Wood Buffalo Environmental Association

ANNUAL REPORT 2011

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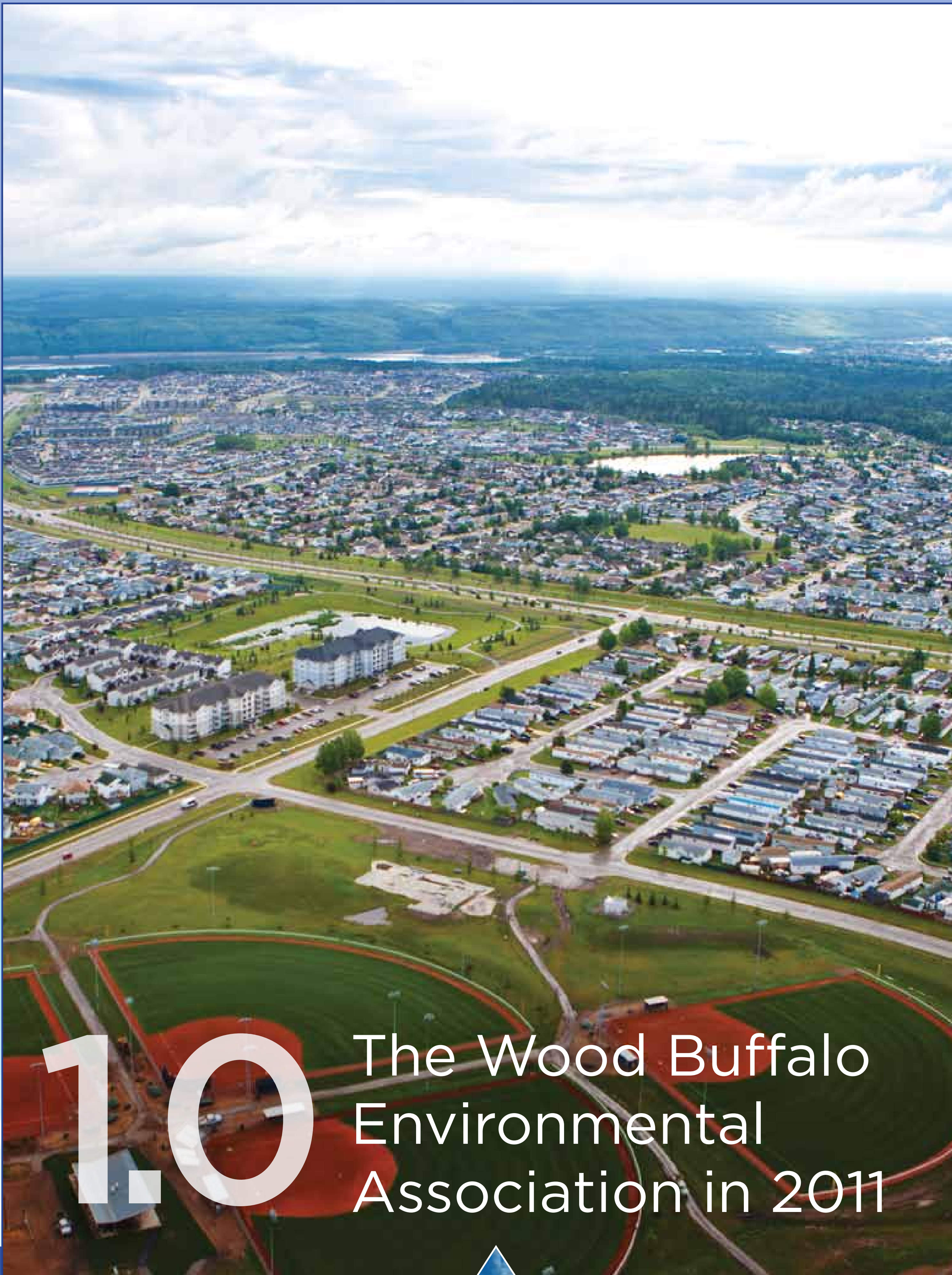


1.0 The Wood Buffalo Environmental Association in 2011

The Wood Buffalo Environmental Association (WBEA) was established as the Air Quality Task Force in 1985 to address environmental concerns raised by the Fort McKay First Nation. WBEA operates the largest airshed in the largest municipality in Canada. Today, as an independent, community-based, not-for-profit association, WBEA monitors the air in the Regional Municipality of Wood Buffalo (RMWB), 24 hours a day, 365 days a year. WBEA does this through a variety of air, land, and human monitoring programs. The information collected from WBEA's 15 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.

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 and respect 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

Alberta Environment and Water has modified the Environment Canada Air Quality Health Index for the province. Alberta's Air Quality Health Index allows the non-scientist to easily gauge air quality. The measurement is made up of several different compounds in the air, including carbon monoxide, nitrogen dioxide, sulphur dioxide, ozone, and fine particulate matter. WBEA collects and transmits raw data, in real time, to Alberta Environment and Water where the index is calculated. The Air Quality Health Index is calculated every hour for four Air Monitoring Stations in Wood Buffalo: Athabasca Valley, Fort Chipewyan, Fort McKay, and Syncrude UE-1. All WBEA air monitoring data are sent to the Clean Air Strategic Alliance Data Warehouse (www.casadata.org), an on-line database for all of Alberta's air monitoring data. This information is both quality controlled and quality assured and safeguards are built in, to identify and communicate problems. A summary of the 2011 Air Quality Health Index data for the RMWB may be found on page 72.

1.2 Terrestrial Monitoring

The Terrestrial Environmental Effects Monitoring (TEEM) program monitors and reports on the long term effects of air emissions on terrestrial ecosystems and plant life.

1.3 Human Monitoring

The Human Exposure Monitoring Program (HEMP) has been redesigned from the original program, to monitor human exposure in the region, including odours.

1.4 Alberta's Airshed Management Zones

Airshed zones are established by local stakeholders to deal with air quality issues in a specific region. The Clean Air Strategic Alliance (CASA) provides the framework within which an airshed zone functions, but each operates independently as a non-profit society. The WBEA airshed is the largest in the country, covering approximately 70,000 square kilometers.

Wood Buffalo Environmental Association (WBEA) covers approximately 70,000 km^2 including Fort McMurray, Fort Chipewyan, Fort McKay, Anzac, Conklin and Janvier and several oil sands developers located in north eastern Alberta. WBEA's monitoring network comprises 15 fixed and 20 passive sites.

(www.wbea.org)

Fort Air Partnership (FAP) monitors air quality in a 4,500 km^2 region north east of Edmonton that includes Fort Saskatchewan, Gibbons, Bon Accord, Bruderheim, Lamont, Redwater, Waskatenau, Thorhild and Elk Island National Park.

(www.fortair.org)

Parkland Airshed Management Zone (PAMZ) encompasses a 42,000 km^2 area of west central Alberta including Rocky Mountain House, Sundre, Banff and the city of Red Deer.

(www.pamz.org)

Palliser Airshed Society (PAS) covers 40,000 km^2 which parallels the Palliser Health Region and includes the city of Medicine Hat and the town of Redcliff.

(www.palliserairshed.com)

Peace Airshed Zone Association (PASZA) covers an area of 38,500 km^2 in north-western Alberta bordered on the north by the Peace River and including the communities of Grand Prairie and High Prairie.

(www.pasza.ca)

West Central Airshed Society (WCAS) covers 46,000 km^2 in mid-Alberta, including the communities of Jasper, Hinton, Edson, Lake Wabamun, Drayton Valley, Pigeon Lake, and surrounding regions.

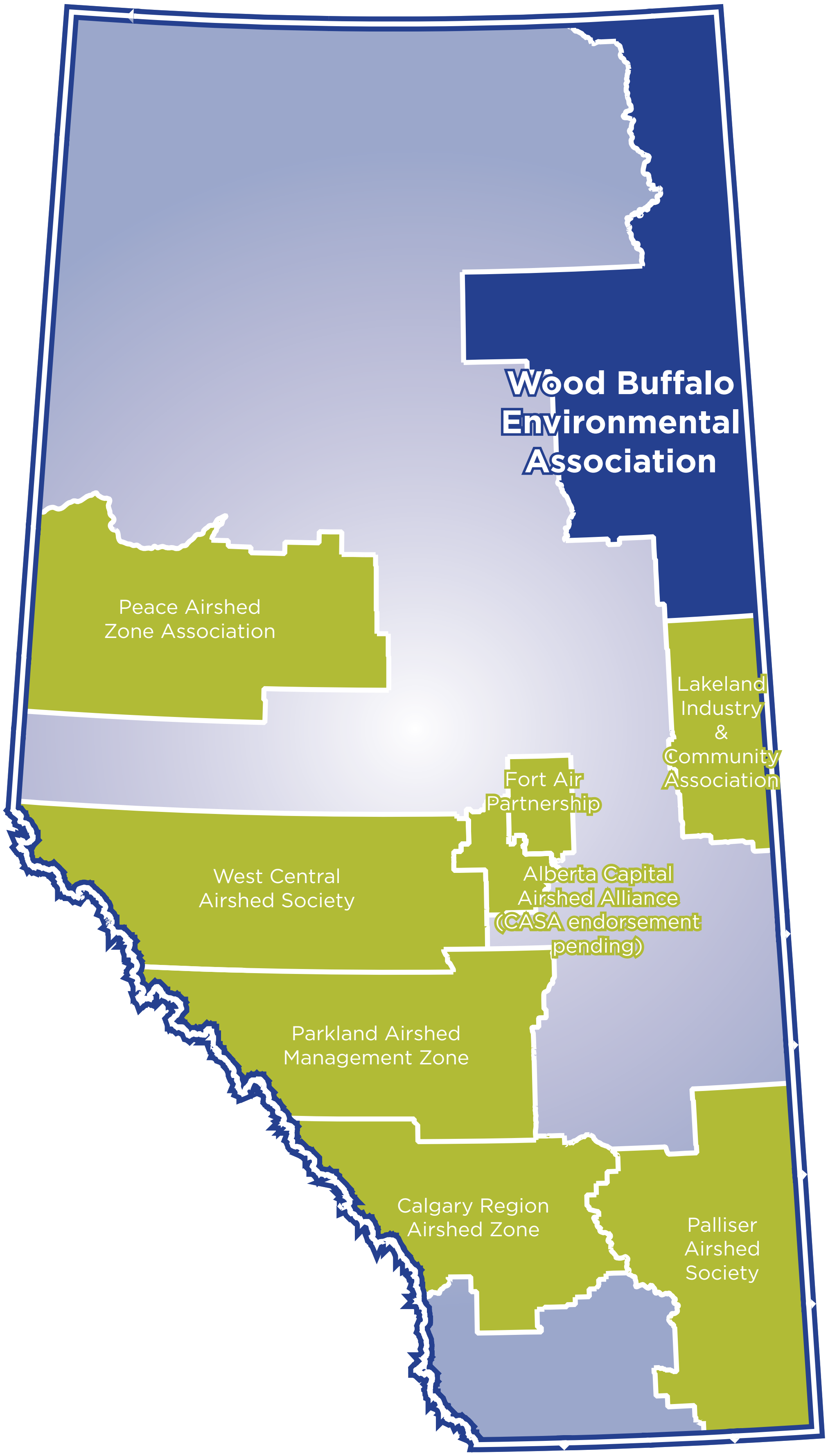
(www.wcas.ca)

Lakeland Industry & Community Association (LICA) an area of 18,000 km^2 in east central part of Alberta serves the Bonnyville, Cold Lake and St. Paul region.

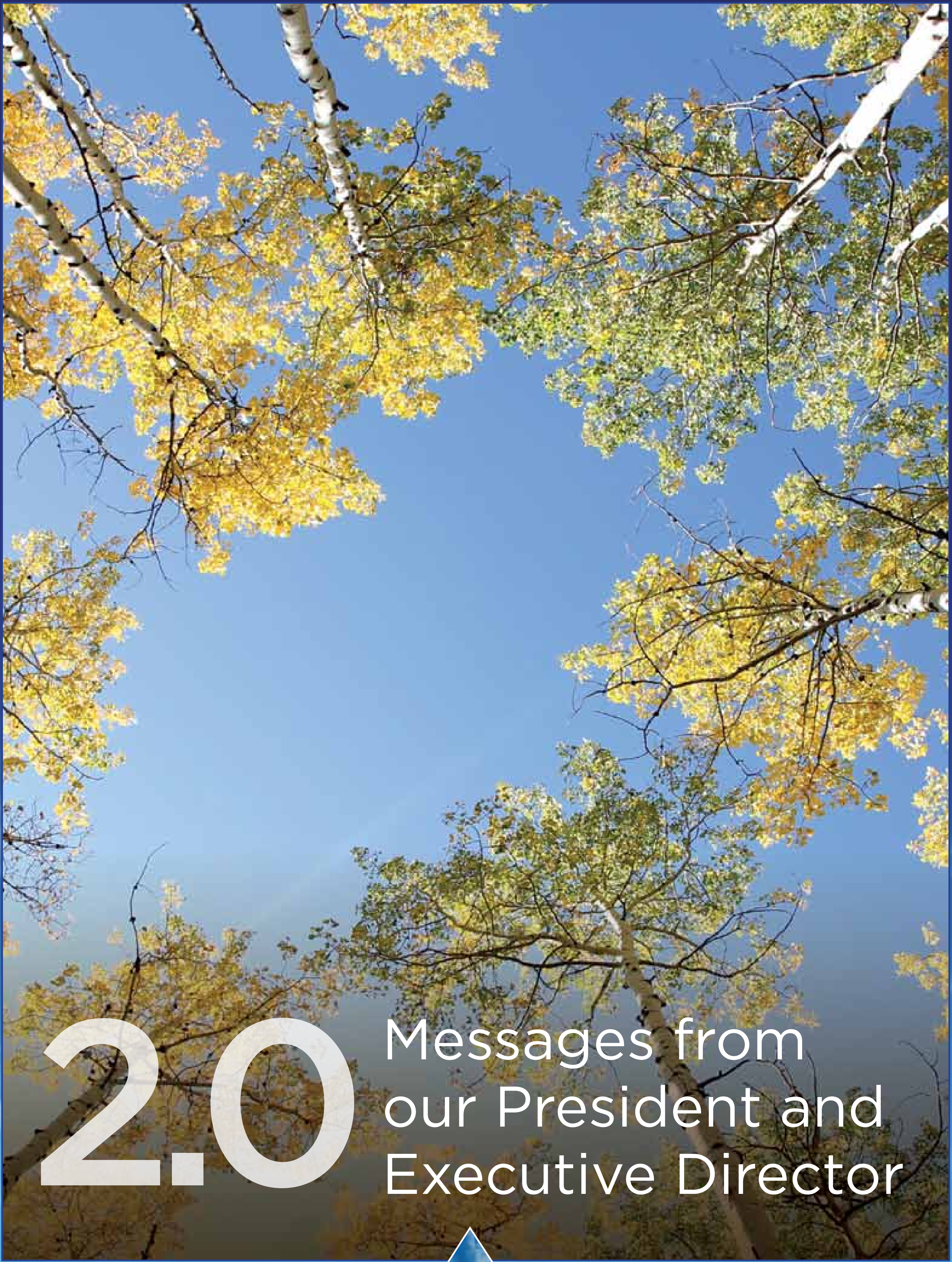
(www.lica.ca)

The Calgary Region Airshed Zone (CRAZ) encompasses an area that approximately follows the boundaries of the Calgary Health Region except for the northern border which is defined by the southern border of the Parkland Airshed Management Zone.

(www.craz.ca)



Alberta's Airshed Management Zones.



2.0 Messages from our President and Executive Director

2.1 President's Message

2011 was another year of growth and change for WBEA. We bid adieu to our Executive Director Carna MacEachern and wish her all the best in her retirement. We appointed Dr. Kevin Percy to the position of Executive Director. WBEA also took over the operation of the air monitoring network. To this end, WBEA hired and trained technicians. We also moved the operations and management department into the Field Operations Centre (FOC) to accommodate the O&M work and to store the mobile monitoring van. WBEA has also positioned itself to be an active participant in the government review of environmental monitoring in the region.

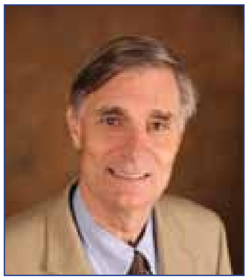
Our committees continue to diligently adhere to work plans approved by the membership. The strategic goals are used to measure progress. Our committees are the drivers of the work. The WBEA staff continues to be a strong support for our committee work.

Overall, 2011 was a time of positive growth for the organization. We saw an increase in membership and we have continued to maintain our standards in monitoring the air within the region.

Ann Dort MacLean
WBEA President

WBEA Members Gathered to Wish Retiring Executive Director Carna MacEachern Well. Front row (l to r) Diane Phillips, Syncrude Canada Ltd.; Megan Storrar, Nexen Inc.; Carna; Ann Dort MacLean, Fort McMurray Environmental Association; back row (l to r) Dan Stuckless, Fort McKay First Nation; Darrell Martindale, Shell Albian Sands; Doug Johnson, Suncor Energy Inc.; Randy Visser, Nexen Inc. ; Michael Aiton, Alberta Environment and Water.

WBEA Members and Staff at the New Field Operations Centre. Front row (l to r) Melissa Pennell, WBEA; Yu Mei Hsu, WBEA; Rachel So, Suncor Energy Inc.; Prabal Roy, Alberta Environment and Water; Allan Legge, WBEA; Jessica Wong, Suncor Energy Inc.; Jane Percy, WBEA; Second row (l to r) Sarah Eaton, WBEA; Shannon Makinson, Cenovus Energy Inc.; Mike Solohub, BioSync Consulting Inc.; Brooke Bennett, Syncrude Canada Ltd. ; Rachel Mintz, Environment Canada; Clementina Okoro, Nexen Inc.; Charles Bower, Nexen Inc.; Martin Zhekov, Canadian Natural Resources Ltd.; Third row(l to r) Ken Foster, WBEA; Kevin Percy, WBEA; Sanjay Prasad, WBEA; Lori Adamache, Fort McKay First Nation; Anne Simpson, Syncrude Canada Ltd.



2.2 Executive Director's Message

2011 was a dynamic and productive year for the Wood Buffalo Environmental Association. WBEA welcomed new members and personnel and successfully delivered on significant milestones set out in our 2011-2015 Strategic Plan.

NEW AND RETURNING MEMBERS

New WBEA members included Cenovus Energy Inc., Finning Canada Ltd., Hammerstone Corporation, and Statoil Canada Ltd. In 2011, Saskatchewan Environment re-joined WBEA. In October, our member's Tour and Open House, a new initiative, provided an opportunity for members to view equipment and operations at AMS #1 Fort McKay, Forest Health Plot JP104 and the Field Operations Centre. During the tour, procedures and data management applications were outlined and WBEA personnel were available to provide details of operations.

NEW PERSONNEL

2011 saw significant personnel changes at WBEA. Carna MacEachern retired as Executive Director after five years. Carna managed many important initiatives during her tenure including the acquisition of operations and management of the Air Monitoring Network, and the opening of the Field Operations Centre. WBEA members, staff and contractors held a reception to thank Carna and wish her well. Veronica Chisholm also retired as TEEM Program Manager in 2011. Veronica oversaw initial planning for the Forest Health Survey, which was successfully completed in 2011.

New additions to WBEA staff and contractors included Kathleen Furlong, Operations Manager; Dr. Ken Foster, TEEM Program Manager; Amanda Horning and Sarah Eaton, TEEM Field Technicians; Kelly Baragar, Senior Air Quality Technician; Dean MacLanders, Air Quality Specialist; and Emilie Rainville, Melissa Lemay, Zach Eastman, and Kendra Thomas, AATC Field Technicians.

OPERATIONS AND MAINTENANCE OF THE AMBIENT AIR QUALITY NETWORK

WBEA assumed responsibility for our air quality monitoring network operations and maintenance on July 1st, 2011. Under this initiative, all activities required in support of the network and pilot projects are now being carried out by WBEA staff.

Sanjay Prasad, Ambient Air Technical Committee (AATC) Program Manager and former Executive Director Carna MacEachern were responsible for the planning and implementation of this very complex and significant undertaking.

In the lead up to July 1st, WBEA hired senior ambient air quality specialists, with many years experience in ambient air quality monitoring. Also hired and trained were four locally based Ambient Air Field technicians. In support of this transition, WBEA leased and finished two large bays at the TaigaNova Industrial Park, Fort McMurray, to house both air, and terrestrial technical staff and their equipment. The new space provides rooms to store and repair air analyzers, bays to hold the Mobile Monitoring van and the new portable monitoring station, office space, a clean lab in support of the Ambient Ion Monitor and other specialized equipment, and space for samples collected during terrestrial monitoring work.

AATC staff has assured continuity and maintenance of high quality data collection, despite the considerable challenges during a relatively short work up period. Training of new staff was provided by Ray Brassard, a former Alberta Environment and Water (AEW) Auditor, and by Campbell Scientific. The senior WBEA air monitoring staff now has a combined 75 years of experience.

WBEA Personnel. Front Row (l to r) Emilie Rainville, Kim Carnochan, Jane Percy, Cynthia Hagan, Lisa Kirby. Second row (l to r) Sarah Eaton, Eric Nosal, Melissa Lemay, Zach Eastman, Melissa Pennell. Third row (l to r) Allan Legge, Sanjay Prasad, Kathleen Furlong, Kevin Percy, Gary Cross, Dean MacLanders, Kendra Thomas. Missing from photo are Kelly Baragar, Yu–Mei Hsu, Martin Hansen, Ken Foster, and Amanda Horning.

NETWORK ASSESSMENT

WBEA's Strategic Plan 2011-2015 recognized the need to examine our Ambient Air Quality Network within the context of current and future Oil Sands regional development. Accordingly, WBEA commissioned a comprehensive scientific and technical evaluation of our network, which is one of the most extensive in Canada, encompassing the 68,000 km^2 Regional Municipality of Wood Buffalo.

The network evaluation was carried out by two well respected experts on the operation of North American air quality networks and assessed the current status of our network in terms of the number of monitoring stations, their locations and the parameters measured at each. The investigators provided recommendations for the air monitoring network based upon their interpretation of local needs, regional plans, and provincial/national contexts for air monitoring. These recommendations were provided to AATC members for consideration.

The investigators visited the Fort McMurray region from May 2nd-5th, 2011, and interviewed a number of WBEA's key regional stakeholders. They also studied approvals to operate, federal and provincial air quality policies, development scenarios for the region, and frameworks such as the Lower Athabasca Regional Plan (LARP). The report and recommendations were presented to WBEA's Ambient Air Technical Committee (AATC), in October, with the final report delivered in January, 2012.

AIR QUALITY HEALTH INDEX

In the fall, Alberta Environment and Water introduced an Air Quality Health Index (AQHI) to replace the former Air Quality Index. WBEA data contributes to the AQHI for four of our stations and streams the AQHI to our website and a new electronic message centre at our headquarters in Fort McMurray.

INTERNATIONAL SYMPOSIUM AND 43RD AIR POLLUTION WORKSHOP

In May, WBEA welcomed over 120 scientists from around the world to Fort McMurray for our International Symposium "Alberta Oil Sands: Energy, Industry and the Environment". Invited key papers were presented by WBEA Principal Investigators and guest scientists that demonstrated the innovative, scientific foundation of our monitoring activities and pilot projects. A peer-reviewed book with 19 chapters will be published from the Symposium.

The 43rd Air Pollution Workshop, held in conjunction with the Symposium, saw the presentation of a wide range of scientific papers on air pollution research and included a field trip to the Suncor site.

RICHARDSON FOREST FIRE

During the Richardson Forest Fire in May and June, WBEA met significant air quality challenges to operations posed by the high to extreme fine particulate matter levels, and played a key role for both members and the public by delivering continuous advisories.

Kevin Percy, Eric Edgerton and Tom Dan during the Evaluation of WBEA's Air Monitoring Network in May 2011.

WBEA Headquarters with Electronic Message Centre.

Scientists Attending the 43rd Air Pollution Workshop were photographed at the 'Big Tire' on the Suncor Site during a Field Trip.

HUMAN EXPOSURE MONITORING

The Human Exposure Monitoring Program (HEMP) held successful workshops focused on odour compound identification and measurement, in April and September, The first HEMP Odour Workshop, on April 13th, served to identify issues, concerns, and knowledge gaps relating to odours in the Wood Buffalo region, summarize existing work on odours, and define a path forward for odour measurement and management. We were pleased to welcome Elders and residents of Fort McKay who attended this workshop. On September 28th, a follow-up workshop focused on technical issues and was attended by both HEMP Committee members and some representatives of the CEMA Air Working Group. Throughout 2011, HEMP oversaw operation of two instruments focused on odour identification and quantification, a Pneumatically Focused Gas Chromatograph and an Electronic Nose.

TERRESTRIAL ENVIRONMENTAL EFFECTS MONITORING

The Terrestrial Environmental Effects Monitoring (TEEM) program successfully managed several important projects in 2011.

During a 6 week period in late summer, the TEEM program successfully and safely carried out the intensive 2011 Forest Health Monitoring Program at 23 plots. We are very proud of this impeccable safety record, given the high level of bear activity due to the fires recorded on, or near our plots. This was a huge logistical undertaking involving one full time field coordinator, two helicopters, two WBEA field technicians, and five crews of scientists. For the first time, Alberta Sustainable Resource Development assisted with the tree condition, measuring incidence and severity of insects and diseases at the 23 plots. The entire program was compressed due to the 700,000 ha forest fire which closed air space in the north until July. Sample and data analysis will continue throughout 2012 with a final report due late next year.

Year three of the Bog Monitoring project was completed. Monitoring was carried out from spring through fall at the three sites.

As Part of the Forest Health Monitoring Program, Jack Pine Needles were Collected for Analysis of Epicuticular Waxes.

The Traditional Environmental Knowledge Project carried out several successful meetings with members of the Fort McKay Berry Focus group. Plans were made to sample berries at various locations in 2012.

In 2011, Jack Pine Monitoring Plot Enhancement work was implemented into the Forest Health Monitoring program. Twelve new ecologically-analogous plots were added to the existing network of 11. Full baseline characterization of these plots was completed in early 2011.

Two 30 meter solar-powered towers were installed at forest health plots 107 and 213 in 2011 to increase WBEA's capacity to measure meteorology and pollutant concentrations outside of the river valley. The continuous meteorological data will be extremely important in attributing cause-effect, and accounting for the role of climate in ecosystem change.

In 2011, work initiated in 2008 with the collection of lichens at 359 sites in the region was incorporated into a source apportionment analysis. High quality, trace level analysis of the lichen samples for a wide range of heavy metals, PAHs, Pb, and Hg stable isotopes was completed. Three statistical models were used to attribute concentrations measured in the lichens to source type.

In 2011, a second-round of stack sampling was completed at one company member using "real-world" techniques, for the Source Characterization project. Two reports on "real-world" portable "on board" emissions measurements completed on the heavy haulers were peer-reviewed. The two reports on stack emissions will be reviewed in 2012.

The three-year Stable Isotope project, co-funded through NSERC to the University of Calgary, was completed. Two manuscripts on stable isotopes as tracers of oil sands emissions were completed for publication.

DATA MANAGEMENT

In 2011, the WBEA Data Management team acquired our servers, and we brought data management systems in-house. Significant improvements to hardware, software, and data processing were achieved. Members will be pleased to learn that our data are even more secure at the end of 2011 than ever before.

COMMUNICATIONS

WBEA Communications coordinated outreach and information activities throughout 2011 including a Community Report; presentations to RMWB mayor and council; a presentation to the Fort McMurray Chamber of Commerce; several media releases; an electronic stakeholder's newsletter, WBEA@Work; registration and logistics for the International Symposium and Air Pollution Workshop; a Forest Health vignette; the revitalization of WBEA's headquarters building signs including installation of an electronic message centre to stream the Air Quality Health Index; and several media interviews.

EXTERNAL RELATIONSHIPS

As WBEA's Lead Scientist, I have been working since October 2010 to ensure that WBEA was heard at the Federal Panels established to review Oil Sands environmental monitoring, despite the fact that their focus was on water. On April 4, WBEA presented to the Alberta Environmental Monitoring Panel (AEMP) convened by Minister Renner. As you know, WBEA was positively reviewed in the report released June 30, and cited by the Panel as having "...many of the attributes essential to a world class monitoring, evaluation, and reporting system."

In late April, I participated in an air workshop, and was a co-author of the resulting Environment Canada "Integrated Monitoring Plan for the Oil Sands-Air Monitoring Component". I was also invited to contribute a section on forest catchments to Environment Canada's "Integrated Monitoring Plan for the Oil Sands: Expanded Geographic Extent for Water Quality and Quantity, Aquatic Biodiversity and Effects, and Acid Sensitive Lake Component".

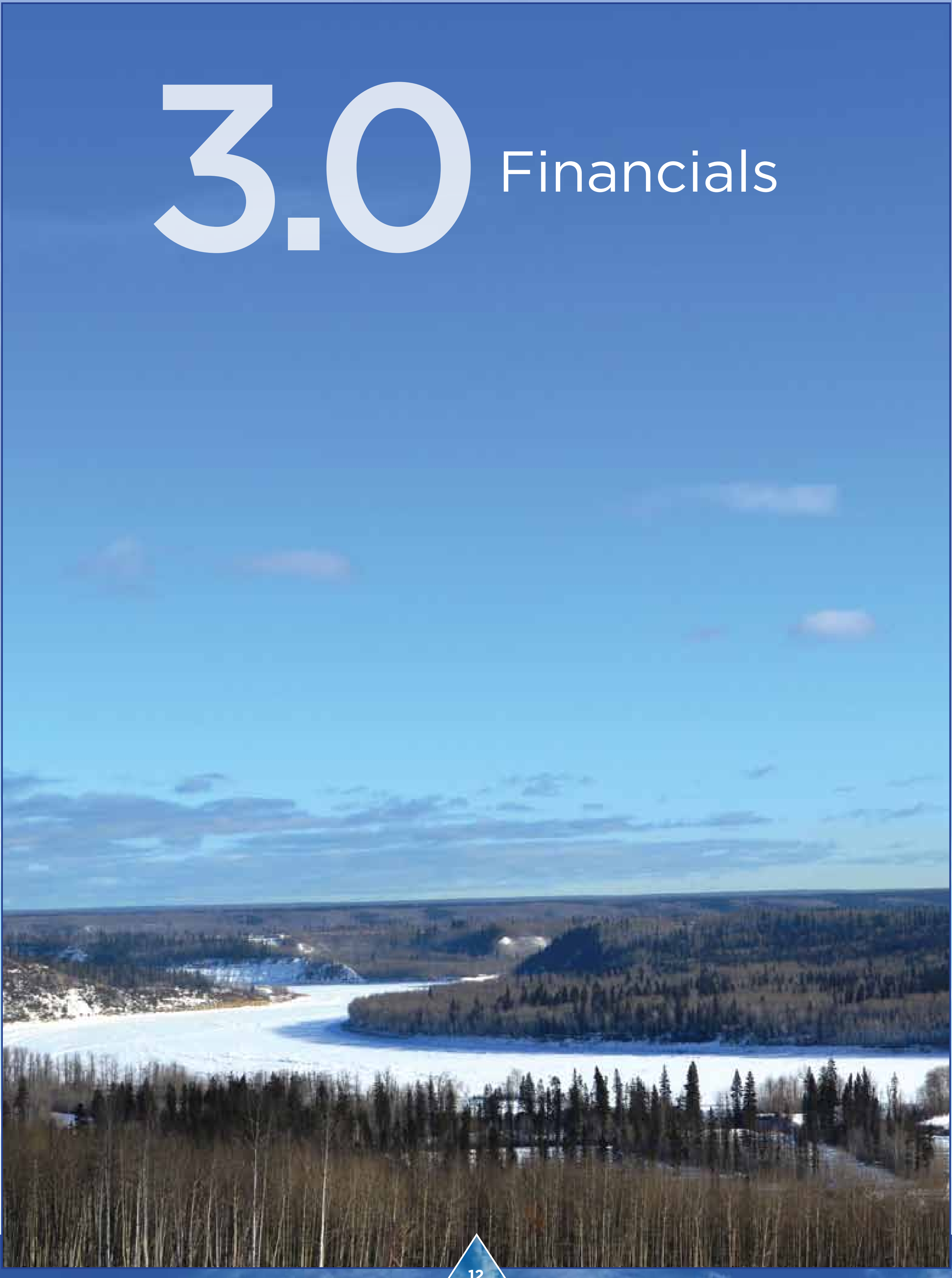
Since becoming your Executive Director in July, I have been continuously engaged on members' behalf with federal and provincial environment departments, and other key decision makers in order to strengthen WBEA's position, and support multi-lateral initiatives underway to enhance monitoring in the region. For instance, this included internal engagement with WBEA members, as well as external discussions with the Alberta Biodiversity Monitoring Institute, Keyano College, and an active role in the Alberta Airsheds Council.

Throughout 2011, WBEA's staff and contractors have worked diligently during a time of considerable change to implement the vision and direction of our Membership. In 2012, WBEA staff will continue to do so as we update policies, procedures and in-house oversight on program delivery. Key initiatives underway include comprehensive health and safety guidelines for both staff and contractors, new staff assignments required to support a more complex program of work, and, of course, implementing recommendations stemming the from the 2011 air monitoring network assessment. I am confident that, with the continued support of our members, WBEA is indeed very well-positioned to continue moving forward with our science build begun in 2008, and to contribute to sound environmental monitoring, evaluation and reporting with the RMWB.

Dr. Kevin Percy,
Executive Director

Alberta Environment and Water Launched the Oil Sands Information Portal in November 2011. Attending the Press Conference were (l to r) Andrew Buffin, Alberta Environment and Water (AEW), Dr. Andrew Leach, University of Alberta, AEW Minister Diana McQueen, Dr. Debra Pozega Osburn, University of Alberta, and Dr. Kevin Percy, WBEA.

3.0 Financials



3.1 Wood Buffalo Environmental Association Statement of Revenue and Expenditures

For the year ended December 31, 2011	2011	2010
Revenue		
Contributions (Schedule 1)	9,517,566	8,000,000
Grant	122,640	112,000
Interest and other income	31,489	33,401
Amortization of deferred capital contributions	20,000	20,000
	9,691,695	8,165,401
Expenditures		
Ambient air monitoring (Schedule 2)	2,329,742	3,123,262
Data Management (Schedule 3)	251,568	332,526
Communications (Schedule 4)	335,400	275,019
Office and administration (Schedule 5)	2,785,688	1,618,497
TEEM vegetation and soil monitoring (Schedule 6)	2,258,331	2,501,504
Human exposure monitoring program (Schedule 7)	297,108	65,675
	8,257,837	7,916,483
Excess (deficiency) of revenue over expenditures before amortization	1,433,858	248,918
Amortization	412,120	395,134
Loss on disposal of capital assets		
Inventory write down		
	412,120	395,134
Excess (deficiency) of revenue over expenditures	1,021,738	-146,216

3.2 Wood Buffalo Environmental Association Deficiency of Revenue over Expenditures after Capital Acquisitions*

For the year ended December 31, 2011	
Excess of revenue over expenditures	1,021,738*
Less: Capital assets acquired from internal funds	(1,062,438)*
Deficit	(40,700)*

* For information purposes only (unaudited)

"Financials are presented as results from 2011 Meyers Norris Penny LLP audit."

3.3 Wood Buffalo Environmental Association Statement of Changes in Net Assets

For the year ended December 31, 2011

	Investment in capital assets	Contributed	Capital asset replacement capital reserve	Internally restricted	Unrestricted	Total 2011	Total 2010
Balance, beginning of year	1,422,785	34,358	206,905	160,000	2,098,970	3,923,018	4,069,234
Excess (deficiency) of revenue over expenditures	-	-	-	-	1,021,738	1,021,738	(146,216)
Transfer from internally restricted net assets	-	-	-	(160,000)	160,000	-	-
Amortization of capital assets internally funded	(392,120)	-	-	-	-	-	-
Capital assets acquired from internal funds	1,062,438	-	(206,905)	-	(855,533)	-	-
Balance, end of year	2,093,103	34,358	-	-	2,817,295	4,944,756	3,923,018

3.4 Wood Buffalo Environmental Association Schedule 1 – Contributions

	2011	2010
Contributions		
Suncor Energy Inc.	3,376,693	2,911,883
Syncrude Canada Ltd.	2,514,590	2,163,191
Shell Canada Ltd.	1,182,070	1,031,002
Canadian Natural Resources Ltd.	811,056	700,376
Nexen Inc.	596,322	517,565
Imperial Oil	510,397	436,080
Total E & P Canada Ltd.	417,523	315,764
Devon Canada	173,655	98,892
Cenovus Energy	155,056	
Husky Energy	92,757	79,251
MEG Energy	90,643	89,397
ConocoPhilips Canada	67,513	51,964
Williams Energy	5,169	4,635
Less: Goods and Services Tax included in contributions	-475,878	-400,000
	9,517,566	8,000,000

"Financials are presented as results from 2011 Meyers Norris Penny LLP audit."

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

	2011	2010
Expenditures		
Air Monitoring Van	19,502	95,085
Ambient air hydrocarbon and sulfur		12,751
Ammonia analyzer - NH_3	3,183	65,641
Auto computer controlled wet precip	43,225	157,055
Compliance and rational document		3,191
Dicot $PM_{2.5}$ and PM_{10}	1,038	
Lab analysis	450,340	370,407
Meetings & Miscellanous		1,965
No_x Analyzer		8,520
Operations and maintenance – regular	1,282,941	1,766,335
Operations and maintenance – extra	116,028	243,607
Passive monitoring analysis	41,268	65,488
Passive monitoring collection	205,316	237,604
QA/QC audit		20,013
Audits (QA/QC, Compliance, AQM Network)	81,943	
Station equipment rental costs		11,100
Station insurance		48,787
Station utilities		15,713
Operational Expense (Insurance, Station Utilites)	84,958	
	2,329,742	3,123,262

3.6 Wood Buffalo Environmental Association Schedule 3 - Data Management Expenditures

	2011	2010
Expenditures		
Development		2,320
Hosting and management	157,602	10,596
Meetings/miscellaneous	2,566	4,531
Routine monthly operation		215,829
Statistical method - data processing	91,400	99,250
	251,568	332,526

"Financials are presented as results from 2011 Meyers Norris Penny LLP audit."

