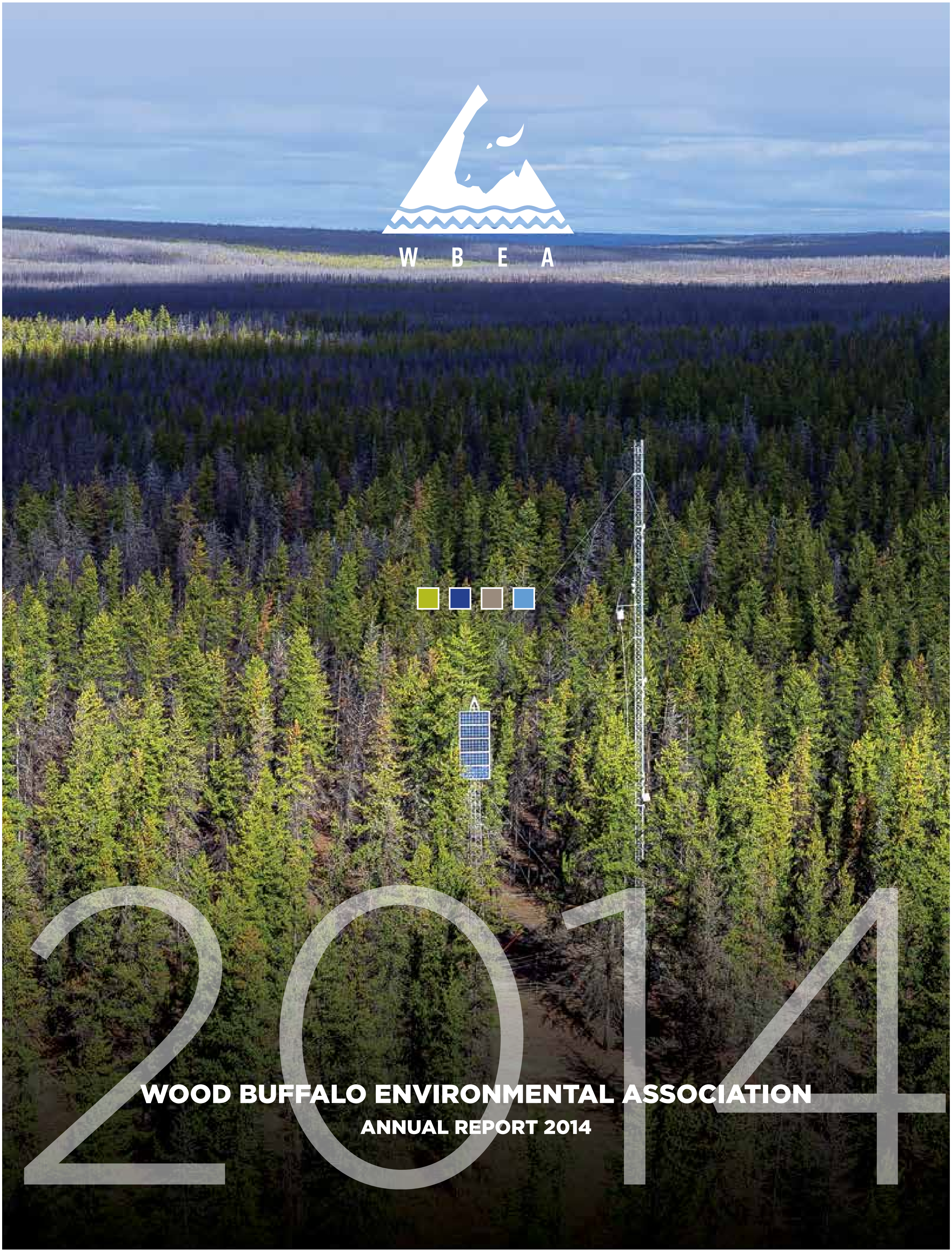


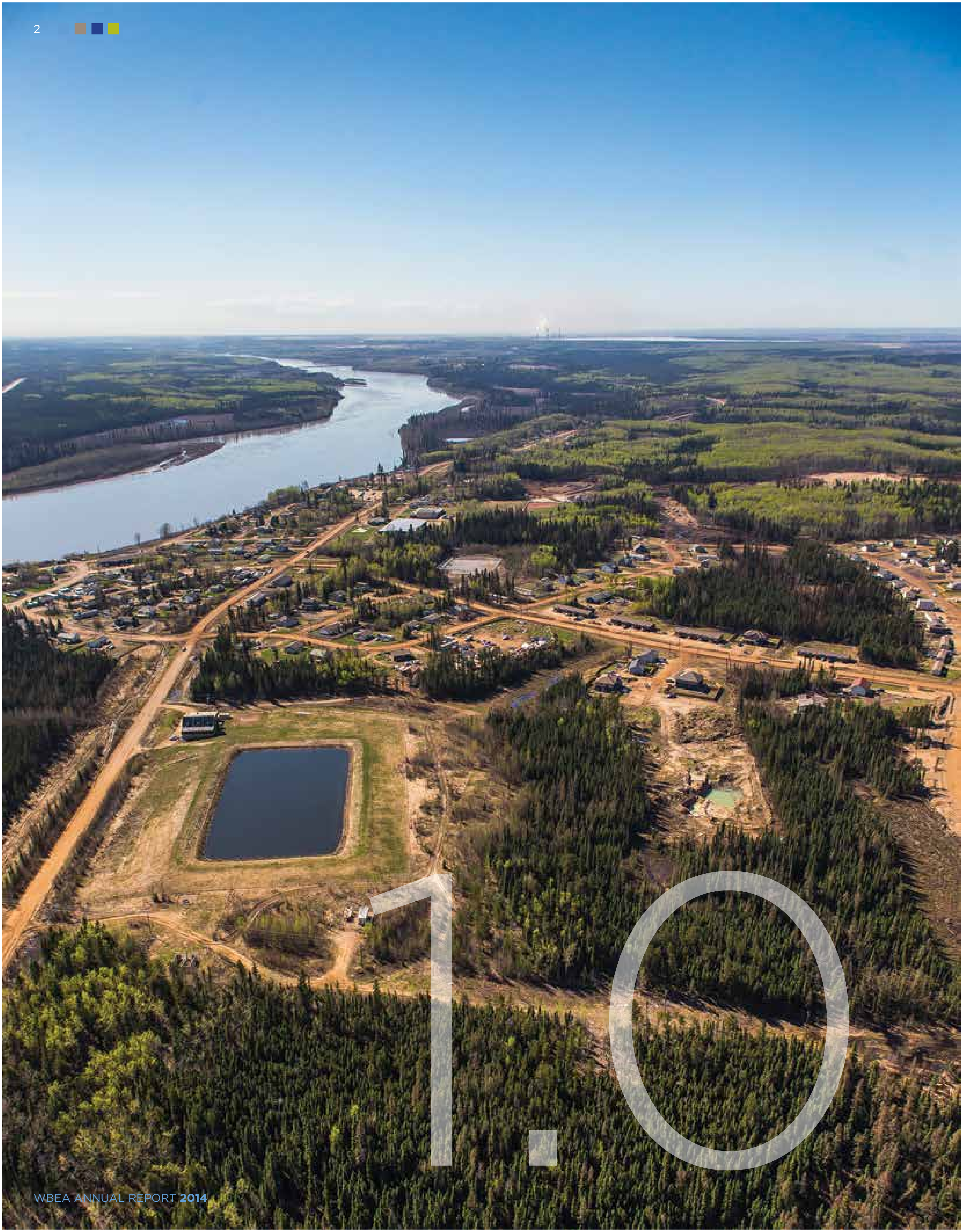
2014

WOOD BUFFALO ENVIRONMENTAL ASSOCIATION

ANNUAL REPORT 2014

table of contents

annual report 2014


1.0

1.0 The Wood Buffalo Environmental Association in 2014

An Air Quality Task Force was established in 1985 to address environmental concerns related to oil sands development raised by the Fort McKay First Nation. In 1990, this Task Force became the Regional Air Quality Coordinating Committee which, in 1996, was endorsed by the Clean Air Strategic Alliance (CASA) as a regional air shed. In 1998, the Wood Buffalo Environmental Association (WBEA) assumed responsibility for air quality monitoring in the regional air shed aligned with the boundary of the Regional Municipality of Wood Buffalo (RMWB), including the Athabasca Oil Sands. In 2014, WBEA became a working partner of the Alberta Environmental Monitoring, Evaluation and Reporting Agency (AEMERA).

WBEA operates the largest air shed in the largest municipality in Canada. Today, as a multi-stakeholder, community-based, not-for-profit association, WBEA monitors the air in the RMWB 24 hours a day and 365 days a year. WBEA does this through a variety of air, land and human monitoring programs. The information collected from WBEA's 17 air monitoring stations between Anzac and Fort Chipewyan - most located at or near oil sands plants - is openly and continuously shared with stakeholders and the public on our website *www.wbea.org* and through Community Reports and outreach activities.

OUR VISION, MISSION AND VALUES:

Vision:

State of the art air monitoring system that meets the needs of residents and stakeholders in the Wood Buffalo Region.

Mission:

The Wood Buffalo Environmental Association monitors air quality and air quality related environmental impacts to generate accurate and transparent information which enables stakeholders to make informed decisions.

Values:

- We are dedicated to utilizing best practices in all we do.
- We will provide accurate and accessible data on a timely basis.
- We will provide credible and useful information.
- We believe in open and transparent communication.
- We value effective stakeholder participation in fulfilling our mandate.
- We recognize, respect and use Traditional Environmental Knowledge.
- We support consensus based decision making.
- We value our relationship with industry and work to having WBEA the forum to fulfill regulatory compliance for air monitoring.

1.1 Air Monitoring

All WBEA air monitoring data are fully quality-assured and then sent within four weeks of month-end to the Clean Air Strategic Alliance Data Warehouse (*www.casadata.org*), an on-line database for all of Alberta's air monitoring data. In 2014, WBEA operated 17 permanent air monitoring stations and four portable stations. WBEA uses continuous, time-integrated and passive techniques to measure air quality in the air shed.

WBEA's air quality data are used by Alberta Environment and Sustainable Resource Development (AESRD) to calculate the hourly Air Quality Health Index (AQHI), which is one measure of air quality. WBEA transmits raw data, in real time, to AESRD where the index is calculated. The AQHI is calculated every hour for four Community Air Monitoring Stations in Wood Buffalo: Fort Chipewyan, Fort McKay South, Athabasca Valley and Anzac. Fort McKay also operates their own Air Quality Index (FMAQI). The FMAQI is calculated by WBEA for Fort McKay. Both measures are displayed and updated, hourly, on WBEA's website.

1.2 Terrestrial Monitoring

The Terrestrial Environmental Effects Monitoring (TEEM) program monitors and reports on certain possible effects of air emissions on terrestrial ecosystems and plant life. TEEM does this through an integrated suite of measurements of air emission *sources* linked to terrestrial *receptors*. TEEM's monitoring work is centered upon a regional network of forest health and peat land monitoring sites. These sites were established to detect early warning of change in key indicators and medium-to-long term detection and quantification of effect or impact. TEEM also operates a Traditional Environmental Knowledge project focused on berry health.

1.3 Human Monitoring

The Human Exposure Monitoring Program (HEMP) is focused on better understanding the frequency and nature of regional odours through an array of specialized air analyzers designed to chemically characterize odour events. In 2014, HEMP coordinated the second year of the volunteer based Community Odour Monitoring Project in Fort McMurray.

1.4 Alberta Environmental Monitoring, Evaluation and Reporting Agency

With the proclamation of the *Protecting Alberta's Environment Act* on April 28, 2014, the Government of Alberta formally established the Alberta Environmental Monitoring, Evaluation and Reporting Agency (AEMERA) as an arm's length organization responsible for providing credible, scientific data and relevant information on the conditions of Alberta's environment.

aemera.org

Mission

To measure, assess and inform the public on the condition of Alberta's environment.

Mandate

Created under the *Protecting Alberta's Environment Act,* AEMERA's mandate is to provide provincial environmental monitoring, evaluation and reporting:

- based on sound science and evidence;
- presented in a timely, open and transparent manner; and,
- that respects and incorporates community and traditional ecological knowledge from Alberta's First Nations and Métis

Milestones in 2014

2014 was a startup year for AEMERA. Initial milestones in the establishment of AEMERA included:

- Appointment of Board of Directors (April 2014)
- Launch of aemera.org website (May 2014)
- Mandate and Roles Document between the Minister of Alberta Environment and Sustainable Resource Development and AEMERA (August 2014)
- Selection and appointment of CEO (October 2014)
- Launch of AEMERIS (November 2014) see box 1

Box 1. Alberta Environmental Monitoring, Evaluation & Reporting Information Service (AEMERIS)

Recognizing the need to provide environmental real-time and historic data and information, as a first step, AEMERA launched AEMERIS – an information-sharing platform to provide access to data on key ambient air, water, land and biodiversity indicators and related environmental information.

Visit AEMERIS at http://aemeris.aemera.org/

Working Partners

In 2014, AEMERA's efforts were primarily focused on environmental monitoring, evaluation and reporting in the oil sands and the Lower Athabasca Region. Working partnerships underway, or in development, in this region in 2014 included:

- Alberta Biodiversity Monitoring Institute (ABMI)(abmi.ca)
- Environment Canada (ec.gc.ca)
- Lakeland Industry and Community Association (LICA) (lica.ca)
- Wood Buffalo Environmental Association (WBEA) (wbea.org)

AEMERA understands the value local organizations such as WBEA have in environmental monitoring, evaluation and reporting. Working with organizations like WBEA, AEMERA has begun to bring together data and information from a variety of sources to provide scientific evaluation and online environmental reporting.

The Road Ahead

With the target of becoming fully operational in 2015, AEMERA's Board of Directors and leaders are committed to building an organization that provides accurate, objective scientific data and relevant, valuable information to better inform environmental decision-making by a broad base of stakeholders.

Key activities planned for 2015 include:

- Completion of Strategic Plan and Business Plan
- Appointment of Science Advisory Panel
- Appointment of Traditional Ecological Knowledge Advisory Panel
- Recruitment and hiring of senior executive team
- Ongoing relationship building with stakeholders to better identify data and information needs
- Organize an annual environmental science and information forum
- Explore opportunities to build new collaborative relationships between the scientific and stakeholder communities locally, nationally and internationally

2.0

2.0 Messages from our President and Executive Director

2.1 President's Message 2014

2014 was WBEA's seventeenth year of environmental monitoring in the Regional Municipality of Wood Buffalo.

The year 2014 was the second in succession during which WBEA work plans were approved under the government-led, three-year Joint Canada/Alberta Implementation Plan for Oil Sands Monitoring (JOSM) process. As part of WBEA's transition into government coordination of monitoring in Alberta, WBEA changed its Financial Year to be April 1st to March 31st at the December 11, 2013 Board meeting.

During the first quarter of calendar year 2014, WBEA continued to invoice industry for the work accomplished under JOSM. In April, Bill 31 was proclaimed in the Alberta Legislature, and the Alberta Environmental Monitoring, Evaluation and Reporting Agency (AEMERA) was established. Beginning April 1, WBEA received its funding directly from AEMERA. Work plan/funding decisions were made by the AEMERA Board for the April 1/2014 – March 31/2015 work plan recommended under existing JOSM process.

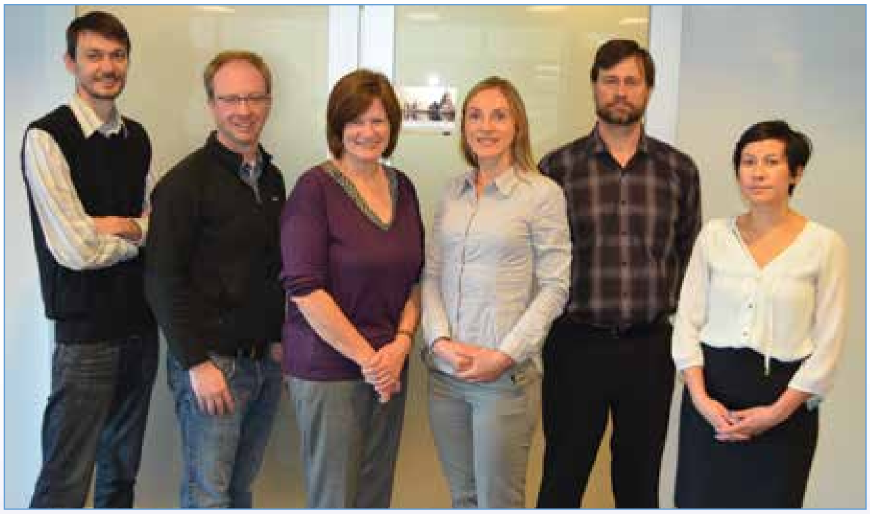
Over the course of the year, WBEA's members continued to be active in the Association's technical committees and Association governance. WBEA's multi-stakeholder Board comprised 38 Members representing Aboriginal, ENGO, Industry and Government sectors. As part of its transition, WBEA engaged proactively with two interim AEMERA CEOs around a "Responsibility Matrix". Led by the GC and reporting to the full WBEA Board, key aspects of the new working relationship between WBEA and AEMERA were elaborated. On December 11th, WBEA was invited to present to the AEMERA Board in Edmonton. The presentation, made by the President and Executive Director, and subsequent discussions focused on WBEA monitoring, evaluation and reporting capacity in the region, as well as elements necessary for a future successful "Working Partner" relationship.

The WBEA Governance Committee provided monthly oversight and guidance to the Executive Director and WBEA staff. To maintain sector balance, the GC comprised three members from the Aboriginal/ENGO sectors, three from industry and one from government. Particular focus was placed on new working relationships, review of business practices, policies and procedures and issues of governance. The Governance Committee reported routinely to the full WBEA Board at its quarterly meetings, as did the Ambient Air Technical Committee (AATC), the Terrestrial Environmental Effects Monitoring (TEEM) Technical Committee, the Human Exposure Monitoring (HEMP) Technical Committee, the Executive Director (Administration/Financials) and the Communications Advisory Committee. WBEA Technical Committees, composed of Member representatives and science advisors, continued to develop and oversee the execution of work plans executed/managed by WBEA's in-house staff and contractors.

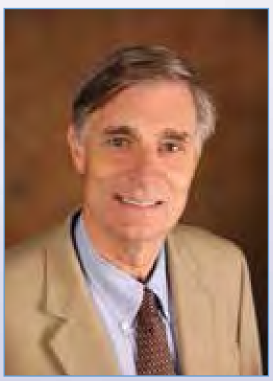
In 2015/16, I look forward to supporting WBEA members and staff as we to continue to deliver upon WBEA's vision of a state of the art air monitoring system that meets the needs of residents and stakeholders in the Wood Buffalo region.

I would personally like to thank members, staff, scientists and contractors for their time and effort in meeting the needs of WBEA's stakeholders and membership.

Diane Phillips
WBEA President



WBEA's Governance Committee includes representatives from Aboriginal, Environmental Non-Government, Government and Industry sectors, thus ensuring a voice for all regional stakeholders in the technical planning and execution of monitoring in the Athabasca Oil Sands. From left to right are Director, Andrew Read, Pembina Institute for Appropriate Development; Vice-President, Peter Fortna, Conklin Resource Development Advisory Board; President, Diane Phillips, Syncrude Canada Ltd.; Director, Linda Aidnell, Chipewyan Prairie Dene First Nation; Secretary-Treasurer, Doug Johnson, Athabasca Oil Corporation and Director, Natasha Rowden, MEG Energy. Missing from the photo is Director, Michael Aiton, Alberta Environment and Sustainable Resource Development.



2.2 Executive Director's Message

As identified in the WBEA President's message, during the calendar year 2014, WBEA transitioned its financial (operating) year to April 1 through March 31. Accordingly, WBEA completed a one-quarter (January 1 to March 31, 2014) reporting period and external audit, followed by a new 2014/15 work plan beginning April 1, 2014. Therefore, I will summarize monitoring and reporting activities completed from January 1, 2014 to March 31, 2015, but technical findings, based on ambient air data, in this Annual Report will comprise data collected and reported to the Clean Air Strategic Alliance (CASA) database over the 2014 calendar year.

Transparently Reporting Ambient Air Quality for Regional Stakeholders, the Public, AEMERA, and the CCME

The following activities were accomplished in 2014 in support of WBEA's commitment to data reporting transparency to our regional stakeholders, the public, the Alberta Environmental Monitoring, Reporting and Evaluation Agency (AEMERA) and the Canadian Council of Ministers of the Environment (CCME):

- WBEA Standard Operating Protocols (SOPs) associated with our air monitoring network were made publically available on our website at *wbea.org/air-monitoring/standard-operating-procedures*. WBEA SOPs are derived from the best practices of WBEA, the U.S. Environmental Protection Agency and Environment Canada (EC).
- WBEA's team of senior air specialists, technicians and data specialists collected and processed over 80 million air quality data points in 2014.
- WBEA's continuous hourly, raw, quality-assured historical air data, with graphical/tabulating functions, were made publically available at *wbea.org/monitoring-stations-and-data/historical-monitoring-data*.
- Five years (2009-2013) of historical time-integrated data were made publically available at *wbea.org/monitoring-stations-and-data/integrated-data*.

- WBEA air data are used to report compliance against Alberta Ambient Air Quality Objectives (AAAQO) for a range of air pollutants.

WBEA Members view a meteorological tower with passive air pollution filters and solar panels which power data transmission to the WBEA server, at Forest Health Site JP104.

- WBEA's particulate matter ($PM_{2.5}$) and ozone (O_3) data are used to report against the Canadian Ambient Air Quality Standards (CAAQS) set by the CCME. WBEA operates ten $PM_{2.5}$, and seven O_3 continuous analyzers in its regional network.
- WBEA air data were quality-assured within one month of the previous month-end and sent to the CASA data base.
- Some of WBEA's data are streamed to EC's National Air Pollution Surveillance (NAPS) database.
- WBEA's hourly sulphur dioxide (SO_2) and nitrogen dioxide (NO_2) data were available in the CASA database for Albert Environment and Sustainable Resource Development (AESRD) to report against annual limits and 99th percentile triggers set under the Lower Athabasca Regional Plan (LARP).

  WBEA operated fifteen SO_2 and eleven NO_2 continuous analyzers in its fixed monitoring stations. WBEA operated three portable stations with SO_2 and NO_2 measurements made for certain periods at several locations.
- WBEA continues to calculate and report the Air Quality Health Index (AQHI) for community stations: Anzac, Fort McKay, Fort McKay South, Fort McMurray and Fort Chipewyan. In 2015, WBEA will also add the Fort McKay Air Quality Index (FMAQI), which expands on the AQHI by including compounds that contribute to odours. The FMAQI will be reported on the WBEA website.

Monitoring Partnership with Environment Canada

- Since signing a Memorandum of Understanding with EC in 2010, and under the Joint Canada-Alberta Implementation Plan for Oil Sands Monitoring (JOSM) (2012-2015), WBEA has worked in partnership with EC's Meteorological Service of Canada (Edmonton, AB) and Science and Technology Branch (Downsview, ON) to continue to provide facilities and essential technical support in order to enable measurement of:
- Total gaseous, reactive gaseous, and particulate mercury
- BTEX - benzene, toluene, ethyl benzene and xylene
- Polycyclic aromatic compounds
- Enhanced deposition at Bertha Ganter-Fort McKay, Buffalo Viewpoint, Wapasu and Conklin Lookout stations.

Membership, Governance and Scientific Outreach

- WBEA welcomed two new members, Conklin Resource Development Advisory Committee and Connacher Oil and Gas Ltd., in 2014.
- In April, AEMERA (www.aemera.org) was established with the proclamation of Bill 31. WBEA is now a working partner with AEMERA.
- The WBEA Governance Committee met monthly.
- The WBEA Board, comprised of representatives of the membership met quarterly.

- WBEA members stewarded the work of the association through their guidance of the air (pictured), terrestrial, human exposure and communications committees. Members viewed WBEA facilities and learned more about air, human exposure and terrestrial monitoring operations and data management at a Member's Open House in September.

- WBEA members contributed $107,800, in-kind, to WBEA operations in 2014.
- The following scientific papers and presentations were given in 2014:
  - In January, the Executive Director gave the keynote address at the Air and Waste Management Association *Air in Saskatchewan Symposium,* held in Saskatoon, about the practice and application of integrated air and land monitoring in a consensus-based, multi-stakeholder setting.
  - The Executive Director presented *Relating Air Quality and Climate Change to Plant Growth, Productivity, Biodiversity and Ecosystems: An Integrative Analysis,* at the 46th International Annual Air Pollution Workshop, held in Guadalajara, México, in May.
  - In June, the Executive Director presented a keynote paper *Ambient Air Quality in the Athabasca Oil Sands Region, Alberta, Canada,* at the 97th Canadian Chemistry Conference and Exhibition, Vancouver, BC.
  - WBEA was well represented at the A&WMA North America Oil and Gas Conference, which was held October 21-22, 2014, in Calgary, with five scientific presentations. WBEA monitoring work presented included:
    - *Windblown Fugitive Dust Characterization in the Athabasca Oil Sands Region.* Judith C. Chow, Research Professor, Desert Research Institute, NV, USA.
    - *Community Odour Monitoring Project: Describing Odour Exposures in Fort McMurray, Alberta.* Thierry Pagé, Odotech Inc., QC, Canada.
    - *Volatile Organic Compound (VOC) Passive Monitoring in Athabasca Oil Sands Region, Alberta, Canada.* Barbara Zielinska, Research Professor, Desert Research Institute, NV, USA.
    - *Real-World Emissions from Heavy Haulers in Alberta Oil Sands Mining.* John G. Watson, Research Professor, Desert Research Institute, NV, USA.
    - *PAH Measurement in the Athabasca Oil Sands Region.* Yu-Mei Hsu, Atmospheric and Analytic Chemist, Wood Buffalo Environmental Association, Fort McMurray, AB, Canada.

WBEA representatives at the Calgary Canadian Prairie and Northern Section Symposium included, from left to right, WBEA President, Diane Phillips, and Science Advisor, Dr. Allan Legge, and from the Desert Research Institute, NV, USA, Research Professors and presenters Dr. Judith Chow, Dr. Barbara Zielinska, and Dr. John Watson.

- On December 11, the President and Executive Director gave a presentation entitled *The Wood Buffalo Environmental Association and AEMERA.*
- WBEA staff or contractors gave four presentations at the *AEMERA-Canada Oil Sands Monitoring Symposium,* February 24-25, 2015, in Edmonton. WBEA presentations are publically available at wbea.org/resources/aemera-information.
  - Percy, K.E. *Overview of Long-term Air and Terrestrial Monitoring in the Wood Buffalo Region*
  - Percy, K.E., Legge, A.H., Maynard D. *Forest Health Monitoring in the Wood Buffalo Region*
  - Porter, R., Twumasi-Smith, A. *Community Odour Monitoring Program*
  - Baker, J.M. *Eating Berries in the Oil Sands: using Traditional Knowledge to Observe Berry Quality* (poster)

- Among visitors welcomed by WBEA in 2014 were:
  - Dennis Bevington, the MP for the Western Arctic, and Lori McDaniel, NDP candidate for Fort McMurray-Athabasca, on March 14.
  - Brad Pickering, then Chief Executive Officer of AEMERA, and Bob Myrick, Manager Air Policy Evaluation, AESRD, on April 24.
  - Students and faculty from the Tuck Business School, Dartmouth College, U.S.A., on May 10.
  - Northern Alberta Institute of Technology (NAIT) representatives, pictured with WBEA staff from left to right, Randy Visser, WBEA Operations Manager; Chris Dambrowitz, Associate VP, Research and Innovation, NAIT; Neil Fassina, Provost and VP Academic, NAIT; and Kevin Percy, WBEA Executive Director.
  - Richard Smith, Acting Associate Regional Director General, West & North, Environment Canada, on July 28.
  - Representatives of the World Presidents' Organization (WPO), *www.wpo.org,* Ontario Chapter.
  - Members of Fort McMurray First Nation 468, Fort McMurray Métis and Chipewyan Prairie Dene First Nation.
  - Delegates with the European Union Energy Study Mission, pictured, visited WBEA on October 1st for a tour and discussions on environmental monitoring in our region. The idea of twinning (Europe-WBEA) forest health plots was discussed, following on from the Executive Director's 2013 keynote presentation to the 2nd United Nations Economic Commission for Europe - International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP-Forests) Scientific Conference, *Today's Evaluations and Future Monitoring,* held in Belgrade, Serbia.

Operations and Administration

- New staff hired in 2014/15 included an Operation's Manager, an Office Administrator, a Sampling Technician, an Ambient Air Technician and an Instrumentation Technician.
- WBEA was awarded the Certificate of Recognition (COR) status after an external audit of the WBEA Health and Safety program was conducted in September. A COR is awarded to employers who develop health and safety programs that meet established provincial standards. Among WBEA's Health and Safety program strengths it was noted by the auditor that 'all employees truly embrace the safety culture of WBEA'.
- Major work on WBEA's Field Operations Centre (FOC) in the Taiga Nova Industrial Park was completed. A third drive-in bay was leased to accommodate building and servicing monitoring stations.
- At a Staff Day in March, an updated Health & Safety Manual and a revised Employee Procedures Manual were delivered to staff.

WBEA staff at the Field Operations Centre.

Ambient Air Monitoring Network

- As of March 31, 2015 WBEA was operating 17 air monitoring stations (AMS) located from Fort Chipewyan in the north to Anzac south of Fort McMurray. Data began streaming to WBEA's website from the newest Air Monitoring Station, Firebag, located near the Suncor SAGD facility. The map of the stations and the hourly updated monitoring data may be viewed at *www.wbea.org.*
- Two of WBEA's AMS, Bertha Ganter-Fort McKay and Wapasu, serve dual roles. They meet community or compliance needs and also serve as stations for enhanced deposition measurements conducted by EC, with analyzers and samplers serviced by WBEA technicians.

WBEA members and staff toured the Bertha Ganter-Fort McKay air monitoring station during the Sept. 18 Annual Member's Open House.

- On March 12, 2014, WBEA staff and contractors transported a new air monitoring station to Fort Chipewyan to replace a smaller, older station.
- In September, most of WBEA's air monitoring stations were externally audited by AEMERA. WBEA achieved an audit success rate of 97.4%, based on assessment of performance of 77 air analyzers and meteorological instruments.
- Work was underway throughout 2014 to install a new enhanced deposition air monitoring station AMS 18 near Conklin, in cooperation with EC and AESRD. The station is on-site and is expected to be operational in the summer of 2015.
- In 2014/15, permitting and legal requirements to enhance WBEA's existing air monitoring station at Buffalo Viewpoint, to accommodate new EC equipment, in support of JOSM were well underway.

- In October, WBEA installed a wind profiler at the Wapasu air monitoring station. A wind profiler is a type of weather observing equipment that uses sound waves (SODAR) to detect wind flow patterns and temperature. This equipment which collects data to 3000 m above ground-level will assist WBEA and others to improve pollution dispersion modelling in our region through more accurate wind flow data.

Human Exposure Monitoring

- The Human Exposure Monitoring Program's portable air monitoring station began streaming data for odour causing compounds to our website from a location in Anzac, pictured, in September 2014. Previous to that it collected data near WBEA's Mildred Lake station.
- WBEA's Community Odour Monitoring Panel (COMP), composed of 37 volunteers from Fort McMurray, and in operation since June 2013, continued throughout 2014. New volunteers were recruited, trained in odour tracking and equipped with odour reporting tools. Quarterly meetings were held to update participants. Results of the COMP may be found in the Human Exposure Monitoring Program section of this report and on the website at: *wbea.org/resources/human-exposure-monitoring-reports*.

Terrestrial Environmental Effects Monitoring

- On February 26 and April 15, 2014 members of the joint WBEA-Fort McKay Berry Focus Group met to review and verify the results of the 2013 field season during which the group made several trips to berry patches to observe plant condition, share Traditional Environmental Knowledge (TEK) and pick berries. Data from passive air pollution monitors, deployed at the patches in 2013, as well as results of the analysis of berry quality were shared with the group and plans for the 2014 field season were drawn up. The group decided to deploy meteorological stations at the berry patches in order to gather local weather data. In the fall of 2014, the group completed the berry harvest, passive pollutant monitoring and weather data measurements at their five regional berry patches.

Shay Laurent (l) and Kevin Percy (r) view a meteorological station at a Fort McKay Berry Focus Group berry patch in 2014.

- An initial meeting of a TEK Working Group was held with Aboriginal members in October 2014 to identify potential future TEK projects. At the March 10, 2015 GM, members voted to establish a WBEA Traditional Knowledge (TK) Committee and invited other members to join.
- Three portable continuous O_3 measurement systems operated at remote locations to the east, southwest and southeast of Fort McMurray in the summer of 2014.

- A new receptor modeling project to investigate polycyclic aromatic hydrocarbon (PAH) concentrations in regional lichen was undertaken in 2014. Lichens were collected from 120 regional sites over the summer by Dr. Keith Puckett, ECOFIN, pictured, and WBEA technical staff. Chemical analysis was completed and a report delivered to TEEM on March 31, 2015. The team of U.S. and Canadian principal investigators used PAH concentrations measured in the lichens, and in emission source materials, to apportion the contribution of natural and man-made PAH sources to the landscape.

- A peer-reviewed manuscript, Fenn, M.E., Bytnerowicz, A., Schilling, S.L. and Ross, C.S. 2015. *Atmospheric deposition of nitrogen, sulfur and base cations in jack pine stands in the Athabasca Oil Sands Region, Alberta, Canada.*, in Environmental Pollution 196: 497-510, was published.
- A comprehensive report on the state of jack pine forest health, *Assessing Forest Health in the Alberta Oil Sands Region* (Clair, T.E., Percy, K.E. Eds.) was published, reviewed by TEEM and accepted as final. The WBEA report summarizes air quality, modeling, deposition, vegetation and soil results relating to the 2011 intensive sampling of 23 regional forest plots, and relates these data to those reported in 2004 and 1998, where possible.

Communications and Outreach

Highlights of WBEA's communications program in 2014/25 included outreach opportunities at local, provincial and national events including the Air in Saskatchewan Symposium, Fort McMurray Métis Festival, Fort McMurray International Air Show, Fort McKay Trade Show, GLOBE 2014 in Vancouver, Emerald Day in Fort McMurray and The North American Oil and Gas Conference in Calgary.

The Executive Director speaks with a visitor to WBEA's booth at the Fort McMurray Métis Festival about WBEA's monitoring programs.

- Educational outreach is strongly supported by WBEA members. In 2014 WBEA staff conducted tours for school and university students, volunteered as judges at science fairs and sponsored the Wood Buffalo Regional Science Fair.
- The Community Odour Monitoring Project vignette, with English, Cree and Dene versions, was completed in October 2014.
- In 2014, WBEA Communications designed and installed colourful exterior decals on the Bertha Ganter-Fort McKay air monitoring station and on the HEMP and Mahihkan, pictured, portable monitoring stations.

- WBEA's website continued to be a source of continuous air monitoring data, the AQHI and updates on monitoring activities. A redesign of the website was initiated in 2014. WBEA was active on social media with Facebook and Twitter accounts.
- WBEA publishes printed and electronic reports and factsheets several times throughout the year:
  - *WBEA@Work,* an interactive electronic newsletter, was published four times in 2014 and sent to 250 stakeholders.
  - The 2013 Annual Report was completed. In 2014, a committee of members reviewed the Report's content and data presentation. The Community Odour Monitoring Project and WBEA data reported for the Lower Athabasca Regional Plan were two special sections in the 2013 Report.
  - Community Reports, published in June and November, informed residents of the RMWB of WBEA's monitoring work and results.

Data Processing, Systems Development and Data Management

Many of the key accomplishments of WBEA's Data Management Program have been covered in the initial section of my report "Transparently Reporting Ambient Air Quality for Regional Stakeholders, the Public, AEMERA, and the CCME".

WBEA's robust, advanced systems monitor a wide range of pollutants in the RMWB. Collecting, presenting and preserving accurate, credible data is central to all WBEA monitoring. With the launch of our redesigned website, in March 2015, seventeen years of quality-assured, continuous monitoring data are now publically available, in addition to 5 minute and hourly raw air data. Furthermore, historical time-integrated data, from 2009 onwards, are now also publically available.

WBEA's data not only fulfill regulatory and compliance directives, they are also used in regional and national reporting systems.

WBEA is continuously working to improve the accuracy, transparency and accessibility of our data capture and dissemination systems.

In closing, I would like to acknowledge WBEA's members who have guided our monitoring activities, supported WBEA staff and helped to navigate the Association's transition to becoming a working partner with AEMERA.

The Association is most grateful for our member's contributions, which constitute a significant commitment of time and energy.

Kevin Percy, PhD.
Executive Director

3.0

3.0 Financials

Financials are presented as results from March 31, 2015 Year End Meyers Norris Penny LLP audit. 2014 totals are based on a three month period, January 1, 2014-March 31, 2014 to adjust for a change in year end.

3.1 Wood Buffalo Environmental Association Statement of Revenue and Expenditures

For the year ended March 31, 2015	**April 1, 2014 – March 31, 2015**	January 1, 2014 – March 31, 2014
Revenue		
AEMERA Grant and Funding	**12,427,634**	-
Interest and other income	**152,631**	5,096
Grants	**129,508**	28,155
In-kind contributions	**107,800**	74,000
Amortization of deferred capital contributions	**-**	28,400
Write-down on deferred capital contributions	**5,000**	146,600
	12,822,573	282,251
Contributions	**-**	3,299,999
Total revenue	**12,822,573**	3,582,250
Expenditures		
Ambient air monitoring (Schedule 2)	**3,678,245**	912,928
Data Management (Schedule 3)	**437,235**	129,884
Communications (Schedule 4)	**363,434**	74,482
Office and administration (Schedule 5)	**3,206,663**	921,110
Deposition monitoring (Schedule 6)	**2,469,015**	657,594
Human exposure monitoring program (Schedule 7)	**394,189**	102,958
	10,548,781	2,798,956
Other expenditures		
Amortization	**1,101,761**	250,310
In-kind expenditures	**107,800**	74,000
Write-down on capital asset	**5,000**	146,600
Contributions repayable expense (recovery)	**(4,602)**	54,787
	1,209,959	525,697
Total expenses	**11,758,740**	3,324,653
Excess of revenue over expenditures	**1,063,833**	257,597

3.2 WOOD BUFFALO ENVIRONMENTAL ASSOCIATION STATEMENT OF CHANGES IN NET ASSETS

For the year ended March 31, 2015	Investment in capital assets	Contributed	Internally restricted	Unrestricted	Total 2015	Total 2014
Net assets, beginning of year	5,021,921	34,358	2,000,000	-	7,056,279	6,798,682
Excess of revenue over expenditures	-	-	-	1,063,833	1,063,833	257,597
Transfer from internally restricted net assets	-	-	(2,230)	2,230	-	-
Amortization of capital assets internally funded	(1,101,761)	-	-	1,101,761	-	-
Capital assets acquired from internal funds	2,020,442	-	-	(2,020,442)	-	-
Due from unrestricted net assets	-	-	2,230	(2,230)	-	-
Net assets, end of year	5,940,602	34,358	2,000,000	145,152	8,120,112	7,056,279

3.3 Wood Buffalo Environmental Association Schedule 1 - Contributions

For the year ended March 31, 2015	**April 1, 2014 – March 31, 2015**	January 1, 2014 – March 31, 2014
Contributions		
Athabasca Oil Corp.	-	5,712
Brion Energy	-	120,998
Canadian Natural Resources Ltd.	-	251,578
Cenovus Energy	-	134,579
Connacher	-	27,356
ConocoPhilips Canada	-	33,575
Devon Canada	-	54,389
Hammerstone Corp.	-	5,250
Husky Energy	-	29,052
Imperial Oil	-	159,858
Japan Canada Oil Sands Limited*	-	23,974
MEG Energy	-	28,390
Nexen Inc.	-	184,106
Shell Canada Ltd.	-	365,606
Statoil	-	74,652
Suncor Energy Inc.	-	1,051,112
Sunshine Oilsands Ltd.	-	7,515
Syncrude Canada Ltd.	-	781,053
Total E & P Canada Ltd.	-	55,235
Williams Energy	-	1,280
Less: Goods and Services Tax included in contributions	-	(95,271)
		3,299,999

**Japan Canada Oil Sands Limited was part of the OSDG funding formula for 2014, however Japan Canada Oil Sands limited did not become a member of WBEA and was not obligated to fund WBEA therefore no funds were received.*

3.4 Wood Buffalo Environmental Association Schedule 2 - Ambient Air Monitoring Expenditures

For the year ended March 31, 2015	**April 1, 2014 – March 31, 2015**	January 1, 2014 – March 31, 2014
Expenditures		
AMS #8 expense	**18,916**	6,368
Air Monitoring Van	**-**	3,714
Ambient Ion Monitoring (URG)	**-**	5,578
Audits (QA/QC, Compliance, AQM Network)	**101,092**	1,853
Field operation center- occupancy	**405,081**	103,973
Gases and Cylinders	**96,946**	19,800
Lab analysis	**568,776**	112,038
Materials and consumables	**186,015**	37,793
Modem lines and phones	**89,950**	15,989
Operational Expense (Insurance, Station Utilities)	**101,115**	22,278
Operations and maintenance	**671,930**	329,141
Professional Fees	**1,159,199**	196,616
Safety	**43,485**	4,997
Shipping	**43,296**	3,608
Station and site maintenance	**41,288**	13,556
Vehicles	**151,156**	35,626
	3,678,245	912,928

3.5 Wood Buffalo Environmental Association Schedule 3 - Data Management Expenditures

For the year ended March 31, 2015	**April 1, 2014 – March 31, 2015**	January 1, 2014 – March 31, 2014
Expenditures		
DMS management, hosting, and operations	**213,463**	65,423
DMS software optimization and maintenance	**76,957**	13,614
Data analysis and management	**146,815**	50,847
	437,235	129,884

3.6 Wood Buffalo Environmental Association Schedule 4 - Communication Expenditures

For the year ended March 31, 2015	**April 1, 2014 – March 31, 2015**	January 1, 2014 – March 31, 2014
Expenditures		
Advertising	**91,946**	12,424
Air Information Line	**12,150**	3,000
Communication merchandise	**98,666**	5,457
Community Relations	**14,620**	17,691
Conference attendance	**23,101**	19,185
Joint Alberta/Canada Monitoring	**3,286**	1,460
Media relations	**21,340**	1,261
Reports	**64,198**	14,004
Website maintenance	**34,127**	-
	363,434	74,482

3.7 Wood Buffalo Environmental Association
Schedule 5 - Office and Administration Expenditures

For the year ended March 31, 2015	**April 1, 2014 – March 31, 2015**	January 1, 2014 – March 31, 2014
Administration and personnel		
Salary and professional fees	**2,068,003**	518,292
Employee benefits	**198,912**	44,902
Office expenses		
Bad debt expense	**-**	117,771
Computer and other expenses	**-**	1,483
Conferences and meetings	**54,873**	22,770
Emergent Items	**22,784**	-
Health & Safety	**6,326**	7,996
Insurance	**33,285**	7,573
Occupancy Costs - Taiganova	**-**	24,372
Occupancy Costs - Thickwood/Taiganova	**409,249**	52,574
Office equipment lease	**33,409**	2,163
Office Expense	**174,712**	38,898
Office Vehicle	**14,249**	2,987
Professional Fees (audit and legal)	**34,184**	34,811
Stakeholder involvement	**37,024**	21,955
Travel	**119,653**	22,563
	3,206,663	921,110

3.8 Wood Buffalo Environmental Association Schedule 6 - Deposition Monitoring Expenditures

For the year ended March 31, 2015	**April 1, 2014 – March 31, 2015**	January 1, 2014 – March 31, 2014
Expenditures		
Dry Deposition Monitoring	**141,866**	-
Forest health monitoring	**218,402**	80,122
Instrumented MET towers	**141,963**	-
Ion exchange resins	**236,093**	-
PRS Probes	**98,361**	-
Peatland monitoring	**-**	40,576
Program maintenance and repairs	**41,104**	-
Program management	**441,454**	94,589
Receptor modelling	**626,922**	-
Remote continuous ozone monitoring	**42,797**	-
Routine passive monitoring	**325,772**	67,238
Source characterization	**-**	290,904
TEK berry health indicator	**154,281**	7,982
Tower instrumentation	**-**	45,855
Workshops	**-**	30,328
	2,469,015	657,594

3.9 Wood Buffalo Environmental Association Schedule 7 - Human Exposure Monitoring Program Expenditures

For the year ended March 31, 2015	**April 1, 2014 – March 31, 2015**	January 1, 2014 – March 31, 2014
Expenditures		
Community based odour panel	**83,491**	14,125
HEMP workshop and reporting	**37,288**	-
Kin-Tek (calibration mixtures)	**-**	459
Labour and professional fees	**107,972**	34,959
Odour Measurement (OdoTech)	**32,369**	16,576
Odour Measurement (VOC)	**129,141**	36,029
Portable Trailer	**3,928**	810
	394,189	102,958


4.0

4.0 Ambient Air Monitoring Program in 2014

4.1 Message from the Ambient Air Monitoring Program Manager

The Wood Buffalo Environmental Association (WBEA) operates an ambient air quality monitoring program whose primary goal is to generate accurate and scientifically defensible data that enable stakeholders to make informed decisions. Ambient Air Technical Committee (AATC) members in 2014 are listed in Appendix III.

The WBEA ambient air program is regularly reviewed for alignment with stakeholder needs and the objectives of the WBEA Strategic Plan and the *Joint Canada - Alberta Implementation Plan for Oil Sands Monitoring (JOSM)*. WBEA objectives for the ambient air program are:

- Collect air quality data for assessment by approval holders, regulators, community users and JOSM.
- Maintain high quality measurement and data sets in support of user needs which involves the application of quality control/protocols to all monitoring and measuring programs.
- Ensure comprehensive documentation and open reporting which includes having a completely accessible library of documentation in paper and electronic form.
- Be in compliance with the Alberta Air Monitoring Directive (AMD).

