated ozone levels generally occur when light intensity and duration is greatest. This trend was observed in Whistler as exceedances of the 1-hour "Maximum Desirable" ozone objective occurred in the daylight hours within the period of May to August (see Table 2.0).

6.2.2 Ozone Comparison With Other Communities

Ground-level ozone concentrations at Squamish, Whistler, Vancouver, Abbotsford, Chilliwack and Hope are summarized in Table 3.0. Three of the comparison sites are located within the Lower Fraser Valley (i.e. Abbotsford, Chilliwack, Hope) and allows Whistler ozone data to be compared with ozone data from an area of the province that has historically experienced high ground-level ozone concentrations[9]. The Squamish site was chosen for comparison as it is located within the same airshed as Whistler.

TABLE 3.0 COMPARISON OF OZONE CONCENTRATIONS AT 6 SAMPLE SITES MAY - DECEMBER 2001

Location	Hours of Data	1-Hour O_3 Concentration ($\mu g/m^3$)			1-Hour "Maximum Desirable" Ozone Objective Exceedances	
		Minimum	Maximum	Average	No. of Hours	Percentage of Sampling Period
Squamish	5634	0	133.8	26.85	19	0.34
Whistler	**5776**	**0**	**121.7**	**36.85**	**55**	**0.95**
Vancouver	5765	0	132.0	24.00	12	0.21
Abbotsford	5773	0	152	31.14	63	1.09
Chilliwack	5770	0	174	34.02	108	1.87
Hope	5763	0	184	33.54	135	2.34

Based on the limited data set available, Whistler had the highest average 1-hour ozone concentration ($36.85 \mu g/m^3$) among all sites and experienced ambient ozone concentrations similar to those in Abbotsford, B.C., a community within an airshed known to experience high ozone concentrations. Vancouver had fewer exceedances than Whistler, Abbotsford had approximately the same number of exceedances as Whistler, while Chilliwack and Hope had a greater number of exceedances than Whistler. The increase in the number of ozone exceedances in a downwind direction in the Fraser Valley airshed is consistent with typical patterns of ozone formation and a similar downwind increase in the number of ozone exceedances (i.e. 19 to 55) was observed between Squamish and Whistler in 2001.

Whistler exhibited a higher average 1-hour ozone concentration (of $36.85 \mu g/m^3$) than Squamish with $26.85 \mu g/m^3$. This is particularly interesting when comparing emission estimates of ozone precursors (i.e. NOx and VOC) in the STS airshed. A review of emission source estimates[17] within the STS airshed indicates NOx and VOC emissions in the lower section of the STS airshed (i.e. Strait of Georgia to Squamish) total approximately 3700 and 8400 tonnes, respectively, while NOx and VOC emissions in the upper section of the STS airshed (Squamish to Pemberton) total approximately 600 and 4900 tonnes, respectively. The large difference in the above numbers is likely a reflection of the main industrial emission sources within the STS airshed being located in the lower portion of airshed. While emission

[17] **Ministry of Water, Land & Air Protection. 2002.** 1995 Sea-to-Sky Airshed Emissions Inventory of Common Air Contaminants - Summary Report. Surrey, B.C. http://wlapwww.gov.bc.ca/sry/p2/air_quality/emiss_inven_report.html

source estimates for NO_x suggest higher ozone concentrations and/or objective exceedances would be more likely to occur in the lower STS airshed (i.e. Squamish) as compared to the upper STS airshed (i.e. Whistler), the opposite was observed. Ozone formation is complex and dependant on a myriad of chemical reactions under the appropriate meteorological conditions. While nitrogen oxides are required to initiate the process of ozone formation, it is the availability of VOCs that typically limit the process. It is possible, under certain conditions, to increase ozone levels through reductions in NOx concentrations. It is possible that the higher ozone concentrations/objective exceedances in Whistler result from precursor/ozone transport from other areas or the area experiences high background ozone concentrations. The lack of meteorological and ambient data within the upper STS limits understanding of ozone formation and transport within the STS. Additional meteorological and ambient monitoring would aid in understanding ozone formation and transport within the STS airshed.

7.0 SUMMARY

In August 1997, the Ministry of Water, Land and Air Protection commenced PM_{10} sampling in Whistler, B.C. A total of 137 samples were collected between August 1997 and December 2001. Eleven (11) of the 137 samples (approximately 8 percent of samples) exceeded the Provincial Ambient Air Quality PM_{10} Level A Objective with 1 of these samples exceeding the Level B Objective. Objective exceedances were only recorded in the 1999 and 2000 sample years, but this does not necessarily indicate these years experienced elevated levels of ambient PM_{10} compared to other sample years; rather, it is more a reflection of the larger number of samples collected in these years.

In April 2001, the Ministry of Water, Land and Air Protection commenced an ozone sampling program in Whistler, B.C. Between April and December 2001, 5776 hours of sampling data were obtained. The Federal 1-hour "Maximum Desirable" Ozone Objective was exceeded 55 times (approximately 1 percent of the sampling period) over 12 days in May, June, July and August. Further ambient air and meteorological monitoring is required to better understand ozone formation and transport within the STS airshed.

