Ambient Air Monitoring Program
Wabamun-Genesee Area

2009 ANNUAL REPORT

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Executive Summary

TransAlta Generation Partnership and Capital Power Corporation operate four coal-fired thermal generating plants in the Wabamun–Genesee area of west-central Alberta; they are Sundance, Keephills, Wabamun and Genesee. These generating plants operate under Alberta Environmental Protection and Enhancement Act approvals. As part of their approvals, the generating plants conduct special environmental monitoring programs, including ambient air monitoring. This 2009 annual report summarizes results of the ambient air monitoring program that are important for understanding the state of air quality in the Wabamun–Genesee area. Components conducted during 2009 included a continuous monitoring program, an intermittent monitoring program, and a passive monitoring program.

Continuous Monitoring Program

Data capture rates for continuously measured air quality parameters at all of the monitoring stations were above the 90 percent criterion for the year as required by the Alberta Environment Air Monitoring Directive (1989). High up-times were indicative that equipment in the four-station continuous air monitoring network was well-maintained. The Wagner station experienced planned and unplanned power outages during May 4, 5, 11 to 15, and 25 to 27, resulting in up-times of 77 percent for monitoring equipment during the month. This station operated normally for the remainder of the year. Overall, air quality was judged to be good at the monitoring stations during 2009, similar to that observed in previous years. A summary of the 2009 continuous monitoring data is as follows:

- Hourly NO₂ concentrations were very low at all four air monitoring stations (below 58 µg/m³ for 98 percent of the time). The observed 9th highest 1-hour NO₂ concentrations ranged from 56 µg/m³ at the Genesee station to 78 µg/m³ at the Meadows station. All of these concentrations fall well below the 1-hour Alberta Ambient Air Quality Objective of 400 µg/m³.

- Hourly SO₂ concentrations were very low at all four air monitoring stations (below 27 µg/m³ for 98 percent of the time). The observed 9th highest 1-hour SO₂ concentrations ranged from 57 µg/m³ at the Powers station to 83 µg/m³ at Genesee station. All of these concentrations fall well below the 1-hour Alberta Ambient Air Quality Objective of 450 µg/m³.

- The annual average O₃ concentration at the Genesee station was 55 µg/m³. Hourly O₃ concentrations at the Genesee station were below 116 µg/m³ for 98 percent of the time during 2009. The 9th highest 1-hour O₃ concentration observed at the Genesee station was 173 µg/m³. O₃ concentrations at the Genesee air monitoring station exceeded the Alberta Ambient Air Quality objective of 160 µg/m³ for 11 hours during 2009. These exceedences occurred for seven hours over July 24 and 25 and for four hours on September 1.

- Median (50th percentile) 24-hour PM₂.₅ concentrations at the Genesee and Powers stations were very low (below 5 µg/m³). The 98th percentile 24-hour PM₂.₅ concentrations at both air monitoring stations were below 22 µg/m³.

Intermittent Monitoring Program

Twenty-four hour average PM₂.₅ and PM₁₀ samples were collected at the Genesee station (n=61) and the Powers station (n=61) according to a National Ambient Pollutant Surveillance (NAPS) six-day cycle sampling frequency. The following summarizes the intermittent monitoring data for 2009:

- Twenty-four hour average PM₂.₅ concentrations were below 22 µg/m³ at both the Genesee station and the Powers station for 98 percent of the time. This is consistent with 24-hour average data observed from continuous monitoring at these stations.

- Twenty-four hour average PM₁₀ concentrations were below 68 µg/m³ at both the Genesee and Powers air monitoring stations for 98 percent of the time.
Passive Monitoring Program

Passive air monitors were deployed at 21 sites in the Wabamun–Genesee area during 2009. The 2009 passive data is outlined as follows:

- At passive sites located within 30 km of the generating plants, annual average NO₂ concentrations ranged from 2.2 to 4.6 ppb (4.1 to 8.7 µg/m³), whereas at the Edmonton East station the annual average NO₂ concentration observed was 28 µg/m³. Annual NO₂ concentrations determined by passive monitors showed a small increase between sites near Lake Wabamun to sites adjacent to the City of Edmonton. This spatial trend is due to the influence of increasing urban NOₓ emissions within and adjacent to the City of Edmonton. Urban source emissions are more important contributors to ambient NO₂ concentrations observed in and around the City of Edmonton compared to emissions from generating plants located in the Wabamun-Genesee area.

- Annual average SO₂ concentrations were very low, ranging from 0.6 to 1.7 ppb (1.6 to 4.5 µg/m³) at all passive sites in the Wabamun–Genesee area. This lack of spatial trend is consistent with that reported in previous studies for the same area.

- Annual average O₃ concentrations observed at passive monitoring sites directly east of the Wabamun–Genesee area ranged from 22 to 30 ppb (43 to 59 µg/m³). Passive monitoring Sites 15 and 16 are located greater than two- to four-hours travel time downwind of the generating plants along an imaginary northwest line on which the generating plants are located. Generating plant plume chemistry maturity and peak production capacities of anthropogenic O₃ and inorganic nitrogen species occur between 30 and 100 km downwind of generating plants (within the range of where these two passive monitoring sites are located). Annual average O₃ concentrations at passive monitoring Sites 15 and 16 were 19 and 26 percent greater, respectively than the annual average O₃ concentration at the Violet Grove station during 2009. The Violet Grove station is located 55 km to the southwest of the four coal-fired thermal generating plants.
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Abbreviations

AAAQO ................................................................. Alberta Ambient Air Quality Objective
AMS ................................................................. air monitoring station
CASA ................................................................. Clean Air Strategic Alliance
COPCs ........................................................... Chemicals of Potential Concern
CPC ................................................................. Capital Power Corporation
CWS .............................................................. Canada-Wide Standard
EPEA ............................................................... Environmental Protection and Enhancement Act
H$_2$SO$_4$ ............................................................. sulphuric acid
HNO$_3$ ............................................................. nitric acid
IQR ................................................................. interquartile range
m$^3$ ............................................................... cubic metre
NAPS ............................................................... National Ambient Pollutant Surveillance
NAS ............................................................... National Academy of Sciences
NO ................................................................. nitric oxide
NO$_2$ .............................................................. nitrogen dioxides
NO$_x$ .............................................................. oxides of nitrogen
O$_3$ ............................................................... ozone
ppb ............................................................... parts per billion
PM ................................................................. particulate matter
PM$_{2.5}$ ............................................................... particulate matter $\geq 2.5 \ \mu m$
PM$_{10}$ .......................................................... particulate matter $\geq 10 \ \mu m$
PAHs ........................................................... polycyclic aromatic hydrocarbons
R$^2$ ............................................................. coefficient of determination
SO$_2$ .............................................................. sulphur dioxide
SO$_3$ ........................................................... sulphur trioxide
MW ............................................................... megawatts
µg ............................................................... microgram
U.S. EPA ........................................................ United States Environmental Protection Agency
UV ................................................................. ultraviolet
VOCs ........................................................... volatile organic compounds
WCAS .......................................................... West Central Airshed Society
1 Introduction

TransAlta Generation Partnership (TransAlta) [www.transalta.com] and Capital Power Corporation (CPC) [www.capitalpower.com] operate four coal-fired thermal generating plants, including Sundance, Keephills, Wabamun, and Genesee, which are located in the Wabamun–Genesee area of west-central Alberta. Figure 1–1 shows the location of each of these generating plants. These generating plants operate under the terms and conditions of their respective Alberta Environmental Protection and Enhancement Act (EPEA) approvals for construction, operation and reclamation, listed in Table 1–1. Collectively, the four generating plants have the capacity to generate a total of 4,441 megawatts (MW) to Alberta's electrical grid.

The Wabamun generating plant is the oldest of TransAlta's three generating plants in the Wabamun area. It is located in the Village of Wabamun (Figure 1–1), and has a generating capacity of 279 MW. Only one generating unit was in operation in 2009, the other three units were retired in 2002 (Unit 3) and 2004 (Units 1 and 2).