3.7 Wood Buffalo Environmental Association Schedule 4 - Communications Expenditures

	2011	2010
Communications		
Advertising (radio, newspaper,billboard)	110,840	
Air Information Line	12,116	12,000
Air pollution workshop	89,716	
Annual report		20,707
Billboard Advertising		11,250
Communication consultant		66,991
Communication merchandise	47,928	14,825
Community Relations	11,579	
Conference attendance	5,400	28,713
Media training	12,296	2,000
Reports (Community report, annual report)	28,895	
Newspaper advertising		16,049
Open house and Trade fair		9,102
Presentation and Promotions		41,732
Radio advertising		45,140
Website maintenance	16,630	6,510
	335,400	275,019

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

	2011	2010
Adminstation and personnel		
Salary and wages	1,834,918	657,138
Employee benefits	83,310	61,108
Office expenses		
Bank charges and interest	2,177	995
Computer and other expenses	4,397	364
Conferences and meetings	28,829	17,843
Insurance	21,363	21,937
Miscellaneous/Vehicle	16,911	1,583
Occupancy Costs - Thickwood	249,940	167,251
Occupancy Costs - Taiganova	147,103	
Office equipment lease	28,096	19,529
Office, Postage and stationery	31,268	15,935
Strategic Plan		29,928
Professional Fees (audit and legal)	37,890	500,567
Repairs and maintenance	86,075	10,047
Staff Development		10,174
Telephone, fax and internet	84,460	63,672
Stakeholder involvement	13,384	16,039
Travel	115,567	24,387
	2,785,688	1,618,497

"Financials are presented as results from 2011 Meyers Norris Penny LLP audit."

3.9 Wood Buffalo Environmental Association
Schedule 6 - TEEM Vegetation and Soil Monitoring Expenditures

	2011	2010
Expenditures		
Ambient ion monitoring (URG)	71,959	73,754
Conferences and meetings		3,075
Deposition model calibration- Lichens	92,735	302,505
Deposition velocity measurement- COTAG	42,491	117,981
Ecological analogue/site selection	86,584	197,191
Foliar wax chemistry		47,593
Forest health monitoring	764,631	35,564
Miscellaneous		12,490
NH_3 and HNO_3		1,908
Passive monitoring (IER,HNO_3, NH_4)	250,893	97,762
Peatland monitoring	271,821	286,308
Procedure manual	14,936	58,038
Roving continuous O_3 monitoring	9,657	
Science advice		179,000
Source characterization	197,336	718,422
Stable iostopes	15,000	114,096
TEK resources	1,556	51,962
Tower instrumentation	435,367	94,452
Uncertainty Mapping		50,000
Workshops	3,365	49,903
Deposition model		9,500
	2,258,331	2,424,675

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

	2011	2010
Expenditures		
Odour Measurement (OdoTech)	63,250	
Odour Measurement (VOC)	219,418	65,675
Meetings/Administration	14,440	
	297,108	65,675

"Financials are presented as results from 2011 Meyers Norris Penny LLP audit."

4.0 Ambient Air Techical Committee

4.1 Message from the AATC Program Manager

The Ambient Air Technical Committee (AATC) continued to fulfill its mandate of compliance and regulatory monitoring balanced with community and regional air monitoring programs. The key deliverable for the air monitoring program is the collection of air quality data related to human and ecosystem health and the reporting of these data to the public. As this committee continues with its ambient air monitoring programs, we remain focused on the quality assurance components of the programs to ensure that the data sets are transparent, consistent and in support of user needs.

AATC committee members were exceptional with providing timely advice and direction this past year. This enabled WBEA to accomplish its monitoring initiatives and to continue with its routine and recurring activities. I would like to thank our committee members, the chairpersons, science advisors and contractors for their dedication and continued support of the ambient air monitoring programs.

The WBEA Strategic Plan milestones for 2011 were accomplished under the direction of this committee.

- The review of the WBEA ambient air monitoring program was completed by two independent experts and the report was made available to WBEA members for comments and discussion. The experts were asked to provide a scientific evaluation of the current monitoring program and recommend future network designs in due considerations of the regional plans, provincial, and national environmental panel recommendations for air monitoring in the Wood Buffalo region.
- AATC members have initiated discussions with communities and organizations for a monitoring plan for the southern part of the airshed zone.
- AATC has proactively approached all levels of government, industry and communities to participate in the AATC committee, to increase member's attendance during the monthly meetings, and to solicit input from various organizations, communities or governments.
- The activities within this committee were elevated with qualitative and quantitative key performance indicators to measure the monitoring program's continual improvement in fulfillment of the WBEA Strategic Plan goals.
- Operations and maintenance of the ambient air monitoring network contracts were evaluated and the key decision to transition from third-party contractors to WBEA personnel for maintenance of the network was made. WBEA hired a program manager and data validation and reporting personnel, three ambient air quality specialists', each with twenty years or more experience, and one intermediate and four junior field technicians. In 2011, all of our personnel had an extended period of air quality monitoring training under the guidance of three ambient air quality specialists and Ray Brassard of R&R Environmental Inc. Our new team also had training on our current data logger systems from Campbell Scientific.

WBEA Members Visit AMS 1 Fort McKay during the Member's Open House in 2011.

AATC Staff Training Session.

AATC Staff Training Session.

While there were many AATC activities in 2011, the following is a representative list of accomplishments:

- WBEA continues to work with Environment Canada (EC) for operation of a Total Gaseous Mercury analyzer and sun photometer at Patricia McInnes air monitoring station in Fort McMurray; an air toxics study comprising passive Polycyclic Aromatic Hydrocarbons (PAH) installed at nine remote passive sites and six sites co-located with continuous stations; PAH, particulate matter and 2 precipitation samplers at the Mannix, Lower Camp and Syncrude UE-1 air monitoring stations; volatile organic compound (VOC) sampling on an every 6 day frequency at Syncrude UE-1 air monitoring station; operation of a continuous BTEX analyzer at the Fort McKay air monitoring station.
- Automated Sequential Precipitation Sampler-Installed at the Patricia McInnes air monitoring station, this equipment will provide event based rain and snow sampling. The samples are analyzed at the University of Michigan for wet precipitation chemistry data for major and minor ions and mercury.
- Automated Sequential Dichot Sampler - Operating at the Fort McKay air monitoring station to detect and characterize fine and coarse particulate matter (PM). The samples are analyzed for ionic and metal species using two analytical methods, Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and X-ray Fluorescence Spectroscopy (XRF). During the initial phase of the program 400 daily sample filters were collected. Its future role is being evaluated by AATC.
- Trace Level Analyzers – Trace level analyzers for SO_2 and NO_X operating at low ranges to capture ambient level concentrations at baseline or near method detection limits were installed at CNRL Horizon and Athabasca Valley air monitoring stations, respectively. These instruments were co-located with similar analyzers operating at higher ranges. Comparison of data from these analyzers will enable scientists to determine uncertainty and precision limits during the operation of these analyzers in field conditions and in compliance with the Air Monitoring Directive - Quality Assurance Program (2006) requirements.

The routine ambient air monitoring program consists of continuous analyzers, passive samplers and integrated (semi-continuous) samples. WBEA currently operates 15 continuous monitoring sites, each measuring from 3 to 10 air quality parameters. The continuously measured air quality parameters include CO, H_2S, NH_3, NO, NO_2, NO_X, O_3, $PM_{2.5}$, SO_2, THC and TRS. All sites also measure temperature, wind speed and wind direction. Selected sites measure relative humidity, barometric pressure, global radiation, precipitation, dew point, surface wetness and vertical temperature gradient. There are 20 passive sites that monitor for SO_2, NO_2, O_3, NH_3, and HNO_3. The semi-continuous samples are sampled (taken) on National Air Pollution Surveillance (NAPS) days for volatile organic compounds, polycyclic aromatic hydrocarbons, particulate matter ($PM_{2.5}$ and PM_{10}), ion deposition, and a weekly sample for precipitation.

WBEA also maintains and operates a mobile monitoring van, equipped to measure H_2S, NH_3, NO, NO_2, NO_X, $PM_{2.5}$, SO_2, THC, wind speed, wind direction, temperature and track GPS location. The unit is available to WBEA member companies for private, facility-associated monitoring and can be deployed for public monitoring in areas of special need or interest. The unit will be used for rapid response to air monitoring needs and utilized for monitoring events that are intermittent periods or less than one month.

WBEA expanded its capacity to provide short-term air monitoring studies via a portable trailer that can be deployed to key locations in the region. In October 2011, a new portable monitoring trailer with capability to be instrumented for specific monitoring needs was commissioned and deployed to Conoco Phillips Surmont facility for 6 months to fulfill an EPEA approval requirement.

In summary, AATC continued to improve the current monitoring program and through special research studies to provide data for informed decision making by the end users.

Sanjay Prasad,
Program Manager
Ambient Air Technical Committee

Air Monitoring Equipment at AMS 6 Patricia McInnes.

AMS 13 Syncrude UE-1

WBEA's Mobile Air Monitoring Unit.

4.2 Message from the Atmospheric and Analytical Chemist

Work continued throughout 2011 on the Ambient Ion Monitor (AIM), the first in Alberta and only the second in Canada. The AIM monitors gas species (hydrogen chloride, nitrous acid, nitric acid and ammonia) and particulate species (chloride, nitrate, sulfate, potassium, sodium, calcium, magnesium and ammonium). This analyzer yields hourly ambient air data that improves our understanding of secondary aerosol formation and photochemical reaction in the Alberta Oil Sands Region. Secondary aerosols are of concern for human health and visibility. To better understand the air quality in this region, work has also been done with the integrated data, e.g., annual report and 10-year O_3, NO_2 and SO_2 passive data for trending and spatial analysis. The following two presentations were given at these international conferences respectively, the 104th Air & Waste Management Association Conference in Orlando, FL and the 7th Asian Aerosol Conference in Xian, China:

- "Long Term Measurements of Ozone, Nitrogen Dioxide and Sulfur Dioxide Concentrations Using Passive Measurements in the Athabasca Oil Sands Region, Canada", Dr. Yu-Mei Hsu and Dr. Kevin Percy. This paper reported ozone (O_3), nitrogen dioxide (NO_2) and sulphur dioxide (SO_2) concentrations in the Alberta Oil Sands Region and defined uncertainty in passive data through co-location of passive samplers at a number of community monitoring stations.
- "Application of an Ambient Ion Monitor in the Athabasca Oil Sands Region", Dr. Yu-Mei Hsu and Dr. Kevin Percy. This paper presented recent results of WBEA's semi-continuous AIM, monitoring low ambient concentrations of inorganic gaseous phase ammonia (NH_3), hydrogen chloride (HCl), nitrous acid (HNO_2), nitric acid (HNO_3) and sulphur dioxide (SO_2), and water-soluble aerosol species of particulate matter ($PM_{2.5}$). Nitrous acid (HNO_2) and nitric acid (HNO_3) concentrations were generally low at AMS 1 Fort McKay during the period of measurement.

Dr. Yu-Mei Hsu
WBEA Atmospheric and Analytical Chemist

Charles Bower, Nexen Inc. and Dr. Yu-Mei Hsu, WBEA, Discuss Operation of WBEA's Ambient Ion Monitor, foreground.

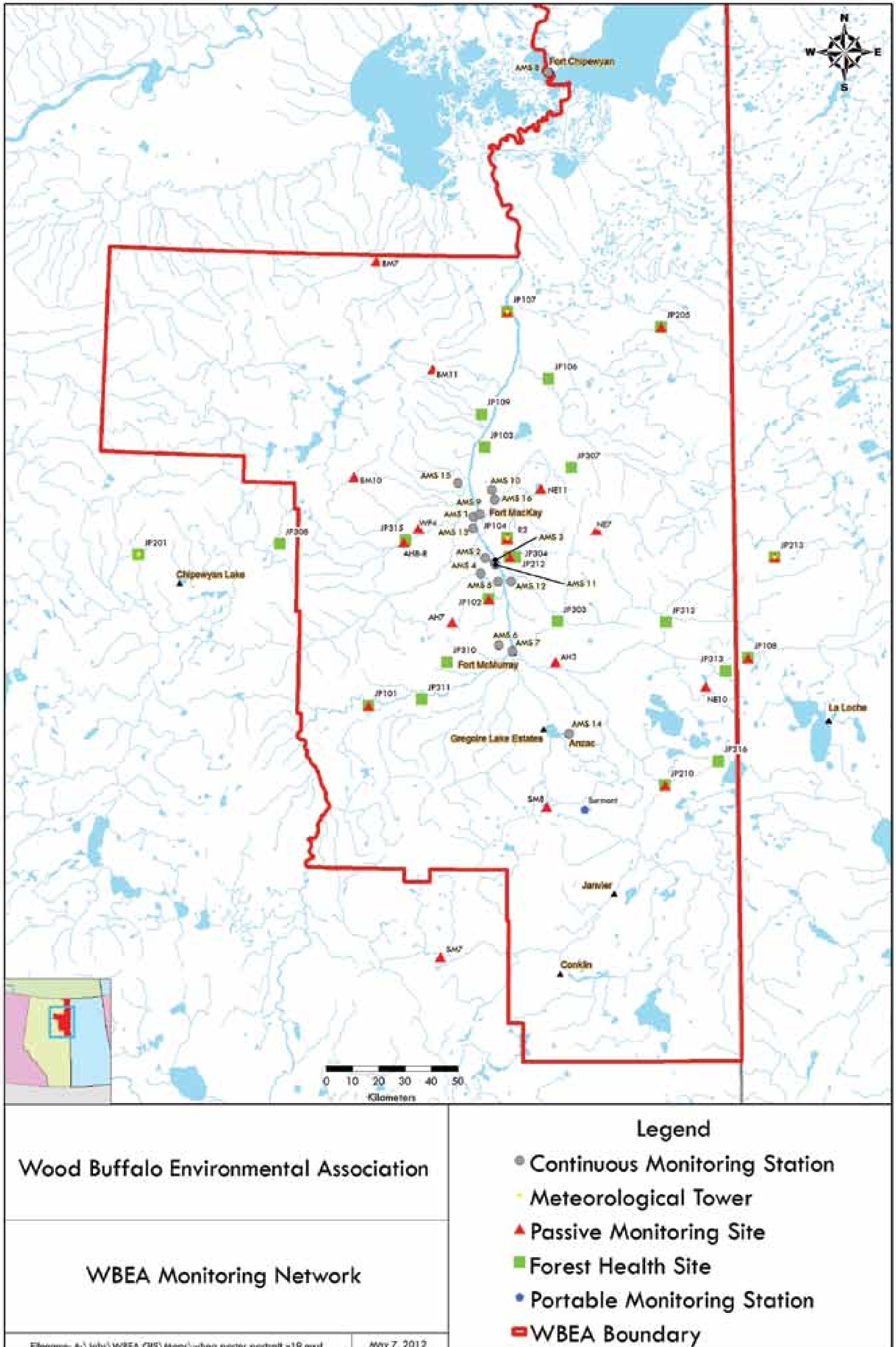
4.3 Ambient Air Quality and Meteorological Monitoring Program

Ambient air quality is monitored in a variety of modes 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, industrial-style shelters. Concentrations are determined inside analyzers by subjecting the air sample to processes in which measureable changes of physical and/or chemical properties in an analyzer's component are in proportion to the amount of gas in the air sample. Meteorological parameters are measured with sensors mounted on meteorological towers, with standard heights of 10 meters, and 20 meters in forested areas. Tower heights of 75 and 167 meters exist at two locations with extended meteorological measurements. Analyzer and sensor signals are measured approximately once per second by a computerized data acquisition system, and processed into data every 5 minutes, 1 hour and 24 hours, depending on the parameter and data requirements. 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 active and passive methods. Active methods utilize computer controlled equipment to initiate and terminate exposure, and draw air through or into the sample collector. Active methods are limited to sites of continuous monitoring, where electrical power and computerized control are 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 shows 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 remote areas. Note that AMS 13 has remained named as Syncrude UE-1 in this report, even though the name was changed during 2011 by Alberta Environment and Water from Syncrude UE-1 to Fort McKay South.


Fort Chipewyan
AMS 8
BM7
JP107
JP205
JP106
BM11
JP109
JP103
JP307
BM10
AMS 15
AMS 10
AMS 16
NE11
AMS 9
AMS 1
Fort MacKay
AMS 13
JP104
NE7
JP315
WP4
E2
AMS 3
JP304
JP212
AMS 2
AMS 4
AMS 5
AMS 12
AMS 11
AH8-8
JP201
JP308
Chipewyan Lake
JP213
JP102
AH7
JP303
JP312
AMS 6
AMS 7
JP310
Fort McMurray
AH3
JP313
JP108
NE10
JP101
JP311
La Loche
AMS 14
Gregoire Lake Estates
Anzac
JP316
JP210
SM8
Surmont
Janvier
SM7
Conklin
0 10 20 30 40 50
Kilometers
Wood Buffalo Environmental Association
WBEA Monitoring Network
Filename: A:\Jobs\WBEA GIS\Maps\wbea poster portrait v19.mxd
May 7, 2012
Legend
Continuous Monitoring Station
Meteorological Tower
Passive Monitoring Site
Forest Health Site
Portable Monitoring Station
WBEA Boundary

BACKGROUND - CONTINUOUS AMBIENT AIR QUALITY MONITORING

There were 7 stations in the WBEA continuous ambient air quality monitoring network when operations commenced in December 1997. An 8th station was commissioned in July 1998. Ambient air quality monitoring has been conducted prior to December 1997 at a number of locations in the region, but the current summary is limited to data collected and processed to the quality standard of the WBEA mandate. Stations have been added to the network since 1998 in response to growth in the area and additional needs. It is important to note that not all continuous air quality parameters have been measured at every location. Results are presented by stations grouped as industrial and community, based on the setting in which they are located. New in 2011 was commissioning by WBEA of a portable monitoring station, AMS 101. It operated in the last 3 months of the year at the Conoco Phillips Surmont Facility.

Table 1. Parameters measured continuously at the 8 original stations monitoring air quality since WBEA's first year of operation in 1998. The locale or station setting is also indicated.

			parameter								
	commissioned	locale	SO_2	NO_2	O_3	$PM_{2.5}$	H_2S	TRS	THC	CO	NH_3**
Fort McKay (AMS 1)	1997	community	●	●	●	●		●	●		●
Mildred Lake (AMS 2)	1997	industrial	●				●		●		
Lower Camp (AMS 3, AMS 11)*	1997	industrial	●				●		●		
Buffalo Viewpoint (AMS 4)	1997	industrial	●				●		●		
Mannix (AMS 5)	1997	industrial	●				●		●		
Patricia McInnes (AMS 6)	1997	community	●	●	●	●		●	●		●
Athabasca Valley (AMS 7)	1997	community	●	●	●	●		●	●	●	
Fort Chipewyan (AMS 8)	1998	community	●	●	●	●***					

* Lower Camp air quality monitoring equipment was relocated a few hundred meters from the original location in 2000 and renamed from AMS 3 to AMS 11.

** Ammonia (NH_3) monitoring commenced in 2006.

*** Particulate matter ($PM_{2.5}$) monitoring commenced in 2001.

Table 2. Parameters measured continuously at stations commissioned after WBEA's first year of operation in 1998.

			parameter								
	commissioned	locale	SO_2	NO_2	O_3	$PM_{2.5}$	H_2S	TRS	THC	CO	NH_3
Barge Landing (AMS 9)	2000	industrial						●	●		
* Albian Mine Site (AMS 10)	2000	industrial	●	●		●			●		
Millennium Mine (AMS 12)	2001	industrial	●	●		●		●	●		
*** Syncrude UE1 (AMS 13)	2002	industrial	●	●	●	●		●	●		
Anzac (AMS 14)	2006	community	●	●	●	●		●	●		
CNRL Horizon (AMS 15)	2008	industrial	●	●		●		●	●		
* Albian Muskeg River (AMS 16)	2009	industrial	●	●		●			●		
** Conoco Phillips Surmont (AMS 101)	2011	industrial	●	●			●				

* The Albian station was relocated 4 km southwest of its original location in February 2009 and renamed from AMS 10 to AMS 16

** Monitoring at Conoco Phillips Surmont occurred in the last 3 months of 2011 using the portable monitoring station

*** AMS 13 remains named as Syncrude UE-1 in this report, even though the name was changed in 2011 by Alberta Environment and Water to Fort McKay South

4.3.1 Meteorological Observations

INFLUENCE OF METEOROLOGY

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 the sources, and the rate and pathways of chemical transformation. Air pollution transport, dispersion and transformation are influenced by wind speed and direction, the temperature structure of the atmosphere, the daily solar cycle, turbulence, precipitation and changes in these elements induced by local topography.

Precipitation may remove pollutants from the atmosphere [scavenging], depositing them on soils and vegetation. Rates of deposition of pollutant gases are highest when vegetation and soils are wet. Vegetation is more susceptible to damage during periods of highest growth.

METEOROLOGICAL MONITORING

Meteorological parameters measured 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.

Wind directions are presented in two formats. A table indicates the frequency of winds from each direction based on an 8-point compass, meaning that direction from the station is divided into 8 sectors of 45 degrees each. Windrose 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 windrose, the length of a radial line indicates the frequency with which winds blew from each direction. For example at Fort McKay (AMS 1), winds were from the south almost 14 percent of the time. The frequency of winds in various speed ranges is indicated by the length of line segments of corresponding thickness. For example, at Fort McKay (AMS 1), south winds of 10 km/hr or less occurred about 12 percent of the time, and south winds greater than 10 km/hr occurred less than 2 percent of the time. South winds from 20 to 30 km/hr occurred with a small frequency.

METEOROLOGICAL OBSERVATIONS IN 2011

Temperatures in the network ranged from -41 ˚C at CNRL Horizon (AMS 15) to 34 ˚C at Fort McKay (AMS 1), Barge Landing (AMS 9) and Albian Muskeg River (AMS 16). Temperatures in Fort McMurray ranged from -39 to 32 ˚C at Patricia McInnes (AMS 6) and from -37 to 32 ˚C at Athabasca Valley (AMS 7). At Fort McKay (AMS 1) temperatures ranged from -40 to 34 ˚C, at Fort Chipewyan (AMS 8) from -39 to 31 ˚C, and at Anzac (AMS 14) from -34 to 31 ˚C.

Winds in Fort McMurray at Athabasca Valley (AMS 7) were predominantly from the southeast (32% of the time). Winds were also frequent from the north (17% of the time). Wind direction was influenced by geography of the location in the river valley. The average wind speed at Athabasca Valley was 9 km/hr with a maximum speed of 45 km/hr.

Winds at Patricia McInnes (AMS 6), also in Fort McMurray, were predominantly from the southwest and north (21% and 17% of the time, respectively) and were also frequent from the southeast and west (with frequencies of 15 and 14% of the time respectively). The average and maximum speeds were 10 and 42 km/hr.

Winds at Fort McKay (AMS 1) averaged 7 km/hr with a maximum speed of 31 km/hr. Winds were predominantly from the south, 24% of the time, and from the north, 22% of the time.

Winds at Fort Chipewyan (AMS 8) were predominantly from the east, with a frequency of 27% of the time. Winds were also frequent from the west and northwest, with frequencies of 16% of the time. The average and maximum wind speeds at Fort Chipewyan were 14 and 45 km/hr.

Winds in Anzac (AMS 14) averaged 8 km/hr with a maximum speed of 30 km/hr. Winds were predominantly from the northwest and west (with frequencies of 23% and 18% of the time).

Table 3. Temperatures (˚C) at WBEA stations in 2011.

Station	Annual Average	1-Hour Maximum	1-Hour Minimum	Percentiles								
				1	5	10	25	50	75	90	95	99
Fort McKay (AMS 1)	1.6	34.0	-40.0	-33.7	-24.9	-19.5	-9.7	2.5	13.8	20.4	24.0	28.4
Mildred Lake (AMS 2)	3.1	33.1	-35.1	-29.5	-22.8	-18.1	-8.3	4.6	15.3	20.8	23.8	27.7
* Lower Camp - original (AMS 3)	2.5	31.2	-36.2	-31.2	-23.7	-18.7	-8.8	4.3	14.9	19.9	22.8	26.3
Buffalo Viewpoint (AMS 4)	2.3	31.7	-39.0	-30.7	-23.4	-18.7	-8.8	4.1	14.4	19.7	22.7	26.4
Mannix (AMS 5)	2.4	32.3	-35.8	-30.1	-23.4	-18.7	-8.7	4.1	14.5	19.8	23.1	26.9
Patricia McInnes (AMS 6)	2.3	31.8	-38.7	-31.3	-23.5	-18.6	-8.3	3.7	14.1	19.6	22.8	26.5
Athabasca Valley (AMS 7)	1.8	32.4	-37.2	-32.1	-24.3	-18.8	-9.6	3.2	14.2	19.7	22.9	26.9
Fort Chipewyan (AMS 8)	0.7	30.7	-38.7	-32.6	-25.2	-20.6	-12.1	2.5	14.4	19.1	21.4	24.9
Barge Landing (AMS 9)	3.6	34.1	-36.7	-29.9	-22.1	-17.6	-8.1	5.0	16.0	21.9	25.1	28.8
* Lower Camp (AMS 11)	2.6	32.8	-37.8	-32.3	-24.1	-18.8	-8.9	4.3	15.1	20.3	23.2	27.1
Millennium Mine (AMS 12)	2.4	32.2	-36.5	-30.4	-23.3	-18.8	-8.7	3.7	14.3	20.3	23.4	27.5
Syncrude UE1 (AMS 13)	1.1	32.8	-39.8	-34.5	-25.9	-20.2	-10.1	2.0	13.2	20.1	23.6	27.6
Anzac (AMS 14)	2.8	30.8	-33.5	-29.6	-21.9	-17.1	-6.2	4.1	13.8	19.1	22.0	25.5
CNRL Horizon (AMS 15)	1.7	32.7	-40.6	-32.7	-23.6	-18.8	-9.5	2.9	13.9	19.8	23.1	26.7
Albian Muskeg River (AMS 16)	4.2	34.3	-38.0	-29.4	-21.3	-17.0	-7.2	5.4	16.8	22.4	25.5	29.1
** Conoco Phillips Surmont (AMS 101)	-2.4	15.7	-22.4	-20.8	-17.0	-12.8	-7.5	-1.9	3.5	7.4	8.9	12.2

* Lower Camp air quality monitoring equipment was relocated a few hundred meters from the original location in 2000 and renamed from AMS 3 to AMS 11

** Monitoring at Conoco Phillips Surmont occurred in the last 3 months of 2011 using the portable monitoring station

Table 4. Wind direction frequency (% time from each direction) at WBEA stations in 2011.

Station	North	NE	East	SE	South	SW	West	NW
Fort McKay (AMS 1)	22	5	4	9	24	12	12	13
Mildred Lake (AMS 2)	25	5	5	16	17	12	10	9
* Lower Camp - original (AMS 3)	26	4	4	28	8	6	12	13
Buffalo Viewpoint (AMS 4)	23	4	4	29	8	10	14	9
Mannix (AMS 5)	16	4	7	27	9	12	15	10
Patricia McInnes (AMS 6)	17	5	6	15	11	21	14	10
Athabasca Valley (AMS 7)	17	3	7	32	6	13	9	13
Fort Chipewyan (AMS 8)	10	5	27	11	8	8	16	16
Barge Landing (AMS 9)	18	9	5	11	22	16	9	11
* Lower Camp (AMS 11)	16	5	7	31	3	5	15	19
Millennium Mine (AMS 12)	18	7	3	20	19	13	10	10
Syncrude UE1 (AMS 13)	23	5	3	8	19	19	16	8
Anzac (AMS 14)	8	5	7	15	13	11	18	23
CNRL Horizon (AMS 15)	20	9	3	7	22	23	9	7
Albian Muskeg River (AMS 16)	3	12	10	4	14	38	13	6
** Conoco Phillips Surmont (AMS 101)	16	4	2	5	10	13	27	25

* Lower Camp air quality monitoring equipment was relocated a few hundred meters from the original location in 2000 and renamed from AMS 3 to AMS 11

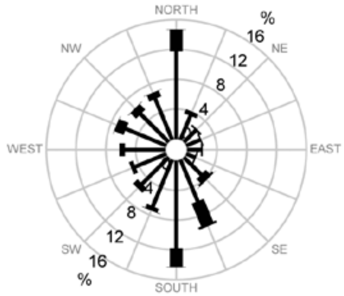
** Monitoring at Conoco Phillips Surmont occurred in the last 3 months of 2011 using the portable monitoring station

Table 5. Wind speeds (km/hr) at WBEA stations in 2011.

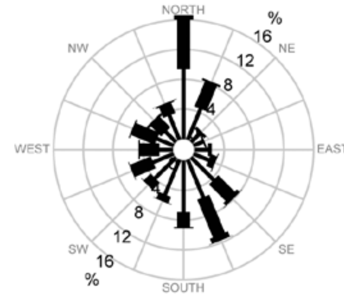
Station	Annual Average	1-Hour Maximum	Percentiles								
			1	5	10	25	50	75	90	95	99
Fort McKay (AMS 1)	6.5	30.5	0.7	1.5	2.1	3.6	5.8	8.7	11.9	13.9	18.6
Mildred Lake (AMS 2)	9.5	36.9	1.2	2.8	3.7	5.8	8.9	12.5	16.2	18.6	23.8
* Lower Camp - original (AMS 3)	8.3	40.6	0.6	1.4	2.1	3.9	7.3	11.7	16.1	18.4	23.4
Buffalo Viewpoint (AMS 4)	12.0	43.9	1.6	3.6	4.8	7.2	10.6	15.6	21.0	24.6	33.0
Mannix (AMS 5)	4.9	20.2	0.7	1.3	1.9	2.9	4.3	6.5	8.9	10.4	13.2
Patricia McInnes (AMS 6)	10.4	41.7	1.3	2.7	3.7	6.0	9.5	13.8	18.2	21.3	26.5
Athabasca Valley (AMS 7)	8.9	44.9	0.5	1.5	2.3	4.3	7.7	12.4	16.9	20.6	26.9
Fort Chipewyan (AMS 8)	14.3	45.1	2.1	4.4	5.9	8.6	12.8	19.0	24.9	28.1	35.4
Barge Landing (AMS 9)	6.2	25.4	0.6	1.6	2.3	3.6	5.5	8.2	11.3	13.3	16.8
* Lower Camp (AMS 11)	13.0	55.9	0.9	2.0	3.0	6.3	11.6	18.1	24.9	28.9	36.4
Millennium Mine (AMS 12)	7.6	31.7	1.2	2.4	3.1	4.4	6.5	9.9	13.4	15.8	21.7
Syncrude UE1 (AMS 13)	4.6	20.4	0.5	1.0	1.3	2.1	3.9	6.4	8.8	10.2	13.0
Anzac (AMS 14)	7.9	29.9	0.9	2.1	3.0	4.8	7.4	10.5	13.6	15.6	19.7
CNRL Horizon (AMS 15)	8.3	32.3	0.9	2.2	3.0	4.9	7.7	10.9	14.8	17.2	21.7
Albian Muskeg River (AMS 16)	10.2	34.7	1.9	3.0	3.8	5.8	8.9	13.6	18.5	21.5	26.7
** Conoco Phillips Surmont (AMS 101)	13.7	42.4	2.0	4.2	6.0	9.1	12.9	17.4	22.3	25.9	33.3

* Lower Camp air quality monitoring equipment was relocated a few hundred meters from the original location in 2000 and renamed from AMS 3 to AMS 11

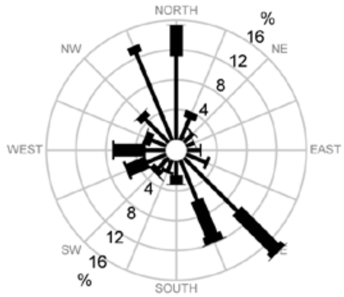
** Monitoring at Conoco Phillips Surmont occurred in the last 3 months of 2011 using the portable monitoring station



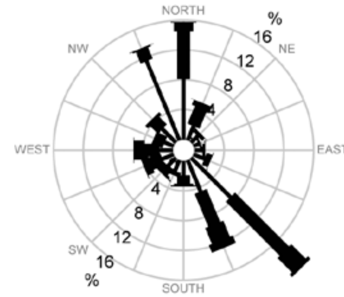
Fort McKay (AMS 1) 10m - 2011 (8696 hours)



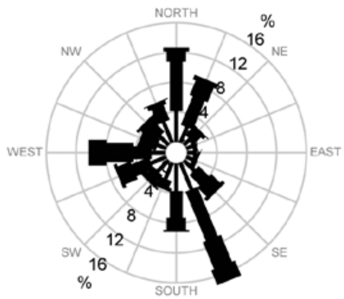
Mildred Lake (AMS 2) 10m - 2011 (8577 hours)



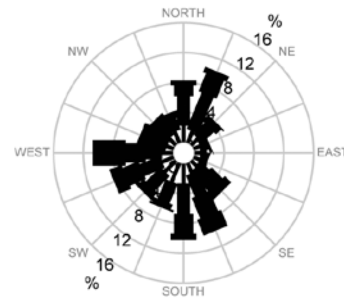
Lower Camp Met Tower (AMS 3) 20m - 2011 (7901 hours)



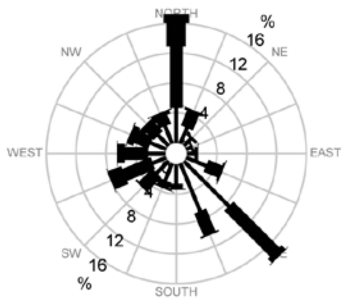
Lower Camp Met Tower (AMS 3) 45m - 2011 (6181 hours)



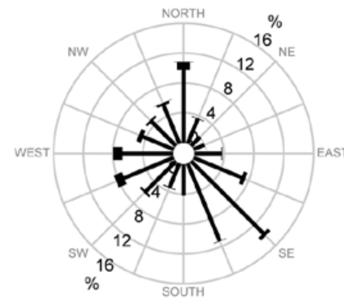
Lower Camp Met Tower (AMS 3) 100m - 2011 (8676 hours)



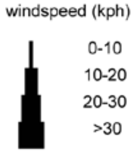
Lower Camp Met Tower (AMS 3) 167m - 2011 (8370 hours)

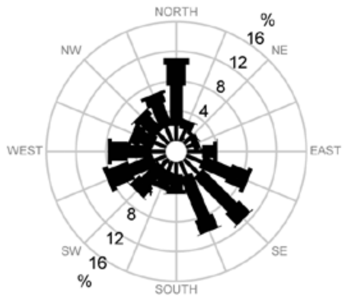


Buffalo Viewpoint (AMS 4) 10m - 2011 (8502 hours)

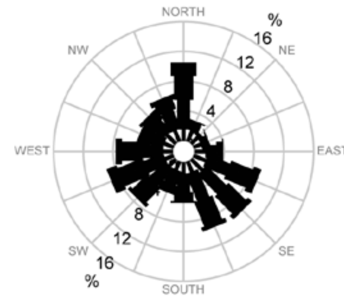


Mannix (AMS 5) 20m - 2011 (8725 hours)

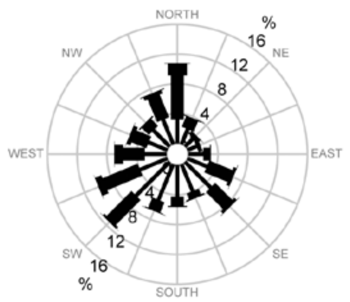




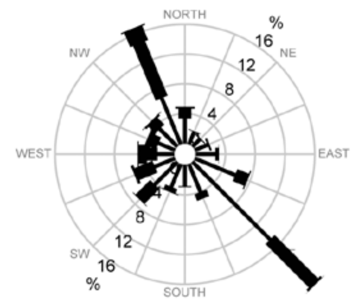
Mannix (AMS 5) 45m - 2011 (8664 hours)



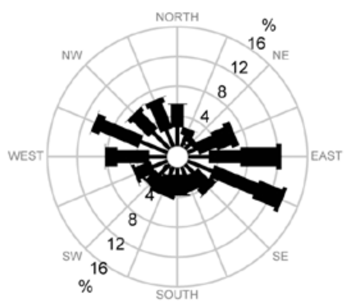
Mannix (AMS 5) 75m - 2011 (8310 hours)



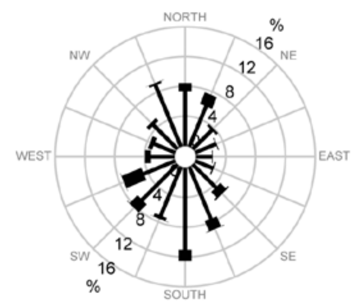
Patricia McInnes (AMS 6) 10m - 2011 (8639 hours)



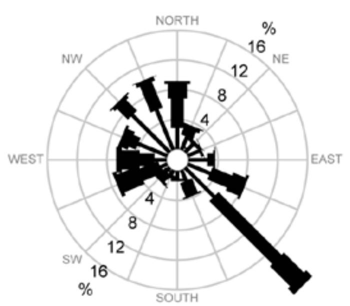
Athabasca Valley (AMS 7) 10m - 2011 (8361 hours)



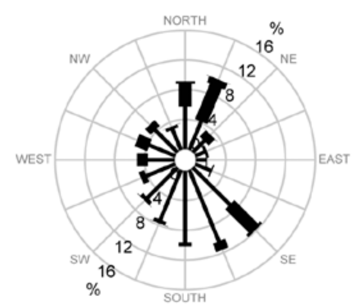
Fort Chipewyan (AMS 8) 10m - 2011 (8755 hours)



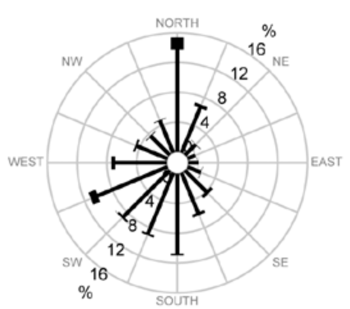
Barge Landing (AMS 9) 10m - 2011 (8503 hours)



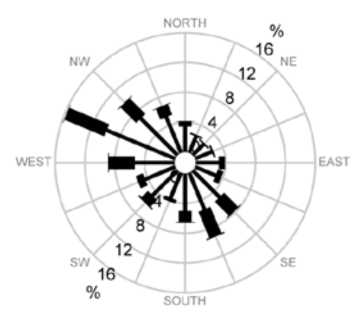
Lower Camp (AMS 11) 10m - 2011 (8614 hours)



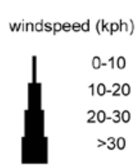
Millennium Mine (AMS 12) 10m - 2011 (8618 hours)



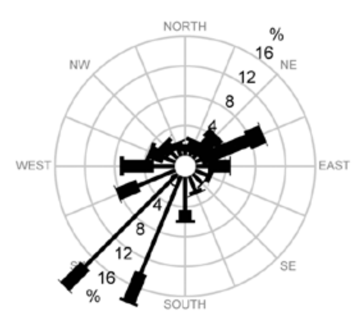
Syncrude UE1 (AMS 13) 10m - 2011 (8680 hours)



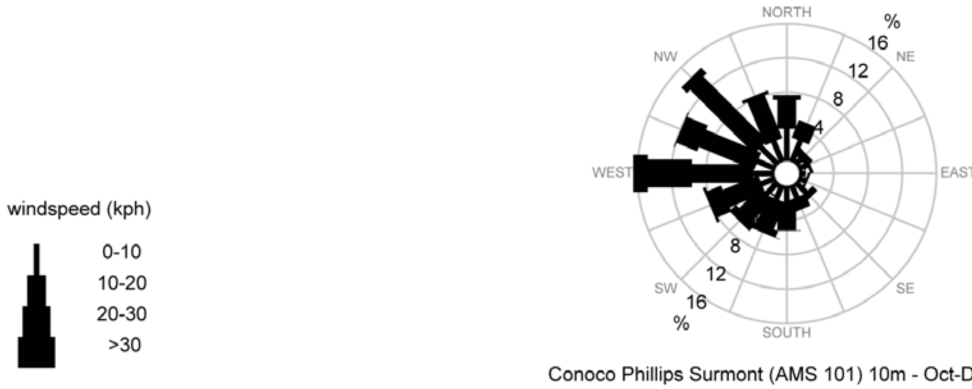
Anzac (AMS 14) 20m - 2011 (8523 hours)



CNRL Horizon (AMS 15) 10m - 2011 (8617 hours)



Albian Muskeg River (AMS 16) 20m - 2011 (8609 hours)



Conoco Phillips Surmont (AMS 101) 10m - Oct-Dec 2011 (2191 hours)

4.3.2 Ambient Air Concentrations

Observed concentrations of each monitored compound at each station are presented as annual average concentrations, highest 1-hour average concentrations and various percentile values.

