TransAlta Corporation and Capital Power Corporation
Ambient Air Monitoring Program

2016 ANNUAL REPORT

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Executive Summary

TransAlta Corporation (TransAlta) and Capital Power Corporation (Capital Power) operate three coal-fired thermal generating stations: Sundance, Keephills and Genesee, which are located in the Wabamun–Genesee area of west-central Alberta. The three generating stations operate under the terms and conditions of their respective Alberta Environmental Protection and Enhancement Act (EPEA) approvals.

As part of their approvals, the generating stations conduct special environmental monitoring programs, including ambient air monitoring. This 2016 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. Types of monitoring conducted in 2016 included a continuous monitoring program, an intermittent monitoring program and a passive monitoring program.

Continuous Monitoring Program

Data capture rates for measured parameters at all of the air monitoring stations (AMS) were well above the 90% criterion for the year as required by the Alberta Environment and Parks Air Monitoring Directive. High up-times were indicative that equipment in the continuous air monitoring network was well-maintained. Air quality was judged to be good at the monitoring stations during 2016, similar to that observed in previous years. A summary of the 2016 continuous monitoring data is as follows:

- Hourly NO\(_2\) concentrations were very low at all four air monitoring stations (below 25 ppb (50 µg/m\(^3\)) for 98% of the time). The observed 9\(^{th}\) highest 1-hour NO\(_2\) concentrations ranged from 26 ppb (49 µg/m\(^3\)) at the Genesee AMS to 35 ppb (65 µg/m\(^3\)) at the Meadows AMS. For comparison purposes, the 9\(^{th}\) highest 1-hour NO\(_2\) concentrations at the Carrot Creek AMS and Edmonton East AMS during 2016 were 35 and 48 ppb (66 and 90 µg/m\(^3\)), respectively. All of these concentrations fall well below the 1-hour Alberta Ambient Air Quality Objective of 159 ppb (300 µg/m\(^3\)).

- Hourly SO\(_2\) concentrations were very low at all four air monitoring stations (below 12 ppb (31 µg/m\(^3\)) for 98% of the time). The 9\(^{th}\) highest 1-hour SO\(_2\) concentrations ranged from 25 ppb (66 µg/m\(^3\)) at the Powers AMS to 33 ppb (87 µg/m\(^3\)) at the Wagner AMS. For comparison purposes, the 9\(^{th}\) highest 1-hour SO\(_2\) concentrations at the Carrot Creek AMS and Edmonton East AMS during 2016 were 7 and 24 ppb (18 and 63 µg/m\(^3\)), respectively. All of these concentrations fall well below the 1-hour Alberta Ambient Air Quality Objective of 172 ppb (450 µg/m\(^3\)).

- The annual average O\(_3\) concentration at the Genesee AMS was 22 ppb (44 µg/m\(^3\)). Hourly O\(_3\) concentrations at the Genesee AMS were below 48 ppb (95 µg/m\(^3\)) for 98% of the time during 2016. The 9\(^{th}\) highest 1-hour O\(_3\) concentration at the Genesee AMS was 60 ppb (120 µg/m\(^3\)). For comparison purposes, the 9\(^{th}\) highest 1-hour O\(_3\) concentrations at the Carrot Creek AMS and Edmonton East AMS were 58 and 60 ppb (116 and 120 µg/m\(^3\)), respectively. O\(_3\) concentrations at the Genesee AMS did not exceed the 1-hour Alberta Ambient Air Quality Objective of 82 ppb (160 µg/m\(^3\)) at any time during 2016. The 4\(^{th}\) highest 8-hour O\(_3\) concentration at the Genesee AMS in 2016 was 54 ppb (108 µg/m\(^3\)). This value is below the Canadian Ambient Air Quality Standard of 63 ppb (124 µg/m\(^3\)).

- Median (50\(^{th}\) percentile) 24-hour PM\(_{2.5}\) concentrations at the Genesee AMS and Powers AMS were very low (below 3 µg/m\(^3\)) in 2016. The 98\(^{th}\) percentile 24-hour PM\(_{2.5}\) concentrations at both air monitoring stations were below 19 µg/m\(^3\) and below the Canadian Ambient Air Quality Standard of 28 µg/m\(^3\). The annual average of 24-hour PM\(_{2.5}\) concentrations at both air monitoring stations were below 5 µg/m\(^3\) and below the Canadian Ambient Air Quality Standard of 10 µg/m\(^3\).

- Concentrations of monitored parameters continue to be low as they have been in previous years of the continuous monitoring program.
Intermittent Monitoring Program

During 2016, twenty-four hour average PM$_{2.5}$ and PM$_{10}$ samples were collected at the Genesee AMS and Powers AMS according to a National Ambient Pollutant Surveillance (NAPS) six-day cycle sampling frequency. The following summarizes the intermittent monitoring data for 2016:

- Twenty-four hour average PM$_{2.5}$ concentrations were below 25 µg/m$^3$ at the Genesee AMS (n=61) and below 28 µg/m$^3$ at the Powers AMS (n=61) for 98% of the time.
- Twenty-four hour average PM$_{10}$ concentrations were below 52 µg/m$^3$ at the Genesee AMS (n=61) and below 47 µg/m$^3$ at the Powers AMS (n=60) for 98% of the time.

Passive Monitoring Program

Passive air monitors were deployed at 15 stations in the Wabamun–Genesee area for approximate 30-day periods during 2016. The 2016 passive data are summarized as follows:

- At passive sites located within 30 km of the generating stations, annual average NO$_2$ concentrations were less than 2.4 ppb (4.5 µg/m$^3$), whereas at the Edmonton East AMS the annual average NO$_2$ concentration was 11.2 ppb or 21 µg/m$^3$. Urban source emissions are recognized as important contributors to ambient NO$_2$ concentrations in and around the City of Edmonton compared to emissions from generating stations located in the Wabamun-Genesee area.
- Annual average SO$_2$ concentrations were very low at passive sites, ranging from 0.5 to 2.2 ppb (1.3 to 5.8 µg/m$^3$) at all passive sites in the Wabamun–Genesee area. This lack of spatial trend is consistent with the results reported in previous studies for the same area. Monthly average SO$_2$ concentrations at the passive sites were well below the 30-day Alberta Ambient Air Quality Objective of 11 ppb.
- Annual average O$_3$ concentrations at 11 passive monitoring sites directly east of the Wabamun–Genesee area ranged from 24 to 36 ppb (49 to 61 µg/m$^3$). Passive sites 15 and 16 are two O$_3$ monitoring sites located more than two-to-four hours travel time downwind of the generating stations along an imaginary northwest line on which the generating stations are located. Previous work by scientists at University of Alabama and Tennessee Valley Authority has indicated that generating station plume chemistry maturity and peak production capacities of anthropogenic O$_3$ and inorganic nitrogen species occurs between 30 and 100 km downwind of generating stations (within the range of where these two passive monitoring sites are located). Site 15 is located 26.7 km away from Genesee AMS towards the southeast, while Site 16 is 39.8 km away from the station. Annual average O$_3$ concentrations at sites 15 and 16 were within 15% of the annual average O$_3$ concentration at the Violet Grove AMS during 2016. The Violet Grove station is located 55 km southwest of the generating stations.
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### Abbreviations