The TransAlta Sundance generating plant consists of six generating units; it is the largest coal-fired generating plant in western Canada. Sundance is situated on the south shore of Lake Wabamun, approximately 70 km west of Edmonton, Alberta (Figure 1–1). The plant has operated since 1970, with steady expansion throughout the 1970s from a single original generating unit to six generating units. Sundance currently has a generating capacity of 2,126 MW.

TransAlta's Keephills generating plant is located 5 km south of Wabamun Lake (Figure 1–1). It has been in operation since 1983. It has a generating capacity of 766 MW, and consists of two generating units.

The Genesee generating plant, located 50 km southwest of Edmonton, consists of three generating units (Figure 1–1). CPC fully owns and operates Units 1 and 2, which have a combined generating capacity of 820 MW. These units have been in operation since 1989 and 1994, respectively. Genesee 3 (Unit 3), commissioned in 2005, is a 50/50 joint venture between TransAlta and CPC. Genesee 3 has a generating capacity of 450 MW.

1.1 Environmental Monitoring Programs for Generating Plants

The generating plants operate under the EPEA approvals listed in Table 1–1. Under their EPEA approvals, the generating plants are committed to conducting special environmental monitoring programs. These programs are designed to:

- Identify and quantify ambient levels and deposition patterns of chemical species of potential concern that are associated with generating plant emissions.
- Generate an inventory of representative baseline data for the chemicals of potential concern (COPCs).
- Provide data for assessing long-term impacts and for evaluating and implementing air quality management plans.
Location of TransAlta and Capital Power Coal-Fired Generating Plants and Air Monitoring Area in the Wabamun-Genesee Area of Alberta
A component of the special environmental monitoring programs included developing and implementing an ambient air quality monitoring program. The ambient air quality monitoring program consists of the following elements (Figure 1–2):

- A continuous monitoring program for: sulphur dioxide (SO₂), nitrogen dioxide (NO₂), and a number of meteorological parameters at four air monitoring stations (AMS) (Genesee AMS, Powers AMS, Meadows AMS, and Wagner AMS); particulate matter with aerodynamic diameter less than or equal to 2.5 μm (PM₂.₅) at two stations (Genesee AMS and Powers AMS); and ozone (O₃) at one station (Genesee AMS).

- An intermittent monitoring program (24-hour sampling every 6 days) for particulate matter with aerodynamic diameter less than or equal to 10 μm (PM₁₀), PM₂.₅ and metals speciation of the PM₂.₅ at two stations (Genesee AMS and Powers AMS).

- A passive monitoring program consisting of monthly passive monitoring for NO₂, SO₂, and O₃ at 21 locations in the Wabamun–Genesee area.

Sections within the EPEA approvals containing specific terms and conditions that refer to the ambient air quality monitoring program are provided in Table 1-1.

### Table 1–1 Alberta Environmental Protection and Enhancement Act (EPEA) Operating Approvals for Four Generating Plants in the Wabamun–Genesee Area

<table>
<thead>
<tr>
<th>Generating Plant Facility</th>
<th>Capacity (MW)</th>
<th>Legal Site Location</th>
<th>Approval No. (as amended)</th>
<th>Applicable Approval Terms</th>
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<td>Sundance</td>
<td>2,126</td>
<td>3.4,8,9,10,16,17,20, and 31-52-04 W5M</td>
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<td>Keephills</td>
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<td>Wabamun</td>
<td>279</td>
<td>2,3,10,11-53-04 W5M</td>
<td>10323-02-03</td>
<td>Sections within Part 6</td>
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<tr>
<td>Genesee</td>
<td>1,270</td>
<td>25-50-03 W5M</td>
<td>773-02-00</td>
<td>Sections within Part 4, Sections within Part 7</td>
</tr>
</tbody>
</table>

### 1.2 Purpose of Report

This annual report summarizes and discusses information collected as part of the 2009 ambient air monitoring program. These data provide a basis for developing an understanding of the state of air quality in relation to emissions from the four coal-fired generating plants in the Wabamun–Genesee area. Monitoring components associated with an acid deposition assessment program and a mercury assessment program in the Wabamun–Genesee area are reported separately in stand-alone documents (TransAlta and CPC 2010a, b).
Location of Passive and Continuous Ambient Air Monitoring Stations in the Wabamun-Genesee Area during 2009

**Acknowledgements:**

Original Drawing by Stantec

**Generating Stations**

- Passive Station (NO₂)
- Passive Station (NO₂, O₃)
- Passive Station (NO₂, SO₂)
- Passive Station (NO₂, SO₂, O₃)
- Passive Station (O₃)
- Continuous Station (Genesee - NO₂, SO₂, O₃)

**Area of Detail**

Scale in Kilometers

0 2.5 5 10 15 20

PREPARED BY: Stantec

DRAFT DATE: 19/05/2009

REVISION DATE: 23/08/2010

PREPARED FOR: TransAlta

FIGURE NO.: 1-2
2 Background on Air Quality Parameters Monitored

A number of COPCs are potentially emitted from the coal-fired generating plants in the Wabamun–Genesee area. With respect to the ambient air monitoring program, these COPCs include: oxides of nitrogen (NOx), sulphur dioxide (SO2), ground-level ozone (O3), and airborne particulate matter. The importance of these COPCs is discussed below.

2.1 Oxides of Nitrogen

Oxides of nitrogen (NOx) is a generic term used to represent a group of reactive gases containing nitrogen and oxygen, mostly in the form of nitric oxide (NO) and nitrogen dioxide (NO2). The NOx concentration is calculated by adding together NO and NO2 concentrations. High temperature combustion of hydrocarbon fuel sources produces NO and smaller quantities of NO2 from reactions with nitrogen gas in the atmosphere. Most of the NO in ambient air rapidly turns into NO2. Almost every combustion source emits NO and produces NO2 (including motor vehicles, generating plants, chemical plants, commercial and residential furnaces, gas stoves, heaters).

Nitrogen dioxide, NO, volatile organic compounds, anthropogenic (man-made) and biogenic (from vegetation) hydrocarbons, and carbon monoxide are precursors in the formation of ground-level ozone (O3) and photochemical smog (U.S. EPA 2008a). NO2 is an oxidant that can react to form other photochemical oxidants, and can also react with compounds such as polycyclic aromatic hydrocarbons (PAHs) to form nitro-PAHs. Finally, NO2 can also be oxidized to form nitric acid (HNO3), which contributes to the acidity of cloud, fog and rainwater, as well as ambient particles.

The Alberta Ambient Air Quality Objectives (AAAQOs) for NOx are expressed as NO2. NOx concentrations are typically expressed as NO2 for comparison to the AAAQOs. The Clean Air Strategic Alliance (CASA) (2006) reported that the 10-year average concentration of NO2 measured at a rural background location in Alberta (Hightower Ridge AMS) was 8 ppb (15 μg/m3). A listing and brief description of the AAAQOs and other air quality standards are given in Section 2.5.

2.2 Sulphur Dioxide

Sulphur dioxide (SO2) and sulphur trioxide (SO3) are produced from oxidation of trace amounts of sulphur during high temperature combustion of hydrocarbon fuels, such as oil and coal. Industrial operations (e.g., electricity generation, petroleum and chemical manufacturing) contribute the majority of anthropogenic SO2 emissions. Transportation-related sources are estimated to contribute small amounts of sulphur emissions to the atmosphere (U.S. EPA 2008b).

Sulphur dioxide can react with moisture in the atmosphere (be oxidized) to form H2SO4, which contributes to acidity of cloud, fog, and rainwater. Sulphur trioxide emitted to the atmosphere reacts rapidly with moisture to form sulphuric acid (H2SO4), which condenses onto existing particles (when particle loadings are high) or acts as a nucleus to form new particles (under low particle loadings) (U.S. EPA 2008b). CASA (2006) reported that the 10-year average concentration of SO2 measured at a rural background location in Alberta (Hightower Ridge AMS) was 2 ppb (5 μg/m3).
2.3 Ground-Level Ozone

Ground-level O\textsubscript{3} can originate in two important ways, by being brought down to the surface from the tropospheric reservoir by daily (diurnal) mixing of the atmospheric boundary layer, and by being photochemically produced. Surface measurements alone are not sufficient for understanding characteristics of ground-level O\textsubscript{3} because the chemical composition of the surface layer largely depends on mixing from above (Zhang and Rao 1999).