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. 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, that concentrations were less than or equal to 2 ppb 90 percent of the time, and that concentrations between 1 and 2 ppb occurred 80 percent of the time.

Each percentile value also divides concentrations into two groups, all concentrations less than the percentile value, and all concentrations greater than the percentile value. For example, 99 percent of measured concentrations are less than the 99th percentile concentration, and 1 percent of measured concentrations are greater than the 99th percentile concentration. As another example, a 99th percentile value of 3 ppb indicates that 99 percent of all concentrations were less than or equal to 3 ppb, or in other words, concentrations were less than or equal to 3 ppb 99 percent of the time. It also indicates that only 1 percent of concentrations were greater than 3 ppb, or in other words, concentrations greater than 3 ppb occurred 1 percent of the time.

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 indicates corresponds to the value of the 10th percentile concentration indicated on the vertical axis, 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 of measurements with 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.

4.3.3 Sulphur Dioxide (SO_2)

CHARACTERISTICS

Sulphur dioxide (SO_2) is a colourless gas with a pungent odour that can be detected by taste and smell at concentrations as low as 300 - 500 parts per billion (ppb).

Sulphur dioxide is formed during the processing and combustion of fossil fuels containing sulphur.

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 OBJECTIVES

Alberta Environment has adopted Environment Canada's maximum desirable levels for sulphur dioxide as Alberta Ambient Air Quality Objectives [AAAQO]. The Alberta Objectives for SO_2 in 2011 were:

- 1-hour average of 172 ppb (450 µg/m^3)
- 24 hour average of 57 ppb (150 µg/m^3) prior to February 15, 2011
- Annual average of 11 ppb (30 µg/m^3) prior to February 15, 2011
- 24 hour average of 48 ppb (125 µg/m^3) effective February 15, 2011
- Annual average of 8 ppb (20 µg/m^3) effective February 15, 2011

CONTINUOUS MONITORING NOTES

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 2011

Annual average SO_2 concentrations at industry stations ranged from less than 1 ppb at CNRL Horizon (AMS 15), to 3.14 ppb at Mildred Lake (AMS 2). The highest annual average concentration of 3.14 ppb was greater than one third of the new Alberta annual average air quality objective of 8 ppb.

Annual average concentrations at community stations ranged from 0.32 ppb at Fort Chipewyan (AMS 8) to 1.58 ppb at Fort McKay (AMS 1). The highest annual average concentration at community stations of 1.58 ppb was less than one quarter of the new Alberta annual average air quality objective of 8 ppb.

The highest 1-hour SO_2 concentrations at industry stations in 2011 ranged from 51.9 ppb at Conoco Phillips Surmont (AMS 101) to 122.5 ppb at Mannix (AMS 5). At community stations, the highest concentrations ranged from 12.0 ppb at Fort Chipewyan (AMS 8) to 82.7 ppb at Fort McKay (AMS 1).

The highest 1-hour SO_2 concentrations at each station in 2011 ranged from 12.0 to 122.5 ppb. The 99th percentile SO_2 concentrations ranged from 4.4 to 44.8 ppb. At each station, 99th percentile concentrations were one tenth to less than half the values of the highest concentrations. (An exception was at Conoco Phillips Surmont (AMS 101) where the fraction was two thirds and monitoring occurred for only 3 months, unlike the entire year at other stations). While the highest concentrations were much greater than concentrations measured 99 percent of the time, these high concentrations occurred much less frequently.

Median values of SO_2 were significantly less (2 to 8 times) than the annual average values in 2011. This occurred because most of the observations were small – between 75 and 90 percent of the observations were less than the average. The annual average was influenced by the highest readings, which were much fewer but much larger than the majority of readings.

Exceedences of the Alberta one-hour ambient air quality objective for SO_2 of 172 ppb did not occur in 2011. Nor were there any exceedences of the Alberta 24-hour ambient air quality objective for SO_2 of 48 ppb, and the Alberta annual average ambient air quality objective for SO_2 of 8 ppb.

Table 6. 1-hour concentrations of SO_2 (ppb) for 2011

Station	Annual Average	1-Hour Maximum	Percentiles								
			1	5	10	25	50	75	90	95	99
industry stations:											
Mildred Lake (AMS 2)	3.14	112.1	0.0	0.0	0.0	0.2	0.6	1.5	7.6	18.3	44.8
* Conoco Phillips Surmont (AMS 101)	2.83	51.9	0.0	0.0	0.1	0.2	0.5	1.6	6.9	17.3	35.6
Mannix (AMS 5)	2.04	122.5	0.0	0.0	0.0	0.2	0.4	1.2	4.6	9.9	29.2
Lower Camp (AMS 11)	1.59	91.9	0.0	0.0	0.0	0.2	0.5	1.0	2.8	6.5	25.5
Albian Muskeg River (AMS 16)	1.28	74.6	0.0	0.0	0.1	0.2	0.5	1.1	2.8	5.1	13.3
Syncrude UE1 (AMS 13)	1.25	57.9	0.0	0.0	0.1	0.2	0.5	0.9	2.1	4.7	17.3
Buffalo Viewpoint (AMS 4)	1.13	95.3	0.0	0.0	0.0	0.1	0.3	0.6	1.5	4.2	21.7
Millennium Mine (AMS 12)	1.11	104.8	0.0	0.0	0.0	0.1	0.4	0.8	1.8	3.8	16.3
CNRL Horizon (AMS 15)	0.75	56.0	0.0	0.0	0.0	0.0	0.1	0.4	1.5	3.6	13.0
community stations:											
Fort McKay (AMS 1)	1.58	82.7	0.0	0.1	0.2	0.5	0.8	1.3	2.6	5.0	17.3
Patricia McInnes (AMS 6)	1.00	65.4	0.0	0.0	0.0	0.1	0.2	0.6	2.6	5.1	13.1
Athabasca Valley (AMS 7)	0.66	62.1	0.0	0.0	0.0	0.0	0.2	0.4	1.2	3.0	9.5
Anzac (AMS 14)	0.58	73.3	0.0	0.0	0.0	0.1	0.2	0.6	1.3	2.5	6.4
Fort Chipewyan (AMS 8)	0.32	12.0	0.0	0.0	0.0	0.0	0.1	0.2	0.8	1.6	4.4
air quality objective (ppb)	8	172									

* Monitoring at Conoco Phillips Surmont occurred in the last 3 months of 2011 using the portable monitoring station

Figure 1. Annual average and 1-hour percentile SO_2 concentrations at industry and community stations.

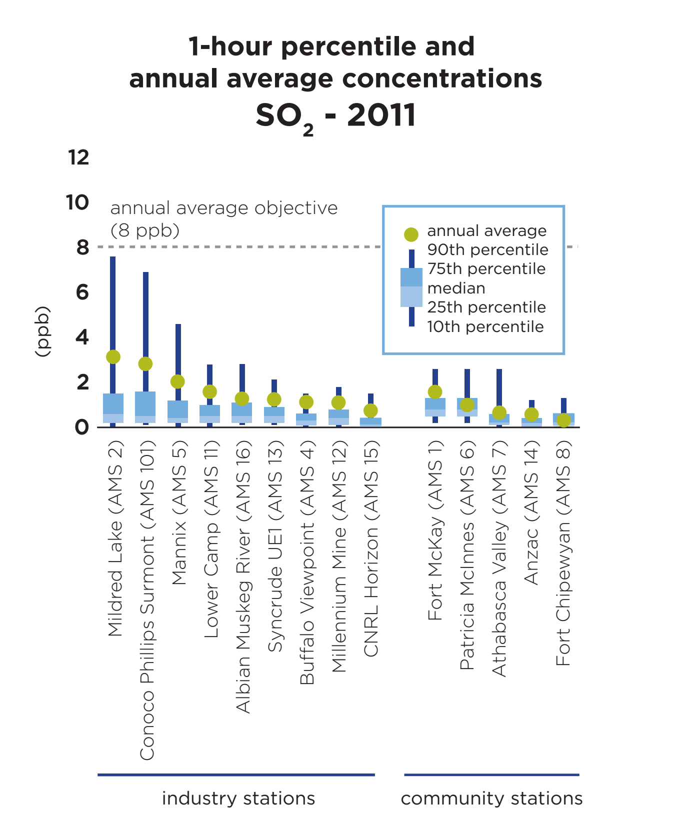
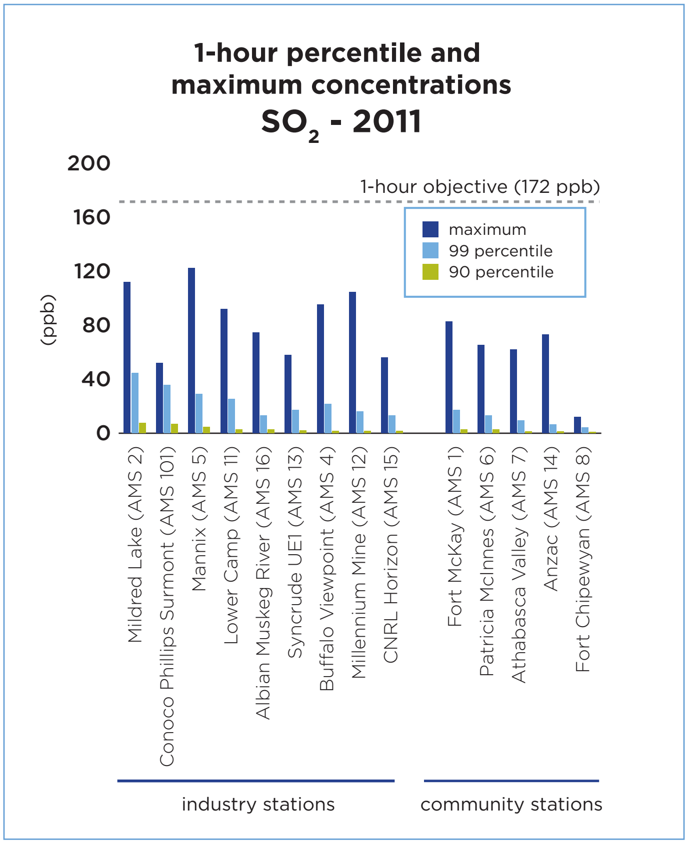


Figure 2. Highest 1-hour SO_2 concentrations and the 99th and 90th percentile values at industry and community stations. There were no exceedences of the 1-hour SO_2 air quality objective.



Average concentrations for each year are presented firstly for 14 years of observation at the 8 original locations operating in 1998. These average concentrations are presented by stations grouped as industrial and community, depending on the setting in which they are located. The average concentration shown was determined as the average of all observations at all stations in the group, so that one number represents results from several stations. For illustrating trends, the presentation is limited to original locations to avoid biasing of results in recent years by observations at stations not operating in earlier years.

Next, annual average concentrations by station are presented for all years at all stations, including those commissioned after 1998. Results in the earliest year at a station may not represent measurements for an entire year, as monitoring could have commenced at some time after the start of the year.

ORIGINAL STATIONS

The average of all SO_2 concentrations observed at all of the 8 original stations for the year 2011 was 1.4 ppb. This concentration was slightly higher than observed in 2010 and 2009, and lower than observed average concentrations ranging from 1.5 to 1.8 ppb observed from 2001 to 2008.

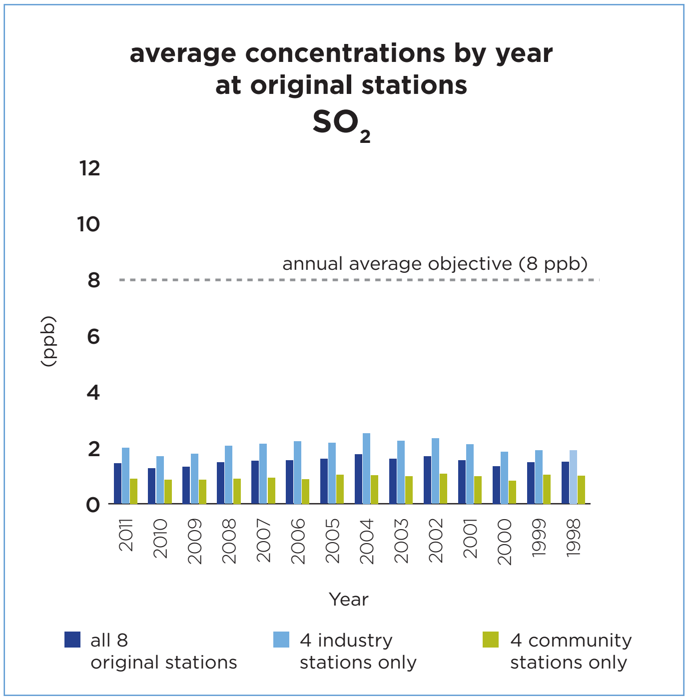
The average of all SO_2 concentrations observed at the 4 original industry stations in 2011 was 2.0 ppb. This value was less than the highest average of all concentrations, 2.5 ppb, which occurred in 2004. The 2004 value was less than one third of the new annual air quality objective for SO_2 of 8 ppb. The 2011 value of 2.0 ppb was higher than in the previous two years, 2010 and 2009. Values in these two years were the lowest recorded since monitoring commenced. The 2011 value was lower than values recorded from 2001 to 2008.

The average of all SO_2 concentrations at the 4 original community stations was 0.9 ppb in 2011. This was the same value as in previous years, and was slightly lower, but comparable to the average of all concentrations in years prior. Average concentrations were 0.8 to 1.1 ppb at all community stations. Average concentrations were 1.7 to 2.5 ppb at all industry stations.

Table 7. Average SO_2 concentrations (ppb) at the 8 stations measuring SO_2 since startup of the WBEA air monitoring network for all, industry and community stations.

	station group		
year	all	industry	community
2011	1.4	2.0	0.9
2010	1.3	1.7	0.9
2009	1.3	1.8	0.9
2008	1.5	2.1	0.9
2007	1.5	2.1	0.9
2006	1.6	2.2	0.9
2005	1.6	2.2	1.0
2004	1.8	2.5	1.0
2003	1.6	2.2	1.0
2002	1.7	2.3	1.1
2001	1.5	2.1	1.0
2000	1.3	1.9	0.8
1999	1.5	1.9	1.0
1998	1.5	1.9	1.0

Figure 3. Average SO_2 concentrations (ppb) at the 8 stations measuring SO_2 since startup of the WBEA air monitoring network for all, industry and community stations



ALL STATIONS

The annual average SO_2 concentrations in the last 14 years at all industry stations, including those commissioned after 1998, ranged from 0.8 ppb at CNRL Horizon (AMS 15) in 2011 and Syncrude UE-1 (AMS 13) in 2002, to 4.2 ppb at Mannix (AMS 5) in 2004.

At all community stations, including those commissioned after 1998, annual average SO_2 concentrations ranged from 0.2 ppb at Fort Chipewyan (AMS 8) in 2000 to 1.6 ppb at Fort McKay (AMS 1) in 2005 and again in 2011. The highest annual average concentration at any station of 4.2 ppb was about one half of the new annual air quality objective for SO_2 of 8 ppb.

Table 8. Annual average SO_2 concentrations (ppb) at all stations since 1998, grouped by industry and community stations, and ordered by the highest annual average concentration.

	year														period		
station	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	highest	average	lowest
industry stations:																	
Mannix (AMS 5)	2.0	2.3	1.9	2.4	2.8	2.8	3.0	4.2	2.8	2.5	2.0	2.2	2.2	2.1	4.2	2.5	1.9
Mildred Lake (AMS 2)	3.1	1.9	2.1	2.6	2.3	2.6	2.2	2.0	2.7	2.9	2.9	2.0	2.4	2.0	3.1	2.4	1.9
** Albian mine site (AMS 10)	.	.	2.9	1.7	1.5	1.5	1.9	1.4	1.9	1.7	1.7	1.6	.	.	2.9	1.8	1.4
*** Conoco Phillips Surmont (AMS 101)	2.8	.	.	.	.	.	.	.	.	.	.	.	.	.	2.8	2.8	2.8
* Lower Camp (AMS 11)	1.6	1.5	1.8	1.9	2.1	2.5	2.2	2.1	2.1	2.1	2.2	1.7	.	.	2.5	2.0	1.5
* Lower Camp - original (AMS 3)	.	.	.	.	.	.	.	.	.	.	1.6	1.8	1.9	2.3	2.3	1.9	1.6
Millennium Mine (AMS 12)	1.1	1.0	1.9	2.2	2.2	1.7	1.6	1.7	1.0	1.3	0.9	.	.	.	2.2	1.5	0.9
Buffalo Viewpoint (AMS 4)	1.1	1.0	1.3	1.2	1.3	1.0	1.2	1.7	1.3	1.8	1.4	1.4	1.1	1.2	1.8	1.3	1.0
** Albian Muskeg River (AMS 16)	1.3	1.7	1.4	.	.	.	.	.	.	.	.	.	.	.	1.7	1.4	1.3
Syncrude UE1 (AMS 13)	1.2	1.2	1.1	1.6	1.0	1.3	1.3	1.1	1.2	0.8	.	.	.	.	1.6	1.2	0.8
CNRL Horizon (AMS 15)	0.8	1.0	1.2	1.1	.	.	.	.	.	.	.	.	.	.	1.2	1.0	0.8
community stations:																	
Fort McKay (AMS 1)	1.6	1.3	1.1	1.5	1.3	1.5	1.6	1.1	1.3	1.1	1.3	1.0	1.4	1.4	1.6	1.3	1.0
Patricia McInnes (AMS 6)	1.0	1.0	1.2	1.0	1.1	0.8	1.1	1.4	1.2	1.4	1.2	1.2	1.2	1.2	1.4	1.1	0.8
Athabasca Valley (AMS 7)	0.7	0.7	0.8	0.8	0.9	0.8	1.1	1.1	1.0	1.3	1.0	0.9	0.9	0.8	1.3	0.9	0.7
Anzac (AMS 14)	0.6	0.5	0.7	0.5	0.6	0.4	.	.	.	.	.	.	.	.	0.7	0.6	0.4
Fort Chipewyan (AMS 8)	0.3	0.4	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.2	0.4	0.3	0.4	0.3	0.2

annual average SO_2 air quality objective : 11 ppb

* Lower Camp air quality monitoring equipment was relocated a few hundred meters from the original location in 2000 and renamed from AMS 3 to AMS 11

** The Albian station was relocated 4 km southwest in February 2009 and renamed from AMS 10 to AMS 16

*** Monitoring at Conoco Phillips Surmont occurred in the last 3 months of 2011 using the portable monitoring station

4.3.4 Total Reduced Sulphur (TRS), Hydrogen Sulphide (H_2S) and Reduced Sulphur Compounds (RSC)

CHARACTERISTICS

Hydrogen sulphide is a colourless gas with a characteristic rotten egg odour.

The term "total reduced sulphur (TRS) compounds" is used to collectively describe a group of compounds including hydrogen sulphide, methyl sulphide, dimethyl sulphide, dimethyl disulphide, methyl mercaptan and other mercaptans.

SOURCES

Hydrogen sulphide is produced both naturally and through industrial processes. It is found naturally in coal, natural gas, oil, sulphur hot springs, sloughs, swamps, and lakes. In the absence of oxygen, decomposition of organic matter by bacteria results in the release of H_2S. This produces the characteristic odour commonly associated with sewers, sewage lagoons, and swamps. Industrial sources are primarily petroleum refining and upgrading petrochemical complexes, and pulp and paper mills.

ALBERTA OBJECTIVES

The objectives for maximum permissible concentrations of H_2S are based on the odour threshold, although many individuals can smell H_2S at levels below the ambient objectives.

TRS concentrations are evaluated against the H_2S air quality guidelines in the WBEA air quality monitoring network, as H_2S is generally the main component of TRS.

The Alberta H_2S objectives are:

- 1-hour average of 10 ppb (14 μg/m^3)
- 24-hour average of 3 ppb (4 μg/m^3)

There is an Alberta Ambient Air Quality Objective (AAAQO) for the following reduced sulphur compound:

- Carbon Disulphide – 1 hour average of 10 ppbv (30 μg/m^3) - adopted 1999

CONTINUOUS MONITORING NOTES – TRS AND H_2S

Hydrogen Sulphide (H_2S) is measured at four stations in the WBEA monitoring network (Mildred Lake – AMS 2, Buffalo Viewpoint – AMS 4, Mannix - AMS 5, and Lower Camp – AMS 11). Total reduced sulphur (TRS) is measured at seven other stations.

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. The chemical conversion creates the same amount of SO_2 as TRS or H_2S in the air sample. Different operating temperatures of the converter determine which of TRS or H_2S is oxidized and subsequently measured. Concentrations of TRS or H_2S are measured by the SO_2 analyzer's fluorescence technology, where concentrations are measured by the intensity of light emitted by SO_2 molecules (converted from TRS or H_2S molecules in the air sample) when exposed to ultraviolet light inside 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 detecting H_2S. This is an interference.

CONTINUOUS MONITORING OBSERVATIONS IN 2011 – TRS AND H_2S

Annual average TRS and H_2S concentrations in 2011 at industry stations ranged from 0.29 ppb at Buffalo Viewpoint (AMS 4) and Syncrude UE1 (AMS 13), to 1.03 ppb at Millennium Mine (AMS 12). At community stations annual average concentrations ranged from 0.31 ppb at Patricia McInnes (AMS 6) to 0.62 ppb at Fort McKay (AMS 1).

The highest 1-hour TRS and H_2S concentrations in 2011 at industry stations ranged from 5.6 ppb at CNRL Horizon (AMS 15) to 98.2 ppb at Mildred Lake (AMS 2). At community stations, the highest concentrations ranged from 3.0 ppb at Patricia McInnes (AMS 6) to 6.6 ppb at Anzac (AMS 14).

The highest 1-hour TRS and H_2S concentrations at all stations in 2011 ranged from 3.0 to 98.2 ppb. The 99th percentile concentrations ranged from 1.1 to 12.7 ppb, and the 95th percentile concentrations ranged from 0.7 to 3.5 ppb. At each station, the highest concentrations were 2 to 20 times greater than the 99th percentile concentrations, and 4 to 41 times greater than the 95th percentile concentrations. In other words, the highest concentrations were 2 to 20 times higher than concentrations that were observed 99 percent of the time, and 4 to 41 times higher than concentrations that were observed 95 percent of the time. The highest one percent of concentrations at most stations were large compared to the remaining 99 percent of concentrations, and they were infrequently measured.

At most industrial stations in 2011, annual average values of TRS and H_2S were significantly greater than the median values. However most of the observations were small - more than 50% of the observations were much less than the average and the 75th percentile values were comparable to but slightly greater than the average values. The high average resulted from weighting by highest readings, which although they were much fewer in number, were much larger than the majority of readings.

The Alberta one-hour ambient air quality objective for H_2S of 10 ppb was exceeded 169 times in 2011 (less than the 614 exceedences in 2010 and the 1,625 exceedences in 2009). All exceedences in 2011 were at industry stations. There were 133 exceedences at Millennium Mine (AMS 12), 13 at Lower Camp (AMS 11), 18 at Mildred Lake (AMS 2), 3 at Conoco Phillips Surmont (AMS 101), and 2 at Mannix (AMS 5). There were no exceedences of the one-hour objective at community stations.

The Alberta 24-hour ambient air quality objective for H_2S of 3 ppb was exceeded 31 times in 2011 (less than the 118 exceedences in 2010 and the 252 exceedences in 2009). All exceedences were at industry stations. There were 23 exceedences at Millennium Mine (AMS 12), 4 at Mildred Lake (AMS 2), 3 at Lower Camp (AMS 11), and 1 at Conoco Phillips Surmont (AMS 101). There were no exceedences of the 24-hour objective at community stations.

All of the H_2S air quality objective exceedences occurred at industry stations. Alberta Environment and Water, and all industries are informed by the WBEA of each exceedence. For each event, industry undertakes an internal investigation to determine a cause and follows up with Alberta Environment and Water on findings and mitigative actions.

Table 9. 1-hour concentrations of TRS/H_2S (ppb) for 2011

Station	Annual Average	1-Hour Maximum	Percentiles								
			1	5	10	25	50	75	90	95	99
industry stations:											
Millennium Mine (AMS 12)	1.03	92.6	0.0	0.1	0.1	0.2	0.3	0.7	1.8	3.5	12.7
Lower Camp (AMS 11)	0.69	30.1	0.0	0.1	0.1	0.2	0.4	0.8	1.5	2.2	5.3
Mildred Lake (AMS 2)	0.63	98.2	0.0	0.0	0.0	0.0	0.2	0.7	1.5	2.4	5.6
* Conoco Phillips Surmont (AMS 101)	0.62	60.4	0.0	0.0	0.1	0.1	0.3	0.8	1.3	1.7	3.0
Mannix (AMS 5)	0.55	12.0	0.0	0.0	0.1	0.2	0.3	0.6	1.3	1.9	4.1
CNRL Horizon (AMS 15)	0.47	5.6	0.2	0.2	0.3	0.3	0.4	0.5	0.7	1.0	1.7
Barge Landing (AMS 9)	0.44	8.5	0.0	0.0	0.1	0.1	0.2	0.5	1.1	1.5	2.7
Syncrude UE1 (AMS 13)	0.31	8.1	0.0	0.0	0.0	0.1	0.2	0.4	0.7	0.9	1.7
Buffalo Viewpoint (AMS 4)	0.29	7.3	0.0	0.0	0.0	0.1	0.2	0.3	0.6	1.1	2.6
community stations:											
Fort McKay (AMS 1)	0.62	5.7	0.0	0.2	0.3	0.4	0.5	0.7	1.2	1.7	2.8
Athabasca Valley (AMS 7)	0.54	3.7	0.1	0.2	0.2	0.4	0.5	0.6	0.8	1.1	1.8
Anzac (AMS 14)	0.38	6.6	0.1	0.2	0.2	0.3	0.4	0.4	0.5	0.7	1.1
Patricia McInnes (AMS 6)	0.31	3.0	0.1	0.1	0.2	0.2	0.2	0.3	0.5	0.7	1.4
air quality objective (ppb)	n/a	10									

* Monitoring at Conoco Phillips Surmont occurred in the last 3 months of 2011 using the portable monitoring station

Figure 4. Annual average and 1-hour percentile TRS and H_2S concentrations at industry and community stations.

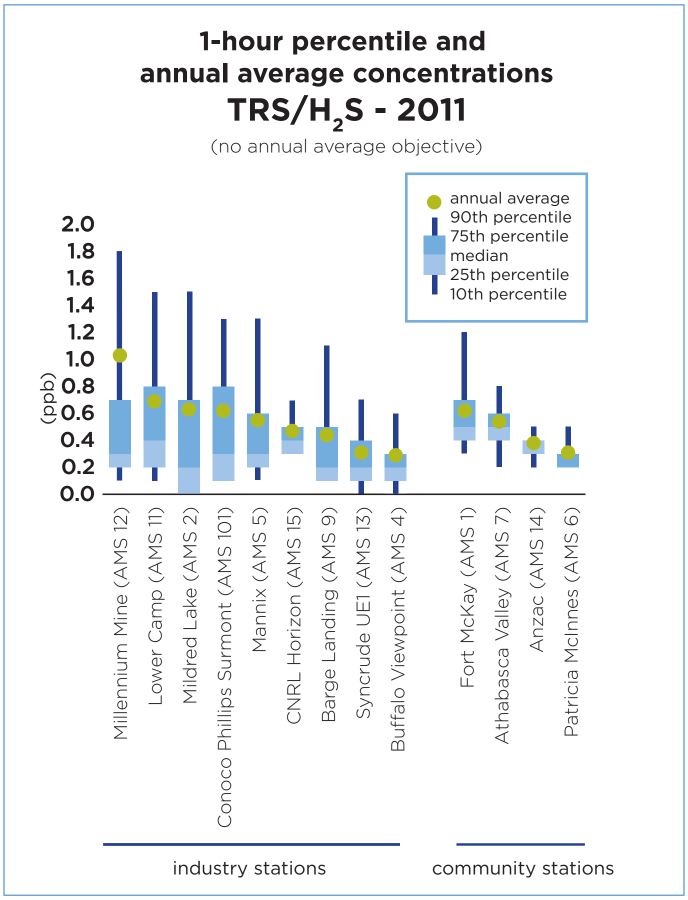


Figure 5. Highest 1-hour TRS and H_2S concentrations and the 99th and 90th percentiles at industry and community stations. The number of 1-hour H_2S air quality objective exceedences are indicated.

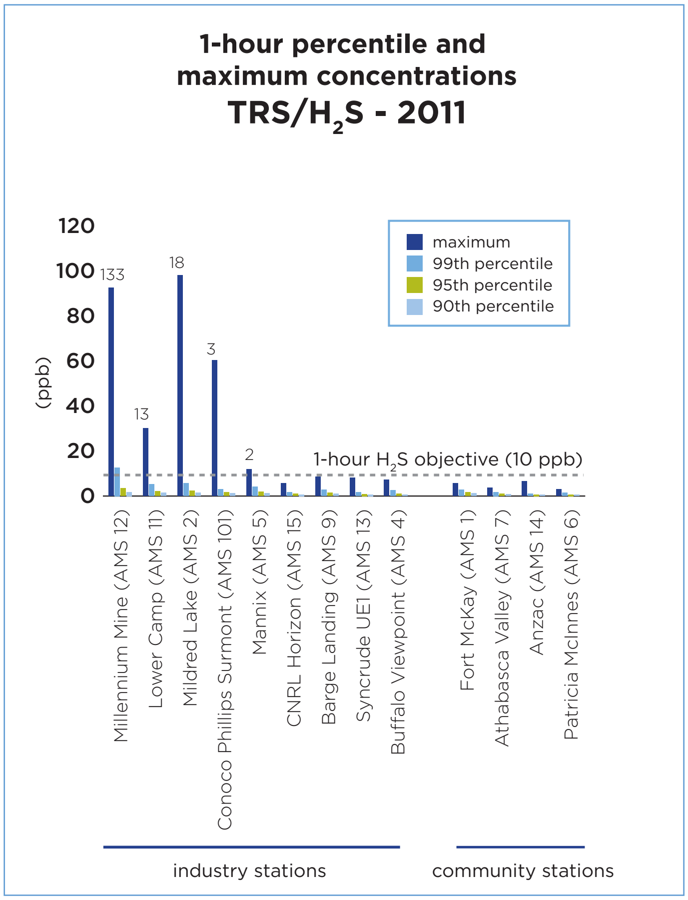


Table 10. 24-hour concentrations of TRS/H_2S (ppb) for 2011

station	24-hour maximum	percentiles									
		1	5	10	25	50	75	90	95	98	99
industry stations:											
Millennium Mine (AMS 12)	23.1	0.0	0.0	0.0	0.1	0.4	0.8	2.1	3.6	7.3	8.6
Mildred Lake (AMS 2)	10.3	0.0	0.0	0.0	0.0	0.4	0.8	1.4	1.8	2.6	3.9
* Conoco Phillips Surmont (AMS 101)	6.6	0.0	0.0	0.1	0.2	0.4	0.8	1.1	1.4	1.9	6.6
Lower Camp (AMS 11)	5.2	0.0	0.0	0.1	0.3	0.5	0.9	1.2	1.6	2.5	3.3
Mannix (AMS 5)	2.8	0.0	0.0	0.0	0.0	0.3	0.8	1.2	1.4	1.7	2.1
Barge Landing (AMS 9)	2.5	0.0	0.0	0.0	0.0	0.2	0.5	0.9	1.3	1.7	1.9
Buffalo Viewpoint (AMS 4)	1.8	0.0	0.0	0.0	0.0	0.0	0.3	0.7	0.8	1.1	1.3
Syncrude UE1 (AMS 13)	1.6	0.0	0.0	0.0	0.0	0.1	0.3	0.6	0.8	1.0	1.1
CNRL Horizon (AMS 15)	1.5	0.0	0.0	0.0	0.0	0.3	0.6	0.9	1.0	1.2	1.3
community stations:											
Fort McKay (AMS 1)	3.3**	0.0	0.0	0.1	0.3	0.6	1.0	1.1	1.3	1.6	2.1
Athabasca Valley (AMS 7)	1.6	0.0	0.0	0.0	0.3	0.7	1.0	1.0	1.0	1.3	1.3
Patricia McInnes (AMS 6)	1.6	0.0	0.0	0.0	0.0	0.0	0.2	0.5	0.7	0.8	0.9
Anzac (AMS 14)	1.0	0.0	0.0	0.0	0.0	0.1	0.4	0.7	0.8	0.9	1.0
air quality objective (ppb)	3										

* Monitoring at Conoco Phillips Surmont occurred in the last 3 months of 2011 using the portable monitoring station

** By convention, concentrations are rounded to prescribed reporting precision for comparison with air quality objectives 3.3 ppb is not an exceedence of the 3 ppb objective

Figure 6. 24-hour percentile TRS and H_2S concentrations at industry and community stations.

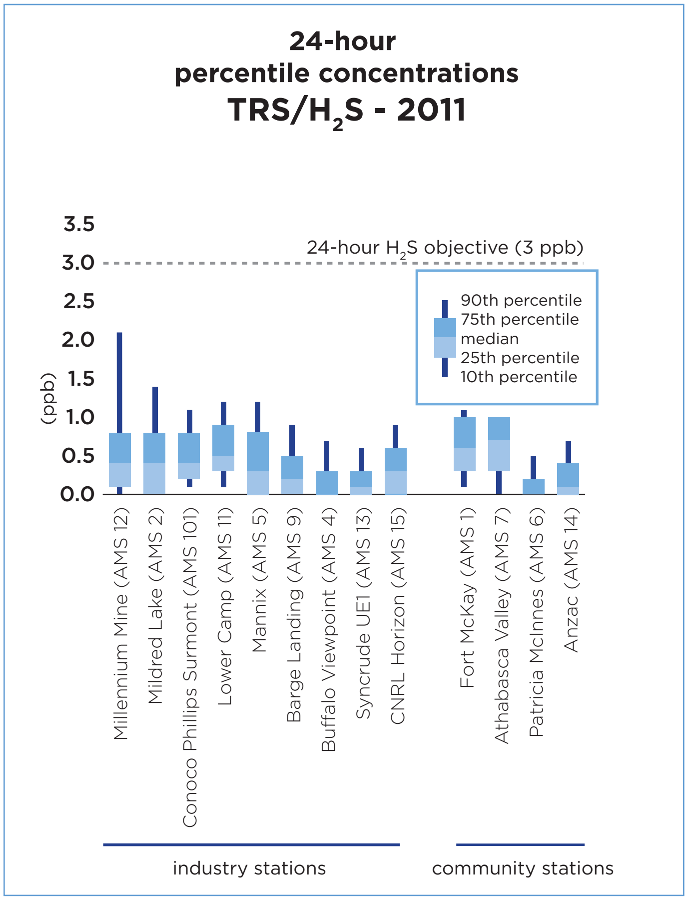
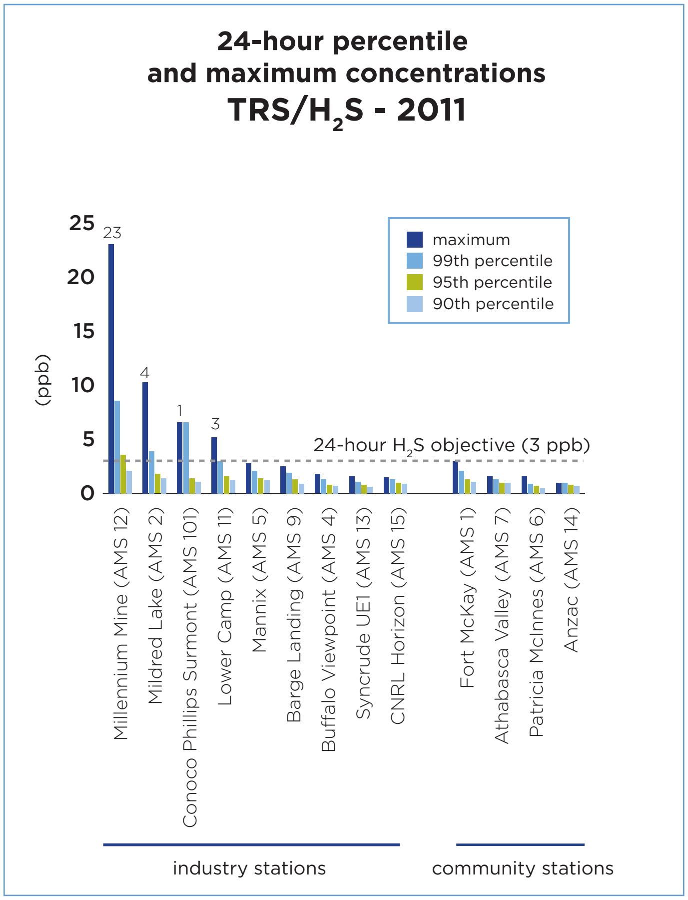


Figure 7. Highest 24-hour TRS and H_2S concentrations and the 99th, 95th and 90th percentiles at industry and community stations. The number of exceedences of the 24-hour H_2S air quality objective is indicated



CONTINUOUS MONITORING TRENDS IN RECENT YEARS

At the start of the WBEA monitoring program in 1998, TRS was measured at 3 community stations and H_2S was measured at 4 industry stations. In this report, TRS is assumed to consist primarily of H_2S, and results are presented together.