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<th>Abbreviation</th>
<th>Definition</th>
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<tr>
<td>AAAQO</td>
<td>Alberta Ambient Air Quality Objective</td>
</tr>
<tr>
<td>AEP</td>
<td>Alberta Environment and Parks</td>
</tr>
<tr>
<td>AMS</td>
<td>air monitoring station</td>
</tr>
<tr>
<td>CAAQS</td>
<td>Canadian Ambient Air Quality Standard</td>
</tr>
<tr>
<td>Capital Power</td>
<td>Capital Power Corporation</td>
</tr>
<tr>
<td>CASA</td>
<td>Clean Air Strategic Alliance</td>
</tr>
<tr>
<td>COPC</td>
<td>Chemicals of Potential Concern</td>
</tr>
<tr>
<td>CMA</td>
<td>Census Metropolitan Area</td>
</tr>
<tr>
<td>EPEA</td>
<td>Environmental Protection and Enhancement Act</td>
</tr>
<tr>
<td>HNO₃</td>
<td>nitric acid</td>
</tr>
<tr>
<td>H₂SO₄</td>
<td>sulphuric acid</td>
</tr>
<tr>
<td>IQR</td>
<td>interquartile range</td>
</tr>
<tr>
<td>km</td>
<td>kilometre</td>
</tr>
<tr>
<td>m³</td>
<td>cubic metre</td>
</tr>
<tr>
<td>MW</td>
<td>megawatts</td>
</tr>
<tr>
<td>NAPS</td>
<td>National Ambient Pollutant Surveillance</td>
</tr>
<tr>
<td>NAS</td>
<td>National Academy of Sciences</td>
</tr>
<tr>
<td>NO</td>
<td>nitric oxide</td>
</tr>
<tr>
<td>NO₂</td>
<td>nitrogen dioxide</td>
</tr>
<tr>
<td>NOₓ</td>
<td>oxides of nitrogen</td>
</tr>
<tr>
<td>O₃</td>
<td>ozone</td>
</tr>
<tr>
<td>ppb</td>
<td>parts per billion</td>
</tr>
<tr>
<td>PM</td>
<td>particulate matter</td>
</tr>
<tr>
<td>PM₂.₅</td>
<td>particulate matter ≤2.5 µm</td>
</tr>
<tr>
<td>PM₁₀</td>
<td>particulate matter ≤10 µm</td>
</tr>
<tr>
<td>PAHs</td>
<td>polycyclic aromatic hydrocarbons</td>
</tr>
<tr>
<td>R²</td>
<td>coefficient of determination</td>
</tr>
<tr>
<td>SO₂</td>
<td>sulphur dioxide</td>
</tr>
<tr>
<td>SO₃</td>
<td>sulphur trioxide</td>
</tr>
<tr>
<td>STI</td>
<td>Sonoma Technology Inc.</td>
</tr>
<tr>
<td>TransAlta</td>
<td>TransAlta Corporation</td>
</tr>
<tr>
<td>µg</td>
<td>microgram</td>
</tr>
<tr>
<td>µm</td>
<td>micrometre</td>
</tr>
<tr>
<td>U.S. EPA</td>
<td>United States Environmental Protection Agency</td>
</tr>
<tr>
<td>UV</td>
<td>ultraviolet</td>
</tr>
<tr>
<td>VOCs</td>
<td>volatile organic compounds</td>
</tr>
<tr>
<td>WCAS</td>
<td>West Central Airshed Society</td>
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1 Introduction

TransAlta Corporation (TransAlta) and Capital Power Corporation (Capital Power) operate three coal-fired thermal generating stations: Sundance, Keephills 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 stations.

The TransAlta Sundance generating station consists of six generating units. It is situated on the south shore of Wabamun Lake, approximately 70 kilometres (km) west of Edmonton, Alberta (Figure 1–1). The station has operated since 1970, with steady expansion throughout the 1970s from a single original generating unit to six generating units. Sundance currently has a net generating capacity of 2,141 megawatts (MW) from Units 1 through 6.

TransAlta’s Keephills generating station has three units and is located 5 km south of Wabamun Lake (Figure 1–1). Keephills Units 1 and 2 have been in operation since 1983. They have a net combined generating capacity of 790 MW. Keephills Unit 3 began commercial operation on September 1, 2011. This plant is a 50/50 joint venture between TransAlta and Capital Power and it has a net generating capacity of 463 MW.

The Genesee generating station consists of three generating units. It is located 80 km southwest of Edmonton (Figure 1–1). Capital Power fully owns and operates Units 1 and 2, which have a combined generating capacity of 800 MW. These units have been in operation since 1994 and 1989, respectively. Genesee Unit 3, commissioned in 2005, is a 50/50 joint venture between TransAlta and Capital Power. Genesee 3 has a net generating capacity of 466 MW.

Collectively, at the end of 2016, these three generating stations had the capacity to generate a net total of 4,660 MW to Alberta’s electrical grid. Table 1–1 summarizes information pertaining to the Environmental Protection and Enhancement Act Operating Approvals for the three generating stations.

1.1 Environmental Monitoring Programs for Generating Stations

The generating stations operate under the Environmental Protection and Enhancement Act (EPEA) approvals listed in Table 1–1. Under their EPEA approvals, the generating stations are required to conduct 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 station emissions;
- generate an inventory of representative baseline data for the chemicals of potential concern (COPC); and
- 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 Stations and Air Monitoring Area in the Wabamun-Genesee Area of Alberta

Acknowledgements:
Original Drawing by Stantec
One aspect of the environmental monitoring programs included developing and implementing an ambient air quality monitoring program. The Ambient Air Monitoring program consists of the following components:

- a continuous monitoring program for sulphur dioxide (SO₂), nitrogen dioxide (NO₂) and a number of meteorological parameters at four air monitoring stations (Genesee, Powers, Meadows and Wagner); particulate matter with aerodynamic diameter less than or equal to 2.5 micrometre (μm) (PM₂.₅) at two stations (Genesee and Powers); and ozone (O₃) at one station (Genesee);
- 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); and
- a passive monitoring program consisting of monthly passive monitoring for NO₂, SO₂, and O₃ at 15 locations in the Wabamun–Genesee area (one of these is at the Genesee AMS).

Sections within the EPEA approvals containing specific terms and conditions that refer to the Ambient Air Monitoring program are provided in Table 1–1.

### Table 1-1 Alberta EPEA Operating Approvals for Three Generating Stations in the Wabamun–Genesee Area

<table>
<thead>
<tr>
<th>Facility</th>
<th>Net Generating Capacity¹ (MW)</th>
<th>Location</th>
<th>Approval No. (as amended)</th>
<th>Ambient Air Monitoring Program Applicable Approval Terms</th>
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</thead>
<tbody>
<tr>
<td>Sundance</td>
<td>2,141</td>
<td>3,4,8,9,10,16,17,20, and 31-52-04 W5M</td>
<td>9830-02-00</td>
<td>Sections within Part 7</td>
</tr>
<tr>
<td>Keephills</td>
<td>1,253</td>
<td>36-51-04 W5M</td>
<td>10324-02-00</td>
<td>Sections within Part 7</td>
</tr>
<tr>
<td>Genesee</td>
<td>1,266</td>
<td>25-50-03 W5M</td>
<td>773-03-00</td>
<td>Sections within Part 7</td>
</tr>
</tbody>
</table>


### 1.2 Purpose of Report

This annual report summarizes and discusses the data collected as part of the 2016 Ambient Air Monitoring Program. These data provide a basis for developing an understanding of the state of air quality in relation to emissions from coal-fired generating stations in the Wabamun–Genesee area. Monitoring components associated with the Acid Deposition Assessment Program and the Mercury Assessment Program conducted in the Wabamun–Genesee area are reported separately in stand-alone reports (TransAlta and Capital Power 2017a, b).
Continuous and Passive Monitoring Locations in the Wabamun-Genesee Area during 2016

Acknowledgements:
Original Drawing by Stantec
2 Background on Air Quality Parameters

A number of chemicals of potential concern (COPC) are emitted from the coal-fired generating stations or formed in the atmosphere as a result of the emissions in the Wabamun–Genesee area. The COPC monitored in the Ambient Air Monitoring Program include: oxides of nitrogen (NO\textsubscript{x}), sulphur dioxide (SO\textsubscript{2}), ground-level ozone (O\textsubscript{3}) and airborne particulate matter (PM). The importance of these COPC is discussed below.