Role of atmospheric boundary layer mixing – The presence of ground-level O\textsubscript{3} at the surface is strongly influenced by the daily development and dissipation of turbulent mixing within the atmospheric boundary layer. When the depth of the boundary layer increases during mid morning hours, O\textsubscript{3} suspended in the air is mixed downward to the earth’s surface and surface concentrations increase (Singh et al. 1978; Taylor and Hanson 1992; Lovett 1994; Aneja et al. 2000; Steinbacher et al. 2004). Once atmospheric boundary layer mixing ceases during late evening and night hours, surface concentrations decrease due to scavenging (oxidation) reactions.

Role of photochemical production – In urban areas and areas downwind influenced by urban air masses, photochemically produced ground-level O\textsubscript{3} and other oxidants form by atmospheric reactions involving mainly two classes of chemical precursors: volatile organic compounds (VOCs) and NO\textsubscript{x} (U.S. EPA, 2006). VOCs refer to all carbon containing gas-phase compounds in the atmosphere, both biogenic and anthropogenic in origin.

Maximum O\textsubscript{3} concentrations from photochemical reactions usually occur four to six hours after maximum emissions of chemical precursors, and under conditions of light winds, usually downwind of urban areas (Chu 1995; U.S. EPA 1998). Weather patterns and meteorological conditions play a major role in establishing conditions favourable to photochemical O\textsubscript{3} formation and accumulation, and in terminating episodes of high O\textsubscript{3} concentrations (NAS 1991). Episodes of high O\textsubscript{3} concentrations from photochemical production are associated with slow-moving, high-pressure weather systems.

Ground-level O\textsubscript{3} is driven by the atmospheric boundary layer mixing effect in areas away from urban emissions and is particularly dominant in the spring and early summer (March through June) period (Singh et al. 1978). Ground-level O\textsubscript{3} can be enhanced by photochemical reactions, particularly in the summer (June through August) period. CASA (2006) reported that the 10-year average concentration of O\textsubscript{3} measured at a rural background location in Alberta (Hightower Ridge AMS) was 42 ppb (81 μg/m\textsuperscript{3}).

2.4 Particulate Matter

Particulate matter (PM) is a general term used to describe mixtures of solid particles and liquid droplets (except for pure water) that are microscopic and found in the air. These mixtures can be considered combinations of larger particles called coarse particles and smaller particles called fine particles. Coarse particles have diameters greater than 2.5 \μm and less than 10 \μm, particles with diameters less than 10 \μm are referred to as PM\textsubscript{10}, while fine particles (PM\textsubscript{2.5}) have diameters less than 2.5 \μm (Health Canada 1999).

Course particles are mainly produced by abrasion at the earth’s surface or by suspension of biological material composed of microorganisms (e.g., bacteria, viruses, fungal spores, pollens) and fragments of living things (e.g., plant and insect debris) while the makeup of fine PM tends to be dominated by particles that form during combustion of material that has volatilized in combustion chambers and then re-condensed before emission to the atmosphere (U.S. EPA 2004). PM mixtures have a wide variety of sources in the environment (U.S. EPA 2004). Anthropogenic sources can include:

- Stationary sources (e.g., fuel combustion for electrical utilities, residential space heating and cooking; industrial boilers; construction and demolition; mills and elevators used in agriculture; erosion from tilled lands; and waste disposal and recycling.)
• Mobile or transportation-related sources (e.g., direct emissions from highway vehicles and non-road sources, as well as fugitive dust from paved and unpaved roads.)

Biomass burning (e.g., forest fires, wood burned for fuel, and burning of vegetation cleared from land) also emits PM mixtures and other environmentally significant compounds (e.g., carbon monoxide, gaseous elemental mercury). CASA (2006) reported that the 10-year average concentration of PM$_{2.5}$ measured at a rural background location (Hightower Ridge AMS) was 2.3 $\mu$g/m$^3$.

### 2.5 Ambient Air Objectives, Guidelines and Standards

Air quality criteria are used to protect human health, safeguard the environment and assess aesthetic quality. Specific AAAQOs, guidelines and Canada-wide Standards (CWS) exist for the criteria air contaminants defined as COPCs to aid with interpreting measured ambient levels of these pollutants. These objectives, guidelines and standards are listed in Table 2–1.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Averaging Time</th>
<th>Alberta Ambient Air Quality Objective</th>
<th>Alberta Ambient Air Quality Guideline</th>
<th>Canada-Wide Standard</th>
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<tr>
<td>NO$_x$ (as NO$_2$)</td>
<td>1 hour</td>
<td>400 $\mu$g/m$^3$ (212 ppb)</td>
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<td>-</td>
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<tr>
<td></td>
<td>24 hour</td>
<td>200 $\mu$g/m$^3$ (106 ppb)</td>
<td>-</td>
<td>-</td>
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<td>annual</td>
<td>60 $\mu$g/m$^3$ (32 ppb)</td>
<td>-</td>
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<tr>
<td></td>
<td>1 hour</td>
<td>450 $\mu$g/m$^3$ (172 ppb)</td>
<td>-</td>
<td>-</td>
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<tr>
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<td></td>
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<td>30 $\mu$g/m$^3$ (11 ppb)</td>
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<td>-</td>
</tr>
<tr>
<td>PM$_{2.5}$</td>
<td>1 hour</td>
<td>-</td>
<td>80 $\mu$g/m$^3$</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>24-hour average based on 99th percentile value over 3 consecutive years</td>
<td>-</td>
<td>-</td>
<td>30 $\mu$g/m$^3$</td>
</tr>
<tr>
<td>O$_3$</td>
<td>1 hour</td>
<td>160 $\mu$g/m$^3$ (82 ppb)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>8 hour average based on 4th highest value over 3 consecutive years</td>
<td>-</td>
<td>-</td>
<td>128 $\mu$g/m$^3$ (65 ppb)</td>
</tr>
</tbody>
</table>

**NOTE:**
- not applicable
3 Methods

3.1 Continuous Monitoring Program

Analytical methods used to determine ambient pollutant concentrations for the continuous program conducted at the Genesee, Meadows, Wagner, and Powers air monitoring stations are described in the following sections. Refer to Figure 1–2 for monitoring site locations. Procedures and guidelines for measuring and analyzing the air quality parameters listed below are described further in the Ambient Air Monitoring Program Quality Assurance Plan for West Central Airshed Society (WBK 2007). A schedule for the sampling program is presented in Table 3–1.

Table 3–1 Sampling Schedule for Parameters in the Ambient Air Quality Monitoring Program in the Wabamun–Genesee Area

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Continuous</th>
<th>Intermittent (every 6th day (NAPS) schedule)</th>
<th>Monthly (passives)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO2</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>NO2</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>O3</td>
<td>•</td>
<td>•</td>
<td>•</td>
</tr>
<tr>
<td>PM10</td>
<td>•</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>PM2.5</td>
<td>•</td>
<td>•</td>
<td></td>
</tr>
<tr>
<td>Wind speed and direction, temperature, relative humidity</td>
<td>•</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.1.1 Nitrogen Dioxide

Nitrogen dioxide is analyzed at the Genesee, Meadows, Wagner, and Powers air monitoring stations. NO2 is measured by chemiluminescence using the TECO 42C (Thermo Electron Corporation, Waltham, MA) or equivalent analyzer. NOx in air is converted to nitric oxide (NO) as it flows over a heated catalyst. The NO is then oxidized by O3, resulting in light emission during the reaction. The light emission, which is proportional to each molecule of NO that is oxidized, is measured and presented on an NO2 basis.