The links to JOSM *(http://environment.gov.ab.ca/info/library/8704.pdf)* plan are:

- Table 1 - Air Quality Implementation Plan Ambient Air Quality Element Activities:
  - (1) Ambient Air Monitoring: continuation and expansion of ambient monitoring network, consistent with the Integrated Monitoring Plan
  - (2) Fixed Platforms: Installation of 7 ecosystem transformation and deposition sites in and around the oil sands area
  - (3) Monitoring Pollutant Transformation: continue seasonal studies on pollutant transformation
  - (4) Focused Studies: continuous measurement of atmospheric visibility
  - (5) Point Sources: Additional monitoring to address gaps in emission inventories.
- Table 2 - Water Implementation Plan Activities:
  - (1) Snow/ Wet Deposition: Wet precipitation sites co-located with 4 WBEA sites (AMS 5, 11, 13, 17).
- Data Management – Work to allow open and transparent access to data.

Visitors with the World Presidents' Organization view samplers at WBEA's Patricia McInnes air monitoring station in 2014.

Following are some of the more significant AATC activities carried out in 2014:

- The WBEA Southern Operators Sub-Committee completed work on a monitoring plan for the southern part of the airshed. The Southern Air Monitoring Plan was finalized in September, following AATC review in late 2013 and early 2014, and engagement sessions with First Nation and Métis communities in late summer. The Plan proposes a three-stage implementation process which includes:
  - Phase 1 - the establishment of two new community stations, one regional background station and meteorological towers at all major SAGD facilities.
  - Phase 2 - setting up fixed or portable stations near major industry sources, complemented by passive monitoring in support of the acid deposition, particulate and ozone management frameworks.
  - Phase 3 - rationalization and revision of monitoring activities, based on data analysis and dispersion modelling.
- Qualitative and quantitative key performance indicators, which allow for the ongoing assessment of the monitoring program's continual improvement efforts and measure program effectiveness against the operational goals specified by the WBEA Strategic Plan, have become an integral part of the Ambient Air Monitoring program's continuous improvement process.
- A major update to WBEA's Quality Assurance Plan (QAP) was initiated in 2014. In conformance with the Quality System Chapter (Chapter 5) of Alberta's revised Air Monitoring Directive 2014, the QAP will be designed to 'establish a set of consistent requirements for the documentation, implementation and maintenance of a Quality System'. This is to ensure the quality and comparability of air monitoring data through consistent air monitoring practices and to provide a quality-based standardized framework for reporting and maintenance activities. Target completion date of the QAP is March 31, 2015.
- WBEA continued to support several of Environment Canada's (EC) regional monitoring initiatives:
  - Operation and maintenance of:
    - BTEX (benzene, toluene, ethylbenzene, xylenes) analyzer at the Bertha Ganter-Fort McKay air monitoring station.
    - Total Gaseous Mercury (TGM) analyzer at Patricia McInnes and TGM and speciated mercury at Lower Camp.
    - Speciated mercury system at Buffalo Viewpoint.
  - Polycyclic Aromatic Compounds (PACs), particulate and precipitation samplers at the Mannix, Lower Camp and Fort McKay South air monitoring stations and PACs at Wapasu under the joint EC-AEMERA Enhanced Deposition program.
  - Volatile organic compound (VOC) sampling at 6-day intervals at Fort McKay South air monitoring station.
- WBEA also provided logistical and technical assistance to Alberta Environmental Monitoring, Evaluation and Reporting Agency (AEMERA) during their campaign to monitor organic compounds in ambient air at Bertha Ganter using a Fourier Transform Infrared Spectroscopy (FTIR) open path instrument.
- New sampling platforms and upgraded power were installed to host the EC-AEMERA Enhanced Deposition monitoring equipment as well as the receptor modelling samplers at the newly expanded air monitoring station compound at Bertha Ganter-Fort McKay. For various logistical and technical reasons outside of WBEA's control, none of the equipment could be installed in 2014.
- Sampling for Polycyclic Aromatic Hydrocarbons (PAHs) under the EC-AEMERA Enhanced Deposition program was initiated during the summer at the Wapasu air monitoring station. This station has been collecting compliance data since December 2013.
- In addition to completing the replacement of Partisol PM samplers with the new 2000i series instruments, as part of an initiative to standardize the technology used to monitor airborne particulate matter, all stations were equipped with duplicate sets of samplers. This was done to enable the separate collection and analysis of particulate matter for ion and elemental species, respectively. This action was taken to help minimize possible contamination of the elemental analyte species from the use of a single filter for the sampling of both ions and elements.
- A new ambient air monitoring station was established in 2014 to monitor industrial emissions in the region of the Firebag SAGD (steam-assisted gravity drainage) operation. The Firebag station, pictured top left, contains analyzers that continuously

measure sulphur dioxide (SO_2), total hydrocarbons (THC), nitric oxide (NO), nitrogen dioxide (NO_2), nitrogen oxides (NO_X), hydrogen sulphide (H_2S), wind speed, wind direction, temperature and humidity.

- Preparation of the Conklin enhanced deposition site was mostly completed in late 2014, following a series of delays resulting from various AESRD land-related approval processes. Connection to the power grid and installation of power within the station compound are expected to occur in early 2015 and final commissioning is anticipated to happen in June.
- Permitting delays also prevented the planned expansion of the existing Buffalo Viewpoint air monitoring site into a combined compliance monitoring, enhanced deposition facility. Site preparation is now expected to start during the summer of 2015 with start-up in the new location anticipated to occur in the fall.
- Detailed site descriptions and photographs were submitted to the National Atmospheric Deposition Program (NADP) office as part of the WBEA application to have one site designated as an official precipitation monitoring site under the NADP's National Trends Network (NTN) program. However, this proposed initiative did not receive AEMERA funding and was therefore postponed pending approval.
- Work on new laboratory services contracts was initiated in 2014 in advance of the expiry of existing contracts at the end of 2014. The only anticipated significant change from the existing roster of service providers is the switch to a new supplier for particulate matter analyses which has necessitated a comprehensive assessment of qualifying candidate laboratories.
- A new REMTECH PA5 upper air wind profiler, pictured, below, to the left of the Wapasu air monitoring station, was installed in October and is now operational. The PA5 is capable of continuously generating three-dimensional profiles of pressure, temperature and humidity at up to 3,000 metres above ground level, at time intervals of less than one minute. The instrument is currently being operated in testing mode pending analysis of preliminary results and repair of the malfunctioning temperature measurement unit.

- Conversion of all operational stations to a standardized digital setup, pictured, is now mostly complete. This brings a common wiring scheme, data acquisition setup and data logger program to all of the stations. As well, the new program allows acquisition of monitoring and diagnostic data by direct digital communications with all analyzers and sensors that have this capability. This now includes 92 of the 98 continuous analyzers, and all temperature and relative humidity sensors in the network. Significant benefits of this new data acquisition and communication setup include cleaner analyzer signal, availability of instrument's full concentration range, real-time remote instrument diagnostic capabilities (i.e. lamp voltage, gas flows, etc.) and access to historical data for comparison.

Continuous ambient air quality and meteorological data are collected through a program administered by the WBEA's Ambient Air Monitoring Program under the direction of WBEA's AATC. By the end of 2014, WBEA was operating 17 continuous monitoring stations, each measuring from 3 to 10 air quality parameters. The continuously measured air quality parameters include CH_4 (methane), CO (carbon monoxide), H_2S (hydrogen sulphide), NMHC (non-methane hydrocarbons), NH_3 (ammonia) NO, NO_2, NO_X, O_3 (ozone), $PM_{2.5}$, (particulate matter 2.5 micrometers in diameter or less) SO_2, THC and TRS (total reduced sulphur compounds). All sites also measure temperature, wind speed and wind direction. Another station, the Lower Camp Met Tower, pictured, functions as a meteorological observation site only. Selected sites measure relative humidity, barometric pressure, global radiation, precipitation, dew point, surface wetness and vertical temperature gradient.

WBEA's mobile monitoring unit did not operate in 2014-15.

As well, WBEA operates four portable trailer-based continuous monitoring stations which are available to be deployed at industry or community sites for various periods of time. Three of these units were purchased in 2013. One is currently dedicated on a full-time basis to the Human Exposure Monitoring Program's (HEMP) Community Odour Monitoring Project. The other three portable stations are equipped to measure SO_2, H_2S, NO_2, NO, NO_X, THC, temperature, relative humidity as well as wind speed and direction. One unit also has a continuous ozone measuring instrument and a $PM_{2.5}$ monitor. All three units can be used for carrying out either compliance or background ambient air quality monitoring.

In 2014, the portable monitoring trailers were deployed at Cenovus Christina Lake from the beginning of January to the end of May, at Statoil Leismer from the beginning of July to the end of September and at ConocoPhillips Surmont from July 1 to December 31.

Since 1998 WBEA has conducted integrated sampling for $PM_{2.5}$, PM_{10}, VOCs and PAHs. The samplers are exposed to ambient air for 24 hours and the sampling schedule conforms to the requirements of the National Air Pollution Surveillance (NAPS) program. Specifically, measurements in the WBEA's network include:

1) $PM_{2.5}$ samplers to obtain quantitative measurements of $PM_{2.5}$ mass, ionic and elemental species
2) PM_{10} samplers to collect PM_{10} mass, ionic and elemental analysis
3) Summa canisters for VOC (volatile organic compounds) and RSC (reduced sulphur compounds) analysis
4) A sampling medium consisting of a PUF (polyurethane foam) plug and a glass fiber filter to collect semi-volatile organic compounds for PAHs (polycyclic aromatic hydrocarbons) analysis
5) A wet precipitation collector for wet precipitation chemistry

In summary, the Ambient Air Monitoring Program, under the direction of WBEA's AATC, continued efforts to improve and expand the current monitoring program to provide data for informed decision making by the end users.

REPORTS/PUBLICATIONS

Blake, D.R., Simpson, I.J. 2014. WBEA VOC Validation Study. University of California, Irvine. WBEA Agreement No: AA106-13. December 31, 2013; Revised June 6, 2014.

Hsu, Y-M. 2014. 2012 Ambient Air Sample Collection and Analytical Program for Integrated $PM_{2.5}$, PM_{10}, VOCs, Semi-Volatile Organics, SO_2, NO_2, O_3, and Wet Precipitation Chemistry (Intermittent Data). Reporting Period January 1st, 2012 to December 31st, 2012. Wood Buffalo Environmental Association. WBEA Report # 2014-08-05.

Whitely, S. 2014. Audit of the Continuous Data Validation & Reporting Process for the Wood Buffalo Environmental Association's Ambient Air Monitoring Network. Data Validation Audit for November 2013. Submitted September 30, 2014.

Southern Operators Sub-Group, Ambient Air Technical Committee. 2014. Southern Air Monitoring Plan. September 10, 2014.

Jean-Guy Zakrevsky
AAM Program Manager

Figure 1: Map of WBEA monitoring sites.

4.2 Ambient Air Quality and Meteorological Monitoring Results

Ambient air quality is measured both continuously and non-continuously by the Wood Buffalo Environmental Association.

Continuous monitoring is performed using electronic instrumentation. Atmospheric gas concentrations are measured by parameter-specific electronic analyzers housed in stationary shelters. Meteorological parameters are measured with sensors mounted on meteorological towers, with standard heights of 10 meters, and 20 meters in forested areas. Meteorological towers with heights of 90 and 167 meters, with an expanded program of meteorological measurements, are in place at two locations. Air quality analyzer and meteorological sensor signals are measured approximately once per second by a computerized data acquisition system, and processed into averages every 5 minutes, 1 hour and 24 hours, depending on the parameter and data requirements. There are a maximum of 8760 hours in a year, during which 1-hour concentrations may be reported. In reality, with daily calibrations (zero/spans) and monthly multi-point calibrations performed, quality-assured continuous one-hour analyzer data comprises some 8,200-8,300 data points per year. Continuous monitoring sites are equipped with permanent electrical power, heating and air conditioning systems, and telephone and internet connections.

Non-continuous monitoring consists of collecting air samples or exposing pollutant-sensitive, chemically treated sample media to the atmosphere for a period of time. Air pollutant concentrations are determined by laboratory analysis of the samples and exposed media. Exposure periods range from 24 hours to 1 month for various sample modes. Non-continuous monitoring is often referred to as integrated sampling, and is performed by both active and passive methods. Active methods utilize a computer controlled pump to draw air through or into the sample collector. Active methods are limited to sites where electrical power is available. Passive methods simply expose a chemically treated medium to the atmosphere. Without the need for support equipment, passive sampling can be performed at remote and isolated locations.

The map in Figure 1 shows the locations of all WBEA ambient air quality monitoring sites. Continuous monitoring sites are located in areas of development, primarily along the Athabasca River valley. Passive sites are located throughout the region, including in remote areas (see Passive monitoring sites map, Section 5.1, page 80).

4.2.1 Ambient Air Quality Monitoring by Station and Parameter in 2014

There were 17 active stations in the WBEA continuous ambient air quality monitoring network in 2014. Stations and monitoring instruments have been added to the network since 1998 in response to growth of industrial activity in the area and based on additional stakeholder needs. The Firebag site is the newest site in the network and began reporting data on July 19, 2014. Table 1 provides a listing of stations with their names and corresponding WBEA identification number and the air quality parameters measured by continuous methods at each site. Parameters measured include hydrogen sulphide (H_2S), total reduced sulphur (TRS), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), total hydrocarbons (THC), methane (CH_4), non-methane hydrocarbons (NMHC) and ammonia. Sites are categorized as industrial or community, based on the setting in which they are located.

The methods for continuous monitoring of $PM_{2.5}$ have evolved since monitoring began in 1997. The original $PM_{2.5}$ instruments deployed in the network used a tapered element oscillating microbalance (TEOM). Beginning in 2011 the TEOM analyzers were replaced with SHARP 5030 analyzers. As of January 2013, SHARP instruments were deployed at all WBEA sites except for 3 sites: Fort Chipewyan (TEOM replaced on June 1, 2013), Millennium (TEOM replaced on February 1, 2014) and CNRL Horizon (TEOM replaced on February 1, 2014). Descriptions of operational principles of each analyzer are presented in the section on Particulate Matter ($PM_{2.5}$) monitoring results.

Table 1: Summary of stations and parameters measured continuously at WBEA sites in 2014.

WBEA ID	LOCALE	STATION NAME	SO_2	NO/ NO_2/ NO_X	O_3	$PM_{2.5}$	TRS	H_2S	THC	Methane/ NMHC	CO	NH_3
1	COMMUNITY	BERTHA GANTER-FORT MCKAY*	X	X	X	X	X		X	X		X
2	INDUSTRIAL	MILDRED LAKE	X					X	X			
4	INDUSTRIAL	BUFFALO VIEWPOINT	X					X	X			
5	INDUSTRIAL	MANNIX	X					X	X			
6	COMMUNITY	FORT MCMURRAY PATRICIA MCINNES	X	X	X	X	X		X	X		X
7	COMMUNITY	FORT MCMURRAY ATHABASCA VALLEY	X	X	X	X	X		X	X	X	
8	COMMUNITY	FORT CHIPEWYAN	X	X	X	X						
9	INDUSTRIAL	BARGE LANDING					X		X			
11	INDUSTRIAL	LOWER CAMP	X					X	X			
12	INDUSTRIAL	MILLENNIUM	X	X		X	X		X			
13	INDUSTRIAL	FORT MCKAY SOUTH	X	X	X	X	X		X			
14	COMMUNITY	ANZAC	X	X	X	X	X		X	X		
15	INDUSTRIAL	CNRL HORIZON	X	X		X	X		X			
16	INDUSTRIAL	SHELL MUSKEG RIVER	X	X		X			X			
17	INDUSTRIAL	WAPASU*	X	X		X		X	X			
19	INDUSTRIAL	FIREBAG+	X	X				X	X			

** Also functions as a JOSM enhanced deposition station.*
+ Firebag began operation on July 19, 2014.

Table 2 provides a listing of stations and air quality parameters measured by integrated methods. Parameters measured include volatile organic compounds (VOC) and reduced sulphur compounds (RSC), particulate matter less than 2.5 µm aerodynamic diameter ($PM_{2.5}$) and associated metals and ions, particulate matter less than 10 µm aerodynamic diameter (PM_{10}) and associated metals and ions and polycyclic aromatic hydrocarbons (PAH).

Table 2: Summary of parameters measured using integrated methods at WBEA sites in 2014.

WBEA ID	LOCALE	STATION NAME	VOC/RSC	$PM_{2.5}$ Mass, Metals and Ions	PM_{10} Mass, Metals and Ions	PAH
1	COMMUNITY	BERTHA GANTER-FORT MCKAY	X	X	X	X
6	COMMUNITY	FORT MCMURRAY PATRICIA MCINNES	X	X	X	X
7	COMMUNITY	FORT MCMURRAY ATHABASCA VALLEY	X	X	X	X
9	INDUSTRIAL	BARGE LANDING	X			
12	INDUSTRIAL	MILLENNIUM	X		X	
13	INDUSTRIAL	FORT MCKAY SOUTH	X		X	
14	COMMUNITY	ANZAC	X	X	X	X
15	INDUSTRIAL	CNRL HORIZON	X		X	
16	INDUSTRIAL	SHELL MUSKEG RIVER			X	

The WBEA air monitoring network in 2014 included 3 portable air monitoring stations. In early January 2014, WBEA operated a portable air monitoring station at the Cenovus Energy Christina Lake facility. The survey at this location was conducted from January 1 to June 17, 2014 to fulfill Alberta Environment's Environmental Protection and Enhancement Act facility approval number 48522-01-00. This station was equipped with ambient air quality analyzers for SO_2, H_2S, NO, NO_2, NO_X and meteorological sensors for ambient temperature, relative humidity, and wind speed and direction.

WBEA commenced ambient air quality monitoring surveys at the Statoil Leismer and ConocoPhillips Surmont facilities on July 1, 2014. The survey at the Statoil Leismer facility was conducted from July 1 to September 30, 2014 to fulfill EPEA approval number 241311-00-02. The survey at the ConocoPhillips Surmont facility started on July 1, 2014 and will continue to June 30, 2015 to fulfill EPEA approval number 48263-00-00. The current EPEA Approval for the ConocoPhillips Surmont Phase 1 project requires ambient air monitoring at the facility for 3 months per calendar year. These two stations are equipped with ambient air quality analyzers for SO_2, H_2S, NO, NO_2, NO_X and meteorological sensors for ambient temperature, relative humidity, and wind speed and direction.

A summary of the portable stations operation period and parameters measured is provided in Table 3.

Table 3: Parameters and locations of continuous monitoring in 2014 by the portable or special study stations.

WBEA ID	PERIOD	LOCALE	STATION NAME	SO_2	$NO/NO_2/NO_X$	O_3	$PM_{2.5}$	H_2S
500	Jan 1 - June 17	INDUSTRIAL	CENOVUS CHRISTINA LAKE	X	X	X	X	X
501	Jul 1 – Sep 30	INDUSTRIAL	STATOIL LEISMER	X	X	X	X	X
502	July 1 – Dec 31	INDUSTRIAL	CONOCOPHILLIPS SURMONT	X	X			X

4.2.2 Meteorological Observations

Air quality is dependent on the rate that pollutants are emitted to the atmosphere, the rate of dispersion as these pollutants are transported away from sources, and the rate and pathways of chemical transformation and deposition over time. Air pollution transport, dispersion, transformation and deposition are influenced by wind speed and direction, the vertical temperature structure of the atmosphere, the daily solar cycle, turbulence, precipitation and influences on these elements induced by local topography and vegetation cover.

Precipitation may remove pollutants from the atmosphere (scavenging), and deposit them on soils and vegetation. For dry deposited (gases, particles) pollutants, deposition rates are highest when vegetation and soils are wet. Vegetation is more susceptible to damage during periods of highest growth.

Meteorological parameters measured at the monitoring sites in support of the ambient air quality monitoring programs include:

- wind speed and direction
- temperature
- vertical temperature gradient (difference in temperature at two heights)
- solar radiation
- relative humidity

Wind speed, wind direction and temperature are measured at all stations, the remainder at selected stations only.

The Lower Camp site contains the 167 m meteorological tower. Wind speed, wind direction and temperature measurements are made at heights of 20, 45, 100 and 167 for this tower. The 90 m meteorological tower is located at the Mannix site. Wind speed, wind direction and temperature measurements are made at heights of 20, 45, 75 and 90 m for this tower.

WIND SPEED AND DIRECTION

Figure 2 shows wind rose plots for the community monitoring stations. The wind rose plots for each station show the joint frequency distribution of wind speed and wind direction. These plots are based on a 16-point compass, with sectors of 22.5 degrees. In a wind rose, the length of a radial line indicates the frequency with which winds blew from each direction. The frequency of winds in various speed ranges is indicated by the length of line segments of different colours. Figure 3 provides wind rose plots from the different levels of the Lower Camp 167 m met tower.

Wind direction patterns reflect site location relative to the local river valleys as well as the size and orientation of the clearing around each site. Most of the WBEA sites are in river valleys where winds near the surface are subject to channeling especially for the stations at lower elevations. The tower measurements are less affected by local flows.

Figure 2: Wind roses for Bertha Ganter-Fort McKay, Fort McMurray Patricia McInnes, Fort McMurray Athabasca Valley, Anzac and Fort Chipewyan (2014).

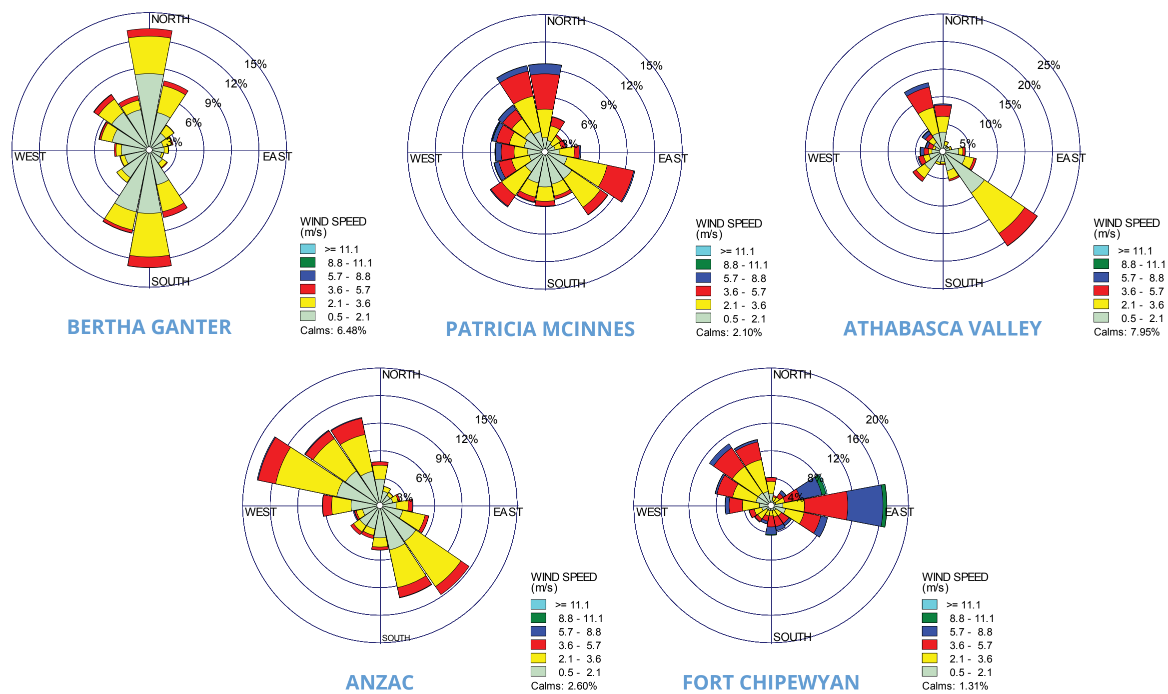
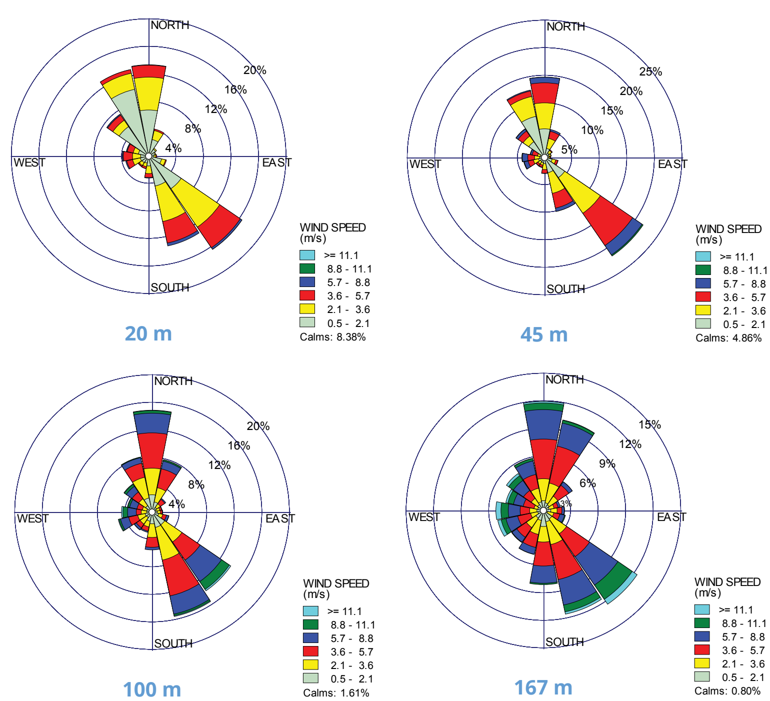


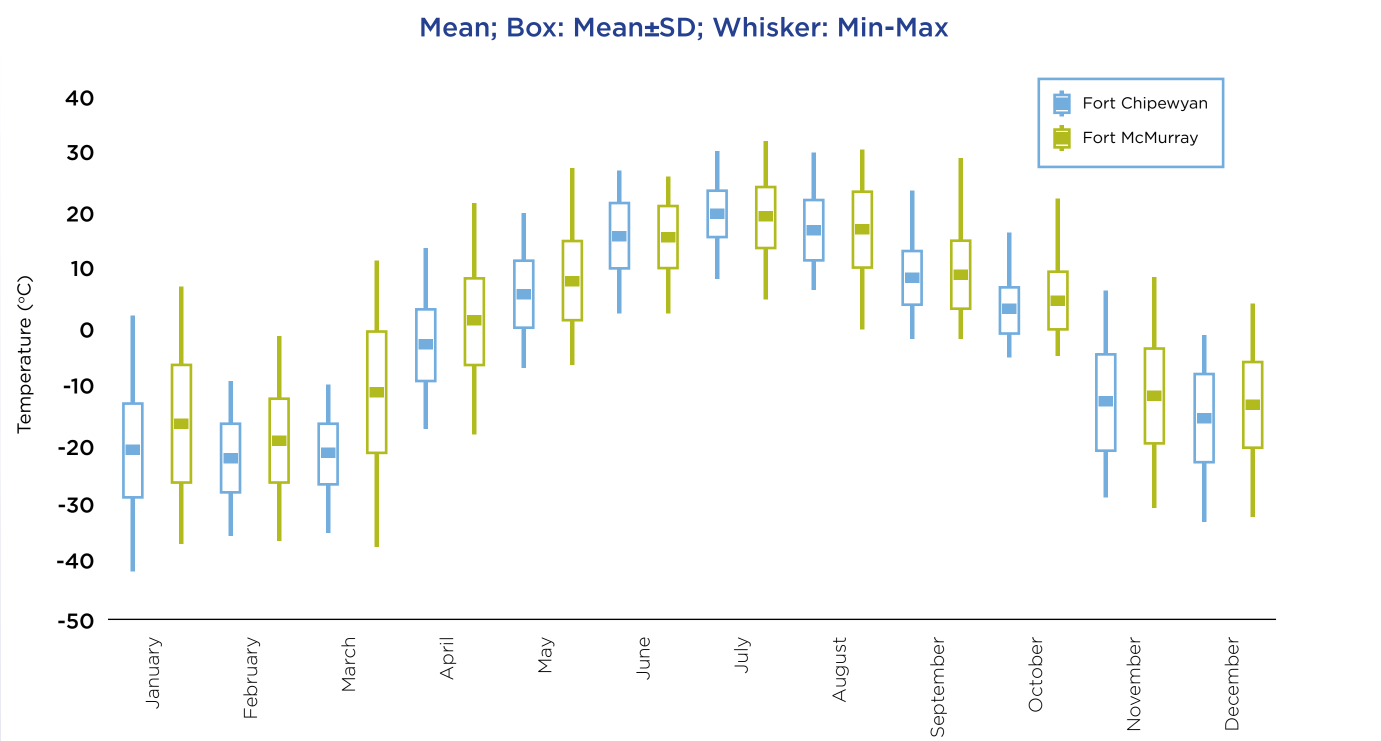
Figure 3: Wind roses by height for Lower Camp met tower (2014).



Temperature

Monthly variations in temperature are summarized for Fort Chipewyan and Fort McMurray for 2014 in Figure 4. The figure provides the mean, the standard deviation of the mean and the minimum and maximum temperature by month for each location. In most months Fort McMurray was slightly warmer than Fort Chipewyan. July was the warmest month and February the coldest for both locations.

Figure 4: Monthly variation in temperature (°C) at Fort McMurray and Fort Chipewyan for 2014.



4.2.3 Ambient Air Concentrations for all Parameters for 2014

Observed concentrations of monitored compounds at each station are presented as annual average concentrations, highest 1-hour average concentrations and various percentile values of the 1-hour concentrations. For parameters which have a 24-hour or daily average air quality objective, the highest 24-hour average and 24-hour percentile concentrations are presented.

Percentile values can be used to indicate how often observed concentrations were low, how often concentrations were high, and how often concentrations were within a range of values. There are 8760 hours in a year. Suppose, for example, there were a 10th percentile concentration value of 1 ppb and a 90th percentile value of 2 ppb. This would indicate that concentrations were less than or equal to 1 ppb 10 percent of the time (876 hours of a possible 8760 hours/year), that concentrations were less than or equal to 2 ppb 90 percent of the time (7884 hours of a possible 8760 hours/year), and that concentrations between 1 and 2 ppb occurred 80 percent of the time (7008 hours of a possible 8760 hours/year).

Selected percentile concentrations of each monitored compound are presented in accompanying figures as boxes with upper and lower vertical whiskers. This format shows the range of observed concentrations, excluding the extreme high and low values. It is also useful for comparing concentrations at different locations. The position of the lower whisker tip corresponds to the value of the 10th percentile concentration indicated on the vertical axis on (the left side), and the box bottom indicates the 25th percentile concentration. The box center indicates the 50th percentile concentration, also referred to as the median value. (One half of the observed concentrations are greater than the median value, and one half are less than the median value). The box top and upper whisker tip indicate the 75th and 90th percentile concentrations. The annual average concentration is indicated by a dot and can be compared to the annual average air quality objective which (when applicable) is indicated by a horizontal line across the figure.

In a 'normal' (standard bell-shaped) statistical distribution, the mean (or average) and median values are the same value. In 'non-normal' distributions most of the concentrations are in the lower or higher part of the range. If measurements have a large number of extremely small values, the mean can be significantly lower than the median value due to weighting by the large number of low values. In 'non-normal' distributions of measurements with extremely large values, the mean can be greater than the median, due to weighting of the mean by the few large values. Distributions of air quality measurements are generally not normal, and vary significantly for different parameters. Measurements of some parameters have a high number of small values, and a small number of relatively large high values.

The following is a summary of the 2014 monitoring data from the WBEA network by parameter. For each parameter general information is provided on the characteristics of the parameter, emission sources, Alberta Ambient Air Quality Objectives (AAAQOs) and current Canadian Ambient Air Quality Standards (CAAQS) where applicable. In terms of the AAAQOs it should be noted that Alberta Environment and Sustainable Resource Development indicates that:

"As the ambient air quality objectives are in many cases not entirely protective of human health and the environment, efforts are made to improve air quality in order to stay well below ambient air quality objectives and if the circumstances warrant, to lower the ambient air quality objectives over time."

Therefore, whenever monitoring data is shown in relation to AAAQOs, caution should be used in the terms of using the AAAQOs as a measure or benchmark of potential effects on receptors.

4.2.4 Sulphur Dioxide (SO_2)

CHARACTERISTICS AND SOURCES

Sulphur dioxide (SO_2) is a colourless, non-flammable gas with a sharp, pungent odour. Since coal and petroleum often contain sulphur compounds, their combustion generates sulphur dioxide unless the sulphur compounds are removed before burning the fuel.

Sulphur dioxide reacts in the atmosphere to form sulphuric acid and acidic aerosols, which contribute to acid deposition. Sulphur dioxide combines with other atmospheric gases to produce fine particles, which may reduce visibility and contribute to potential health impacts.

Alberta Ambient Air Quality Objectives (AAAQO)

The applicable Alberta objectives for SO_2 in 2014 were:

- 1-hour average of 172 ppb (450 µg/m^3)
- 24 hour average of 48 ppb (125 µg/m^3)
- 30-day average of 11 ppb (30 µg/m^3)
- Annual average of 8 ppb (20 µg/m^3)

MONITORING METHOD

Continuous measurements of SO_2 are made with electronic analyzers using fluorescence technology. Concentrations of SO_2 are measured by the intensity of light emitted by SO_2 molecules in the air sample when exposed to ultraviolet light inside the analyzer.

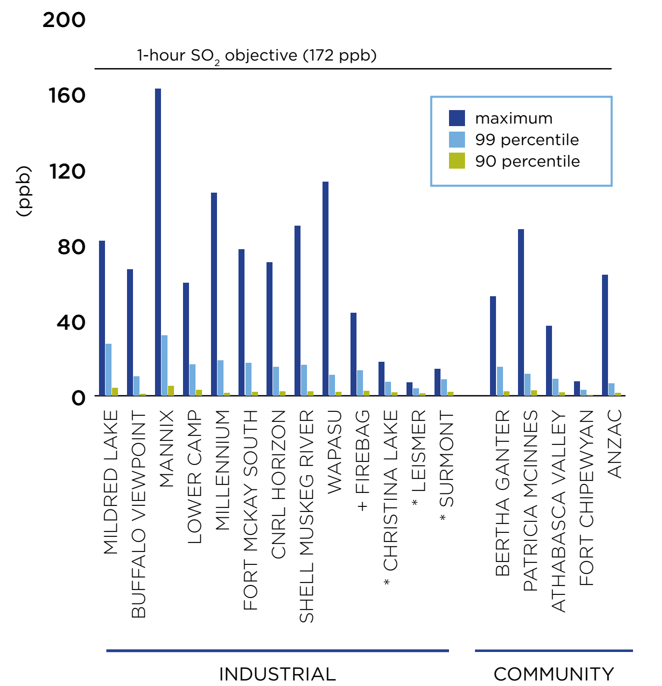
CONTINUOUS MONITORING OBSERVATIONS IN 2014

The maximum 1-hour SO_2 concentrations (Figure 5) monitored over the entire year at industrial locations ranged from 44 ppb at Firebag to 162 ppb at Mannix. At community locations, the highest 1-hour concentrations over the entire year ranged from 7 ppb at Fort Chipewyan to 88 ppb at Patricia McInnes.

The 99th percentile SO_2 concentrations at the industrial locations ranged from 13 to 32 ppb and from 3 to 15 ppb at the community sites. Typically 99th percentile concentrations were one tenth to one third the values of the maximum concentrations.

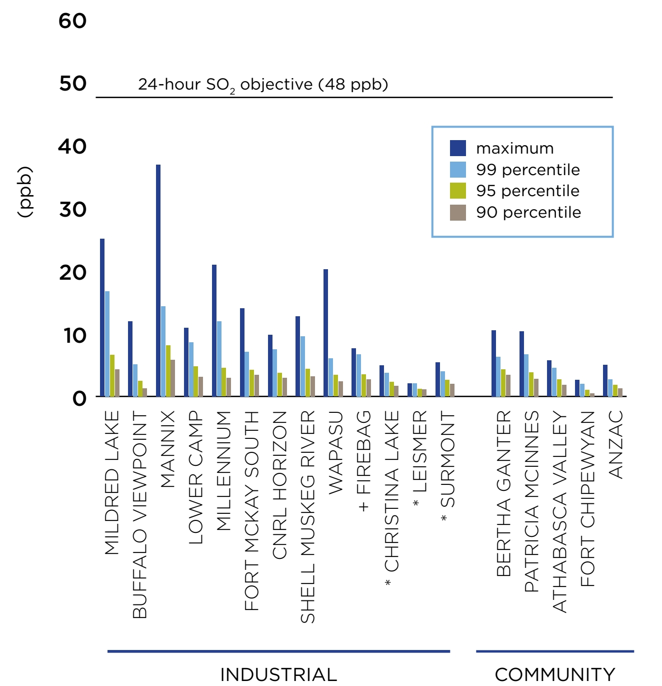
There were no exceedances of the Alberta one-hour ambient air quality objective for SO_2 of 172 ppb during 2014. There were no exceedances of the Alberta 24-hour ambient air quality objective for SO_2 of 48 ppb (Figure 6) or of the Alberta annual average ambient air quality objective for SO_2 of 8 ppb. Maximum 24h concentrations of SO_2 ranged from 8 to 37 ppb at the industrial sites and mean concentrations of SO_2 at all sites ranged from 0.2 to 2.3 ppb. For exceedances of the Lower Athabasca Regional Plan (LARP) trigger levels, please see Section 4.3, page 62.

Figure 5: Maximum 1-hour SO_2 concentrations and the 99th and 90th percentile values at industry and community locations.



* Portable monitoring sites operated for only part of the year (see Table 3).
+ Firebag site began operation on July 19, 2014.

Figure 6: Maximum 24-hour SO_2 concentrations and the 99th, 95th and 90th percentile values at industry and community locations.



* Portable monitoring sites operated for only part of the year (see Table 3).
+ Firebag site began operation on July 19, 2014.

4.2.5 Continuous Monitoring of Total Reduced Sulphur (TRS) and Hydrogen Sulphide (H_2S) and Integrated Measurements of Reduced Sulphur Compounds (RSC)

CHARACTERISTICS AND SOURCES

Hydrogen sulphide (H_2S) is a colourless gas with a characteristic rotten egg odour. The term "total reduced sulphur compounds" (TRS) is used to collectively describe a group of compounds including hydrogen sulphide, dimethyl sulphide, dimethyl disulphide, carbon disulphide, carbonyl sulphide, thiophenes, methyl mercaptan and other mercaptans. The term "reduced sulphur compounds" (RSC) is applied to selected sulphur compounds analyzed for in lab analyses of time-integrated canister samples.

Reduced sulphur compounds (RSCs) are produced both naturally and through industrial processes. Natural sources of RSC in air include volcanoes and sulphur springs, oceans and estuaries, and exposed faces of sulphur-containing oil and coal deposits. In the absence of oxygen, decomposition of organic matter by bacteria results in the release of RSCs. This produces the characteristic odour commonly associated with sewers, sewage lagoons, and swamps. Industrial sources are primarily petroleum refining, petrochemical complexes, and pulp and paper mills. In the WBEA airshed most industrial TRS and H_2S emissions are from upgraders (stack emissions) and tailings ponds (fugitive emissions). There is a natural background ambient air concentration of the reduced sulphur compound carbonyl sulphide of approximately 0.5 ppb.

ALBERTA AMBIENT AIR QUALITY OBJECTIVES (AAAQO)

The objectives for ambient air concentrations of H_2S are based on an odour threshold, although many individuals can smell H_2S at levels below the ambient objectives. In the WBEA air quality monitoring network, TRS concentrations are evaluated against the H_2S air quality objectives.

The Alberta ambient air quality objectives for H_2S are:

- 1-hour average of 10 ppb (14 $\mu g/m^3$)
- 24-hour average of 3 ppb (4 $\mu g/m^3$)

There is also an Alberta ambient air quality objective for the following reduced sulphur compound:

- Carbon Disulphide – 1 hour average of 10 ppb (30 $\mu g/m^3$) - adopted 1999

MONITORING METHODS FOR TRS AND H_2S

Hydrogen sulphide (H_2S) is measured at six locations in the WBEA monitoring network (Mildred Lake, Buffalo Viewpoint, Mannix, Lower Camp, Wapasu and Firebag) and in the three portable stations. Total reduced sulphur (TRS) is measured at eight other locations.

Continuous monitoring is employed to measure TRS and H_2S. Electronic analyzers for TRS and H_2S consist of a sulphur dioxide (SO_2) analyzer with additional components. A scrubber first removes all SO_2 from the air sample, and then a converter oxidizes TRS or H_2S to SO_2, which is then measured by the analyzer.

It should be noted that H_2S continuous analyzers at the air monitoring stations may detect other reduced sulphur compounds in addition to H_2S. Also the TRS analyzers may not oxidize all of the reduced sulphur compounds present and therefore may underestimate TRS concentrations.

CONTINUOUS MONITORING OBSERVATIONS IN 2014

The maximum 1-hour TRS and H_2S concentrations monitored over the entire year (Figure 7) at industry locations ranged from 3 ppb at Firebag to 39 ppb at Buffalo Viewpoint. At community locations, the highest concentrations ranged from 4 ppb at Patricia McInnes to 9 ppb at Bertha Ganter-Fort McKay and Anzac.

The 99th percentile concentrations ranged from 0.9 to 4.3 ppb at the industrial sites and the 95th percentile concentrations ranged from 0.5 to 2.29 ppb. At all locations, typically the maximum concentrations were 2 to 17 times greater than the 99th percentile concentrations, and 4 to 40 times greater than the 95th percentile concentrations.

The Alberta one-hour ambient air quality objective for H_2S of 10 ppb was exceeded 31 times in 2014. The following number of exceedances of the Alberta 1-hour ambient air quality objective for H_2S were recorded at these stations, in 2014:

Mildred Lake - 7
Buffalo Viewpoint - 3
Mannix - 14
Lower Camp - 4
Millennium - 1
Fort McKay South - 2

The Alberta 24-hour ambient air quality objective for H_2S of 3 ppb was exceeded twice in 2014 (Figure 8). One exceedance occurred at Mannix and one at Buffalo Viewpoint.

Alberta Environment and Sustainable Resource Development (AESRD), and all industries are informed by WBEA of each exceedance, regardless of location. For each event, industry undertakes an internal investigation to determine a cause and follows up with AESRD on findings and mitigative actions.

Figure 7: Maximum 1-hour TRS and H_2S concentrations and the 99th, 95th and 90th percentiles at industry and community locations. The number of exceedances of the 1-hour H_2S air quality objective exceedances is indicated.

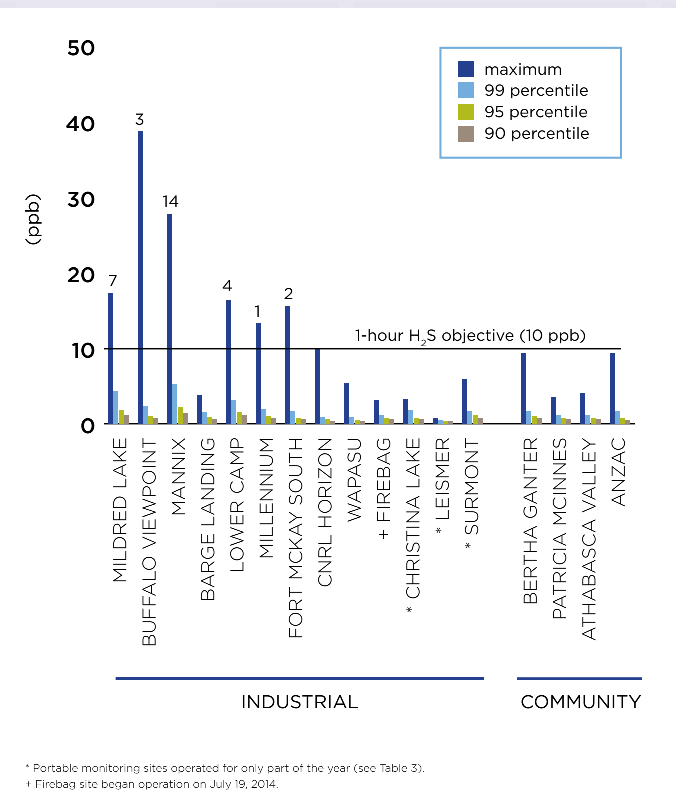
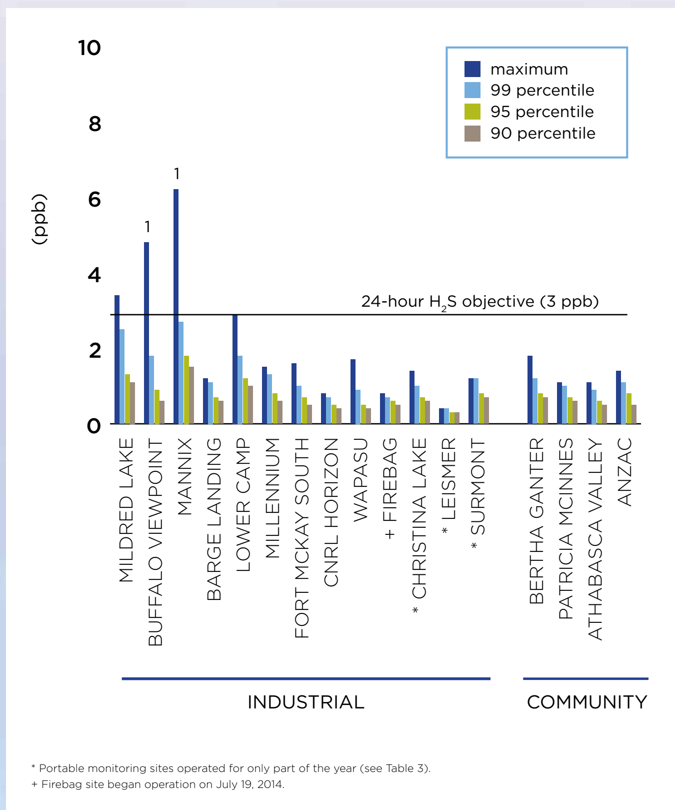


Figure 8: Maximum 24-hour TRS and H_2S concentrations and the 99th, 95th and 90th percentiles at industry and community locations. The number of exceedances of the 24-hour H_2S air quality objective is indicated.