2.1 Oxides of Nitrogen

NO\textsubscript{x} 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 NO\textsubscript{2}. The NO\textsubscript{x} concentration is calculated by adding together NO and NO\textsubscript{2} concentrations. High temperature combustion of hydrocarbon fuel sources produces NO and smaller quantities of NO\textsubscript{2} from reactions with nitrogen gas in the atmosphere. Most of the NO in ambient air rapidly turns into NO\textsubscript{2}. In Alberta, almost every combustion source emits NO, which reacts in the atmosphere to create NO\textsubscript{2}. This includes motor vehicles, commercial and residential furnaces, gas stoves and heaters, conventional oil & gas extraction & processing, generating stations, oil sands development and petroleum and chemical manufacturing plants.

NO\textsubscript{2}, NO, volatile organic compounds (VOCs), anthropogenic (man-made) and biogenic (from vegetation) hydrocarbons and carbon monoxide are all precursors that may be involved in the formation of ground-level O\textsubscript{3} and photochemical smog (United States Environmental Protection Agency (U.S. EPA) 2008a, internet reference). NO\textsubscript{2} 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, NO\textsubscript{2} can also be oxidized to form nitric acid (HNO\textsubscript{3}), which contributes to the acidity of cloud, fog and rainwater, as well as to the formation of ambient fine particulate matter.

The Alberta Ambient Air Quality Objectives (AAAQOs) for NO\textsubscript{x} are expressed as NO\textsubscript{2}. Therefore, NO\textsubscript{x} concentrations are typically expressed as NO\textsubscript{2} for comparison to the AAAQOs. A listing and brief description of the AAAQOs for NO\textsubscript{2} and other air quality standards are given in Section 2.5.

The Clean Air Strategic Alliance (CASA) (2006, internet reference) reported that the 10-year average concentration of NO\textsubscript{2} measured at a rural background location in Alberta (Hightower Ridge AMS) was 8 parts per billion (ppb) (15 microgram per cubic metre (μg/m\textsuperscript{3})).

2.2 Sulphur Dioxide

SO\textsubscript{2} and sulphur trioxide (SO\textsubscript{3}) are produced from oxidation of trace amounts of sulphur during high temperature combustion of hydrocarbon fuels including oil and coal. Industrial operations (e.g., conventional oil & gas, electricity generation, oil sands development and petroleum and chemical manufacturing) contribute the majority of anthropogenic SO\textsubscript{2} emissions to the atmosphere in Alberta (AEP 2015, internet reference). Transportation-related sources are estimated to contribute small amounts of sulphur emissions to the atmosphere (U.S. EPA 2008b, internet reference).

SO\textsubscript{2} can react with moisture in the atmosphere (and is oxidized) to form sulphuric acid (H\textsubscript{2}SO\textsubscript{4}), which contributes to acidity of cloud, fog and rainwater. SO\textsubscript{3} emitted to the atmosphere reacts rapidly with moisture to form H\textsubscript{2}SO\textsubscript{4}, which condenses onto existing particles (when particle loadings are high) or acts as nuclei to form new particles (under low particle loadings) (U.S. EPA 2008b, internet reference).
CASA (2006, internet reference) 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 O₃ can originate in two important ways: (i) by being brought down to the surface from the tropospheric reservoir by daily (diurnal) mixing of the atmospheric boundary layer, and (ii) by being photochemically produced. Surface measurements alone are not sufficient for understanding characteristics of ground-level O₃ because the chemical composition of the surface layer largely depends on mixing from above (Zhang and Rao 1999).

**Mixing of the atmospheric boundary layer** – The presence of ground-level O₃ 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, O₃ suspended in the air is mixed downward to the earth’s surface and surface concentrations O₃ 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.

**Photochemical production** – In urban areas and areas downwind that are influenced by urban air masses, photochemically produced ground-level O₃ and other oxidants form by atmospheric reactions involving mainly two classes of chemical precursors: VOCs and NOₓ (U.S. EPA 2006, internet reference). VOCs refer to all carbon-containing gas-phase compounds in the atmosphere, both biogenic and anthropogenic in origin.

Maximum O₃ concentrations from photochemical reactions usually occur four to six hours after peak 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 for photochemical O₃ formation and accumulation, and in terminating episodes of high O₃ concentrations (National Academy of Science (NAS) 1991). Episodes of high O₃ concentrations from photochemical production are associated with slow-moving, high-pressure weather systems.

Sonoma Technology Inc. (STI) (2010, internet reference) conducted a study on behalf of the Capital Airshed Partnership (CAP) to assess the suitability of O₃ monitoring locations in the Edmonton Census Metropolitan Area (CMA) and to analyze related trends in O₃ and O₃ precursors. The Edmonton CMA includes the Wabamun–Genesee area. STI (2010, internet reference) stated that the location of highest O₃ concentrations in the Edmonton CMA are probably found in an area east-southeast of Edmonton and beyond the current range of monitors.

STI (2010, internet reference) further stated that, at a minimum, a monitoring site for measuring potential O₃ maxima concentrations in the Edmonton CMA should be at least 20 km downwind and potentially 200 km downwind of the Strathcona Industrial Area and the southeastern boundary of the Edmonton CMA. This is consistent with expected behavior of maximum O₃ concentrations from photochemical reactions in urban areas and areas downwind influenced by urban air masses as described above.

Ground-level O₃ 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) (Singh et al. 1978). Ground–level O₃ can be enhanced by photochemical reactions, particularly in the summer (June through August). CASA (2006, internet reference) reported that the 10-year average concentration of O₃ measured at a rural background location in Alberta (Hightower Ridge AMS) was 42 ppb (81 μg/m³).
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$_{10}$, while fine particles (PM$_{2.5}$) have diameters less than 2.5 μm (Health Canada 1999).

Coarse 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) (U.S. EPA 2009, internet reference). The makeup of fine particles (i.e., PM$_{2.5}$) tends to be dominated by particles that form during combustion of material that has volatilized during combustion and then re-condensed before emission to the atmosphere (U.S. EPA 2009, internet reference). PM mixtures have a wide variety of sources in the environment (U.S. EPA 2009, internet reference). 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 potentially environmentally significant compounds (e.g., carbon monoxide and gaseous elemental mercury).

CASA (2006, internet reference) reported that the 10-year average concentration of PM$_{2.5}$ measured at a rural background location (Hightower Ridge AMS) was 2.3 μg/m$^3$. Western Canadian National Ambient Pollution Surveillance (NAPS) stations located in semi-rural areas or well-ventilated coastal locations receiving relatively high levels of precipitation have background levels of 3 to 4 μg/m$^3$ for PM$_{2.5}$ (Vingarzan 2009, internet reference).

