FOCUSED STUDY ACTIVITY WORK PLAN

General Information

Work Plan Unique Identifier:	*A-PD-5-1718*	
Focused Study Activity Title:	Atmospheric Process Study – Enhanced Ground-Based Monitoring – Oski-ôtin monitoring site	
Focused Study Category:	Monitoring Design, Method Improvement, and Program Design	
Geographic Location (*choose from drop-down menu. If Project Location is in more than one area choose from second drop-down***)**	Regional Municapility of Wood Buffalo	
Monitoring Site(s) Coordinates *(latitude and longitude)*	Latitude: 57.149 Longitude: -111.642	
Responsible Managers:	Stewart Cober Jaime Dawson	
Organization and contact information:	Environment and Climate Change Canada Air Quality Processes Research Section, Air Quality Research Division (AQRD), Atmospheric Science and Technology Directorate (ASTD) 4905 Dufferin Street, Toronto ON M3H 5T4 stewart.cober@canada.ca; tel. 416-739-4618 jaime.dawson@canada.ca; tel. 905-336-4883	
Date Study initiated:	**July 2013**	
Monitoring Category: *(From OSM long-term plan; choose from drop-down menu)*	Atmospheric Monitoring	
Strategic Objective of Focused Study: *(From OSM long-term plan; choose from drop-down menu)*	Objective A1: Detect and report concentration levels and trends of atmospheric substances that are likely to cause adverse human and/or environmental health effects.	
Hypotheses: *(Briefly outline the specific hypotheses that your focused study is aiming to address)*	<u>Monitoring Design and Method Improvement</u> H1) Multi-year comprehensive air quality measurements provide seasonality and detailed information on air pollutant mixtures associated with a wide range of oil sands related activities. H2) Multi-dimensional, particle, gas-phase chemistry, meteorological, and vertical structure measurements provide critical information to evaluate the performance of the Global Environmental Multiscale – Modelling Air-quality and CHemistry (GEM-MACH) numerical air quality prediction model.	

	H3) Remote sensing technology provides useful tools to understand local to regional scale three-dimensional (3D) atmospheric transport processes (e.g. LIDAR (Light Detection and Ranging), satellite, Wind RASS (Radio Acoustic Sounding System)). H4) Source apportionment of volatile organic compounds (VOC), reduced sulphur and fine particulate matter (PM2.5) can be refined through concurrent comprehensive multi-pollutant (gas and particle) and meteorological measurements at Oski-ôtin. <u>Investigation of Cause or Potential Ecological Impact</u> H5) The cause of acute air quality (AQ) events, including odour events, in the local oil sands area can be better understood through concurrent measurements of surface and vertical chemistry and meteorology and conditional sampling.
Deliverables: *What tangible goal (s) and/or product(s) will the monitoring produce and when?*	<u>Monitoring Design and Method Improvement</u> D1) Delivery of a fast resolution, comprehensive long-term dataset including: a) Research grade products: VOC and particulate matter (PM) speciation, total sulphur, black carbon, CO (carbon monoxide), CH_4 (methane), CO_2 (carbon dioxide) (from Picarro), LIDAR (aerosol backscatter, ozone), vertical column densities from PANDORA spectrometer, CIMEL sunphotometer, WindRASS; and b) Conventional AQ and meteorological data for integration with the surrounding monitoring network and comparison with other regions within Canada (O_3 (ozone), NO (nitrogen oxide), NO_2 (nitrogen dioxide), SO_2 (sulfur dioxide), PM2.5, H_2S (hydrogen sulfide), 24 hour integrated VOCs and meteorology). D2) Provide broad access to our stakeholders and the public by a weekly upload of the level 1 data to the oil sands (OS) portal. This is in keeping with the Alberta Energy Regulator (AER) list of recommendations that state “All parties should have access to real-time monitoring data collected by Environment Canada in the community of Fort McKay”. D3) Develop and improve measurement methods for long term monitoring and potential technology transfer for the following species: total sulphur (TS) and total reduced sulphur (TRS), VOC and PM semi continuous speciation, CO (carbon monoxide), CH_4 (methane), CO_2; attempt to develop new method for NMHC (non-methane hydrocarbons); attempt to develop a conditional sampling method for TRS and hydrocarbons. Increase capacity for high time resolution VOC speciation through evaluation and application of multiple currently available instruments. D4) Evaluate a new method for observing vertical ozone profiles and assess the combined value of coincident vertical aerosol profiles in understanding the 3D atmospheric transport and chemical