INTEGRATED MONITORING METHOD FOR REDUCED SULPHUR COMPOUNDS (RSC)

Reduced sulphur compounds (RSC) were analyzed from canister samples collected in the volatile organic compound (VOC) integrated sampling program. Air was drawn into a Silcosteel® canister at the monitoring station. The canister was shipped to a laboratory where the contents were withdrawn and analyzed using gas chromatography. Samples were analyzed for 63 VOC compounds and 23 RSC compounds.

RSC were measured for 1-day (24-hour) periods at 4 industry stations: Barge Landing, Millennium Mine, Fort McKay South and CNRL Horizon; and at 4 community stations: Bertha Ganter-Fort McKay, Patricia McInnes, Athabasca Valley, and Anzac. RSC were measured every 6 days (approximately 60 possible sample days in the year) at all stations.

INTEGRATED MONITORING OBSERVATIONS IN 2014 – RSC

A complete list of RSC species measured and frequency of detection using data from all community sites is found in Table 4 and using data from industrial sites in Table 5. Carbonyl sulphide was the most frequently reported RSC in the canister results. Carbonyl sulphide is the most abundant sulphur compound naturally present in the atmosphere because it is emitted from oceans, volcanoes and deep sea vents. It is a significant compound in the global sulphur cycle and its reported background level in the atmosphere is 0.5±0.05 ppb. The other most frequently detected compounds were carbon disulphide and hydrogen sulphide. There were few detectable concentrations of the other sulphur species (mercaptans, sulphides and thiophenes) at any of the sites.

A comparison of mean and maximum hydrogen sulphide, carbonyl sulphide and carbon disulphide concentrations by site is provided in Figure 9. As shown in Figure 9 maximum concentrations of hydrogen sulphide and carbon disulphide were generally higher at the industrial sites and at Bertha Ganter-Fort McKay, than at the community monitoring sites. However, there was a low frequency of detection for these species.

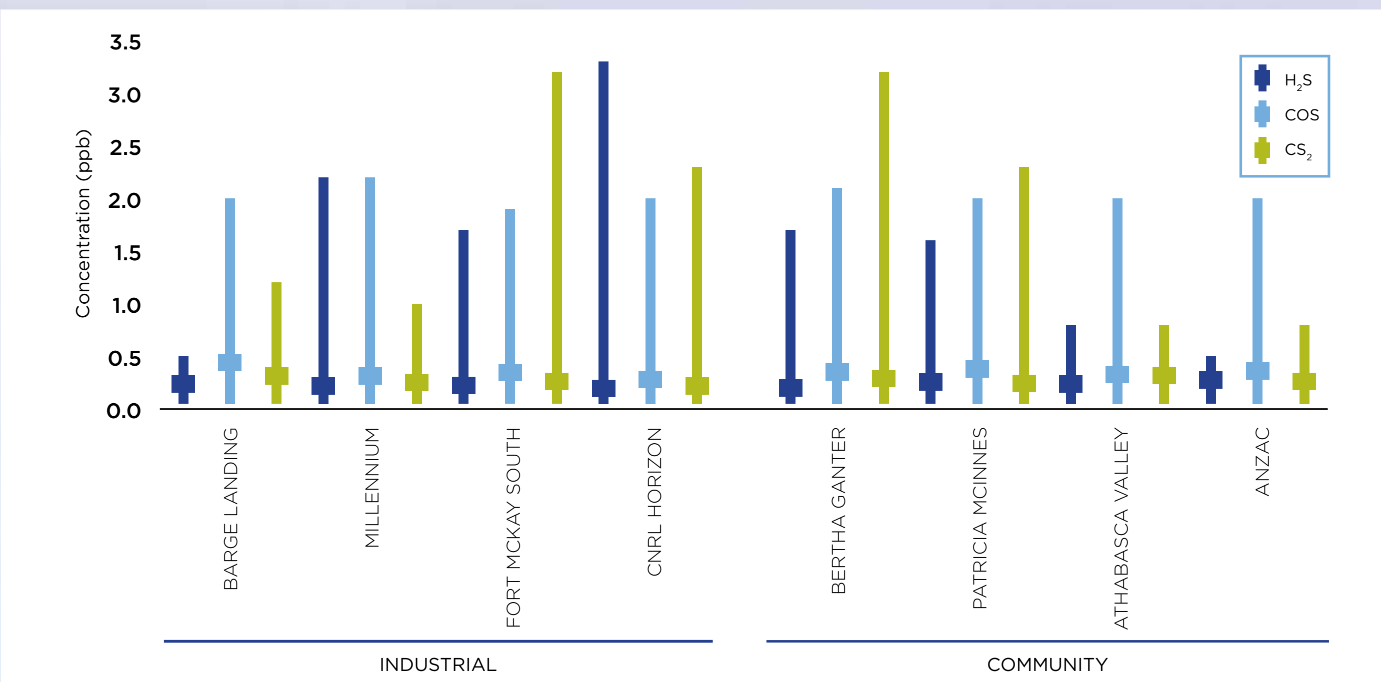
Table 4: RSC Species measured and reported 24 h concentrations (ppb) in canister samples at all community sites for 2014 (sorted by frequency of detection - detection limit was ~0.1 to 1 ppb).

Compound	% Detect	95th Percentile	Max.	Mean	Std. Dev.	Median
Carbonyl sulphide	20.3%	1.00	2.10	0.20	0.47	< 0.1
Carbon disulphide	10.5%	0.60	3.20	0.07	0.30	< 0.1
Hydrogen sulphide	2.5%	< 0.1	1.70	0.02	0.17	< 0.1
Thiophene	2.5%	<0.1	0.70	0.01	0.05	<0.1
Dimethyl disulphide	1.7%	< 0.1	4.00	0.03	0.28	< 0.1
2-methyl Thiophene	1.3%	< 0.1	4.10	0.02	0.27	< 0.1
3-methyl Thiophene	1.3%	< 0.1	4.30	0.03	0.29	< 0.1
2-ethyl Thiophene	1.3%	< 0.1	1.10	0.01	0.08	< 0.1
2,5-dimethyl Thiophene	1.3%	< 0.1	2.00	0.02	0.18	< 0.1
Isobutyl mercaptan	0.8%	< 0.1	0.08	0.00	0.01	< 0.1
Ethyl mercaptan	0.4%	< 0.1	4.00	0.02	0.26	< 0.1
Isopropyl mercaptan	0.4%	< 0.1	0.90	0.00	0.06	< 0.1
Pentyl mercaptan	0.4%	< 0.1	2.00	0.01	0.13	< 0.1
Methyl mercaptan	0.0%					
Dimethyl sulphide	0.0%					
tert-Butyl mercaptan	0.0%					
Propyl mercaptan	0.0%					
Ethyl sulphide	0.0%					
Butyl mercaptan	0.0%					
tert-Pentyl mercaptan	0.0%					
Allyl sulphide	0.0%					
sec-Butyl mercaptan	0.0%					

Table 5: RSC species measured and reported 24 h concentrations (ppb) in canister samples at all industrial sites for 2014 sorted by frequency of detection (detection limit was ~0.1 to 1 ppb).

Compound	% Detect	95th Percentile	Max.	Mean	Std. Dev.	Median
Carbonyl sulphide	19.5%	1.00	2.20	0.20	0.46	< 0.1
Carbon disulphide	11.4%	0.70	3.20	0.08	0.32	< 0.1
Hydrogen sulphide	3.4%	< 0.1	3.30	0.04	0.29	< 0.1
2-ethyl Thiophene	1.3%	< 0.1	3.30	0.03	0.31	< 0.1
Ethyl mercaptan	0.4%	< 0.1	4.00	0.02	0.26	< 0.1
Isopropyl mercaptan	0.4%	< 0.1	0.60	0.00	0.04	< 0.1
tert-Butyl mercaptan	0.4%	< 0.1	0.20	0.00	0.01	< 0.1
Dimethyl disulphide	0.4%	< 0.1	0.60	0.00	0.04	< 0.1
3-methyl Thiophene	0.4%	< 0.1	1.60	0.01	0.10	< 0.1
2,5-dimethyl Thiophene	0.4%	< 0.1	1.80	0.01	0.12	< 0.1
Thiophene	0.4%	< 0.1	1.00	0.00	0.07	< 0.1
Methyl mercaptan	0.0%					
Dimethyl sulphide	0.0%					
Propyl mercaptan	0.0%					
Ethyl sulphide	0.0%					
Butyl mercaptan	0.0%					
tert-Pentyl mercaptan	0.0%					
2-methyl Thiophene	0.0%					
Pentyl mercaptan	0.0%					
Allyl sulphide	0.0%					
Isobutyl mercaptan	0.0%					
sec-Butyl mercaptan	0.0%					

Figure 9: Mean, minimum and maximum hydrogen sulphide (H_2S), carbonyl sulphide (COS) and carbon disulphide (CS_2) concentrations (ppb) by site – 2014.



4.2.6 Continuous Measurements of Total Hydrocarbons (THC), Non-Methane Hydrocarbons (NMHC) and Integrated Measurements of Volatile Organic Compounds (VOC)

CHARACTERISTICS AND SOURCES

Volatile organic compounds, or VOCs, are generally defined as compounds containing at least one carbon atom (excluding carbon dioxide and carbon monoxide) and with a vapour pressure of 0.01 kPa or greater at 25°C. Although there are many thousands of organic compounds in the natural and polluted atmosphere that meet the definition of a VOC, most measurement programs have concentrated on VOCs that are important in: a) ozone formation, usually the 50 to 150 most abundant C_2 to C_{12} hydrocarbons consisting of the general formula C_xH_y and C_2 to C_6 carbonyls or b) toxics, which are those VOCs (including halogenated hydrocarbons) that are of concern from a human health perspective due to known acute or chronic effects. Some VOCs fit into both categories.

Total non-methane hydrocarbons (total NMHC) are defined as the sum of all identified C_2 to C_{12} hydrocarbons. Total VOCs are defined as total NMHC plus carbonyls and other polar species such as alcohols. NMHC also includes a number of species emitted from biogenic sources including isoprene, α-pinene, β-pinene, δ-limonene and camphene.

A major hydrocarbon in the atmosphere is methane, a colourless, odourless gas, which is an important contributor to the greenhouse effect. Methane exists naturally in the atmosphere with background concentrations of about 1.8 to 1.9 ppm and is produced through the decay of vegetation.

Petroleum and chemical industries, motor vehicle exhaust and gasoline handling are the major sources of VOC from human activity. Trees and plants are major natural emitters of VOC.

ALBERTA AMBIENT AIR QUALITY OBJECTIVES (AAAQO)

There are no Alberta ambient air quality objectives for continuously monitored NMHC.

Alberta ambient air quality objectives include the following VOCs:

- acetaldehyde – 1 hour average: 50 ppb (90 μg/m³) - adopted 1999
- acetone - 1 hour average: 2,400 ppb (5,900 μg/m³) - adopted 1999, reviewed in 2005
- acrolein – 1 hour average: 1.9 ppb (4.5 μg/m³) – adopted 2013
  - 24 hour average: 0.17 ppb (0.4 μg/m³) – adopted 2013
- benzene – 1 hour average: 9 ppb (30 μg/m³) - adopted in 1999, reviewed in 2012
- ethyl benzene – 1 hour average: 460 ppb (2,000 μg/m³) - adopted 2005
- formaldehyde – 1 hour average: 53 ppb (65 μg/m³) - adopted 1999, reviewed 2007
- methanol – 1 hour average: 2,000 ppb (2,600 μg/m³) - adopted 1999
- styrene – 1-hour average: 52 ppb (215 μg/m³) - adopted in 1999
- toluene – 1 hour average: 499 ppb (1,880 μg/m³) - adopted 2005
  - 24 hour average: 106 ppb (400 μg/m³) - adopted 2005
- xylenes – 1 hour average: or 530 ppb (2,300 μg/m³) - adopted 2005
  - 24 hour average: 161 ppb (700 μg/m³) - adopted 2005

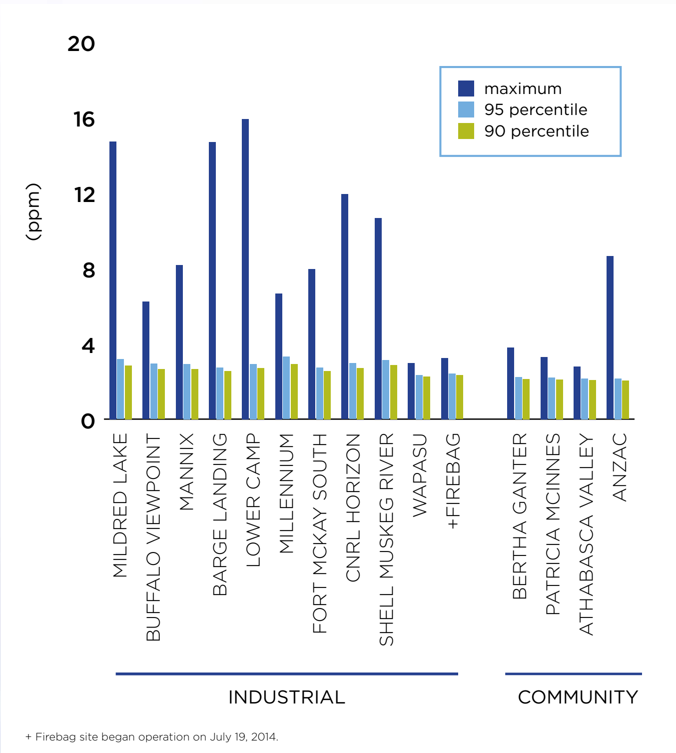
CONTINUOUS MONITORING METHOD FOR THC

Continuous measurements of THC are made using electronic analyzers that employ flame ionization technology. An electric current is generated when carbon molecules from the air sample are burned (ionized) by a hydrogen-fuelled flame in an electrified chamber. Concentrations of hydrocarbon molecules in ambient air are measured by changes of electric current in the flame chamber due to the presence of carbon ions. Methane and NMHC are measured and reported together as THC.

CONTINUOUS MONITORING OBSERVATIONS IN 2014 - THC

THC concentrations were measured at 14 monitoring stations in 2014 and results are shown in Figure 10. Mean concentrations of THC were similar at all sites reflecting the contribution of background methane. Maximum THC concentrations reached levels of 10 to 15 ppm at a number of the industrial sites. Maximum THC concentrations at the community sites ranged from 3 to 9 ppm.

Figure 10: Maximum 1-hour THC concentrations (ppm) and the 95th and 90th percentiles at all monitoring locations in 2014.



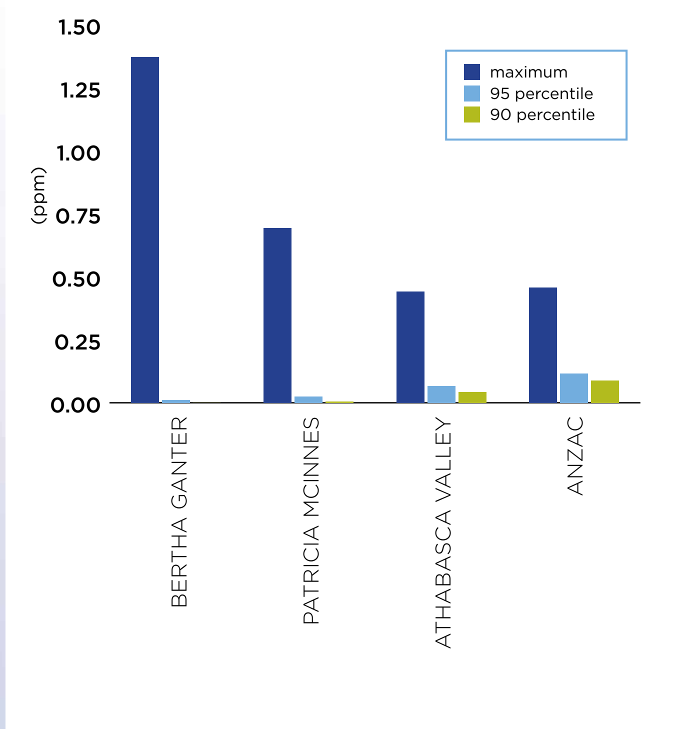
CONTINUOUS MONITORING METHOD FOR NMHC

Continuous measurements of NMHC are made using electronic analyzers that employ flame ionization technology. An electric current is generated when carbon molecules from the air sample are burned (ionized) by a hydrogen-fuelled flame in an electrified chamber. Concentrations of hydrocarbon molecules in ambient air are measured by changes of electric current in the flame chamber due to the presence of carbon ions. Methane and NMHC are co-measured using a back-flush chromatography system that provides a direct measurement of NMHC.

CONTINUOUS MONITORING OBSERVATIONS IN 2014 - NMHC

NMHC measurements were made at 4 community sites in 2014. Maximum 1-hour NMHC concentration monitored over the entire year (Figure 11) at the community sites ranged from 0.4 ppm at Anzac to 1.4 ppm at Bertha Ganter-Fort McKay.

Figure 11: Maximum 1-hour NMHC concentrations (ppm) and the 95th and 90th percentiles at all community monitoring locations in 2014.



INTEGRATED MONITORING METHOD FOR VOC

Volatile organic compounds (VOC) were analyzed from air samples collected at monitoring stations. Air was drawn into a Silcosteel® canister at the monitoring station through a valve controlled by a computerized electronic sampling device. The canister was shipped to a laboratory where the contents were withdrawn and analyzed using gas chromatography. Samples were analyzed for 62 individual VOC compounds.

Volatile organic compounds were measured for 24-hour periods at 4 industry stations: Barge Landing, Millennium Mine, Fort McKay South and CNRL Horizon and at 4 community stations: Bertha Ganter-Fort McKay, Patricia McInnes, Athabasca Valley, and Anzac. VOCs were measured every 6 days (approximately 60 possible sample days in the year) at all stations.

INTEGRATED MONITORING OBSERVATIONS IN 2014 - VOC

The twenty most frequently detected VOC species and summary statistics are shown in Table 6 for community sites and in Table 7 for industrial sites. The most frequently detected species were toluene, acetone, methanol, benzene, butane, isobutane, isopentane and acetaldehyde at both groups of sites. Alpha pinene and isoprene were also frequently detected and originate from coniferous and deciduous trees respectively. Methanol and acetone both have a large natural component and acetaldehyde is largely formed in the atmosphere from photochemical reactions of other VOC.

Figure 12 compares mean and maximum concentrations between sites for a group of frequently detected VOC that have Alberta AAQO's: benzene, toluene, ethyl benzene, styrene, xylenes, acetone, methanol and acetaldehyde. There were two measured 24-h average benzene concentrations that were above the 1-hour AAQO of 9 ppb (41.5 ppb measured at Anzac and 11.9 ppb measured at Millennium). One 24-h average acetaldehyde measurement from Athabasca Valley exceeded the 1-hour AAQO of 50 ppb. No other measurements exceeded the 1-hour or 24-hour Alberta AAQO values.

Table 6: Twenty most frequently detected VOC compounds and summary statistics for community sites for 2014 sorted by frequency of detection (detection limit was ~0.03 ppb).

Compound	% Detect	95th Percentile	Max.	Mean	Std. Dev.	Median
Acetone	84.5%	9.13	63.80	3.31	4.89	2.36
Benzene	72.0%	0.55	41.50	0.37	2.68	0.19
Methanol	62.8%	44.30	197.00	12.95	28.43	4.28
Toluene	61.5%	2.87	16.50	0.57	1.86	0.12
Butane	60.3%	2.81	105.00	1.38	6.94	0.70
Isopentane	60.3%	2.20	22.20	0.66	1.62	0.32
Acetaldehyde	48.5%	6.83	115.00	2.38	7.69	< 0.03
Isobutane	47.7%	1.56	59.60	0.56	3.87	< 0.03
m, p-Xylene	25.1%	0.38	3.97	0.08	0.30	< 0.03
Isoprene**	22.6%	2.43	6.02	0.38	1.02	< 0.03
alpha Pinene**	20.9%	0.38	0.93	0.05	0.13	< 0.03
Hexane	20.5%	0.98	56.30	0.51	3.82	< 0.03
3-Methylpentane	19.2%	0.54	16.60	0.16	1.11	< 0.03
Pentane	17.2%	2.36	19.50	0.52	2.07	< 0.03
2-Methylpentane	17.2%	0.53	8.69	0.14	0.72	< 0.03
1-Butene	16.3%	0.61	12.10	0.13	0.81	< 0.03
Methylcyclopentane	14.2%	0.43	18.70	0.13	1.22	< 0.03
Methylcyclohexane	12.1%	0.34	1.22	0.04	0.14	< 0.03
Ethyl benzene	12.1%	0.12	1.38	0.02	0.11	< 0.03
o-Xylene	11.3%	0.11	1.27	0.02	0.10	< 0.03

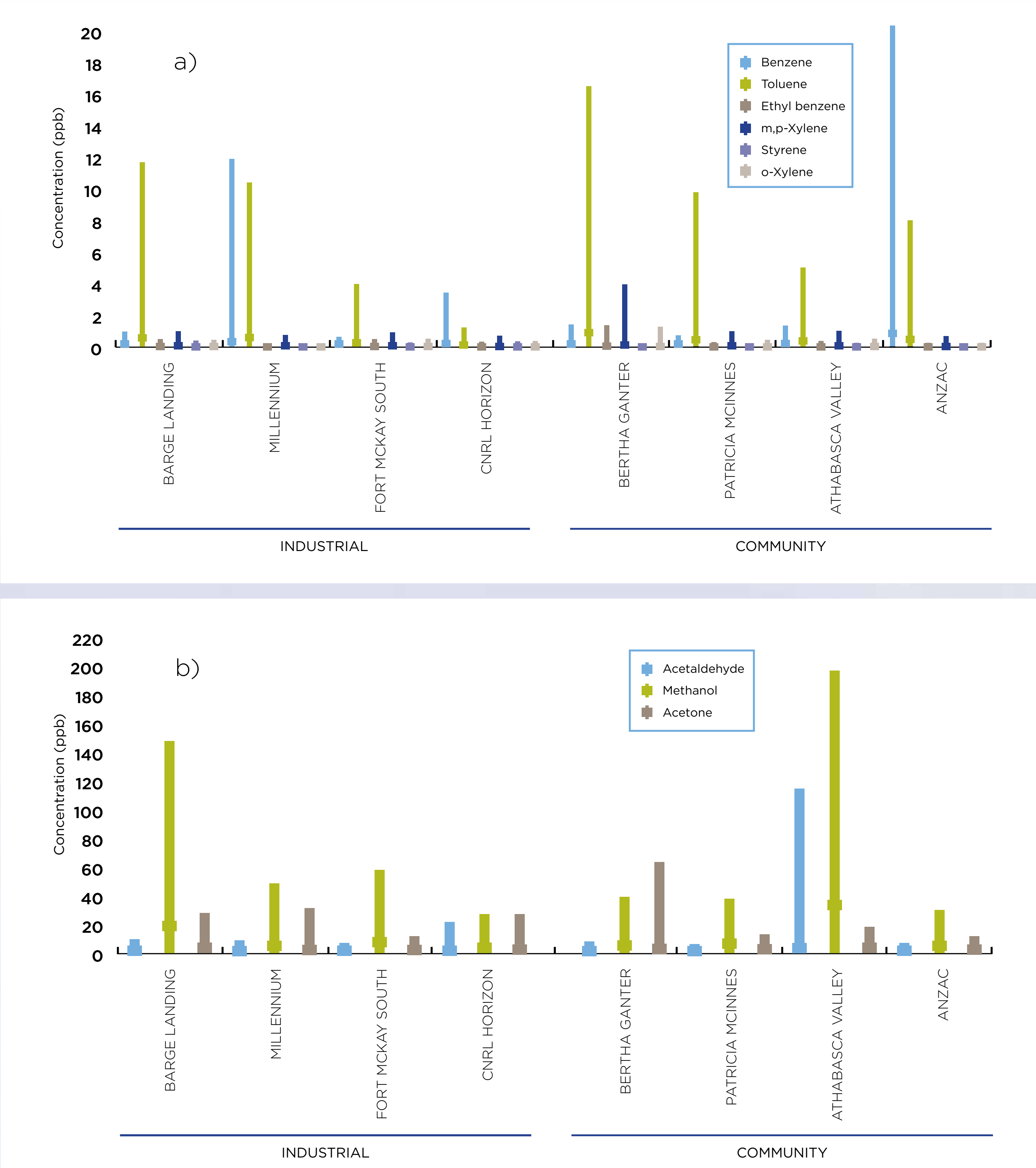
** Biogenic species

Table 7: Twenty most frequently detected VOC compounds and summary statistics for industrial sites for 2014 sorted by frequency of detection (detection limit was ~0.03 ppb).

Compound	% Detect	95th Percentile	Max.	Mean	Std. Dev.	Median
Acetone	80.0%	9.43	31.70	2.99	3.93	2.20
Isopentane	66.3%	6.05	175.00	2.01	11.54	0.56
Benzene	66.3%	0.56	11.90	0.24	0.80	0.17
Methanol	59.6%	41.40	148.00	9.03	17.81	3.55
Butane	57.1%	2.79	1260.00	6.04	81.29	0.61
Toluene	54.6%	1.23	11.70	0.40	1.49	0.08
Isobutane	46.3%	2.05	572.00	2.94	36.93	< 0.03
Acetaldehyde	43.8%	6.24	22.10	1.94	2.75	< 0.03
3-Methylpentane	28.8%	1.06	22.90	0.41	2.21	< 0.03
m, p-Xylene	26.7%	0.35	0.99	0.07	0.15	< 0.03
Methylcyclohexane	24.6%	0.58	5.88	0.13	0.48	< 0.03
alpha Pinene**	23.3%	0.45	1.12	0.07	0.16	< 0.03
Isoprene**	22.5%	3.33	7.34	0.41	1.10	< 0.03
Pentane	21.7%	3.68	140.00	1.21	9.25	< 0.03
Hexane	21.3%	1.11	137.00	1.37	11.72	< 0.03
2-Methylpentane	17.9%	1.01	22.80	0.33	1.84	< 0.03
Heptane	17.9%	0.54	1.79	0.08	0.24	< 0.03
Methylcyclopentane	17.5%	0.58	24.30	0.31	2.13	< 0.03
Cyclohexane	15.8%	0.67	5.02	0.14	0.58	< 0.03
2,3-Dimethylbutane	13.8%	0.61	1.97	0.08	0.27	< 0.03

** Biogenic species

Figure 12: Comparison of selected VOC concentrations (ppb) from community and industrial monitoring sites in 2014 (statistics shown are mean and maximum concentrations). Note that the maximum benzene concentration of 41.5 ppb at Anzac is not shown due to the scale of the graph.



4.2.7 Continuous Measurement of $PM_{2.5}$ and Integrated Measurements of $PM_{2.5}$, PM_{10} and associated metals and ions.

CHARACTERISTICS AND SOURCES

Particulate air pollution consists of a complex mixture of solid particles and liquid droplets, with varying chemical and physical composition and so is not defined by its chemical composition. Particulate matter is comprised of both inorganic (sulphates, nitrates, ammonium, mineral dust and trace elements including metals) and carbonaceous compounds. Particulates are usually classified according to size with a range of aerodynamic diameters from 0.005 µm to 100 µm, although most suspended particles are less than 40 µm in diameter. Suspended particulates are commonly classified as follows: less than 0.1 µm in diameter (ultrafine); less than 2.5 µm in diameter (fine, or respirable fraction) and between 2.5 and 10 µm in diameter (coarse or inhalable fraction). The sum of the fine and coarse fractions is referred to as PM_{10} (i.e. particulate matter less than 10 µm in aerodynamic diameter).

- Ultrafine particles (less than 0.1 µm in diameter) are formed directly in combustion exhaust, mainly from the condensation of hot vapours, but can aggregate and coagulate over time to form fine particulates. Ultrafine particles typically last only a short time in the atmosphere.
- Particles in the fine fraction (2.5 µm in diameter or less) are produced mainly by combustion processes and by atmospheric reactions between precursor gases such as sulphur dioxide, nitrogen oxides, ammonia and some volatile organic compounds. Fine particles are composed primarily of sulphate, nitrate, ammonium, inorganic and organic carbon compounds, and heavy metals.
- In the coarse fraction (between 2.5 and 10 µm in diameter), particles are mainly from re-suspended road dust, windblown dust, and material handling, grinding and crushing operations. Derived mainly from the Earth's crust, these particles may contain oxides of iron, calcium, silicon and aluminum.

The primary man-made sources of $PM_{2.5}$ in Canada are industrial sources and home firewood burning. Emissions from natural sources (e.g., forest fires) and open sources (e.g., road dust) can be much larger than primary man-made sources. Generally $PM_{2.5}$ concentrations in the atmosphere are dominated by secondary components such as sulphates, nitrates and organic carbon with primary $PM_{2.5}$ accounting for only a small fraction of total mass.

The $PM_{2.5}$ fraction of particulate matter is measured continuously in the WBEA network.

ALBERTA OBJECTIVES AND GUIDELINES

The Environment Canada and Alberta Environment and Sustainable Resource Development (AESRD) ambient air quality objective for $PM_{2.5}$ concentration is:

- 30 µg/m^3 for a 24-hour averaging time
- AESRD also has a guideline value for $PM_{2.5}$ which is:
- 80 µg/m^3 for a 1-hour averaging time

CANADIAN AMBIENT AIR QUALITY STANDARDS (CAAQGS) FOR $PM_{2.5}$

The numerical values of the CAAQS for $PM_{2.5}$ are shown in Table 7. There are both annual and 98th percentile of 24-hour averages CAAQS and there are different values for the achievement target years of 2015 and 2020.

Table 7: Canadian Ambient Air Quality Standards (CAAQS) for fine particulate matter ($PM_{2.5}$).

Pollutant	Averaging Time	Standards		Metric
		2015	2020	
$PM_{2.5}$	24-hour	28 µg/m³	27 µg/m³	The 3-year average of the annual 98th percentile of the daily 24-hour average concentrations
$PM_{2.5}$	Annual	10.0 µg/m³	8.8 µg/m³	The 3-year average of the annual average concentrations.

MONITORING METHODS FOR $PM_{2.5}$

Beginning in 1997 continuous monitoring of $PM_{2.5}$ was accomplished using a tapered element oscillating microbalance (TEOM) instrument. In more recent years it has been established that the TEOM continuous $PM_{2.5}$ instruments do not meet the data quality objectives (DQOs) that have been recommended for comparison with reference method samplers. Specifically, TEOMs often under-report levels in comparison to manual filter-based samplers due to the loss of semi-volatile particulate matter caused by heating of the sampled air to 40° C in order to remove unwanted water. This loss is typically larger in the winter than in the summer because of the larger differences between the TEOM filter and ambient temperatures in winter and higher concentrations of semi-volatile nitrates in winter. Instruments approved as U.S. EPA Class III Federal Equivalent Methods (FEM) do meet DQOs. The SHARP 5030 instrument is an approved FEM method and beginning in 2011 and into 2014, the TEOM analyzers have been replaced with the SHARP 5030 analyzers in the WBEA air monitoring network. These instruments employ a combination of beta attenuation and light scattering technology.

As of January 1, 2014, SHARP instruments were deployed at all WBEA sites except for 2 sites: Millennium (TEOM replaced on February 1, 2014) and CNRL Horizon (TEOM replaced on February 1, 2014).

CONTINUOUS MONITORING OBSERVATIONS IN 2014

There was a significant forest fire impact during August 2014 and maximum 1-hour $PM_{2.5}$ concentrations (Figure 13) at industry locations ranged from 276 μg/m³ at Millennium to 617 μg/m³ at Fort McKay South. At community locations the highest 1-hour concentrations ranged from 187 μg/m³ at Anzac to 530 μg/m³ at Bertha Ganter-Fort McKay.

The Alberta 24-hour ambient air quality objective for $PM_{2.5}$ of 30 μg/m³ was exceeded 89 times in 2014 (Figure 14). The objective was exceeded 43 times at industry locations and 46 times at community locations. For the community sites maximum 24-hour $PM_{2.5}$ concentrations ranged from 62 μg/m³ at Athabasca Valley to 206 μg/m³ at Fort Chipewyan.

Figure 13: Maximum 1-hour $PM_{2.5}$ concentrations and the 99th, 98th and 90th percentiles at industry and community stations.

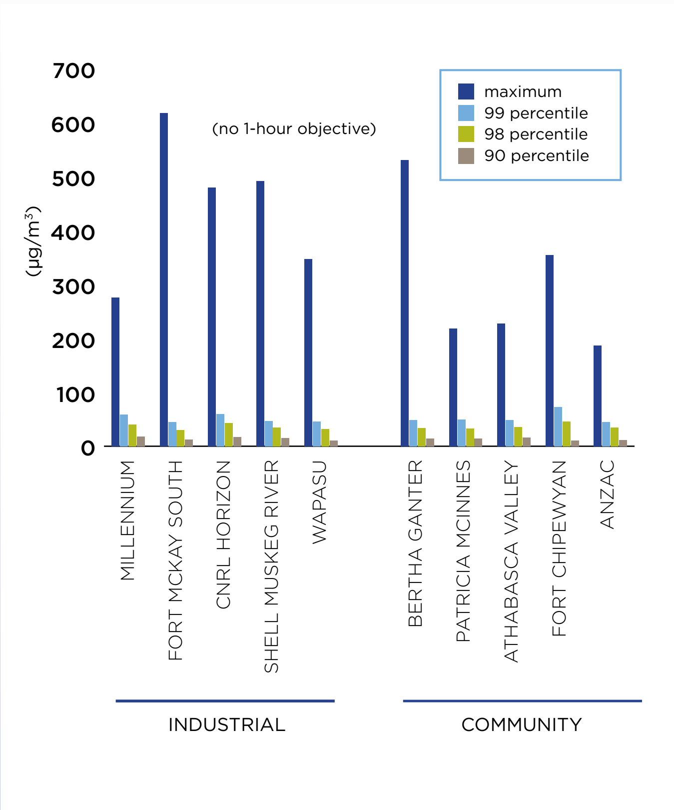
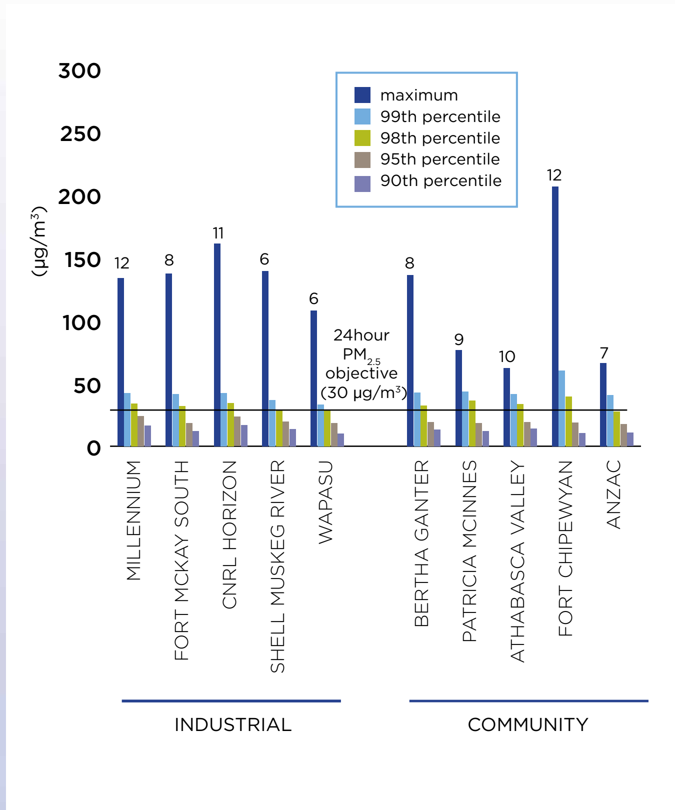


Figure 14: Maximum 24-hour $PM_{2.5}$ concentrations and the 99th, 98th, 95th and 90th percentiles at industry and community stations. The number of exceedances of the Alberta 24-hour $PM_{2.5}$ air quality objective is indicated.



In Figure 15 annual results for the WBEA sites for 2012 to 2014 are compared to the annual mean and 98th percentile CAAQS metrics (the official CAAQS numbers are based on a three year average). Results from the sites were affected by forest fires in both 2012 and 2014. In 2013 all sites were below the 98th percentile CAAQS target and two industrial sites slightly exceeded the annual mean CAAQS target. Due to the changeover in instrumentation some sites did not have sufficient data to calculate an annual mean in 2012. Comparing the three year averages (2012-2014) with the 2015 CAAQS, no sites exceeded the annual mean CAAQS and three industrial sites exceeded the 98th percentile CAAQS. In formal reporting on CAAQS, high concentrations due to occurrences such as forest fires can be excluded from the calculations of 98th percentile. If this were done for WBEA sites then the calculated 98th percentile values for all sites would be significantly lower.

Figure 15: Annual mean and 98th percentile of 24-h average $PM_{2.5}$ (µg/m³) for WBEA sites for 2012 to 2014 and compared to the 2015 CAAQS 3-year average metrics.

INTEGRATED MONITORING METHOD FOR $PM_{2.5}$ AND PM_{10} MASS AND ASSOCIATED METALS AND IONS

Samples were collected on pre-weighed laboratory filters. Air flow passed first through cyclones limiting particles to those of sizes less than either 2.5 or 10 microns. Air then passed through the filter at flow rates controlled and measured by the sampling system. Filters were then re-weighed back at the laboratory to determine the amount of mass collected, and the average concentration in the sampling period. In Canada and the United States filter based mass measurements as described above are considered the reference method for both $PM_{2.5}$ and PM_{10}.

Filters were then processed using inductively-coupled plasma mass spectrometry (ICP-MS) to determine concentrations of metals (i.e. lead, zinc, etc.) and by ion chromatography to determine concentrations of selected ions (i.e. sulphate, nitrate, etc.). Samples were analyzed for 21 metals and 8 ions. The sampling system was controlled by the station's data acquisition system and operated for 1-day, 24-hour periods (from midnight to midnight) every six days. This sampling frequency provides for a maximum of 60 samples for the year.

Measurements of $PM_{2.5}$ were made at 4 community locations: Bertha Ganter-Fort McKay, Patricia McInnes, Athabasca Valley and Anzac. Measurements of PM_{10} were made at the same community locations, and also at 4 industry locations: Millennium Mine, Fort McKay South, CNRL Horizon and Albian Muskeg River.

Results for metal and ion concentrations from $PM_{2.5}$ and PM_{10} filters are based on samples satisfying preliminary quality assurance (QA) conditions, such as adequate flow and sampling time, and concentrations greater than detection limits of the measurement system and laboratory procedures. There were between 55 and 60 samples per site satisfying these criteria and having detectable concentrations for one or more ion and metal compounds.

INTEGRATED MONITORING OBSERVATIONS IN 2014 – IONS

Sulphate and nitrate were the two ions most frequently detected in $PM_{2.5}$ filters at all sites. Figure 16 compares mean and maximum concentrations of measured ions in the $PM_{2.5}$ samples at the community sites. Sulphate, ammonium and nitrate were the ions with the highest mean concentrations in $PM_{2.5}$ filters at all four sites. Concentration data for individual community locations are published in the WBEA 2014 Annual Ambient Air Report that was submitted to AEMERA. It can be found at *http://www.wbea.org/resources/ambient-air-monitoring-reports/ambient-annual-reports.*

Figure 17 provides mean and maximum concentrations of the measured ions in the PM_{10} samples at the community sites. Sulphate and calcium were the ions with the highest mean concentrations at the sites. The Athabasca Valley site recorded the highest maximum concentrations of sodium and chloride in the PM_{10} samples likely due to the impact of road salting on the nearby highway and bridge.

The ratio of the $PM_{2.5}$ to PM_{10} 24-hour ion concentrations are shown in Figure 18 for the community sites. As PM_{10} is made up of both fine ($PM_{2.5}$) and coarse PM, ratios approaching one indicate that the ion is predominantly found in the $PM_{2.5}$ fraction and is associated with atmospheric formation processes or direct source emissions. A smaller ratio indicates the ion is also found in the coarse fraction and is likely associated with re-suspended road dust, windblown dust and/or material handling, grinding and crushing operations.

Mean and maximum concentrations of the most frequently measured ions in the PM_{10} samples at the industrial sites are shown in Figure 19. Mean concentrations were very similar to the community sites with higher mean calcium levels measured at the Millennium Mine and Albian Muskeg River sites.

Figure 16: Mean concentrations (µg/m³) of ions measured from $PM_{2.5}$ filters (24-hour sampling) for community locations in 2014 (mean for all sites and 95th confidence interval for mean are shown).

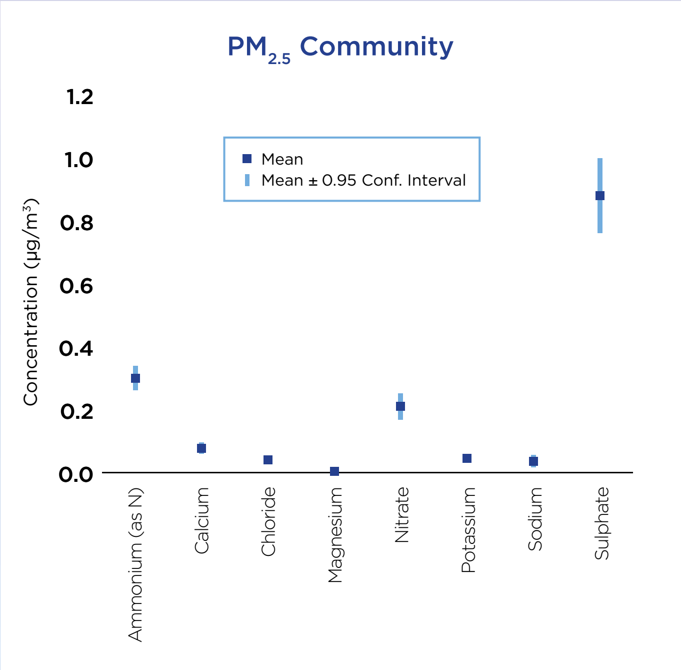


Figure 17: Mean concentrations (µg/m³) of ions measured from PM_{10} filters (24-hour sampling) for community locations in 2014 (mean for all sites and 95th confidence interval for mean are shown).

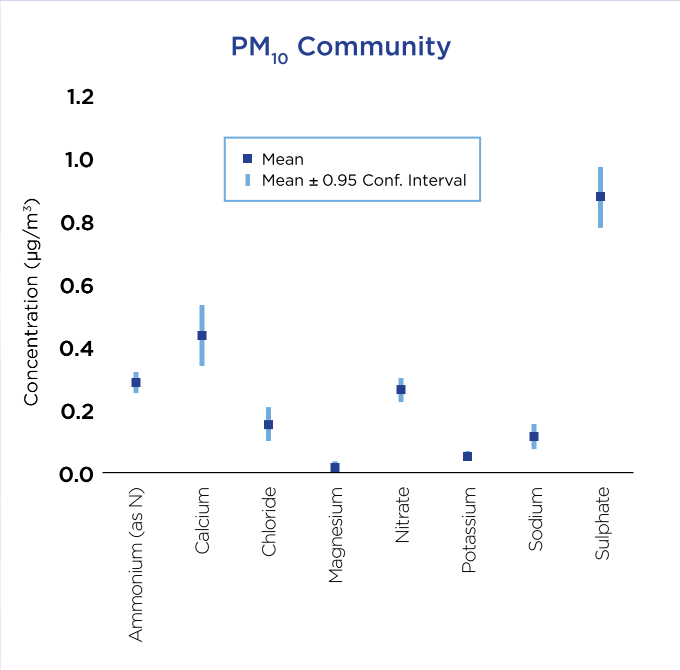


Figure 18: Ratio of 24-hour $PM_{2.5}$ to PM_{10} concentrations for ions measured at community locations in 2014 (mean for all sites and 95th confidence interval for mean are shown). These data show the ratio of contribution from coarse and fine particles.

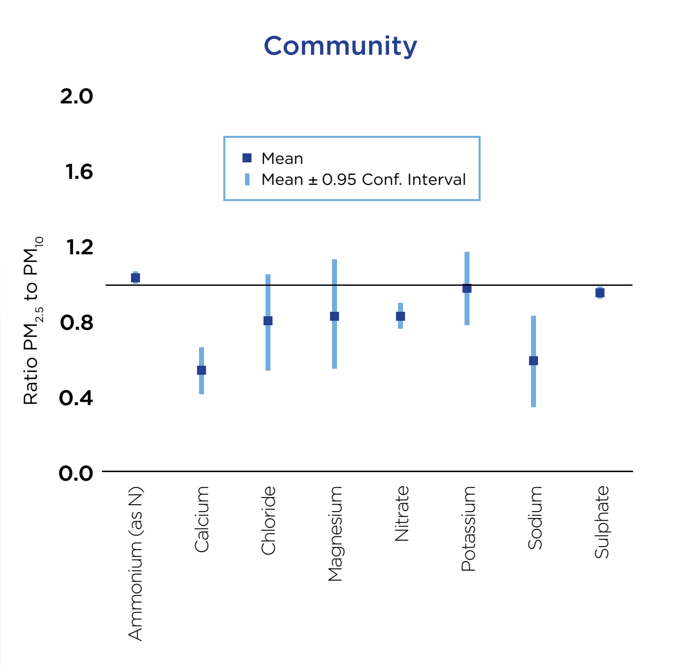
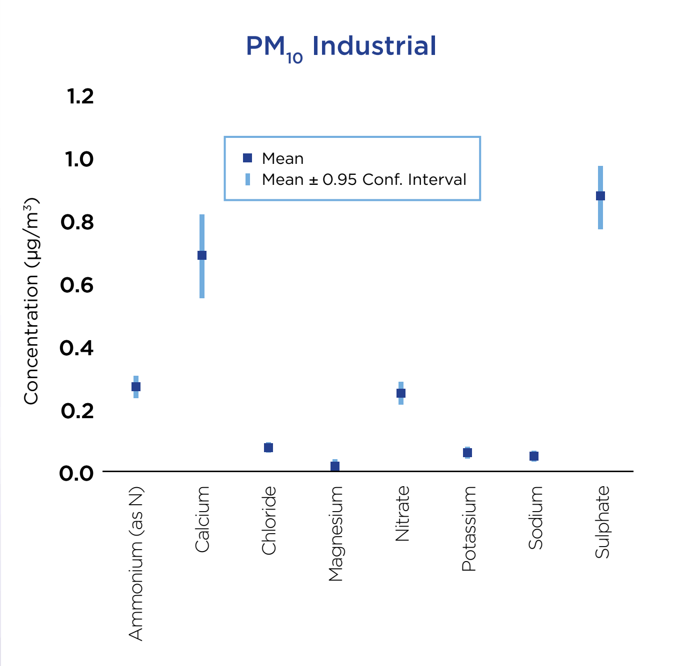


Figure 19: Mean concentrations (µg/m³) of ions measured from PM_{10} filters (24-hour sampling) for industrial locations in 2014 (mean for all sites and 95th confidence interval for mean are shown).