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 Alberta Environment and Parks AAAQOs, regulatory guidelines and national Canada Ambient Air Quality Standards (CAAQS) exist for the criteria air contaminants defined as COPC to aid with interpreting measured ambient levels of these pollutants. Current objectives, guidelines and standards for 2016 are listed in Table 2–1.
### Table 2–1 Ambient Air Quality Objectives, Guidelines and Standards for Specific Criteria Air Contaminants Defined as COPC Related to Generating Station Emissions in the Wabamun–Genesee Area

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Averaging Time</th>
<th>Alberta Ambient Air Quality Objective¹</th>
<th>Alberta Ambient Air Quality Guideline¹</th>
<th>Canadian Ambient Air Quality Standard²</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOₓ (as NO₂)</td>
<td>1 hour</td>
<td>300 µg/m³ (159 ppb)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>annual</td>
<td>45 µg/m³ (24 ppb)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>SO₂</td>
<td>1 hour</td>
<td>450 µg/m³ (172 ppb)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>24 hour</td>
<td>125 µg/m³ (48 ppb)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>30–day</td>
<td>30 µg/m³ (11 ppb)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>annual</td>
<td>20 µg/m³ (8 ppb)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>PM₂.₅</td>
<td>1 hour</td>
<td>-</td>
<td>80 µg/m³</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>24–hour</td>
<td>30 µg/m³</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>24–hour average based on 98th percentile value over 3 consecutive years</td>
<td>-</td>
<td>-</td>
<td>28 µg/m³</td>
</tr>
<tr>
<td></td>
<td>3–year average of the annual average</td>
<td>-</td>
<td>-</td>
<td>10 µg/m³</td>
</tr>
<tr>
<td>O₃</td>
<td>1 hour</td>
<td>160 µg/m³ (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>124 µg/m³ (63 ppb)</td>
</tr>
</tbody>
</table>

Notes:

1 AEP (2017a, internet reference).
2 CCME (2012).
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 and meteorological parameters listed below are described further in the Ambient Air Monitoring Program Quality Assurance Plan for West Central Airshed Society (AMEC Earth & Environmental [AMEC] 2011). 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>Passive (monthly)</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

NO2 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 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

SO2 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

O3 is measured at the Genesee AMS with a TECO 49i UV photometric 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

In 2016, fine particulate matter (PM2.5) was continuously 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 2016, 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 PM10 and PM2.5 samples are collected at the Powers AMS and Genesee AMS. 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 PM10 and PM2.5 samples are described further in the Ambient Air Monitoring Program Quality Assurance Plan for West Central Airshed Society (AMEC 2011).

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 Innotech Alberta (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 PM2.5 samples are currently archived electronically. Results for metals analyses up to the end of 2013 were used to undertake source apportionment (quantitative identification of relative contributions of different source types to airborne particle concentrations). Results were submitted in the fall of 2014 (TransAlta and Capital Power 2014). A schedule for the sampling program is presented in Table 3−1.

3.3 Passive Monitoring Program

Passive air monitors are deployed at 15 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 NO2, SO2, and O3. Procedures and guidelines for collecting and analyzing, NO2, SO2 and O3 passive samplers are described further in the Ambient Air Monitoring Program Quality Assurance Plan for West Central Airshed Society (AMEC 2011).
The passive approach collects gas from the atmosphere at a rate controlled by its 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 ±2 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.

### 3.3.1 2015 Performance Evaluation of the Maxxam Passive Samplers

An independent field performance evaluation of the Maxxam passive samplers was carried out by Bari et al. (2015) for measuring ambient concentrations of NO$_2$, SO$_2$ and O$_3$. Monthly passive and hourly continuous air monitoring data from four regional air monitoring networks in Alberta were evaluated over a 5-year period (2006 to 2010):

- **Precision** describes the closeness of agreement among a set of replicate measurements. Geometric mean precision values of the Maxxam passive samplers reported by Bari et al. (2015) were 14.8% (NO$_2$), 17.9% (SO$_2$), and 4.7% (O$_3$) from duplicate passive sampling.

- **Accuracy** describes the closeness of a measurement to a true or accepted value. As a measure of accuracy, geometric mean of the relative error of the Maxxam passive samplers reported by Bari et al. (2015) was 32% (median = 40%, IQR = 25–64%) for NO$_2$, 30% (median = 33%, interquartile range, IQR, = 15–63%) for SO$_2$, and 12% (median = 17%, IQR = 8–27%) for O$_3$.

The independent field performance study stated that measures of accuracy for the Maxxam SO$_2$ and NO$_2$ passive samplers, as a measure of uncertainty, fell outside of data quality objectives recommended by the United States National Institute of Safety and Health (1994) and the European Union Directive (2008, internet reference) of ±25%.
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 operating (i.e., capturing valid data). In general, the Air Monitoring Directive (Alberta Environment (AENV) 1989, internet reference) requires greater than 90% completeness. Tables 4–1 to 4–4 show data capture rates (% completeness) for air quality parameters at the four air monitoring stations in the Wabamun–Genesee area during 2016.

<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>
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<tbody>
<tr>
<td>NO₂</td>
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<td>99.6</td>
<td>99.9</td>
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<td>SO₂</td>
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<td>99.6</td>
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<td>100</td>
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</tr>
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<td>RH</td>
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<td>99.1</td>
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<td>100</td>
<td>95.8</td>
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<td>99.5</td>
</tr>
</tbody>
</table>

Notes:
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.

<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>
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<tbody>
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<td>99.7</td>
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<td>100</td>
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<td>100</td>
<td>99.4</td>
</tr>
</tbody>
</table>

Notes:
WSP = wind speed; WDR = wind direction; T₂ = temperature at 2-metre height above ground; RH = relative humidity.
Table 4–3 Monthly and Annual Data Capture Rates (% completeness) for Powers Air Monitoring Station during 2016

<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>PM₂.₅</td>
<td>100</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>
</tbody>
</table>

Notes: 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 2016

<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>WSP</td>
<td>100</td>
</tr>
<tr>
<td>WDR</td>
<td>100</td>
</tr>
<tr>
<td>T₂</td>
<td>100</td>
</tr>
<tr>
<td>RH</td>
<td>100</td>
</tr>
</tbody>
</table>

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

Monthly data capture rates for all stations were well above the 90% criterion stipulated in the Air Monitoring Directive (AENV 1989, internet reference). High up-times indicate that equipment in the continuous air monitoring network was well-operated and maintained.

4.1.2 Air Pollutant Concentration Statistics for 2016

One method of displaying a set of air quality concentration statistics is to use box-and-whisker plots. Box-and-whisker plots help interpret the distribution of data because they only illustrate certain statistics rather than all of the data. Box-and-whisker plots presented here mostly show five values for individual pollutants collected at each air monitoring station during 2016: 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 (i.e., minimum) is not shown in these plots because the values represented by bottom whiskers are less essential for understanding the distribution of data and where the interest is concentrations at the middle and high end of the distribution.
4.1.2.1 Nitrogen Dioxide

Figure 4–1 is a box-and-whisker plot that compares key statistical values for 1-hour NO₂ concentrations observed at the four ambient air monitoring stations during 2016. 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 stations (Carrot Creek AMS, AEP 2017b, internet reference) and an urban station (Edmonton East AMS, AEP 2017b, internet reference). In Figure 4–1, the bottom of the yellow box, boundary of the yellow and blue boxes, top of the blue box, and top tee represent the 25th, 50th, 75th, and maximum values, respectively. The star symbol in each plot represents the annual arithmetic mean concentration.

![Box-and-Whisker Plot of 1-hour Average NO₂ Concentrations at Selected Air Monitoring Stations in Central Alberta during 2016](image)

<table>
<thead>
<tr>
<th>Station Name</th>
<th>1-hour NO₂ Concentration (µg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genesee</td>
<td></td>
</tr>
<tr>
<td>Meadows</td>
<td></td>
</tr>
<tr>
<td>Powers</td>
<td></td>
</tr>
<tr>
<td>Wagner</td>
<td></td>
</tr>
<tr>
<td>Carrot Creek</td>
<td></td>
</tr>
<tr>
<td>Edmonton East</td>
<td></td>
</tr>
</tbody>
</table>

**Guideline (Alberta Ambient Air Quality Objective): 300 µg/m³**

(* = annual arithmetic mean)

All of the benchmark NO₂ concentrations were highest at the urban (Edmonton East) AMS for the 1-hour averaging periods during 2016. For monitoring stations in the air monitoring area, annual average NO₂ concentrations ranged from 5.4 µg/m³ at Powers AMS to 13 µg/m³ at Meadows AMS. These concentrations are higher than the 10-year average concentration reported by CASA (2006, internet reference) for the Hightower Ridge AMS (5 µg/m³), but much lower than the 2016 annual average NO₂ concentration at the Edmonton East AMS (21 µg/m³). There were no exceedances of the AAAQO for NO₂ in 2016 for a 1-hour averaging time (Figure 4–1).
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 NO$_2$ concentrations observed during 2016 ranged from 49 µg/m$^3$ at the Genesee AMS to 65 µg/m$^3$ at the Meadows AMS. For comparison purposes, the 9th highest 1-hour NO$_2$ concentrations observed during 2016 at the Carrot Creek AMS and Edmonton East AMS were 65 and 90 µg/m$^3$, respectively (AEP 2017b, internet reference).