ORIGINAL STATIONS

The average of all TRS and H_2S concentrations observed at all of the 7 original stations in 2011 was 0.5 ppb. This value was lower than the highest value of 1.3 observed in 2009 and less than values of at least 0.8 which have been observed since 2007. The 2011 value was comparable to values of about 0.5 ppb observed in the first 8 years, prior to 2006.

The averages of all concentrations at industrial and community locations were within 0.1 ppb the 4 years 2011, 2005, 2004 and 2003, with values ranging from 0.4 to 0.7 ppb. In years before 2003 and after 2005, averages of 0.3 to 0.5 ppb at community stations were about half the averages of 0.5 to 1.1 ppb at industry stations.

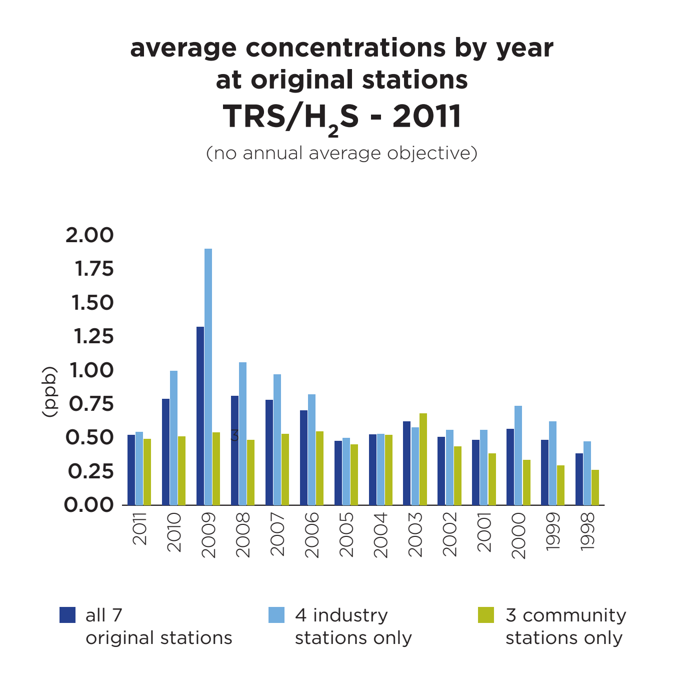
The average concentration of 0.5 ppb at all industry stations in 2011 was much less than the average concentrations ranging from 1.0 to 1.9 ppb at all industry stations in the previous four years, and was comparable to the average of all concentrations in years prior to 2006.

The average of all concentrations at the 3 community stations has been generally the same for the last 10 years, at 0.5 ppb, except for the slightly higher value of 0.7 ppb in 2003. This trend is different from what has been seen at the industry stations.

Table 11. Average TRS and H_2S concentrations (ppb) at the 7 stations measuring TRS and H_2S since startup of the WBEA air monitoring network.

	station group		
year	all	industry	community
2011	0.5	0.5	0.5
2010	0.8	1.0	0.5
2009	1.3	1.9	0.5
2008	0.8	1.1	0.5
2007	0.8	1.0	0.5
2006	0.7	0.8	0.5
2005	0.5	0.5	0.4
2004	0.5	0.5	0.5
2003	0.6	0.6	0.7
2002	0.5	0.6	0.4
2001	0.5	0.6	0.4
2000	0.6	0.7	0.3
1999	0.5	0.6	0.3
1998	0.4	0.5	0.3

Figure 8. Average TRS and H_2S concentrations (ppb) at the 7 stations measuring TRS and H_2S since startup of the WBEA air monitoring network.



ALL STATIONS

The annual average TRS and H_2S concentrations in the last 14 years at all industry stations ranged from 0.1 ppb at both Buffalo Viewpoint (AMS 4) in 2004 and at Millenium Mine (AMS 12) prior to 2004, to 2.8 ppb at Mildred Lake (AMS 2) in 2009. At community stations, annual average TRS and H_2S concentrations ranged from 0.1 ppb at Patricia McInnes (AMS 6) in 2008 to 0.9 ppb at Fort McKay (AMS 1) in 2009.

Table 12. Annual average TRS and H_2S concentrations (ppb) since 1998 at all stations, grouped by industry and community stations, and ordered by the highest annual average concentration

	year														period		
station	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	highest	average	lowest
industry stations:																	
Mildred Lake (AMS 2)	0.6	1.3	2.8	1.6	1.3	1.1	0.8	0.6	0.6	0.6	0.6	0.8	0.5	0.4	2.8	1.0	0.4
Mannix (AMS 5)	0.6	1.2	2.3	1.0	1.2	1.1	0.5	0.7	0.6	0.8	0.7	0.8	0.6	0.6	2.3	0.9	0.5
* Lower Camp (AMS 11)	0.7	1.1	1.8	1.0	1.0	0.9	0.6	0.7	0.9	0.6	0.5	0.5	.	.	1.8	0.9	0.5
Millennium Mine (AMS 12)	1.0	1.3	1.4	1.1	1.1	0.8	0.5	0.5	0.1	0.1	0.1	.	.	.	1.4	0.7	0.1
* Lower Camp - original (AMS 3)	.	.	.	.	.	.	.	.	.	.	.	1.0	1.1	0.7	1.1	1.0	0.7
Barge Landing (AMS 9)	0.4	0.6	0.8	0.3	0.4	0.6	0.6	0.5	0.6	0.3	0.3	0.4	.	.	0.8	0.5	0.3
Syncrude UE1 (AMS 13)	0.3	0.2	0.5	0.5	0.6	0.6	0.5	0.4	0.3	0.3	.	.	.	.	0.6	0.4	0.2
Buffalo Viewpoint (AMS 4)	0.3	0.3	0.6	0.6	0.4	0.2	0.2	0.1	0.2	0.2	0.4	0.4	0.3	0.2	0.6	0.3	0.1
** Conoco Phillips Surmont (AMS 101)	0.6	.	.	.	.	.	.	.	.	.	.	.	.	.	0.6	0.6	0.6
CNRL Horizon (AMS 15)	0.5	0.5	0.5	0.4	.	.	.	.	.	.	.	.	.	.	0.5	0.4	0.4
community stations:																	
Fort McKay (AMS 1)	0.6	0.7	0.9	0.8	0.8	0.8	0.5	0.4	0.7	0.7	0.5	0.5	0.4	0.3	0.9	0.6	0.3
Athabasca Valley (AMS 7)	0.5	0.5	0.6	0.5	0.6	0.7	0.5	0.7	0.8	0.3	0.2	0.3	0.2	0.3	0.8	0.5	0.2
Anzac (AMS 14)	0.4	0.3	0.2	0.3	0.6	0.3	.	.	.	.	.	.	.	.	0.6	0.4	0.2
Patricia McInnes (AMS 6)	0.3	0.3	0.2	0.1	0.2	0.2	0.3	0.4	0.5	0.3	0.4	0.2	0.3	0.2	0.5	0.3	0.1

no annual average air quality objective for H_2S

* Lower Camp air quality monitoring equipment was relocated a few hundred meters from the original location in 2000 and renamed from AMS 3 to AMS 11.

** Monitoring at Conoco Phillips Surmont occurred in the last 3 months of 2011 using the portable monitoring station

INTEGRATED MONITORING NOTES - RSC

Reduced sulphur compounds (RSCs) 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 60 VOC compounds and 22 RSC compounds.

Reduced sulphur compounds were measured for a 1-day, 24-hour period at 4 industry stations: Barge Landing (AMS 9), Millennium Mine (AMS 12), Syncrude UE1 (AMS 13), and CNRL Horizon (AMS 15); and at 4 community stations: Fort McKay (AMS 1), Patricia McInnes (AMS 6), Athabasca Valley (AMS 7), and Anzac (AMS 14). RSCs were measured every 12 days (approximately 30 possible sample days in the year) at all stations except Barge Landing (AMS 9), where they were measured every 6 days (60 possible sample days in the year).

In 2011 and 2010 for quality assurance purposes, duplicate samples and replicate analyses were introduced occasionally at selected sites and for selected samples. A duplicate sample is a second container collecting air at the same time as the routine container collects air. A replicate analysis is a second analysis of air from a sample container that has already been analyzed in routine analysis. When undertaken, duplicate sampling and replicate analysis practices create more than one set of results for a sampling day. Presented results are based sample days, and with results averaged for duplicate samples, and results from replicate analyses excluded. Results for all RSC parameters with measurable concentrations at each station are summarized in the table.

Results from 3 samples in 2011 were excluded from the summary because at press time an ongoing investigation of suspected cyclohexane contamination was incomplete. Excluded sample results were from Patricia McInnes (AMS 6) and Athabasca Valley (AMS 7) on March 22nd, and from Syncrude UE-1 (AMS 13) on February 14th.

INTEGRATED MONITORING OBSERVATIONS IN 2011 - RSC

At industry stations, the RSC compounds with the highest measured 24-hour concentrations were thiophene, with a maximum concentration of 6.8 ppb at Millenium Mine (AMS 12), carbonyl sulphide, with a maximum concentration of 3.4 ppb at CNRL Horizon (AMS 15), hydrogen sulphide, with a maximum concentration of 2.7 ppb at CNRL Horizon (AMS 15), and carbon disulphide, with a maximum concentration of 2.7 ppb at CNRL Horizon (AMS 15). Corresponding average concentrations at each station were 6.8, 1.8, 1.7, and 0.4 ppb. Average concentrations were generally much less than the highest concentrations, except when detected in only one or a few samples.

At community stations, the RSC compounds with the highest measured 24-hour concentrations were carbon disulphide with a maximum concentration of 13.4 ppb and carbonyl sulphide with a maximum concentration of 9.0 ppb, both measured at Patricia McInnes (AMS 6). Corresponding average concentrations were 4.6 and 0.8 ppb. Other compounds measured a community stations included hydrogen sulphide and dimethyl disulphide.

Table 13. Summary of all 24-hour RSC concentrations measured at each station, ordered by highest concentration.

station	compound	number of samples containing	fraction of samples containing (%)	maximum concentration (ppb)	average concentration in all samples (ppb)
industry stations:					
Barge Landing (AMS 9)	thiophene	1 / 56	2	3.4	3.35
	carbonyl sulphide	52 / 56	93	2.5	0.72
	carbon disulphide	13 / 56	23	1.6	0.34
	hydrogen sulphide	13 / 56	23	1.5	0.38
	dimethyl disulphide	1 / 56	2	0.2	0.22
Millennium Mine (AMS 12)	thiophene	1 / 26	4	6.8	6.75
	carbonyl sulphide	25 / 26	96	1.0	0.57
	carbon disulphide	5 / 26	19	0.4	0.23
	hydrogen sulphide	3 / 26	12	0.3	0.24
Syncrude UE1 (AMS 13)	carbonyl sulphide	25 / 27	93	1.7	0.56
	carbon disulphide	2 / 27	7	1.4	0.76
	hydrogen sulphide	4 / 27	15	0.7	0.32
	dimethyl disulphide	1 / 27	4	0.5	0.51
CNRL Horizon (AMS 15)	carbonyl sulphide	28 / 29	97	3.4	1.83
	hydrogen sulphide	4 / 29	14	2.7	1.70
	carbon disulphide	16 / 29	55	2.7	0.39
	dimethyl disulphide	4 / 29	14	0.3	0.12
community stations:					
Fort McKay (AMS 1)	carbon disulphide	8 / 28	29	6.7	1.12
	carbonyl sulphide	26 / 28	93	2.2	0.71
	hydrogen sulphide	7 / 28	25	1.1	0.30
	dimethyl disulphide	2 / 28	7	0.4	0.28
Patricia McInnes (AMS 6)	carbon disulphide	3 / 29	10	13.4	4.62
	carbonyl sulphide	28 / 29	97	9.0	0.82
	hydrogen sulphide	4 / 29	14	0.7	0.28
	dimethyl disulphide	1 / 29	3	0.2	0.16
Athabasca Valley (AMS 7)	carbonyl sulphide	25 / 27	93	1.4	0.53
	carbon disulphide	4 / 27	15	0.8	0.39
	hydrogen sulphide	5 / 27	19	0.3	0.18
	dimethyl disulphide	1 / 27	4	0.3	0.27
Anzac (AMS 14)	carbonyl sulphide	22 / 28	79	2.5	0.61
	hydrogen sulphide	1 / 28	4	0.9	0.94
	carbon disulphide	4 / 28	14	0.1	0.11

4.3.5 HYDROCARBONS (THC, VOC, PAH)

CHARACTERISTICS

Hydrocarbons are divided into two broad categories, reactive and non-reactive. The reactive hydrocarbons consist of a suite of compounds collectively called volatile organic compounds (VOCs). The major non-reactive hydrocarbon in the atmosphere is methane, a colourless, odourless gas, which is a major contributor to the greenhouse effect. Methane exists naturally in the atmosphere with background concentrations of about 1.8 ppm.

Some VOCs react with the oxides of nitrogen in the atmosphere to form ozone. These include primarily ethylene, propane, butane, benzene and α-pinene.

Polycyclic aromatic hydrocarbons (PAHs) are hydrocarbon compounds of higher molecular weight and less volatility.

SOURCES

The simplest hydrocarbon, methane (CH_4), is produced naturally through the decay of vegetation.

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

Combustion processes, both natural, such as forest fires, and human influenced, such as industrial activities and the use of motor vehicles, result in the formation of PAHs.

ALBERTA OBJECTIVES

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

There are Alberta Ambient Air Quality Objectives (AAAQO) for the following VOCs:

- acetaldehyde – 1 hour average: 50 ppbv (90 µg/m^3) - adopted 1999
- acetone - 1 hour average: 2400 ppbv (5900 µg/m^3) - adopted 1999, reviewed in 2005
- benzene – 1 hour average: 9 ppbv (30 µg/m^3) - adopted in 1999
- ethylbenzene – 1 hour average: 460 ppbv (2000 µg/m^3) - adopted May 1, 2005
- formaldehyde – 1 hour average: 53 ppbv (65 µg/m^3) - adopted 1999, revised 2007
- methanol – 1 hour average: 2,000 ppbv (2,600 µg/m^3) - adopted 1999
- styrene – 1-hour average: 52ppbv (215 µg/m^3)- -adopted from Texas
- toluene – 1 hour average: 499 ppbv (1,880 µg/m^3)
  24 hour average: 106 ppbv (400 µg/m^3) - adopted May 1, 2005
- xylenes – 1 hour average: or 530 ppbv (2,300 µg/m^3)
  24 hour average: 161 ppbv (700 µg/m^3) - adopted 2005

CONTINUOUS MONITORING NOTES - 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 presence of carbon ions.

Calibration procedure of continuous THC monitors was changed in 2010 to conform to guidance issued by Alberta Environment. The gas used to calibrate THC monitors was changed from methane only to a mixture of methane and propane. The change was implemented over the period from February 2 to May 7, 2010. There could be a small systematic difference in measured results before and after the change.

CONTINUOUS MONITORING OBSERVATIONS IN 2011 - THC

Annual average total hydrocarbon concentrations in 2011 at industry stations ranged from the lowest value of 2.15 ppm at CNRL Horizon (AMS 15), to 2.46 ppm at Millenium Mine (AMS 12). At community stations annual average THC concentrations ranged from 2.10 ppm at Anzac (AMS 14) and Patricia McInnes (AMS 6) to 2.2 ppm at Fort McKay (AMS 1).

The highest 1-hour THC concentration in 2011 at industry stations ranged from 5.6 ppm at Lower Camp (AMS 11) to 9.4 ppm at CNRL Horizon (AMS 15). At community stations, the highest 1-hour concentrations ranged from 3.1 ppm at Anzac (AMS 14) to 5.4 ppm at Fort McKay (AMS 1).

The highest 1-hour THC concentrations at all stations in 2011 ranged from 3.1 to 9.4 ppm. The 99th percentile concentrations ranged from 2.4 to 4.7 ppm, and the 95th percentile concentrations ranged from less than 2.3 to 3.5 ppb. At each station, the highest concentrations were 1 to 3 times greater than the 99th percentile concentrations, and were also 1 to 3 times greater than the 95th percentile concentrations. In other words, the highest concentrations were up to 3 times higher than concentrations that were observed 99 and 95 percent of the time. The highest THC concentrations were not significantly larger than concentrations that were measured most of the time.

Median THC concentrations were comparable to average concentrations, indicating absence of significantly high concentrations, or a large number of very small concentrations.

Table 14. 1-hour concentrations of THC (ppm) for 2011

Station	Annual Average	1-Hour Maximum	Percentiles								
			1	5	10	25	50	75	90	95	99
industry stations:											
Millennium Mine (AMS 12)	2.46	9.1	2.0	2.0	2.1	2.2	2.3	2.5	3.0	3.5	4.7
Mildred Lake (AMS 2)	2.39	6.5	1.9	2.0	2.1	2.2	2.3	2.5	2.8	3.1	3.8
Barge Landing (AMS 9)	2.39	9.0	2.1	2.1	2.2	2.2	2.3	2.5	2.7	2.9	3.2
Lower Camp (AMS 11)	2.26	5.6	1.9	2.0	2.0	2.1	2.2	2.4	2.6	2.8	3.2
Albian Muskeg River (AMS 16)	2.26	6.9	1.8	1.8	1.9	2.0	2.2	2.4	2.7	2.9	3.8
Buffalo Viewpoint (AMS 4)	2.24	7.2	2.0	2.0	2.0	2.1	2.2	2.3	2.5	2.7	3.4
Mannix (AMS 5)	2.17	7.9	1.8	1.8	1.9	2.0	2.1	2.3	2.5	2.7	3.3
Syncrude UE1 (AMS 13)	2.17	8.1	1.8	1.9	1.9	2.0	2.1	2.3	2.5	2.7	3.2
CNRL Horizon (AMS 15)	2.15	9.4	1.8	1.9	1.9	2.0	2.1	2.2	2.4	2.6	3.3
community stations:											
Fort McKay (AMS 1)	2.20	5.4	1.8	1.9	1.9	2.0	2.2	2.3	2.5	2.7	3.0
Athabasca Valley (AMS 7)	2.12	3.8	1.8	1.9	1.9	1.9	2.1	2.2	2.4	2.4	2.7
Patricia McInnes (AMS 6)	2.10	3.3	1.9	1.9	2.0	2.0	2.1	2.1	2.3	2.4	2.7
Anzac (AMS 14)	2.10	3.1	1.9	2.0	2.0	2.0	2.1	2.2	2.2	2.3	2.4
air quality objective (ppm)	n/a	n/a									

Figure 9. Annual average and 1-hour percentile THC concentrations at industry and community stations.

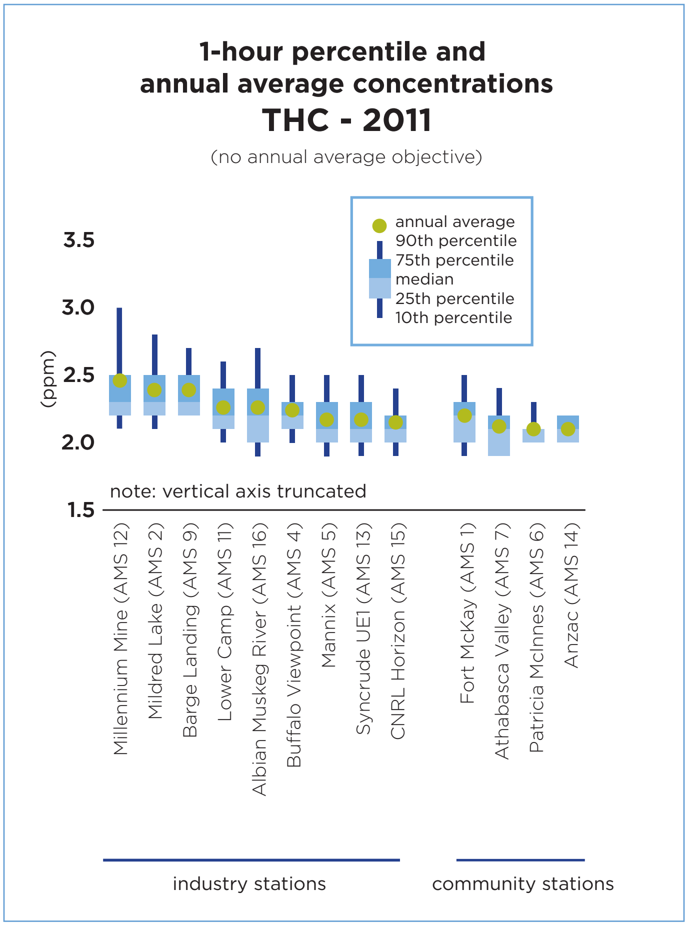
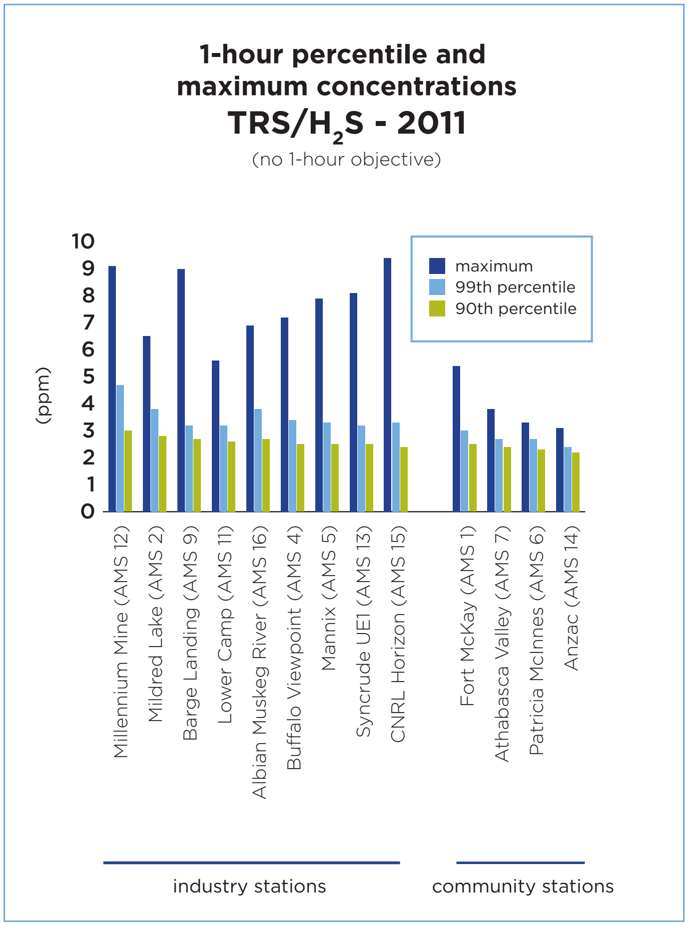


Figure 10. Highest 1-hour THC concentrations and the 99th and 90th percentiles at industry and community stations



INTEGRATED MONITORING NOTES– 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 60 VOC compounds and 22 reduced sulphur compounds (RSC).

Volatile organic compounds were measured for 1-day, 24-hour periods at 4 industry stations: Barge Landing (AMS 9), Millennium Mine (AMS 12), Syncrude UE1 (AMS 13), and CNRL Horizon (AMS 15); and at 4 community stations: Fort McKay (AMS 1), Patricia McInnes (AMS 6), Athabasca Valley (AMS 7), and Anzac (AMS 14). VOCs were measured every 12 days (approximately 30 possible sample days in the year) at all stations except Barge Landing (AMS 9), where they were measured every 6 days (60 possible sample days in the year).

In 2010 and 2011 for quality assurance purposes, duplicate samples and replicate analyses were introduced occasionally at selected sites and for selected samples. A duplicate sample is a second container collecting air at the same time as the routine container collects air. A replicate analysis is a second analysis of air from a sample container that has already been analyzed in routine analysis. When undertaken, duplicate sampling and replicate analysis practices create more than one set of results for a sampling day. Presented results are based sample days, and with results averaged for duplicate samples, and results from replicate analyses excluded.

Results from 3 samples in 2011 were excluded from the summary because at press time an ongoing investigation of suspected cyclohexane contamination was incomplete. Excluded sample results were from Patricia McInnes (AMS 6) and Athabasca Valley (AMS 7) on March 22nd, and from Syncrude UE-1 (AMS 13) on February 14th.

INTEGRATED MONITORING OBSERVATIONS IN 2011 - VOC

Summary tables are presented for compounds with the 10 highest concentrations at each station, and for the ten most frequently observed VOC compounds at each station.

At industry stations, the VOC compounds with the highest measured 24-hour concentrations were cyclohexane, with a maximum concentration of 520 ppb at Barge Landing (AMS 9) and 163 ppb at CNRL Horizon (AMS 15), isopentane with a maximum concentration of 78 ppb at CNRL Horizon (AMS 15), butane with a maximum concentration of 73 ppb at CNRL Horizon (AMS 15), and acetone with a maximum concentration of 43 ppb at Barge Landing (AMS 9). Corresponding average concentrations were 27, 16, 3, 4 and 3 ppb, respectively. Average concentrations from all samples at industry stations were much lower than maximum concentrations except when detected in only one or a few samples.

VOC compounds observed in every sample from at least one industry station included acetone, benzene and toluene.

At community stations, the VOC compound with the highest measured 24-hour concentrations was cyclohexane, with maximum concentrations of 121, 120, 71 and 59 ppb at Anzac (AMS 14), Patricia McInnes (AMS 6), Athabasca Valley (AMS 7) and Fort McKay (AMS 1), respectively.

Other VOC compounds with highest measured 24-hour concentrations were isopentane with a maximum concentration of 42 ppb and butane with a maximum concentration of 39 ppb at Athabasca Valley (AMS 7). Next highest concentrations were for acetone, with a maximum concentration of 19 ppb at Anzac (AMS 14).

Corresponding average concentrations of cyclohexane were 20, 22, 9, and 6 ppb.

Corresponding average concentrations for isopentane, butane and acetone were 2, 3 and 3 ppb.

The only VOC compound observed in all samples at any community stations was benzene at Anzac (AMS 14). VOC compounds observed in all but 2 samples at any station included acetone, benzene, butane, isobutene, isopentane, and toluene.

Table 15. The ten highest 24-hour concentrations of VOC compounds measured at each industry station in 2011.

station	compound	number of samples containing	fraction of samples containing (%)	maximum concentration (ppb)	average concentration in all samples (ppb)
industry stations:					
Barge Landing (AMS 9)	cyclohexane	24 / 58	41	519.8	26.77
	acetone	54 / 58	93	42.5	3.36
	3-methylhexane	13 / 58	22	20.9	1.73
	2,3-dimethylpentane	7 / 58	12	10.0	1.49
	cyclopentane	25 / 58	43	9.6	0.77
	pentane	36 / 58	62	9.3	1.06
	butane	46 / 58	79	8.4	0.86
	methylcyclohexane	35 / 58	60	8.1	0.34
	2-methylhexane	13 / 58	22	6.4	0.65
	acetaldehyde	2 / 58	3	5.2	3.19
Millennium Mine (AMS 12)	acetone	25 / 26	96	9.5	2.30
	cyclohexane	13 / 26	50	9.4	1.15
	beta pinene	1 / 26	4	2.9	2.90
	butane	23 / 26	88	2.9	0.81
	isopentane	23 / 26	88	2.2	0.35
	methyl ethyl ketone	6 / 26	23	1.0	0.43
	isobutane	19 / 26	73	1.0	0.33
	methylcyclohexane	18 / 26	69	0.9	0.15
	pentane	13 / 26	50	0.9	0.40
	heptane	13 / 26	50	0.7	0.17
Syncrude UE1 (AMS 13)	cyclohexane	13 / 27	48	39.8	3.98
	acetone	27 / 27	100	15.0	2.75
	beta pinene	8 / 27	30	12.5	2.00
	3-methylhexane	8 / 27	30	10.2	1.38
	butane	24 / 27	89	7.2	0.86
	2,3-dimethylpentane	6 / 27	22	5.7	0.98
	isopentane	23 / 27	85	5.3	0.53
	methylcyclohexane	14 / 27	52	5.1	0.48
	isobutane	24 / 27	89	4.8	0.54
	acetaldehyde	1 / 27	4	4.5	4.45
CNRL Horizon (AMS 15)	cyclohexane	13 / 30	43	162.7	15.94
	isopentane	27 / 30	90	78.2	3.36
	butane	27 / 30	90	73.3	3.61
	isobutane	18 / 30	60	32.5	2.97
	pentane	17 / 30	57	30.0	2.81
	acetone	29 / 30	97	16.3	6.58
	2-methylpentane	16 / 30	53	14.3	1.06
	acetaldehyde	1 / 30	3	14.0	13.95
	benzene	30 / 30	100	8.7	3.60
	3-methylpentane	16 / 30	53	7.4	0.61

Table 16. The ten most frequently observed VOC compounds at each industry station in 2011.

station	compound	number of samples containing	fraction of samples containing (%)	maximum concentration (ppb)	average concentration in all samples (ppb)
industry stations:					
Barge Landing (AMS 9)	benzene	55 / 58	95	1.7	0.27
	acetone	54 / 58	93	42.5	3.36
	toluene	52 / 58	90	4.4	0.38
	isopentane	48 / 58	83	2.6	0.64
	butane	46 / 58	79	8.4	0.86
	isobutane	44 / 58	76	2.8	0.39
	hexane	40 / 58	69	1.5	0.22
	pentane	36 / 58	62	9.3	1.06
	2-methylpentane	35 / 58	60	1.6	0.37
	methylcyclohexane	35 / 58	60	8.1	0.34
	m,p-xylene	35 / 58	60	1.3	0.19
Millennium Mine (AMS 12)	acetone	25 / 26	96	9.5	2.30
	toluene	25 / 26	96	0.5	0.16
	benzene	24 / 26	92	0.6	0.20
	butane	23 / 26	88	2.9	0.81
	isopentane	23 / 26	88	2.2	0.35
	isobutane	19 / 26	73	1.0	0.33
	methylcyclohexane	18 / 26	69	0.9	0.15
	2-methylpentane	18 / 26	69	0.4	0.13
	2,3-dimethylbutane	18 / 26	69	0.3	0.13
	2,2-dimethylbutane	17 / 26	65	0.3	0.12
Syncrude UE1 (AMS 13)	acetone	27 / 27	100	15.0	2.75
	benzene	27 / 27	100	1.5	0.24
	butane	24 / 27	89	7.2	0.86
	isobutane	24 / 27	89	4.8	0.54
	toluene	24 / 27	89	2.3	0.27
	isopentane	23 / 27	85	5.3	0.53
	2-methylpentane	17 / 27	63	1.1	0.24
	alpha pinene	17 / 27	63	0.7	0.17
	pentane	16 / 27	59	3.5	0.93
	m,p-xylene	16 / 27	59	0.7	0.14
CNRL Horizon (AMS 15)	benzene	30 / 30	100	8.7	3.60
	toluene	30 / 30	100	5.8	0.94
	acetone	29 / 30	97	16.3	6.58
	butane	27 / 30	90	73.3	3.61
	isopentane	27 / 30	90	78.2	3.36
	1-butene	24 / 30	80	2.3	0.62
	m,p-xylene	24 / 30	80	4.5	0.30
	alpha pinene	24 / 30	80	0.5	0.21
	methyl ethyl ketone	19 / 30	63	1.8	0.74
	isobutane	18 / 30	60	32.5	2.97

Table 17. The ten highest 24-hour concentrations of VOC compounds measured at each community station in 2011.

station	compound	number of samples containing	fraction of samples containing (%)	maximum concentration (ppb)	average concentration in all samples (ppb)
community stations:					
Fort McKay (AMS 1)	cyclohexane	13 / 28	46	58.9	6.14
	acetone	21 / 28	75	9.2	2.77
	beta pinene	7 / 28	25	7.0	1.51
	benzene	22 / 28	79	1.8	0.31
	1-butene	15 / 28	54	1.4	0.32
	butane	20 / 28	71	1.3	0.56
	isopentane	20 / 28	71	1.2	0.39
	methyl ethyl ketone	14 / 28	50	1.2	0.54
	isoprene	5 / 28	18	1.2	0.52
	pentane	16 / 28	57	1.1	0.54
Patricia McInnes (AMS 6)	cyclohexane	10 / 29	34	119.7	21.65
	toluene	27 / 29	93	16.3	0.92
	acetone	24 / 29	83	11.9	2.75
	pentane	16 / 29	55	2.9	0.67
	m,p-Xylene	23 / 29	79	2.7	0.23
	heptane	15 / 29	52	2.6	0.33
	butane	27 / 29	93	2.5	0.75
	octane	10 / 29	34	2.4	0.41
	methylcyclohexane	15 / 29	52	2.4	0.25
	benzene	28 / 29	97	2.4	0.32
Athabasca Valley (AMS 7)	cyclohexane	9 / 28	32	71.3	8.75
	isopentane	27 / 28	96	40.9	1.90
	butane	25 / 28	89	39.2	2.55
	isobutane	24 / 28	86	16.7	1.05
	pentane	11 / 28	39	14.0	1.67
	acetone	25 / 28	89	7.1	2.77
	2-methylpentane	19 / 28	68	6.4	0.45
	beta pinene	4 / 28	14	5.4	1.63
	acetaldehyde	1 / 28	4	4.7	4.72
	3-methylpentane	17 / 28	61	3.7	0.29
Anzac (AMS 14)	cyclohexane	9 / 28	32	120.5	20.11
	acetone	27 / 28	96	19.3	3.15
	beta pinene	6 / 28	21	10.4	3.09
	toluene	26 / 28	93	1.8	0.16
	pentane	13 / 28	46	1.4	0.53
	methyl ethyl ketone	13 / 28	46	1.0	0.41
	butane	24 / 28	86	1.0	0.50
	1-butene	12 / 28	43	0.9	0.24
	isoprene	10 / 28	36	0.7	0.29
	isopentane	21 / 28	75	0.6	0.22

Table 18. The ten most frequently observed VOC compounds at each community station in 2011.

station	compound	number of samples containing	fraction of samples containing (%)	maximum concentration (ppb)	average concentration in all samples (ppb)
community stations:					
Fort McKay (AMS 1)	toluene	26 / 28	93	1.1	0.26
	benzene	22 / 28	79	1.8	0.31
	acetone	21 / 28	75	9.2	2.77
	m,p-xylene	21 / 28	75	0.4	0.15
	butane	20 / 28	71	1.3	0.56
	isopentane	20 / 28	71	1.2	0.39
	isobutane	19 / 28	68	0.5	0.24
	2-methylpentane	18 / 28	64	0.9	0.19
	pentane	16 / 28	57	1.1	0.54
	hexane	16 / 28	57	0.5	0.18
	alpha pinene	16 / 28	57	0.5	0.16
	3-methylpentane	16 / 28	57	0.6	0.13
Patricia McInnes (AMS 6)	benzene	28 / 29	97	2.4	0.32
	toluene	27 / 29	93	16.3	0.92
	butane	27 / 29	93	2.5	0.75
	isopentane	27 / 29	93	1.0	0.36
	isobutane	27 / 29	93	0.7	0.31
	acetone	24 / 29	83	11.9	2.75
	m,p-xylene	23 / 29	79	2.7	0.23
	1-butene	17 / 29	59	1.6	0.29
	hexane	17 / 29	59	0.8	0.16
	2-methylpentane	17 / 29	59	0.5	0.15
Athabasca Valley (AMS 7)	isopentane	27 / 28	96	40.9	1.90
	toluene	27 / 28	96	2.4	0.35
	benzene	27 / 28	96	0.9	0.25
	acetone	25 / 28	89	7.1	2.77
	butane	25 / 28	89	39.2	2.55
	isobutane	24 / 28	86	16.7	1.05
	m,p-xylene	22 / 28	79	1.3	0.22
	2-methylpentane	19 / 28	68	6.4	0.45
	hexane	17 / 28	61	3.3	0.31
	3-methylpentane	17 / 28	61	3.7	0.29
Anzac (AMS 14)	benzene	28 / 28	100	0.5	0.21
	acetone	27 / 28	96	19.3	3.15
	toluene	26 / 28	93	1.8	0.16
	butane	24 / 28	86	1.0	0.50
	isopentane	21 / 28	75	0.6	0.22
	isobutane	20 / 28	71	0.6	0.21
	pentane	13 / 28	46	1.4	0.53
	methyl ethyl ketone	13 / 28	46	1.0	0.41
	1-butene	12 / 28	43	0.9	0.24
	hexane	12 / 28	43	0.2	0.09

INTEGRATED MONITORING NOTES– PAH

Polycyclic aromatic compounds (PAHs) are sampled by drawing air through a treated poly urethane foam filter using electronically controlled flow devices to control timing and flow. The foam is shipped to a laboratory, dissolved and analyzed using gas chromatography. Two filters (primary or front, and secondary or back) may be used in series to evaluate capture efficiency.