INTEGRATED MONITORING OBSERVATIONS IN 2014 - METALS

Iron, zinc and aluminum were the metals most frequently detected and found with highest mean and maximum concentrations at all community sites. Figure 20 compares mean concentrations of all measured metals in the $PM_{2.5}$ samples at the community sites.

Figure 21 provides mean concentrations of the measured metals in the PM_{10} samples at the community sites. Results are similar to $PM_{2.5}$ for the relative abundance of the metals. The ratios of the $PM_{2.5}$ to PM_{10} 24-hour metal concentrations are shown in Figure 22 for the community sites. Again, ratios approaching one indicate that the metal is predominantly found in the $PM_{2.5}$ fraction and is associated with direct source emissions. A smaller ratio indicates the metal is found in the coarse fraction and is likely associated with re-suspended road dust, windblown dust and/or material handling, grinding and crushing operations. The lowest ratios are found for iron, aluminum and barium which are components of soil. Ratios close to one are found for zinc, chromium, lead and cobalt.

Mean concentrations of the measured metals in the PM_{10} samples at the industrial sites are shown in Figure 23. Higher levels of the crustal elements iron, aluminum and barium were found at the Millennium Mine and Albian Muskeg River sites.

Figure 20: Mean concentrations (µg/m³) of metals measured from $PM_{2.5}$ filters (24-hour sampling) for community locations in 2014 (mean for all sites and 95th confidence interval for mean are shown).

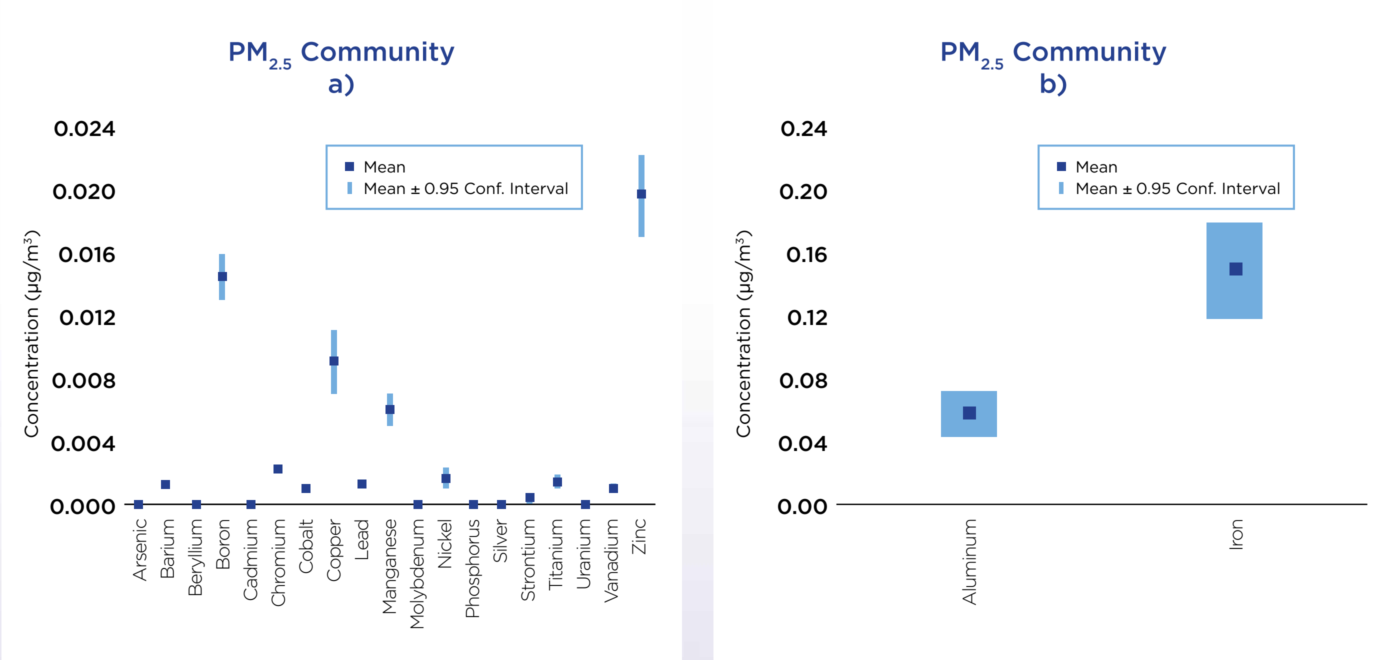


Figure 21: Mean concentrations (µg/m³) of metals measured from PM_{10} filters (24-hour sampling) for community locations in 2014 (mean for all sites and 95th confidence interval for mean are shown).

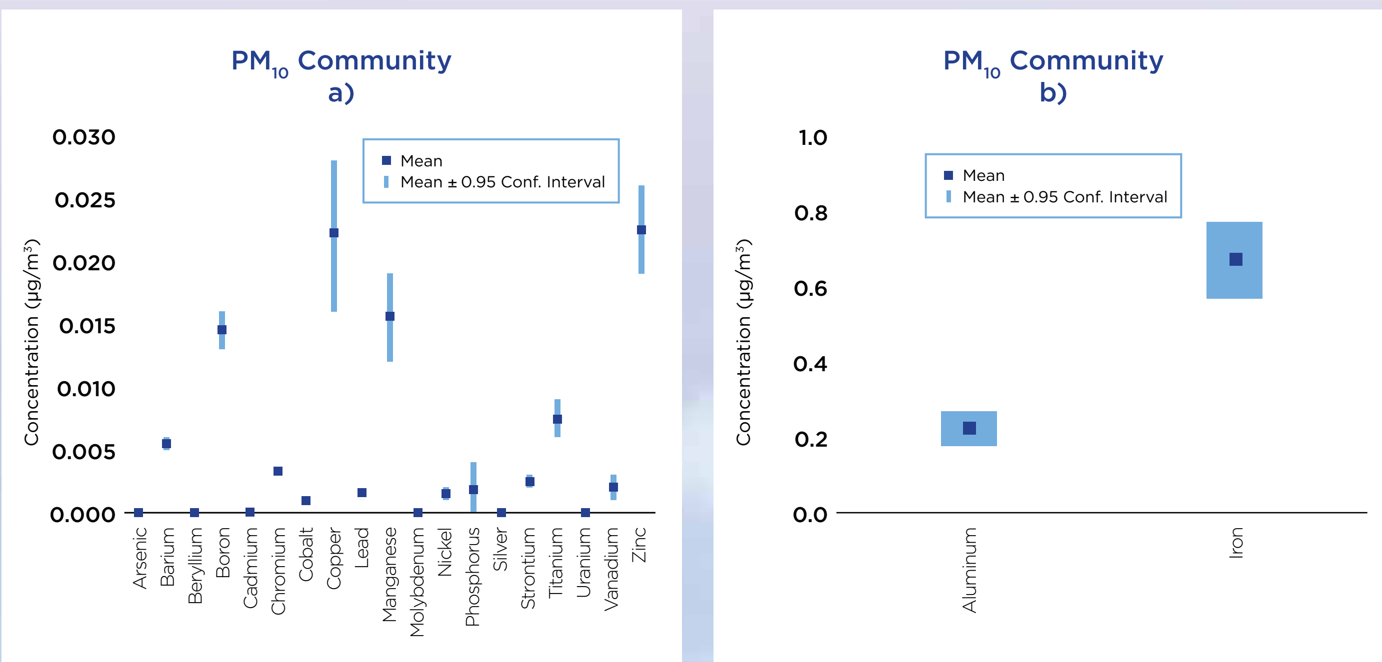


Figure 22: Ratio of 24-hour $PM_{2.5}$ to PM_{10} concentrations for metals measured at community locations in 2014 (mean for all sites and 95th confidence interval for mean are shown).

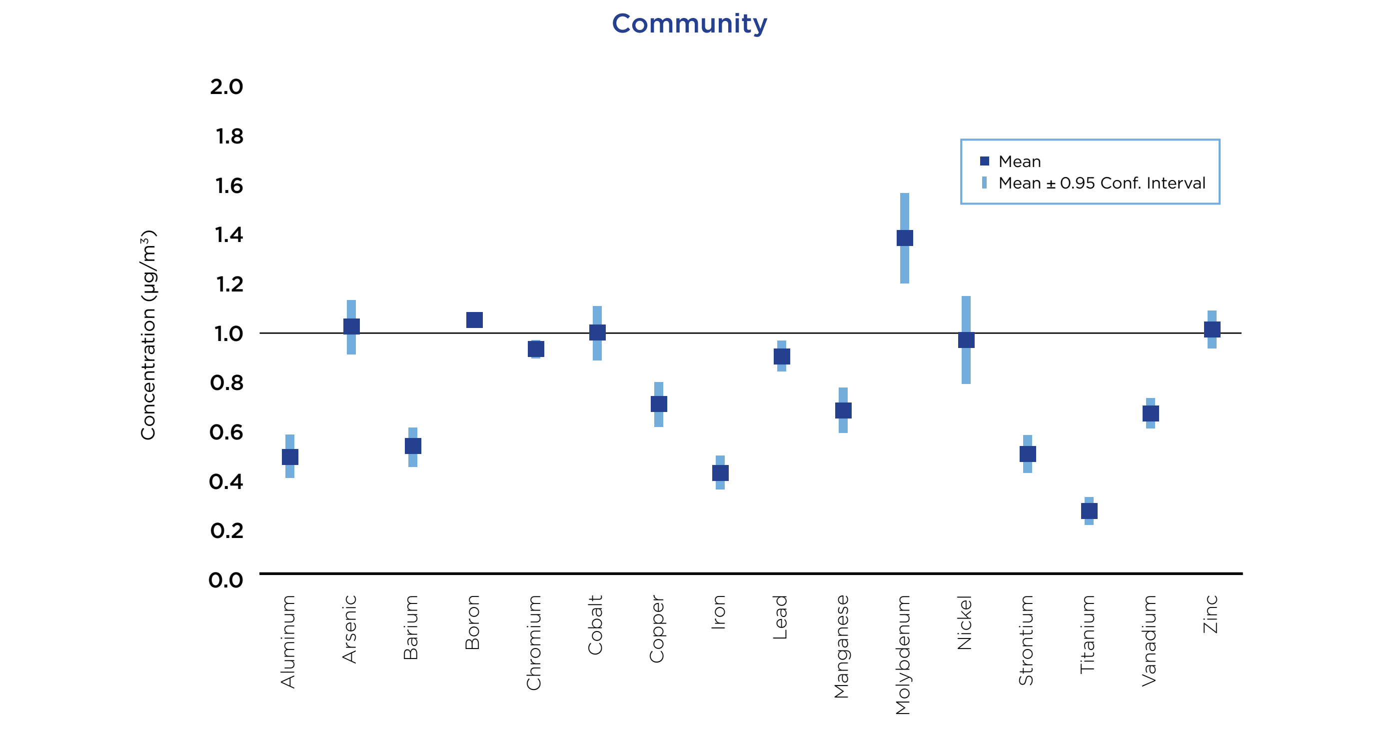
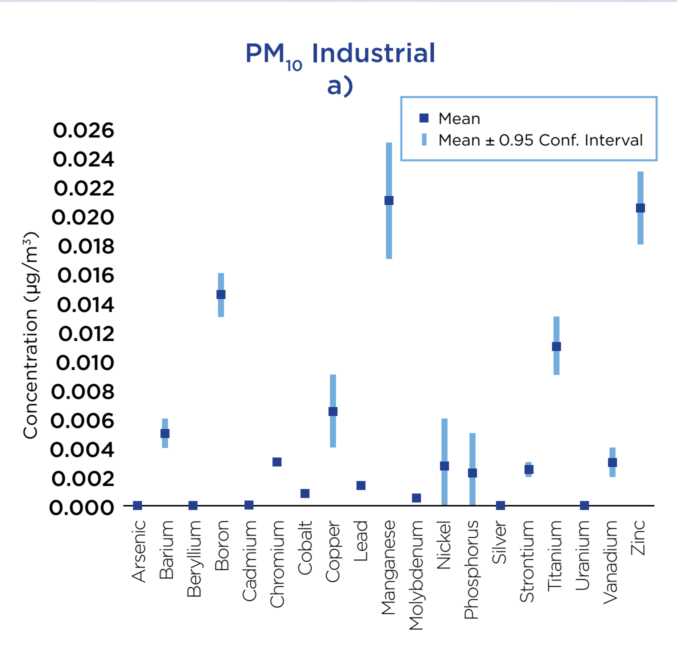
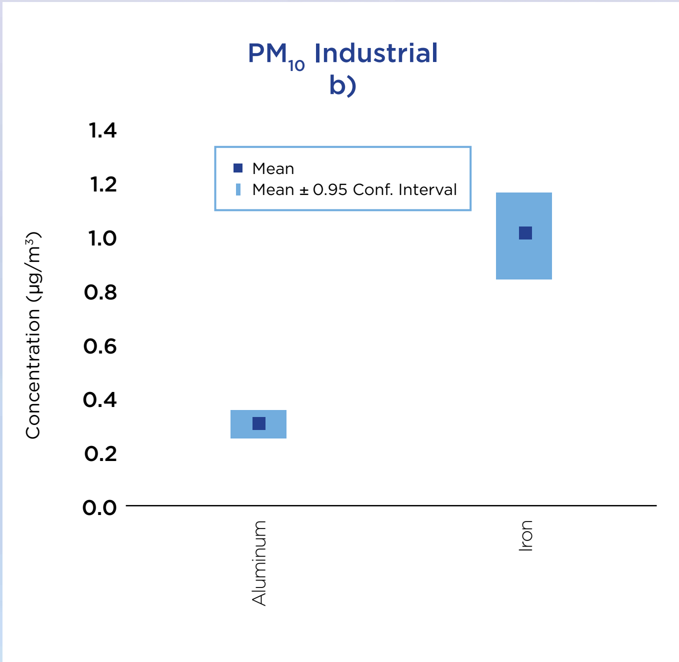


Figure 23: Mean concentrations (µg/m³) of metals measured from PM_{10} filters (24-hour sampling) for industrial locations in 2014 (mean for all sites and 95th confidence interval for mean are shown).





4.2.8 Ozone (O_3)

CHARACTERISTICS

Ozone (O_3) is a reactive, unstable form of oxygen. In concentrations found in outdoor air, even in the most severe pollution episodes, O_3 is both colourless and odourless. It is not emitted directly but it is formed in the air from precursor pollutants, most notably nitrogen oxides (NO_X) and reactive hydrocarbons or volatile organic compounds (VOCs). Ozone concentrations are influenced largely by presence of nitrogen oxides and reactive hydrocarbons, and also by strong sunlight and warmer temperatures. Unlike other pollutants, ozone is also a natural component of the atmosphere with greater concentrations at higher altitudes.

ALBERTA OBJECTIVES AND GUIDELINES

The Alberta ambient air quality objective for O_3 is:

- 1-hour average of 82 ppb (160 µg/m^3)

CANADIAN AMBIENT AIR QUALITY STANDARDS (CAAQS) FOR OZONE

The numerical values of the CAAQS for ozone are shown in Table 8. The standard is based on the fourth highest daily maximum 8-hour ozone value for each year and is averaged over a three-year period.

Table 8: Canadian Ambient Air Quality Standard (CAAQS) for ozone.

Pollutant	Averaging Time	Standards		Metric
		2015	2020	
Ozone	8-hour	63 ppb	62 ppb	The 3-year average of the annual 4th highest daily maximum 8-hour average concentrations.

MONITORING METHOD FOR OZONE

Continuous monitoring of O_3 is conducted with electronic analyzers using ultraviolet photometry. Concentrations of O_3 are indicated by the reduction of intensity for a wavelength specific light due to absorption by O_3 molecules in the air sample.

CONTINUOUS MONITORING OBSERVATIONS IN 2014

The highest 1-hour O_3 concentrations (Figure 24) at the two industry locations were 105 and 109 ppb. At community stations, the highest 1-hour concentrations over the entire year ranged from 66 ppb at Anzac to 104 ppb at Bertha Ganter-Fort McKay.

The Alberta one-hour ambient air quality objective for O_3 of 82 ppb was exceeded 16 times in 2014.

In Figure 25 annual results for the WBEA sites for 2012 to 2014 are compared to the CAAQS metric. All sites were below the 63 ppb three-year average 2015 CAAQS target.

Figure 24: Maximum 1-hour O_3 concentrations and the 99th and 90th percentiles at industry and community locations.

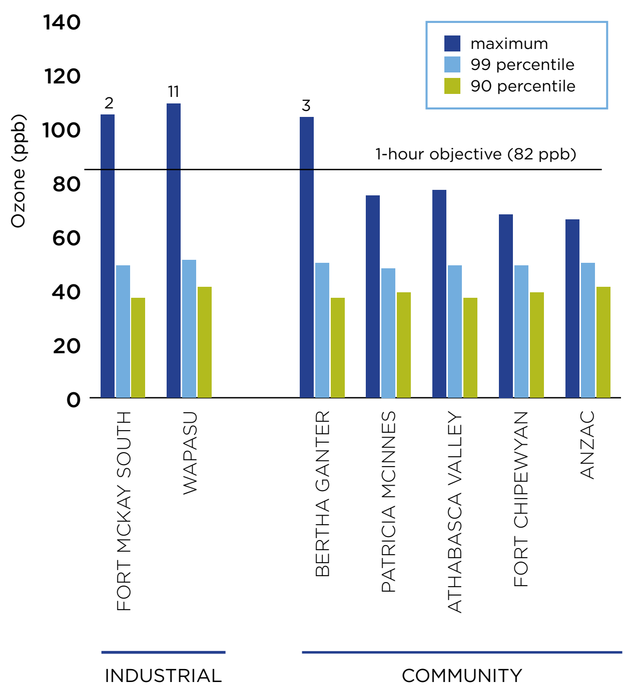
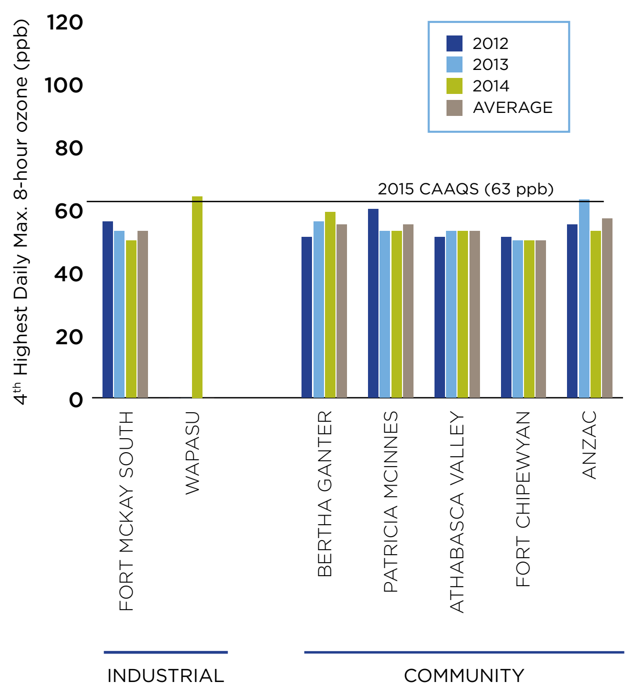


Figure 25: Fourth highest daily maximum 8-hour ozone for WBEA sites for 2012 to 2014 and compared to the 2015 CAAQS 3-year average metric.



4.2.9 Nitrogen Dioxide (NO_2)

CHARACTERISTICS AND SOURCES

Nitrogen dioxide (NO_2) is a reddish-brown gas with a pungent, irritating odour. Oxides of nitrogen, mostly in the form of nitric oxide, NO, and nitrogen dioxide, NO_2, are produced by the combustion of fossil fuels. Nitric oxide is rapidly converted to NO_2 and other oxides of nitrogen such as peroxyacetyl nitrate (PAN), nitric acid (HNO_3) and particulate nitrate (p-NO_3). The major end-product of NO oxidation is nitric acid (HNO_3). Nitric acid is very water soluble and is rapidly deposited to the landscape via wet and dry deposition. Nitrogen dioxide plays a major role in atmospheric photochemical reactions and ground level ozone formation and destruction.

ALBERTA OBJECTIVES AND GUIDELINES

Alberta ambient air quality objectives for NO_2 are:

- 1-hour average of 159 ppb (300 µg/m^3)
- Annual average of 24 ppb (45 µg/m^3)

For exceedances of the Lower Athabasca Regional Plan (LARP) trigger levels, please see Section 4.3, page 62.

MONITORING METHOD FOR NO_2

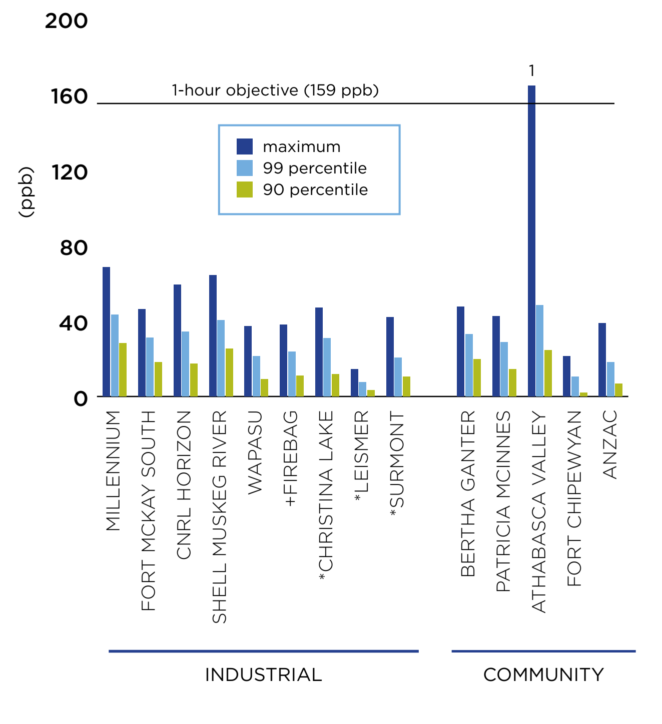
Monitoring of NO_2 is conducted using electronic analyzers that employ chemiluminescence, in which light given off by a chemical reaction is proportional to concentration of gas in the reaction. At different stages of the analyzer's process, NO, and then NO_x converted to NO, are reacted with O_3 to produce light. The intensities of light indicate concentrations of NO and concentrations of NO_x in the air sample. From these concentrations, the analyzer calculates and outputs the concentration of NO_2.

CONTINUOUS MONITORING OBSERVATIONS IN 2014

The maximum 1-hour NO_2 concentrations monitored over the entire year (Figure 26) at industry locations ranged from 37 ppb at Wapasu to 68 ppb at Millennium. At community locations, the maximum 1-hour concentrations ranged from 21 ppb at Fort Chipewyan to 165 ppb at Athabasca Valley. The 99th percentile NO_2 concentrations ranged from 11 to 48 ppb at the community sites and from 21 to 43 ppb at the industrial sites. There was one exceedance of the Alberta 1-hour average air quality objective of 159 ppb at the Athabasca Valley site. The annual average objective of 24 ppb was not exceeded at any station in 2014 with annual means ranging from 1 to 10 ppb at the community sites.

A recent analysis of WBEA 1998-2012 hourly ambient air community station data by Bari and Kindzierski (2015) concluded that, while there were no significant trends in ambient concentrations for SO_2, O_3 and $PM_{2.5}$, small increasing concentration trends were observed for NO_2 (<1 ppb/year) at the Fort McKay and Fort McMurray stations.

Figure 26: Maximum 1-hour NO_2 concentrations and the 99th and 90th percentile values at industry and community locations.



* Portable monitoring sites operated for only part of the year (see Table 3).
\+ Firebag site began operation on July 19, 2014.

4.2.10 Ammonia (NH_3)

CHARACTERISTICS AND SOURCES

Ammonia (NH_3) is a naturally occurring, colourless, acrid-smelling gas. It is volatile and highly water-soluble. On a global scale, more than 99% of the ammonia present in the atmosphere is the result of natural processes, mainly biological degradation of organic matter, such as plants and animals, and chemical and microbial degradation of animal wastes, in particular, urine. The major sources for atmospheric emissions of ammonia in Alberta are agricultural activities (animal feedlot operations and other activities), biomass burning (including forest fires), fertilizer plants, and to a lesser extent fossil fuel combustion and accidental releases. Ammonia is used for scrubbing SO_2 from one emission source in the RMWB.

Gaseous ammonia is a very important basic compound in the atmosphere. It reacts readily with acidic substances or sulphur dioxide to form ammonium salts that occur predominantly in the fine fraction of particulate matter ($PM_{2.5}$).

ALBERTA OBJECTIVES AND GUIDELINES

The Alberta ambient air quality objective for ammonia is:

- 1-hour average of 2000 ppb (1400 µg/m^3), reviewed 2004

MONITORING METHOD FOR AMMONIA

The ammonia analyzers operate on the same principle as the oxide of nitrogen analyzers but an additional heated stainless steel converter (725 °C) is used to convert both NO_2 and NH_3 to NO. The ammonia concentration is determined by difference with a typical detection limit of 1 ppb.

CONTINUOUS MONITORING OBSERVATIONS IN 2014

Ammonia is monitored at two community stations, Bertha Ganter-Fort McKay and Patricia McInnes. Ammonia concentrations were below detection for more than 99% of hours at both sites. A maximum 1-hour concentration of 10 ppb was measured at the Bertha Ganter-Fort McKay site and a maximum 1-hour concentration of 20 ppb at the Patricia McInnes site.

4.2.11 Carbon Monoxide (CO)

CHARACTERISTICS AND SOURCES

Carbon monoxide (CO) is a colorless, odorless gas emitted from combustion processes. Carbon monoxide is formed from the incomplete combustion of carbon in fossil fuels. Transportation and vehicle emissions are the major source of carbon monoxide with elevated concentrations during the morning and evening rush hours. Other sources include building heating systems, boilers, and industrial operations.

ALBERTA OBJECTIVES AND GUIDELINES

The Alberta ambient air quality objectives for carbon monoxide are:

- 1 hour average of 13 ppm (15,000 $\mu g/m^3$)
- 8 hour average of 5 ppm (6,000 $\mu g/m^3$)

MONITORING METHOD FOR CO

Measurement of CO is conducted using analyzers that employ infrared absorption. CO absorbs infrared radiation of wavelength 4.6 microns. Reduction in intensity of light with this wavelength from a calibrated light source when passed through an air sample is indicative of the concentration of CO in ambient air.

CONTINUOUS MONITORING OBSERVATIONS IN 2014

Carbon monoxide is monitored only at the Athabasca Valley location in Fort McMurray. The maximum one-hour average concentration measured at the site was 1.3 ppm in 2014 which was well below the Alberta ambient air quality objective of 13 ppm for CO. The median CO concentration for the site was less than 0.1 ppm and the 90th percentile concentration was 0.2 ppm.

4.2.12 Polycyclic Aromatic Hydrocarbons (PAH)

CHARACTERISTICS AND SOURCES

Polycyclic aromatic hydrocarbons (PAH) are one of a group of compounds called semi-volatile organic compounds (SVOC). SVOC are transported in the atmosphere in both the gas and particle phase. The distribution between these phases depends on the physical and chemical properties (especially vapour pressure) and the concentration of the compound, the ambient air temperature, humidity and the concentration and nature of the atmospheric particles. Wet and dry deposition and chemical transformation remove particle-associated SVOCs from the atmosphere.

PAHs are found in the environment as a result of natural sources such as forest fires or volcanic eruptions. Many human activities contribute to PAH emissions with aluminum smelting, automobile and truck transport exhaust and coal-fired power generation being three major sources of PAHs to the environment. In the event of forest fires which occur yearly, this will form the largest source of PAHs to the environment.

MONITORING METHOD FOR PAH

Polycyclic aromatic compounds (PAHs) are sampled by drawing air through a fibre glass filter and then a polyurethane foam filter (PUF) using electronically controlled flow devices to control timing and flow. The filter and PUF are shipped to a laboratory, extracted and analyzed using gas chromatography and mass selective detection (MSD).

Polycyclic aromatic compounds were sampled every 6 days for a 24-hour period at 4 community stations: Bertha Ganter-Fort McKay, Patricia McInnes, Athabasca Valley, and Anzac. During the year there were approximately 60 days of results from each station.

Samples were analyzed for 23 compounds. The results summary includes combined results from the filter and PUF. The current PAH sampler, PUF with glass fibre filter, has low collection efficiencies for acenaphthylene, and acenaphthene. The collection efficiency of naphthalene is around 35% according to USEPA TO13A.

INTEGRATED MONITORING OBSERVATIONS IN 2014 – PAH

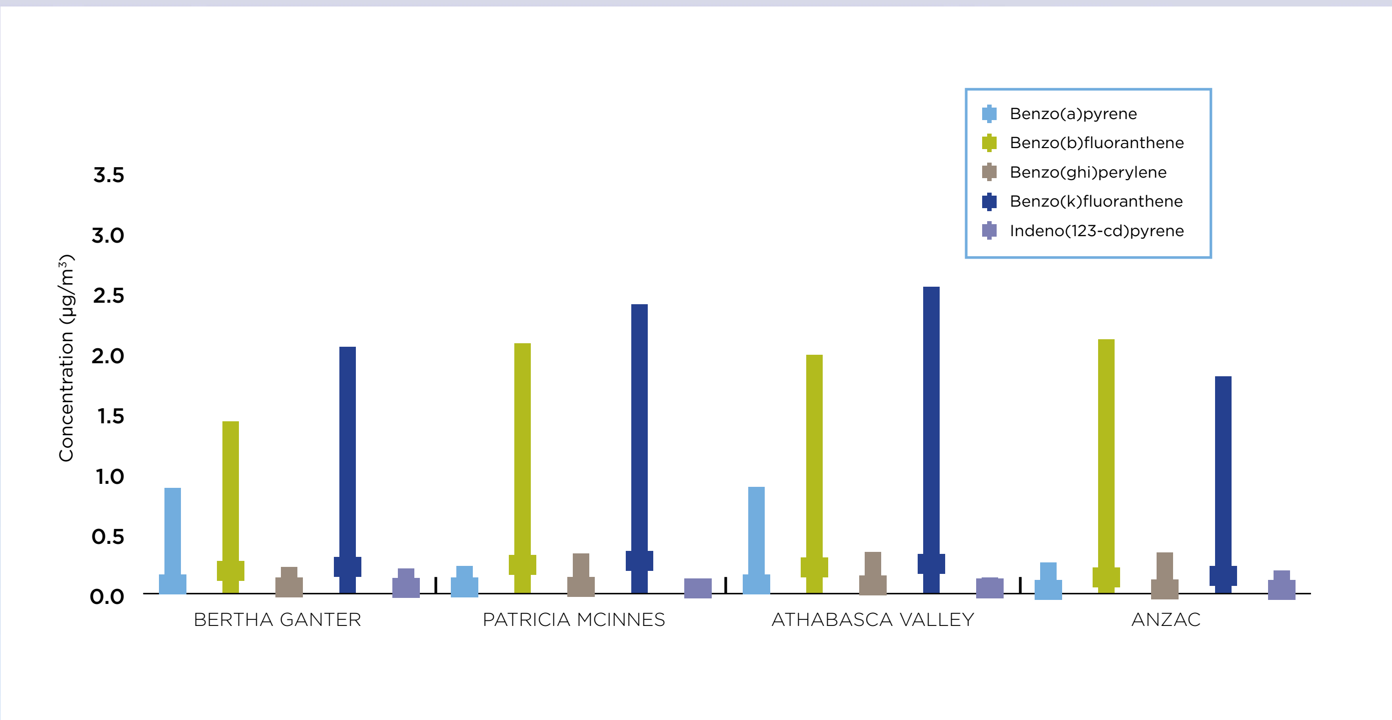
Measured species and summary statistics for 2014 for all samples are summarized in Table 9. Reported units for PAH are ng/m^3. The low molecular weight PAH had the highest mean and maximum concentrations. These species exist predominantly in the vapour phase and as previously noted the sampler is not an efficient collector of naphthalene, acenaphthylene or acenaphthene especially during periods of warmer temperatures.

Figure 27 compares concentrations of some of the more important (from a health effects point of view) high molecular weight PAH measured at the sites in 2014. These species are usually measured predominantly in the particulate phase. The figure shows mean, minimum and maximum concentrations of benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(123-cd)pyrene and benzo(ghi)perylene by site. Mean concentrations were very similar at all four community sites with the highest maximum concentrations of benzo(a)pyrene measured at Athabasca Valley and Bertha Ganter-Fort McKay.

Table 9: Measured PAH species and summary statistics (ng/m³) for all 24-hour samples collected in 2014 (234 total samples).

Compound	% Detect	90th Percentile	95th Percentile	Maximum	Mean	Std. Dev.
Naphthalene	100.0%	39.12	53.66	250.73	21.69	29.30
Acenaphthylene	98.7%	2.99	4.73	17.01	1.08	1.90
Acenaphthene	100.0%	4.68	13.46	126.72	3.88	12.74
Fluorene	100.0%	5.13	8.93	77.64	3.20	8.33
Phenanthrene	100.0%	8.97	13.47	99.47	4.92	11.26
Anthracene	98.3%	0.82	1.17	5.83	0.43	0.78
Acridine	95.7%	0.76	1.13	2.92	0.32	0.43
Fluoranthene	100.0%	1.07	2.13	4.29	0.48	0.65
Pyrene	100.0%	1.00	1.54	4.80	0.44	0.57
Benzo(c)phenanthrene	48.7%	0.10	0.22	0.44	0.04	0.06
Benz(a)anthracene	65.4%	0.15	0.28	2.02	0.08	0.20
Chrysene	68.8%	0.18	0.36	2.06	0.09	0.20
7,12-Dimethylbenz(a)anthracene	79.9%	0.52	0.73	1.87	0.19	0.27
Benzo(b)fluoranthene	76.1%	0.47	0.66	2.11	0.19	0.34
Benzo(k)fluoranthene	86.3%	0.52	0.74	2.55	0.22	0.37
Benzo(a)pyrene	58.5%	0.12	0.19	0.88	0.06	0.10
3-Methylcholanthrene	53.0%	0.17	0.26	0.58	0.07	0.09
Indeno(123-cd)pyrene	52.6%	0.10	0.12	0.21	0.04	0.04
Dibenz(a,h)anthracene	36.8%	0.08	0.10	0.18	0.03	0.03
Benzo(ghi)perylene	55.1%	0.12	0.19	0.35	0.05	0.06
Dibenzo(a,h)pyrene	20.9%	0.06	0.07	0.09	0.02	0.02
Dibenzo(a,i)pyrene	24.8%	0.06	0.09	0.11	0.02	0.03
Dibenzo(a,l)pyrene	47.0%	0.08	0.10	0.23	0.04	0.04

Figure 27: Concentrations of selected PAH (ng/m³) at community monitoring sites for 2014 (mean and minimum and maximum concentrations are shown).



4.2.13 References

ALBERTA AMBIENT AIR QUALITY OBJECTIVES:

Alberta Ambient Air Quality Objectives and Guidelines, issued April 2011. Government of Alberta, Environment, 5pp. http://environment.gov.ab.ca/info/library/5726.pdf

OTHER:

Bari, M.A., Kindzierski, 2015. Fifteen-year trends in critical air pollutions in the oil sands communities of Alberta, Canada. Environment International 74, 200-208.

U.S. Environmental Protection Agency (USEPA) 1999. Compendium Method TO-13A. Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air. Determination of Polycyclic Aromatic Hydrocarbons (PAHs) in Ambient Air Using Gas Chromatography/Mass Spectrometry (GC/MS). EPA/625/R-96/010b. U.S. Environmental Protection Agency, Cincinnati, OH.

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4.3 Reporting for the Lower Athabasca Regional Plan

The Lower Athabasca Regional Plan (LARP) was the first regional plan developed under the Alberta Land-Use Framework. The LARP website may be found at: *www.landuse.alberta.ca/RegionalPlans/LowerAthabascaRegion/Pages/default.aspx*

The LARP came into effect in September 2012. The intent of LARP, for air, is to:

- Manage air quality limits and triggers for NO_2 and SO_2
- Monitor and evaluate ambient air quality data in the planning region
- Evaluate the effectiveness of the air framework in meeting the air quality objectives stated in the regional plan *(http://esrd.alberta.ca/focus/cumulative-effects/cumulative-effects-management/management-frameworks/documents/LARP-AnnualProgressReport-2013.pdf).*

WBEA supports LARP by conducting regional air quality monitoring and providing quality-assured data to the Clean Air Strategic Alliance (CASA) for use by Alberta Environment and Sustainable Resource Development (AESRD). In 2014, SO_2 was measured continuously by WBEA at fifteen Air Monitoring Stations (AMS): Bertha Ganter-Fort McKay, Mildred Lake, Buffalo Viewpoint, Mannix, Patricia McInnes, Athabasca Valley, Fort Chipewyan, Lower Camp, Millennium Mine, Fort McKay South, Anzac, CNRL Horizon, Albian Muskeg River, Wapasu and Firebag. In 2014, NO_2 was measured continuously by WBEA at eleven air monitoring stations: Bertha Ganter-Fort McKay, Patricia McInnes, Athabasca Valley, Fort Chipewyan, Millennium Mine, Fort McKay South, Anzac, Albian Muskeg River, Wapasu and Firebag. Triggers and limits set under Section 23(1) (b) of the LARP, and the hourly-average concentrations measured in 2014 by WBEA, expressed against the LARP limits and triggers, are shown in Tables 1 and 2.

Table 1. LARP NO_2 limits and triggers with WBEA measured concentrations.

LARP Metrics	LARP Concentration	WBEA stations exceeding (concentration)
Annual average		
Limit	24 ppb	None
Level 3 trigger	16 ppb	None
Level 2 trigger	8 ppb	Athabasca Valley (10.3 ppb) Millennium Mine (12.1 ppb) Muskeg River (11.7 ppb)
99th Percentile		
Level 4 trigger	92 ppb	None
Level 3 trigger	62 ppb	None
Level 2 trigger	30 ppb	Bertha Ganter-Fort McKay (32.9 ppb) Athabasca Valley (48.3 ppb) Millennium Mine (43.2 ppb) Fort McKay South (31.1 ppb) CNRL Horizon (34.2 ppb) Muskeg River (40.3 ppb)

In 2014, no WBEA AMS exceeded the NO_2 annual average-based limit (24ppb) or level 3 trigger (16 ppb). Three AMS exceeded the annual NO_2 average-based trigger 2 level of 8 ppb. No WBEA AMS exceeded the LARP NO_2 99th percentile-based level 4 trigger (92 ppb) or level 3 trigger (62 ppb). Six stations exceeded the LARP NO_2 percentile-based level 2 trigger of 30 ppb (Table1).

Table 2. LARP SO_2 limits and triggers with WBEA measured concentrations.

LARP Metrics	LARP Concentration	WBEA stations exceeding (concentration)
Annual average		
Limit	8 ppb	None
Level 3 trigger	5 ppb	None
Level 2 trigger	3 ppb	None
99th Percentile		
Level 4 trigger	36 ppb	None
Level 3 trigger	24 ppb	Mildred Lake (28.0 ppb) Mannix (32.0 ppb)
Level 2 trigger	12 ppb	Bertha Ganter-Fort McKay (15.0 ppb) Patricia McInnes (12.0 ppb) Lower Camp (16.0 ppb) Millennium Mine (19.0 ppb) Fort McKay South (17.0 ppb) CNRL Horizon (15.0 ppb) Muskeg River (16.0 ppb)

In 2014, no WBEA AMS exceeded the annual average-based SO_2 limit (8 ppb), or the annual level 3 (5 ppb) or level 2 trigger (3 ppb) concentrations. No WBEA AMS exceeded the LARP SO_2 99th percentile-based level 4 trigger of 36 ppb. Two WBEA AMS exceeded the LARP SO_2 99th percentile-based level 3 trigger of 24 ppb. Seven AMS exceeded the annual LARP SO_2 99th percentile-based level 2 trigger of 12 ppb (Table2).

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2014 ambient air quality data from WBEA's air monitoring stations, including Athabasca Valley, pictured, were reported to Alberta Environment and Sustainable Resource Development for inclusion in the Lower Athabasca Regional Plan (LARP).

4.4 Air Quality Health Index Values for WBEA Community Air Monitoring Stations

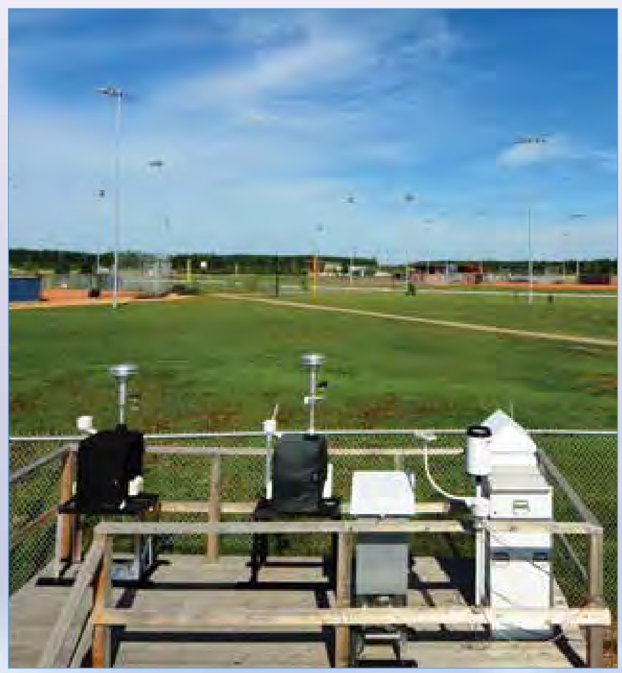
The Air Quality Health Index (AQHI) provides the public with an easily accessible guide to regional air quality and any possible health effects, based upon data for a limited mixture of common pollutants: ozone (O_3), nitrogen dioxide (NO_2), and fine particulate matter ($PM_{2.5}$). It is important to note that many common odour-causing compounds are not included in this calculation. The AQHI was developed by Environment Canada and Health Canada. It has been adopted by all provinces. WBEA, in partnership with Alberta Environment and Sustainable Resource Development (AESRD), began reporting the AQHI for our community air monitoring stations in 2011. In January 2014, the AQHI for the Anzac station became available. A forecast component predicts the AQHI, at each station, for the following day.

The AQHI reports air quality in terms of Low, Moderate, High and Very High Health Risk. The 2014 hourly AQHI values in this article were provided by AESRD, and the percentage of values within each of the four risk categories were calculated for participating WBEA stations. WBEA is grateful to Andrew Clayton, Ambient Air Specialist, AESRD, for providing the annual AQHI summaries. The AQHI is now available in over 20 communities across Alberta. View the current and forecasted provincial AQHI on the AESRD website at: *http://www.environment.alberta.ca/apps/aqhi/aqhi.aspx*

WBEA's continuous air analyzers provide hourly data for O_3, NO_2 and $PM_{2.5}$. Alberta's AQHI values are calculated using a formula which combines the readings of these three pollutants. However, because of Alberta's energy based economy, additional pollutants - sulphur dioxide (SO_2), hydrogen sulphide (H_2S), total reduced sulphur (TRS) and carbon monoxide (CO) - are considered in the AQHI calculation - but only when their concentrations exceed set thresholds. For example, if established pollutant thresholds for $PM_{2.5}$, O_3, NO_2, SO_2, H_2S/TRS or CO are exceeded when the AQHI value is at a Low or Moderate Risk, then the AQHI value is immediately replaced with the appropriate High or Very High Risk value.

Once calculated by AESRD, AQHI values are streamed to WBEA's website, mobile AQHI app, regional message centers and the WBEA headquarters electronic sign in Fort McMurray.

In 2014, four WBEA air monitoring stations – Anzac, Athabasca Valley (in Fort McMurray), Fort McKay South and Fort Chipewyan - automatically streamed hourly data to AESRD for calculation of the AQHI. The percentage hourly average measurements (maximum 8,760 hours/year/ air monitoring station) calculated as Low, Moderate, High Risk or Very High Risk to human health at each station in 2014 are shown in the following graph. Percentages for each station have been rounded.



Above: WBEA streams data for air pollutants such as fine particulate matter ($PM_{2.5}$), seen in the Fort McMurray air during a forest fire, to AESRD for calculation of the Air Quality Health Index

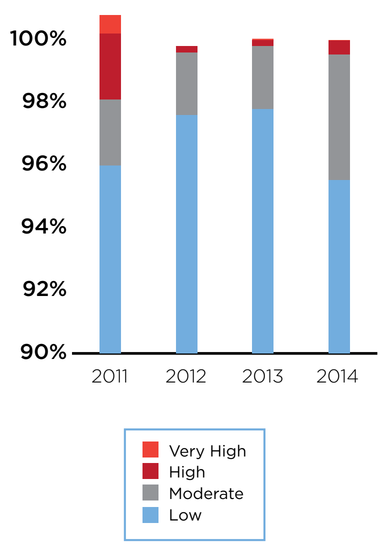
Below: Particulate matter, one of the pollutants which is used to calculate the AQHI, is monitored by analyzers such as these at Patricia McInnes air monitoring station, Fort McMurray.