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 Figure 4–1). 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 at the Meadows AMS for hourly data (Figure 4–1). However, the IQR for NO$_2$ at the Meadows AMS was small (e.g., 15 µg/m$^3$ for hourly concentrations), indicating little variation in hourly concentrations throughout 2016.

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. Cumulative distribution plots illustrated here show the values of the indicator (i.e., hourly concentration) on the vertical axis and percentage of the hours (and by inference the overall population) less than or equal to each value on the horizontal axis.

The distributions were presented in this manner in order to facilitate interpretation when comparing several cumulative distributions in one figure. Distributions whose values are lower have lower concentrations and thus better air quality during the year than distributions whose values are higher for a given percentile. Figure 4–2 shows a cumulative distribution plot for hourly NO$_2$ 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 transparent methods as described by Bari et al. (2016), Bari and Kindzierski (2015) or Kindzierski et al. (2009, internet reference).

These percentile values can be calculated from year to year to examine changes in air quality over time. Statistically significant changes in these percentile values over a period of several years (e.g., 5-10 years) are indicative of short-term trends (changes) in the concentration data, whereas statistically significant changes in these percentile values over a period of several decades (e.g., at least more than 20 years) are indicative of long-term changes (Weatherhead et al. 1998).

Cumulative distribution data from the Genesee, Powers, and Wagner air monitoring stations (Figure 4–2) 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 NO$_2$ concentrations were low at all four air monitoring stations (<50 µg/m$^3$ for 98% of the time during 2016).
4.1.2.2 Sulphur Dioxide

Figures 4–3 and 4–4 are box-and-whisker plots for 1-hour and 24-hour SO\textsubscript{2} concentrations, respectively. Median (50\textsuperscript{th} percentile) hourly SO\textsubscript{2} concentrations at all four air monitoring stations shown in Figure 4–3 were very low (≤1 μg/m\textsuperscript{3}). All 1-hour and 24-hour concentrations were well below AAAQOs shown in Table 2–1.

The 1-hour maximum value of 220 μg/m\textsuperscript{3} at the Powers AMS (Figure 4–3) occurred on January 8, hour 2 corresponding to winds of 2.7 km/hr from the west-southwest. The 9\textsuperscript{th} highest 1-hour SO\textsubscript{2} concentrations observed during 2016 ranged from 66 μg/m\textsuperscript{3} at the Powers AMS to 87 μg/m\textsuperscript{3} at the Wagner AMS. For comparison purposes, the 9\textsuperscript{th} highest 1-hour SO\textsubscript{2} concentrations observed during 2016 at the Carrot Creek AMS and Edmonton East AMS were 18 and 63 μg/m\textsuperscript{3}, respectively (AEP 2017\textsuperscript{b}, internet reference).
Annual average SO₂ concentrations at the four air monitoring stations represented less than 10% of the annual AAAQO for SO₂ of 30 µg/m³. Annual mean 1-hour and 24-hour concentrations were less than the 10-year average measured at Hightower Ridge (5 µg/m³) (CASA 2006, internet reference). The Genesee AMS had the largest IQR (i.e., largest box) for 1-hour data (Figure 4-3) and the Wagner AMS had the largest IQR for 24 hour data (Figure 4-4). However, the IQR for SO₂ at all stations was very small (e.g., ≤4 µg/m³ for hourly and 24-hour concentrations) indicating extremely small variation in hourly and 24-hour concentrations throughout 2016.
Figure 4–4 Box-and-Whisker Plot of 24-hour Average SO\textsubscript{2} Concentrations at Selected Air Monitoring Stations in Central Alberta during 2016

Note: 25\textsuperscript{th} %ile (bottom of box), 50\textsuperscript{th} %ile (line inside box), 75\textsuperscript{th} %ile (top of box), maximum (top T), and annual 24-hour average concentration (star symbol). Some of the values cannot be clearly observed in the figure (e.g., the 25\textsuperscript{th} to 75\textsuperscript{th} percentiles) because their magnitudes are too small.
Figure 4–5 shows the cumulative distribution and key percentile values for hourly SO₂ concentrations at the Powers, Meadows, Wagner and Genesee air monitoring stations. Overall, hourly SO₂ concentrations were very low at all four stations (<31 µg/m³ for 98% of the time during 2016).

![Cumulative Distribution Plot of 1-hour Average SO₂ Concentrations at Air Monitoring Stations in the Wabamun–Genesee Area during 2016](image)

### Key Percentile Indices (µg/m³)

<table>
<thead>
<tr>
<th>Percentile</th>
<th>Powers AMS</th>
<th>Meadows AMS</th>
<th>Wagner AMS</th>
<th>Genesee AMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>50th</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>65th</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>80th</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>90th</td>
<td>3</td>
<td>4</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>95th</td>
<td>6</td>
<td>10</td>
<td>17</td>
<td>10</td>
</tr>
<tr>
<td>98th</td>
<td>13</td>
<td>23</td>
<td>30</td>
<td>23</td>
</tr>
</tbody>
</table>
4.1.2.3 Ozone

Figure 4–6 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 average O$_3$ concentration based on hourly concentrations at the Genesee AMS was 39 µg/m$^3$ in 2016. The 1-hour maximum value of 127 µg/m$^3$ at the Genesee AMS for 2016 (Figure 4–6) occurred on June 7, hour 18 corresponding to winds of 5.5 km/hr from the southeast. The 9$^{th}$ highest 1-hour O$_3$ concentration observed in 2016 at Genesee AMS was 120 µg/m$^3$. For comparison purposes, the 9$^{th}$ highest 1-hour O$_3$ concentrations observed at the Carrot Creek AMS and Edmonton East AMS were 116 and 120 µg/m$^3$, respectively (AEP 2017b, internet reference). One-hour O$_3$ concentrations at the Genesee AMS did not exceed the Alberta Ambient Air Quality 1-hour objective of 160 µg/m$^3$ at any time during 2016.

Figure 4–6  Box-and-Whisker Plot of 1-hour Average O$_3$ Concentrations at Selected Air Monitoring Stations in Central Alberta during 2016

Note:  25$^{th}$ %ile (bottom of box), 50$^{th}$ %ile (line inside box), 75$^{th}$ %ile (top of box), maximum (top T), and 98$^{th}$ %ile concentration (diamond symbol). Minimum values are not shown in the figure because they are unimportant.
Figure 4–7 shows the cumulative distribution and key percentile values for hourly O₃ concentrations at the Genesee AMS during 2016. Hourly O₃ concentrations were less than 95 µg/m³ for 98% of the time during 2016. This is well below the Alberta Ambient Air Quality 1-hour objective of 160 µg/m³.