3.1.2 Sulphur Dioxide

Sulphur dioxide is analyzed at the Genesee, Meadows, Wagner, and Powers air monitoring stations. SO2 is measured with pulsed fluorescence using the TECO 43 (Thermo Electron Corporation, Waltham, MA) or equivalent analyzer. Air samples are bombarded with pulses of ultraviolet (UV) light that excite SO2 molecules to higher energy levels. When the SO2 molecules return to their original energy state, light is emitted; this light is measured in the analyzer and is proportional to the amount of SO2 in air.

3.1.3 Ozone

Ozone is measured at the Genesee AMS with a TECO 49 UV-absorption ozone analyzer (Thermo Electron Corporation, Waltham, MA). This measurement is based on ozone’s ability to absorb UV light. A sample of air is exposed to UV light and the amount absorbed is measured. The UV light absorbed is proportional to the amount of O3 in air.
3.1.4 Fine Particulate Matter

Fine Particulate Matter (PM$_{2.5}$) is measured at the Powers AMS and the Genesee AMS using a tapered element oscillating microbalance (TEOM) (Thermo Electron Corporation, Waltham, MA). Particulates in air are separated by diameter and passed through a filter attached to a tapered element vibrating at its natural frequency. As particles deposit on the filter, the vibration frequency of the element changes in proportion to the mass of particles deposited.

3.1.5 Meteorology

Wind speed, wind direction, air temperature, and relative humidity are monitored at Genesee, Meadows, Wagner, and Powers air monitoring stations using standard meteorological monitoring equipment.

In 2009, West Central Airshed Society (WCAS) technicians maintained and calibrated the analyzers at the continuous stations. The continuous data collected were reviewed for errors and omissions by WCAS personnel and the information was reported on a monthly, quarterly, and annual basis. The raw data were also made available to the public on the WCAS website (www.wcas.ca) on a real-time basis.

3.2 Intermittent Monitoring Program

Twenty-four hour average PM$_{10}$ and PM$_{2.5}$ samples are collected at the Powers and Genesee air monitoring stations. These samples are collected according to a National Air Pollution Surveillance (NAPS) six-day cycle sampling frequency using Partisols (Thermo Electron Corporation, Waltham, MA). Procedures and guidelines for measuring and analyzing PM$_{10}$ and PM$_{2.5}$ samples are described further in the Ambient Air Monitoring Program Quality Assurance Plan for West Central Airshed Society (WBK 2007).

The Partisols separate particulates in sampled air according to size, which allows for size-selective collection on a filter. Technicians from Ambitech Inc. (Edmonton, AB) collect Partisol filters according to the Environment Canada National Air Pollution Surveillance (NAPS) Network schedule and ship the filters to the Alberta Research Council (Vegreville, AB) for gravimetric and metals analyses. WBK & Associates Inc. personnel review the analytical results on an as-received basis.

Results from metals analyses of 24-hour average PM$_{2.5}$ samples are currently archived electronically. They will be used to undertake source apportionment, which is the quantitative identification of relative contributions of different source types to airborne particle concentrations. Source apportionment for PM$_{2.5}$ will define the total contribution that different sources in the Wabamun-Genesee area make to airborne particle concentrations at the Powers and Genesee air monitoring stations. Generally, greater than 100 PM$_{2.5}$ samples are required to undertake source apportionment (≥2 years of monitoring data). A schedule for the sampling program is presented in Table 3-1.

3.3 Passive Monitoring Program

Passive air monitors are deployed at 21 stations in the Wabamun–Genesee area (Figure 1–2). Maxxam Analytics (Edmonton, AB) PASS samplers are deployed for durations of approximately one month to measure SO$_2$, NO$_2$, and O$_3$. Procedures and guidelines for collecting and analyzing SO$_2$, NO$_2$, and O$_3$ passive samplers are described further in the Ambient Air Monitoring Program Quality Assurance Plan for West Central Airshed Society (WBK 2007).

The passive approach collects gas from the atmosphere at a rate controlled by the gas’ natural diffusion across a membrane. Passive collection of a given air pollutant is achieved by chemical absorption or by
physical adsorption onto a medium in the sampler. Ambitech Inc. technicians collect the passive samplers and deploy fresh samplers within two days of the end of each month. The samplers are delivered to Maxxam Analytics (Edmonton, AB) for laboratory analyses. A schedule for the sampling program is presented in Table 3–1.
4 Results and Discussion

4.1 Continuous Monitoring Program

4.1.1 Percent Completeness

An important component for understanding quality of continuous monitoring data is completeness. Completeness indicates the percentage of time that a continuous monitor is up and operating (i.e., capturing valid data). In general, the Air Monitoring Directive (Alberta Environment (AENV) 1989) requires greater than 90 percent completeness. Tables 4–1 to 4–4 show data capture rates (percent completeness) for air quality parameters at the four air monitoring stations in the Wabamun–Genesee area during 2009.

Table 4–1 Monthly and Annual Data Capture Rates (% completeness) for Genesee Air Monitoring Station during 2009

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Up-time (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Jan</td>
</tr>
<tr>
<td>NO₂</td>
<td>100</td>
</tr>
<tr>
<td>SO₂</td>
<td>100</td>
</tr>
<tr>
<td>O₃</td>
<td>100</td>
</tr>
<tr>
<td>PM₁₀</td>
<td>98.4</td>
</tr>
<tr>
<td>WSP</td>
<td>100</td>
</tr>
<tr>
<td>WDR</td>
<td>100</td>
</tr>
<tr>
<td>T₂</td>
<td>100</td>
</tr>
<tr>
<td>T₁₀</td>
<td>100</td>
</tr>
<tr>
<td>RH</td>
<td>100</td>
</tr>
</tbody>
</table>

NOTES:
Key: WSP = wind speed; WDR = wind direction; T₂ = temperature at 2-metre height above ground; T₁₀ = temperature at 10-metre height above ground; RH = relative humidity.

Monthly data capture rates for all stations were well above the 90 percent criterion stipulated in the Air Monitoring Directive (AENV 1989), except as noted by bold font (i.e., Table 4–4). High up-times indicate that equipment in the continuous air monitoring network was generally well-maintained. The Wagner AMS experienced planned and unplanned power outages May 4, 5, 11 to 5, and 25 to the 27. These incidents were reported to Alberta Environment on May 29, 2009 (Reference Number 214592).
Table 4–3 Monthly and Annual Data Capture Rates (% completeness) for Powers Air Monitoring Station during 2009

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Up-time (%)</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Annual</th>
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</thead>
<tbody>
<tr>
<td>NO₂</td>
<td></td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>99.9</td>
<td>99.5</td>
<td>99.7</td>
<td>99.6</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>99.9</td>
</tr>
<tr>
<td>SO₂</td>
<td></td>
<td>99.5</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>99.9</td>
<td>99.5</td>
<td>99.7</td>
<td>99.6</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>99.9</td>
</tr>
<tr>
<td>PM₂.₅</td>
<td></td>
<td>96.5</td>
<td>100</td>
<td>99.6</td>
<td>99.9</td>
<td>99.9</td>
<td>99.2</td>
<td>98.9</td>
<td>98.8</td>
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<td>99.9</td>
</tr>
<tr>
<td>WSP</td>
<td></td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>99.9</td>
<td>100</td>
<td>99.7</td>
<td>99.6</td>
<td>100</td>
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<tr>
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<td>99.7</td>
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<td>T₂</td>
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<td>99.6</td>
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<td>100</td>
<td>100</td>
<td>99.9</td>
</tr>
<tr>
<td>RH</td>
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<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>99.9</td>
<td>100</td>
<td>99.7</td>
<td>99.6</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>99.9</td>
</tr>
</tbody>
</table>

NOTES:
Key: WSP = wind speed; WDR = wind direction; T₂ = temperature at 2-metre height above ground; RH = relative humidity.