Table 1. Percentage of hours each AQHI Health Risk Level was recorded at a WBEA Community Air Monitoring Station in 2014.

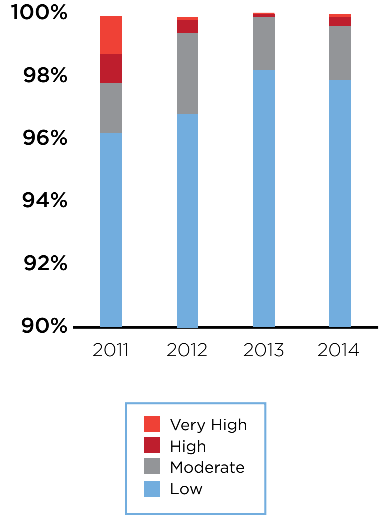
WBEA Community Air Monitoring Station	2014 Air Quality Health Index (AQHI) Values, as a Percentage of the Year			
	Low Health Risk	Moderate Health Risk	High Health Risk	Very High Health Risk
Anzac	98.61%	1.27%	0.12%	0.01 %
Athabasca Valley	95.53%	4.00%	0.46%	0.01 %
Fort McKay South	97.89%	1.71%	0.31%	0.08 %
Fort Chipewyan	97.70%	1.42%	0.66%	0.22 %

The following graphs compare the AQHI values at three community Air Monitoring Stations for 2011, 2012, 2013 and 2014.

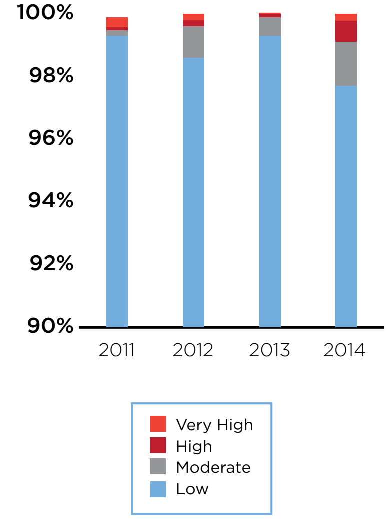
Comparison of AQHI Values at WBEA Athabasca Valley Air Monitoring Station 2011-2014



Comparison of AQHI Values at WBEA Fort McKay South Air Monitoring Station 2011-2014



Comparison of AQHI Values at WBEA Fort Chipewyan Air Monitoring Station 2011-2014



WBEA indicates here that it is important to note that the pollutants (NO_2, O_3, and $PM_{2.5}$) measured to calculate the AQHI do not include the reduced sulphur compounds and volatile organic compounds that WBEA's specialized odour compound measurements have identified as contributing to odour episodes experienced in communities within the region. Therefore, the AQHI should not be used to evaluate the potential health risk from odours, nor as a complete indication of air quality in the region.

FORT MCKAY AIR QUALITY INDEX

The community of Fort McKay has developed a Fort McKay Air Quality Index (FMAQI), based upon air quality measured by WBEA at our Bertha Ganter-Fort McKay air monitoring station. The FMAQI incorporates the pollutants NO_2, O_3, and $PM_{2.5}$ measured to calculate the existing AQHI. In addition, the FMAQI incorporates measurements made by WBEA of TRS, total hydrocarbons (THC), and SO_2. Threshold levels for potential odour-causing TRS and THC, used to calculate the FMAQI, were based on sensitivity analysis of reported concentrations measured when odours were present in the community.

During 2013, Fort McKay First Nation and the WBEA Executive Director engaged AESRD in discussion around the efficacy of the AQHI, as currently configured, in representing air quality when odours are present. AESRD committed to a follow-on sensitivity analysis to establish a threshold TRS concentration that could be implemented to more accurately reflect air quality when odour-causing compounds were present.

In 2014 discussions were ongoing between WBEA and Fort McKay concerning the FMAQI. Following an external scientific validation conducted by WBEA, the FMAQI began streaming on the WBEA website in 2015.

The Fort McKay Sustainability Department advises Fort McKay Community members to use the FMAQI as a general indicator of air quality. When the hourly FMAQI number is much higher than the AQHI number, it generally indicates that odours are likely to be present in Fort McKay. The FMAQI includes odour-causing compounds such as some hydrocarbons and reduced sulphurs, but does not compute health risk.

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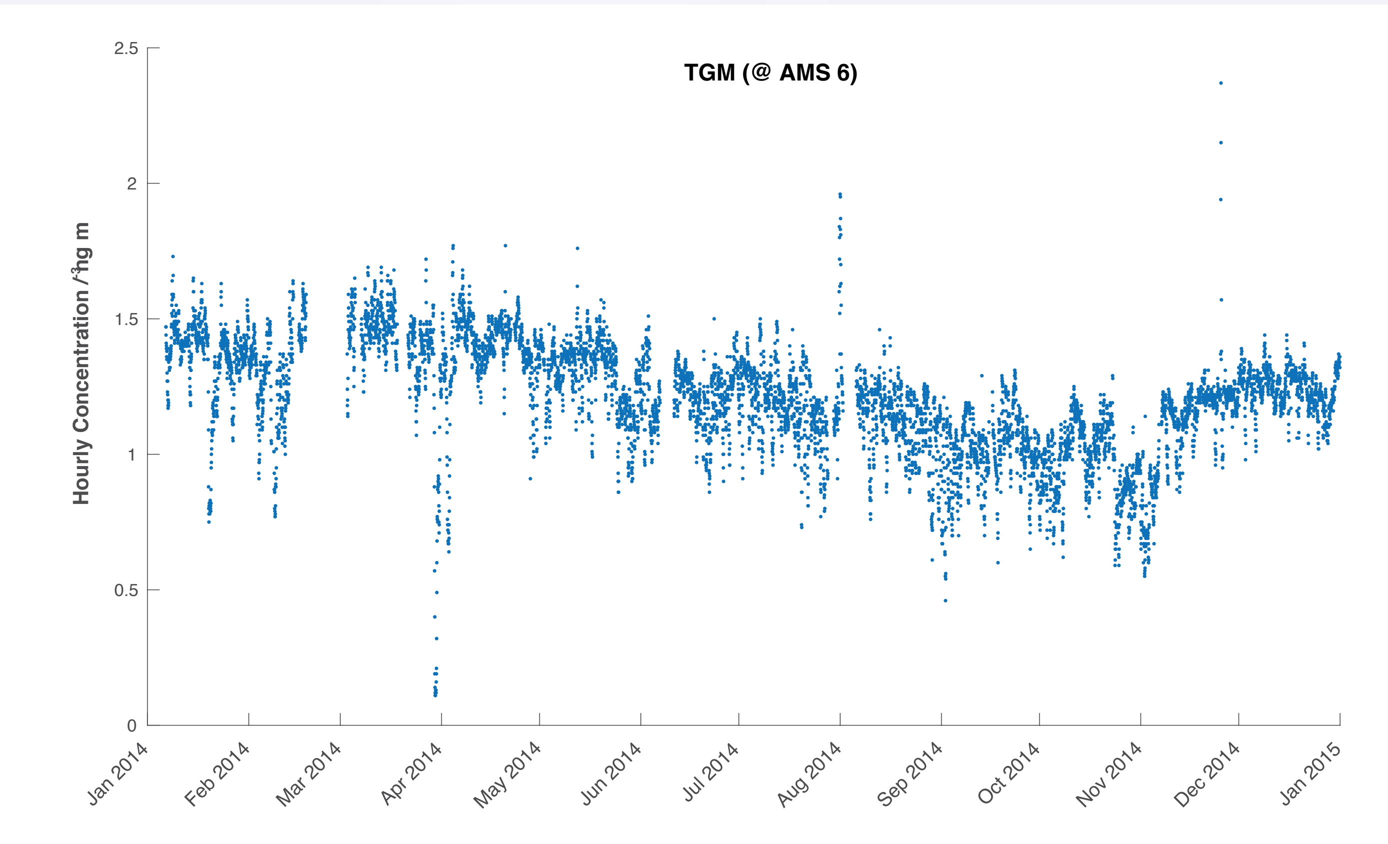
4.5 Environment Canada's Atmospheric Mercury and Volatile Organic Compound Monitoring in the Regional Municipality of Wood Buffalo

ATMOSPHERIC MERCURY

Environment Canada has been monitoring ambient mercury at the Wood Buffalo Environmental Association's Patricia McInnes air monitoring station (AMS 6) since October 2010. Total gaseous mercury (TGM) is monitored in the environment to better understand the overall mercury cycle through the environment and for its potential to form methylmercury, which acts as a neurotoxin for humans and animals. The monitoring method uses cold-vapour atomic fluorescence spectrometry to continuously measure TGM concentration with a sampling period of 5 minutes. The average hourly TGM concentration measured at AMS 6 was 1.21 ng/m^3 during 2014. A seasonal trend has been identified with higher concentrations in the spring, and lower concentrations in the fall. Environment Canada continues to monitor ambient mercury and speciated mercury in partnership with WBEA to better understand mercury chemistry in this region.

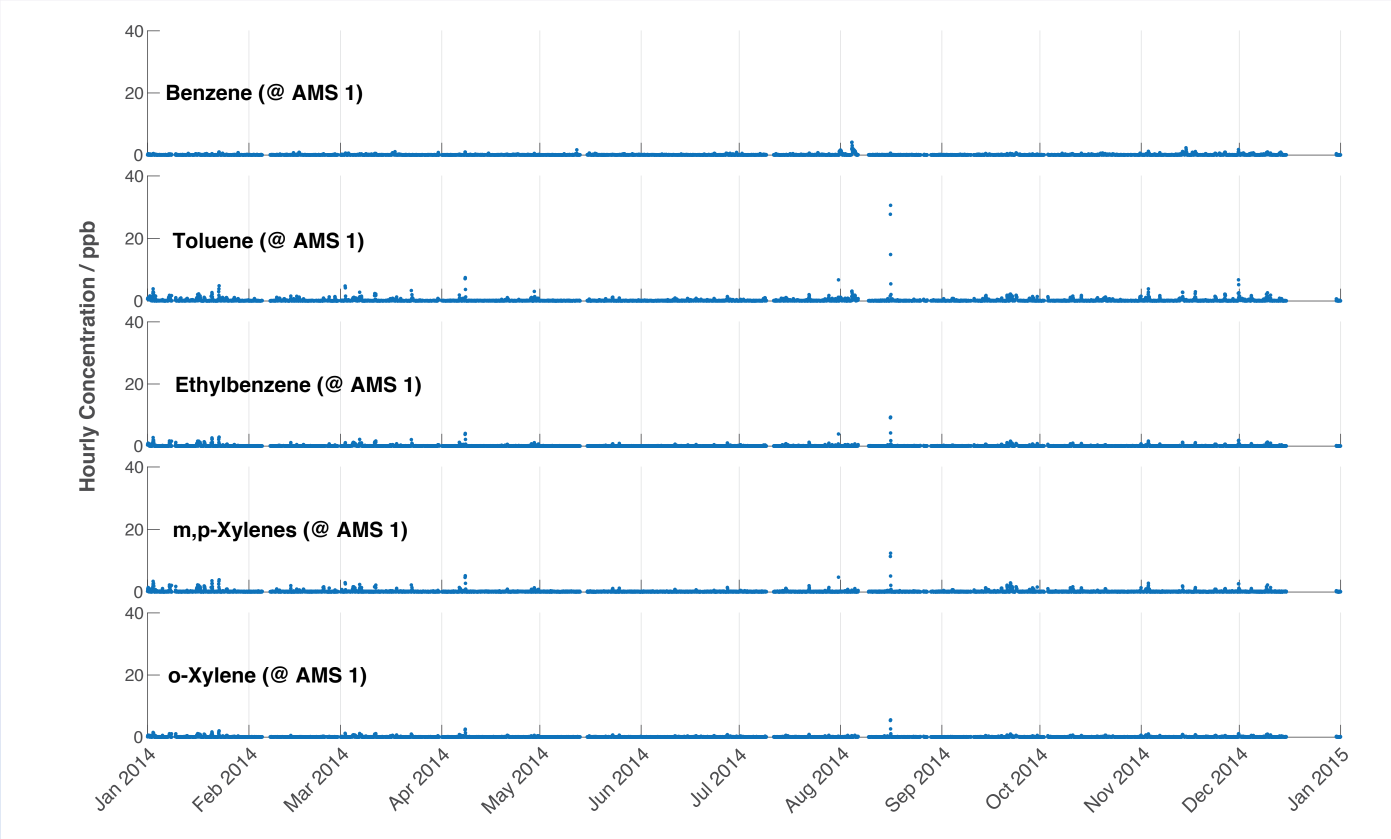
Hourly averaged concentration of total gaseous mercury (TGM) measured at Patricia McInnes - Fort McMurray (AMS 6).



VOLATILE ORGANIC COMPOUNDS

Environment Canada has been monitoring ambient volatile organic compounds (VOCs) at the Wood Buffalo Environmental Association's Bertha Ganter-Fort McKay air monitoring station (AMS 1) since October 2011. VOCs monitored at AMS 1 are benzene, toluene, ethylbenzene, m,p-xylenes, and o-xylene—species that are collectively referred to as BTEX. BTEX species are monitored in the atmosphere because they can impact human health. Benzene is a known carcinogen and all BTEX species can contribute to secondary particulate formation. Hourly Alberta Ambient Air Quality Objectives (AAAQOs) exist for benzene (9 ppb), toluene (499 ppb), ethylbenzene (460 ppb), m,p-xylenes (529 ppb), and o-xylene (529 ppb). An annual AAAQO also exists for benzene (0.9 ppb). The monitoring method uses gas chromatography with a photoionization detector to continuously measure BTEX concentrations with a sampling period of 15 minutes. The monitoring instrumentation is capable of quantifying the concentrations of each BTEX species above the lowest reportable limit (LRL) for each BTEX species. Due to the low ambient concentrations of BTEX species, only 6% (m,p-xylenes) to 19% (toluene) of observations were above the lowest reportable limit. To handle this large fraction of non-detect data, a robust regression order statistical approach (see Helsel, *Environ. Sci. Technol.*, 2005) was applied to estimate annual mean concentrations of each BTEX species. Using this approach, the estimated average hourly benzene, toluene, ethylbenzene, m,p-xylenes, and o-xylene concentrations were 0.11, 0.20, 0.09, 0.17, and 0.10 ppb, respectively. Maximum observed hourly concentrations of benzene, toluene, ethylbenzene, m,p-xylenes, and o-xylene were 4.14, 30.60, 9.35, 12.43, and 5.58 ppb, respectively. BTEX concentrations were generally low through 2014, with no exceedances of AAAQOs.

Hourly averaged concentration of selected volatile organic compounds (VOCs) measured at Bertha Ganter - Fort McKay (AMS 1).



SUMMARY STATISTICS

Parameter	Hourly			
	Minimum	Maximum	Mean	Unit
TGM	0.11	2.37	1.21	ng/m^3
Benzene	<LRL [a]	4.14	0.11 [b]	ppb
Toluene	<LRL [a]	30.60	0.20 [b]	ppb
Ethylbenzene	<LRL [a]	9.35	0.09 [b]	ppb
m,p-Xylenes	<LRL [a]	12.43	0.17 [b]	ppb
o-Xylene	<LRL [a]	5.58	0.10 [b]	ppb

a Below Lowest Reportable Limit (LRL).
b Estimated using a robust regression order statistical approach to handle observations below Lowest Reportable Limit.

LOWEST REPORTABLE LIMITS FOR BTEX MONITOR

Species	Lowest Reportable Limit (ppb)
Benzene	0.32
Toluene	0.31
Ethylbenzene	0.30
m,p-Xylenes	0.60
o-Xylene	0.29

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4.6 Regional Emission Sources

Ambient air quality measured by the Wood Buffalo Environmental Association (WBEA) monitoring program is strongly influenced by emission sources located within the WBEA region. An understanding of the type and magnitude of these emissions is required to determine the linkages between the sources and measured ambient air quality. This understanding contributes to the development of a responsive air quality management system that can address multiple interests. For example, linkages can be used to determine the adequacy of existing emission control technology for different source types. Furthermore, the understanding can be used to help refine the design and operation of ambient monitoring programs.

4.6.1 Emission Source Types

There are wide ranges of emission sources located in the region where WBEA conducts its monitoring program. The largest emission sources for many of the compounds result from industry sources (primarily oil sands or bitumen extraction related). These industrial sources can be broadly defined as combustion related or as fugitive. Combustion related sources include stacks that primarily service upgrader and bitumen extraction plants, and mine fleet exhausts. The fuel used for these sources include coke products, diesel, produced gas, process gas, and natural gas. Fugitive sources result in the volatization of gases from processing plants, exposed mine faces, tailings pond surfaces, and dust emissions from haul roads and other surface disturbance activities.

Other smaller regional sources include community heating sources, local community traffic, and highway traffic. While these sources are generally smaller than industrial emission sources, they contribute to residential exposures since they are located within the communities. Community emissions also result from combustion and fugitive sources. Although combustion sources are primarily associated with the use of natural gas for heating purposes, the use of wood for heating or recreational purposes can result in relatively large emissions. Fugitive community sources include dust emissions from local roads and highways.

Natural emission sources that influence air quality in the WBEA region can be local (within the region) and distant (from outside the region). The main source, familiar to those in the region, is the periodic occurrence of wildfire emission events that tend to occur during the summer. Other sources include emissions resulting from biogenic activity and windblown dust from naturally exposed surfaces. Natural sources located outside the region include distant wildfires, intercontinental scale dust transport, volcanos, and long-range transport of ozone. For these distant sources, it is often difficult to determine whether the emissions are natural or anthropogenic.

Regional industrial emissions sources include stacks, above, and exhaust from mine fleets, below.

Smoke from regional wildfires is a natural source of emissions in the Regional Municipality of Wood Buffalo.

The compounds that are of interest from an air quality management perspective include gaseous compounds and particles. In some cases, compounds of interest are not directly emitted to the atmosphere, but are formed in the atmosphere due to atmospheric chemical reactions (e.g., ozone (O_3) can be formed from photochemical reactions of nitrogen oxides (NO_X) with volatile organic compounds (VOCs)). Different source types emit different compounds, which are depicted in Table 1. The compounds include common gaseous air contaminants (e.g., NO_X, sulphur dioxide (SO_2), carbon monoxide (CO)), gaseous hydrocarbon compounds (e.g., VOC, polycyclic aromatic hydrocarbons (PAH), and particles (e.g., total suspended particulate (TSP), particulate matter <10µm in diameter (PM_{10}), particulate matter < 2.5 µm in diameter ($PM_{2.5}$), PAH and metals).

4.6.2 Emission Estimate Approach

Emission estimates are conducted by industry on an annual basis to meet Environmental Enhancement and Protection Act (EEPA) approval and National Pollution Release Inventory (NPRI) reporting requirements. For larger stacks, the emission estimates are based on direct measurements using continuous stack emission monitoring systems. For smaller stacks and for the mine fleets, the emissions are calculated from operation parameters and the application of unit specific emission factors. WBEA recently conducted a program to obtain measurements of emission factors specific to the haul trucks used by the oil sands operators (Watson et al, 2011). The application of these factors provides a higher level of confidence in estimating haul truck emissions than the use of more generic diesel truck emission factors.

The estimation of fugitive sources is similar in that unit specific emission factors are also applied to each fugitive source type. However, the uncertainties with fugitive emission factors are greater than those for stacks. While industry has taken steps to refine the estimation of fugitive emissions and associated emission factors, there is still considerable variability. Specific programs conducted by industry include flux chamber measurements to estimate fugitive tailings pond and mine face VOC and reduced sulphur compound (RSC) emissions. Although the Alberta Environment and Sustainable Resource Development (AESRD) has provided protocols to increase confidence levels, a large degree of spatial and temporal variability remains. There is a greater degree of uncertainty relating to the estimation of fugitive plant emissions as the associated measurement programs tend to be intermittent and often accompanied with limited documentation.

Fugitive dust emissions result in TSP emissions, and smaller amounts of PM_{10} and $PM_{2.5}$ emissions. As was pointed out in previous WBEA Terrestrial Environmental Effects Monitoring (TEEM) studies, fugitive particle emissions play a critical role with respect to regional base cation, PAH, and metal emissions (Studebaker et al 2012, Landis et al 2012). To obtain a better understanding of these emissions, TEEM collected and analysed fugitive dust from various industry and non-industry sources in the region to determine the composition of dust that could be entrained into the atmosphere by surface disturbance activities (e.g., a haul road or handling coke) (Watson et al 2014).

Non-industry emissions are not measured and are derived from other information sources. Typically, the federal government estimates heating and traffic emissions on a provincial basis using provincial fuel consumption data. In Alberta, the provincial emission estimates are allocated to the different census divisions. The WBEA region falls in Census Division 16. The Census Division 16 emissions are typically allocated to each community on the basis of population. Highway emissions are allocated on the basis of traffic counts.

While they can be very important from a community exposure perspective, natural emissions are not typically accounted for in regional emission inventories. This is because these sources are intermittent and of short duration, and are not managed in the same manner as industrial emissions. Therefore, these emissions are typically excluded as they are outside source management control.

4.6.3 Current LAR Emission Rates

While individual oil sands industry members submit their emission estimates on an annual basis to the appropriate regulatory agencies, there is no regulator or industry group that systematically reviews, combines, and reports each year's emission estimates for the oil sands region. The integration of the data on a regional basis is complicated by the limited distribution of the industry emission reports. For this reason, snapshots of regional emissions tend to generated by industry association projects or by industry members during the preparation of regulatory applications. The former tend to be focussed (e.g., specifically on sulphur or nitrogen compounds) while the latter typically covers a broader air quality spectrum.

The most recent regulatory application was submitted to the Alberta Energy Regulator (AER) and the Canadian Environmental Assessment Agency (CEAA) in June 2015 (Teck Resources Limited 2015). This application identified and quantified stack and fugitive emissions in the Lower Athabasca Region (LAR) based on data collected over the 2008 to 2013 period. The LAR includes the conventional oil sands production region north of Fort McMurray, and the in situ bitumen extraction facilities that extend south to the Cold Lake area. This assessment likely represents the most recent integrated emission inventory for the region. The inventory has the benefit of recent data collected by WBEA and industry that resulted in several refinements not found in previous inventories: (1) it includes the WBEA mine haul road speciation profiles, (2) it includes 2013 industry fugitive mine face and tailings pond emission estimates and speciation profiles, (3) it includes fugitive dust emissions and associated speciation, and (4) it includes non-industry source contributions.

The emission inventory values representing current conditions in the LAR are provided in Tables 2 to 7. The results indicate:

- Table 2 provides **common air contaminant** and **TSP, Hydrocarbons (HC), PAH, RSC and metal** emission rates by source type. Most of the NO_X emissions are from stacks (64%) or mine fleets (30%). Most of the SO_2 emissions are from stacks (99%). About 50% of the CO and $PM_{2.5}$ emissions are from stacks. Virtually all the TSP emission result from fugitive dust.
- Table 3 provides selected **VOC compound and compound group** emission rates by source type. Fugitive emissions (i.e., plant, mine face and tailings) are the largest VOC emission source (79%). For fugitive plant and tailings pond sources, the largest emissions are associated with the aliphatic C5 to C8 group. For mine faces, the largest emissions are associated with the C9 to C16 group.
- Table 4 provides **halocarbon and carbonyl** emission rates by source type. Most of the halocarbons are from the mine fleet exhausts (98%). Most of the carbonyls are from stacks and non-industrial traffic sources.
- Table 5 provides selected **PAH compound and compound group** emission rates by source type. Based on the identified priority PAHs, most are from fugitive dust (36%) followed by mine fleet (24%) and stacks (21%).
- Table 6 provides selected **RSC compound** emission rates by source type. Fugitive emissions (i.e., plant, mine face and tailings) are the largest RSC emission source (88%). Fugitive Plant and tailings ponds are the main sources for carbonyl sulphide (COS) emissions. Stacks are the main sources of carbon disulphide (CS2) and hydrogen sulphide (H_2S) emissions.
- Table 7 provides selected **metal** emission rates by source type. Based on the identified priority metals, most of the metals are from stacks (54%). While fugitive dust sources are the smallest source of the metals (9%), fugitive dust sources are the largest contributor for many of the other metals (e.g., aluminum, antimony, barium, chromium, lead, manganese, strontium, tin, and thallium).

Emission inventories are not static databases; they are continuingly being updated to represent changes to emission sources that vary with time, and to reflect a more refined understanding of calculation approaches. The emission inventory information and the ambient air quality measurements can be used in combination with each other to confirm similarities and reconcile differences. Convergence of information from both components provides an indication of understanding the emission source to ambient air quality pathway.

Since the preparation of the emission data presented in Tables 2 to 7, other studies have been conducted, and additional studies are planned to refine current emission estimates for the region. These studies will help refine and update the emission data that are presented herein.

4.6.4 Closing Comment

The emission estimates provided in this section were prepared for a specific integrated mine and extraction regulatory application. The focus of the assessment and the chemical speciation profiles were selected on this basis. Any uses which a third party makes of these data, or any reliance on decisions made based on it, are the sole responsibilities of such third parties.

Mervyn Davies
Stantec Consulting Ltd.

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Table 1: Source Types and Associated Emissions

	Source Type	NO_x	SO_2	CO	$PM_{2.5}$	TSP	HC	PAH	RSC	Metals
Stacks	Coke based fuel	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Natural gas	Yes	-	Yes	Yes	-	Yes	Yes	-	-
	Produced Gas/Process Gas	Yes	Yes	Yes	Yes	-	Yes	Yes	Yes	-
Vehicles	Bitumen Mine Fleet	Yes	-	Yes	Yes	-	Yes	Yes	-	Yes
	Quarry Fleet	Yes	-	Yes	Yes	-	Yes	Yes	-	Yes
Fugitive	Processing Plant	-	-	-	-	-	Yes	Yes	Yes	-
	Mine Face	-	-	-	-	-	Yes	Yes	Yes	-
	Tailings	-	-	-	-	-	Yes	Yes	Yes	-
	Haul Road Dust	-	-	-	-	Yes	Yes	Yes	-	Yes
Non-Industrial	Heating	Yes	-	Yes	Yes	-	Yes	Yes	Yes	Yes
	Wood Burning	Yes	-	Yes	Yes	-	Yes	Yes	Yes	Yes
	Local Traffic	Yes	-	Yes	Yes	-	Yes	Yes	Yes	Yes
	Highway	Yes	-	Yes	Yes	-	Yes	Yes	Yes	Yes
Natural	Wild fires	Yes	-	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Biogenic	-	-	-	-	-	Yes	-	Yes	-

Yes indicates that the indicated source type is associated with the indicated emissions.

Table 2: Current Lower Athabasca Emission Rates

	Emission Rate (t/d)						Emission Rate (kg/d)		
Source Type	NO_x	SO_2	CO	$PM_{2.5}$	TSP	HC	PAH	RSC	Metals
Stacks	248.2	309.9	134.2	7.3	-	7.6	60.6	317.6	104.1
Plant Fugitive	-	-	-	-	-	48.5	1.9	1,937	-
Mine Fleet	118.0	2.7	80.9	4.5	-	12.8	65.5	-	23.1
Mine Face Fugitive	-	-	-	-	-	31.2	144.5	144.7	-
Fugitive Dust	-	-	-	0.9	35.4	-	8.0	-	1,213
Tailings Fugitive	-	-	-	-	-	23.1	88.0	540.0	-
Non-Industrial	21.0	0.4	73.2	1.6	-	5.1	21.5	-	23.5
Total	**387.2**	**312.9**	**288.3**	**14.4**	**35.4**	**128.3**	**390.0**	**2,939**	**1,364**

HC = non methane hydrocarbon compounds.

Table 3: Current Lower Athabasca Region VOC Emission Rates

VOC (t/d)	Stacks	Plant Fugitive	Mine Fleet	Mine Face Fugitive	Tailings Fugitive	Non-Industrial	Total
1,3-butadiene	0.0079	-	0.15	-	-	0.022	0.18
Aliphatic alcohols	0.223	1.07	0	0.622	0.065	0.092	2.07
Aliphatic aldehydes	-	0.0027	0.034	0.23	0.0012	0.457	0.725
Aliphatic C17-C34	-	0	0	0.119	0.000287	0.025	0.144
Aliphatic C2-C4	3.4	6.4	6.33	2.59	0.155	0.919	19.8
Aliphatic C5-C8	1.53	26.2	2.85	6.26	8.35	1.05	46.3
Aliphatic C9-C16	0.0032	7.39	0.897	14.2	0.164	0.14	22.8
Aliphatic ketones	-	1.46	0.052	1.37	0.0057	0.084	2.97
Aromatic ketones	-	-	-	1.64	-	-	1.64
Aromatic C9-C16	0.00068	0.717	0.057	0.0062	0.345	0.187	1.31
Benzene	0.164	0.196	0.35	0.021	0.345	0.145	1.22
Ethylbenzene	0.0064	0.493	0.037	-	0.162	0.048	0.747
Isopropylbenzene	0.000058	0.034	0.032	0.142	-	0.00033	0.208
n-Hexane	0.989	0.843	0.025	-	0.55	0.084	2.49
Phenols	-	-	-	0.109	-	0.00045	0.109
Styrene	0.00096	3.61E-05	0.0089	0.09	-	0.0109	0.111
Toluene	0.143	1.29	0.387	-	0.47	0.34	2.63
Trimethylbenzenes	0.0062	0.264	0.058	0.113	-	0.096	0.536
Xylenes	0.028	1.75	0.185	0.79	1.04	0.199	3.99
Total	**6.51**	**48.1**	**11.3**	**27.5**	**11.6**	**3.9**	**110**

VOC compounds are associated with gas phase emissions, and therefore no VOC emissions are associated with fugitive dust sources.

The uncertainty associated with plant fugitive emissions is greater than those associated with mine face fugitive or tailings fugitive emissions.

Table 4: Current Lower Athabasca Region Halocarbon and Carbonyl Emission Rates

	Stacks	Plant Fugitive	Mine Fleet	Mine Face Fugitive	Tailings Fugitive	Non-Industrial	Total
Halocarbon (t/d)							
1,1,2,2-Tetrachloroethane	0.0014	-	0.107	-	-	-	0.109
1,2,3-trichlorobenzene	-	-	-	0.00067	-	-	0.00067
1,3,5-trichlorobenzene	-	-	-	0.00068	-	-	0.00068
Chlorobenzene	0.00025	-	0.0034	-	-	-	0.0036
Chloroform	0.00064	-	0.0044	-	-	-	0.005
Dibromochloromethane	-	-	0.017	-	-	-	0.017
Dichlorobenzenes	0.00075	-	0.023	0.0026	-	0.000041	0.026
Dichlorodifluoromethane	0.00031	-	0.039	-	0.00028	-	0.039
Dichloromethane	0.0048	-	0.499	-	0.00031	-	0.504
Hexachlorobutadiene	2.64E-05	8.55E-05	-	0.0068	-	-	0.0069
1,1,2-Trichloro-1,2,2-Trifluoroethane	8.88E-05	-	0.012	-	-	-	0.012
Tetrachloromethane	0.0002	-	0.005	-	-	-	0.0052
Tetrachloroethene	0.0006	-	0.437	-	-	-	0.438
Trichloroethylene	0.00024	-	0.0035	-	0.00026	-	0.004
Total halogens	**0.0092**	**8.55E-05**	**1.15**	**0.011**	**0.00085**	**0.000041**	**1.17**
Carbonyl (t/d)							
Acetaldehyde	0.187	-	0.062	-	-	0.337	0.587
Acrolein	0.053	-	0.0012	-	-	0.031	0.085
Benzaldehyde	0.0093	-	0.0054	-	-	0.032	0.047
Formaldehyde	0.536	-	0.052	-	-	0.242	0.83
Total Carbonyls	**0.785**	**-**	**0.121**	**-**	**-**	**0.641**	**1.55**

These compounds are associated with gas phase emissions, and therefore no halogen or carbonyl emissions are associated with fugitive dust sources.

Table 5: Current Lower Athabasca Region PAH Emission Rates

PAH (kg/d)	Stacks	Plant Fugitive	Mine Fleet	Mine Face Fugitive	Fugitive Dust	Tailings Fugitive	Non-Industrial	**Total**
Naphthalene	25.1	1.89	-	144	-	88	11.7	**271**
Acenaphthene group	1.25	-	-	-	0.71	-	0.631	**2.59**
Fluorene	0.544	-	-	-	0.033	-	0.244	**0.821**
Phenanthrene	0.639	-	0.818	-	0.2	-	0.658	**2.32**
Anthracene	0.171	-	0.703	-	0.073	-	0.088	**1.04**
Fluoranthene	0.12	-	0.205	-	0.02	-	0.374	**0.72**
Pyrene	0.186	-	0.371	-	0.028	-	0.507	**1.09**
Benzo(ghi)fluoranthene	0.02	-	0.141	-	0.048	-	0.041	**0.249**
Methylfluoranthene	0.027	-	0.179	-	0.26	-	-	**0.462**
Cyclopenta[cd]pyrene	0.408	-	3.38	-	0.16	-	0.015	**3.95**
Benzo[a]anthracene	0.132	-	0.077	-	1.6	-	0.021	**1.86**
Benzo(c)phenanthrene	0.032	-	0.077	-	0.073	-	-	**0.182**
Chrysene	0.114	-	0.077	-	1.6	-	0.024	**1.85**
Methylchrysene	-	-	-	-	0.14	-	-	**0.14**
Benzo[a]fluoranthene	0.011	-	0.026	-	0.022	-	-	**0.058**
Benzo[b]fluoranthene	0.074	-	0.064	-	0.037	-	0.0000391	**0.174**
Benzo[j+k]fluoranthene	0.081	-	0.064	-	0.06	-	0.0000339	**0.205**
Benzo[a]pyrene	0.054	-	-	-	0.12	-	0.0000336	**0.17**
Indeno[1,2,3-cd]pyrene	0.048	-	0.064	-	0.000568	-	0.0000401	**0.113**
Dibenzo[a,h]anthracene	0.0372	-	0.051	-	0.000899	-	0.0000314	**0.0893**
Benzo[ghi]perylene	0.048	-	-	-	0.00189	-	0.0000429	**0.0498**
Benzo(b)chrysene	-	-	0.077	-	0.00114	-	-	**0.078**
Dibenzo[a,e]pyrene	0.00101	-	0.051	-	-	-	-	**0.0522**
Aromatic C9-C16	0.079	-	58.5	-	0.48	-	4.92	**64**
Aromatic C17-C34	31.3	-	0.601	-	2.3	-	2.34	**36.6**
Total (all)	**60.6**	**1.89**	**65.5**	**144**	**8.01**	**88**	**21.5**	**390**
Total (13 PPE)	**2.25**	**-**	**2.49**	**-**	**3.77**	**-**	**1.92**	**10.50**

Plant Fugitive, Mine Face Fugitive, and Tailings Fugitive measurements only focussed on naphthalene. The sampling and analytical approach did not target the higher molar mass PAHs.

The 13 priority pollutants are highlighted in orange.

Table 6: Current Lower Athabasca Region RSC Emission Rates

RSC (kg/d)	Stacks	Fugitive Plant	Fugitive Mine Face	Fugitive Tailings	Total
Carbon disulphide	243	26.5	25.6	-	295
Hydrogen sulphide	61.5	7.11	5.53	19	93.2
Pentyl mercaptan	-	0.00024	-	-	0.000236
Isobutyl mercaptan	-	0.0278	-	-	0.0278
Methyl ethyl disulphide	-	-	1.25	5.55	6.81
Methyl mercaptan	-	1.11	-	0.323	1.43
Carbonyl sulphide	-	270	45.9	116	432
Allyl sulphide	-	0.0033	-	-	0.00326
Dimethyl disulphide	-	0.069	6.19	34.2	40.5
Dimethyl sulphide	-	0.534	2.24	2.9	5.67
Thiophenes	-	1474	3.89	225	1703
Total	**304**	**1779**	**90.6**	**403**	**2577**

RSC emissions are not associated with mine fleet, fugitive dust, or non-industry community sources.

Table 7: Current Lower Athabasca Region Metal Emission Rates

Metal (kg/d)	Stacks	Mine Fleet	Fugitive Dust	Non-Industrial	Total
Aluminum (Al)	29.3	-	1127	5.2	**1162**
Antimony (Sb)	-	-	0.67	0.153	**0.82**
Arsenic (As)	3.09	-	0.021	0.066	**3.18**
Barium (Ba)	4.31	0.028	11.7	1.72	**17.8**
Beryllium (Be)	0.02	-	-	0.0058	**0.026**
Cadmium(Cd)	1.23	-	0.11	0.213	**1.55**
Chromium (Cr)	1.17	-	1.5	0.161	**2.86**
Cobalt (Co)	10.9	-	0.064	3.39	**14.4**
Copper (Cu)	10.6	1.26	1.1	3.24	**16.2**
Lead (Pb)	0.291	0.031	0.85	0.428	**1.6**
Manganese (Mn)	1.14	0.262	27.8	0.181	**29.3**
Mercury (Hg)	0.433	-	0.0031	0.134	**0.57**
Molybdenum (Mo)	2.27	0.226	0.15	0.546	**3.19**
Nickel (Ni)	3.23	-	0.57	0.791	**4.58**
Selenium (Se)	14	0.311	0.0066	0.016	**14.3**
Silver (Ag)	1.01	-	0.18	0.049	**1.24**
Strontium (Sr)	0.989	0.176	5.48	0.255	**6.9**
Tin (Sn)	0.491	-	0.59	0.105	**1.18**
Thallium (Tl)	0.106	-	0.24	0.074	**0.424**
Vanadium (V)	4.65	-	2.1	0.312	**7.05**
Zinc (Zn)	14.8	20.8	3.19	6.43	**45.2**
Total (all)	**104**	**23.1**	**1183**	**23.5**	**1334**
Total (13 PPE)	**50.0**	**22.4**	**8.4**	**11.8**	**92.6**

Plant Fugitive, Mine Face Fugitive, and Tailings Fugitive measurements are not associated the metal emissions.

The 13 priority metals are highlighted in orange.

5.0

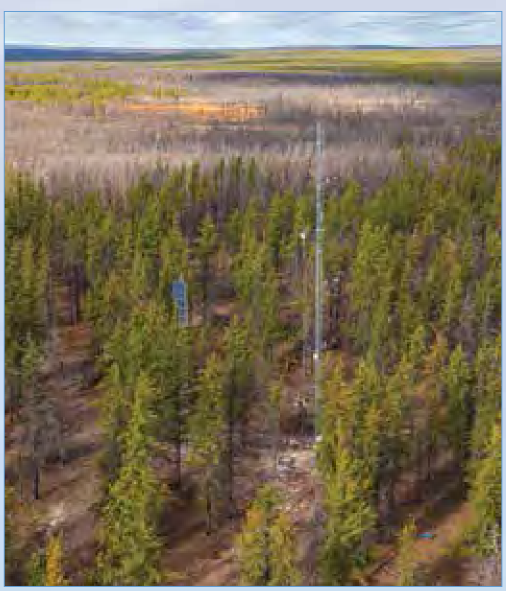
5.0 Terrestrial Environmental Effects Monitoring Program in 2014

5.1 Introduction

WBEA's Terrestrial Environmental Effects Monitoring (TEEM) program's goal is to operate a long term, ecosystem health-based program to detect, characterize and quantify the impact that air emissions have had, or may have, on terrestrial ecosystems and traditional land resources in the Athabasca Oil Sands Region. TEEM accomplishes this through an integrated set of multidisciplinary projects that uses practical science to measure at key points along the air pollutant pathway. This "emission source" to "receptor sink" approach is implemented by a team of scientists with essential assistance from WBEA staff. The TEEM program is managed by a WBEA staff Program Manager, and is overseen by the TEEM Committee comprised of WBEA member representatives. TEEM Committee Members are listed in Appendix IV. The TEEM committee meets quarterly, or more often as required to review the status of current projects and to plan ahead.

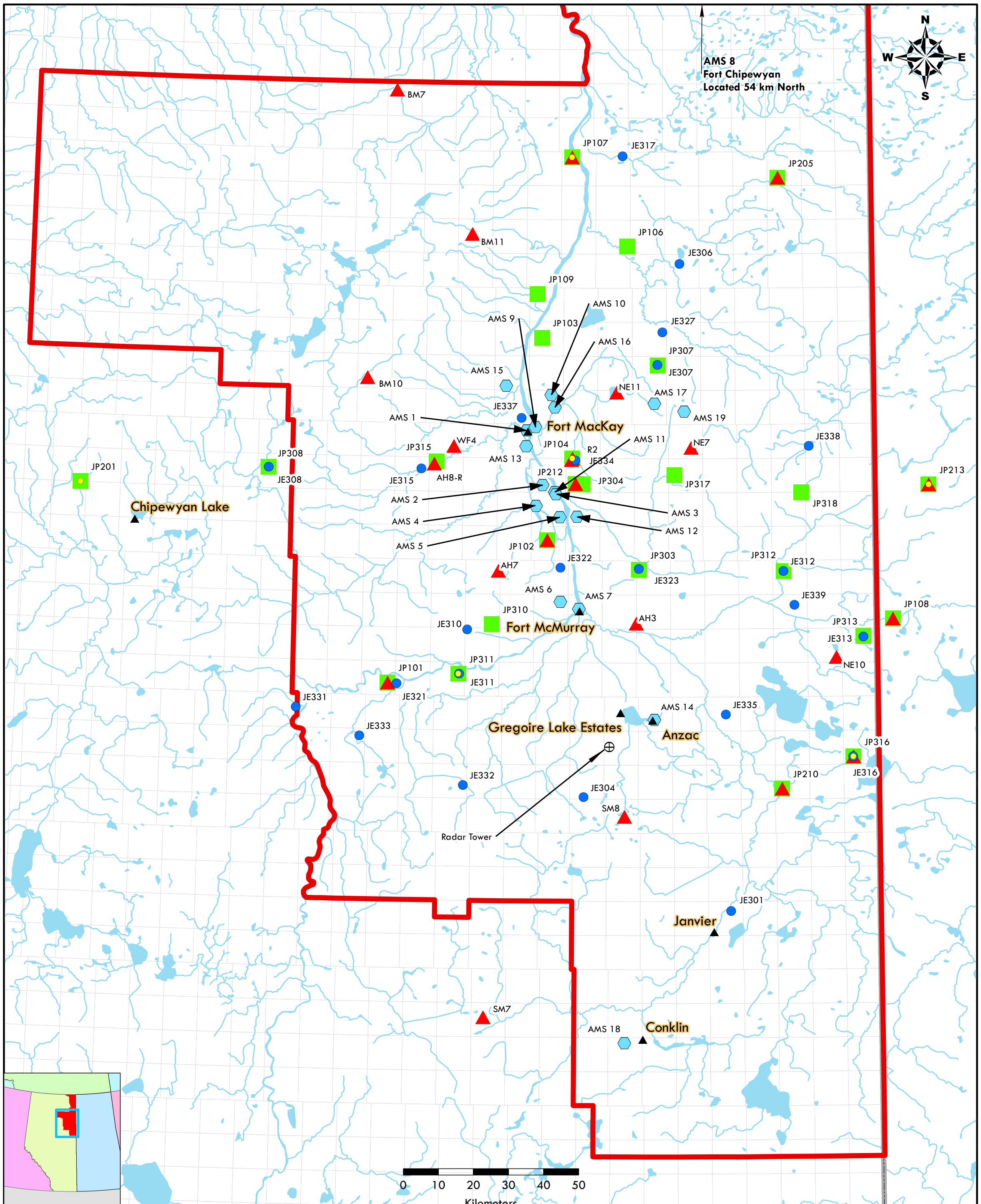
Between 2008 and 2012, the TEEM program underwent a major scientific enhancement with the active participation and funding support of WBEA members. The monitoring program was re-organized around 4 sub-components:

- Effects Monitoring
- Deposition Monitoring
- Receptor Modeling
- Frameworks and Reporting



The Forest Health (FH) concept for monitoring was adopted and a more representative, responsive, specific, robust chemical/biological set of indicators were deployed based upon internal and external expert science advice. When plots are purposely selected, through intensive field investigation over a number of years, to be as similar to each other in such characteristics as plant understory composition and depth to water table, then the opportunity to detect a pollution signal is maximized. The FH network of plots received considerable investment and by 2011 had been expanded from 11 to 25 ecologically analogous jack pine plots stratified across the pollutant deposition gradients, as indicated on the following TEEM Forest Health Sites map.

Six of these plots have been equipped with 30 meter tall towers, one of which, JP 213, is pictured. These towers operate on solar/battery power and provide continuous measurement of above-and-below jack pine canopy meteorology and pollutants, including measurements within forest soil.



Wood Buffalo Environmental Association

WBEA Air and Terrestrial Monitoring Network

June 2, 2014

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Legend

- Air Monitoring Stations
- Passive Monitor
- Forest Health Site
- Meteorological Tower
- Jack Pine Edge Plots
- WBEA Boundary
- Community

This was supplemented, in 2012, by a closely-associated network of 18 jack pine edge plots located at the wetland/upland forest interface, where air pollutant concentrations are at their maximum. Six more edge plots were added in 2013, bringing the total number to 24. The edge plots function in an "early warning" capacity, so change can be measured long before an impact is observed.

A TEEM Traditional Environmental Knowledge (TEK) project was initiated in 2010 in partnership with the community of Fort McKay. Active participation from Fort McKay First Nation and Métis elders and residents in the Fort McKay Berry Focus Group has allowed the project to develop from early engagement and workshops to field visits and initial berry sampling. The project is led by Berry Focus Group members with the assistance of the Fort McKay Sustainability Department and WBEA staff.

Helicopters are used to access and change passive samplers at all but one of WBEA's 24 regional Forest Health sites.