Polycyclic aromatic compounds were sampled approximately once per month for a sampling period of approximately 10 days at 4 community stations: Fort McKay (AMS 1), Patricia McInnes (AMS 6), Athabasca Valley (AMS 7), and Anzac (AMS 14). Samples were analyzed for 23 compounds. During the year there were 13 or 14 sets of results from each station. The results summary includes results from the primary (front) filter and excludes results from the secondary (back) filer. There were no duplicate samples taken.

The current PAH sampler, PUF with glass fiber 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 2011 - PAH

Phenanthrene was the highest measured compound and was also measured at all sites. The highest concentration of 33.4 ng/m^3 was observed at Fort McKay (AMS 1). The three highest measured concentrations at any station included the compounds of fluorene, pyrene, acenaphthene, acenaphthylene and fluoranthene.

Fluorene was within the three highest observed concentrations at 3 stations, with the highest concentration of 43.8 ng/m^3 at Fort McKay (AMS 1). Pyrene was also within the three highest observed concentrations at 2 stations, with the highest concentration of 2.4 ng/m^3 at Anzac (AMS 14).

Acenaphthene, acenaphthylene and fluoranthene were observed in the three highest concentrations at any station once only. An acenaphthene concentration of 4.6 ng/m^3 was measured at Fort McKay (AMS 1). An acenaphthylene concentration of 2.7 ng/m^3 was measured at Athabasca Valley (AMS 7) A fluoranthene concentration of 1.6 ng/m^3 was measured at Patricia McInnes (AMS 6).

An acenaphthylene concentration of 4.2 ng/m^3 was measured at Fort McKay (AMS 1), but it was the 4th highest PAH at that station. A fluoranthene concentration of 2.4 ng/m^3 was measured at Fort McKay, AMS 1, but it was the 6th highest PAH at that station.

Table 19. The ten highest concentrations of PAH compounds measured at each station in 2011.

station	compound	number of samples containing	fraction of samples containing (%)	maximum concentration (ng/m³)	average concentration in all samples (ng/m³)
community stations:					
Fort McKay (AMS 1)	phenanthrene	14 / 14	100	33.4	5.88
	fluorene	14 / 14	100	4.8	1.22
	acenaphthene	14 / 14	100	4.6	0.46
	acenaphthylene	14 / 14	100	4.2	0.75
	anthracene	14 / 14	100	2.7	0.57
	fluoranthene	14 / 14	100	2.4	1.10
	pyrene	14 / 14	100	2.0	0.95
	7,12-dimethylbenz(a)anthracene	14 / 14	100	1.7	0.42
	benzo(c)phenanthrene	14 / 14	100	1.2	0.18
	acridine	14 / 14	100	1.0	0.30
Patricia McInnes (AMS 6)	phenanthrene	14 / 14	100	9.0	2.47
	fluoranthene	14 / 14	100	1.6	0.68
	pyrene	14 / 14	100	1.3	0.58
	fluorene	14 / 14	100	1.3	0.55
	acenaphthylene	14 / 14	100	4.0	0.51
	7,12-dimethylbenz(a)anthracene	14 / 14	100	1.4	0.28
	anthracene	14 / 14	100	0.8	0.25
	acridine	14 / 14	100	1.1	0.19
	naphthalene	14 / 14	100	0.6	0.15
	benz(a)anthracene	14 / 14	100	0.3	0.09
Athabasca Valley (AMS 7)	phenanthrene	13 / 13	100	7.8	3.01
	fluorene	13 / 13	100	3.1	0.80
	acenaphthylene	13 / 13	100	2.7	0.34
	7,12-dimethylbenz(a)anthracene	13 / 13	100	2.2	0.31
	pyrene	13 / 13	100	1.9	0.79
	fluoranthene	13 / 13	100	1.6	0.80
	acridine	13 / 13	100	1.0	0.26
	naphthalene	13 / 13	100	0.6	0.15
	anthracene	13 / 13	100	0.6	0.31
	chrysene	13 / 13	100	0.4	0.10
Anzac (AMS 14)	phenanthrene	13 / 13	100	15.5	6.06
	fluorene	13 / 13	100	4.4	1.61
	pyrene	13 / 13	100	2.4	0.62
	anthracene	13 / 13	100	1.5	0.56
	fluoranthene	13 / 13	100	1.5	0.76
	acenaphthene	13 / 13	100	1.1	0.32
	acenaphthylene	13 / 13	100	1.1	0.23
	7,12-dimethylbenz(a)anthracene	13 / 13	100	0.8	0.19
	acridine	13 / 13	100	0.7	0.19
	naphthalene	13 / 13	100	0.4	0.13

4.3.6 PARTICULATE MATTER ($PM_{2.5}$)

CHARACTERISTICS

Ambient particulate matter (PM) consists of a mixture of atmospheric particles of varying size and chemical composition. Measurements of the PM_{10} (aerosols and particles with aerodynamic diameter smaller than 10 micrometres, or microns) include the $PM_{2.5}$ fraction, which are particles that are less than 2.5 micrometres in diameter.

SOURCES

Sources of PM_{10} include windblown soil, road dust, and industrial activities. $PM_{2.5}$ are formed from gases released to the atmosphere by combustion processes, from motor vehicles, power generating plants, gas processing plants, compressor stations, household heating, and forest fires.

ALBERTA OBJECTIVES

The objective for ambient air $PM_{2.5}$ concentration is 30 $\mu g/m^3$ for a 24-hour averaging time, as outlined by the provincial and federal governments.

CONTINUOUS MONITORING NOTES

Continuous monitoring of $PM_{2.5}$ is performed using a tapered element oscillating microbalance (TEOM). Air is passed through a cyclone to exclude particles larger than 2.5 microns, and then drawn through a filter on a spring. Concentrations of $PM_{2.5}$ are indicated by response of the spring to deposits onto the filter.

CONTINUOUS MONITORING OBSERVATIONS IN 2011

Annual average $PM_{2.5}$ concentrations in 2011 at industry stations ranged from 9.22 $\mu g/m^3$ at Syncrude UE-1 (AMS 13) to 12.81 $\mu g/m^3$ at Millenium Mine (AMS 12). At community stations annual average $PM_{2.5}$ concentrations ranged from 3.18 $\mu g/m^3$ at Fort Chipewyan (AMS 8) to 10.29 $\mu g/m^3$ at both Fort McKay (AMS 1) and Athabasca Valley (AMS 7).

The highest 1-hour $PM_{2.5}$ concentrations in 2011 at industry stations ranged from 437.2 $\mu g/m^3$ at CNRL Horizon (AMS 15) to in excess of 450 $\mu g/m^3$ at all other industry stations. 450 $\mu g/m^3$ is the TEOM analyzer's operating range upper limit. At community stations, the highest 1-hour concentrations ranged from 222.9 $\mu g/m^3$ at Anzac (AMS 14), to in excess of 450 $\mu g/m^3$at Fort McKay (AMS 1), Athabasca Valley (AMS 7) and Patricia McInnes (AMS 6). Large scale and persistent forest fires throughout the region in May and June 2011 contributed to the highest 1-hour readings at most stations. Smoke from the fires also contributed to the abnormal situation where highest ambient readings exceeded the measurement range of the instrument.

The 99th percentile $PM_{2.5}$ concentrations at each station ranged from 19.0 to 176.4 $\mu g/m^3$. The 95th percentile $PM_{2.5}$ concentrations at each station ranged from 7.2 to 30.3 $\mu g/m^3$. The highest concentrations at each station were greater than the 99th percentile concentrations by factors ranging from 2 to 4, were greater than the 95th percentile concentrations by factors ranging from 14 to 56. In other words, the highest 5 percent of concentrations were 14 to 56 times greater than concentrations observed 95 percent of the time. Median values at each station were 2 to 3 times less than annual average values, indicating that annual average values were largely influenced by the high concentrations.

The Alberta 24-hour ambient air quality objective for $PM_{2.5}$ of 30 $\mu g/m^3$ was exceeded 97 times in 2011. Of these, 94 exceedences occurred in the month of May and June, coincident with the widespread forest fires. The objective was exceeded 49 times at community stations and 48 times at industry stations. At industry stations there were 9 exceedences at Syncrude UE1 (AMS 13), 13 at CNRL Horizon (AMS 15), 10 at Albian Muskeg River (AMS 16), and 16 at Millennium Mine (AMS 12). At community stations there were 12 at exceedences at Fort McKay (AMS 1), 17 at Athabasca Valley (AMS 7), 3 at Fort Chipewyan (AMS 8), 11 at Patricia McInnes (AMS 6), and 6 at Anzac (AMS 14). All but 3 exceedences occurred in May and June, months associated with the widespread and persistent forest fire activity in the region.

Table 20. 1-hour concentrations of $PM_{2.5}$ (µg/m³) for 2011

Station	Annual Average	1-Hour Maximum*	Percentiles 1	5	10	25	50	75	90	95	99
industry stations:											
Millennium Mine (AMS 12)	12.81	451.4	1.8	3.4	4.2	5.8	8.4	12.8	20.5	30.3	110.9
CNRL Horizon (AMS 15)	11.89	437.2	0.6	2.0	2.7	3.9	5.6	9.0	16.1	28.8	173.4
Albian Muskeg River (AMS 16)	10.03	449.8	0.0	0.1	0.8	2.0	4.1	7.5	14.1	23.8	158.0
Syncrude UE1 (AMS 13)	9.22	450.7	0.0	0.0	0.3	1.4	3.0	5.9	11.3	20.4	176.4
community stations:											
Fort McKay (AMS 1)	10.29	449.8	0.0	0.4	0.8	1.8	3.7	7.6	14.2	25.5	171.7
Athabasca Valley (AMS 7)	10.27	448.6	0.4	1.5	2.2	3.9	6.3	9.7	15.3	23.0	111.6
Patricia McInnes (AMS 6)	6.92	449.4	0.0	0.0	0.0	1.0	2.6	5.2	9.3	17.1	133.9
Anzac (AMS 14)	5.18	222.9	0.0	0.0	0.3	1.2	2.7	5.2	9.8	15.4	51.7
Fort Chipewyan (AMS 8)	3.18	406.5	0.0	0.0	0.0	0.6	1.6	2.8	5.0	7.2	19.0
air quality objective (µg/m³)	n/a	n/a									

* The instrument operating range is 450 µg/m³

Figure 11. Annual average and 1-hour percentile $PM_{2.5}$ concentrations at industry and community stations.

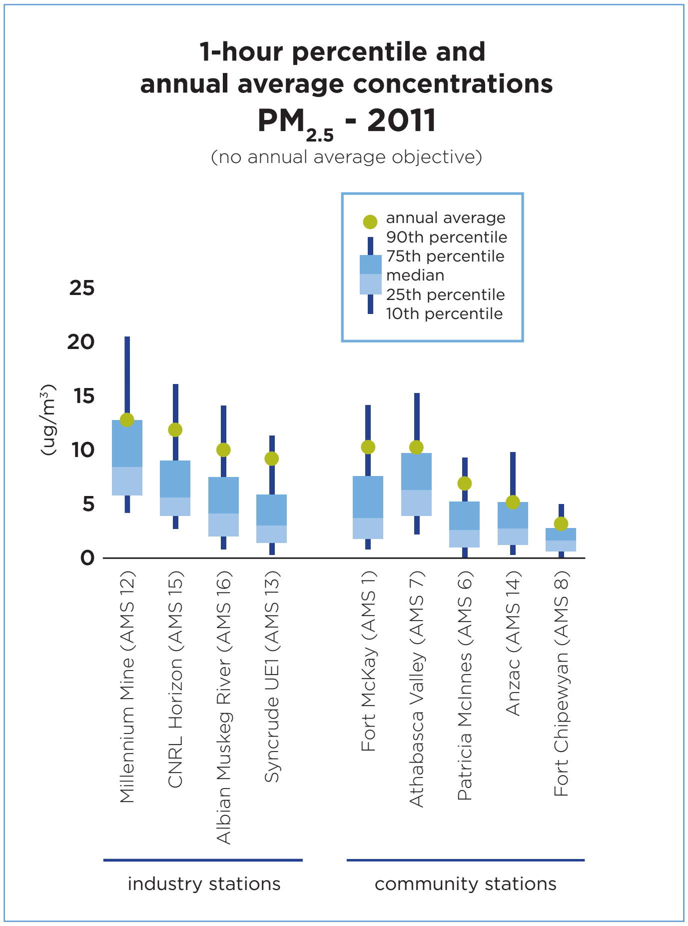


Figure 12. Highest 1-hour $PM_{2.5}$ concentrations and the 99th and 90th percentiles at industry and community stations.

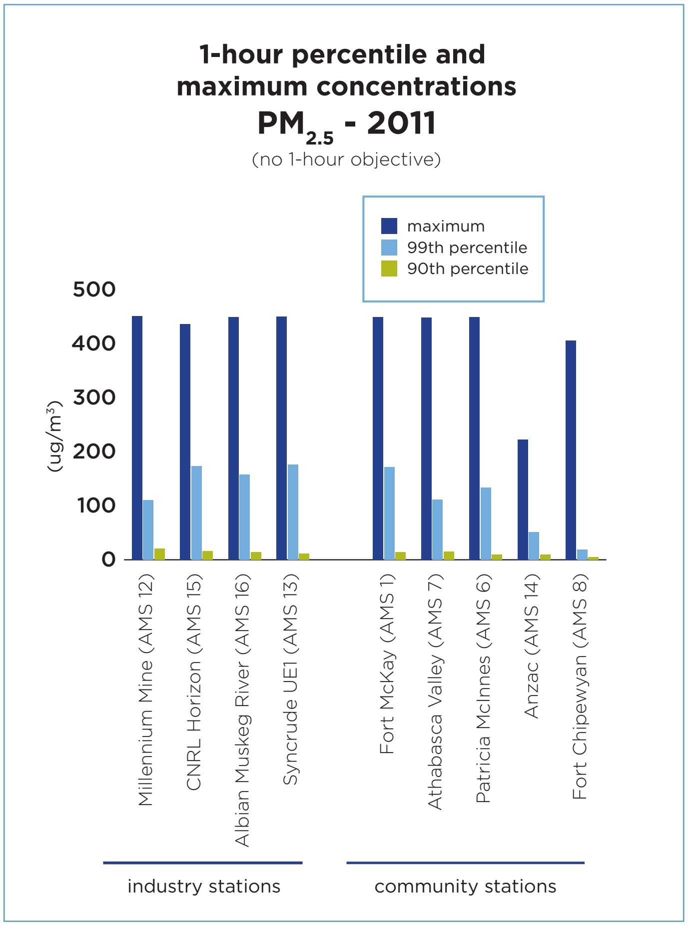


Table 21. 24-hour concentrations of $PM_{2.5}$ (µg/m³) for 2011

station	24-hour maximum	percentiles									
		1	5	10	25	50	75	90	95	98	99
industry stations:											
Syncrude UE1 (AMS 13)	221.4	0.5	1.0	1.3	2.2	3.4	5.7	9.2	17.0	49.2	127.9
CNRL Horizon (AMS 15)	190.6	2.6	3.0	3.6	4.8	6.2	9.5	13.5	18.0	61.0	121.0
Albian Muskeg River (AMS 16)	160.5	0.4	1.3	1.8	2.8	4.6	7.4	11.9	18.2	51.8	89.8
Millennium Mine (AMS 12)	120.3	3.6	4.9	5.9	7.1	9.2	12.4	18.4	26.0	70.0	94.6
community stations:											
Fort McKay (AMS 1)	164.4	0.5	1.2	1.6	2.6	4.4	7.8	12.5	20.8	59.6	122.1
Athabasca Valley (AMS 7)	137.1	1.9	2.8	3.8	5.0	6.8	9.3	12.9	29.5	79.9	91.8
Fort Chipewyan (AMS 8)	132.0	0.2	0.4	0.5	1.0	1.7	2.6	4.5	6.6	12.8	29.2
Patricia McInnes (AMS 6)	118.9	0.2	0.7	0.9	1.8	3.0	4.8	8.1	14.1	64.8	82.2
Anzac (AMS 14)	79.6	0.3	0.9	1.2	1.9	3.0	5.3	8.4	14.9	29.2	46.9
air quality objective (µg/m³)	30										

Figure 13. 24-hour percentile $PM_{2.5}$ concentrations at industry and community stations.

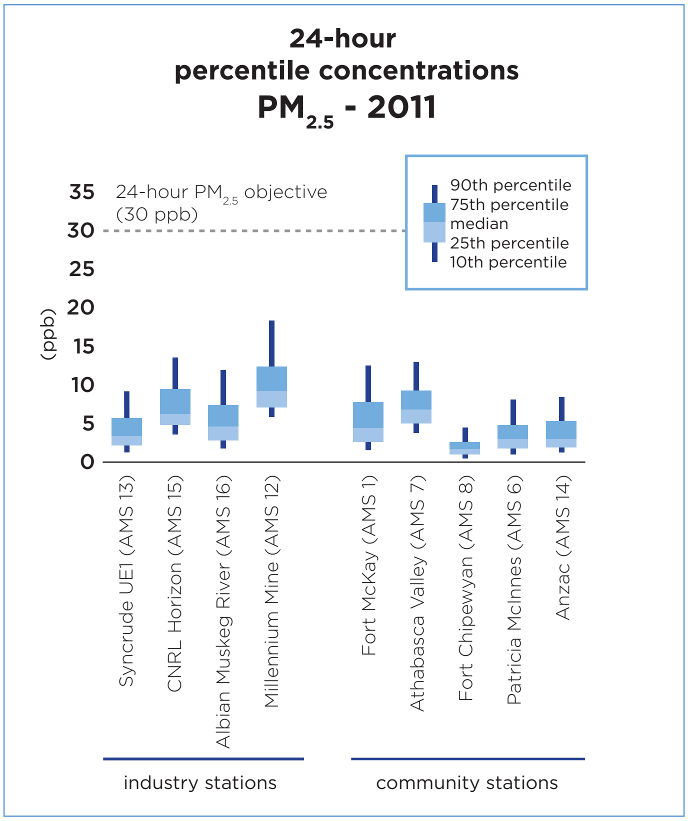
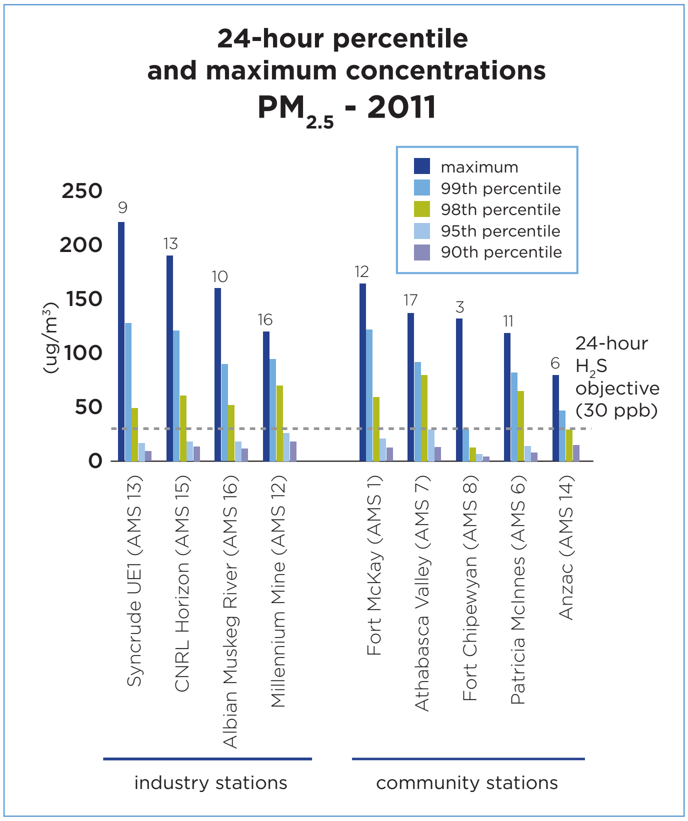


Figure 14. Highest 24-hour $PM_{2.5}$ concentrations and the 99th, 95th and 90th percentiles at industry and community stations. The number of exceedences of the 24-hour $PM_{2.5}$ air quality objective is indicated.



CONTINUOUS MONITORING TRENDS IN RECENT YEARS

At the start of the WBEA monitoring program in 1997, $PM_{2.5}$ was measured at 3 community stations only. Measurements of $PM_{2.5}$ commenced at the community station of Fort Chipewyan (AMS 8) and at industry stations in 2000. The summaries of results at original stations contain results for the 3 community stations only.

ORIGINAL STATIONS

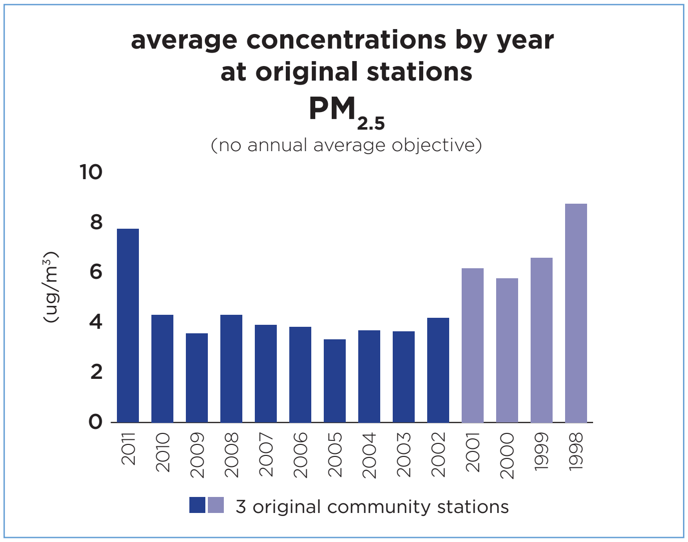
The average of all $PM_{2.5}$ concentrations observed at all of the 3 original community stations for the year 2011 was 7.8 µg/m³. This value was the highest recorded since 1998, and generally about twice the values of recent years. The average of all $PM_{2.5}$ concentrations in 2011 was influenced by abnormally widespread and persistent forest fires throughout the area in May and June.

Average concentrations of $PM_{2.5}$ at the original stations in the 9 years preceeding 2011 were similar with a 9-year average of 3.9 µg/m³. Concentrations in the first four years of the monitoring period were much higher, ranging from 5.8 to 8.8 in 1998 to 2001. In 2001-2002 there was a change in instrument operating parameters to be consistent with protocols of Alberta Environment.

Table 22. Average $PM_{2.5}$ concentrations (µg/m³) at the 3 stations measuring $PM_{2.5}$ since startup of the WBEA air monitoring network.

	station group		
year	all	industry	community
2011	7.8	.	7.8
2010	4.3	.	4.3
2009	3.6	.	3.6
2008	4.3	.	4.3
2007	3.9	.	3.9
2006	3.8	.	3.8
2005	3.3	.	3.3
2004	3.7	.	3.7
2003	3.6	.	3.6
2002	4.2	.	4.2
2001	6.2	.	6.2
2000	5.8	.	5.8
1999	6.6	.	6.6
1998	8.8	.	8.8

Figure 15. Average $PM_{2.5}$ concentrations (µg/m³) at the 3 stations measuring $PM_{2.5}$ since startup of the WBEA air monitoring network.



ALL STATIONS

The annual average $PM_{2.5}$ concentrations in the last 14 years at the 5 industry stations ranged from 2.7 µg/m³ at Syncrude UE-1 (AMS 13) in 2002, to 15.1 µg/m³ at Millenium Mine (AMS 12) in 2007. At community stations, annual average $PM_{2.5}$ concentrations ranged from 2.3 µg/m³ at Fort Chipewyan (AMS 8) in 2007 and 2009, to 10.3 µg/m³ at Fort McKay (AMS 1) and Athabasca Valley (AMS 7) in 2011. Average concentrations at all industry stations and most community stations in 2011 were greater than average concentrations in previous years. The high concentrations in 2011 were due to widespread, persistent forest fires throughout the region.

Table 23. Annual average $PM_{2.5}$ concentrations (µg/m³) since 1998 at all stations, grouped by industry and community stations, and ordered by the highest annual average concentration.

	year														period		
station	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	highest	average	lowest
industry stations:																	
Millennium Mine (AMS 12)	12.8	9.8	8.3	7.8	15.1	8.1	4.7	4.7	2.8	4.3	5.1	.	.	.	15.1	7.6	2.8
CNRL Horizon (AMS 15)	11.9	7.5	5.7	7.1	.	.	.	.	.	.	.	.	.	.	11.9	8.1	5.7
** Albian Muskeg River(AMS 16)	10.0	9.2	7.2	.	.	.	.	.	.	.	.	.	.	.	10.0	8.8	7.2
Syncrude UE1 (AMS 13)	9.2	4.8	3.8	4.2	3.9	4.0	3.4	3.2	3.6	2.7	.	.	.	.	9.2	4.3	2.7
** Albian mine site (AMS 10)	.	.	8.7	6.9	5.3	5.4	4.7	4.8	4.5	5.0	7.3	7.2	.	.	8.7	6.0	4.5
community stations:																	
Fort McKay (AMS 1)	10.3	4.7	4.0	5.0	4.2	4.3	4.1	4.2	5.0	5.0	6.6	6.3	5.9	8.5	10.3	5.6	4.0
Athabasca Valley (AMS 7)	10.3	4.7	4.2	5.6	5.2	4.5	3.5	3.8	3.8	4.5	6.9	6.3	7.3	9.2	10.3	5.7	3.5
Patricia McInnes (AMS 6)	6.9	4.2	3.7	4.1	3.9	4.0	3.2	4.4	3.4	4.8	6.8	6.4	6.6	8.6	8.6	5.1	3.2
Anzac (AMS 14)	5.2	3.8	3.3	3.5	5.1	7.9	.	.	.	.	.	.	.	.	7.9	4.8	3.3
Fort Chipewyan (AMS 8)	3.2	3.7	2.3	2.6	2.3	2.6	2.4	2.4	2.4	2.4	4.4	4.0	.	.	4.4	2.9	2.3

no annual average air quality objective for $PM_{2.5}$

** The Albian station was relocated 4 km southwest of its original location in February 2009 and renamed from AMS 10 to AMS 16

4.3.7 Ozone (O_3)

CHARACTERISTICS

At low concentrations, ozone in air affects organic materials such as latex, plastics, animal lung tissue and sensitive plants. Ozone is a powerful oxidizing agent facilitating many atmospheric reactions with most metals, nitric oxide, ammonia, sulfides, carbon and hydrogen sulphide.

SOURCES

Unlike other pollutants, ozone is also a natural component of the atmosphere with greater concentrations at higher altitudes. Ozone is also produced in the atmosphere through a series of complex chemical reactions, some of which involve other emitted substances. Ozone concentrations are influenced largely by presence of nitrogen oxides and reactive hydrocarbons, and also by strong sunlight and warmer temperatures.

ALBERTA OBJECTIVES

The Alberta air quality objective for ozone is:

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

CONTINUOUS MONITORING NOTES

Continuous monitoring of O_3 is made with electronic analyzers using ultraviolet photometry. Concentrations of O_3 are indicated by reduction in intensity of wavelength specific light due to absorption by O_3 molecules.

CONTINUOUS MONITORING OBSERVATIONS IN 2011

The annual average O_3 concentration in 2011 at Syncrude UE-1 (AMS 13), the only industry station measuring O_3, was 20.36 ppb. At community stations annual average O_3 concentrations ranged from 19.59 ppb at Athabasca Valley (AMS 7) to 28.62 ppb at Fort Chipewyan (AMS 8).

The highest 1-hour O_3 concentration in 2011 at the Syncrude UE-1 (AMS13) industry station was 90.6 ppb. At community stations, the highest 1-hour concentrations ranged from 76.8 Athabasca Valley (AMS 7), to 88.8 ppb at Fort McKay (AMS 1).

The 99th percentile O_3 concentrations ranged from 51.9 to 67.0 ppb. The 99th percentile concentrations were two thirds to three quarters of the highest concentrations which ranged from 76.8 to 90.6 ppb. Median and average concentrations were comparable. These observations indicate the absence of significantly large concentrations, and the absence of a large number of very small concentrations.

The Alberta one-hour ambient air quality objective for O_3 of 82 ppb was exceeded 15 times at WBEA monitoring stations in 2011. All exceedences occurred in the month of May, a month associated with abnormal widespread and persistent forest fires in the region. In addition, highest concentrations of O_3 have typically been observed in the late spring.

Table 24. 1-hour concentrations of O_3 (ppb) for 2011

Station	Annual Average	1-Hour Maximum	Percentiles 1	5	10	25	50	75	90	95	99
industry stations:											
Syncrude UE1 (AMS 13)	20.36	90.6	0.4	0.8	1.7	7.3	18.9	30.3	40.4	47.7	62.7
community stations:											
Fort Chipewyan (AMS 8)	28.62	83.5	10.4	14.5	17.4	22.6	28.3	34.0	40.0	43.6	51.9
Anzac (AMS 14)	27.81	78.9	2.0	8.3	12.2	19.4	27.3	35.4	44.4	50.2	58.5
Patricia McInnes (AMS 6)	23.48	77.3	0.6	3.5	7.4	14.9	23.3	31.3	38.4	43.8	57.5
Fort McKay (AMS 1)	22.13	88.8	0.4	1.1	3.1	10.8	21.2	31.5	41.1	48.1	67.0
Athabasca Valley (AMS 7)	19.59	76.8	0.3	1.4	2.8	8.4	18.0	28.5	38.5	44.5	55.4
air quality objective (ppb)	n/a	82									

Figure 16. Annual average and 1-hour percentile O_3 concentrations at industry and community stations.

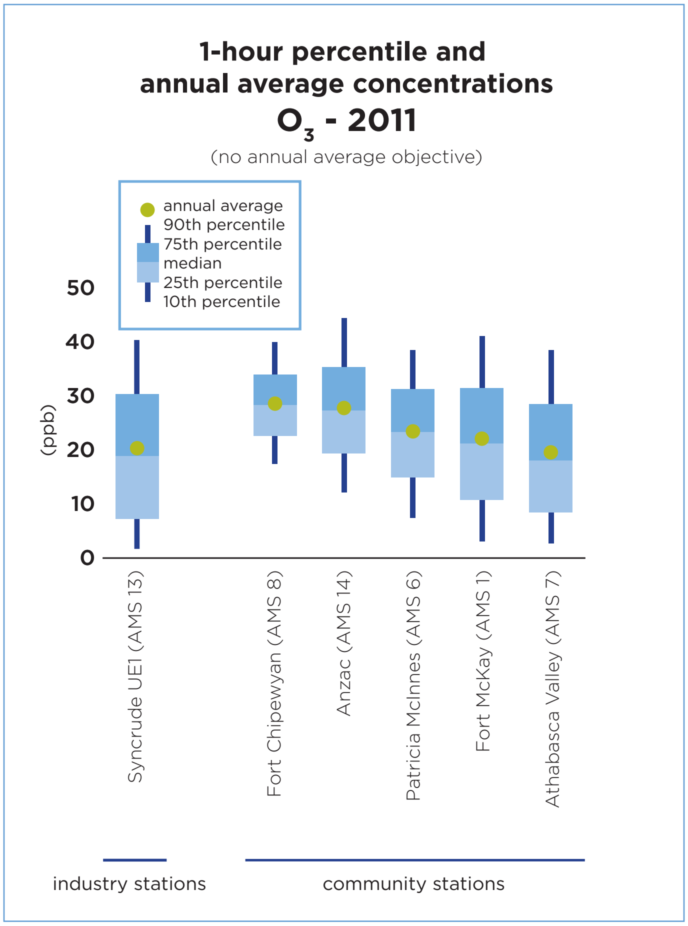
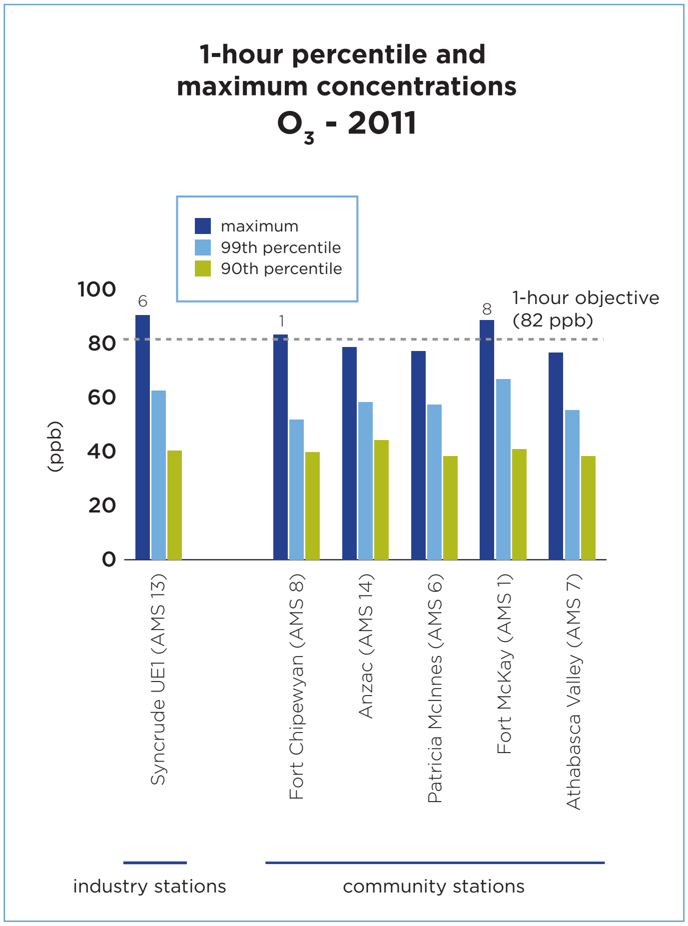


Figure 17. Highest 1-hour O_3 concentrations and the 99th and 90th percentiles at industry and community stations. The number of exceedences of the 1-hour O_3 air quality objective is indicated.



CONTINUOUS MONITORING TRENDS IN RECENT YEARS

At the start of the WBEA monitoring program in 1997, O_3 was measured at 4 community stations only. Measurements of O_3 commenced at one industrial station in 2002. As a result, the summary of results at original stations contains results for community stations only.

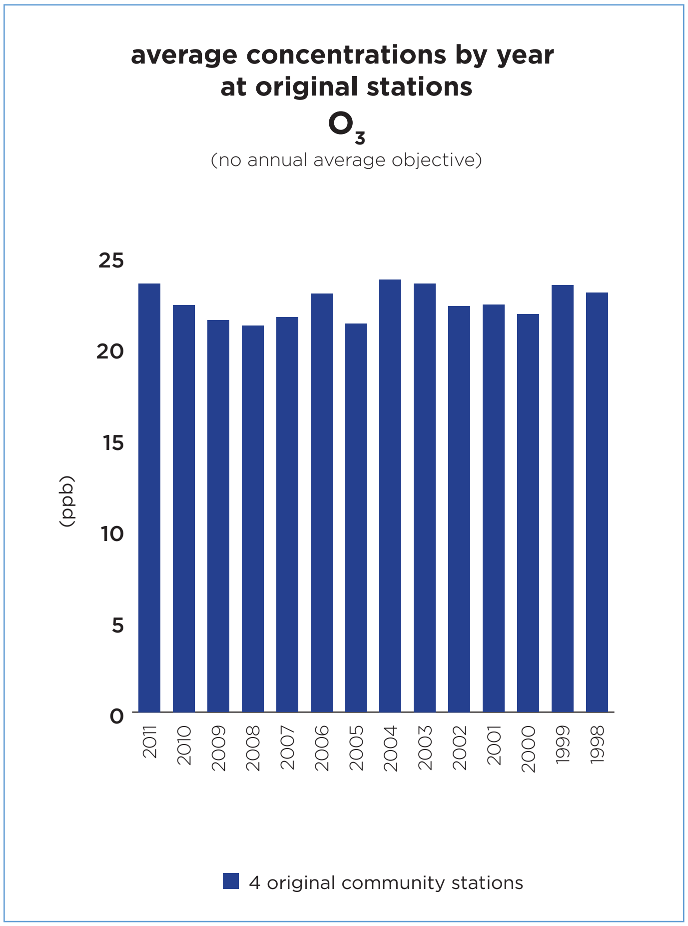
ORIGINAL STATIONS

The average of all O_3 concentrations observed at all of the 4 original community stations for the year 2011 was 23.5 ppb. This value was within the range of 21.2 to 23.7 ppb observed over the 14-year period. Average O_3 concentrations in the last 2 years have been slightly higher than average concentrations in the preceeding 3 years, but comparable to the average of all concentrations observed in 1998 and 1999, and from 2003 to 2004.

Table 25. Average O_3 concentrations (ppb) at the 4 community stations measuring O_3 since startup of the WBEA air monitoring network.

	station group		
year	all	industry	community
2011	23.5	n/a	23.5
2010	22.3	n/a	22.3
2009	21.5	n/a	21.5
2008	21.2	n/a	21.2
2007	21.6	n/a	21.6
2006	22.9	n/a	22.9
2005	21.3	n/a	21.3
2004	23.7	n/a	23.7
2003	23.5	n/a	23.5
2002	22.3	n/a	22.3
2001	22.3	n/a	22.3
2000	21.8	n/a	21.8
1999	23.4	n/a	23.4
1998	23.0	n/a	23.0

Figure 18. Average O_3 concentrations (ppb) at the 4 community stations measuring O_3 since startup of the WBEA air monitoring network.



ALL STATIONS

The annual average O_3 concentrations at the single industry station, Syncrude UE-1 (AMS 13), ranged from 13.9 in 2002 to 21.1 ppb in 2003. At community stations annual average O_3 concentrations ranged from 17.1 ppb at Athabasca Valley (AMS7) in 2000 to 30.0 ppb at Fort Chipewyan (AMS 8) in 2004. Annual average O_3 concentrations at the single industry station were at least 8 ppb less in each year than the highest annual average concentration at any of the 5 community stations. The average concentration in 2011 was the highest on record at only one station, Anzac (AMS 14), which also has the shortest period of record.