![Cumulative Distribution Plot of 1-hour Average O₃ Concentrations at the Genesee Air Monitoring Station during 2016](Figure 4-7)

<table>
<thead>
<tr>
<th>Key Percentile Indices (µg/m³)</th>
<th>Genesee</th>
</tr>
</thead>
<tbody>
<tr>
<td>50th</td>
<td>36</td>
</tr>
<tr>
<td>65th</td>
<td>44</td>
</tr>
<tr>
<td>80th</td>
<td>55</td>
</tr>
<tr>
<td>90th</td>
<td>69</td>
</tr>
<tr>
<td>95th</td>
<td>81</td>
</tr>
<tr>
<td>98th</td>
<td>94</td>
</tr>
</tbody>
</table>
Figure 4–8 is a box-and-whisker plot of 8-hour O₃ concentrations measured at the Genesee AMS for the years 2014, 2015 and 2016. The 4th highest 8-hour O₃ concentration at the air monitoring station was 108 µg/m³ and less than 112 µg/m³ for 2014, 2015 and 2016. These values are below the Canadian Ambient Air Quality Standard of 124 µg/m³ (63 ppb). Interquartile ranges for 24-hour O₃ concentrations at the air monitoring station were narrow (<27 µg/m³), indicating little variation in 24-hour average concentrations throughout 2014–2016.

![Box-and-Whisker Plot of 8-hour Average O₃ Concentrations at the Genesee and Powers Air Monitoring Stations (2014, 2015 and 2016)](image)

**Figure 4–8**  Box-and-Whisker Plot of 8-hour Average O₃ Concentrations at the Genesee and Powers Air Monitoring Stations (2014, 2015 and 2016)

*Note: 25th %ile (bottom of box), 50th %ile (line inside box), 75th %ile (top of box), maximum (top T), and 98th %ile concentration (diamond symbol). Minimum values are not shown in the figure because their magnitudes are unimportant.*
### 4.1.2.4 Fine Particulate Matter

Figure 4–9 is a box-and-whisker plot of 1-hour PM$_{2.5}$ concentrations measured at the Genesee AMS and Powers AMS in 2016. Median (50th percentile) 1-hour PM$_{2.5}$ concentrations at both stations were very low, less than 3 µg/m$^3$. Also shown in Figure 4–9 is the current Alberta Ambient Air Quality Guideline, which is used as a general performance indicator, for airshed planning and management and to assess local concerns (AEP 2016a, internet reference).

The 1-hour maximum value of 94 µg/m$^3$ at the Genesee AMS for 2016 (Figure 4–9) occurred on May 8, hour 18 corresponding to strong winds of 50 km/hr from the southeast. The 9th highest 1-hour PM$_{2.5}$ concentration observed in 2016 at Genesee AMS was 44 µg/m$^3$. For comparison purposes, the 9th highest 1-hour PM$_{2.5}$ concentration observed at the Edmonton East AMS was 67 µg/m$^3$ (AEP 2017b, internet reference).

The 1-hour maximum value of 201 µg/m$^3$ at the Powers AMS for 2016 (not shown in Figure 4–9) occurred on May 11, hour 11 corresponding to winds of 6.7 km/hr from the southeast. The 9th highest 1-hour PM$_{2.5}$ concentration observed in 2016 at Powers AMS was 85 µg/m$^3$. For comparison purposes, the 9th highest 1-hour PM$_{2.5}$ concentration observed at the Edmonton East AMS was 67 µg/m$^3$ (AEP 2017b, internet reference).

![Box-and-Whisker Plot of 1-hour Average PM$_{2.5}$ Concentrations at the Genesee and Powers Air Monitoring Stations in 2016](image-url)

**Figure 4–9** Box-and-Whisker Plot of 1-hour Average PM$_{2.5}$ Concentrations at the Genesee and Powers Air Monitoring Stations in 2016

*Note: 25th %ile (bottom of box), 50th %ile (line inside box), 75th %ile (top of box), maximum (top T), and 98th %ile concentration (diamond symbol). Minimum values are not shown in the figure because their magnitudes are too small.*
Figure 4–10 shows the cumulative distribution plot for hourly PM$_{2.5}$ concentrations measured at the Genesee AMS and Powers AMS. Hourly PM$_{2.5}$ concentrations were low at these two stations, less than 19 µg/m$^3$ for 98% of the time during 2016.

![Cumulative Distribution Plot](image)

**Figure 4–10** Cumulative Distribution Plot of 1-hour Average PM$_{2.5}$ Concentrations at the Genesee and Powers Air Monitoring Stations during 2016
Figure 4–11 is a box-and-whisker plot of 24-hour PM$_{2.5}$ concentrations measured at the Genesee AMS and Powers AMS in 2014, 2015 and 2016. Median (50th percentile) 24 hour PM$_{2.5}$ concentrations at both stations were low, less than 4 µg/m$^3$ for all years. The 98th percentile 24-hour PM$_{2.5}$ concentration at the Genesee AMS and Powers AMS in 2016 was 14 and 18 µg/m$^3$. The 98th percentile 24-hour PM$_{2.5}$ concentrations at both air monitoring stations were less than 19 µg/m$^3$ for all years. These values are below the Canadian Ambient Air Quality Standard of 28 µg/m$^3$. Interquartile ranges for 24 hour PM$_{2.5}$ concentrations at both air monitoring stations were very narrow (<4 µg/m$^3$), indicating very little variation in 24-hour average concentrations throughout 2014–2016.
Figure 4–12 is a box-and-whisker plot of annual average of 24-hour PM_{2.5} concentrations measured at the Genesee AMS in 2014, 2015 and 2016. The annual average of 24-hour PM_{2.5} concentrations at the Genesee AMS was 3.4 µg/m³ in 2016. Annual average of 24-hour PM_{2.5} concentrations at Genesee AMS was low, less than 5 µg/m³ for all three years. These values are below the Canadian Ambient Air Quality Standard of 10 µg/m³.

Figure 4–13 is a box-and-whisker plot of annual average of 24-hour PM_{2.5} concentrations measured at the Powers AMS in 2014, 2015 and 2016. The annual average of 24-hour PM_{2.5} concentrations at the Powers AMS in 2016 was 4.4 µg/m³. Annual average of 24-hour PM_{2.5} concentrations at Powers AMS were low, less than 5 µg/m³ for all three years. These values are below the Canadian Ambient Air Quality Standard of 10 µg/m³.

Figure 4–12 Box-and-Whisker Plot of Annual Average PM_{2.5} Concentrations at the Genesee Air Monitoring Station (2014, 2015 and 2016)

Note: 25th %ile (bottom of box), 50th %ile (line inside box), 75th %ile (top of box), maximum (top T), and 98th %ile concentration (diamond symbol). Minimum values are not shown in the figure because their magnitudes are unimportant.
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 with a wind class frequency distribution plot. These plots show the percentage of time that different wind speeds occur. The 2016 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 4–14 to 4–21.

Winds blew from the north-northwest to west-southwest directions greater than 39% of the time at the four air monitoring stations (Genesee 42%, Figure 4–14; Meadows 47%, Figure 4–16; Powers 45%, Figure 4–18; Wagner 39%, Figure 4–20).
Figure 4–14 Annual Wind Rose Plot for the Genesee Air Monitoring Station during 2016

Figure 4–15 Annual Wind Class Frequency Distribution Plot for the Genesee Air Monitoring Station during 2016
Figure 4–16  Annual Wind Rose Plot for the Meadows Air Monitoring Station during 2016

Figure 4–17  Annual Wind Class Frequency Distribution Plot for the Meadows Air Monitoring Station during 2016
Figure 4–18  Annual Wind Rose Plot for the Powers Air Monitoring Station during 2016

Figure 4–19  Annual Wind Class Frequency Distribution Plot for the Powers Air Monitoring Station during 2016
Figure 4–20  Annual Wind Rose Plot for the Wagner Air Monitoring Station during 2016

Figure 4–21  Annual Wind Class Frequency Distribution Plot for the Wagner Air Monitoring Station during 2016
4.2 Intermittent Monitoring Program

4.2.1 PM$_{2.5}$ Concentration Statistics for 2016

Results of the intermittent PM monitoring program for 2016 are shown in Figure 4–22, (PM$_{2.5}$), and Figure 4–23, (PM$_{10}$). Figure 4–22 is the box-and-whisker plot of 24-hour average PM$_{2.5}$ data collected on a 1-in-6 day National Air Pollution Surveillance (NAPS) schedule. The 98$^{th}$ percentile 24-hour average PM$_{2.5}$ concentration was 25 µg/m$^3$ at the Genesee AMS (n=61). The corresponding 98$^{th}$ percentile 24-hour average PM$_{2.5}$ concentration calculated from continuous measurements at Genesee AMS (Figure 4–11) was much lower at 14 µg/m$^3$.