Ion Exchange Resin samplers at WBEA Forest Health site.

Deposition monitoring, using both passive and active sampling techniques for air and terrestrial systems, has been ongoing from the very beginning of the TEEM program. A network of 24 ecosystem-based towers serves to house passive air monitoring samplers that yield monthly average concentrations for five air pollutants of concern. As only one FH site is accessible by road, passive samplers have to be changed out by helicopter access.

Passive data are used to determine relative exposure levels across the region and to provide needed on-site data for cause-effect linkage. As can be seen from the TEEM Forest Health Sites map, many passive towers are co-located with FH monitoring sites. Denuders constitute a potential alternative to traditional passive sampling techniques for dry deposition parameters such as nitric acid and ammonia. WBEA continued operation of actively-sampling denuders at 4 FH sites in 2014 following a successful testing phase in 2013.

Deposition to forest ecosystems is measured using the passive ion exchange resin (IER) technique, with samplers located in the open and under the jack pine canopy for measurement of anion/cation loadings in remote areas where continuously-measuring technology cannot be deployed due to lack of power. As well, PRS probes are utilized as a surrogate for root uptake, mimicking nutrient absorption by plant roots and they therefore constitute a convenient and economical means of monitoring soil ion activity and supply rate.

Reporting, whether through internal TEEM reports, the open scientific literature, or the WBEA web site, is important for information sharing. The TEEM program has been enhanced to provide timely, credible data and information so that stakeholders can make informed decisions on airshed management. In that sense, it is focused on practical, long-term scientific monitoring that has many drivers beyond the measurement of ecosystem state for reporting on ecosystem health. Included among the drivers are the AESRD Acid Deposition Management Framework, the AESRD Ozone and PM Management Frameworks, and regulatory approvals. In 2011, TEEM completed the third cycle of its intensive FH monitoring at jack pine plots. The 2011 soil and vegetation data were used in early 2015 to report on the state of forest health, along with change from measurements taken in 1998 and 2004.

5.2 Report on 2014 Activities

The 2014 TEEM program was again substantial in scope. Field work focused on ongoing passive measurements, the seasonal change out of ion exchange resins (IERs) and plant root simulator (PRS) probes, data entry and infrastructure deployment and repair. A new receptor modelling project was initiated with lichen sampling for PAHs and elemental species being the main components of this study.

The following is a summary of the deliverables achieved by TEEM in 2014.

EFFECTS MONITORING:

- **Forest Health Monitoring:** The annual AESRD forest health campaign was carried out at most of the FH stand plots. As pollution can predispose trees to attack by insects and disease this campaign measures the incidence and severity of insects and diseases on numbered plot trees.
- **Peatland Monitoring:** Villanova University conducted a synoptic survey in 2013 to identify up to 20 bogs for use in a future monitoring program together with the development of quantitative measurements to assess lichen response to N and S deposition for uses as an early warning indicator in bogs. As well, the investigators developed the relationship of lichen chemistry (N and S concentration in lichen) with other air quality samplers (ion exchange resins) to strengthen the value of using lichens as bio-indicators of air pollution in remote locations.

  Peatland monitoring through establishment of a regional network of bogs was not funded in 2014. Two final reports, one on the 2013 monitoring campaign and synoptic survey and the other one on the development of monitoring protocols for nitrogen-sensitive bog ecosystems, were submitted in 2014 to WBEA by Villanova University.

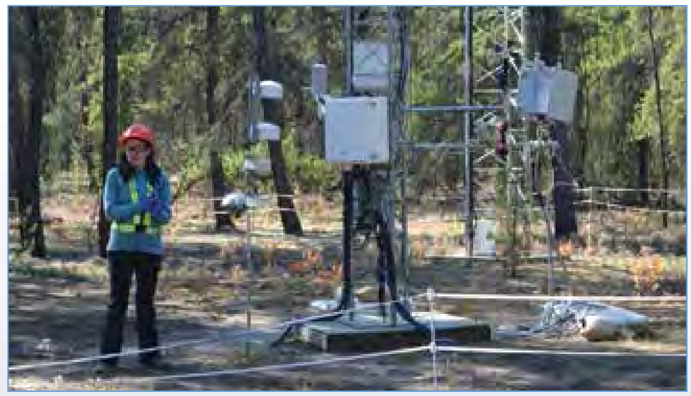
  In 2014 Vile et al. (2014) published initial results from their five-year bog monitoring study funded by WBEA. They reported high rates of N2 fixation in in pristine bogs in Alberta, and that peatlands in the Fort McMurray region were just beginning to receive elevated N deposition related to development of the oil sands. They speculated that because all N2- fixation scenarios involve substantial C-costs, exposure to enhanced N deposition, biotic feedbacks will likely down-regulate biological N2-fixation, with potentially important implications for the vulnerability of global peatland C and N stores, as well as for potential changes in methane fluxes. Increasing N deposition against a backdrop of high rates of N fixation could have potential consequences for peatland functioning.
- **Traditional Environmental Knowledge (TEK):** Work continued with the community of Fort McKay on the berry monitoring program that twins traditional and western scientific indicators of berry abundance and quality. Several workshops were held during the year. Spring and summer visits to local berry-producing areas and Moose Lake were made, and berries were observed and sampled. A subsequent validation report comprising recordings, pictures, and notes taken during the visits will be presented to the Berry Focus Group, in early 2015. Berries were analyzed for trace metals. Passive monitoring for volatile organic compounds and passive sampling of SO_2, NO_2, NH_3, HNO_3 at four berry patches was conducted. Berry quality analyses, for health-promoting constituents, were conducted by the National Research Council in Halifax, NS.

Celina Harpe, a member of the Fort McKay Berry Focus Group since 2010, with blueberries picked in August 2014 at one of the berry patches.

- **Site Maintenance, Security, and Safety:** TEEM staff met with personnel from Lakeshore Helicopters to draw up plans for the clearing and widening of helicopter landing pads at interior sites and for putting in logs at wet landing sites. A standard minimum landing pad diameter was established to guide future prevention-based helicopter landing safety efforts. A major landing site maintenance campaign, led by Lakeshore pilots and support staff, will take place between January and April 2015. As well, Safe Work Practices were developed to advise WBEA staff of their responsibilities when approaching, boarding, travelling aboard and disembarking from a helicopter. The use of SPOT units, combined with the adoption of the web-based SafetyLine software, have allowed for more efficient and effective remote monitoring of employee location as they work offsite. Comprehensive safety protocols were also developed to help employees deal with wildlife sightings and encounters.

DEPOSITION MONITORING

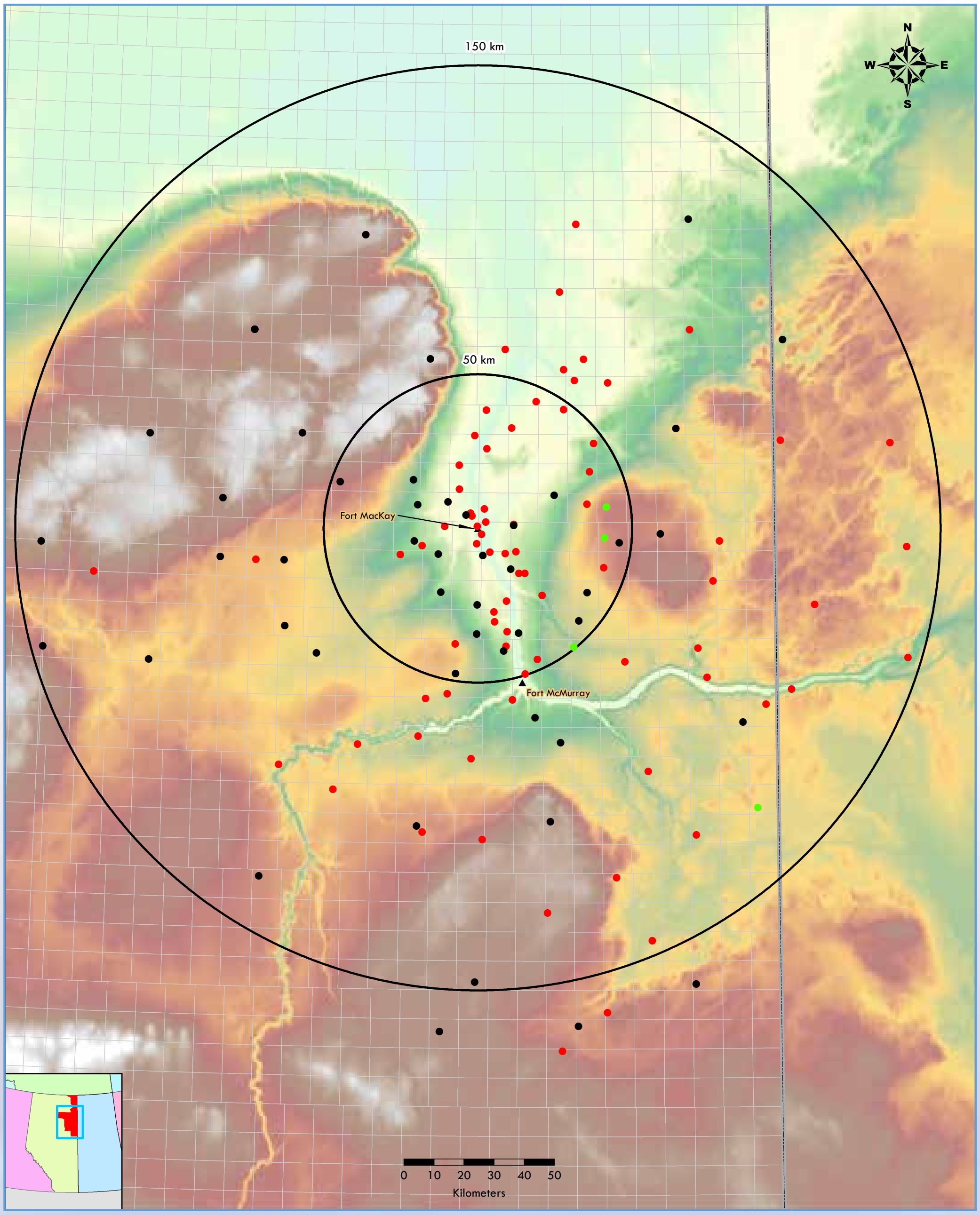
- **Ambient Air Passive Monitoring:** Ozone (O_3), sulphur dioxide (SO_2), nitrogen dioxide (NO_2), nitric acid (HNO_3) and ammonia (NH_3) data were collected monthly (bi-monthly in winter for safety reasons) at 30 sites, including in open areas near six edge sites where 2m mini-tower systems were installed, and at air monitoring stations, for the purpose of data validation.
- **Dry Deposition:** Denuders were re-deployed at four remote sites following upgrades to more robust pumps to enhance the overall collection efficiency for nitric acid and ammonia. Pulley systems were also installed at each tower site to facilitate routine changeover of denuder cartridges by WBEA staff. As well, an insulated shell and a heating device were added to each unit to enable winter operation. An interpretive report was submitted to WBEA.



WBEA technician Natalie Bonnell demonstrates a passive filter change at Forest Health Site JP104, during the Member's Open House.

- **Ion Exchange Resin (IER) Deposition Monitoring:** Sampling took place at 23 sites during the spring and fall of 2014. A paper was released online in 2014 with the hardcopy journal version expected to be available in early 2015.
- **Plant Root Simulator (PRS) Soil Probes:** Probe change out took place at 50 sites during the spring and fall of 2014.
- **Instrumented Towers:** Routine maintenance and repair of meteorological sensors and instruments took place as required throughout 2014. Rain gauges were operational at all six meteorological tower sites. Level 1 data (non QC'd) from the instrumented meteorological towers is now accessible via a web-based interface. A formal and detailed QA/QC review of meteorological data going back to 2008 was initiated. A data summary will be released during the first quarter of 2015. Online access to the QA'd data is expected to be available during the second quarter of 2015.
- **Remote Ozone Monitoring:** Portable ozone monitoring systems were tested at 3 sites. The addition of a calibrator and telemetry at each site, along with the installation of more robust sampling pumps, is expected to result in a more reliable monitoring system.

Dr. Keith Puckett collects lichens in 2014 for WBEA's PAH source apportionment project.



RECEPTOR MODELING:

- **"Real-World" Source Characterization:** The field component of a project to chemically and physically characterize regional sources of man-made and natural dust was completed in 2013 with a major dust sampling campaign carried out by Desert Research Institute (DRI) investigators at that time. Two reports were produced in 2014 as a result of this work.
- **Source Apportionment:** In 2014/15, WBEA was funded to execute phase 1 of a PAH Receptor Modelling Project. The multi-disciplinary team of scientists who published the previous trace element receptor modeling results was re-engaged. For the PAH project, a rigorous quality assurance plan was drafted, a pilot study to choose receptor lichen species completed and over 130 regional sites, as plotted in the map above, were identified, confirmed and the lichen species sampled. Lichens were prepared and analyzed for both parent and alkylated PAH's. A report will be submitted by March 31, 2015.
- **Support to External Programs** WBEA continued to provide assistance to an Environment Canada air toxics study through the routine bi-monthly sampling of polycyclic aromatic hydrocarbons (PAHs) at seven remote passive sites and eight continuous air monitoring stations.

5.3 Frameworks and Reporting

The preparation of a 15-year TEEM Report, initiated in 2013, is nearing completion with expected release during the first quarter of 2015. At the time of printing, the report is available at *http://www.wbea.org/resources/terrestrial-monitoring-reports.*

TEEM received a number of reports from its contracted scientists in 2014. These were reviewed internally or externally, depending upon report content and potential visibility, and can be found on the website under the Resources folder.

5.4 Selected References

Edgerton, E. 2014. Pilot Study Testing of Low-Power Denuder Systems for Measurement of HNO_3, NH_3 and fine particulate sulfate, nitrate and ammonium at WBEA Forest Health Sites. Status Report-May-August 2014. Submitted by ARA, Inc. September 26, 2014. WBEA Independent Contractor Agreement No. T106-14.

Fenn, M.E., Bytnerowicz, A., Schilling, S.L., Ross, C.S. 2015. Atmospheric deposition of nitrogen, sulfur and base cations in jack pine stands in the Athabasca Oil Sands Region, Alberta, Canada. Environmental Pollution, 196 497-510.

Vile, M.A., Wieder, R.K., Vitt, D.H., Berryman, S. 2014. Development of Monitoring Protocols for Nitrogen-sensitive Bog Ecosystems, including Further Development of Lichen Monitoring Tools – 2009-2013. WBEA Final Report. Agreement No: T102-09, T102-10, T102-11, T105-12 – November 2013. Villanova University, Villanova, PA 19085 USA.

Vile, M.A., Wieder, R.K. 2014. Peatland Monitoring and Synoptic Survey – 2013. Final report submitted to WBEA. Villanova University, Villanova, PA 19085 USA.

Watson, J.G., Chow, J.C., Wang, X., Kohl, S.D. 2014. Chemical Source Profiles for Geological Dust Samples from the Athabasca Oil Sand Region. Submitted to WBEA March 28, 2014, under DRI Contract Number: 010109-123109. Desert Research Institute, 2215 Raggio Parkway, Reno, NV, 89512.

Watson, J.G., Chow, J.C., Wang, X., Kohl, S.D., Yatavelli, L.N.R. 2014. Windblown Fugitive Dust Characterization in the Athabasca Oil Sands Region. Submitted to WBEA March 31, 2014, under WBEA-DRI Agreement Number: T108-13. Desert Research Institute, 2215 Raggio Parkway, Reno, NV, 89512.

Fred Payne
TEEM Program Chair

5.5 Meteorology Tower Data Summary for 2014

Fulfilling another requirement in monitoring forest health, a system for co-measurement of predictors and indicators, and supplemental process-oriented investigations that more thoroughly test cause and effect relationships among stresses and responses is being deployed. As of 2014, six forest health plots (JP104, JP107, JP201, JP213, JP311 and JP316) were equipped with 30 m tall towers. With no power available, and a need for continuous meteorological measurements to account for the influence of inter-annual climate differences, a second tower is fitted at each plot with a solar array and ground-installed batteries to provide year-round power supply. Data from 10 m and 2 m above the canopy height, and 2 m below canopy/3m above ground on wind direction/speed, relative humidity, temperature, radiation (global/PAR) are continuously measured and uploaded through cell modem/satellite connection daily to the WBEA data base in Calgary.

Automated precipitation measurements are collected and uploaded, along with continuous ozone at several of the sites. Below-ground soil moisture and temperature sensors operate seasonally at two depths and these data are also transmitted to the database. Plant root simulator (PRS™) probes (ion exchange membranes) are installed to determine the soluble ion concentrations at two soil depths (10 and 50 cm.) For this Report, data showing wind direction and speed at the four tower heights are shown. In 2015, all tower data will be publically available at wbea.org.

The WBEA meteorological tower and associated solar tower at forest health plot JP104, bottom, and one of four wind sensors, top.

Figures 1 to 7 show wind rose plots from the 30 m towers located at JP104, JP107, JP201, JP213, JP311 and JP316. Wind direction and wind speed (along with a number of other meteorological parameters) are measured at heights of 2 m, 16 m, 21 m and 29 m at these sites. Figure 7 compares the 29 m wind roses for the six sites.

Figure 1: Wind rose plots for 2m, 16 m, 21 m and 29 m heights at JP104 meteorological tower.

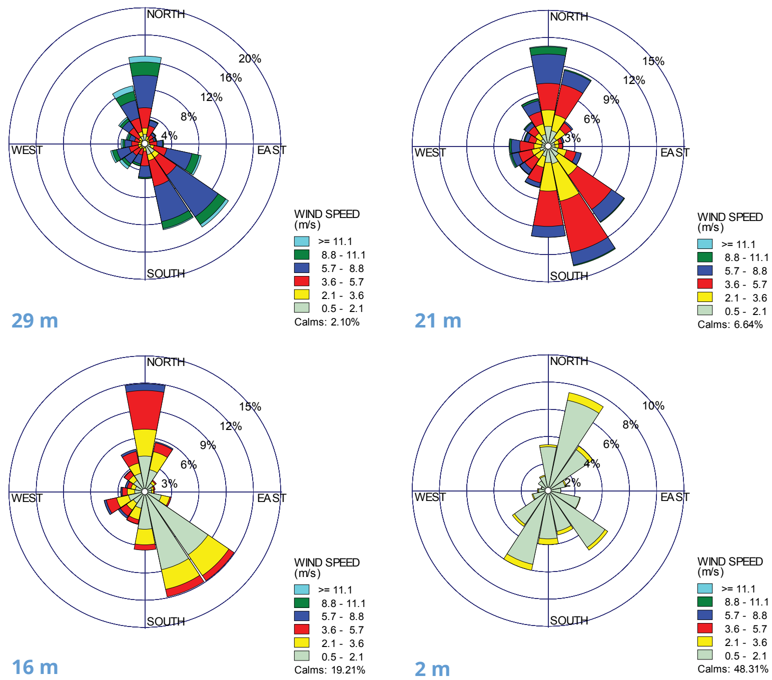


Figure 2: Wind rose plots for 2m, 16 m, 21 m and 29 m heights at JP107 meteorological tower.

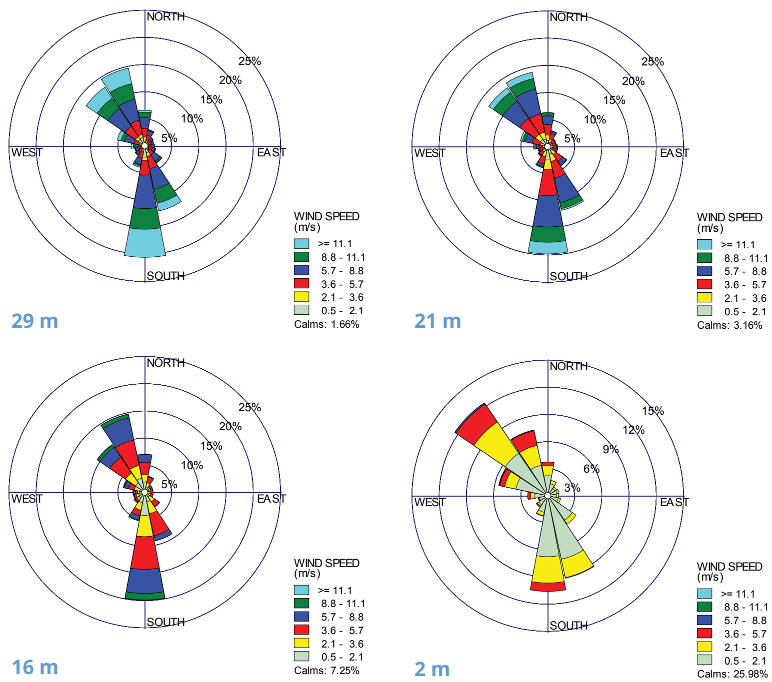


Figure 3: Wind rose plots for 2m, 16 m, 21 m and 29 m heights at JP201 meteorological tower.

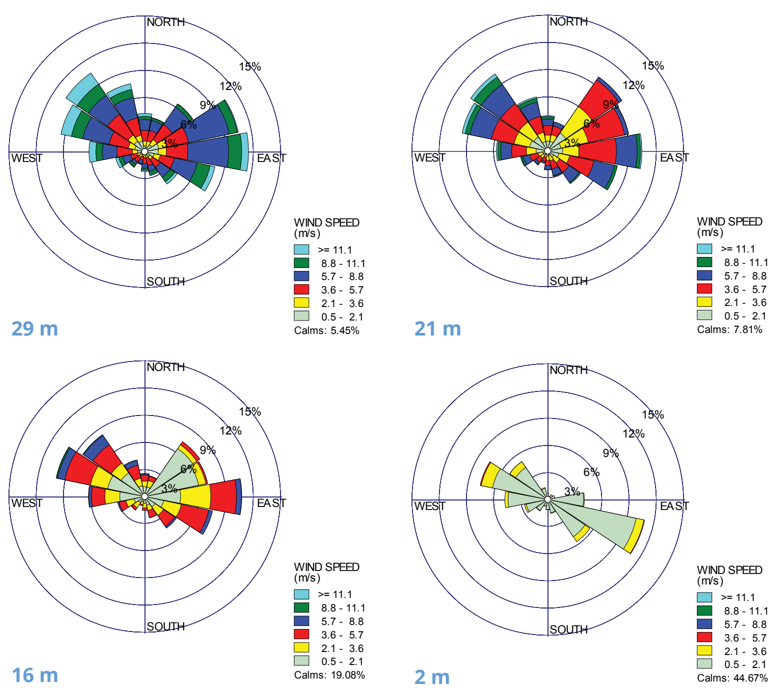


Figure 4: Wind rose plots for 2m, 16 m, 21 m and 29 m heights at JP213 meteorological tower.

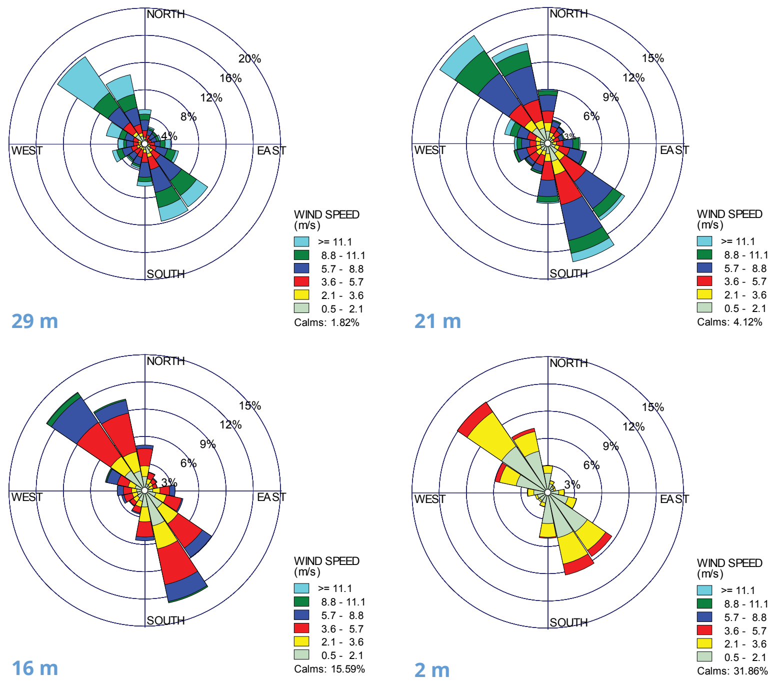


Figure 5: Wind rose plots for 2m, 16 m, 21 m and 29 m heights at JP311 meteorological tower.

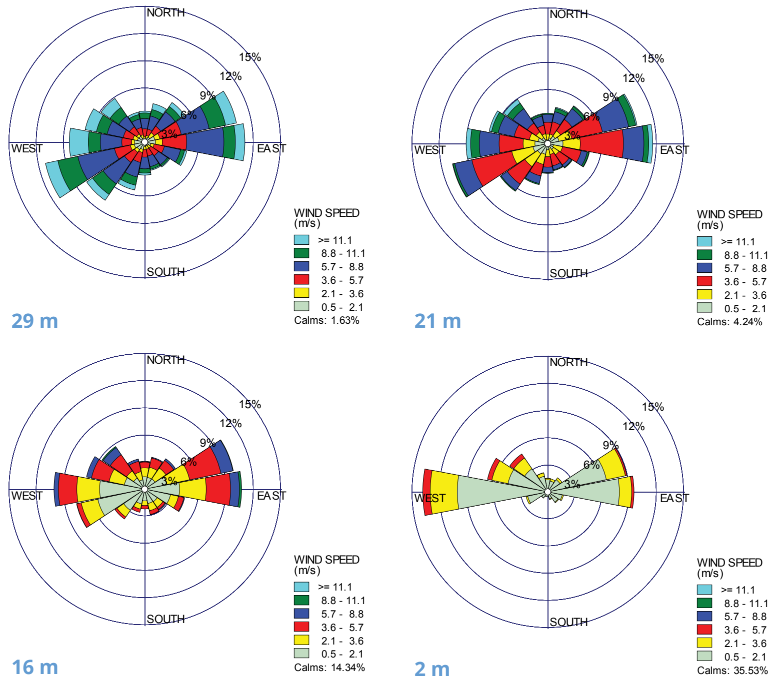


Figure 6: Wind rose plots for 2m, 16 m, 21 m and 29 m heights at JP316 meteorological tower.

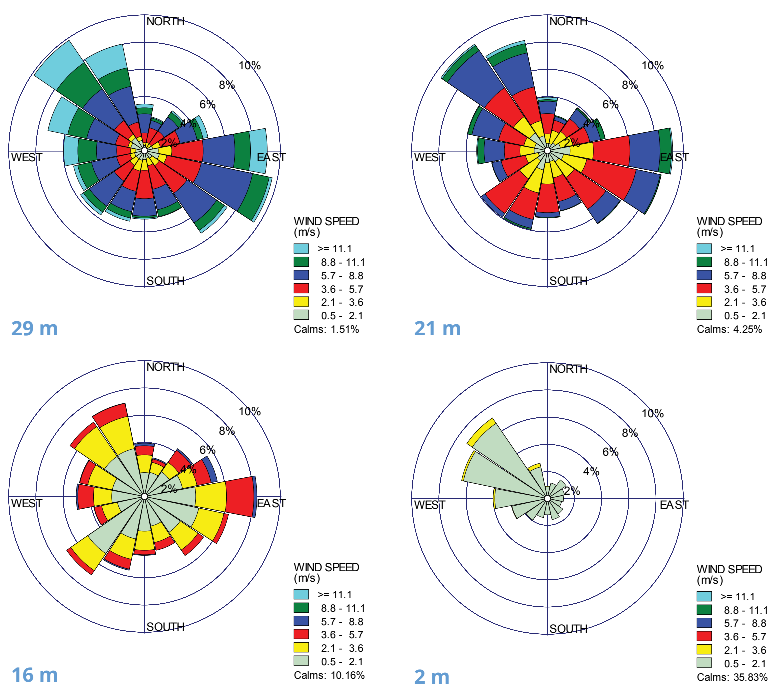
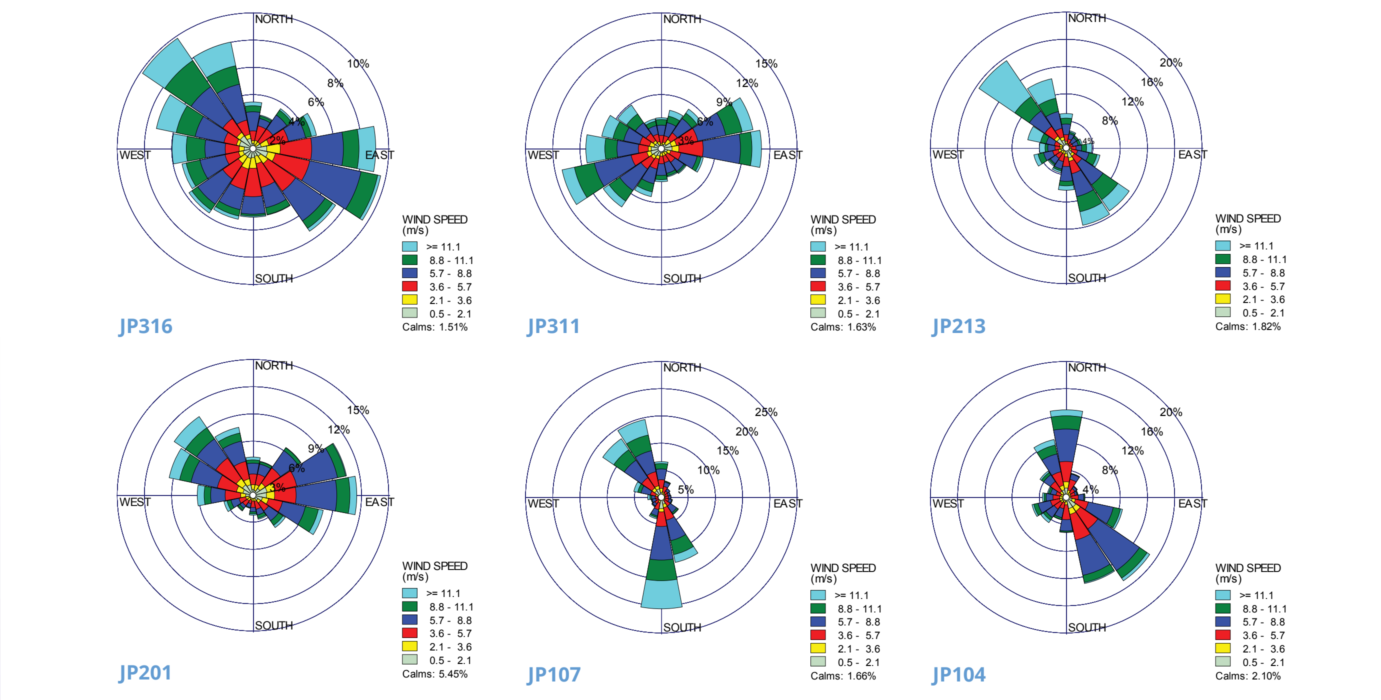


Figure 7: Wind rose plots for 29 m height at JP104, JP107, JP201, JP213, JP311 and JP316 meteorological towers.



Tom Dann
RS Environmental

5.6 Passive Monitoring (Sulphur Dioxide, Nitrogen and Ozone)

Passive sampling is used in remote areas, where no power is available to operate continuous air analyzers. Air passes continuously over the passive sampler surface and pollutant gases diffuse into the sampler. Passive data cannot be directly compared to data from active analyzers, where air is pumped into the analyzer, continuously. Passive data average the pollutant concentrations that diffuse into the samplers over a one month period. These data, however, are useful to establish estimates of pollutant exposure over periods of time. Passive monitoring sites are shown on the map on page 80.

Figure 1 shows passive sampling results for SO_2 (sulphur dioxide) and NO_2 (nitrogen dioxide) for December 2013 through October 2014 based on all available sample results (sites with incomplete data were excluded). The plot shows the mean and the 95th percent confidence interval for the mean using all samples for each site. The highest mean SO_2 concentrations were 1.9 at JP104 and 1.7 at JP102 and AH7.

The highest mean NO_2 concentrations were 3.4 ppb at JP104, 2.6 ppb at JP212 and 2.4 ppb at R2. The lowest mean concentrations of NO_2 ranged from 0.2 to 0.3 ppb at a number of sites.

Figure 2 shows mean SO_2 and NO_2 concentrations as a function of distance (km) from Mildred Lake. As shown in the figure, the highest passive SO_2 and NO_2 concentrations were measured at sites less than 25 km from Mildred Lake.

Figure 1: Results from passive samplers for SO_2 and NO_2 (ppb) for December 2013 to October 2014.

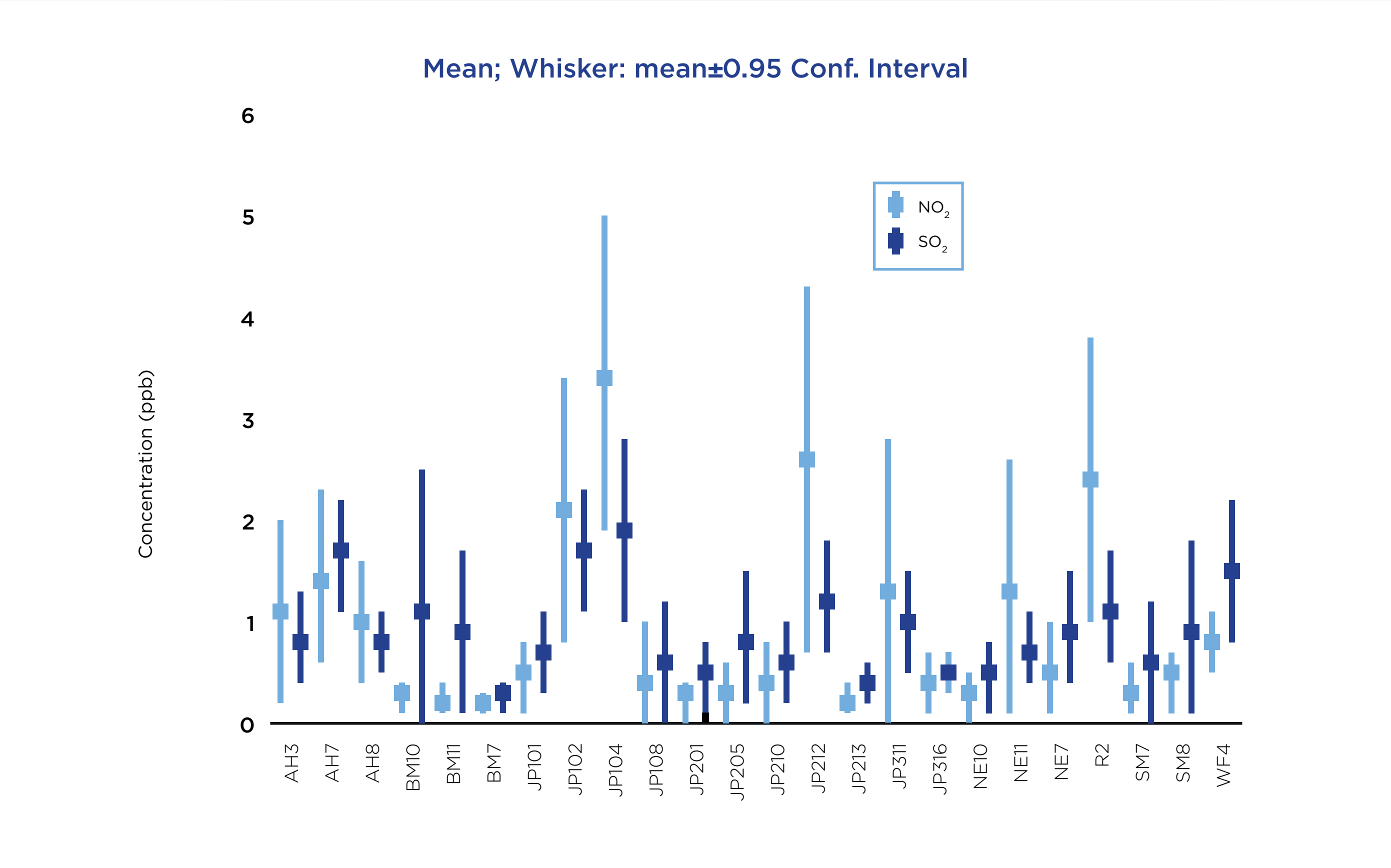


Figure 2: Results from passive samplers for SO_2 and NO_2 (ppb) as a function of distance from Mildred Lake (December 2013 to October 2014).

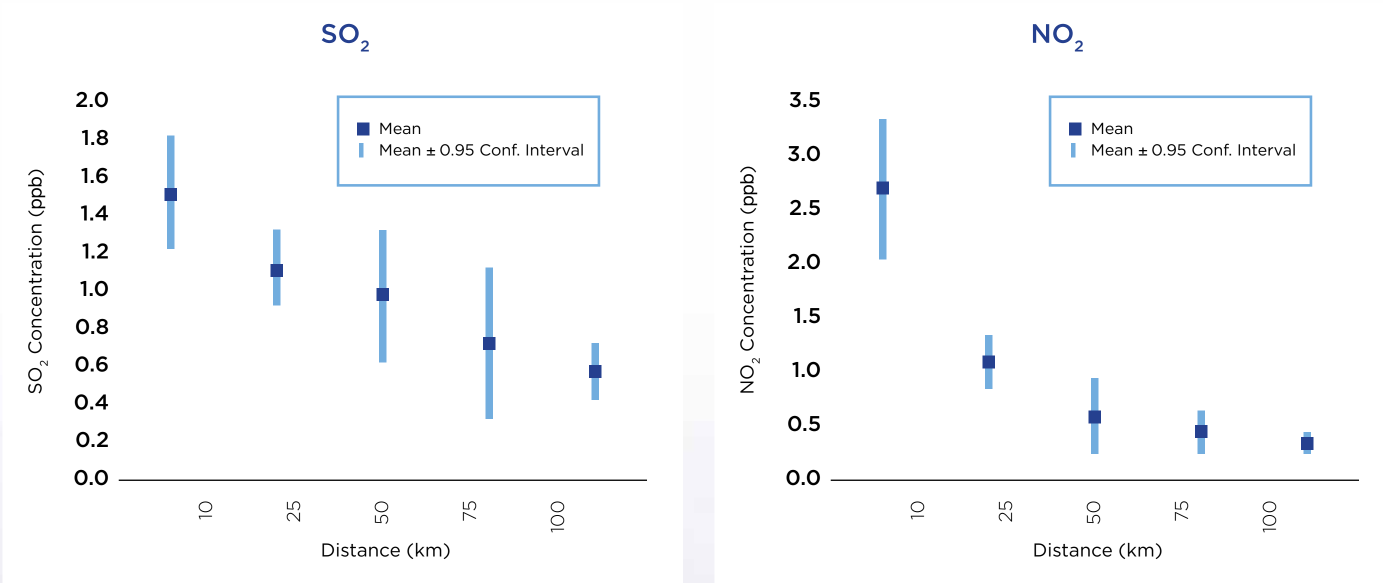
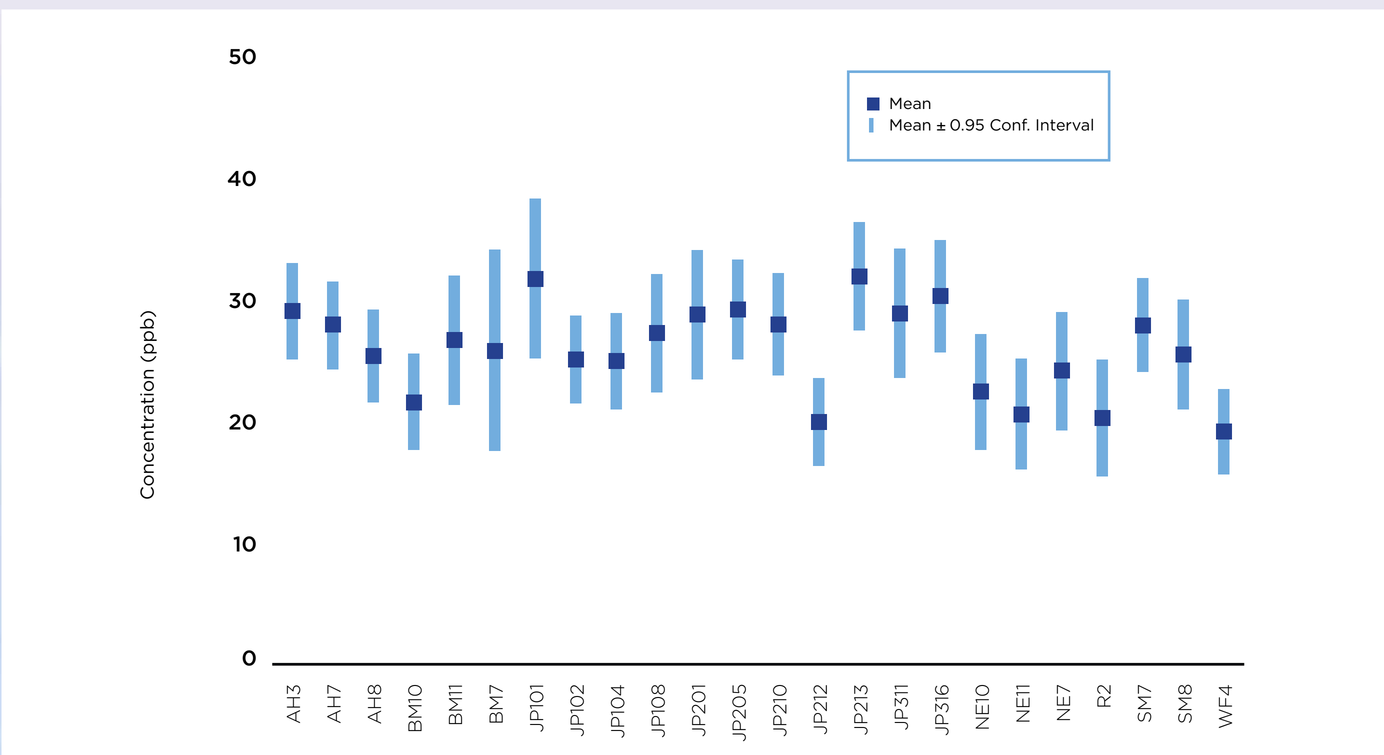


Figure 3 shows results for ozone (O_3) from the passive samplers. Lower ozone concentrations generally occurred at sites with the highest NO_2 concentrations.

Figure 3: Results from passive samplers for ozone (ppb) for December 2013 to October 2014.



Tom Dann
RS Environmental

5.7 Low-Power Denuder Systems for Measurement of HNO_3 and NH_3 at WBEA Forest Health Sites

BACKGROUND

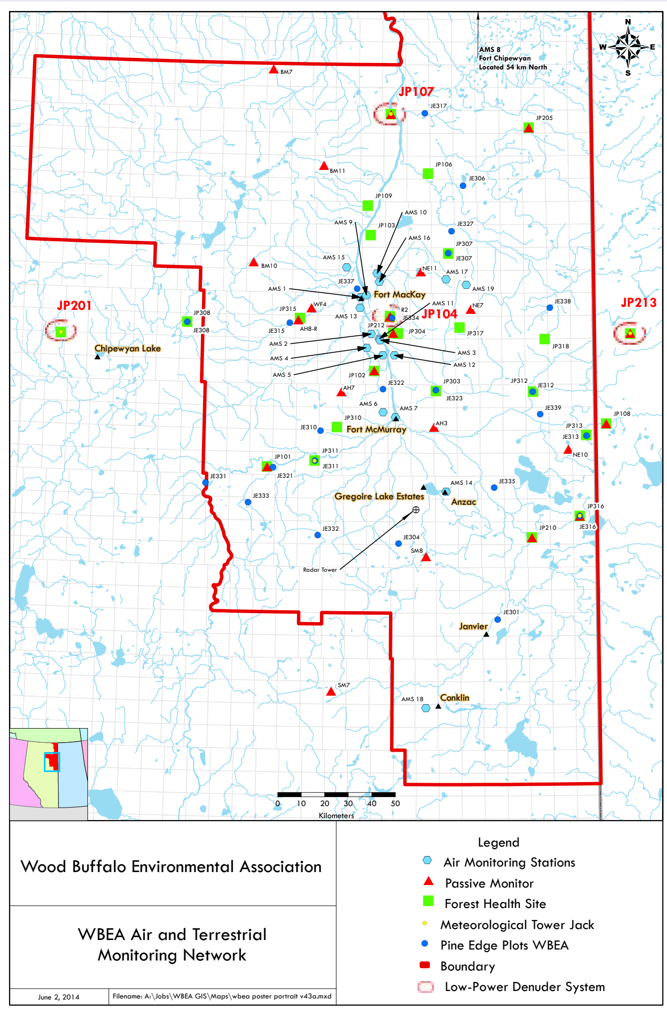
Gas phase nitric acid (HNO_3) and ammonia (NH_3) are important nutrient compounds for terrestrial and aquatic ecosystems. HNO_3 is formed in the atmosphere, primarily via oxidation of nitrogen dioxide (NO_2) by hydroxyl radical. NH_3 is emitted to the atmosphere by vegetation and anthropogenic sources (motor vehicles and industrial processes). HNO_3 and NH_3 are highly water soluble and help mediate the acidity of precipitation and aerosols. They also react together under certain atmospheric conditions (low temperature and high RH) to produce particulate ammonium nitrate (NH_4NO_3), an important component of $PM_{2.5}$. High quality measurements of HNO_3 and ammonia (NH_3) are therefore critical to understanding the transport, transformation and deposition of nutrients and acidifying species to the landscape.

OBJECTIVES AND SAMPLER DESIGN

The objective of this study was to field test a low-power, low-flow annular denuder system for the measurement of ambient HNO_3 and NH_3 at remote sites. The sampler design was based on well-proven annular denuder techniques for measurement of trace atmospheric gases. Each system consisted of two 150 mm long concentric glass annular denuders, a low-power pump, a mass flow controller and an RS485 relay housed in a weatherproof enclosure (Figure 1). Total power consumption of the system was 10 watts, or less, and therefore was deemed compatible with remote, solar powered monitoring sites. The annular denuders were coated with KCl for collection of HNO_3 and citric acid for collection of NH_3.