Table 4–4 Monthly and Annual Data Capture Rates (% completeness) for Wagner Air Monitoring Station during 2009

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Up-time (%)</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO₂</td>
<td></td>
<td>100</td>
<td>98.8</td>
<td>98</td>
<td>100</td>
<td>77.7</td>
<td>100</td>
<td>99.7</td>
<td>99.1</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>97.8</td>
</tr>
<tr>
<td>SO₂</td>
<td></td>
<td>100</td>
<td>98.8</td>
<td>98</td>
<td>100</td>
<td>77.7</td>
<td>100</td>
<td>99.7</td>
<td>99.2</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>97.8</td>
</tr>
<tr>
<td>WSP</td>
<td></td>
<td>100</td>
<td>98.8</td>
<td>98</td>
<td>100</td>
<td>77.7</td>
<td>100</td>
<td>100</td>
<td>99.2</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>97.8</td>
</tr>
<tr>
<td>WDR</td>
<td></td>
<td>100</td>
<td>98.8</td>
<td>98</td>
<td>100</td>
<td>77.7</td>
<td>100</td>
<td>100</td>
<td>99.2</td>
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<td>100</td>
<td>100</td>
<td>100</td>
<td>97.8</td>
</tr>
<tr>
<td>T₂</td>
<td></td>
<td>100</td>
<td>98.8</td>
<td>98</td>
<td>100</td>
<td>77.7</td>
<td>100</td>
<td>100</td>
<td>99.2</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>97.8</td>
</tr>
<tr>
<td>RH</td>
<td></td>
<td>100</td>
<td>98.8</td>
<td>98</td>
<td>100</td>
<td>77.7</td>
<td>100</td>
<td>100</td>
<td>99.2</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>97.8</td>
</tr>
</tbody>
</table>

NOTES:
Key: WSP = wind speed; WDR = wind direction; T₂ = temperature at 2-metre height above ground; RH = relative humidity.
Bolded value indicates <90% completeness for monitoring period.

4.1.2 Air Pollutant Concentration Statistics

One method of displaying a set of air quality data is using box-and-whisker plots. Box-and-whisker plots are helpful in interpreting the distribution of data because they only illustrate certain statistics rather than all of the data. The plots presented here show five values for individual pollutants collected at each air monitoring station during 2009: 25th percentile (bottom of box), 50th percentile (line inside box), 75th percentile (top of box), maximum (top T), and annual arithmetic mean concentration (star symbol). In some cases, the 98th percentile (diamond symbol) rather than the annual arithmetic mean concentration is shown, as applicable. The bottom whisker is not shown in these plots because the values represented by bottom whiskers are very small and not essential for data interpretation.

4.1.2.1 Nitrogen Dioxide

Figures 4–1 and 4–2 are box-and-whisker plots that compare key statistical values for 1-hour and 24-hour NO₂ concentrations observed at the four ambient air monitoring stations during 2009. For comparison purposes, box-and-whisker plots are shown in Figure 4–1 for a background station relative to the air monitoring area for the generating plants (Carrot Creek AMS, CASA 2010) and an urban station (Edmonton East AMS, CASA 2010). In Figures 4–1 and 4–2, the bottom of the yellow zone, boundary of the yellow and blue zones, top of the blue zone, and top tee represent the 25th, 50th, 75th, and maximum values, respectively. The star symbol in each plot represents the annual arithmetic mean concentration.
Figure 4–1  Box-and-Whisker Plot of 1-hour Average NO₂ Concentrations at Selected Air Monitoring Stations in Central Alberta during 2009

Note: 25th %ile (bottom of box), 50th %ile (line inside box), 75th %ile (top of box), maximum (top T), and annual arithmetic mean concentration (star symbol). Some of the values cannot be clearly observed in the figure (e.g., the 25th to 75th percentiles) because their magnitudes are too small.

All of the benchmark NO₂ concentrations, except for the maximum concentration, were highest at the urban (Edmonton East) AMS for the 1-hour averaging periods (Figure 4–1), reflecting the influence of motor vehicle emissions on ambient concentrations. Annual average NO₂ concentrations ranged from 6.6 µg/m³ at Powers AMS to 15 µg/m³ at Meadows AMS. These concentrations are higher than the 10-year average concentration reported by CASA (2006) for the Hightower Ridge AMS (5 µg/m³). There were no exceedances of the AAAAQO for NO₂ in 2009. for 1-hour (Figure 4–1) or 24-hour (Figure 4–2) averaging times.

The 9th highest 1-hour concentration represents a 99.9th percentile concentration from a distribution of hourly values during a year. The 9th highest 1-hour NO₂ concentrations observed during 2009 ranged from 56 µg/m³ at the Genesee AMS to 78 µg/m³ at the Meadows AMS. For comparison purposes, the 9th highest 1-hour NO₂ concentrations observed during 2009 at the Carrot Creek AMS and Edmonton East AMS were 68 and 130 µg/m³, respectively (CASA 2010).

The interquartile range (IQR) is the distance between the 75th percentile and the 25th percentile for a set of data (i.e., height of each box in Figures 4–1 and 4–2). The IQR provides a good quantitative indication of the variation or degree to which values in a set of data are spread out or clustered together, because it is not affected by outliers or extreme values. Of the four air monitoring stations, the largest IQR (i.e., largest box) occurred for the Meadows AMS for hourly data (Figure 4–1) and for 24-hour data (Figure 4–2). However, the IQRs for NO₂ at the Meadows AMS were narrow (e.g., 21 µg/m³ for hourly concentrations and 12 µg/m³ for 24-hour concentrations), indicating little variation in hourly concentrations throughout 2009.
Figure 4–2  Box-and-Whisker Plot of 24-hour Average NO₂ Concentrations at Selected Air Monitoring Stations in Central Alberta during 2009

Note: 25th %ile (bottom of box), 50th %ile (line inside box), 75th %ile (top of box), maximum (top T), and annual arithmetic mean concentration (star symbol). Some of the values cannot be clearly observed in the figure (e.g., the 25th to 75th percentiles) because their magnitudes are too small.

Another method of displaying a set of air quality data is with a cumulative distribution plot. A cumulative distribution plot shows the fraction (or percentage) of concentration values for a pollutant that is less than or equal to a particular value. Figure 4–3 shows a cumulative distribution plot for hourly NO₂ concentrations at each of the stations in the Wabamun–Genesee area. Percentile values (50th, 65th, 80th, 95th, and 98th) are shown in this plot to assist comparison with future data and allow examination of trends in ambient air pollutant concentrations using simple methods as described by Faisal et al. (2006) and Haque et al. (2006).

These percentile values can be calculated from year to year to examine changes to air quality over time. Statistically significant changes in these percentile values over a period of several years (e.g., >5 years) are indicative of trends (changes) in the concentration data. Cumulative distribution data from the Genesee, Powers, and Wagner air monitoring stations (Figure 4–3) followed the same general distribution. The Meadows AMS data exhibited a greater concentration variation between the 50th and 98th percentile values compared with the other stations. Overall, hourly NO₂ concentrations were low at all four air monitoring stations (<58 µg/m³ for 98 percent of time during 2009).