	processes. D5) Improved estimates of column NO2 and SO2 on local and regional scales through the use of ground-based instruments at Oski-ôtin and satellite-retrieved observations. D6) Improve our understanding of processes on a local scale through GEM-MACH model predictions. D7) Improve regional understanding of transport and transformation of air pollutants from source to ambient by integrating Oski-ôtin results with other air quality monitoring stations in support of recommendations #14 made by the AER - "Establish an integrated, consistent approach to air quality monitoring from source (industry emissions), to fence line (Mildred Lake [AMS02], Mannix [AMS05], and Lower Camp [AMS11]) to ambient monitoring stations (AMS 01 and Oski-ôtin).". Investigation of Cause or Potential Ecological Impact D8) Detailed characterization of acute air quality events will lead to improvement in the high resolution air quality model. D9) Assess the impact of pollutants by acquiring long term trends on key chemical species combined with modelling efforts to improve our understanding of the fate of the emissions in the oil sands (OS) region.

Detailed Study Plan

(Please provide detailed information on the specifics of your focused study including – (**keywords, hypothesis and the assumptions and constraints behind your hypothesis**)

Provide a maximum of 10 key words that describe this project. Use commas to separate them:

Total reduced Sulphur (TRS), Total Sulphur (TS) Volatile Organic Compounds (VOCs), LIDAR and PANDORA remote sensing, satellite remote sensing, particle chemistry, gas-phase chemistry, oil sands region, Fort McKay community, Numerical air quality prediction modelling, atmospheric processes, source apportionment

Describe how you will test your hypothesis:

Monitoring Design and Method Improvement

H1) Multi-year comprehensive air quality measurements provide seasonality and detailed information on air pollutant mixtures associated with a wide range of oil sands related activities.

The core component of the work is the continued operation of a comprehensive suite of measurements at the Oski-ôtin site in Fort McKay, AB (see Table 1) which contribute to the Oil Sands Monitoring (OSM) objectives of understanding the emissions, transport, transformation, fate and impacts of oil sands pollutants. These measurements can also address recommendations from the AER odour report. These 'supersite' activities can be used to support other targeted measurement projects obtained from complementary nearby locations in the region. Characterizing the air pollutant mixtures impacting Fort McKay over a sustained period of time will help refine the knowledge of what is being emitted to the atmosphere from oil sands activities, by capturing a wider range of conditions than possible through short-term measurement campaigns. The sustained multi-pollutant measurements of a variety of gaseous and particulate pollutants, including in the vertical dimension will lead to observed recurrence of common mixtures thereby providing a unique dataset suitable for identifying the predominant sources impacting the region and the main local-scale atmospheric processes influencing pollutant transport, transformation and deposition.

The current spatial distribution (Oski-ôtin and AMS 01) of semi continuous VOC measurements provides information on how widespread VOC pollutants are within the community of Fort McKay. The inter-comparison of the 2013-14 datasets, including the 24 hour canisters, conducted in fiscal year (FY) 2016-17, indicated reasonable correspondence, but evidence of very local sources of benzene and toluene near Oski-ôtin. To be more indicative of VOCs associated with oil sands activities this inter-comparison will be expanded to include more compounds, particularly solvents (C6-C8) involved in bitumen extraction, which are more common than BTEX (benzene, toluene, ethylbenzene and xylene) in the oil sands region. The Alberta Environment and Parks (AEP) Fourier Transform Infrared spectrometer (FTIR) will also be deployed to Oski-ôtin for up to 2 months of this expanded inter-comparison period. This instrument will provide additional direct inter-comparison with the existing Oski-ôtin measurements and increase the compounds detected. Furthermore, this comparison exercise will help with the interpretation of the FTIR data obtained concurrently in previous years with AMS (Atmospheric Monitoring Station) 01 and Oski-ôtin measurements, but at different locations. Once six to nine months of data have been obtained with the additional suite of VOC components (i.e., some from all seasons) from the two sites, the semi-continuous VOC measurements at AMS01 will be discontinued. Focus will be on the Oski-ôtin measurements and inclusion of the larger suite of VOCs through expansion of the Syntech monitoring system to be operated by MSC. The instrument removed from AMS01 and a new VOC instrument owned by ECCC will be configured for future special studies that require temporary multi-site operation. These studies, which are expected to be part of intensives in future fiscal years, would be designed to meet our project goals and provide new insight regarding AER's recommendations.
(Timeframe: 2017-18 to 2021)