Table 26. Annual average O_3 concentrations (ppb) since 1998 at all stations, grouped by industry and community stations, and ordered by the highest annual average concentration.

	year														period		
station	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	highest	average	lowest
industry stations:																	
Syncrude UE1 (AMS 13)	20.4	18.7	18.3	17.3	19.1	19.2	18.4	20.8	21.1	13.9	.	.	.	.	21.1	18.7	13.9
community stations:																	
Fort Chipewyan (AMS 8)	28.6	27.4	25.3	26.9	27.0	28.3	26.3	30.0	29.5	28.1	28.9	27.5	27.1	23.7	30.0	27.5	23.7
Anzac (AMS 14)	27.8	25.9	27.0	25.7	23.3	24.9	.	.	.	.	.	.	.	.	27.8	25.8	23.3
Patricia McInnes (AMS 6)	23.5	22.9	22.5	19.5	20.2	22.2	20.0	22.1	22.6	22.3	21.7	22.9	25.0	24.8	25.0	22.3	19.5
Fort McKay (AMS 1)	22.1	20.3	19.9	19.9	20.9	21.2	20.0	22.4	22.6	19.5	20.7	19.7	21.0	22.8	22.8	20.9	19.5
Athabasca Valley (AMS 7)	19.6	17.8	18.1	18.3	18.7	20.2	18.9	20.4	19.3	19.2	18.0	17.1	20.5	20.8	20.8	19.1	17.1

no annual average air quality objective for O_3

4.3.8 Nitrogen Dioxide (NO_2)

CHARACTERISTICS

Nitrogen dioxide (NO_2) is a reddish-brown gas with a pungent, irritating odour.

Oxides of nitrogen, mostly in the form of nitrogen oxide, NO, and nitrogen dioxide, NO_2, are produced by the combustion of fossil fuels. Nitrogen oxide is the predominant species emitted by combustion sources and is rapidly converted to nitrogen dioxide in the atmosphere. NO_2 is the major component of nitrogen oxides in the ambient atmosphere.

Nitrogen dioxide plays a major role in atmospheric photochemical reactions and ground level ozone formation and destruction.

ALBERTA OBJECTIVES

Alberta Objectives are based on the prevention of human health effects. They are the same as Environment Canada's maximum desirable ambient air quality objectives. The Alberta objectives for nitrogen dioxide (issued April 2011) are:

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

CONTINUOUS MONITORING NOTES

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, is 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 the concentrations of NO and NO_x, the analyzer calculates and outputs the concentration of NO_2.

CONTINUOUS MONITORING OBSERVATIONS IN 2011

Annual average NO_2 concentrations in 2011 at industry stations ranged from 4.90 ppb at CNRL Horizon (AMS 15) to 15.18 ppb at Millenium Mine (AMS 12). Annual average concentrations at community stations ranged from 1.14 ppb at Fort Chipewyan (AMS 8) to 11.27 ppb at Athabasca Valley (AMS 7). The highest annual average concentration of 15.18 ppb was about two thirds the Alberta annual average air quality objective of 24 ppb.

The highest 1-hour NO_2 concentrations at industry stations in 2011 ranged from 52.4 ppb at CNRL Horizon (AMS 15) to 153.9 ppb at Millenium Mine (AMS 12). At community stations, the highest 1-hour concentrations ranged from 42.4 ppb at Fort Chipewyan (AMS 8) to 66.3 ppb at Anzac (AMS 14). The highest 1-hour average concentration of 154 ppb was comparable to but slightly less than the Alberta annual 1-hour average air quality objective of 159 ppb.

The highest 1-hour NO_2 concentrations at each station in 2011 ranged from 42.4 to 153.9 ppb. The 99th percentile NO_2 concentrations ranged from 13.0 to 49.8 ppb. At each station 99th percentile concentrations were generally one to two thirds less than the highest concentrations. Thus values of the highest concentrations were somewhat but not significantly greater than highest concentrations measured 99 percent, or most of the time.

The Alberta one-hour ambient air quality objective for NO_2 of 159 ppb was not exceeded at any station in 2011. Neither was the Alberta annual average ambient air quality objective for NO_2 of 24 ppb exceeded at any station in 2011.

Table 27. 1-hour concentrations of NO_2 (ppb) for 2011

Station	Annual Average	1-Hour Maximum	Percentiles 1	5	10	25	50	75	90	95	99
industry stations:											
Millennium Mine (AMS 12)	15.18	153.9	0.3	1.0	1.7	4.7	12.5	23.1	32.2	38.0	49.8
Albian Muskeg River (AMS 16)	12.19	79.2	0.2	0.6	1.1	3.2	9.6	19.1	27.2	31.8	41.3
* Conoco Phillips Surmont (AMS 101)	6.69	69.1	0.3	0.6	0.9	1.6	3.5	8.5	16.4	23.3	37.0
Syncrude UE1 (AMS 13)	6.27	56.3	0.0	0.1	0.3	0.7	3.2	9.4	17.3	22.3	31.6
CNRL Horizon (AMS 15)	4.90	52.4	0.0	0.1	0.2	0.5	1.7	5.9	14.6	22.5	32.8
community stations:											
Athabasca Valley (AMS 7)	11.27	64.5	0.7	1.5	2.2	4.6	8.9	15.7	24.0	29.3	38.7
Fort McKay (AMS 1)	6.61	51.3	0.0	0.1	0.2	0.8	3.0	9.8	18.7	24.5	34.4
Patricia McInnes (AMS 6)	6.13	44.6	0.0	0.2	0.4	1.3	3.7	8.2	16.2	21.8	29.8
Anzac (AMS 14)	2.87	66.3	0.0	0.1	0.3	0.6	1.5	3.5	7.1	10.5	20.2
Fort Chipewyan (AMS 8)	1.14	42.4	0.0	0.1	0.1	0.2	0.3	0.9	2.8	5.7	13.0
air quality objective (ppb)	24	159									

* Monitoring at Conoco Phillips Surmont occurred in the last 3 months of 2011 using the portable monitoring station

Figure 19. Annual average and 1-hour percentile NO_2 concentrations at industry and community stations.

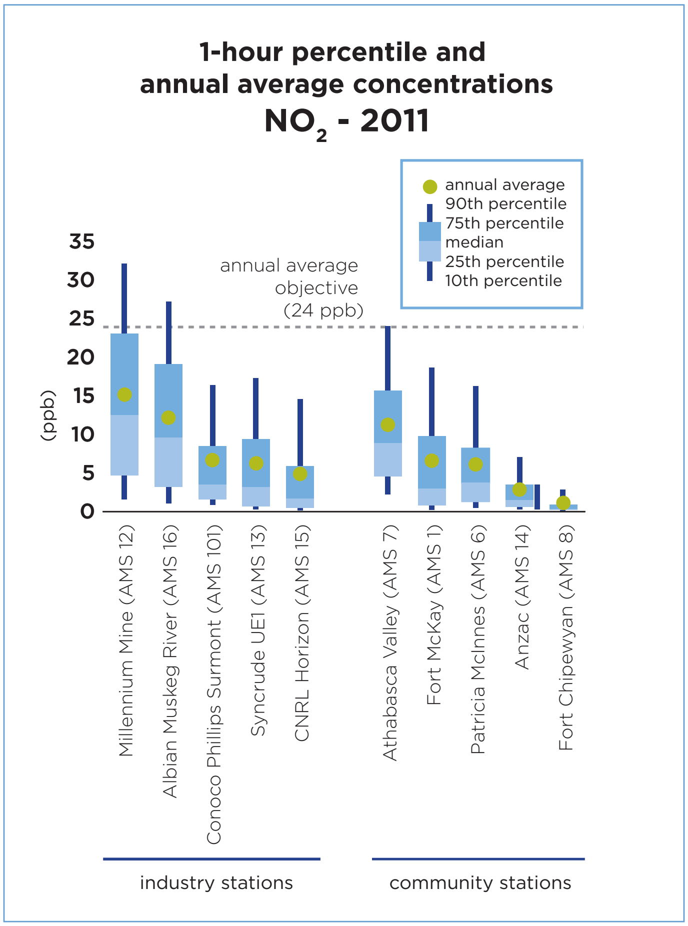
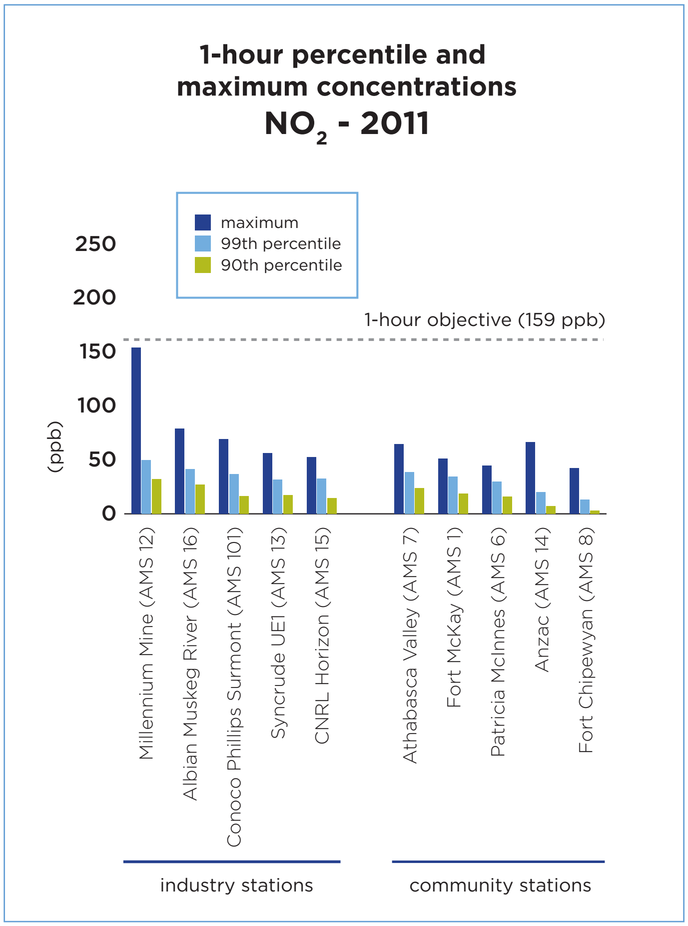


Figure 20. Highest 1-hour NO_2 concentrations and the 99th and 90th percentile values at industry and community stations. There were no exceedences of the 1-hour NO_2 air quality objective.



CONTINUOUS MONITORING TRENDS IN RECENT YEARS

At the start of the WBEA monitoring program in 1998, NO_2 was measured at 4 community stations only. Measurements of NO_2 commenced at industrial stations in 2000. As a result, the summary of results at original stations contains results for community stations only.

ORIGINAL STATIONS

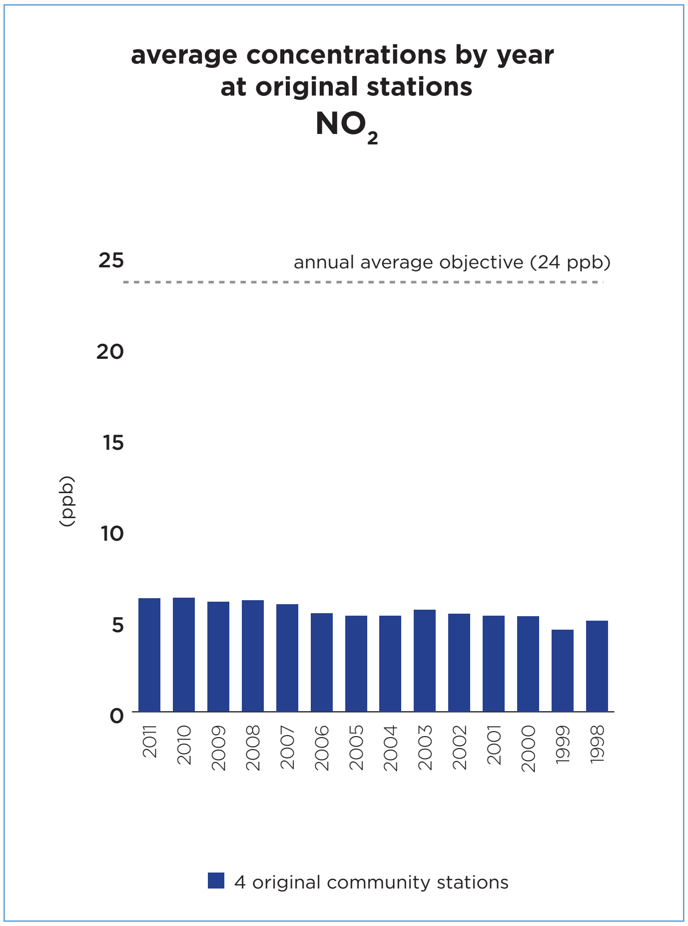
The average of all NO_2 concentrations observed at all of the 4 original community stations for the year 2011 was 6.2 ppb, the same as in the previous year. Although these values were the highest ever observed, they were still comparable to values observed in recent years. The 2011 and 2010 concentrations of 6.2 ppb were about one quarter of the annual air quality objective for NO_2 of 24 ppb.

The range between lowest and highest average NO_2 concentrations at original stations in the past 14 years is small, 4.5 to 6.2 ppb. The average of concentrations in the last 5 years, 6.1 ppb, is slightly greater than the 5.2 ppb average of concentrations in the earlier years.

Table 28. Average NO_2 concentrations (ppb) at the 4 community stations measuring NO_2 since startup of the WBEA air monitoring network.

	station group		
year	all	industry	community
2011	6.2	.	6.2
2010	6.2	.	6.2
2009	6.0	.	6.0
2008	6.1	.	6.1
2007	5.9	.	5.9
2006	5.4	.	5.4
2005	5.3	.	5.3
2004	5.3	.	5.3
2003	5.6	.	5.6
2002	5.4	.	5.4
2001	5.3	.	5.3
2000	5.2	.	5.2
1999	4.5	.	4.5
1998	5.0	.	5.0

Figure 21. Average NO_2 concentrations (ppb) at the 4 community stations measuring NO_2 since startup of the WBEA air monitoring network.



ALL STATIONS

The annual average NO_2 concentrations in the last 14 years at all industry stations ranged from 3.6 ppb at Millenium Mine (AMS 12) in 2002 to 18.0 ppb at Millenium Mine (AMS 12) in 2008. (This range excludes the value of 29.7 ppb at Albian Mine, AMS 10, which operated for less than two months in 2009). At community stations annual average NO_2 concentrations ranged from 0.8 ppb at Fort Chipewyan (AMS 8) in 2005 to 11.3 ppb at Athabasca Valley (AMS 7) in 2011. The highest station annual average concentration of 18.0 ppb (again, excluding the 2009 AMS 10 concentration) was three quarters of the annual air quality objective for NO_2 of 24 ppb.

Table 29. Annual average NO_2 concentrations (ppb) since 1998 at all stations, grouped by industry and community stations, and ordered by the highest annual average concentration.

	year														period		
station	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	1998	highest	average	lowest
industry stations:																	
** Albian mine site (AMS 10)	.	.	29.7	14.8	11.5	9.1	9.1	9.9	9.8	7.4	9.9	10.5	.		29.7	12.2	7.4
Millennium Mine (AMS 12)	15.2	16.7	17.2	18.0	15.8	14.3	11.8	11.6	7.3	3.6	3.7	.	.	.	18.0	12.3	3.6
** Albian Muskeg River (AMS 16)	12.2	12.9	11.4	.	.	.	.	.	.	.	.	.	.	.	12.9	12.2	11.4
*** Conoco Phillips Surmont (AMS 101)	6.7	.	.	.	.	.	.	.	.	.	.	.	.	.	6.7	6.7	6.7
Syncrude UE1 (AMS 13)	6.3	6.2	5.7	6.5	5.9	4.3	4.4	4.4	4.5	4.9	.	.	.	.	6.5	5.3	4.3
CNRL Horizon (AMS 15)	4.9	5.5	4.8	5.9	.	.	.	.	.	.	.	.	.	.	5.9	5.3	4.8
community stations:																	
Athabasca Valley (AMS 7)	11.3	11.0	10.8	10.3	9.7	10.3	9.1	9.2	10.1	9.4	9.7	9.4	8.8	9.3	11.3	9.9	8.8
Fort McKay (AMS 1)	6.6	7.0	6.3	6.9	6.2	5.3	5.4	5.6	5.8	6.5	5.5	5.9	3.7	2.7	7.0	5.7	2.7
Patricia McInnes (AMS 6)	6.1	5.9	5.8	6.1	6.0	5.0	5.8	5.5	5.3	4.8	4.9	4.7	4.5	4.8	6.1	5.4	4.5
Anzac (AMS 14)	2.9	2.7	2.5	3.2	3.3	2.2	.	.	.	.	.	.	.	.	3.3	2.8	2.2
Fort Chipewyan (AMS 8)	1.1	1.1	1.1	1.2	1.6	0.9	0.8	1.0	1.1	0.9	0.9	1.0	1.1	0.9	1.6	1.1	0.8

annual average NO_2 air quality objective : 24 ppb

** The Albian station was relocated 4 km southwest of its original location in February 2009 and renamed from AMS 10 to AMS 16

*** Monitoring at Conoco Phillips Surmont occurred in the last 3 months of 2011 using the portable monitoring station

4.3.9 Ammonia (NH_3)

CHARACTERISTICS

Ammonia 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.

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 particle (size less than 2.5 μm) fraction. A small amount of gaseous ammonia is converted to nitric oxide (NO).

EXPOSURE

Two types of potential health effects are considered important for ammonia: acute non-cancer effects that may result from short-term exposure, and chronic non-cancer effects that may result from long-term exposure.

Uptake and detoxification of ammonia in vegetation can result in changes in tissue nitrogen content, amino acid composition, increased chlorophyll content, leaf gas exchange and nutrient imbalances caused by increased nitrogen content. These changes can result in reduced resistance to drought and frost, increased susceptibility to insect pests and disease, and altered growth and productivity. Nitrogen inputs can also have effects at the ecosystem level.

ALBERTA OBJECTIVES

Alberta ambient air quality objectives issued by Alberta Environment, under Section 14 (1), the Environmental Protection and Enhancement Act, 1992 (EPEA). This document replaces all previous versions of the Ammonia Ambient Air Quality Objective.

- The 1-hour average Alberta Ambient Air Quality Objective for ammonia is 2000 ppb (1400 μg/m^3) based on odour.

CONTINUOUS MONITORING NOTES

Monitoring of NH_3 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. In different stages of the analyzer's process, concentrations of various nitrogen compounds (NO, NO_X and NH_3) are determined by conversion to NO, reaction with O_3, and measuring resulting light which is proportional to the concentration of each compound. From these, the analyzer calculates and outputs the concentration of NH_3.

CONTINUOUS MONITORING OBSERVATIONS IN 2011

Ammonia is monitored at two community stations, Fort McKay (AMS 1) and Patricia McInnes (AMS 6). Measurements of NH_3 concentrations were below the detection limit of the analyzer most of the time. This is reflected in the annual average concentrations of less than 1 ppb. The highest one-hour average concentrations were 123.0 ppb at Patricia McInnes (AMS 6) and 48.6 ppb at Fort McKay (AMS 1). The 98th percentile concentration at both sites was undetectable indicating the very infrequent measurements of NH_3. There were no exceedences of the Alberta ambient air quality objective for NH_3 of 2000 ppb.

Table 30. 1-hour concentrations of NH_3 (ppb) for 2011

Station	Annual Average	1-Hour Maximum	Percentiles								
			1	5	10	25	50	75	90	95	99
community stations:											
Patricia McInnes (AMS 6)	0.52	123.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0
Fort McKay (AMS 1)	0.16	48.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3
air quality objective (ppb)	n/a	2000									

4.3.10 Carbon Monoxide (CO)

CHARACTERISTICS

Carbon monoxide (CO) is a colourless, odourless, and tasteless gas.

SOURCES

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

The Alberta Ambient Air Quality Objectives for the concentrations of carbon monoxide are:

- 1 hour average of 13 ppm (15,000 μg/m^3)
- 8 hour average of 5 ppm (6,000 μg/m^3)

CONTINUOUS MONITORING NOTES

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

CONTINUOUS MONITORING OBSERVATIONS IN 2011

Carbon monoxide is monitored only at the Athabasca Valley site in Fort McMurray (AMS 7). The annual average concentration measured in 2011 was 0.19 ppm. The maximum one-hour average concentration was 2.7 ppm. The 99th percentile concentration of 0.8 ppm was less than one third the maximum concentration. Median and average concentrations were comparable, indicating absence of both extremely large concentrations and many small concentrations. There were no exceedences of the Alberta ambient air quality guidelines for CO in 2011.

Table 31. 1-hour concentrations of CO (ppm) for 2011

Station	Annual Average	1-Hour Maximum	Percentiles								
			1	5	10	25	50	75	90	95	99
community station:											
Athabasca Valley (AMS 7)	0.19	2.7	0.0	0.0	0.1	0.1	0.2	0.2	0.3	0.4	0.8
air quality objective (ppm)	n/a	13									

Figure 22. Annual average and 1-hour percentile CO concentrations at the only CO monitoring station.

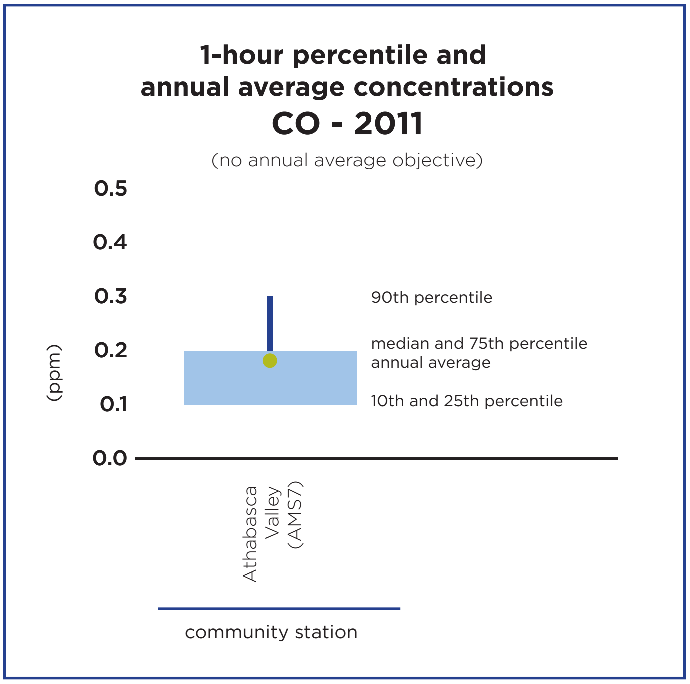
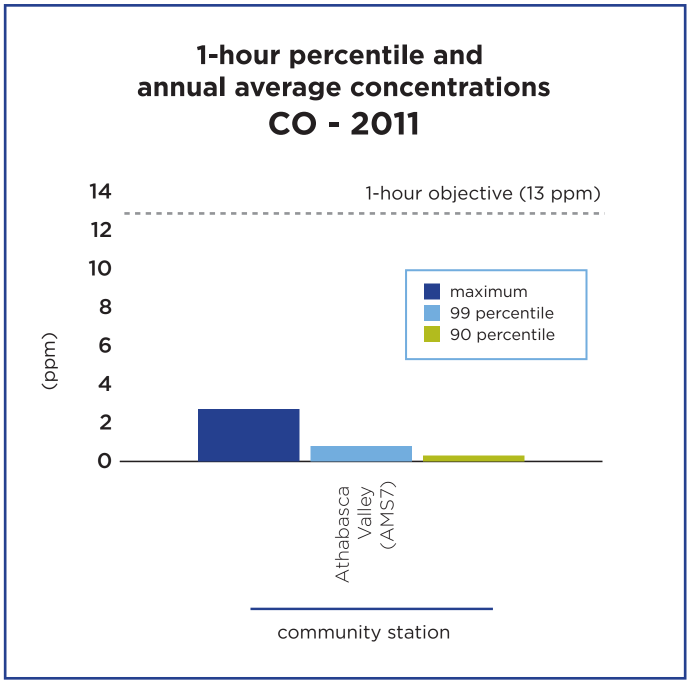


Figure 23. Highest 1-hour CO concentrations and the 99th and 90th percentiles at the only CO monitoring station.



CONTINUOUS MONITORING TRENDS IN RECENT YEARS

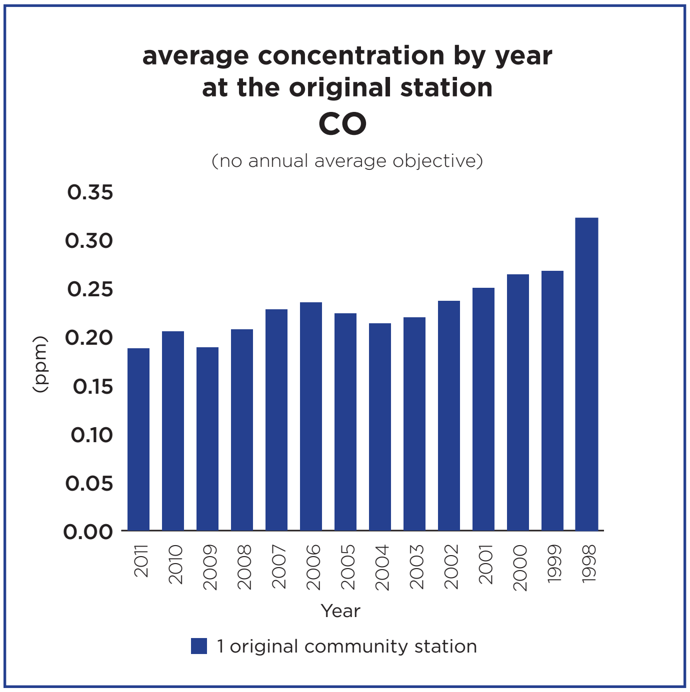
Measurements of CO are made at only 1 station in the network, the community station of Athabasca Valley (AMS 7). These measurements commenced at the start of WBEA monitoring in 1998.

The average CO concentration observed in 2011 at Athabasca Valley (AMS 7) was 0.2 ppm. This value was comparable to average concentrations of 0.2 to 0.3 ppm observed over the last 14 years of monitoring. Although a slight decreasing trend in average concentrations can be seen over the period of record, variation in average concentrations of CO in the last 14 years has been small.

Table 32. Average CO concentrations (ppm) at the 1 station measuring CO since startup of the WBEA air monitoring network.

	station group		
year	all	industry	community
2011	0.2	.	0.2
2010	0.2	.	0.2
2009	0.2	.	0.2
2008	0.2	.	0.2
2007	0.2	.	0.2
2006	0.2	.	0.2
2005	0.2	.	0.2
2004	0.2	.	0.2
2003	0.2	.	0.2
2002	0.2	.	0.2
2001	0.2	.	0.2
2000	0.3	.	0.3
1999	0.3	.	0.3
1998	0.3	.	0.3

Figure 24. Average CO concentrations (ppm) at the 1 station measuring CO since startup of the WBEA air monitoring network.



4.3.11 Passive Monitoring (SO_2, NO_2, O_3, H_2S, HNO_3, NH_3)

The current passive monitoring program at WBEA came into being over time with various subprograms initiated for specific and different purposes. This resulted in variations in monitoring from site to site, including: parameters measured, sample period length, number of samples per parameter (duplicate, triplicate sampling) and monitoring at multiple elevations. A number of factors impacted the passive monitoring program in 2011. Sampling periods at continuous air monitoring sites (AMS) changed from 12 to 10 samples per year, consistent with periods at forestry sites which have 2-month sampling periods in winter months. Ammonia (NH_3) sampling using Maxxam samplers was introduced in 2011. Re-naming of some forestry sites occurred. Sampling using USDA passives was discontinued at a number of sites. The sampling program operations were disrupted by widespread forest fires throughout the region in May and June, and for some months afterward at many sites. Some forest sites were destroyed by the fires.

Passive sampling results for 2011 were based on all available laboratory results at the time of press. Results for HNO_3 and NH_3 from USDA samples were based on results from January to July only. The last sample deployment dates shown for Maxxam samples generally indicated October 2011, with results representing exposures for the months of October and November 2011. All results for each site and parameter were averaged for presentation, regardless of the variations noted in the previous paragraph.

Highest passive SO_2 concentrations were measured at sites closer to industrial areas and lower concentrations at sites at greater distances from industrial areas. The highest average SO_2 concentrations were 3.6 ppb at Mildred Lake (AMS 2), 2.5 ppb at AH7 and 1.9 ppb at JP104. The lowest SO_2 concentrations of 0.2 ppb occurred at JP108, and 0.3 ppb at Fort Chipewyan (AMS 8) and BM 7.

Concentrations of NO_2 were highest in industrial and urban areas and at Fort McKay, which is influenced by industrial sources. Highest passive NO_2 concentrations ranged from 5.1 to 2.6 ppb at Mildred Lake (AMS 2), JP104, R2 and JP212. The next highest NO_2 concentrations were 2.2 ppb at Patricia McInnes (AMS 6) and 2.1 ppb at Fort McKay (AMS 1). Concentrations of NO_2 were less than passive monitor detection (values of 0.0 ppb) at JP213 and BM7.

Ozone concentrations from passive samplers ranged from highest values of 29.7 ppb at JP107 and 29.5 at JP213, to lowest values of 17.9 at NE11, 17.6 at Fort McKay (AMS 1) and 16.8 at R2. The lower O_3 concentrations generally occurred at sites with the highest NO_2 concentrations.

The highest passive NH_3 concentrations occurred at Mildred Lake (AMS 2), with average USDA and Maxxam sampler concentrations of 14.4 and 15.1 ppb, respectively. The next highest concentrations of 7.3 and 5.6 ppb occurred at lakes sites SM7 and WF4, respectively. The lowest passive NH_3 concentrations of around 1.0 ppb or less occurred at lake and forest sites NE7, R2, NE11, JP213 and JP107.

Table 33. Average passive monitoring concentrations of SO_2, NO_2, O_3, HNO_3 and NH_3 in 2011

		Maxxam Passives											USDA Passives**			
			deployment period		SO_2		NO_2		O_3		NH_3		HNO_3		NH_3	
station	group	number of sampling periods	first (yymm)	last (yymm)	sample count	mean (ppb)	sample count	mean (ppb)	sample count	mean (ppb)	sample count	mean (ppb)	sample count	mean (ppb)	sample count	mean (ppb)*
AMS 1	AMS	10	1102	1111	27	1.0	27	2.1	27	17.6	27	0.9	15	0.5	15	3.1
AMS 14	AMS	10	1012	1110	27	0.5	27	0.9	27	23.4	27	1.1	15	0.6	15	1.4
AMS 2	AMS	9	1102	1110	24	3.6	24	5.1	24	19.5	24	15.1	15	0.3	15	14.4
AMS 6	AMS	10	1102	1111	27	0.9	27	2.2	27	22.5	27	0.8	15	0.6	15	2.6
AMS 8	AMS	9	1012	1110	21	0.3	21	0.2	21	25.7	24	0.7	11	0.6	11	1.8
AH3	forest	10	1012	1110	18	0.6	18	0.7	18	27.2	.	.	10	0.6	10	1.6
AH7	forest	5	1012	1105	8	2.5	6	1.6	7	27.4	.	.	4	0.3	4	1.6
AH8-R	forest	10	1012	1110	18	0.6	18	0.6	18	22.6	.	.	10	0.3	10	1.9
JP101	forest	10	1012	1110	18	0.9	18	0.5	18	26.4	.	.	10	0.5	10	3.3
JP102	forest	10	1012	1110	18	1.4	18	2.0	18	24.5	.	.	10	0.7	10	3.5
JP104	forest	10	1012	1110	18	1.9	18	3.4	18	23.5	.	.	10	0.5	10	2.1
JP107	forest	4	1012	1104	6	1.1	6	1.3	6	29.7	.	.	4	0.2	4	0.7
JP108	forest	7	1105	1110	12	0.2	12	0.1	12	20.0	.	.	6	0.6	6	2.0
JP205	forest	9	1012	1110	16	0.7	16	0.3	16	23.3	.	.	8	0.3	6	1.4
JP210	forest	10	1012	1110	18	0.4	18	0.2	18	27.5	.	.	10	0.5	10	1.2
JP212	forest	9	1012	1109	9	1.4	9	2.6	9	18.3	.	.	5	0.6	5	2.4
JP213	forest	5	1012	1105	7	0.6	8	0.0	8	29.5	.	.	4	0.2	6	1.0
R2	forest	9	1012	1110	9	1.6	9	3.3	9	16.8	2	0.9	4	0.9	4	1.1
BM10	lake	10	1012	1110	10	0.6	10	0.2	10	22.4	.	.	5	1.0	5	2.6
BM11	lake	10	1012	1110	10	0.9	10	0.1	10	24.6	.	.	5	0.6	5	1.5
BM7	lake	10	1012	1110	10	0.3	10	0.0	10	27.7	.	.	5	0.4	5	1.3
NE10	lake	10	1012	1110	10	0.4	10	0.2	10	23.1	.	.	5	0.3	5	2.0
NE11	lake	9	1012	1110	8	1.0	8	1.2	8	17.9	.	.	5	0.4	5	1.0
NE7	lake	9	1012	1110	9	1.2	9	0.7	9	23.6	.	.	5	0.5	5	1.1
SM7	lake	10	1012	1110	10	0.5	10	0.3	10	26.6	.	.	5	0.7	5	7.3
SM8	lake	10	1012	1110	10	0.5	10	0.2	10	26.0	.	.	5	0.4	5	1.3
WF4	lake	10	1012	1110	8	0.9	9	0.7	9	19.0	.	.	5	0.5	5	5.6

* USDA concentrations converted from $\mu g/m^3$ to ppb at 1 atm and 25˚C

** deployment periods for USDA sampes were from 1101 to 1107

Average concentrations from passive monitoring were compared with average concentrations from continuous monitoring at sites where both modes of measurement were conducted. Continuous and passive results for SO_2, NO_2 and O_3 were available at Fort McKay (AMS 1), Patricia McInnes (AMS 6) and Anzac (AMS 14). Continuous and passive results for NH_3 were available at Fort McKay (AMS 1) and Patricia McInnes (AMS 6). Continuous results in the comparison were averaged over the passive deployment period (assumed to include the month indicated in the first deployment period and one month after the month indicated in the last deployment period).

Average continuous SO_2 concentrations were generally higher than average passive concentrations, with factors ranging from 0.9 to 1.7. Average continuous NO_2 concentrations were greater than passive concentrations by factors of 2.5 to 4.9. Average continuous O_3 concentrations were generally greater than passive concentrations by factors of 1.1 to 1.3. Average continuous NH_3 concentrations were less than passive concentrations by factors of 0.2 ppb at Patricia McInnes (AMS 6) and 0.7 ppb at Fort McKay (AMS 1). Concentrations of NH_3 were well below the operational detection limits of the continuous analyzers most of the time.

Table 34. Comparison of average continuous and passive monitoring results

station	parameter	continuous	passive	ratio
Fort McKay (AMS 1)	SO_2	1.6	1.0	1.7
Mildred Lake (AMS 2)		3.3	3.6	0.9
Patricia McInnes (AMS 6)		0.9	0.9	1.0
Fort Chipewyan (AMS 8)		0.3	0.3	1.3
Anzac (AMS 14)		0.6	0.5	1.2
Fort McKay (AMS 1)	NO_2	5.8	2.1	2.7
Patricia McInnes (AMS 6)		5.4	2.2	2.5
Fort Chipewyan (AMS 8)		1.1	0.2	4.9
Anzac (AMS 14)		3.0	0.9	3.3
Fort McKay (AMS 1)	O_3	22.9	17.6	1.3
Patricia McInnes (AMS 6)		24.2	22.5	1.1
Fort Chipewyan (AMS 8)		28.4	25.7	1.1
Anzac (AMS 14)		27.3	23.4	1.2
Fort McKay (AMS 1)	NH_3	0.6	0.9	0.7
Patricia McInnes (AMS 6)		0.2	0.8	0.2

4.3.12 References

ALBERTA AMBIENT AIR QUALITY OBJECTIVES:

Alberta Ambient Air Quality Objectives and Guidelines, issued December 2010. Government of Alberta, Environment, 5pp. http://environment.gov.ab.ca/info/library/5726.pdf

OTHER:

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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Air Quality Meteorologist

4.4 2011 Air Quality Health Index Values for the RMWB

The Air Quality Health Index or "AQHI" is a health protection tool which can assist residents of the RMWB to determine how the current air quality may affect their health. The AQHI was introduced province wide, by Alberta Environment and Water (AEW), in September 2011. This tool has been developed by Health Canada and Environment Canada, in collaboration with the provinces and key health and environment stakeholders.

Alberta Environment and Water (AEW) states Alberta's former Air Quality Index (AQI) measured two additional components, in order to address the province's unique air quality issues resulting from the oil and gas industry. Under Alberta's adoption of the AQHI, these additional components and two others – hydrogen sulphide and total reduced sulphur –are measured, but not included in the AQHI numerical value. The Alberta AQHI website provides notice when visibility is a concern and when odours may be detected. Data in the AQHI is also reported hourly under Alberta's system, rather than the federal system's practice of reporting every three hours.

The AQHI is now available in over 20 locations across Alberta. The forecast component was first available in Edmonton, Calgary, Red Deer, Fort McKay and Fort McMurray, with the remaining locations added in 2012. The AQHI allows individuals to adjust their level of outdoor activity according to their individual health concerns and the current or forecasted levels of air borne pollution in the region. The AQHI reports air quality in terms of low, medium, high and very high health risks. WBEA reports hourly AQHI readings, which are then used by AEW to calculated AQHI values for four of our air monitoring stations: Fort McKay (AMS 1); Fort McMurray, (AMS 7); Fort Chipewyan (AMS 8); Fort McKay South (AMS 13).

In this report, the 2011 hourly AHQI values were provided by AEW, and the percent of the values within each of the four risk categories were calculated for participating WBEA stations, as well as five other Alberta stations. With any air monitoring operation, the goal is to have data available for all 8760 hours in any given year. For the Alberta stations shown below, data availability was as follows: WBEA-AMS 7- Fort McMurray (98.5%), WBEA-AMS 1- Fort McKay (93.4%), WBEA-AMS 13- Fort McKay South (99.5%), WBEA-AMS 8- Fort Chipewyan (88.3%), Calgary (99.9%), Edmonton (100%), Fort Saskatchewan (92.7%), Red Deer (95.7%), and Medicine Hat (90.2%).