The 98$^{th}$ percentile 24-hour average PM$_{2.5}$ concentration was 27.9 µg/m$^3$ at the Powers AMS (n=61). The corresponding 98$^{th}$ percentile 24-hour average PM$_{2.5}$ concentration calculated from continuous measurements at Powers AMS (Figure 4–11) was also much lower at 18 µg/m$^3$. The IQRs for the intermittent PM$_{2.5}$ monitoring program at Genesee AMS and Powers AMS were both similar and small at 6 and 5.7 µg/m$^3$, respectively, indicating little variation in 24-hour concentrations throughout 2016.

![Figure 4–22 Box-and-Whisker Plot of Intermittent 24-hour Average PM$_{2.5}$ Concentrations at Genesee and Powers Air Monitoring Stations in 2016](image-url)

Note: 25$^{th}$ %ile (bottom of box), 50$^{th}$ %ile (line inside box), 75$^{th}$ %ile (top of box), maximum (top T), and 98$^{th}$ %ile concentration (diamond symbol).
4.2.2 PM\textsubscript{10} Concentration Statistics for 2016

Figure 4–23 is the box-and-whisker plot of 24-hour average PM\textsubscript{10} concentrations at the Genesee AMS and Powers AMS during 2016. Twenty-four hour average PM\textsubscript{10} concentrations were less than 52 µg/m\textsuperscript{3} at the Genesee AMS (n=61) and less than 47 µg/m\textsuperscript{3} at the Powers AMS (n=60) for 98% of the time. The IQRs for 24-hour average PM\textsubscript{10} concentrations in 2016 were 8 µg/m\textsuperscript{3} at Genesee AMS and 11 µg/m\textsuperscript{3} at Powers AMS.

![Box-and-Whisker Plot of Intermittent 24-hour Average PM\textsubscript{10} Concentrations at Genesee and Powers Air Monitoring Stations in 2016](image)

Note: 25th %ile (bottom of box), 50th %ile (line inside box), 75th %ile (top of box), maximum (top T), and 98th %ile concentration (diamond symbol).

4.2.3 PM\textsubscript{2.5} concentrations versus PM\textsubscript{10} concentrations

Figures 4–24 and 4–25 show 24-hour average PM\textsubscript{2.5} concentrations versus PM\textsubscript{10} concentrations at the Genesee and Powers air monitoring stations during 2016. Linear regression relationships were used to show the degree of comparison between PM\textsubscript{2.5} and PM\textsubscript{10} concentrations. The purpose was to show the ability of the PM\textsubscript{2.5} concentrations to predict PM\textsubscript{10} concentrations.

Coefficient of determination (R\textsuperscript{2}) values were calculated from PM\textsubscript{2.5}–PM\textsubscript{10} paired data for each air monitoring station (Genesee and Powers) and are shown in Figures 4–24 and 4–25. The coefficient of determination (R\textsuperscript{2}) is the proportion of sample variance of a response variable (PM\textsubscript{10} concentration) that is "explained" by predictor variables (PM\textsubscript{2.5} concentrations) for a linear regression between two variables.
Results for the Genesee AMS ($R^2 = 0.38$, $n=61$) suggest that only 38 percent of variance in 24-hour average PM$_{10}$ concentrations was explained by variation in 24-hour average PM$_{2.5}$ concentrations. Results for the Powers AMS ($R^2 = 0.60$, $n=60$) suggest that 60 percent of variance in 24-hour average PM$_{10}$ concentration was explained by variation in 24-hour average PM$_{2.5}$ concentrations.
4.3 Passive Monitoring Program

Bubble plots are used to show the size of measured values in a spatial plot. In this case, bubble plots were used to show annual average concentrations of NO₂, SO₂ and O₃ at the 15 passive monitoring sites in the Wabamun–Genesee area during 2016 (Figure 1–2). Annual concentrations were determined by averaging 12 monthly monitoring results at each passive site tabulated in Appendix A.

In addition, annual concentrations of NO₂, SO₂ and O₃ 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 Alberta Environment and Parks (AEP) airdata warehouse for 2016 (AEP 2017b, internet reference).

4.3.1 Nitrogen Dioxide

Figure 4–26 is a bubble plot of annual average NO₂ concentrations measured at 12 NO₂ passive monitoring sites during 2016. Figure 4–22 indicates that annual NO₂ concentrations estimated by passive monitors increased slightly from sites 4B, 4D and 4E between Lake Wabamun and sites closer to the City of Edmonton. The highest annual average NO₂ concentration shown in Figure 4–26 was observed at the Edmonton East station (11.2 ppb or 21 µg/m³) compared to less than 2.4 ppb (4.5 µg/m³) observed at passive sites located within 30 km of the generating stations. These data show that urban source emissions contribute more to the monthly average ambient NO₂ concentrations observed in and around the City of Edmonton than generating station emissions from the Wabamun–Genesee area.
4.3.2 Sulphur Dioxide

Figure 4–27 is a bubble plot of annual average SO$_2$ concentrations measured at seven SO$_2$ passive monitoring sites during 2016. Annual average SO$_2$ concentrations were very low, ranging from 0.5 to 2.2 ppb (1.3 to 5.8 µg/m$^3$) across all sites. These low annual average values and associated lack of spatial trend are 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 station expansion (EPCOR 2001), as well as with concentrations measured in the continuous program discussed previously in Section 4.1.2. Finally, monthly average SO$_2$ concentrations (Table A–2, Appendix A) were well below the 30-day AAAQO of 11 ppb (Table 2–1).

4.3.3 Ozone

Figure 4–28 is a bubble plot of annual average O$_3$ concentrations measured at eleven O$_3$ passive monitoring sites during 2016. Annual average O$_3$ concentrations observed at passive monitoring sites directly east of the Wabamun–Genesee area ranged from 24.4 to 30.6 ppb (49 to 61 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 4–24). A partial explanation for this spatial trend is 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 a higher NO$_2$ concentration observed within the City of Edmonton, as shown in Figure 4–26.

Passive monitoring sites 15 and 16 (Figures 4–26 and 4–28) 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 stations are located. Based on annual average wind speeds in the area, these sites are located more than two-to-four hours travel time downwind of the generating stations.

University of Alabama and Tennessee Valley Authority scientists (Gillani et al. 1998) and U.S. EPA (1998) indicated that generating station plume chemistry maturity and peak production capacities of anthropogenic O$_3$ and inorganic nitrogen species occur between 30 and 100 km downwind of generating stations. 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 stations. Site 15 is located 26.7 km away from Genesee AMS towards the southeast, while Site 16 is 39.8 km away from the station (Figure 1–2). These sites were established to help understand whether anthropogenic O$_3$ production may be occurring farther away from the stations. 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 sites 15 and 16 were within 15% of the annual average O$_3$ concentration at the Violet Grove AMS during 2016. The Violet Grove station is located 55 km southwest of the generating stations.