Table 1

Measurement(s)	Instrument	Monitoring Dates
NO_x (nitrogen oxide), O_3 (ozone), SO_2, H_2S (ppb)	Airpointer with Thermo sensors for pollutants Trace level Thermos r	Aug. 2013-Aug 2016 Aug 2016- Current
Temperature (C), pressure (mb), relative humidity (%), wind speed (m/s), wind direction (degrees), precipitation rate/occurrence (mm/hr) and solar radiation (watts/m^2)	CAM-1 (Vaisala and Deka): LIDAR trailer (RM Young, Rotronix and Vaisala) Climatronics Met One	Aug. 2013-Current Aug 2016- Current
NO, NO2 and NOy (total of oxidized forms of nitrogen) (ppb)	Thermo Model 42CTL with a Mo converter	Aug. 2013-December 2015
CO (ppb)	Thermo Model 48CTL	Aug.2013-Aug. 2014
Total Sulfur (TS) (ppb)	Thermo Model 43 TL with Thermal Converter (950C) at inlet	Aug. 2013-Current
CO (ppb), CO_2, and CH_4 (ppm)	Picarro (cavity Ring Down spectrometer)	Aug. 2013-Current

Benzene, toluene, ethylbenzene xylenes (BTEX)	Syntech (GC/PID at AMS 01	2011-Current
C_5-C_9 Hydrocarbons (ppb) (every 30 min)	Syntech GC/PID	Aug. 2013-Current
$PM_{2.5}$ (µg/m^3)	5030 Thermo SHARP	Aug. 2013-Current
Black Carbon (B_{abs} in Mm^{-1})	Droplet Measurement Technologies –Photoacoustic Spectormeter	Aug. 2013-Current
Particle surface bound polycyclic aromatic hydrocarbons (PAHs), semi-quantitative (ng/m^3)	EcoChem Photo-ionization detector	Aug. 2013-Current
Particle size distributions 0.03-30 µm (number/cm^3)	GRIMM Dust monitor with Nano Particle counter	Aug. 2013-Current
Collected samples analyzed for C2-C12 VOCs (µg/m^3)	Xontech canister sampler	Aug. 2013-Current
Particle size distributions 0.5-0.30 um and aerodynamic sizing (number/cm3)	TSI Aerodynamic Particle Sizer	Aug. 2013-Current
Aerosol Optical Depth (AOD) (every 3 minutes during direct sunlight hours)	CIMEL Sunphotometer	Mid Aug. 2013-Nov.2013 Mid Feb. 2014-Current
Wind Speed (m/s) and direction (deg), turbulence and temperature (C) vertical profiles up to at least 300 meters (every 15 min)	Radio Acoustic Sounding system (RASS)	Aug. 2013-Current
Vertical column density SO_2 and NO_2 (Dobson Units) (10 min averages during direct sunlight periods)	Pandora spectrometer	Mid Aug. 2013-Nov.2013; Mid Aug. 2014-Current
Vertical aerosol profiles into the upper troposphere (Backscatter ratio)	Light Detection and Ranging (LIDAR)	Oct. 2013-Current
Vertical ozone profiles from near ground to 7 km	DIfferential Absorption LIDAR (DIAL)	Nov 2016 - Current

H2) Multi-dimensional, particle, gas-phase chemistry, meteorological, and vertical structure measurements provide critical information to evaluate the performance of the Global Environmental Multiscale – Modelling Air-quality and CHemistry (GEM-MACH) numerical air quality prediction model.

Oski-ôtin provides a key time series for more detailed, long-term evaluation of air quality model predictions, compared to what is available from the ongoing compliance monitoring in the region. Collectively, the data will contribute to the evaluation and improvement of the air quality numerical prediction model (GEM-MACH) so that it can used with greater confidence to study atmospheric transport, transformation and deposition in order to determine the fate of oil sands emissions and to complement the assessment of potential long-term ecosystem effects and human health impacts.

Local scale model runs will be undertaken to evaluate the model's capability in predicting the atmospheric fate of emissions, using the Oski-ôtin data to validate and constrain the model output. For example, the model derived plume rise and plume height plays a significant role in determining the transport of the air pollutants. The plume height derived from the ECCC LIDAR data could help constrain this parameter to improve model predictions. AEP will contribute to the program by providing simulated air quality using the Air Mapping Tool and participating in the joint VOC source apportionment and data analysis. The particle size distributions data from CAM1 (Canadian Air Monitoring trailer) can be used to validate the model predicted particle size distributions that are used to calculate the dry deposition of particulate matter in the region.