4.1.2.2  Sulphur Dioxide

Figures 4–4 and 4–5 are box-and-whisker plots for 1-hour and 24-hour SO₂ concentrations, respectively. Median (50th percentile) hourly SO₂ concentrations at all four generating plant air monitoring stations shown in Figure 4–4 were very low (1 µg/m³). All 1-hour and 24-hour concentrations were well below AAAQOs. The 9th highest 1-hour SO₂ concentrations observed during 2009 ranged from 57 µg/m³ at the Powers AMS to 83 µg/m³ at the Genesee AMS. For comparison purposes, the 9th highest 1-hour SO₂ concentrations observed during 2009 at the Carrot Creek AMS and Edmonton East AMS were 24 and 71 µg/m³, respectively (CASA 2010).
Figure 4–3  Cumulative Distribution Plot of 1-hour Average NO₂ Concentrations at Air Monitoring Stations in the Wabamun–Genesee Area during 2009

Figure 4–4  Box-and-Whisker Plot of 1-hour Average SO₂ Concentrations at Selected Air Monitoring Stations in Central Alberta during 2009

Note: 25th %ile (bottom of box), 50th %ile (line inside box), 75th %ile (top of box), maximum (top T), and annual arithmetic mean concentration (star symbol). Some of the values cannot be clearly observed in the figure (e.g., the 25th to 75th percentiles) because their magnitudes are too small.
4.1.2.3 Ozone

Figure 4–7 is a box-and-whisker plot of 1-hour $O_3$ concentrations measured at the Genesee, Carrot Creek, and Edmonton East air monitoring stations. The annual hourly average $O_3$ concentration at the Genesee AMS was 55 $µg/m^3$. The 9th highest 1-hour $O_3$ concentration observed in 2009 at Genesee AMS was 173 $µg/m^3$. For comparison purposes, the 9th highest 1-hour $O_3$ concentrations observed at the Carrot Creek AMS and Edmonton East AMS were 130 and 132 $µg/m^3$, respectively (CASA 2010). One-hour $O_3$ concentrations at the Genesee AMS exceeded the Alberta Ambient Air Quality 1-hour objective of 160 $µg/m^3$ eleven times during 2009.

These exceedences occurred for seven hours over July 24 and 25 and for four hours on September 1. This resulted in several 8-hour average $O_3$ concentrations at the station being above the Canada Wide Standard value of 125 ug/m$^3$ during both July and September.
However the 98th percentile 8-hour concentrations were 114 and 105 µg/m³, respectively for these months – which are below the Canada Wide Standard. The smallest IQR for O₃ (37 µg/m³) occurred at the Genesee AMS for hourly data, indicating that hourly O₃ concentrations showed the least amount of variation at this location compared with the Carrot Creek AMS and Edmonton East AMS.

**Figure 4–6** Cumulative Distribution Plot of 1-hour Average SO₂ Concentrations at Air Monitoring Stations in the Wabamun–Genesee Area during 2009

**Figure 4–7** Box-and-Whisker Plot of 1-hour Average O₃ Concentrations at Selected Air Monitoring Stations in Central Alberta during 2009

Note: 25th %ile (bottom of box), 50th %ile (line inside box), 75th %ile (top of box), maximum (top T), and 98th %ile (diamond symbol).
The 25th, 50th, 75th and 98th percentile concentration values at the Edmonton East AMS were lower than that observed at the Genesee AMS and Carrot Creek AMS. This is consistent with central Alberta O₃ trend data from the last seven years reported by Kindzierski et al. (2006) and Kindzierski (2006). A primary reason for these lower concentrations observed at the Edmonton East AMS is due to scavenging reactions with NOₓ emissions from urban motor vehicle emissions.

Figure 4–8 shows the cumulative distribution and key percentile values for hourly O₃ concentrations at the Genesee AMS during 2009. Hourly O₃ concentrations were <116 µg/m³ for 98 percent of the time during 2009.

![Cumulative Distribution Plot of 1-hour Average O₃ Concentrations at the Genesee Air Monitoring Station during 2009](chart.png)

### Key Percentile Indices (µg/m³)

<table>
<thead>
<tr>
<th>Percentile</th>
<th>Genesee</th>
</tr>
</thead>
<tbody>
<tr>
<td>50th</td>
<td>51</td>
</tr>
<tr>
<td>65th</td>
<td>63</td>
</tr>
<tr>
<td>80th</td>
<td>78</td>
</tr>
<tr>
<td>90th</td>
<td>93</td>
</tr>
<tr>
<td>95th</td>
<td>105</td>
</tr>
<tr>
<td>98th</td>
<td>116</td>
</tr>
</tbody>
</table>

**Figure 4–8** Cumulative Distribution Plot of 1-hour Average O₃ Concentrations at the Genesee Air Monitoring Station during 2009

#### 4.1.2.4 Fine Particulate Matter

Figure 4–9 is a box-and-whisker plot of 24-hour PM₂.₅ concentrations measured at the Genesee AMS and Powers AMS in 2007, 2008 and 2009. Median (50th percentile) 24-hour PM₂.₅ concentrations at both stations were low, <5 µg/m³ for all years. The 98th percentile 24-hour PM₂.₅ concentrations at both air monitoring stations were <22 µg/m³ for all years. These values are below the CWS of 30 µg/m³, (98th percentile, averaged over three years) also shown in Figure 4-9. Interquartile ranges for 24-hour PM₂.₅ concentrations at both air monitoring stations were very narrow (<5 µg/m³), indicating very little variation in 24-hour average concentrations throughout 2007, 2008, and 2009.

Figure 4–10 shows the cumulative distribution plot for hourly PM₂.₅ concentrations measured at the Genesee and Powers air monitoring stations. Hourly PM₂.₅ concentrations were low at these two stations, <17 µg/m³ for 98 percent of the time during 2009. There were three hours during 2009 in which the hourly PM₂.₅ concentration was greater than the Alberta Ambient Air Quality Guideline of 80 µg/m³.
Figure 4–9  Box-and-Whisker Plot of 24-hour Average PM$_{2.5}$ Concentrations at the Genesee and Powers Air Monitoring Stations (2007, 2008 and 2009)

Figure 4–10  Cumulative Distribution Plot of 1-hour Average PM$_{2.5}$ Concentrations at the Powers and Genesee Air Monitoring Stations during 2009
4.1.3 Wind Speed and Direction Statistics

A wind rose plot is used to show information about the distribution of wind speeds and frequency of the varying wind directions at the air monitoring stations. These plots are derived from hourly meteorological observations of wind speeds and directions. The wind rose plots shown here were divided into 16 sectors, one sector for each 22.5 degrees of the horizon. The radius of the 16 outermost, wide wedges in a wind rose plot gives the relative frequency of each of the 16 wind directions (i.e., the percent of the time that the wind is blowing from that direction). The colours indicate the wind speed range (in m/s) for a particular direction.

Another method of displaying a year of wind data at the air monitoring stations is a wind class frequency distribution plot. These plots show the percent of time that different wind speeds occur. The 2009 annual wind rose plots and annual wind class frequency distribution plots for the four continuous air monitoring stations in the Wabamun–Genesee area are shown in Figures 4–11 to 4–18.

Winds blew approximately 40 percent of the time from the north-northwest to westerly direction at all four air monitoring stations (Genesee 41 percent, Figure 4-11; Meadows 42 percent, Figure 4-13; Powers 36 percent, Figure 4-15; Wagner 43 percent, Figure 4-17).

![Annual Wind Rose Plot for the Genesee Air Monitoring Station during 2009](image-url)
Section 4: Results and Discussion

Figure 4–12  Annual Wind Class Frequency Distribution Plot for the Genesee Air Monitoring Station during 2009

Figure 4–13  Annual Wind Rose Plot for the Meadows Air Monitoring Station during 2009
Figure 4–14  Annual Wind Class Frequency Distribution Plot for the Meadows Air Monitoring Station during 2009

Figure 4–15  Annual Wind Rose Plot for the Powers Air Monitoring Station during 2009
Figure 4–16  Annual Wind Class Frequency Distribution Plot for the Powers Air Monitoring Station during 2009

Figure 4–17  Annual Wind Rose Plot for the Wagner Air Monitoring Station during 2009
4.2 Intermittent Monitoring Program

Results of the intermittent PM monitoring program are shown in Figure 4–19 (PM$_{2.5}$) and Figure 4–20 (PM$_{10}$). Figure 4–19 is a box-and-whisker plot of 24-hour average PM$_{2.5}$ data collected on a 1-in-6 day schedule (NAPS). Twenty-four hour average PM$_{2.5}$ concentrations were <22 µg/m$^3$ at both the Genesee and Powers air monitoring stations for 98 percent of the time. This is consistent with 24-hour average data observed from continuous monitoring at these stations during 2009 (Figure 4–9).