PM_{10} and ozone sampling to date indicates the Whistler area does not experience poor air quality relative to other areas of the province; however, the data clearly indicates that PM_{10} and ozone occur at levels associated with negative health effects. The area continues to grow rapidly which increases the potential for impacts to air quality through activities such as land clearing, construction, home heating, commercial/industrial activity, transportation etc. Reductions in air quality increases the risk of negative impacts to human health and the environment which, in turn, may impact the recreational and tourism-based economy of the region. The CCME (see Section 3.3) acknowledges that most areas of Canada experience ambient levels of ozone and particulate matter below CWS levels but still above levels associated with observable health effects, and the best strategy to avoid future impacts is to "keep clean areas clean". The CCME has agreed to include provisions in the CWS for environmental management in areas where ambient levels are below CWS levels (guidelines for the CWS "keeping clean areas clean" provisions are being developed). Achievement of the CWS (as well as meeting other federal and provincial ambient Air Quality Objectives) in Whistler and the STS corridor will ensure economic expansion will not result in the degradation of air quality in the region. Continued ambient air quality monitoring in Whistler will allow for comparison to the CWS and Air Quality Objectives and, more importantly, allow for the analysis of trends in air quality (i.e. improving, unchanged, degrading) as expansion proceeds in Whistler and the STS corridor.

APPENDIX A

WHISTLER MEADOW PARK SPORTS CENTRE
1997 and 1998 PM_{10} SAMPLING RESULTS

Month/Year	Day	µg/m³ (24 hr. ave.)	Month/Year	Day	µg/m³ (24 hr. ave.)
August 1997	02	22	December 1997	06	10
	08	16		12	15
	13	5		18	no sample
	20	16		24	8
	26	4		30	21
September 1997	01	9	January 1998	05	no sample
	07	7		12	21
	13	3		17	9
	19	10		23	11
	25	no sample		30	16
October 1997	01	no sample	February 1998	04	no sample
	07	12		10	no sample
	13	14		16	no sample
	19	11		22	no sample
	25	3		28	no sample
	31	5			
November 1997	06	no sample	March 1998	sampling program suspended	
	12	no sample			
	18	no sample			
	24	no sample			
	30	no sample			

APPENDIX B

WHISTLER MEADOW PARK SPORTS CENTRE
1999 PM_{10} SAMPLING RESULTS

Month	Day	µg/m³ (24 hr. ave.)	Month	Day	µg/m³ (24 hr. ave.)
January	sampling program suspended		July	05	no sample
				11	no sample
				17	no sample
				23	no sample
				29	6
February			August	04	no sample
				10	no sample
				16	6
				22	**36**
March				28	**36**
			September	03	no sample
	13	15		09	no sample
	19	**27**		15	**54**
	25	8		21	**44**
	31	**33**		27	**30**
April	06	13	October	03	21
	12	3		09	15
	18	20		15	22
	24	20		21	23
	30	13		27	14
May	06	7	November	02	**28**
	12	3		08	17
	18	< 2		14	20
	24	no sample		20	14
	30	8		26	14
June	05	4	December	02	8
	11	8		08	8
	18	19		14	6
	23	5		20	9
	30	3		26	9

Bolded indicates exceedance of the Ambient Air Quality Objectives.

APPENDIX C

WHISTLER MEADOW PARK SPORTS CENTRE
2000 PM_{10} SAMPLING RESULTS

Month	Day	µg/m³ (24 hr. ave.)	Month	Day	µg/m³ (24 hr. ave.)
January	01	8	July	06	4
	07	12		12	12
	13	7		18	13
	19	6		23	4
	25	8		29	5
	31	13			
February	06	5	August	04	10
	12	21		10	8
	18	no sample		16	10
	24	no sample		22	6
March	01	10		28	6
	07	**39**	September	03	8
	13	17		09	3
	19	13		15	11
	25	**28**		21	6
	31	**31**		27	12
April	06	9	October	03	9
	12	15		09	6
	18	17		15	8
	24	5		21	14
	30	3		27	16
May	06	2	November	02	16
	12	no sample		08	6
	18	5		14	15
	24	8		20	11
	30	4		26	13
June	05	6	December	02	no sample
	11	2		sampling program suspended	
	17	8			
	23	8			
	29	13			

Bolded indicates exceedance of the Ambient Air Quality Objectives.

APPENDIX D

WHISTLER MEADOW PARK SPORTS CENTRE
2001 PM_{10} SAMPLING RESULTS

Month	Date	µg/m³ (24 hr. ave.)	Month	Date	µg/m³ (24 hr. ave.)
January	sampling program suspended		July	06	7
				12	no sample
				18	no sample
				24	no sample
				30	no sample
February			August	05	no sample
				11	13
				17	13
				23	no sample
March				29	no sample
			September	04	no sample
				09*	8
				16	10
				22	no sample
April				28	9
			October	04	7
				10	no sample
				16	no sample
	25	no sample		22	4
May	01	no sample		28	no sample
	07	9	November	03	22
	13	no sample		09	no sample
	19	no sample		15	no sample
	25	no sample		21	7
	31	6		27	10
June	06	3	December	03	4
	12	no sample		09	7
	18	5		15	13
	24	3		21	5
	30	9		27	5

* sample date should have been September 10