In mid-2013, samplers were deployed above canopy level at four solar-powered forest health sites (JP104, JP107, JP201 and JP213) and used to collect 1-month samples in the summer and 2-month samples in the winter (Figure 2).

Duplicate systems were installed at JP104 to assess measurement precision.



Top: Low-power sampler.

Bottom: WBEA Forest health study sites.

RESULTS

The low-power samplers performed well during a 4-month pilot test at the end of 2013 and during eight months of routine operation in 2014. Overall, data capture for sample flow was >95% and sample flows were found to be stable within +/- 2% down to temperatures of -30 C. Flow reductions were observed in two systems at temperatures below -30C. This was corrected by installation of low-wattage, thermostatically-controlled, heaters on the pumps in 2014. Detection limits for HNO_3 and NH_3 were found to be <0.03 µg/m³, based on monthly field blanks; and overall precision for HNO_3 and NH_3 was found to be 11% and 13%, respectively, based on collocated samples from JP104.

Concentration data exhibited interesting site to site variability and month to month variability. HNO_3 concentrations were consistently highest at JP104 and JP107 (means roughly 0.2 µg/m³) and lowest at JP201 or JP213 (means roughly 0.1 µg/m³). The spatial pattern suggests very slight, but detectable, increases in HNO_3 within the Athabasca River valley (JP104 and JP107) compared to remote sites west and east of the valley (JP201 and JP213). All sites, except JP213, showed highest HNO_3 concentrations in July or August and lowest concentrations between October and December. This temporal pattern is expected based on photochemical oxidation rates boundary layer structure and thermodynamically driven gas-particle partitioning.

NH_3 concentrations were somewhat higher than HNO_3, but showed similar spatial and temporal variability. Mean NH_3 values were 0.3-0.4 µg/m³ for JP104 and JP107 and 0.1-0.2 µg/m³ for JP201 and JP213. Peak concentrations of NH_3 were observed at all sites in July and August 2014. August concentrations exceeded 1 g/m³ at JP104 and JP107 and were very likely influenced by several large wildfires north of Fort McKay. Concentrations decreased dramatically from fall into winter as a result of reduced biological activity, snow cover and gas-particle partitioning.

In general, results suggest that the sampler operates reliability at remote, solar-powered sites, and is capable of providing high-quality data for detection of real world spatial gradients, source impacts and month to month or season to season temporal variability.

Figure 3. Monthly and bimonthly HNO_3 concentrations. Samples labelled Nov-13, Oct-14 and Dec-14 were collected over two months.

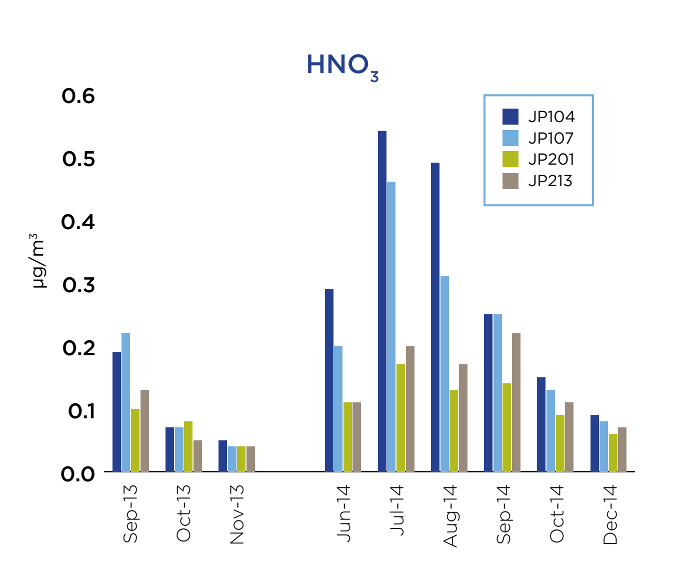
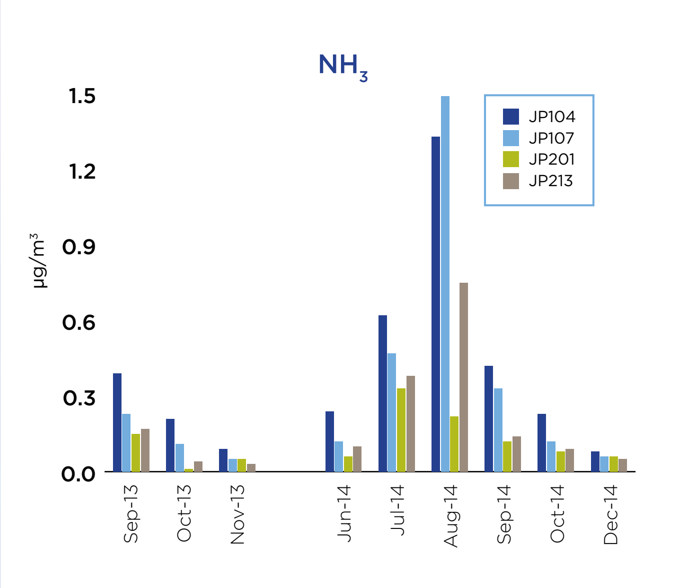


Figure 4. Monthly and bimonthly NH_3 concentrations.



Eric Edgerton
Atmospheric Research & Analysis

5.8 Wood Buffalo Environmental Association's Forest Health Report

WBEA'S FOREST HEALTH MONITORING PROGRAM

Shortly after its inception in 1997, the Wood Buffalo Environmental Association (WBEA) established a program to determine if anthropogenic emissions of acidifying compounds such as sulphur dioxide (SO_2) and nitrogen oxide (NO_X) gases were having long-term adverse effects on the regional terrestrial environment, and, if so, to assess the magnitude of any impact. The Athabasca Oil Sands Region (AOSR) is situated within the Canadian Boreal Plains Ecozone (with some extension of the Canadian Shield into the northeast), dominated by upland jack pine, aspen, and mixed forest, along with bogs and wetlands.

In 1998, WBEA initiated measurement and sampling at a network of 10 jack pine (*Pinus banksiana* Lamb.) dominated interior forest stand plots (AMEC, 2000). Five additional plots were added between 1999 and 2003, and two were lost to development.

Another cycle of measurement and sampling of soils and vegetation occurred at 13 jack pine plots in 2004 (8 plots were previously sampled in 1998, and one in 2001). Findings from the 2004 intensive sampling included:

- No direct emissions-related effects were found on foliar retention rate or needle condition.
- No anomalous abiotic effects on tree condition were observed at any of the 13 plots.
- Foliar chemistry data showed that the effect of local industrial emissions was evident in increased concentrations of total sulphur, inorganic sulphur, iron and nickel, all of which are known to be components of oil sands emissions.
- Despite evidence of increased elemental concentrations in foliage with greater modeled deposition levels, there was no evidence of a negative effect on forest productivity.
- An unexpected, positive association was found between modeled potential acid input and soluble and exchangeable soil magnesium (Mg) and potassium (K) concentrations.
- This was attributed to ecological site differences unrelated to the impacts of industrial air emissions.
- To improve the ability to compare results between monitoring sites throughout the region, a decision was made, following an external science review, to adopt a more comprehensive, integrated Forest Health approach to future monitoring.

The Forest Health monitoring approach establishes/determines cause-effect relationships between air pollutants and forest ecosystem function. Between 2008 and 2011, WBEA embarked on a significant science build, including adoption of the ecological analogue approach to site selection, adoption of new biological/physical/chemical indicators, and instrumentation of plots. By 2011/12, WBEA's Forest Health Network had expanded to 25 interior jack pine stand plots, 25 forest edge plots for early warning of change prior to a measureable effect, 6 meteorological towers, and passive/active monitoring analyzers.

In 2011, a multidisciplinary team of scientists and technical professionals completed an extensive sampling and measurement at the 21 of the regional forest health plots. Four of the 25 plots were consumed in the Richardson Fire, which burned through 700,000 ha, from May through June in 2011.

WBEA'S 2015 FOREST HEALTH MONITORING REPORT

The Forest Health Report, *Assessing Forest Health in the Athabasca Oil Sands Region*, is available at *http://wbea.org/resources/terrestrial-monitoring-reports.* The report summarizes the results of the 2011 survey and compares them to the 1998 and 2004 surveys, where possible. Specifically, results from the following sampling cycles:

- 1998: measurement and sampling at a network of 11 jack pine (*Pinus banksiana* Lamb.) plots took place.
- 2004: measurement and sampling of soils and vegetation occurred at 13 plots.
- 2011/12: the enhanced forest health network of 21 plots was sampled.

The twelve chapter WBEA Forest Health report integrates monitoring history, network design, results from air/deposition monitoring, deposition modeling, above-and below-ground biological and chemical measurements made in 2011/12, as well as comparative status of some indicators measured at five plots that were sampled in 1998, 2004 and 2011/12. The results of the air, deposition, soil, lichen, vegetation and microbiology sampling are presented in the Report as follows:

- *Introduction to the report: Assessing forest health in the Alberta Oil Sands Region* - Thomas Clair, Wood Buffalo Environmental Association, Fort McMurray, AB, Mervyn Davies, Stantec Consulting Ltd., Calgary, AB, Keith Puckett, ECOFIN, Waldemar, ON, and Kevin Percy, Wood Buffalo Environmental Association, Fort McMurray, AB
- *Air pollution and dry deposition of nitrogen and sulphur in the AOSR estimated using passive samplers* - Yu-Mei Hsu, Wood Buffalo Environmental Association, Fort McMurray, AB and Andrzej Bytnerowicz, US Department of Agriculture, Forest Service, Pacific Southwest Research Station, Riverside, CA, USA
- *Wet and dry deposition in the AOSR collected by ion exchange resin samplers* - Mark Fenn, US Department of Agriculture Forest Service, Pacific Southwest Research Station, Riverside, CA, USA
- *Predicted spatial variations of sulphur and nitrogen compound concentrations and deposition in the AOSR* - Mervyn Davies, Kanwardeep Bajwa and Reid Person, Stantec Consulting Ltd., Calgary, AB
- *Site selection and field methods for the Forest Health study* - Kenneth Foster, Owl Moon Environmental Inc., Calgary, AB
- *Plot tree layer description* - Ellen Macdonald, Department of Renewable Resources, University of Alberta, Edmonton, AB
- *Soil Biology in the AOSR using phospholipid fatty acid analysis* - Jacynthe Masse, Carolyn Churchland and Sue J. Grayston, Department of Forest and Conservation Sciences, Faculty of Forestry, University of British Columbia, Vancouver, BC
- *Routine foliar and soil analysis of 15 years monitoring in the AOSR* - Doug Maynard, Natural Resources Canada, Canadian Forest Service, Victoria, BC
- *Responses of understory vegetation to deposition from oil sand processing operations* - Ellen Macdonald, Department of Renewable Resources, University of Alberta, Edmonton, AB
- *Chemical composition and lichen community change in the AOSR* - Keith Puckett, ECOFIN, Waldemar, ON
- *The application of critical loads and estimates of exceedance for sulphur and nitrogen deposition to forests in the AOSR* - Shaun Watmough, Trent University, Peterborough, ON and Colin Whitfield, Centre for Hydrology, University of Saskatchewan, Saskatoon, SK
- *State of the jack pine forest* - Thomas Clair and Kevin Percy, Wood Buffalo Environmental Association, Fort McMurray, AB

Left: Measuring jack pine branches at a WBEA Forest Health site. Right: A technician surveys the plant species at a WBEA Forest Health site.

KEY RESULTS FROM WBEA'S 2015 FOREST HEALTH MONITORING REPORT

Key results from the Report include:

- The highest passively measured and modeled air concentrations of SO_2, NO_2, ammonia (NH_3), and nitric acid (HNO_3) were reported nearer to the oil sands operations. NH_3 was increased in the southern portion of the region, due to agricultural input.
- Ozone (O_3) concentrations, as expected, increased with distance from oil sands operations.
- Similar patterns of air concentrations and spatial deposition for sulphur (S) and nitrogen (N) were reported.
- A west to east pattern was detected which resulted in higher S and N concentrations/deposition east of the mining and upgrading operations, than to the west.
- A north-south pattern in air concentrations was detected, which demonstrated the influence of valley topography upon pollutant dispersion.
- Air quality and deposition measurements showed that N and S concentrations/deposition amounts are enhanced within 30 km of oil sands operations, and decline with increasing distance from them.
- N and S air concentrations and deposition amounts reach background levels approximately 40-50 km away from the main oil sands emission sources.
- Trace element and heavy metal concentrations in vegetation generally follow the same spatial distribution pattern.
- Levels of S and N in jack pine foliage at six plots increased from 1998 to 2012.
- Sulphur in soils was correlated with modeled S+N deposition at the LFH, 0-5 and 5-15 and 15-30 cm depths. (L,F,H is an organic soil horizon containing > 17% organic C (approximately ≥ 30% organic matter) by weight. It is developed primarily from the accumulation of leaves, twigs, and woody materials with or without a minor component of mosses. It is also normally associated with upland forested soils with imperfect drainage or drier).

Left: the plant species present in a forest quadrant and their relative abundance are recorded. Right: Soil sampling during the 2011 WBEA Forest Health Survey.

- Nitrogen is being taken up in vegetation, and is not accumulating in mineral soils.
- Neither soil N nor pH showed any correlation with measured deposition.
- Soil microflora, as well as vascular cover, forb cover and shrub richness were strongly and positively related to atmospheric deposition of base cations.
- There was no correlation between ecosystem variables and S and N as acidifiers due to the deposition of base cations which neutralizes the acid input.
- The role of atmospheric N deposition, as a nutrient, has the potential to increase in relative importance.
- Aluminium (Al) toxicity is considered an important factor in forest deterioration caused by soil acidification. A ratio of base cations (BC) to Al in the soil solution is widely used as an indicator for potentially adverse effects on tree health.
- There was no correlation between base cation/aluminum (BC: Al) ratios in the LFH and mineral soil and modeled S and N deposition.
- The BC:Al trigger set under the CEMA Acid Deposition Management Framework (*http://cemaonline.ca/index.php/cema-recommendations/acid-deposition*) was not exceeded, in 2011/12.

Environmental monitoring must never remain complacent, and must always be innovative, adaptive and responsive as is demonstrated in this report. We hope science-based monitoring continues to be responsive, and adaptable to continuing oil sands development, and will be fully supported and adequately funded going forward.

Kevin Percy, PhD
Executive Director

5.9 An Update on Temporal and Spatial Deposition of Nitrogen and Sulphur

INTRODUCTION

Nitrogen (N) and sulphur (S) pollutants are among the major pollutants emitted from industrial and other activities in the Athabasca Oil Sands Region (AOSR). Such pollutants are emitted to the atmosphere in both gaseous and particulate forms. Overarching questions to which these data contribute include the levels of acidifying and buffering pollutants, the levels of N deposited, and the spatial and temporal patterns of such deposition (Fenn, 2015). Nitrogen has both acidifying and eutrophying (or at least growth promoting) potential for trees, other plants and biota. Sensitive species can be negatively affected by N enrichment.

Deposition to the forest or land surface can be measured in solution as precipitation to 'open' or tree canopy-free areas, or in throughfall solutions collected below tree canopies. Deposition measured in continuously-exposed collectors in open sites is referred to as bulk deposition, because some dry deposition is also collected along with the main wet deposition component. Throughfall solution samples collected below tree canopies is a particularly useful measurement in the AOSR, where the majority of air pollutants reach ecosystems through dry deposition processes. Throughfall, therefore, includes wash off of pollutants initially deposited to the tree canopy as dry deposition (gases and particulates), in addition to some direct precipitation which does not interact directly with the relatively open jack pine canopies in the AOSR. Thus, throughfall is a lower-bound estimate of total deposition to the canopy.

The results presented in this update are based on ion exchange resin (IER) samplers (Fenn and Poth, 2004) which collect ions from solution onto IER columns for an entire 6-month season (summer and winter) after which the ions are extracted from the columns in the laboratory and analyzed for nitrate (NO_3), ammonium (NH_4) and sulfate (SO_4). Data on deposition to open-site and throughfall collectors are reported as summer and winter spatial patterns for the years between 2008 and 2014. To show change over time, only data from monitoring sites having a longer deposition record are presented; that is, generally 4-7 winter and summer exposures. This monitoring record is too short to detect definitive long-term trends, but it is nonetheless worthwhile to look for sites where deposition flux values may indicate increases or decreases, possibly as a result of changes in industrial activities.

RESULTS AND DISCUSSION

Spatial Patterns:

The IER sites used in this analysis are mapped on page 102. Congruent with previous published work in the AOSR, N and S deposition declined exponentially with distance from the main upgrading area. Fenn et al. (2015) showed the spatial patterns of deposition on an annual basis. In this brief report, throughfall deposition of NH_4, NO_3 and SO_4 spatially and by season is summarized. Data from the Anzac Air Monitoring Station (AMS14) continuous monitoring site in Anzac were omitted from the spatial analysis because this site is apparently affected by relatively large local emissions, resulting in higher deposition than would be expected based on its location in what is a regional plot network.

The IER data show the order of deposition (highest to lowest amount) for N and S ions as $SO_4 > NH_4 > NO_3$. For all three ions, an exponential decrease in throughfall deposition is seen with distance from the main upgrading area. At distances of 40 km or greater, NH_4 deposition (Figure 2) in throughfall is near regional background levels. However, NO_3 (Figure 3) is slightly enhanced above regional background at 40 km distance, particularly in winter. Sulphate (SO_4) is the ion that shows the largest deposition footprint. Summertime throughfall deposition values of 3-4 kg/ha were recorded at 90 km distance from the main upgrading area (Figure 4).

Temporal Changes:

An unexpected finding was the large increase in SO_4 deposition at the R2 throughfall site (adjacent to JP104) since 2011 for summer, and since 2012 for winter except winter 2013/2014 when SO_4 deposition was relatively low. However it was also much lower at the lysimeter site, suggesting this may have been precipitation driven, or S and N industrial emissions could have been lower in winter 2013/2014.

The observation of increased SO_4 deposition in recent years at R2 is also reflected in deposition to open collectors at the adjacent JP104 open site. The degree of increase in SO_4 deposition at R2 for example is greater in throughfall than in the JP104 open site. This was expected because the tree canopies function as effective dry deposition collectors; the accumulated dry deposition is later washed from the canopy during precipitation or snow melt events, resulting in a pulse of ionic deposition that isn't measured in open-site collectors. The JP212 site, located south of the R2 and JP104 sites, also shows a potential increase in SO_4 deposition to open collectors in winter, but not in summer. The industrial/natural sources of the large increase in SO_4 deposition at the sites near R2 has not been investigated yet.

The lysimeter site is a useful reference point for interpreting the relative levels of deposition at the R2 and JP104 open sites. The lysimeter site is situated at the centre of the upgrading area. Stacks, especially as part of the bitumen upgrading process, are responsible for some 99% of SO_2 emitted in the AOSR. Thus, the lysimeter site is has the highest S deposition measured within the regionally-focused IER monitoring network. Sulfate deposition in throughfall at R2 since 2011 has been similar to, and sometimes higher than at the lysimeter site. Increases in SO_4 deposition have occurred in the area near the R2 site. That the increase is mainly due to dry deposition of SO_4 is illustrated by the much higher deposition of throughfall SO_4 compared to bulk deposition in the open-site 104 collectors (Figure 4).

It is not clear what role on-road transportation emissions play in this increase given the construction and other traffic that has been using the East Athabasca Highway since 2009. Highway emissions occur some 100 m from the edge of the R2 jack pine stand which is fully exposed to the highway. Nonetheless, the trends at R2 may merely reflect the more regional temporal trends at the lysimeter site. The period of monitoring is too short to conclude that SO_4 deposition is increasing at R2 and not at the lysimeter site. This is particularly the case considering that no IER collectors were in place at lysimeter during the summer 2011 season as the total site became a large forest fire fighting camp during the Richardson Fire.

The data also suggest that NO_3 deposition in summer throughfall may also have increased at R2 and at the open JP104 site in summer and winter. Likewise at the Anzac Air Monitoring Station (AMS14) in the open during winter. These are only at this time preliminary and short term observations. More data will be needed to detect significant trends.

CONCLUSIONS

The new IER deposition data support previous data showing the rapid decline in N and S deposition with distance from the source area. A longer deposition record is needed to delineate temporal trends of deposition in the AOSR. These early findings suggest a possible increase since 2011 in SO_4 deposition in the region near the R2, JP104 and JP212 sites. The data also suggest that NO_3 may have also increased at the R2 and JP104 sites, although to a lesser degree than for SO_4.

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Dr. Mark E. Fenn
USDA Forest Service
Pacific Southwest Research Station
Riverside, CA, U.S.A.

Figure 1. Location of IER sampling sites. Reproduced from Fenn et al. (2015).

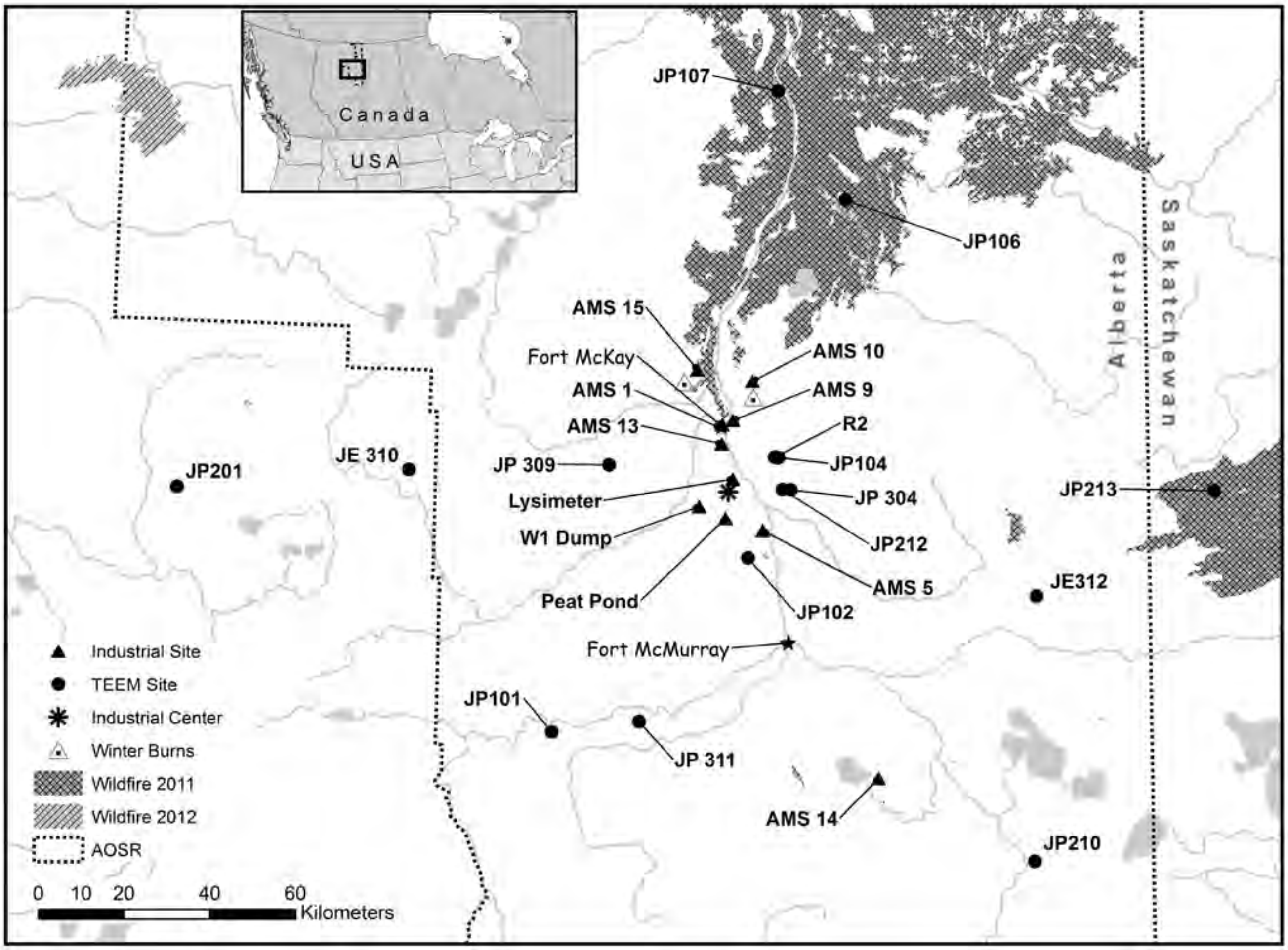
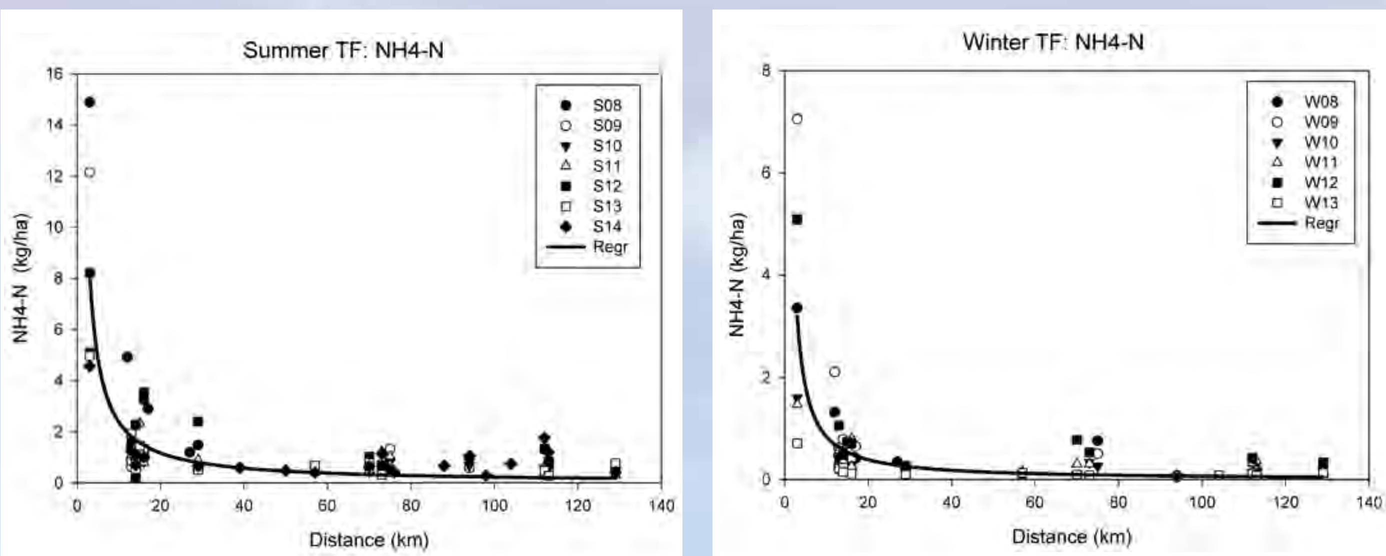


Figure 2.



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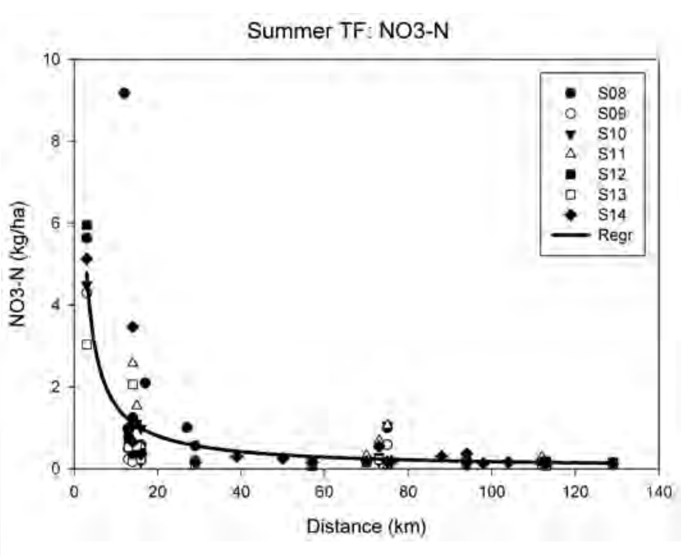


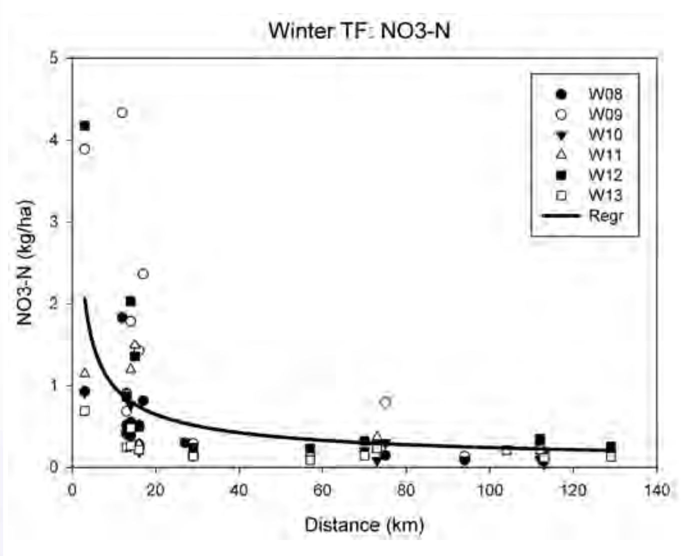
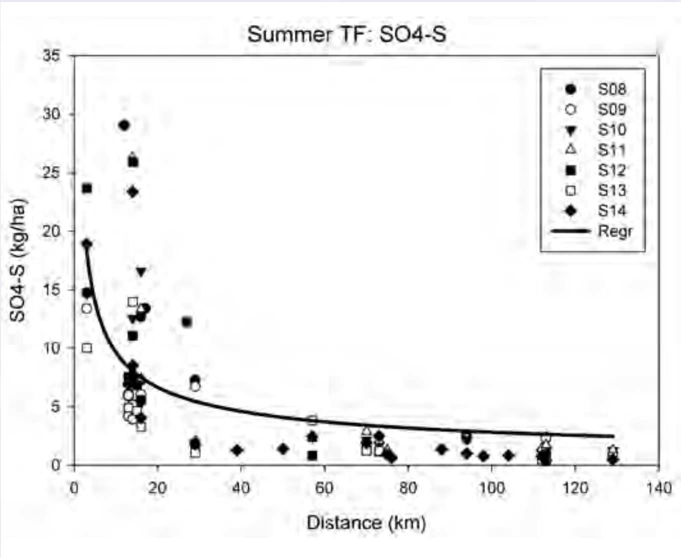
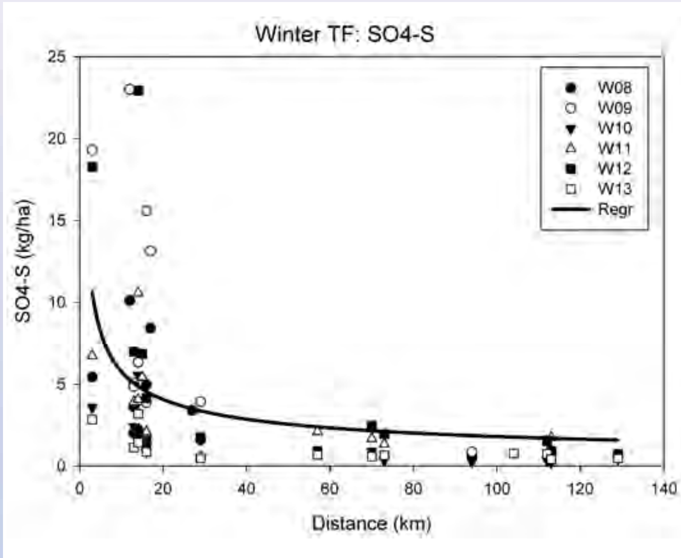


Figure 4






Wood Buffalo Environmental Association
Your Independent Air Quality Reporter

6.0

6.0 Human Exposure Monitoring Program in 2014

6.1 Human Exposure Monitoring Program in 2014

Human Exposure Monitoring Program (HEMP) activities in 2014 continued to focus on odour detection and chemical characterization in communities where public concerns about odours had been expressed. Through the use of both instrumentation and the human nose, HEMP monitored and complied odour-related data. These data were reviewed by the HEMP Committee (Appendix V). Both analyzer data and volunteer-generated odour reports for 2014, are to be incorporated into a final Odour Integration Report, in order to assess and communicate odour-related human exposure results to stakeholders in the Regional Municipality of Wood Buffalo.

In 2014, HEMP monitored odours with specialized odour analyzers including an Electronic Nose (eNose) and a Pneumatic Focusing Gas Chromatograph (PFGC). A community volunteer based odour monitoring initiative, called the Community Odour Monitoring Project (COMP), which operated for the second year in 2014, in Fort McMurray, contributed to HEMP's understanding of the human perception of odour related air quality issues in the region.

ODOUR ANALYZERS

Two WBEA air monitoring stations are assigned to incorporate HEMP odour monitoring activities:

1. The Bertha Ganter-Fort McKay air monitoring station is a permanent, continuous air monitoring station located in the community of Fort McKay.
2. The HEMP Portable air monitoring station is a portable air monitoring station which may be deployed throughout the region for odour-related monitoring at recommended locations.

WBEA air analyzers and meteorology instruments, installed in these stations, continuously monitored total reduced sulphurs (TRS), total hydrocarbons (THC), methane/non-methane hydrocarbons, wind speed, wind direction, temperature and relative humidity. In conjunction with these instruments, the eNose, which detects odour strength and odour events and the PFCG, which identifies volatile organic compounds (VOC), were installed in Bertha Ganter-Fort McKay. A PFGC also operated in the HEMP Portable during 2014.

The 2013 Odour Integration Report, completed in 2014, provided HEMP with a more complete understanding of correlations that exist between odour analyzing instruments and the community monitoring method.

HEMP Program Manager, Abena Twumasi-Smith and Technician, Zach Eastman, calibrate the odour analyzing instruments in the HEMP Portable air monitoring station.

COMMUNITY ODOUR MONITORING PROGRAM

The COMP program began in Fort McMurray in June 2013 and continued in the community for two years until May 31, 2015. COMP odour summaries were generated from volunteer's odour reports. The first year of the Fort McMurray project concluded on May 31st, 2014. The project was renewed for a 2nd year, and ran from June 1st, 2014 until May 31, 2015.

A total of 156 odour observations were reported for year 1, while 285 reports were submitted for year 2. Among the commonly reported odours perceived in 2014/15 were Fuel-Solvent, Asphalt-Tar, Burnt-Smoke and Fecal-Septic.

ADDITIONAL HEMP ACTIVITIES IN 2014

HEMP participated in collaborative monitoring activities with other agencies in 2014. In August 2014, HEMP was asked by AEMERA to assist their team in the set-up and deployment of a Fourier Transform Infrared spectroscopy (FTIR) for a 2-month period of operation at Bertha Ganter-Fort McKay. The FTIR detects the presence of VOC and other gas species.

In September 2014, work plan recommendations to address stakeholder's requests, contributed to a focus of HEMP's odour monitoring in Anzac. The HEMP Portable was relocated to Anzac, in September 2014, to monitor and report odours. Continuing concerns of local residents, including Aboriginal communities, about odours prompted the HEMP committee to propose Anzac as the new location of COMP. Monitoring in Anzac continues in 2015, as the COMP program assists local residents to track and report the odours they encounter. The eNose will be relocated to Anzac in 2015.

In October 2014, the community odour monitoring project results, along with other WBEA air quality monitoring results, were presented to a wider audience at the North American Oil and Gas Conference in Calgary during the presentation *Community Odour Monitoring Project: Describing Odour Exposures in Fort McMurray, Alberta* by Thierry Pagé, Odotech Inc., QC, and Canada. This was another opportunity to share data with stakeholders and the public, which is one of HEMP's key objectives.

Abena Twumasi-Smith
HEMP Program Manager

During the 2014 Member's Open House, HEMP Program Manager, Abena Twumasi-Smith, centre top, speaks about the HEMP Program. The FTIR instrument is housed in the tent above.

HEMP COMP volunteer Karen Nixon participates in odour identification training prior to the start of the 2014-2015 Fort McMurray project.

6.2 Community Odour Monitoring Project 2013 - 2015

The Community Odour Monitoring Project (COMP) is a component of WBEA's Human Exposure Monitoring Program (HEMP). COMP is a community based odour monitoring approach. The objective of COMP is to involve residents in the assessment of air quality odours and the identification of regional odour types.

COMP has operated in the community of Fort McMurray for a 2 year period. From June 1, 2013 to May 31, 2015 volunteers from Fort McMurray identified and reported the odours they perceived. The cumulative reports of these project volunteers have helped to determine the impact of odour exposure encountered in day-to-day activities.

The monitoring areas of the Fort McMurray COMP included the various divisions within the community: Abasand Heights, Beacon Hill, Dickensfield, Downtown Fort McMurray, Gregoire, Parsons Creek North, Saline Creek, Thickwood, Timberlea and Waterways.

Volunteers with the WBEA Community Odour Monitoring Project (COMP) during odour identification and intensity training.

The ten most frequently documented odour types in the Fort McMurray area were identified at the start of the project in 2013 in order to distinguish key regional odours. These odour types originate from a variety of commonly described regional 'smells' and from various sources in the local air-environment.

ODOUR OBSERVATIONS

The numbers of odour observations, by odour type reported in Year 1 & Year 2 included:

2013 – 2014 (Year 1)	2014 – 2015 (Year 2)
Ammonia/Cat Pee - 10	Ammonia/Cat Pee - 21
Asphalt/Tar - 38	Asphalt/Tar - 53
Burnt/Smoke - 24	Burnt/Smoke - 82
Chemical/Plastic - 4	Chemical/Plastic - 5
Fecal/Septic - 21	Fecal/Septic - 21
Fuel/Solvent - 40	Fuel/Solvent - 59
Natural Gas - 1	Natural Gas - 13
Rotten Egg - 5	Rotten Egg - 10
Skunk - 2	Skunk - 9
Other - 11	Other - 12

Volunteers were trained to recognize and report community odours through one of the following methods – a smart phone application, a website, a hard-copy observation card or an automated phone system.

Data were collected, analyzed, summarized and grouped into 3 month quarters throughout the year. For each odour report, participants were asked to answer the following questions:

- Date and time of the observation
- Location of the observation (anywhere in the project area)
- Physical state of the volunteer (healthy or sick)
- Meteorological conditions
- Wind condition
- Type of odour perceived
- Intensity of the odour
- Appreciation of the odour
- Any additional comments

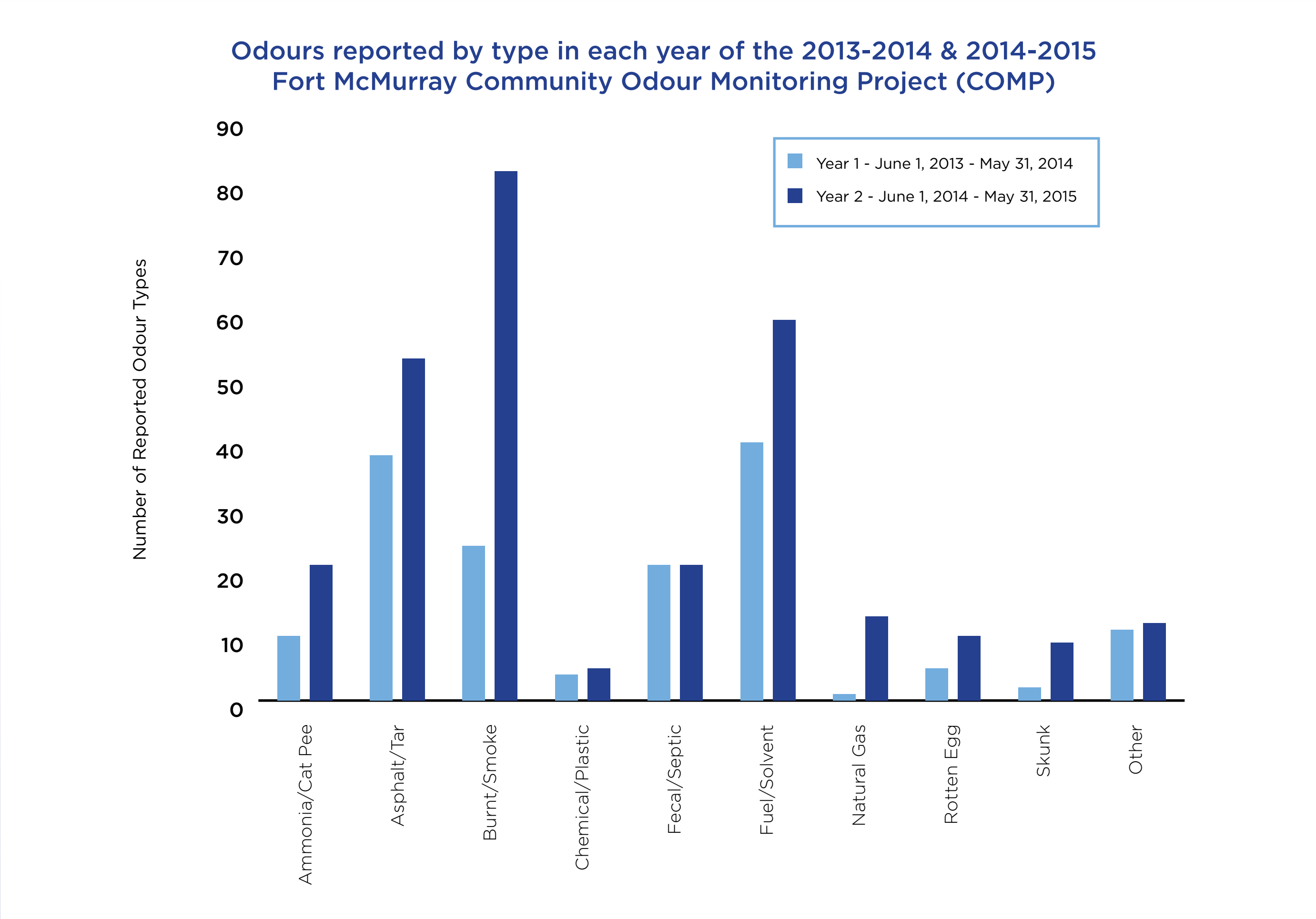
In year 1, a total of 156 odour types were reported from June 1, 2013 - May 31, 2014. These reports reflect the following:

- 88 observations from June – August 2013
- 23 observations from September – November 2013
- 12 observations from December 2013 – February 2014
- 33 observations from March – May 2014

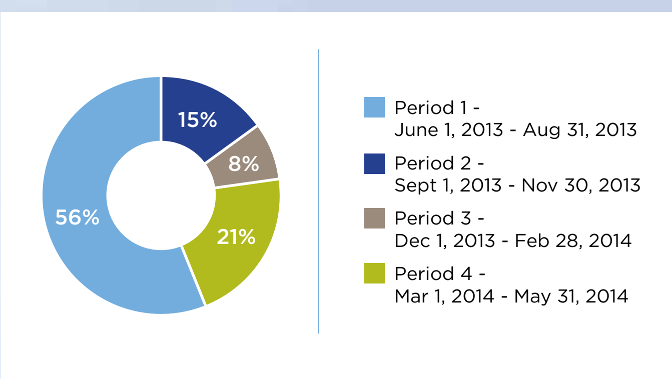
In year 2, a total of 285 odour types were reported from June 1, 2014 – May 31, 2015, as follows:

- 139 observations from June – August 2014
- 51 observations from September – November 2014
- 33 observations from December 2014 – February 2015
- 62 odour types reported from March – May 31, 2015.

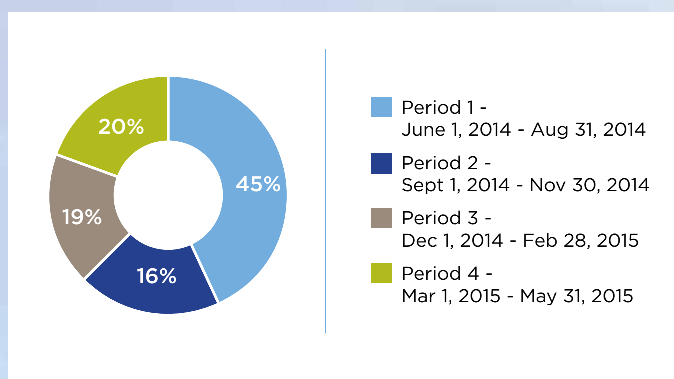
The following graphs summarize the total number of odour observations received by odour types and percentage of odours reported by observation periods in each year of the project.



Percentage of odours reported by observation period in Year 1 (2013-2014) of the Fort McMurray Community Odour Monitoring Project (COMP)



Percentage of odours reported by observation period in Year 2 (2014-2015) of the Fort McMurray Community Odour Monitoring Project (COMP)



ODOUR INTENSITY

HEMP-COMP participants were asked to rate the intensity (from very weak to very high) of the odour(s) they perceived.

Table 1 summarizes the odour intensity reported and the type of odours associated with intensity in year 1 (2013/14). In 2013/14, of all the odour observations, 74% were reported as weak or medium intensity, while 23% were reported as high or very high. In 2013/14, asphalt/tar odours were perceived with all levels of intensity from very weak to very high and accounted for 37% of the observations reported with high or very high intensity. Fuel/solvent odours were associated with intensity ranging from very weak to high. Odours of fecal/septic were reported with intensity ranging from weak to very high.

Table 1. Odour Intensity Reported by COMP Volunteers in Fort McMurray 2013-14

* Observations may report more than one type of odour but only one level of intensity.