Figure 4–20 is a box-and-whisker plot of 24-hour average PM$_{10}$ concentrations at the Genesee AMS and Powers AMS during 2009. Twenty-four hour average PM$_{10}$ concentrations were <68 µg/m$^3$ at both the Genesee and Powers air monitoring stations for 98 percent of the time. Similar variation in 24-hour average PM$_{10}$ concentrations was observed at the two air monitoring stations. The IQRs were 11 µg/m$^3$ at Genesee AMS and 13 µg/m$^3$ at Powers AMS.

Figures 4–21 and 4–22 show 24-hour average PM$_{2.5}$ concentrations versus PM$_{10}$ concentrations at the Genesee and Powers air monitoring stations during 2009. Linear regression relationships were used to show the degree of comparison between individual 24-hour average PM$_{2.5}$ concentrations and PM$_{10}$ concentrations. The purpose was to show the ability of the PM$_{2.5}$ concentrations to predict PM$_{10}$ concentrations.

Coefficient of determination ($R^2$) values were calculated from PM$_{2.5}$/PM$_{10}$ matched pair data for each air monitoring station (Genesee and Powers) and are shown in Figures 4–21 and 4–22. A coefficient of determination ($R^2$) is the proportion of sample variance of a response variable (PM$_{10}$ concentration) that is "explained" by predictor variables (PM$_{2.5}$ concentrations) when a linear regression is done.
Figure 4–19  Box-and-Whisker Plot of Intermittent 24-hour Average PM$_{2.5}$
Concentrations at Genesee and Powers Air Monitoring Stations in 2009
Note: 25th %ile (bottom of box), 50th %ile (line inside box), 75th %ile (top of box), maximum (top T),
and 98th %ile (diamond symbol).

Figure 4–20  Box-and-Whisker Plot of Intermittent 24-hour Average PM$_{10}$
Concentrations at Genesee and Powers Air Monitoring Stations in 2009
Note: 25th %ile (bottom of box), 50th %ile (line inside box), 75th %ile (top of box), maximum (top T),
and 98th %ile (diamond symbol).
Section 4: Results and Discussion

Figure 4–21  Twenty-four Hour Average PM$_{2.5}$ Concentration versus PM$_{10}$ Concentration at the Genesee Air Monitoring Station during 2009

\[ y = 1.28x + 6.63 \]
\[ R^2 = 0.29 \]

Figure 4–22  Twenty-four Hour Average PM$_{2.5}$ Concentration versus PM$_{10}$ Concentration at the Powers Air Monitoring Station during 2009

\[ y = 2.41x + 0.74 \]
\[ R^2 = 0.42 \]
Results for the Genesee AMS ($R^2 = 0.29$, $n=61$) indicated that only 29 percent of variance in 24-hour average PM$_{10}$ concentrations was explained by variation in 24-hour average PM$_{2.5}$ concentrations. These findings indicate that 24-hour average PM$_{2.5}$ measurements at the Genesee AMS would be poor predictors of expected 24-hour average PM$_{10}$ concentrations.

Results for the Powers AMS ($R^2 = 0.42$, $n=61$) indicated that only 42 percent of variance in 24-hour average PM$_{10}$ concentration was explained by variation in 24-hour average PM$_{2.5}$ concentrations. Again, these findings indicate that 24-hour average PM$_{2.5}$ measurements at the Powers AMS would be poor predictors of expected 24-hour average PM$_{10}$ concentrations.

4.3 Passive Monitoring Program
Bubble plots are used to show spatially the size of measured values. In this case, bubble plots were used to show annual average concentrations of NO$_2$, SO$_2$, and O$_3$ at the 21 passive monitoring sites in the Wabamun–Genesee area during 2009 (Figure 1–2). Annual average concentrations were determined by averaging 12 monthly monitoring results at each passive site tabulated in Appendix A.

In addition, annual average concentrations during 2009 of NO$_2$, SO$_2$, and O$_3$ at selected continuous monitoring stations in the area were plotted for comparison purposes (i.e., the Violet Grove AMS and the Edmonton East AMS). This information was obtained from the CASA Data Warehouse for 2009 (CASA 2010).

4.3.1 Nitrogen Dioxide
Figure 4–23 is a bubble plot of annual average NO$_2$ concentrations measured at 18 NO$_2$ passive monitoring sites during 2009. Figure 4–23 indicates that annual NO$_2$ concentrations determined by passive monitors increase slightly from sites between Lake Wabamun and sites adjacent to the City of Edmonton. The highest annual average NO$_2$ concentration shown in Figure 4–23 was observed at the Edmonton East station (15 ppb or 28 µg/m$^3$) compared to a range of 2.2 to 4.6 ppb (4.1 to 8.7 µg/m$^3$) observed at passive sites located within 30 km of the generating plants. These data show that urban source emissions contribute more to ambient NO$_2$ concentrations observed in and around the City of Edmonton relative to generating plant emissions from the Wabamun–Genesee area.

4.3.2 Sulphur Dioxide
Figure 4–24 is a bubble plot of annual average SO$_2$ concentrations measured at 11 SO$_2$ passive monitoring sites during 2009. Annual average SO$_2$ concentrations were very low, in the 0.6 to 1.7 ppb (1.6 to 4.5 µg/m$^3$)range across all sites. These low values and associated lack of spatial trend is consistent with that reported by Kindzierski (2002) for the same area, based on a passive monitoring study conducted by Alberta Environment between July 2000 and September 2001 (Myrick 2002, pers. comm.). This lack of trend is also consistent with predictions of future cumulative SO$_2$ emissions in the area associated with the Genesee generating plant expansion (EPCOR 2001), as well as with concentrations measured in the continuous program discussed previously in Section 4.1.2.

4.3.3 Ozone
Figure 4–25 is a bubble plot of annual average O$_3$ concentrations measured at 12 O$_3$ passive monitoring sites during 2009. Annual average O$_3$ concentrations observed at passive monitoring sites directly east of the Wabamun–Genesee area ranged from 22 to 30 ppb (43 to 59 µg/m$^3$). In general, lower annual average O$_3$ concentrations were observed within the City of Edmonton compared with passive monitoring sites directly east of the Wabamun–Genesee area (Figure 4–25). A partial explanation for this spatial trend is because of increased O$_3$ scavenging due to increased NO$_x$ emissions within the City of Edmonton.
(Kindzierski et al. 2006; Kindzierski 2006). This spatial trend is consistent with slightly increasing NO$_2$ concentrations observed towards the City of Edmonton, as shown in Figure 4–23.

Passive monitoring Sites 15 and 16 (Figures 4–23 and 4–25) were commissioned in February 2006. These sites are situated downwind of a principal wind-flow direction (winds from the northwest) along an imaginary northwest line on which the generating plants are located. Based on annual average wind speeds in the area, these sites are located greater than two- to four-hours travel time downwind of the generating plants. Gillani et al. (1998) and U.S. EPA (1998) have indicated that generating plant plume chemistry maturity and peak production capacities of anthropogenic O$_3$ and inorganic nitrogen species occur between 30 and 100 km downwind of generating plants. Annual average O$_3$ concentrations at sites 15 and 16 were 19 and 26 percent greater, respectively than the annual average O$_3$ concentration at the Violet Grove AMS during 2009. The Violet Grove station is located 55 km to the southwest of the four coal-fired thermal generating plants.

Passive monitoring Sites 15 and 16 were established to examine whether O$_3$ levels are higher, lower, or similar compared to levels from O$_3$ sampling sites closer to the generating plants. These sites were established to help understand whether anthropogenic O$_3$ production may be occurring farther away. It was important to avoid siting these sampling locations near urban areas because NO$_x$ scavenging becomes more dominant, resulting in lower O$_3$ levels. Annual average O$_3$ concentrations at passive monitoring Sites 15 and 16 (Figure 4–25) were 19 and 26 percent greater, respectively than the annual average O$_3$ concentration at the Violet Grove AMS during 2009.