Fine particulate matter ($PM_{2.5}$) is a key pollutant included in the AQHI calculation. Highly elevated levels of $PM_{2.5}$ measured in regional forest fire smoke greatly affected WBEA's instrument performance from May to June, 2011, resulting in less data being available for the AQHI. In November and December 2011, in comparison, WBEA's network (84 analyzers) averaged 99.8 % data availability (performance). The following pie charts summarize the AQHI results for all these air monitoring stations.

As can be seen, air quality at the four WBEA stations presented a low health risk between 96% and 99.3% of the time in 2011. This compared to low health risk AQHI numbers at these locations for the following percentages of time: 89.8% (Edmonton), 90.3% (Red Deer), 92.6% (Calgary), 95.4% (Fort Saskatchewan), and 98.2% (Medicine Hat). The 2011 AQHI percentages for the four WBEA, and other Alberta stations are shown for information only. The stations measured air quality in communities of very different sizes, and were subject to different emission source profiles. Some stations reflect urban sources, some like Fort McKay and Fort Saskatchewan more industrial sources, one a mixture of both (Edmonton). Fort McKay, in particular, is more affected by industrial emissions than local sources.

AQHI values presenting a moderate risk to health at WBEA stations occurred between 0.18% (Fort Chipewyan) and 2.1% (Fort McMurray) of the time in 2011. Values at other selected Alberta stations shown below were in the moderate risk to health range 1.8% (Medicine Hat), 4.5% (Fort Saskatchewan), 7.3% (Calgary), 9.4% (Red Deer), and 9.7% (Edmonton) of the time in 2011.

In 2011, AQHI values presenting a high health risk occurred between 0.09% (Fort Chipewyan) and 1.3% (Fort McMurray) of available hours. This compared to between 0% (Medicine Hat) and 0.44% (Edmonton) of available hours at other Alberta stations.

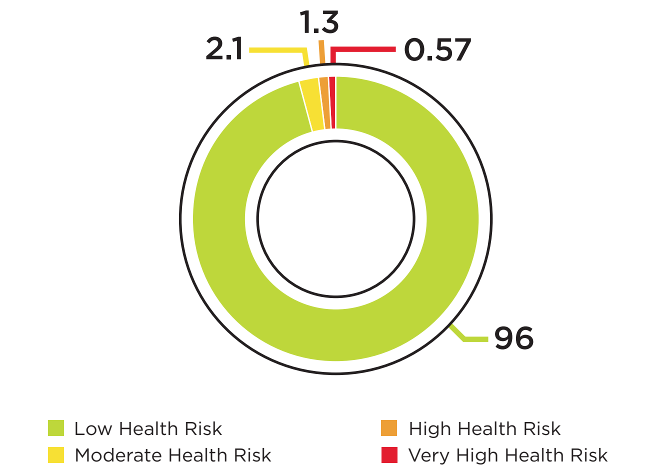
Almost all hourly AQHI values recorded in the moderate (4 to 6) to high (7 to 10) risk to health categories at WBEA stations were reported during the extended May to June 2011 regional wildfire episode, which consumed some 700, 000 hectares and resulted in extended periods of greatly reduced visibility.

According to Alberta Environment and Water when the amount of air pollution is abnormally high, such as air quality associated with wild fire smoke, the AQHI number may exceed 10. AQHI numbers above 10, indicating very high health risk, occurred between 0.32% (Fort Chipewyan) and 1.2 % (Fort McKay, Fort McMurray South) of the time. All hours with AQHI values above 10 occurred during the most intense portions of the regional fire smoke episode. Extremely high concentrations of fine particulate matter, causing reduced visibility, were measured by WBEA during this event, as well as occasional elevated levels of ground level ozone.

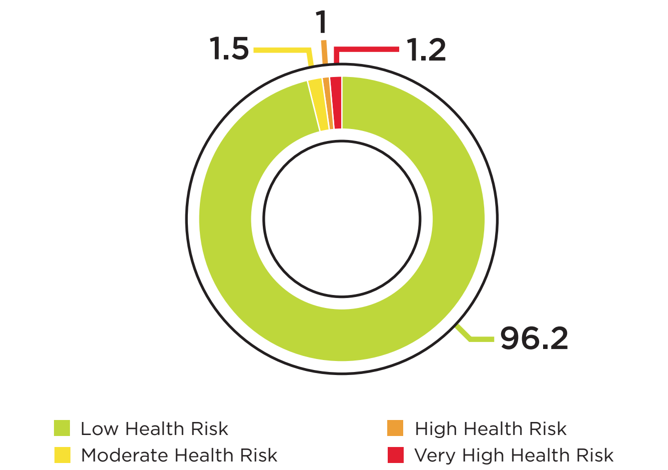
It is important to note that the pollutants measured to calculate the AQHI do not include the reduced sulphur compounds (RSC) and volatile organic compounds (VOC) that contribute to odour events experienced in several communities within the RMWB. Public notice, however, will be given if concentrations of hydrogen sulphide and total reduced sulphur exceed the Alberta ambient air quality objective. Therefore, the AQHI should not be used to evaluate the potential health risk from odours.

Dr. Kevin Percy,
Executive Director

Fort McMurray



Fort McKay



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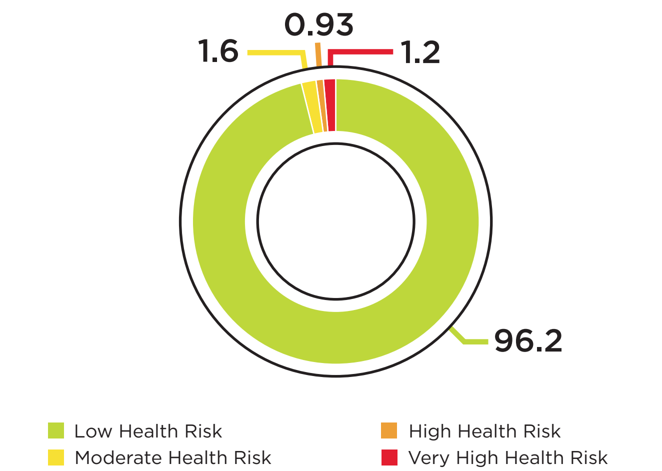
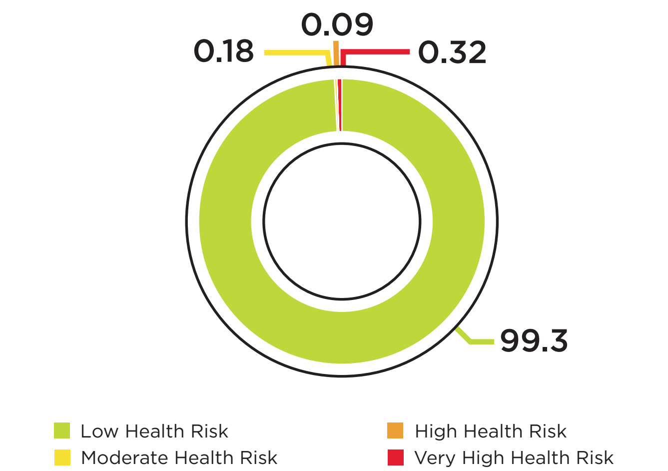
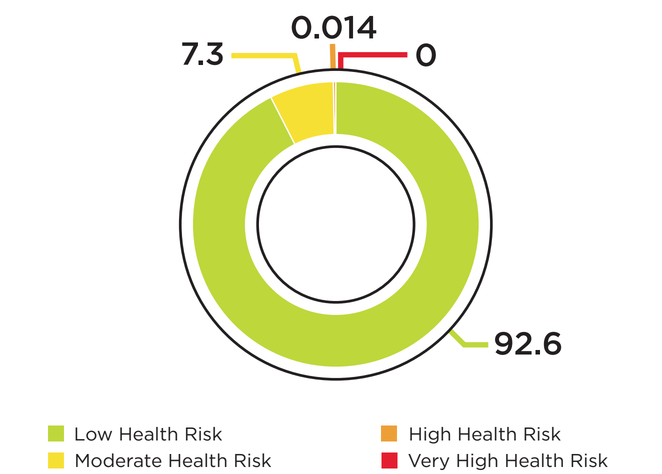


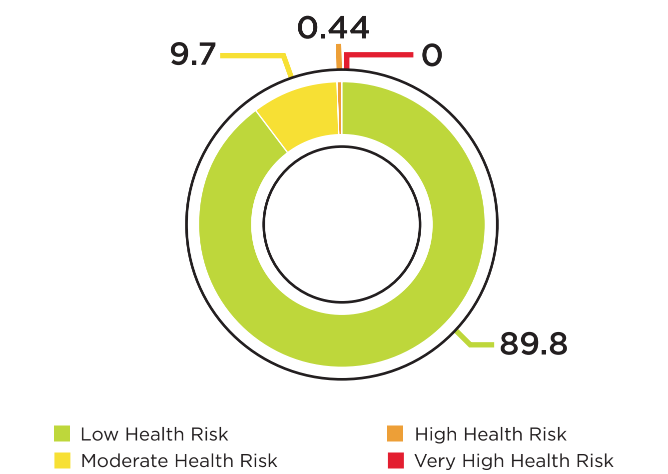
Fort Chipewyan

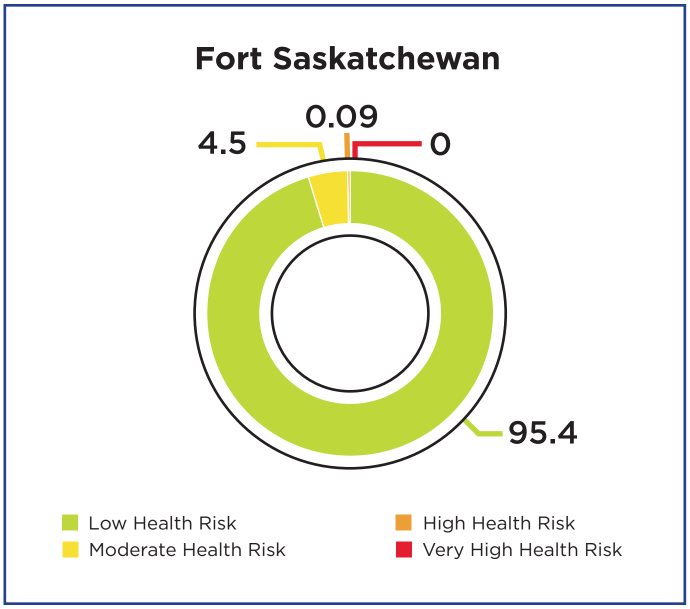


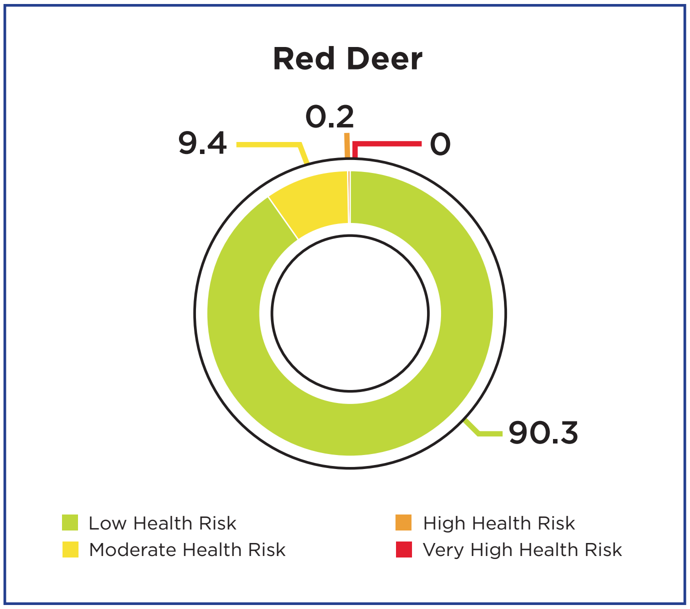
Calgary

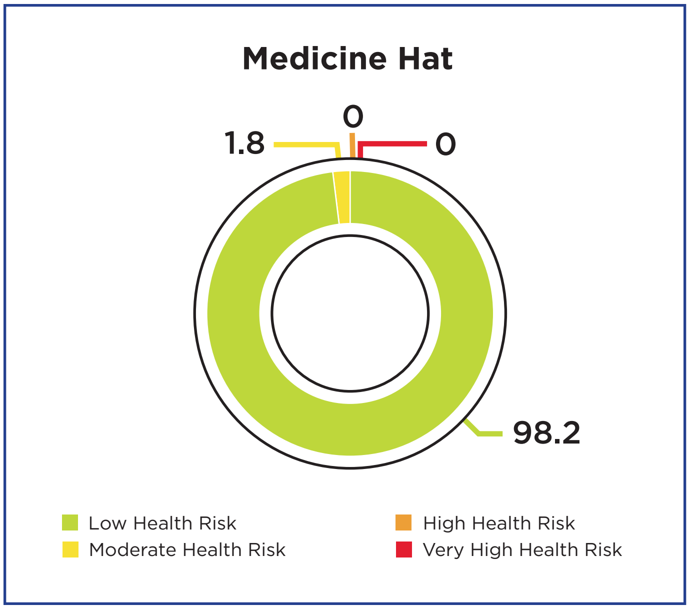


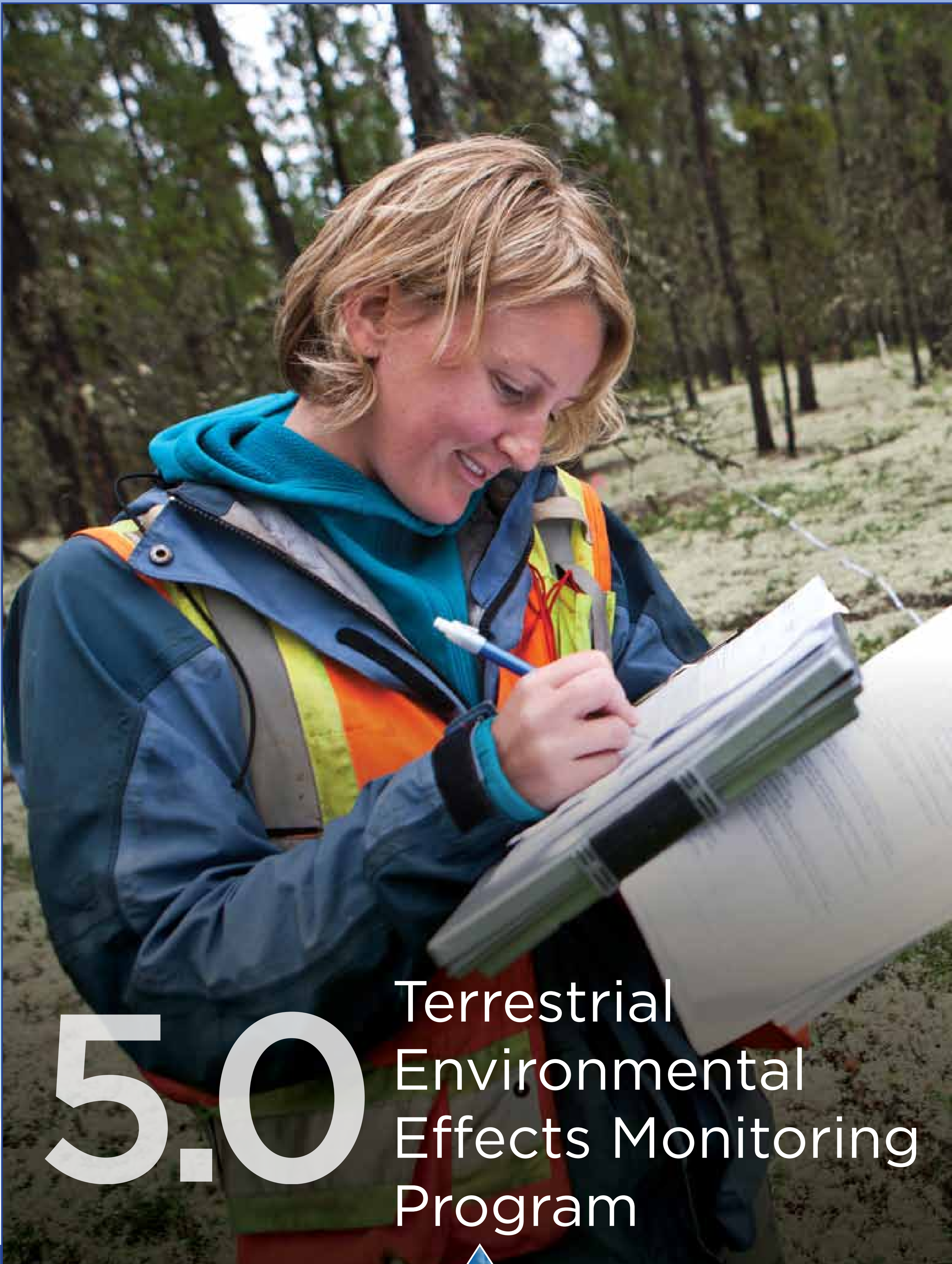
Edmonton




Fort Saskatchewan
4.5
0.09
0
95.4
Low Health Risk
Moderate Health Risk
High Health Risk
Very High Health Risk


Red Deer
9.4
0.2
0
90.3
Low Health Risk
Moderate Health Risk
High Health Risk
Very High Health Risk


Medicine Hat
1.8
0
0
98.2
Low Health Risk
Moderate Health Risk
High Health Risk
Very High Health Risk



5.0 Terrestrial Environmental Effects Monitoring Program

5.1 A Message from the TEEM Program Manager

The Terrestrial Effects Monitoring (TEEM) program's mandate is to develop and operate a long term program to detect, characterize, and quantify the impact that air emissions have had, or may have in the long term, on terrestrial ecosystems and traditional land resources in the Athabasca Oil Sands Region.

The 2011 TEEM program was substantial in scope, focused on measurement and sampling of the network of jack pine monitoring plots, and on completion of supporting science programs. TEEM continued communication with the Cumulative Effects Management Association's Air Working Group in 2011, to share information on programs addressing common issues.

The following is a summary of the status and progress of the projects undertaken by TEEM in 2011. The projects have been grouped according to their role in fulfilling the TEEM mandate.

ECOLOGICAL RECEPTOR/INDICATOR MONITORING:

- **Forest Health Monitoring:** Execution of the intensive cycle of measurement and sampling of jack pine plots for indicators of exposure to air emissions and deposition, including:
  - Morphological measurements of jack pine trees, in the 11 plots that were established from 1998 to 2004, and in 10 plots that were added to the program in 2011;
  - Sampling of soils, needles, and lichens for chemical analysis.
  - An assessment of insect and disease incidence and severity on the trees at each plot;
  - Characterization of the vegetation community composition within each jack pine plot, to determine whether changes in the plant community may be related to changes in nitrogen deposition;
  - Sampling of soils for microbiological analysis, a preliminary examination of potential changes in soil microbiology that may be occurring due to sulphur and/or nitrogen deposition.

The major forest fires that occurred in May through July resulted in the burning of six sites established between 1998 and 2004. These sites were re-established after the fires, and the complete suite of measurements and sampling were conducted. Forest fire is a natural process in the boreal forest, therefore, continued monitoring at burned plots is being undertaken.

Laboratory analyses, data entry, and data quality assurance/quality control will continue beyond 2011, with the complete dataset expected to be available for interpretation and reporting in late 2012.

The first complete version of the TEEM Procedures Manual was received in March 2011, and implemented into the Forest Health monitoring program. Changes to procedures based on field experience, and upgrades to incorporate new monitoring programs and/or scientific advances are expected in 2012.

- **Bog Monitoring:** This program was established to identify indicators that may be suitable for long-term monitoring of peatland responses to deposition of compounds containing nitrogen and sulphur. Five bog monitoring sites were established, one of which was lost to forest fires in 2011. The indicators and measurements being evaluated include: net primary production of moss, precipitation (rain and snow) for analyses of NO_3-N, NH_4-N, and SO_4-S; pore water for chemistry analyses of pH, electric conductivity (EC), NO_3-N, NH_4-N, and total dissolved C, N and inorganic C; sampling of shrubs, trees and lichens for total C, N and S; and lichen richness and diversity. In addition, lichen (*Evernia mesomorpha*) transplants were collected for total C, N, and S analyses as well as analysis of chlorophyll and various other pigments to determine if a qualitative list of lichen health indicators can be developed. Weather stations were installed at 4 of the bog sites to provide information on site specific growing conditions.

Sampling Soil at JP 311

- **Traditional Environmental Knowledge (TEK):** TEEM continued to work with the community of Fort McKay to develop a berry monitoring program that integrates traditional and scientific indicators of berry abundance and quality. Several workshops were held during the year, leading to a conceptual program that will be initiated in 2012. This program will include several spring and early summer trips to berry-producing areas and a trip to Moose Lake in the fall, during which berry samples will be obtained and evaluated against traditional and scientific criteria.

ECOLOGICAL RECEPTOR/EMISSION MAPPING:

- **Lichen Deposition Mapping Project:** This project will map spatial patterns and the extent of air pollution deposition (source apportionment) using epiphytic lichens as bio-indicators and help validate modeled N and S deposition patterns in the region. In 2011, lichen samples from 2008 were analysed for trace elements and stable isotopes.

EMISSION MONITORING/INSTRUMENTATION/CHARACTERIZATION:

- **Ambient Ion Monitoring:** This project collects data on trace concentrations of gases, anions, and cations in ambient air which are used to verify the accuracy of data collected by other instruments at WBEA's monitoring stations. The URG9000 unit was located at AMS 1, near Fort McKay until October. There is a strong correlation between SO_2 concentrations measured by the URG9000 instrument and the continuous SO_2 monitoring instrument. In late 2011, the instrument trailer was moved to AMS 7 and the URG inlet was modified.
- **Instrumented Towers:** Two new instrumented 30 m towers were installed in 2011, one at each of JP107 (north of Ft. McMurray) and JP213 (northeast of Ft. McMurray). This brings the total number of towers to four, with towers at JP201 (west of Ft. McMurray) and JP104 (north of Ft. McMurray, off the East Athabasca Highway) already operating. These towers provide continuous meteorological and site-condition (e.g., light intensity, soil moisture) data necessary for proper interpretation of air quality and ecological monitoring data.
- **Source Characterization:** This project quantifies "real-world" emission rates and chemical fingerprints for source and receptor models that can be used to identify possible ecosystem impacts of different source types. The first stack emission characterization program completed in 2010 was supplemented with a winter 2011 sampling program. The draft reports of stack monitoring have been received. Reports from both the heavy hauler and stack programs will be completed in 2012; these will be the basis for several scientific manuscripts.

  For the rationale and history of "real world" source characterization conducted by DRI for WBEA since 2008, please see the special article following the TEEM report.
- **Stable Isotopes:** The project will establish to what extent stable isotope ratios can be used to trace the fate of emissions in the surrounding terrestrial environment. A number of samples from TEEM programs have been archived, and some of these will be selected for isotopic analysis in 2012. Several scientific manuscripts are in preparation and a PhD thesis was successfully defended.

Lichens.

Mine Heavy Hauler.

IER Resins at JP 311.

- **IER Resin Monitoring:** Understanding ecosystem responses to atmospheric deposition requires the quantification of that deposition. Wet deposition is being measured in bulk precipitation (rain and snow that has not interacted with vegetative cover) and in throughfall (wash-off passing though tree branches). Results indicate that N and S deposition is 2 to 3 times higher at JP sites near the industrial zone compared to remote JP sites. Resins have been deployed at JP sites since May 2010. Solar-powered electric fencing is being used to reduce the potential for bear damage to monitoring equipment. This program will continue in 2012, with resin monitoring systems being more broadly deployed.
- **NH_3 and HNO_3 Passive Monitoring.** Gaseous nitric acid (HNO_3) and ammonia (NH_3) air contaminants are components of the atmospheric dry deposition to forests and other ecosystems. These passive samplers were first deployed in May 2005. Levels of NH_3 and HNO_3 measured in 2011 were similar to those observed in previous years. Both pollutants are characterized by their high spatial and temporal variability. Passive monitoring will continue in 2012. A complete review of the data collected to date will be completed in 2012, after which adjustments to the program may be made.
- **Passive Monitoring:** TEEM staff supported the routine passive monitoring program throughout 2011. These data were supplied to the Ambient Air Technical Committee for their incorporation into the WBEA air quality monitoring database.

DEPOSITION MODELING:

- **CoTAG (Conditional Time Averaged Gradient):** The CoTAG instrument was developed to measure deposition velocities of compounds such as nitric acid, sulphur dioxide and ammonia in areas with low vegetation cover types to estimate dry deposition. Results will be used to calibrate deposition models and estimate dry deposition. The instrument was deployed to JP104 (formerly JPH4) in the summer of 2011, where it performed well. Limitations to the data and instrument performance may be related to the small size of the open area in which it was operated; to test remote performance in a large open area, the CoTAG will be deployed to a remote site in 2012. Decisions on the ongoing use of the instrument, in near and/or remote settings, will be made at the conclusion of the field program in 2012.

43RD AIR POLLUTION WORKSHOP AND INTERNATIONAL SYMPOSIUM:

- Many of the TEEM contractors, scientists and staff participated in the International Symposium and Air Pollution Workshop in May, 2011. The multi-year results of several TEEM projects including emissions characterization and receptor modeling were presented, and will be published in the peer-reviewed book "Alberta Oil Sands: Energy, Industry and the Environment."

Dr. Ken Foster
TEEM Program Manager

5.2 Characterization of Emission Sources under Real-World Conditions

OVERVIEW

Air pollutants in the Athabasca Oil Sands Region (AOSR) are emitted to ambient air by engine exhaust pipes (mostly associated with large haulers and land-moving equipment), large stationary sources through vents and ducts, and fugitive dust from area sources such as unpaved roads, mining pits, and tailings piles. Other emitters in AOSR include on-road diesel and gasoline vehicles, a wood-processing facility, periodic wildfires in the boreal forest, wintertime residential heating, and residential and commercial construction to accommodate a rapidly expanding population. Annual average emission rates are estimated by the operating companies, Alberta Environment and Water, and Environment Canada for the criteria air contaminants of carbon monoxide (CO), oxides of nitrogen (NO_X), sulphur dioxide (SO_2), volatile organic compounds (VOC), ammonia (NH_3), and size-fractionated particulate matter ($PM_{2.5}$ and PM_{10}, mass of particles with aerodynamic diameters < 2.5 and 10 μm). Climate forcing gases and particles and a selection of potentially toxic chemicals are also estimated. Although consistent throughout the country to track spatial and temporal distributions, the data used to derive these emissions are generic and do not necessarily correspond to the real-world fuels, equipment, and operating conditions used in the AOSR.

The goal of WBEA's real-world emissions characterization component is to continuously improve the accuracy of real-world emission rates and compositions that can be used for multiple purposes that include: 1) improving emission inventories that allow implementing cost-effective and multi-pollutant control strategies; 2) modeling air quality transport and dispersion to estimate current and future ambient concentrations, deposition, and ecosystem effects; 3) verifying source contributions using chemical fingerprints of different emission sources; and 4) evaluating the effects of emission reduction measures. WBEA emissions characterization is complementary to, rather than duplicative of, compliance-oriented emissions tests. Tests to date include emissions from different types of heavy haulers, major stacks at mining and upgrading facilities, and fugitive dust from roads, tailings ponds, construction, and natural surfaces.

HEAVY HAULERS

The AOSR mine fleet contains >200 heavy haulers with high power (>2500 kW) diesel engines and high fuel consumption rates (~230 L/hr). Four Caterpillar 797B (CAT) and one Liebherr T282B haulers were tested.

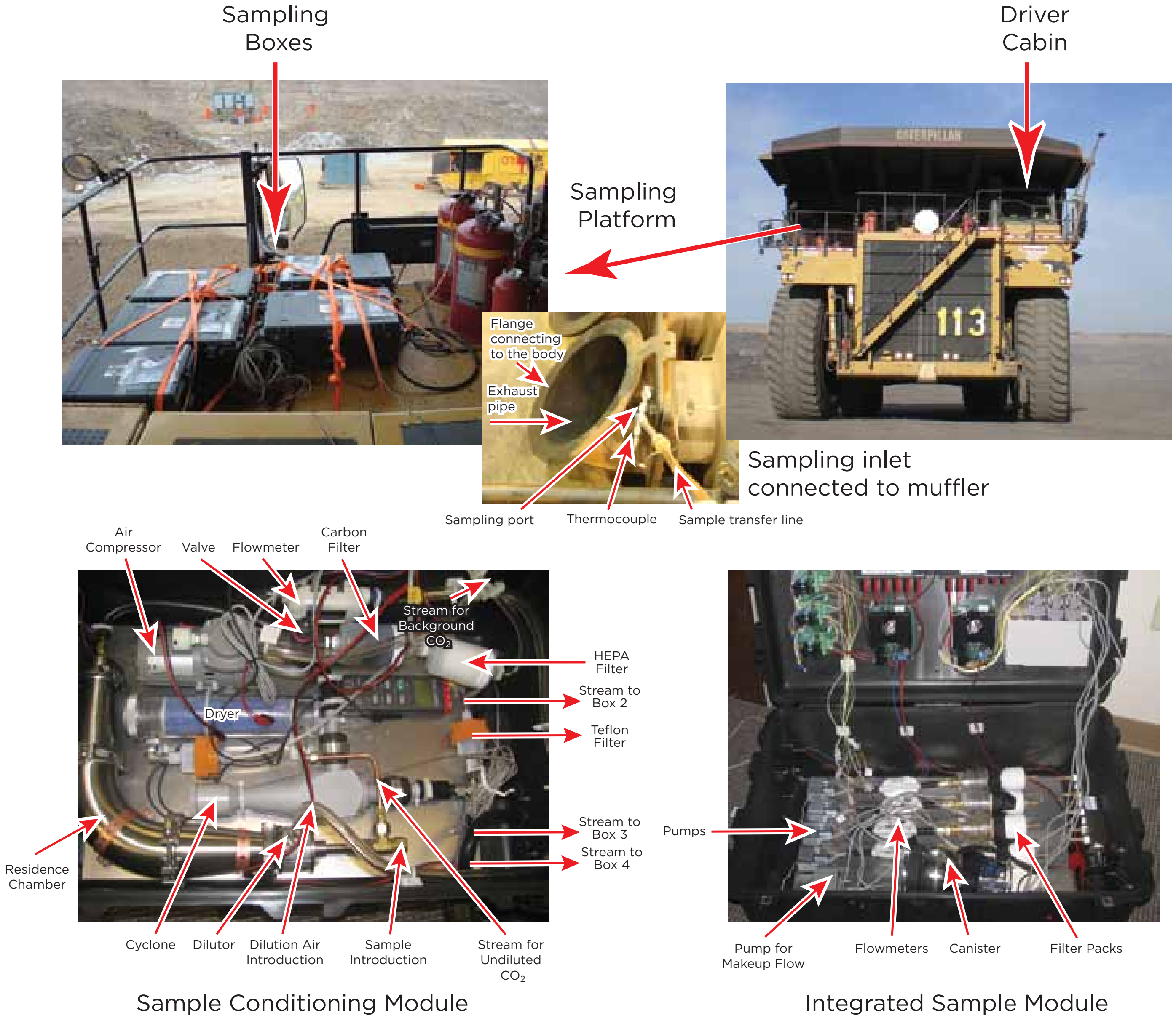
The test system (Figure 1) used small, battery-powered sensors, filters, and canisters to obtain a wide range of emission rates, many of them of short duration (a few seconds). For criteria contaminants, emissions from all five heavy haulers were within the voluntary Canadian off-road Tier 1 emission limits for CO, the non-methane hydrocarbon (NMHC) portion of VOCs, and $PM_{2.5}$, even though their engines were not required to meet these limits. Two of the five trucks showed higher than Tier 1 limits for NO_X by 11% and 93%, indicating the effects of variability in fuels, hardware, and operating conditions. Fuel-based emission factors (mg pollutant/kg fuel consumed) for the Caterpillar 797Bs were lower or comparable to those for other diesel engines, although their high fuel consumption rates makes them important emitters in the region. Alkanes/cycloalkanes and alkenes originated from unburned or decomposed fuel were the most abundant species among the measured NMHC. Organic and elemental carbon (OC and EC, respectively) were the most abundant $PM_{2.5}$ components, accounting for 68-88% of $PM_{2.5}$ emissions. Chemical source markers for diesel particulate included high temperature soot, lubrication oil constituents (e.g., calcium [Ca], zinc [Zn], phosphorus [P], and sulfur [S]), and certain organic compounds (e.g., alkanes, polycyclic aromatic hydrocarbons [PAHs], hopanes, and steranes) that are not common in other carbon sources. Aside from CO_2, methane (CH_4) and black carbon (BC) were the most important climate-forcing emissions. Other climate forcing material had negligible emissions.

STATIONARY POINT SOURCES

Tall stacks are used in oil sands processing facilities to vent process and combustion gases, most of which have passed through pollution control devices. The tall stacks allow primary emittants to be diluted when they reach nearby ground locations, but they also facilitate transport of pollutants over long distances. Emitted gases can transform into other gases and particles during this transport, and eventually deposit on potentially sensitive receptors. Large stationary sources in Alberta are tested for compliance using Method 5 of the Alberta Stack Sampling Code in which the front filter is heated to ~120 °C, and the remaining gases are passed through a set of ice-cooled impingers containing water solutions to capture "condensables." The heated filters pass condensable gases and thus underestimate PM, while the wet impingers collect non-condensable as well as condensable gases and thus overestimate PM.

A dilution sampling system (Figure 2), similar to that used for certification testing of engine exhaust from mobile sources was used to measure gas and PM emissions from three highest-emitting stacks in the AOSR during the summer and winter of 2008 and 2011, respectively. Hot stack emissions were diluted with clean air in a mixing and residence chamber that simulated the dilution, cooling, and aging when the flue gas exits the stack. Sufficient residence time was provided for gas-particle phase equilibrium while minimizing sampling losses and contamination. Real-time concentrations of gases (i.e., CO, CO_2, and NO_X), particles (i.e., $PM_{2.5}$, PM_{10}), and particle size distributions were measured. Precursor gases (i.e., SO_2, hydrogen sulfide [H_2S], and NH_3) as well as $PM_{2.5}$ mass and chemical composition were collected with stacked filter packs. Continuous measurements generated data to calculate average pollutant concentrations and emission rates, and also detected short-duration emission variability,

Figure 1. Real-world Sampling Uses On-Board Instruments to Sample Plumes and Normalize Concentrations to CO_2 and Fuel Carbon Content to Obtain Fuel-Based Emission Factors in g-pollutant/kg-fuel.

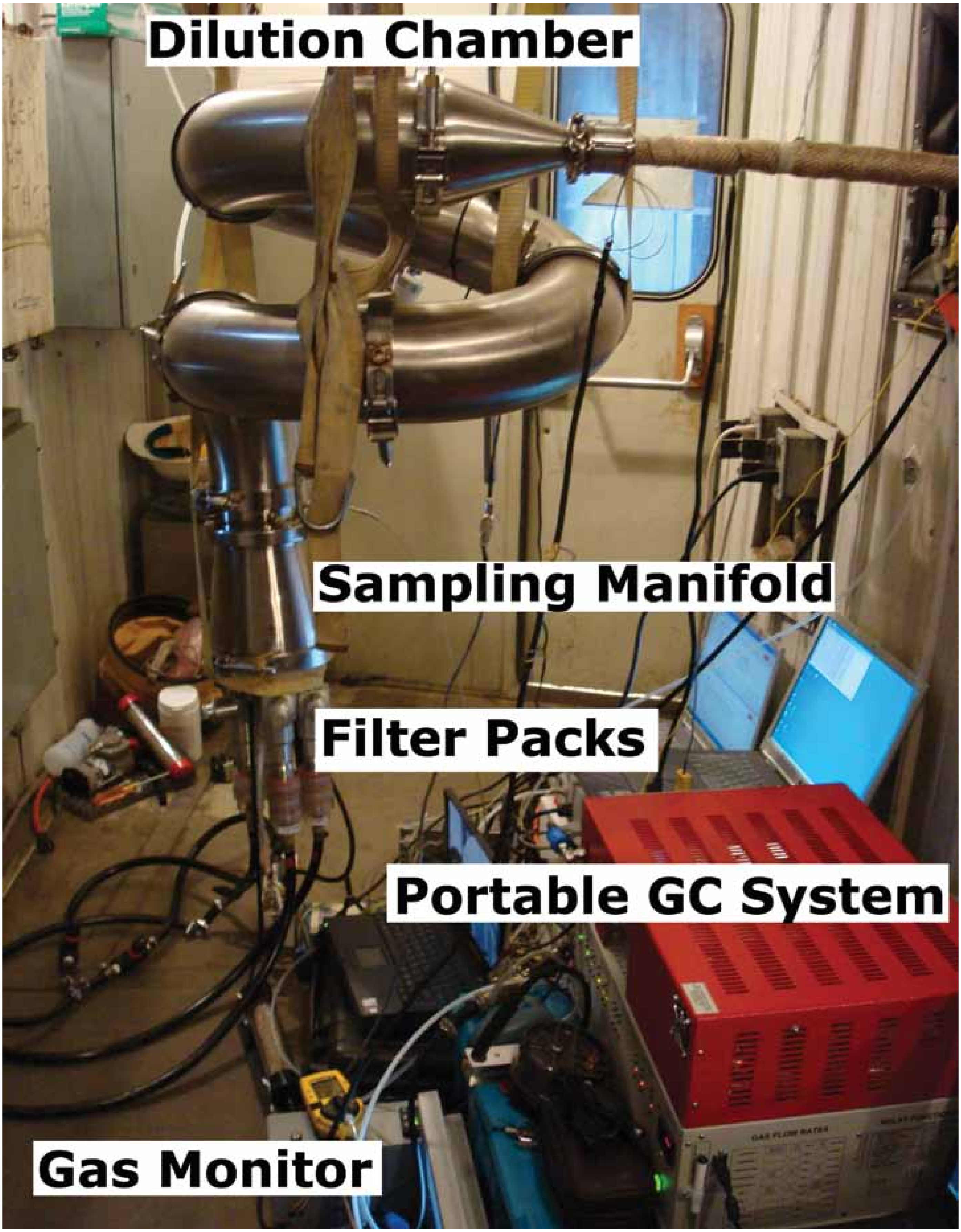


while integrated filter samples allowed for comprehensive laboratory analyses. Emission rates of major air pollutants were found to be lower than the emission guidelines for each stack during the test period, except that one of the stacks emitted 10% higher NO_x than the guideline during the winter testing period. Major components in the emitted particulate matter included ammonium sulfate [$(NH_4)_2SO_4$] or sulfuric acid [H_2SO_4) droplets. Vandium (V) and nickel (Ni), common markers for crude oil, were detected in the emissions at low and variable abundances. The winter 2011 tests showed lower abundances for these markers than the summer 2008 tests. The differences were probably due more to improvements in the process control and feedstocks than seasonal differences.