Intensity	Number of Observations	Type of Odour (# of Observations)*
Very High	8	Ammonia/Cat's Pee (2), Asphalt/Tar (3), Burnt/Smoke (1), Fecal/Septic (1), Asphalt/Tar and Chemical/Plastic (1)
High	27	Ammonia/Cat's Pee (2), Asphalt/Tar (10), Burnt/Smoke (4), Chemical/Plastic (1), Fecal/Septic (3), Fuel/Solvent (3), Other (1), Fuel/Solvent and Asphalt/Tar (1), Asphalt/Tar and Natural Gas (1), Asphalt/Tar and Ammonia /Cat's Pee (1)
Medium	67	Ammonia/Cat's Pee (5), Asphalt/Tar (14), Burnt/Smoke (8), Chemical/Plastic (2), Fecal/Septic (16), Fuel/Solvent (12), Rotten Egg (4), Other (6)
Weak	45	Asphalt/Tar (4), Burnt/Smoke (11), Fecal/Septic (3), Fuel/Solvent (23), Rotten Egg (1), Other (2), Fuel/Solvent and Asphalt/Tar (1)
Very Weak	3	Asphalt/Tar (1), Fuel/Solvent (1), Other (clean, natural air) (1)
Unspecified	1	Asphalt/Tar (1)

Table 2 summarizes the odour intensity reported and the type of odours associated with it, in year 2 (2014/15). In 2014/15, of all observations, 73% were reported as weak or medium, while 27% were reported as high or very high intensity. Ammonia/cat's pee, asphalt/tar, burnt/smoke and fuel/solvent odours were associated with intensity ranging from weak to very high. Burnt/smoke odours accounted for 29% of the observations reported with high or very high intensity. Odours of fecal/septic, natural gas, rotten eggs and other were reported with intensity ranging from weak to high.

Table 2. Odour Intensity Reported by COMP Volunteers in Fort McMurray in 2014-15

* Observations may report more than one type of odour but only one level of intensity.

Intensity	Number of Observations	Type of Odour (# of Observations)*
Very High	16	Ammonia/Cat's Pee (4), Asphalt/Tar (3), Burnt/Smoke (6), Fuel/Solvent (3)
High	60	Ammonia/Cat's Pee (6), Asphalt/Tar (15), Burnt/Smoke (16), Chemical/Plastic (1), Fecal/Septic (5), Fuel/Solvent (6), Natural Gas (1), Rotten Egg (6) and Other (4)
Medium	157	Ammonia/Cat's Pee (9), Asphalt/Tar (28), Burnt/Smoke (47), Chemical/Plastic (4), Fecal/Septic (11), Fuel/Solvent (34), Natural Gas (10), Rotten Egg (3), Skunk (6) and Other (5)
Weak	51	Ammonia/Cat's Pee (2), Asphalt/Tar (7), Burnt/Smoke (13), Fecal/Septic (5), Fuel/Solvent (16), Natural Gas (2), Rotten Egg (1), Skunk (2) and Other (3)
Very Weak	1	Skunk (1)

Throughout the project WBEA hosted quarterly meetings for COMP volunteers to review the collected information and discuss observations about odours in the community. These meetings provided opportunities to provide feedback regarding the odour project. Final COMP reports for the Fort McMurray cohort are available on the WBEA website at *wbea.org/resources/human-exposure-monitoring-reports.*

Through their odour observations, recorded over the two year course of the project, Fort McMurray residents, have enhanced the understanding of the odour patterns seen in the community. WBEA will continue to gather and report odour information, through the community odour monitoring method, as COMP is introduced into the community of Anzac for the 2015-2016 year. WBEA stakeholders and local residents will continue to be informed about the odour impacts on human exposure through future community odour monitoring projects. At time of publishing, the Odour Integration Report for 2014 data, which attempts to integrate all odour-related data, was not yet available.

Abena Twumasi-Smith
HEMP Program Manager

7.0

7.0 Communications in 2014

The goal of the WBEA Communications program is to engage, educate and inform stakeholders throughout the Regional Municipality of Wood Buffalo (RMWB) and beyond, about the Association's monitoring work and results.

WBEA'S COMMUNICATIONS ADVISORY COMMITTEE

This committee, composed of the following representatives of WBEA's General Membership, provided guidance and advice at quarterly meetings:

Ann Dort MacLean - Fort McMurray Environmental Association - Chair (January - June)

Peter Fortna - Member - Conklin Resource Advisory Board - Chair (July - December)

Diane Phillips - Member - Syncrude Canada Ltd.

Shayla Chowdry - Member - Shell Canada Ltd.

Shannon Makinson - Member - Cenovus Energy Inc.

Carla Davidson - Member - Fort McKay First Nation

Sarita Parks - Member - Husky Energy Inc. (January - June)

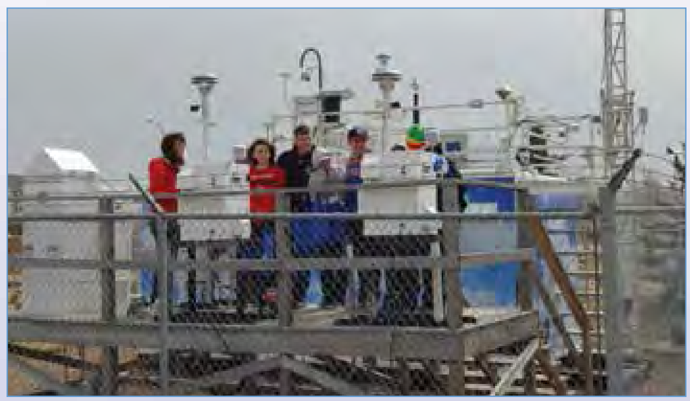
Jennifer Shalagan - Husky Energy Inc. (June – December)

Kevin Percy – WBEA

EDUCATIONAL OUTREACH

In 2014 WBEA Communications undertook a number of opportunities to meet with, inform and educate school, university and college students. Some of the key accomplishments were:

- Coordination of WBEA staff as judges at the Father Mercredi Junior High School Science Fair, Fort McMurray, in April.
- WBEA was a proud silver level sponsor of the 7th Annual Wood Buffalo Regional Science Fair also held in April. WBEA Communications hosted an information booth at the awards ceremony and WBEA President, Diane Phillips, presented five Crystal Clean Environment Awards to students who had demonstrated environmental stewardship in their projects. Winners of the 2014 Crystal Clean Environment Awards were:
    - Manar Dawud and Malak Saleh, representing Fort McMurray Islamic School, for their project: *Which Plant Fights Acid Rain the Best?*
    - Jacob Sacrey and Clayton MacDonald, representing Fort McMurray Christian School, for their project: *Air Pollution Revolution.*
    - Harshil Bhesania, representing École McTavish Junior High, for his project: *Veggie Plastics.*
- WBEA Communications and technical staff hosted two classes of Grade 7 science students from Father Mercredi School at an air monitoring station, pictured, and the Field Operations Centre for tours and interactive science activities on May 7th.



- On May 10th, WBEA welcomed a group of MBA students and professors from the Tuck School of Business at Dartmouth College, Hanover, NH, USA, for a presentation with Lead Scientist, Dr. Tom Clair, and Executive Director, Dr. Kevin Percy, followed by a tour of an air monitoring station, pictured.

- At the RMWB *Mad Science Summer Camp,* an outdoor summer community drop-in event for children, Communications provided an hour of entertaining activities related to air quality.
- In August, WBEA Communications made a presentation to Girls Inc. Summer Camp attendees, combined with interactive air quality science activities.

COMMUNITY OUTREACH

WBEA Communications hosted information booths or made presentations at the following events:

- Fort McMurray Senior's Group – an Earth Day presentation and question time with the senior's group who meet at the Fort McMurray Public Library.
- Fort McMurray Métis Festival - an opportunity to converse with festival visitors about the work of the Association.
- Fort McMurray International Air Show - a celebration of the opening of the new Fort McMurray International Airport, in early June, presented a venue to engage with local residents and visitors from outside the region.
- Fort McKay Trade Show - WBEA welcomed Fort McKay community members to an information booth at the Sept. 11th event. The work of the Traditional Environmental Knowledge (TEK) WBEA-Fort McKay Berry Focus Group was of great interest to community members.
- Fort McMurray Spring and Fall Trade Shows – Opportunities to speak with the public about the Community Odour Monitoring Program and to recruit volunteers.
- Emerald Day in Fort McMurray - WBEA hosted a booth at this fall event which recognized environmental work taking place in our region.

Gary Cross, WBEA, speaks to visitors to the WBEA Fort McMurray Trade Show booth.

WBEA VISITORS

WBEA Communications coordinated visits and tours of WBEA facilities and monitoring sites for several delegates and groups throughout the year, including:

- On March 14th, Dennis Bevington, the MP for the Western Arctic, and Lori McDaniel, NDP candidate for Fort McMurray-Athabasca.
- Brad Pickering, CEO of the Alberta Environmental Monitoring, Evaluation and Reporting Agency (AEMERA) and Bob Myrick, Manager Air Policy Evaluation, AESRD.
- Representatives of the World Presidents' Organization (WPO), *www.wpo.org,* Ontario Chapter, toured WBEA's Patricia McInnes Air Monitoring Station in Timberlea during their trip to the region, in May.
- Richard Smith, Acting Associate Regional Director General, West & North Environment Canada, visited WBEA on July 28th.
- Delegates with the European Union Energy Study Mission, visited WBEA on October 1st for a tour and discussions on environmental monitoring in our region.

MEMBER'S OUTREACH

- On September 18th, WBEA members toured sites in WBEA's regional monitoring network during the annual Member's Open House. WBEA Communications coordinated the event. Members learned about and viewed equipment dedicated to Air and Human Exposure Monitoring at WBEA's Bertha Ganter-Fort McKay air monitoring station. At forest health site JP 104, off the Firebag Road, members toured a forest health plot and meteorological tower, pictured, which is part of the with the Terrestrial monitoring network. One of the Fort McKay Berry Focus Group blueberry plots, with passive air pollution monitors, was also observed. Later, at WBEA's Field Operations Center in Fort McMurray, members viewed an air monitoring station being prepared for deployment. A short presentation on access to and operation of the WBEA Data Management System concluded the tour.

- WBEA Communications coordinated the following special meetings with members:
    - o During a visit with leadership of the Fort McMurray First Nation 468, at their headquarters, WBEA presented an overview of our air monitoring program including data capture as well as the Community Odour Monitoring Project.
    - o Fort McMurray Métis invited WBEA to present on the HEMP's Community Odour Monitoring Project at their monthly membership meeting at the Nistawoyou Friendship Centre in Fort McMurray.
    - o Representatives of the Chipewyan Prairie Dene First Nation (CPDFN) toured a WBEA air monitoring station and a forest health plot. During their visit, the CPDFN representatives engaged in discussions on air, odours, deposition and Traditional Environmental Knowledge monitoring.
- Communications coordinated orientation and outreach with the following new members in 2014:
    - o Conklin Resource Development Advisory Board
    - o Connacher Oil and Gas Ltd.

ADVERTISING

WBEA Communications employed varied advertising strategies and formats to reach stakeholders and key audiences:

- Streaming real-time Air Quality Health Index readings for the Wood Buffalo Region to LCD screens at MacDonald Island Park, the Anzac Recreational Centre, the Fort McMurray International Airport and the Wood Buffalo YMCA.
- Publication of daily AQHI forecast in *Fort McMurray Today* newspaper.
- Scripting regular advertising spots on key local radio stations; including Mix 103.7, Country 93.3 and Cruz FM.
- Drafting and designing advertising for special events that WBEA attended, such as the Fort McMurray Tourism Trade Shows, and the Fort McMurray International Air Show.
- Drafting and designing advertising in support of WBEA's Community Odour Monitoring Project.
- Drafting and designing advertising for supplemental editions of the Fort McMurray Today and other trade magazines and community publications, including Connect Magazine, SNAP Wood Buffalo, Red River Current (Fort McKay) and the Willow Lake Newsletter (Anzac area).

SIGNAGE

In 2014, WBEA Communications conceived designs and facilitated installation of large exterior decals to wrap one permanent and two portable air monitoring stations. The station wraps attribute the units to WBEA and identify their purpose. This is particularly important for the portable units which are transported from site to site, to monitor upon request, or in the event of an air quality incident. The new station wraps include:

- The Bertha Ganter-Fort McKay Air Monitoring Station, located in the Fort McKay First Nation, was wrapped in a decal featuring an eagle in flight, pictured.
- The HEMP Portable, which monitors for air quality as well as odours, was wrapped in a scene of children hiking.
- WBEA's Mahihkan Portable Air Monitoring Station was wrapped in an image of wolves. Mahihkan is the Cree word for wolf.

MEDIA RELATIONS

- WBEA issued the following media releases in 2014:
- *WBEA approves 2014/2015 operating budget* - April 8, 2014.
- *WBEA air monitoring video translated for Cree & Dene stakeholders* - April 24, 2014.
- *WBEA's Standard Operating Procedures now available on website* - May 8, 2014.
- *WBEA elects Aboriginal, Industry, Government and ENGO members to Governance Committee* - June 13, 2014.
- *New video features volunteer-based Fort McMurray Community Odour Monitoring Project* - August 28, 2014.
- *WBEA translates project video for Cree & Dene stakeholders* - November 7, 2014.

WBEA participated in interviews with several media outlets in 2014, including the Edmonton Journal, Fort McMurray Today, CBC French Radio and Television, Mix 103.7, Cruz FM, Rock 97.9 and Country 93.3 radio stations, CHQR Radio Calgary and 630 CHED Radio Edmonton.

CONFERENCE ATTENDANCE

Conference attendance provided WBEA with opportunities to engage directly with regional, national and international audiences in 2014. WBEA Communications attended the following conferences:

- In January, at the *Air in Saskatchewan Symposium,* held in Saskatoon, WBEA Communications hosted an information booth and spoke with delegates about our multi-stakeholder, consensus-based monitoring association.
- WBEA Communications hosted a booth at GLOBE 2014 in March. GLOBE is North America's largest international environmental business summit, and as such, provided a national and international outreach opportunity.
- The North American Oil and Gas Conference, which was held in Calgary from October 21-22, allowed WBEA Communications to engage with industry and government stakeholders at this international scientific event.

WBEA Communications Advisors Jane Percy (left) and Melissa Pennell (right) speak to visitors to the WBEA booth at GLOBE 2014, held in Vancouver in March.

REPORTS

WBEA informs stakeholders of monitoring results, new initiatives, program updates, events and scientific outcomes through printed and electronic reports.

WBEA's *Report to the Community* is a colourful, printed tabloid, produced twice a year and mailed to the 28,500 addresses in the region. In 2014, the *Report to the Community* was published in June and November. WBEA Communications wrote, edited and solicited articles of interest to the general public including:

- *Measuring Atmospheric Mercury in Northeastern Alberta* - Daniel McLennan, Dr. Matthew Parsons, Monique Laplame, Chris Nayet, Corinna Watt, Rachel Mintz, Environment Canada and Dr. Kevin Percy, WBEA
- *Fort McMurray's Weather in 2013 and Past Years* - Martin Hansen, Rawin Consulting
- *Staff Profile of WBEA Technician Natalie Bonnell*
- *WBEA Community-Based Air Quality Monitoring Summary for 2013* - a summary of sulphur dioxide, nitrogen dioxide, particulate matter and total reduced sulphur data for community air monitoring stations in 2013.
- *WBEA's Proposed Southern Monitoring Plan* - As the number of resource extraction projects in the southern portion of the air shed continue to increase, WBEA members have developed a plan to monitor ambient air quality in that region - Sanjay Prasad, WBEA
- *WBEA-Fort McKay Berry Focus Group in 2014* - Janelle Baker, Little Seed Consulting, Inc.


WOOD BUFFALO ENVIRONMENTAL ASSOCIATION
Report to the Community
WINTER 2014

Measuring Atmospheric Mercury in Northeastern Alberta

Concerns over mercury entering the environment in northeastern Alberta have been raised, most notably in the work by Kelly, et al. (Proc. Natl. Acad. Sci., 2010). Understanding how mercury in the air is but one element required to paint the bigger picture of how mercury moves and transforms throughout the wider ecosystem, and Environment Canada has partnered with WBEA in an effort to do just that.

WBEA's New Video Shows Community Odour Monitoring Project in Action

Check out the new video in the Library section of WBEA's website or on our YouTube channel!

WBEA@Work, an interactive electronic newsletter, was published four times in 2014. *WBEA@Work* reports on scientific results of WBEA's three monitoring programs and other items of interest to Association Members. WBEA Communications wrote, edited and solicited articles.

- The April edition included articles on passively measured NO_2 and SO_2 in the southern Regional Municipality of Wood Buffalo, WBEA's Communications initiatives, our Health and Safety Program and the Executive Director's Update.
- Highlights of other 2014 issues include:
  - *HEMP Community Odour Monitoring Project Reports First Year of Results* - August 2014
  - *Accessing WBEA Air Monitoring Data* - August 2014
  - *Windblown Fugitive Dust Characterization in the Oil Sands Region* - November 2014
  - *WBEA Members View Operations at Annual Open House* - November 2014
  - *Volatile Organic Compound Passive Monitoring in the Athabasca Oil Sands Region, Alberta, Canada* - December, 2014
  - *Reporting for the Lower Athabasca Regional Plan* - December 2014

The WBEA 2013 Annual Report was completed. A committee of members reviewed content and data presentation in the Report. Articles about the Community Odour Monitoring Project, as well as the WBEA data reported for the 2013 Lower Athabasca Regional Plan, were two special sections in the 2013 Report.

WEBSITE/ONLINE TOOLS

The WBEA website is a vital tool for the dissemination of data and information. The website provides hourly updated air quality and meteorological data from WBEA's fixed, portable and mobile monitoring stations. Air Quality Health Index (AQHI) data for four WBEA community Air Monitoring Stations is also continuously streamed to the website. Throughout 2014, discussions were underway about streaming the Fort McKay developed Air Quality Index (FMAQI) on WBEA's website. After scientific review, WBEA adopted the FMAQI in March 2015, for streaming to the website, alongside the AQHI.

Throughout 2014, Communications continued to populate the site with new information and materials, including:

- media releases
- videos
- photos
- committee information
- reports
- newsletters
- fact sheets

In mid-2014 Communications initiated a website redevelopment project in order to enhance the user experience and provide better access to information and services for our members and stakeholders. The redeveloped WBEA website will be more professional, easier to navigate and visually appealing. Among its many enhanced features, the new website will include an interactive, multi-layered, GIS map of all WBEA monitoring sites, including fixed continuous air monitoring stations, passive sites, forest health sites, edge plots, etc. The new website is set to launch in March 2015.

WBEA's Facebook and Twitter profiles, and WBEA's YouTube channel, were used throughout 2014 to expand WBEA's outreach. All of WBEA's social media profiles are coordinated and integrated in order to maximise impact and outreach.

COMMUNICATIONS MATERIALS AND BRANDING

Among the many products developed by Communications in 2014, to support WBEA education and outreach, were:

- A vignette focusing on *WBEA's Community Odour Monitoring Project (COMP)*. The vignette featured interviews with COMP volunteers from the community of Fort McMurray, explaining how they are trained to monitor and report odours. The volunteers also conveyed the value that COMP brings to them personally and to the community. The video was translated into Dene and Cree.

- A *Southern Monitoring Plan Factsheet* was designed and printed and the WBEA, Air Monitoring and Terrestrial Monitoring factsheets were updated with new data and photos.
- A 2015 desk calendar featuring WBEA's monitoring programs, governance, stakeholders and outreach was designed and mailed out to 250 stakeholders.

WBEA PROGRAM SUPPORT

Communications assisted WBEA's monitoring programs in the following ways:

- In 2014, WBEA Communications assisted with recruitment of the second cohort of volunteers to HEMP's Community Odour Monitoring Project through advertising, special display banners, speaking with community members at various events and basket draws at the Spring and Fall Fort McMurray Trade Shows.
- Maps were designed and printed in poster format for the air and deposition monitoring programs.
- WBEA Communications took photographs and coordinated professional photography for WBEA.

JOINT CANADA – ALBERTA IMPLEMENTATION PLAN FOR OIL SANDS MONITORING (JOSM) AND THE ALBERTA ENVIRONMENTAL MONITORING, EVALUATION AND REPORTING AGENCY (AEMERA)

Communications participated in several AEMERA Engagement/Communications Component Advisory Committee (CAC) meetings throughout 2014, including providing input and advice for the 2015/2016 work plan and budget.

In support of all of the activities carried out in 2014, WBEA Communications gratefully acknowledges the Communications Advisory Committee and WBEA Members for their guidance, and WBEA staff for their enthusiastic help!

Jane Percy and Melissa Pennell
WBEA Communications

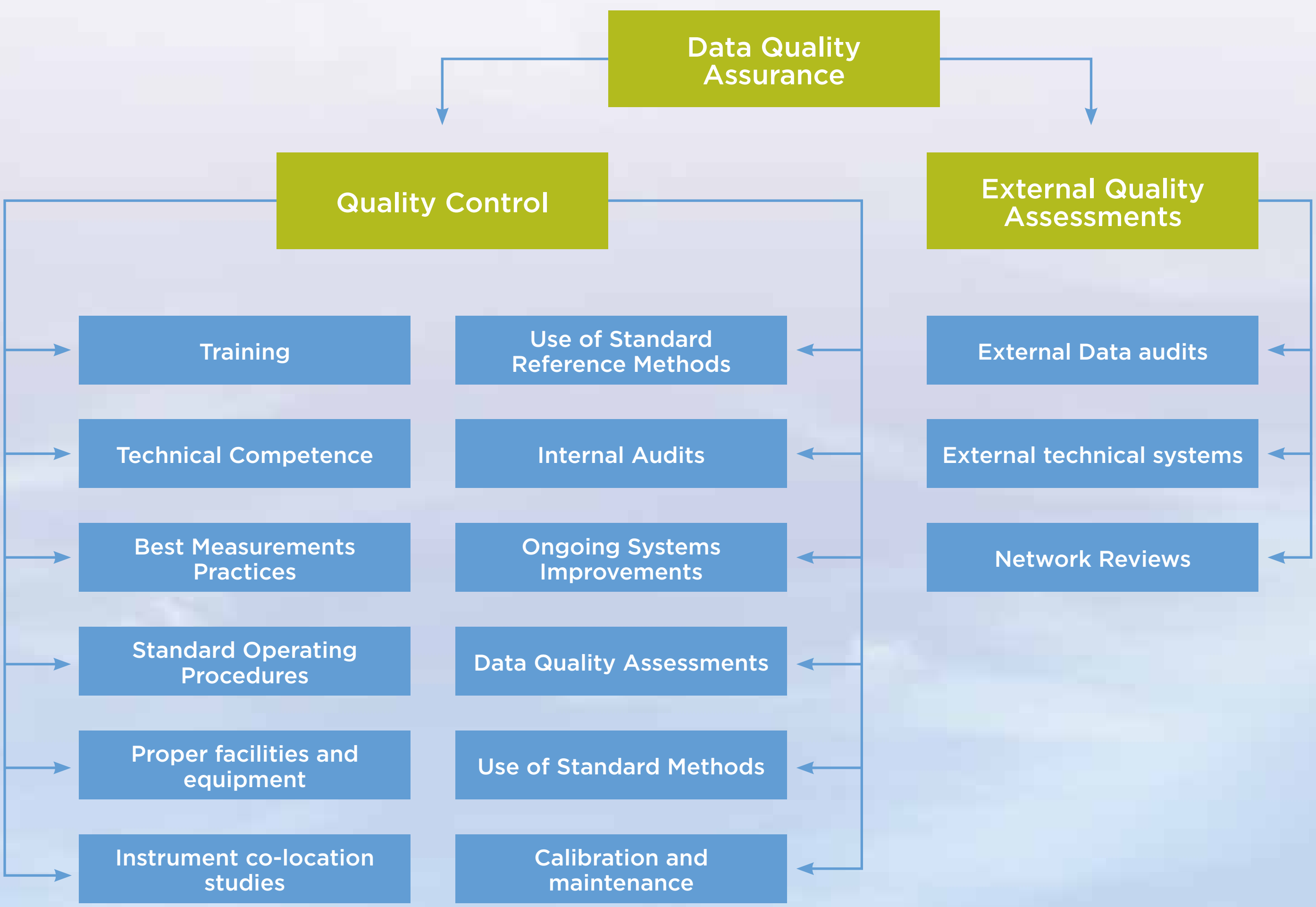
8.0

8.0 Data Management in 2014

8.1 Data Management in 2014

The Wood Buffalo Environmental Association (WBEA) has implemented comprehensive quality assurance and quality control programs to ensure data are accurate, reliable and fit for multiple objectives and intended purposes.

After review of multiple monitoring models, the concept design for WBEA's air monitoring program resembles most closely that of the Ministry of Environment in New Zealand. The ambient air program has established comprehensive quality control procedures and planning, and external audits for quality assurance and continuous improvement to the ambient air monitoring network. WBEA has designed and implemented procedures for daily, monthly and annual routines to ensure that operations and maintenance of the ambient air monitoring network are consistent with overall goals and objectives.

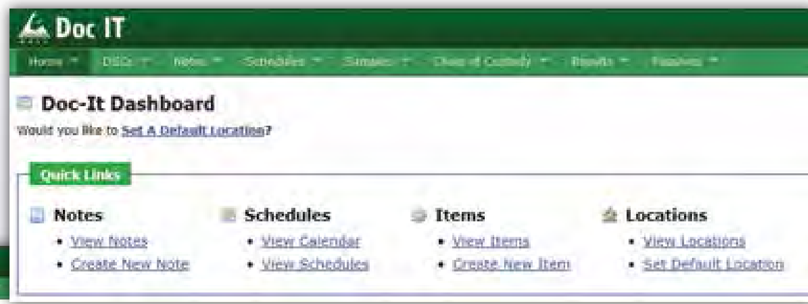


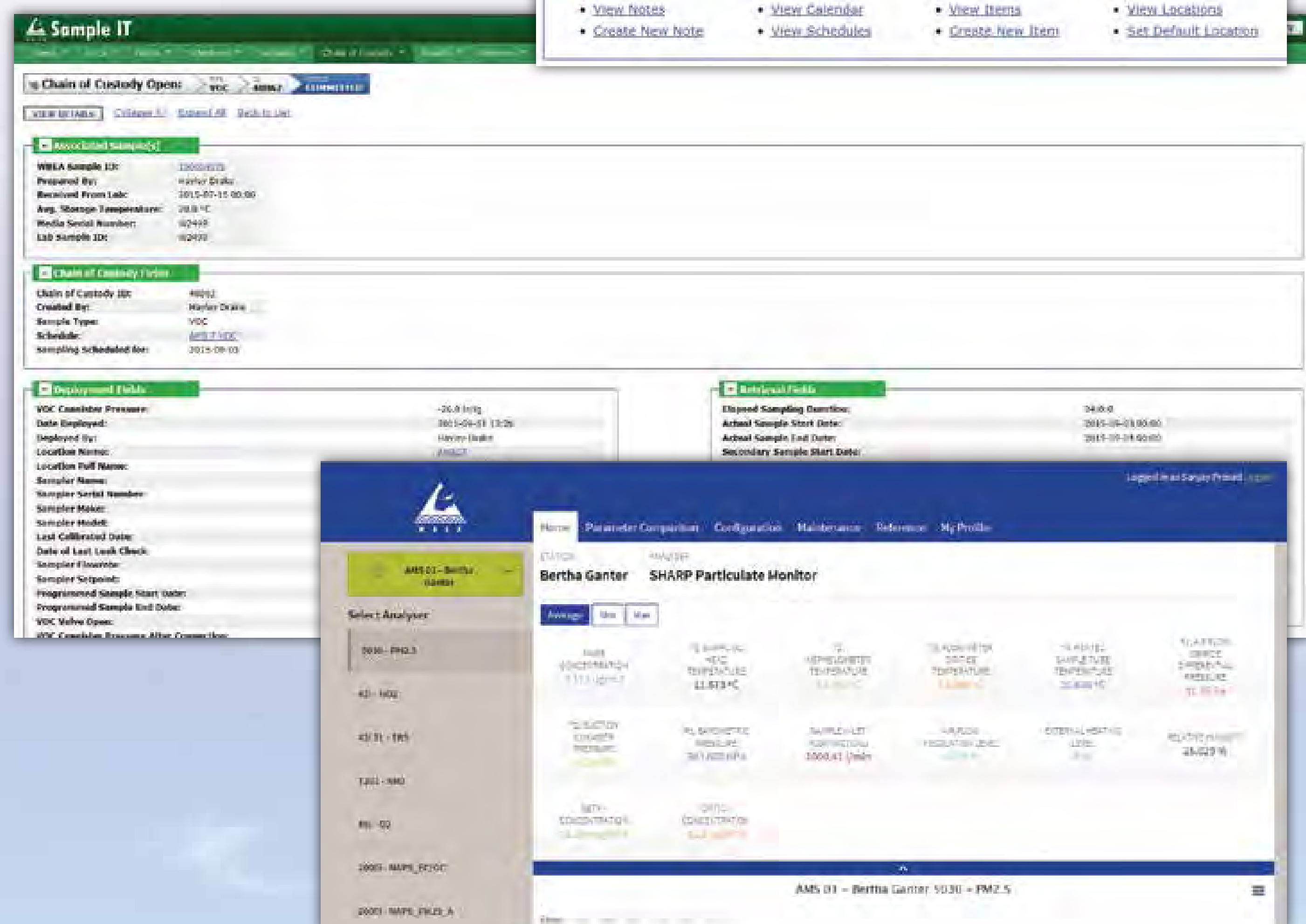
Operations and maintenance of the ambient air monitoring network and associated data collection generates in excess of 80 million data points annually, which must be properly recorded for users, today and into the future. WBEA has developed three software systems for our web interfaced documentation systems. Specifically, these three programs are named *DOC-it, Sample-it and Diagnostic Information System.*

DOC-it captures all daily routines and inspections of the network and tracks events at each station. This tool is used by field personnel to log in operations notes and observations and is used by personnel to review current and historical station information and operational notes.

The *Sample-it* program is used to record information required for samples collected in the network and subsequently shipped to contracting laboratories for analysis. This software tool is similar to chain of custody forms. The data collected on these electronic sample information sheets ensures that current users or future reviewers can interpret the historical monitoring data with confidence.

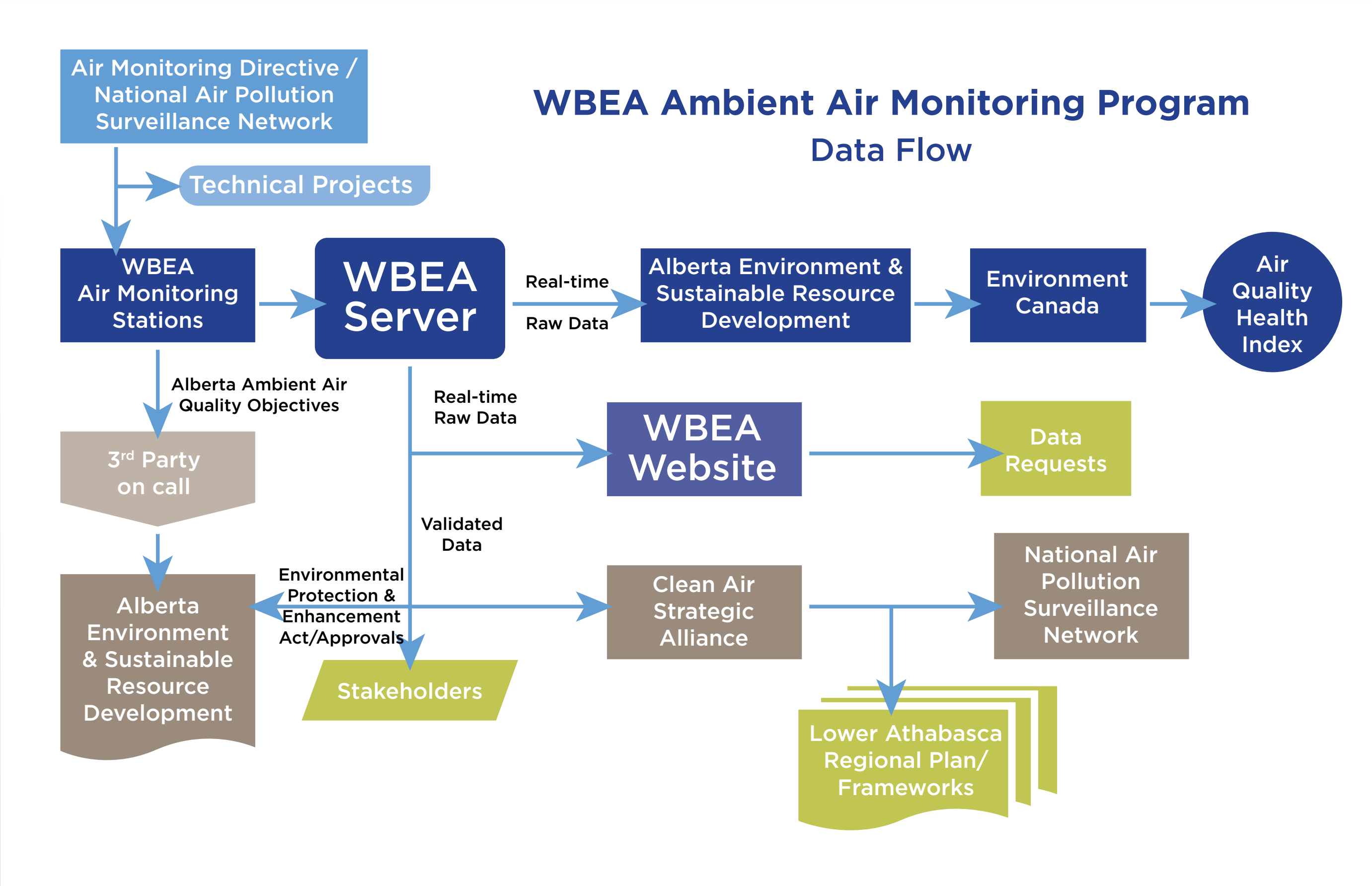
The *Diagnostic Information System* tool utilizes the unique protocols of specific analyzers to poll diagnostic information to a cloud-based central server. A web based user interface program is used to review and analyze data for analyzer performance and maintenance schedules.





WBEA has developed a Data Management System (DMS) that ensures data are transmitted in near real-time to the WBEA website. Raw data are validated and archived for future analysis. WBEA's validated data are available 30 days after the month in which they were collected. The validated data are then provided to stakeholders, regulators and the public to ensure information is available for informed decisions.

This diagram shows the flow of information from our monitoring stations to various data repositories.



WBEA has made available the raw and quality control and quality assured data on the website. Supporting documents such as the Standard Operation Protocols and site documentations are available publically at *www.wbea.org*.

Sanjay Prasad
Aurora Atmospherics


9.0

9.0 Wood Buffalo Environmental Association Publications in 2014

In 2014, Wood Buffalo Environmental Association (WBEA) staff and scientists contracted to WBEA published the following peer reviewed papers and reports:

Blake, D.R., Simpson, I.J. 2014. WBEA VOC Validation Study. University of California, Irvine. WBEA Agreement No: AA106-13.

Edgerton, E. 2014. Pilot Study Testing of Low-Power Denuder Systems for Measurement of HNO_3, NH_3 and fine particulate sulfate, nitrate and ammonium at WBEA Forest Health Sites. Status Report-May-August 2014. Submitted by ARA, Inc. WBEA Independent Contractor Agreement No. T106-14.

Fenn, M.E., Bytnerowicz, A., Schilling, S.L., Ross, C.S. 2015. Atmospheric deposition of nitrogen, sulfur and base cations in jack pine stands in the Athabasca Oil Sands Region, Alberta, Canada. *Environmental Pollution, 196: 497-510.*

Hsu, Y-M. 2014. 2012 Ambient Air Sample Collection and Analytical Program for Integrated $PM_{2.5}$, PM_{10}, VOCs, Semi-Volatile Organics, SO_2, NO_2, O_3, and Wet Precipitation Chemistry (Intermittent Data). Reporting Period January 1st, 2012 to December 31st, 2012. Wood Buffalo Environmental Association. WBEA Report # 2014-08-05.

Hsu et al. 2015. PAH Measurements in Air in the Athabasca Oil Sands Region. *Environmental Science & Technology 49, 5584-5592.*

Hsu and Clair 2015. Measurement of fine particulate matter water-soluble inorganic species and precursor gases in the Alberta Oil Sands Region using an improved semi-continuous monitor. *Journal of the Air and Waste Management Association 65, 423-435.*

Southern Operators Sub-Group, Ambient Air Technical Committee. 2014. Southern Air Monitoring Plan.

Vile et al. 2014. N_2-fixation by methanotrophs sustains carbon and nitrogen accumulation in pristine peatlands. *Biogeochemistry Letters 121, 317-328.*

Vile, M.A., Wieder, R.K., Vitt, D.H., Berryman, S. 2014. Development of Monitoring Protocols for Nitrogen-sensitive Bog Ecosystems, including Further Development of Lichen Monitoring Tools – 2009-2013. WBEA Final Report. Agreements No: T102-09, T102-10, T102-11, T105-12. Villanova University, Villanova, PA 19085 USA.

Vile, M.A., Wieder, R.K. 2014. Peatland Monitoring and Synoptic Survey – 2013. Final report submitted to WBEA. Villanova University, Villanova, PA 19085 USA.

Watson, J.G., Chow, J.C., Wang, X., Kohl, S.D. 2014. Chemical Source Profiles for Geological Dust Samples from the Athabasca Oil Sand Region. DRI Contract Number: 010109-123109. Desert Research Institute, 2215 Raggio Parkway, Reno, NV, 89512.

Watson, J.G., Chow, J.C., Wang, X., Kohl, S.D., Yatavelli, L.N.R. 2014. Windblown Fugitive Dust Characterization in the Athabasca Oil Sands Region. WBEA-DRI Agreement Number: T108-13. Desert Research Institute, 2215 Raggio Parkway, Reno, NV, 89512.

Whitely, S. 2014. Audit of the Continuous Data Validation & Reporting Process for the Wood Buffalo Environmental Association's Ambient Air Monitoring Network. Data Validation Audit for November 2013.

10.0

10.0 Appendices

Appendix I – WBEA Governance Committee Members in 2014

Diane Phillips, President - Syncrude Canada Ltd.

Nick Veriotes, Vice President - Total E&P Canada Ltd. (January - June 2014)

Peter Fortna, Vice-President - Conklin Resource Development Advisory Board (June - December 2014); Director - Fort McKay Métis (January - June 2014)

Lance Miller, Secretary - Treasurer - Devon Canada Corporation (January - June 2014)

Doug Johnson, Secretary - Treasurer - Athabasca Oil Corporation (June - December 2014)

Angela Pohl, Director - Suncor Energy Inc. (January - June 2014)

Daniel Stuckless, Director - Fort McKay First Nation (January - June 2014)

Linda Aidnell, Director - Chipewyan Prairie Dene First Nation (June - December 2014)

Michael Aiton, Director - Alberta Environment and Sustainable Resource Development

Andrew Read, Director - Pembina Institute for Appropriate Development (June - December 2014)

Natasha Rowden, Director - MEG Energy (June - December 2014)

Appendix II – WBEA Membership in 2014

Aboriginal Members

Chipewyan Prairie Dene First Nation

Christina River Dene Nation Council

Conklin Resource Development Advisory Board

Fort McKay First Nation

Fort McKay Métis Local 63

Fort McMurray First Nation 468

Fort McMurray Métis Local 1935

Environmental Organization Members

Pembina Institute for Appropriate Development

Government Members

Alberta Energy Regulator

Alberta Environment and Sustainable Resource Development

Alberta Health Services

Alberta Health and Wellness

Environment Canada

Health Canada

Parks Canada

Regional Municipality of Wood Buffalo

Saskatchewan Environment

Industry Members

Athabasca Oil Corporation

Brion Energy

Canadian Natural Resources Limited

Cenovus Energy Inc.

Connacher Oil and Gas Ltd.

ConocoPhillips Canada

Devon Canada Corporation

Finning Canada Ltd.

Hammerstone Corporation

Husky Energy Inc.

Imperial Oil Limited

MEG Energy Corp.

Nexen Energy ULC

Shell Canada Energy

Statoil Canada Ltd.

Suncor Energy Inc.

Sunshine Oilsands Ltd.

Syncrude Canada Ltd.

Teck Resources Ltd.

Total E&P Canada Ltd.

Williams Energy (Canada) Inc.

Appendix III – Ambient Air Technical Committee (AATC) Membership in 2014

Anne Simpson, Chair - Syncrude Canada Ltd.

Megan Storrar, Alternate Chair - Nexen Energy ULC

Erin Davies - Statoil Canada Ltd.

Al Clark - Alberta Environment and Sustainable Resource Development

Prabal Roy - Alberta Environment and Sustainable Resource Development

Shannon Makinson - Cenovus Energy Inc.

Amy Myette - Suncor Energy Inc.

Justin Van Maarion - Cenovus Energy Inc.

Cindy Robinson - Brion Energy

Ben Hale - Husky Energy Inc.

Nasir Aden - Husky Energy Inc.

Tina Ding - Shell Canada Ltd.

Corinna Watt - Environment Canada

Dan McLennan - Environment Canada

Jean-Pierre Charland - Environment Canada

Pamela Poon - ConocoPhillips Canada

Ken Omotani - ConocoPhillips Canada

Heather Gallant - ConocoPhillips Canada

Martin Zhekov - Canadian Natural Resources Limited

Gladys Onovwiona – Alberta Energy Regulator

David Spink - Fort McKay

Sachin Bhardwaj – MEG Energy Corp.

Lance Miller – Devon Canada Corporation

Chris Wellwood – Hammerstone Corporation

Nick Veriotes – Total E&P Canada Ltd.

Allan Legge, Science Advisor - WBEA

Jean-Guy Zakrevsky, AATC Program Manager - WBEA

Appendix IV – Terrestrial Environmental Effects Monitoring (TEEM) Committee Membership in 2014

Fred Payne, Chair - Syncrude Canada Ltd.

Sunny Cho - Alberta Environment and Sustainable Resource Development

Bernie Schmidt - Alberta Environment and Sustainable Resource Development

Jessica Wong - Suncor Energy Inc.

Shayela Chowdhury - Shell Canada Ltd.

Greg Rideout - Environment Canada

Sum Chi Lee - Environment Canada

David Bruisima - Pembina Institute for Appropriate Development

Tiffanie Billey - Total E&P Canada Ltd.

Mike Aiton - Alberta Environment and Sustainable Resource Development

Natasha Rowden - Canadian Natural Resources Limited

Dianne McIsaac - Nexen Energy ULC

Torey McLeish - Husky Energy Inc.

Carla Davidson - Fort McKay First Nation

Kevin Percy - WBEA Executive Director

Jean-Guy Zakrevsky - WBEA AATC/TEEM Program Manager

Allan Legge, Science Advisor, WBEA

Ellen MacDonald, Science Advisor, WBEA - University of Alberta

Doug Maynard, Science Advisor, WBEA - Canadian Forestry Service

Appendix V – Human Exposure Monitoring (HEMP) Committee Membership in 2014

Wally Qiu, Chair - Alberta Environment and Sustainable Resource Development

Brooke Bennett, Alternate Chair - Syncrude Canada Ltd.

Bruce Tester - Suncor Energy Inc.

Ann Dort McLean - Fort McMurray Environmental Association

Heather Gallant - ConocoPhillips Canada

Merry Turtiak - Alberta Health Services

Olusegun Motajo - Alberta Health Services

Tracy Smith - Shell Canada Energy

Natasha Rowden - Canadian Natural Resources Limited

Nicole Morin - Health Canada

Mark Anderson - Husky Energy Inc.

Sarita Parks - Husky Energy Inc.

Nick Veriotes - Total E&P Canada Ltd.

Martin Zhekow - Canadian Natural Resources Limited

Shamini Samuel - Suncor Energy Inc.

Mark Jackson - Alberta Health Services

Opel Vuzi - Health Canada

Abena Twumasi-Smith - WBEA HEMP Program Manager

Allan Legge - WBEA Science Advisor

Randy Visser - Nexen Energy ULC

Emilie Rainville - Nexen Energy ULC

Michael Trefry - Imperial Oil Ltd.

Ken Omotani - ConocoPhillips Canada

Mark Jackson - Alberta Health Services

Tony Mak - Alberta Health Services

Appendix VI – Communications Advisory Committee Membership in 2014

Peter Fortna – Conklin Resource Development Advisory Committee (Chair)

Diane Phillips - Syncrude Canada Ltd.

Carla Davidson - Fort McKay First Nation

Shayela Chowdhury – Shell Canada Energy

Shannon Makinson - Cenovus Energy Inc.

Jennifer Shalagan - Husky Energy Inc.

Sarita Parks - Husky Energy Inc.

Ann Dort MacLean - Fort McMurray Environmental Association

Kevin Percy - WBEA

Jane Percy - WBEA

Melissa Pennell - WBEA

Randy Visser - WBEA

Appendix VII – U.S. Environmental Protection Agency National Ambient Air Quality Standards (NAAQS)*

Pollutant	Averaging Time	Level	Form
SO_2	1-hour	75 ppb	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
NO_2	1-hour	100 ppb	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
O_3	8-hour	75 ppb	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years
$PM_{2.5}$	24-hour	35 µg/m^3	98th percentile, averaged over 3 years
$PM_{2.5}$	annual	12 µg/m^3	Annual mean, averaged over 3 years
PM_{10}	24-hour	150 µg/m^3	Not to be exceeded more than once per year on average over 3 years

**http://www.epa.gov/air/criteria.html*

Appendix VIII – Canadian Ambient Air Quality Standards (CAAQS)*

Pollutant	Averaging Time	Level	Form
O_3	8-hour	63 ppb	Three-year average of the annual 4th highest daily maximum 8-hour average concentrations
$PM_{2.5}$	24-hour	28 µg/m^3	Three-year average of the annual 98th percentile of the daily 24-hour average concentrations
$PM_{2.5}$	annual	10.0 µg/m^3	3-year average of the annual average concentrations

**http://www.ccme.ca/en/current_priorities/air/caaqs.html*

The WBEA 2014 Annual Report
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Jane Percy, Editor

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