Figure 4–29 shows monthly average concentrations measured at O$_3$ passive monitoring sites during 2016. The highest monthly average O$_3$ concentrations observed in the network occurred in month 2 (February). The lowest monthly average O$_3$ concentrations observed in the network occurred during the period of August to November. 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 in ground level O$_3$ 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 NO\textsubscript{2} Concentrations [ppb] at Passive Monitoring Sites and at Selected Continuous Monitoring Station Locations in Central Alberta during 2016.

Acknowledgements:
Original Drawing by Stantec
Bubble Plot of Annual Average SO₂ Concentrations [ppb] at Passive Monitoring Sites and at Selected Continuous Monitoring Station Locations in Central Alberta during 2016

Acknowledgements:
Original Drawing by Stantec
Bubble Plot of Annual Average O₃ Concentrations [ppb] at Passive Monitoring Sites and at Selected Continuous Monitoring Station Locations in Central Alberta during 2016
Figure 4–29 Monthly Average O₃ Concentration at Passive Monitoring Sites in Central Alberta during 2016
5 Summary

Continuous Monitoring Program

A continuous monitoring program was conducted at the Genesee, Meadows, Wagner and Powers air monitoring stations in the Wabamun–Genesee area during 2016. Data capture rates for measured parameters at all of the air monitoring stations were well above the 90% criterion for the year as required by the AEP Air Monitoring Directive (AENV 1989, internet reference). High up-times were indicative that equipment in the continuous air monitoring network was well-maintained.

Overall, air quality was judged to be good at the monitoring stations during 2016, similar to that observed in previous years. A summary of the 2016 continuous monitoring data is as follows:

- Hourly NO2 concentrations were very low at all four air monitoring stations (below 25 ppb (50 µg/m3) for 98% of the time). The observed 9th highest 1-hour NO2 concentrations ranged from 26 ppb (49 µg/m3) at the Genesee AMS to 35 ppb (65 µg/m3) at the Meadows AMS. For comparison purposes, the 9th highest 1-hour NO2 concentrations at the Carrot Creek AMS and Edmonton East AMS during 2016 were 35 and 48 ppb (66 and 90 µg/m3), respectively. All of these concentrations fall well below the 1-hour Alberta Ambient Air Quality Objective of 159 ppb (300 µg/m3).

- Hourly SO2 concentrations were very low at all four air monitoring stations (below 12 ppb (31 µg/m3) for 98% of the time). The 9th highest 1-hour SO2 concentrations ranged from 25 ppb (66 µg/m3) at the Powers AMS to 33 ppb (87 µg/m3) at the Wagner AMS. For comparison purposes, the 9th highest 1-hour SO2 concentrations at the Carrot Creek AMS and Edmonton East AMS during 2016 were 7 and 24 ppb (18 and 63 µg/m3), respectively. All of these concentrations fall well below the 1-hour Alberta Ambient Air Quality Objective of 172 ppb (450 µg/m3).

- The annual average O3 concentration at the Genesee AMS was 22 ppb (44 µg/m3). Hourly O3 concentrations at the Genesee AMS were below 48 ppb (95 µg/m3) for 98% of the time during 2016. The 9th highest 1-hour O3 concentration at the Genesee AMS was 60 ppb (120 µg/m3). For comparison purposes, the 9th highest 1-hour O3 concentrations at the Carrot Creek AMS and Edmonton East AMS were 58 and 60 ppb (116 and 120 µg/m3), respectively. O3 concentrations at the Genesee AMS did not exceed the 1-hour Alberta Ambient Air Quality Objective of 82 ppb (160 µg/m3) at any time during 2016. The 4th highest 8-hour O3 concentration at the Genesee AMS in 2016 was 54 ppb (108 µg/m3). This value is below the Canadian Ambient Air Quality Standard of 63 ppb (124 µg/m3).

- Median (50th percentile) 24-hour PM2.5 concentrations at the Genesee AMS and Powers AMS were very low (below 3 µg/m3) in 2016. The 98th percentile 24-hour PM2.5 concentrations at both air monitoring stations were below 19 µg/m3 and below the Canadian Ambient Air Quality Standard of 28 µg/m3. The annual average of 24-hour PM2.5 concentrations at both air monitoring stations were below 5 µg/m3 and below the Canadian Ambient Air Quality Standard of 10 µg/m3.

- Concentrations of monitored parameters continue to be low as they have been in previous years of the continuous monitoring program.
Intermittent Monitoring Program

During 2016, twenty-four hour average PM$_{2.5}$ and PM$_{10}$ samples were collected at the Genesee AMS and Powers AMS according to a NAPS six-day cycle sampling frequency. The following summarizes the intermittent monitoring data for 2016:

- Twenty-four hour average PM$_{2.5}$ concentrations were below 25 µg/m$^3$ at the Genesee AMS (n=61) and below 28 µg/m$^3$ at the Powers AMS (n=61) for 98% of the time.
- Twenty-four hour average PM$_{10}$ concentrations were below 52 µg/m$^3$ at the Genesee AMS (n=61) and below 47 µg/m$^3$ at the Powers AMS (n=60) for 98% of the time.

Passive Monitoring Program

Passive air monitors were deployed at 15 stations in the Wabamun–Genesee area for approximate 30-day periods during 2016. The 2016 passive data are summarized as follows:

- At passive sites located within 30 km of the generating stations, annual average NO$_2$ concentrations were less than 2.4 ppb (4.5 µg/m$^3$), whereas at the Edmonton East AMS the annual average NO$_2$ concentration was (11.2 ppb or 21 µg/m$^3$). Urban source emissions are recognized as important contributors to ambient NO$_2$ concentrations in and around the City of Edmonton compared to emissions from generating stations located in the Wabamun-Genesee area.
- Annual average SO$_2$ concentrations were very low at passive sites, ranging from 0.5 to 2.2 ppb (1.3 to 5.8 µg/m$^3$) at all passive sites in the Wabamun–Genesee area. This lack of spatial trend is consistent with the results reported in previous studies for the same area. Monthly average SO$_2$ concentrations at the passive sites were well below the 30-day Alberta Ambient Air Quality Objective of 11 ppb.
- Annual average O$_3$ concentrations at 11 passive monitoring sites directly east of the Wabamun–Genesee area ranged from 24 to 36 ppb (49 to 61 µg/m$^3$). Passive sites 15 and 16 are two O$_3$ monitoring sites located more than two-to-four hours travel time downwind of the generating stations along an imaginary northwest line on which the generating stations are located. Previous work by scientists at University of Alabama and Tennessee Valley Authority has indicated that generating station plume chemistry maturity and peak production capacities of anthropogenic O$_3$ and inorganic nitrogen species occurs between 30 and 100 km downwind of generating stations (within the range of where these two passive monitoring sites are located). Site 15 is located 26.7 km away from Genesee AMS towards the southeast, while Site 16 is 39.8 km away from the station. Annual average O$_3$ concentrations at sites 15 and 16 were within 15% of the annual average O$_3$ concentration at the Violet Grove AMS during 2016. The Violet Grove station is located 55 km southwest of the generating stations.
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*, 13-16 February 2006, Banff, AB.


National Institute for Occupational Safety and Health (NIOSH), 1994. NIOSH manual of analytical methods, 4th edition DHHS publication 94-113, Atlanta, GA.


6.2 Personal Communications


6.3 Internet Sites


Appendix A   Passive Monitoring Data for 2016
### Table A–1 2016 NO₂ Passive Monitoring Data (monthly average concentration in ppb)

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### Table A–2 2016 SO₂ Passive Monitoring Data (monthly average concentration in ppb)

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