FUGITIVE DUST

Fugitive dust refers to small particles of geological origin that are suspended into the atmosphere from non-ducted emitters by mechanical processes or high wind speeds. Overburden, oil sands, tailings ponds, paved and unpaved parking lots, paved and unpaved roads and shoulders, construction sites, unenclosed storage piles (coke and sulfur), and material transfer systems are the major fugitive dust sources in the AOSR. Visible dust plumes are often noticed over these sources when wind speeds are high and when vehicles are moving. Fugitive dust characterization focuses on measuring source profiles and surface resuspension characteristics.

Figure 2. Stack Emission Dilution Sampling System Collects Condensables and Allows for Measurement of Many Chemical Components.



The dust chemical fingerprint may be useful to distinguish one fugitive dust source from another in the AOSR. In a 2008 pilot study, geological grab samples were collected from 27 locations that are believed to represent the surface-suspendable material. Three or more samples were taken over the surface and mixed to represent the average expected composition. These samples were dried and then sieved to 38 μm geometric diameter. The smallest sieved fraction was then puffed into the resuspension chamber for sampling through $PM_{2.5}$ and PM_{10} size-selective inlets onto filters for chemical analysis and development of source profiles. In addition to elements, ions, and carbon, rare earth elements, isotopic abundances (especially for lead), and organic compounds were analyzed in search of source markers and potential pollution sources. Analyses of these samples shows that some of the non-geological components are enriched over native soils at locations closer to emission sources, but the abundances are highly variable.

Other important fugitive dust properties include their size distributions, the amount available for suspension, and the threshold friction velocity. These can be characterized using a *P*ortable *I*n-*S*itu *W*ind *E*rosion *L*aboratory (PI-SWERL) during summer of 2012 to improve emission rates and chemical markers for several wind erodible surfaces, including tailings ponds, unpaved and paved roads, bare land surfaces, limestone quarry, aggregate processing plants, native soils, coke/sulfur storage piles, and de-icing/sanding materials. Results can be used to improve the accuracy of windblown dust emission inventories and to evaluate efficacy of dust control measures. Additional information of particle size distribution and chemical composition of the windblown dust can be used to evaluate particle transport distance, heath effect, and source apportionment.

REPRESENTATIVENESS OF EMISSION MEASUREMENTS

Tests to date have been comprehensive in terms of the components measured in each emission source, with more than 300 quantifiable compounds sought in each source type (Wang et al., 2011; 2012; Watson et al., 2008; 2010a; 2010b; 2011a; 2011b). Even though many of these were undetectable in some sources, the measurements provide valid upper limits on what might be contributed to the atmosphere by each source. In addition to chemicals that might adversely affect the environment, source markers such as specific elements, organic compounds, and isotopic ratios were sought that would allow identification and quantification of source contributions at sensitive ecosystem receptors. Future tests will involve smaller, more practical test procedures that focus on fewer variables, but that can be more cost-effectively deployed at a larger number of times and places. It is hoped that results from these real-world emissions tests will encourage modification of the compliance and certification methods currently in use to better represent actual AOSR emissions that can be used to evaluate effects.

REFERENCES

Wang, X.L.; Robbins, C.; Hoekman, S.K.; Chow, J.C.; Watson, J.G.; Schuetzle, D. (2011). Dilution sampling and analysis of particulate matter in biomass-derived syngas. *Frontiers of Environmental Science and Engineering in China*, 5(3):320-330.

Wang, X.L.; Watson, J.G.; Chow, J.C.; Gronstal, S.; Kohl, S.D. (2012a). An efficient multipollutant system for measuring real-world emissions from stationary and mobile sources. *Aerosol and Air Quality Research*, 12(1):145-160.

Watson, J.G.; Chow, J.C. (2008). Real-world emissions characterization and data uses in Northern Alberta. prepared by Desert Research Institute, Reno, NV, USA, for Wood Buffalo Environmental Association, Fort McMurray, AB, Canada.

Watson, J.G.; Chow, J.C.; Wang, X.; Kohl, S.D.; Sodeman, D.A. (2010a). Measurement of real-world stack emissions with a dilution sampling system. Report Number 010109-123109; prepared by Desert Research Institute, Reno, NV, for Ft. McMurray, AB, Canada, Wood Buffalo Environmental Association.

Watson, J.G.; Chow, J.C.; Wang, X.; Kohl, S.D.; Gronstahl, S. (2010b). Measurement of in-use emissions from non-road diesel trucks. Report Number 010109-123109; prepared by Desert Research Institute, Reno, NV, for Ft. McMurray, AB, Canada, Wood Buffalo Environmental Association.

Watson, J.G.; Chow, J.C.; Wang, X.L.; Kohl, S.D.; Gronstal, S. (2011a). Winter stack emissions measured with a dilution sampling system. prepared by Desert Research Institute, Reno, NV, for Ft. McMurray, AB, Canada, Wood Buffalo Environmental Association.

Watson, J.G.; Chow, J.C.; Wang, X.L.; Lowenthal, D.H.; Kohl, S.D.; Gronstal, S. (2011b). Real-world emissions from non-road mining trucks. Report Number 010109-123109; prepared by Desert Research Institute, Reno, NV, for Ft. McMurray, AB, Canada, Wood Buffalo Environmental Association.

Dr. John G. Watson, Dr. Judith C. Chow, and Dr. Xiaoliang Wang
Division of Aerosol Sciences, Desert Research Institute, Nevada System of Higher Education, Reno, NV, USA

6.0 Human Exposure Monitoring Program

6.1 Message from the HEMP Chair

The Human Exposure Monitoring Program (HEMP) accomplished several committee initiatives in 2011.

In 2009, HEMP's mandate was refocused toward odour detection and chemistry. During 2011, the two specialized instruments brought into the region for odour detection and quantification continued to yield data.

The Pneumatically Focused Gas Chromatograph (PFGC), pictured, was operational at AMS #1 Fort McKay throughout the year. The PFGC can simultaneously detect volatile organic compounds (VOCs) and sulphur-containing compounds. In addition to near-continuous monitoring for a range of VOCs, the PFGC also provides speciation information for a wide range of inorganic and organic sulphur compounds.

WBEA worked with ODOTEC Inc., specialists in the measurement and monitoring of odours, to install an electronic nose, pictured, at AMS# 1-Fort McKay. The "e-nose" measures the strength and frequency of odours at Fort McKay.

HEMP held two member's workshops in 2011 to discuss the data generated from these instruments. The first HEMP Odour Workshop, on April 13th, served to identify issues, concerns, and knowledge gaps relating to odours in the Wood Buffalo region, summarize existing work on odours, and define a path forward for odour measurement and management. Fort McKay elders and community members also attended this workshop.

A follow up Odour Workshop, on September 28th, focused on technical issues and was attended by HEMP Committee members along with some members of the CEMA Air Working Group.

During the extended regional forest fire episode in the spring of 2011, WBEA provided twice daily updates on air quality and particulate matter concentrations to the Alberta Health Services regional medical health officer to inform public health announcements; the community of Fort McKay which was in close proximity to the fire; and industry members operating within the fire's reach. Messages on WBEA's Air Information Hotline and website were updated three times a day during the height of this extended air quality incident.

Top Left: Pneumatically Focused Gas Chromatograph.

Bottom Left: Electronic Nose.

Right: A WBEA-HEMP Odour Workshop was Held on September 28th. Attendees were (front row l to r) Shamini Samuel, Suncor; Sunny Cho, Alberta Environment and Water(AEW); Jane Percy, WBEA; Kim Carnochan, WBEA; Prabal Roy, AEW; Mark Anderson, Husky; Angela Pohl, Suncor; Lori Adamache, AEW; Wally Qin, AEW; Brooke Bennett, Syncrude; John Dennis, Fort McKay and WBEA-HEMP Alternate Chair; Allan Legge, WBEA; back row (l to r) Bob O'Brien, VOC Technologies; Randy Visser, Nexen and WBEA-HEMP Chair; David Spink, Fort McKay; Thierry Pagé, Odotech; Lance Miller, Devon; Kevin Percy, WBEA; Nick Veriotes, Total; Asish Mohapatra, Health Canada.

In September, WBEA began to report the Air Quality Health Index (AQHI) which was introduced provincially by Alberta Environment and Water (AEW) to replace the former Air Quality Index. The AQHI is an index designed to explain the level of risk that changes in air quality can have upon health. The four components of the AQHI are: a number from 1 to 10 indicating the air quality; a category that describes the level of health risk; a customized health message for each category; and current hourly AQHI readings with maximum values for the present and future.

The national AQHI is calculated based on the relative health risks of a combination of common air pollutants which are known to harm human health. These include Ozone (O_3) at ground level, Particulate Matter ($PM_{2.5}$/PM_{10}) and Nitrogen Dioxide (NO_2). Because of Alberta's energy-based economy, other pollutants monitored in this province are also considered when reporting the Alberta AQHI. These pollutants include sulphur dioxide (SO_2), hydrogen sulphide (H_2S), total reduced sulphur (TRS), and carbon monoxide (CO). The AQHI also suggests how a person may adjust their activity level depending on their individual health risk from air pollution. The AQHI provides citizens of the RMWB with immediate air quality information related to health.

Data from four WBEA air monitoring stations Fort McKay (AMS #1), Athabasca Valley (AMS #7), Fort Chipewyan (AMS #8), and Fort McKay South (AMS #13), are used to calculate the AQHI. A "next day" forecast function is also available for AMS #1, 7, and 13. The AQHI is update hourly and reported on our website and an electronic message centre at our headquarters.

Throughout 2011, WBEA's HEMP improved knowledge of industrial odours, provided vital information about air quality during regional forest fires, and WBEA lead the way in reporting the new AQHI in the region. HEMP will continue to respond to the concerns of our stakeholders with innovative solutions to regional odour concerns.

Randy Visser, Nexen Inc.
HEMP Chair

7.0 Data Management Program

The goal of the Data Management Program is to develop, operate and maintain a Data Management System (DMS) that is secure, robust, reliable and transparent. Redundant and reliable data collection, paired with simple data access portals enables WBEA to consistently provide data to its members and the general public.

To enhance redundant and reliable data collection and distribution, the DMS underwent major changes. In 2011, the Data Management Program made outstanding strides towards improving the reliability and quality of the DMS. Achievements for 2011 include:

1. In-house Data Management System management
2. Re-locating Data Management Servers
3. Replacement server acquisition - AATC O&M transition to in-house
4. Data Management System Development
5. Data Management System Documentation

The following is a description of each achievement of the Data Management Program for 2011.

1) In-house Data Management System Management

Prior to 2011, the Data Management System was managed by a 3rd party. In 2011, WBEA assumed the responsibility of maintaining the DMS. With the management of the DMS in-house, WBEA can rapidly and reliably improve on the system, as a whole, based on the needs of its members and the general public. The following tasks are now performed by WBEA:

i. Data Management System Hosting and Administration:

- Website Server Management/Maintenance. The WBEA website (http://wbea.org), is now hosted and maintained by WBEA. The website is the public portal to WBEA's data and other relevant information.
- Database Server Management/Administration. The continuous air monitoring data is stored in an OSI Pi database. Regular maintenance, including backups, of this data is required.
- Data Management Network security and administration. The WBEA servers were subject to a Distributed Denial of Service (DDoS) attack in July 2011. With the installed security appliance, and Q9 monitoring the network traffic, the staff of WBEA was able to detect, and minimize the impact of the DDoS attack on the DMS servers.

ii. Data Management System Application Management and Support

- WBEA now provides direct support, troubleshooting and bug fixes for all DMS applications.

iii. Data Management System Development

- Website modifications
- Application development
- Implementation of new data interfaces
- Integration with other data systems

iv. Documentation

- All documentation about the DMS is now compiled and maintained by WBEA.

2) Re-locating Data Management Servers

There are currently four individual servers in the DMS. These servers were distributed throughout the province of Alberta. As a major milestone for WBEA in 2011, these servers have all been consolidated into a single collocation facility - Q9 Networks. (http://www.q9.com/index.html) Q9's data centres and network are backed by an industry leading Service Level Agreement (SLA) which guarantees 100% network and power availability. This translates to increased reliability of, and accessibility to WBEA's environmental data. Q9 is the industry leading data centre providing:

- Redundant internet connectivity - Connections from multiple internet service providers are piped through the data center with full Border Gateway Patrol (BGP) switching. This allows the DMS servers to connect to clients with the least amount of latency, providing fast connections coupled with high reliability.
- Redundant power supplies - The Q9 facility has two independent power lines supplying power to the DMS servers. In addition, each of these power lines have backup generators in the event of a failure.
- High Availability Cooling - A major enemy of computers is heat. Under load, servers can generate a large amount of heat. It is important to dissipate this heat efficiently. Overheating machines lead to shorter operation life, and even catastrophic failure. The cooling systems in Q9 are engineered to meet the demands of modern high-density computer hardware. Air handling systems monitor temperature and humidity to ensure maximum reliability and effective cooling of equipment.
- Restricted Biometric Access - To gain access to the DMS servers, one must pass through a mantrap which uses three authentication methods: access card scan, weight and fingerprint. Once through the mantrap, the access card and fingerprint are required again to unlock the rack unit housing the servers. This prevents unauthorized or unwanted physical access to access the DMS servers.

In addition to the increased reliability and availability of the DMS servers, they are now all housed in the same location. Inter-server communication is now 100% reliable as it does not depend on availability of an internet connection.

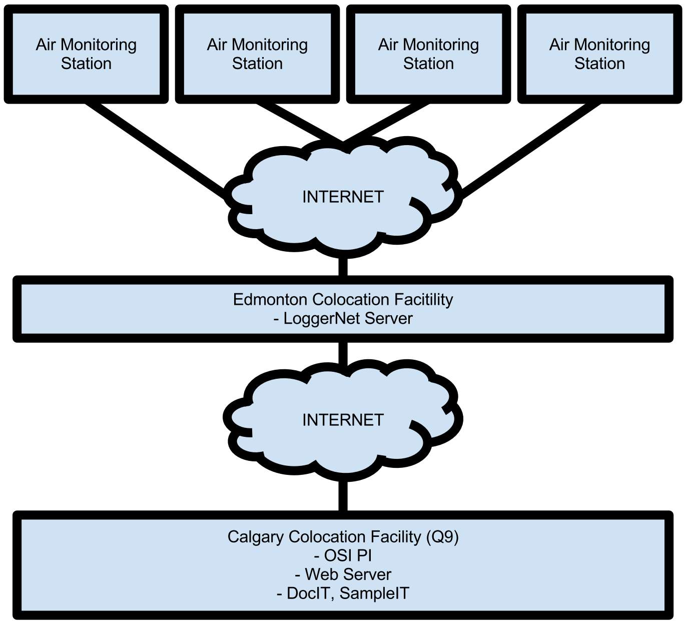
3) Replacement Server Acquisition

In anticipation of moving the Operations and Management of the WBEA air monitoring network in-house, the Data Management Program acquired a high powered server for the purpose of collecting continuous air monitoring data from each of the air monitoring stations. The server specifications are:

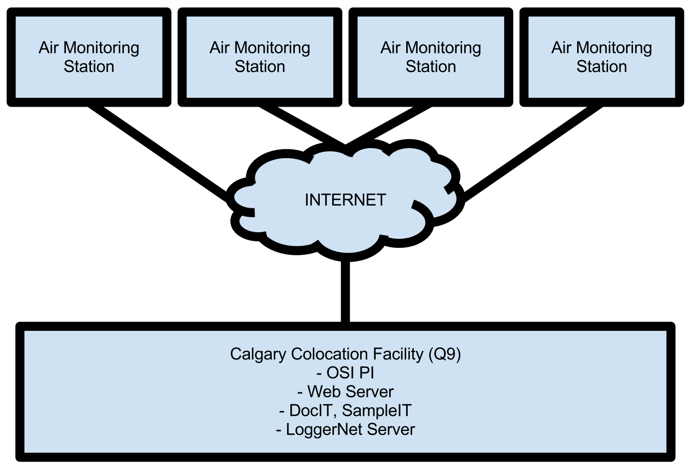
- Intel Server System SR2600URBRPR 2U Rack-mountable, hotswap 3.5"
- Intel Xeon E5649 Processor 2.53GHz
- 24 GB System Memory
- 3x1 TB 7200 RPM Western Digital Enterprise Hard Drives configured in RAID 5
- VMWare ESXi
- Windows Server 2008 64-bit

This server was installed in Q9. Housing the server in Q9 allows it to communicate directly with the existing servers in the DMS. With the high power processor (6 cores, 2 threads per core = 12 effective cores), and large memory, this computer was designed to run as a virtual machine server. This means that it will be running several installations of Windows and Linux at the same time. This creates the opportunity to design a more modular and flexible system, while simultaneously addressing issues such as load balancing. The current setup has Windows Server 2008 R2, and Windows 7 Professional installed to cover the needs of AATC. It is in the vision of the Data Management Program that this machine will eventually take on more roles of the DMS as older server hardware is phased out. This will avoid the chance of data loss due to failure of an older server.

Currently, the new server is running in conjunction with the previous AATC server (located in Edmonton). The redundant (old) servers will be shut down in early 2012, and the complete DMS will be operating from a single location.



This diagram depicts a bird's eye view of the DMS as it was at the beginning of 2011. Note that a communication interruption between the Edmonton LoggerNet server, and the Calgary collocation facility would cause a disruption in the data capture to OSI PI.



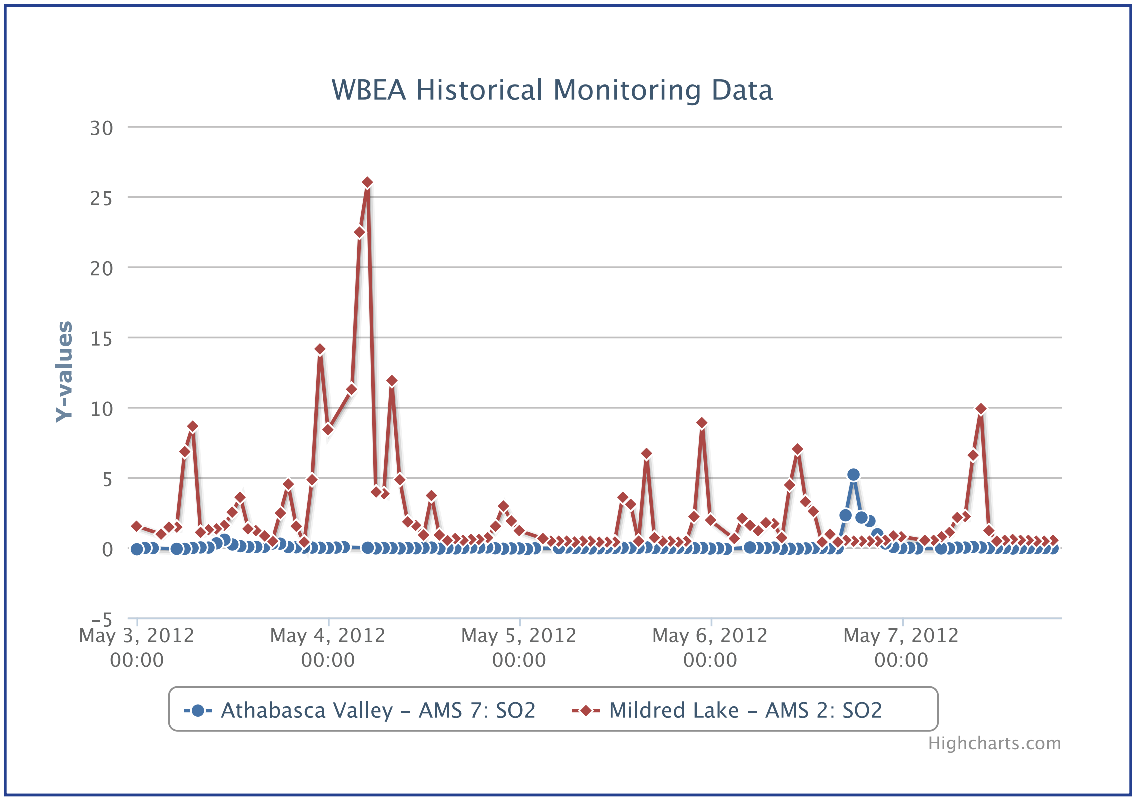
This diagram depicts the network configuration of the DMS after building, installing and activating the new server in Q9. Since the communication pathways are simplified, there are fewer points of failure. This configuration, in fact, minimizes the number of points of communication failure.

4) Data Management System Development

In 2011, some time has been dedicated to development of the DMS. In addition to streamlining the background data flow, some new applications have undergone development.

TEEM DATA FORMS

These forms were designed in 2011 to match the forms used by the scientists collecting data in the field for the forest health study. In addition to storing data for the current health study, the database was designed with the requirement that historical forest health studies can also be stored in the same location. These forms are still in the development stage, and will be fully operational by early 2012.



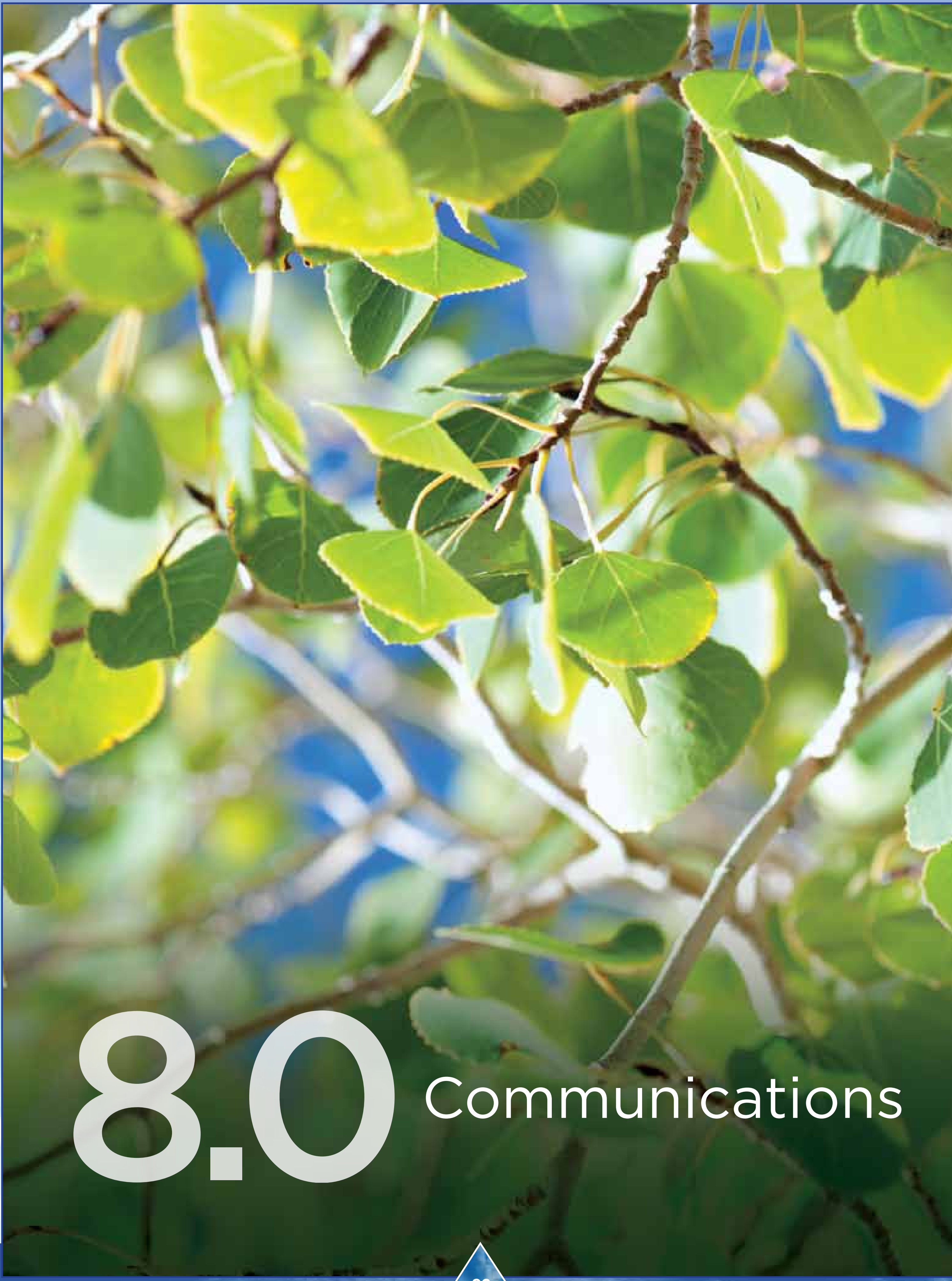
UPDATED REAL TIME GRAPHING FUNCTIONALITY

Some of the components of the DMS do not function with respect to the functional requirements of the members. One example of this was the graphing widget. The original graphing tool on the website allowed users to plot data for two parameters from a single station. It had been expressed that this functionality was not adequate for the needs of the members. As a result, the graphing functionality was rewritten to allow graphing of any number of parameters across any number of stations. The figure depicts the new graphing functionality. The SO_2 concentrations at Athabasca Valley and Mildred Lake are plotted on the same graphs so that they can be compared. Further development is underway to upgrade the user interface to be fully functional.

5) Data Management System Documentation

Since the Data Management System has grown more complex over the years, it is important to have a document which has details about all aspects of the system. This manual, started in 2011, is a living document (changes as the DMS changes) which describes the DMS structure and components, while providing a “user guide” to operating and maintaining the DMS. In the event that the current operators of the DMS are unavailable, this document will be an invaluable resource to those who will be operating and maintaining the DMS. For further details on this document, please contact Eric Nosal at enosal@wbea.org.

Eric Nosal
Data Management Specialist



8.0 Communications

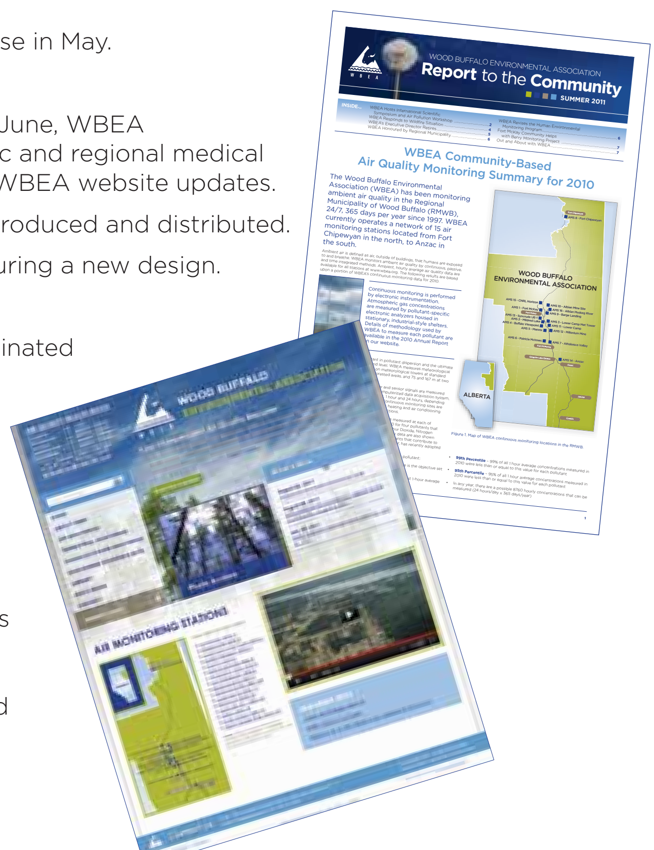
Throughout 2011, WBEA Communications sought opportunities to create awareness and understanding of WBEA through the proactive, timely and effective communication of information about our innovative, science-based monitoring programs.

- In May 2011, WBEA hosted an International Symposium entitled "Alberta Oil Sands: Energy, Industry and the Environment" and the 43rd Air Pollution Workshop. Over 120 scientists, students and researchers from around the world attended both events in Fort McMurray. WBEA Communications coordinated the electronic and printed invitations, delegate registration, promotional materials, Oil Sands Discovery Centre visit, the venue, meals, banquet entertainment, the printed program, and media relations around this very important Symposium showcasing WBEA's science.
- WBEA Communications coordinated presentations to the Mayor and Council of the Regional Municipality of Wood Buffalo, the Fort McMurray Chamber of Commerce, RMWB- MLA Guy Boutilier, The Canadian Institute "Oil Sands Environmental Management" conference, and the Minister of Alberta Environment and Water.
- WBEA was a sponsor of the 2011 Wood Buffalo Science Fair and presented three Crystal Clean Environment Awards. WBEA Communications staffed an information booth for students at the fair.
- WBEA Communications, and WBEA personnel, represented WBEA at the Oil Sands Trade Show and the Spring and Fall Fort McMurray Tourism Trade Shows held at MacDonald Island Park.

Left: Tricia Robinson, Fort McMurray Composite High School, won a WBEA Crystal Clean Environment Award during the 2011 Wood Buffalo Regional Science Fair.

Right: WBEA Booth at the Fort McMurray Spring Trade Show.

- WBEA hosted an information booth at the Conklin Open House in May.
- WBEA launched a Facebook page and YouTube channel.
- During the extended Richardson regional wildfire in May and June, WBEA Communications provided air quality information to the public and regional medical health officers through the toll-free Air Information Line and WBEA website updates.
- Two issues of WBEA@Work and a Community Report were produced and distributed.
- WBEA's website underwent a significant re-organization featuring a new design.
- The 2010 WBEA Annual Report was published.
- WBEA issued numerous media releases and advisories, coordinated several interviews, and provided information to journalists throughout the year.
- WBEA Communications coordinated a presentation to the Keyano College Environmental Technology class.
- WBEA Communications participated in the Traditional Environmental Knowledge Berry Monitoring project workshops with community members of Fort McKay.
- WBEA Communications coordinated the redesign of the signs on the façade of the WBEA headquarters building, including the installation of an electronic message centre to stream Air Quality Health Index readings (AQHI). The sign is operated by Communications.



Filming the Forest Health Survey Vignette.

- WBEA's collection of photographic images was enhanced by a professional photographer who photographed WBEA staff, program activities and the Wood Buffalo region. These images were used in the production of a 2012 desk calendar.
- WBEA Communications produced a vignette featuring the TEEM 2011 Forest Health Survey, focusing on the scientists and sampling protocols used. WBEA's video library may be found at http://wbea.org/library/wbea-videos-a-sound-clips
- Through radio and print advertisements, WBEA Communications informed the region of our programs, publications and activities. A new corporate print ad template was developed.
- WBEA Communications made presentations on our work and future initiatives to the Governance Committee and the General Membership throughout the year.

WBEA Communications will continue to promote awareness of the organization, its vision, mission and values in 2012.

Jane Percy and Melissa Pennell
WBEA Communications Consultants

9.0 Appendices

Appendix I – WBEA Governance Committee Members

Ann Dort-MacLean, President - Fort McMurray Environmental Association

Kevin Scoble, Vice President – Regional Municipality of Wood Buffalo

Michael Aiton, Director - Alberta Environment and Water

Patrick Dixon, Director – Nexen Inc. (January- September)

Lance Miller, Director - Devon Canada Corp. (December)

Doug Johnson, Director – Suncor Energy Inc.

Diane Phillips, Director – Syncrude Canada Ltd.

Dan Stuckless, Director - Fort McKay First Nation

Appendix II –

Alberta Environment and Water

Alberta Health Services

Alberta Health and Wellness

Alberta Sustainable Resource Development

Canadian Natural Resources Ltd.

Cenovus Energy Inc.

Conoco Phillips Canada

Devon Canada Corp.

Energy Resources Conservation Board

Environment Canada

Finning Canada Ltd.

Fort McKay First Nation

Fort McKay Métis

Fort McMurray Environmental Association

Hammerstone Corp.

Health Canada

Husky Energy Inc.

Imperial Oil Ltd.

MEG Energy

Nexen Inc.

Pembina Institute for Appropriate Development

Regional Municipality of Wood Buffalo

Saskatchewan Environment

Shell Canada Ltd.

Statoil Canada Ltd.

Suncor Energy Inc.

Syncrude Canada Ltd.

Total E&P Canada Ltd.

Williams Energy

Appendix III – Glossary of Terms

ABBREVIATIONS

BTEX – Benzene, Toluene, Ethylbenzene and Xylene are volatile aromatic compounds. When found in sufficient quantities they can affect human health. Benzene is a known carcinogen.

CASA - Clean Air Strategic Alliance is a multi-stakeholder society sponsored by the Alberta Health and Wellness, Alberta Energy Resources Conservation Board and Alberta Environment and Water. CASA provides a forum to discuss and address issues related to air monitoring and quality in the province of Alberta.

Chlorosis – Yellowing of leaf tissue due to a lack of chlorophyll.

CH_4 - methane is a colourless, odourless gas, which is the most common hydrocarbon in the earth's atmosphere. It is of significance as a greenhouse gas responsible for global warming. About 20% of the total greenhouse effect is attributable to methane.

NH_3 - ammonia 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), followed by biomass burning (including forest fires), fertilizer plants, and to a lesser extent fossil fuel combustion, and accidental releases.

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 particle ($\leq PM_{2.5}$ µm) fraction. A small amount of gaseous ammonia is converted to nitric oxide.

NO_x - oxides of nitrogen are formed when nitrogen combines with oxygen during the combustion of fossil fuels. Other sources are the natural degradation of vegetation and the use of chemical fertilizers. Oxides of nitrogen affect visibility and lead to ozone formation. For monitoring purposes nitrogen oxides are considered the sum of nitric oxide and nitrogen dioxide.

NO - nitric oxide is the major oxide of nitrogen produced by combustion. It is rapidly oxidized to nitrogen dioxide in the atmosphere.

NO_2 - nitrogen dioxide is the most abundant of the oxides of nitrogen in the atmosphere. It is a reddish-brown gas. The Alberta Ambient Air Quality Objectives (April 2011) for a 1-hour average concentration of 159 ppb, and an annual average concentration of 24 ppb, are based on the prevention of human effects.

O_3 - ozone at ground level is formed by the chemical reaction of hydrocarbons and NO_X in the presence of sunlight. At high concentrations, it may contribute to vegetation damage and cause respiratory problems. The Alberta objective for ozone is 82 ppb for a 1-hour average. In the stratosphere, ozone protects the earth from excessive ultraviolet radiation.

pH - the measurement of the degree of acidity on a scale of 1 to 14. One is very acidic, 7 is neutral and 14 is very alkaline. The natural pH of precipitation in the absence of pollution is 5.6.

PM_{10} - particles less than 10 micrometres (µm) in diameter, small enough to be inhaled but do not reach the lungs.

$PM_{2.5}$ - particles less than or equal to 2.5 micrometres (µm) in diameter, small enough to be inhaled and may reach the lungs. Concentrations greater than 30 µg/m^3 are thought to adversely affect pulmonary function.

SO_2 - Sulphur dioxide is formed during the processing and combustion of fossil fuels containing sulphur. It is a colourless gas with a pungent odour, and can be detected by taste and odour at concentrations as low as 300 ppb. Once emitted, SO_2 is oxidized in the plume, or, after dilution with the surrounding air to form H_2SO_4 (acid rain) and sulphates.

TRS – Total reduced sulphur compounds are composed mainly of hydrogen sulphide, methyl mercaptans, dimethyl sulphide, and dimethyl disulphide. TRS is increasingly referred to as reduced sulphur compounds, RSC.

VOCs - volatile organic compounds can be emitted naturally or as by-products of industrial processes. Examples are terpenes produced by forests, ethylene from industrial and natural sources, and chloroform from industry.

UNITS OF MEASURE

ppb - parts per billion by volume

ppm - parts per million by volume

µg/m^3 - micrograms per cubic metre

keq ha^{-1}yr - 1 - kilo equivalents per hectare per year

kg ha^{-1}yr - 1 - kilograms per hectare per year

DEFINITION OF TERMS

Alberta Ambient Air Quality Objectives (AAAQO) - concentration values adopted by the Province of Alberta with the intention to protect Alberta's air quality. AAAQO's for SO_2, NO_2, O_3 and other pollutants are based on an evaluation of scientific, social, technical and economic factors. AAAQO's may be set for 1 hour, 24 hours, 30 days, or 1-year average concentrations.

Ambient Air Quality - the concentration of pollutants in the ambient air. Generally, the concentrations of gases or particles to which the general population would be exposed, as opposed to the concentration of pollutants emitted by a specific source.

Average Annual Concentration - the sum of the 1-hour average concentration measurements for the year divided by the number of hours that valid measurements were made within that year. It can be compared against the recommended guideline for the same period to assess absolute air quality or against other year's data to assess improvement or degradation of air quality in the same air.

Critical Load - is a measure of how much pollution an ecosystem can tolerate; in other words, the threshold above which the pollutant load harms the environment. Different regions have different critical loads. Ecosystems that can tolerate acidic pollution have high critical loads, while sensitive ecosystems have low critical loads.

Target Load - the maximum level of acidic atmospheric deposition that affords long-term protection from adverse ecological consequences and that is practically and politically achievable.

Volume-weighted pH - the average pH of precipitation throughout the year when the volume of rainfall and the H+ concentration of each precipitation sample is considered.

NOTES

For more information on the Wood Buffalo Environmental Association please contact:

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Fax: (780) 715-2016
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Clean Air Strategic Alliance

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