Figure 4–26 shows monthly average concentrations measured at O$_3$ passive monitoring sites during 2009. The highest monthly average O$_3$ concentrations observed in the network occurred in spring, peaking in March. This temporal trend is consistent with historical data reported by He et al. (2005) and Kindzierski et al. (2006) for other O$_3$ monitoring sites in west central Alberta. Seasonal variation is influenced by stratospheric intrusion of O$_3$ that has been frequently observed in previous studies in Alberta (Sandhu 1999; Chaikowsky 2001).
Bubble Plot of Annual Average NO₂ Concentrations [ppb] at Passive Monitoring Sites and at Selected Continuous Monitoring Station Locations in Central Alberta during 2009

Acknowledgements:
Original Drawing by Stanec

Scale in Kilometers
Bubble Plot of Annual Average SO$_2$ Concentrations [ppb] at Passive Monitoring Sites and at Selected Continuous Monitoring Station Locations in Central Alberta during 2009
Bubble Plot of Annual Average O₃ Concentrations [ppb] at Passive Monitoring Sites and at Selected Continuous Monitoring Station Locations in Central Alberta during 2009

Acknowledgements:
Original Drawing by Stantec

Scale in Kilometers

Area of Detail

PREPARED BY
PREPARED FOR

DRAFT DATE 23/07/2009
REVISION DATE 23/08/2010
PROJECT 4-25
FIGURE NO. 4-25
Figure 4–26  Monthly Average O$_3$ Concentration at Passive Monitoring Sites in Central Alberta during 2009

Note – refer to Figure 1–2 for location of passive monitoring sites.
5 Summary

A continuous program was conducted at the Genesee, Meadows, Wagner and Powers air monitoring stations in the Wabamun–Genesee area during 2009. Data capture rates for measured parameters at all of the air monitoring stations were above the 90 percent criterion for the year as required by the AENV Air Monitoring Directive (AENV1989). High up-times were indicative that equipment in the continuous air monitoring network was well-maintained. The Wagner AMS experienced planned and unplanned power outages May 4, 5, 11 to 15, and 25 to 27, resulting in up-times of 77 percent for monitoring equipment during the month. This station operated normally for the remainder of the year.

Overall, air quality was judged to be good at the monitoring stations during 2009, similar to that observed in previous years. A summary of the 2009 continuous monitoring data is as follows:

- Hourly NO$_2$ concentrations were very low at all four air monitoring stations (below 58 µg/m$^3$ for 98 percent of the time). The observed 9th highest 1-hour NO$_2$ concentrations ranged from 56 µg/m$^3$ at the Genesee AMS to 78 µg/m$^3$ at the Meadows AMS. For comparison purposes, the 9th highest 1-hour NO$_2$ concentrations observed during 2009 at the Carrot Creek AMS and Edmonton East AMS were 68 and 130 µg/m$^3$, respectively. All of these concentrations fall well below the 1-hour Alberta Ambient Air Quality Objective of 400 µg/m$^3$.

- Hourly SO$_2$ concentrations were very low at all four air monitoring stations (below 27 µg/m$^3$ for 98 percent of the time). The observed 9th highest 1-hour SO$_2$ concentrations ranged from 57 µg/m$^3$ at the Powers AMS to 83 µg/m$^3$ at the Genesee AMS. For comparison purposes, the 9th highest 1-hour SO$_2$ concentrations observed during 2009 at the Carrot Creek AMS and Edmonton East AMS were 24 and 71 µg/m$^3$, respectively. All of these concentrations fall well below the 1-hour Alberta Ambient Air Quality Objective of 450 µg/m$^3$.

- The annual average ozone (O$_3$) concentration at the Genesee AMS was 55 µg/m$^3$. Hourly O$_3$ concentrations at the Genesee AMS were below 116 µg/m$^3$ for 98 percent of the time during 2009. The 9th highest 1-hour O$_3$ concentration observed at the Genesee AMS was 173 µg/m$^3$. For comparison purposes, the 9th highest 1-hour O$_3$ concentrations observed at the Carrot Creek AMS and Edmonton East AMS were 130 and 132 µg/m$^3$, respectively. O$_3$ concentrations at the Genesee AMS exceeded the Alberta Ambient Air Quality objective of 160 µg/m$^3$ eleven hours during 2009. These exceedences occurred for seven hours over July 24 and 25 and for four hours on September 1.

- Median (50th percentile) 24-hour PM$_{2.5}$ concentrations at the Genesee and Powers air monitoring stations were very low (below 5 µg/m$^3$). The 98th percentile 24-hour PM$_{2.5}$ concentrations at both air monitoring stations were below 22 µg/m$^3$.

During 2009, twenty-four hour average PM$_{2.5}$ and PM$_{10}$ samples were collected at the Genesee and Powers air monitoring stations according to a NAPS six-day cycle sampling frequency. The following summarizes the intermittent monitoring data for 2009:

- Twenty-four hour average PM$_{2.5}$ concentrations were below 22 µg/m$^3$ at both the Genesee and Powers air monitoring stations for 98 percent of the time. This is consistent with 24-hour average data observed from continuous monitoring at these stations.

- Twenty-four hour average PM$_{10}$ concentrations were below 68 µg/m$^3$ at both the Genesee and Powers air monitoring stations for 98 percent of the time.
Passive air monitors were deployed at 21 stations in the Wabamun–Genesee area during 2009. The 2009 passive data are summarized as follows:

- At passive sites located within 30 km of the generating plants, annual average NO$_2$ concentrations ranged from 2.2 to 4.6 ppb (4.1 to 8.7 µg/m$^3$), whereas at the Edmonton East AMS the annual average NO$_2$ concentration observed was 28 µg/m$^3$. Annual NO$_2$ concentrations determined by passive monitors showed a small increase between sites near Lake Wabamun to sites adjacent to the City of Edmonton. This spatial trend is consistent with previous studies in the same area and is due to the influence of increasing urban NO$_x$ emissions within and adjacent to the City of Edmonton. Urban source emissions are more important contributors to ambient NO$_2$ concentrations observed in and around the City of Edmonton compared to emissions from generating plants located in the Wabamun–Genesee area.

- Annual average SO$_2$ concentrations were very low, ranging from 0.6 to 1.7 ppb (1.6 to 4.5 µg/m$^3$) at all passive sites in the Wabamun–Genesee area. This lack of spatial trend is consistent with that reported in previous studies for the same area.

- Annual average O$_3$ concentrations observed at passive monitoring sites directly east of the Wabamun–Genesee area ranged from 22 to 30 ppb (43 to 59 µg/m$^3$). Sites 15 and 16 are located greater than two to four-hours travel time downwind of the generating plants along an imaginary northwest line on which the generating plants are located. Previous work by others has indicated that generating plant plume chemistry maturity and peak production capacities of anthropogenic O$_3$ and inorganic nitrogen species occurs between 30 and 100 km downwind of generating plants (within the range of where these two passive monitoring sites are located). Annual average O$_3$ concentrations at Sites 15 and 16 were 19 and 26 percent greater, respectively than the annual average O$_3$ concentration at the Violet Grove AMS during 2009. The Violet Grove station is located 55 km to the southwest of the four coal-fired thermal generating plants.
6 References

6.1 Literature Cited


Kindzierski, W.B. 2006. Analysis of historical O3 and PM2.5 trends from ambient air monitoring data in central Alberta. Air Quality 2006: Piecing the Puzzle, the Fourth Canadian Workshop on Air Quality, 13 to 16 February 2006, Banff, AB.


6.2 Personal Communications


6.3 Internet Sites


APPENDIX A
PASSIVE MONITORING DATA FOR 2009
## Appendix A Passive Monitoring Data for 2009

**Table A–1** 2009 NO$_2$ Passive Monitoring Data (monthly average concentration in ppb)

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**Table A–2** 2009 SO$_2$ Passive Monitoring Data (monthly average concentration in ppb)

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Table A-3  2009 O₃ Passive Monitoring Data (monthly average concentration in ppb)

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