Ongoing evaluation of the model is necessary to improve the model and/or demonstrate model skill

('validate'), which helps reduce and/or quantify uncertainty in model predictions of ambient concentrations and deposition over and downwind of the oil sands region. These predictions are essential for the air component's integration with the water and wildlife components to understand potential effects and ultimately for determining if and/or when and/or where long-term ecosystem effects of oil sands emissions may be occurring.
(Timeframe: 2017-18 to 2021)

H3) Remote sensing technology provides useful tools to understand local to regional scale 3D atmospheric transport processes (e.g., LIDAR, satellite, WIND RASS).
ECCC has designed, developed and tested a new ozone LIDAR system for deployment to the site. To maintain current capability of aerosol vertical profiling and complement the ozone vertical profiles a new 3D wavelength aerosol LIDAR is housed in the same trailer facility. These new data will be used to help determine reasons that ozone in the region is low despite large emissions of NOx and VOCs (e.g., it is possible that O3 is low because of the proximity of NOx sources). LIDAR observations will also provide valuable data for model evaluation and studies of ozone long range transport and stratosphere-troposphere exchange. The continued use of secondary products that predict planetary boundary layer height, long-range transport events and plume height characteristics provide information on the 3D atmospheric processes.

An addition to the LIDAR measurements, column derived SO2 and NO2 from the PANDORA instrument and column aerosol optical depth from a CIMEL sunphotometer provide measurements that can be used to ground-truth the satellite observations. Satellite-based measurement of air pollutant vertical column measurements over the surface, which can also be used to estimate near-surface concentrations, is an emerging technology for long-term monitoring. However, development of methods for using these data and assessment of their reliability requires surface-based 'ground-truthing' using comparable approaches. The vertical measurements obtained at Oski-ôtin are essential for this purpose and thus ultimately increase confidence in satellite-based measurements over the oil sands and elsewhere in Canada. Continued operation of the WIND RASS sonar system provides the local meteorological wind fields directly determining the up wind sources near ground level and aloft over the site. These remote sensors provide a coherent 3D picture of the transport processes impacting the ground site and the region nearby.

These large datasets will be analyzed, data posted to the portal, and the results published in scientific journals. This analysis will also create the knowledge base to produce the Ground and Satellite-based Remote Sensing Synthesis report in 2019/2020.
(Timeframe: 2017-18 to 2021)

H4) Source apportionment of VOC, reduced sulphur and PM2.5 can be refined through concurrent comprehensive multi-pollutant (gas and particle) and meteorological measurements at Oski-otin.
AER Recommendation #15 states "Using the best available knowledge, improve consistency of H2S and total reduced sulphur monitoring, including examination of individual sulphur compounds in the ambient air monitoring network in the oil sands".

Testing improved measurement techniques for total reduced sulphur (TRS) that reduce the interference from ambient dust and improve the detection limit. This work involves collaboration with Wood Buffalo Environmental Association (WBEA) and AEP in order to improve our overall understanding of TRS and alternative measurement methods in the region.
(Timeframe: 2017-18 to 2021)

Investigation of Cause or Potential Ecological Impact

H5) The cause of acute AQ events, including odour events, in the local oil sands area can be better understood through concurrent measurements of surface and vertical chemistry and meteorology and conditional sampling.

Oski-ôtin monitoring data obtained as described above are a backbone of these investigations. Integrated data analyses focusing on events, their pollutant mixture signatures, their meteorological conditions and 3D structure (vertically profiled information from the ECCC LIDAR unit, CIMEL, Pandora and WIND RASS), is the core activity for this component of the research. This will also include accessing and interpreting GEM-MACH model runs for key events. Furthermore, these data analyses will aim to answer the key questions in AER's Recommendation #14 ("Establish an integrated, consistent approach to air quality monitoring from source (industry emissions), to fence line (Mildred Lake [AMS02], Mannix [AMS05], and Lower Camp [AMS11]) to ambient monitoring stations (AMS 01 and Oski-ôtin. ….."). Concurrent WBEA data will be included to be able to link measurements along the pollutant transport path. It is expected that knowledge gained from this analysis will inform possible deployment of additional measurement platforms during the 2018 Aircraft Campaign, which will help understand the processes at play within the community airshed and the apportioning of local versus industrial sources.
(Timeframe: 2017-18 to 2021)

NOTE: AEP is leading a focus study, Strengthen Community Reporting of Odours - Ambient Air Odour Study (A-CM-1-1718), under which air monitoring will be conducted to identify the components of odour in select communities within the Municipality of Wood Buffalo, including Fort McKay and Fort McMurray. The AEP activity will be coordinated with this Focus Study.

Assumptions and Constraints behind the hypothesis and the testing method:

We assume that the constraints limiting the frequent posting of data to the portal can be overcome so that a mechanism for posting regular data at weekly or more frequent interval will be possible. Widely accessible near real-time Oski-ôtin data also depends upon very regular staffing availability to produce the dataset.

Related to data accessibility, is the capacity to quality assure/quality control (QA/QC) new data. As an example, the total number of compounds to be measured at AMS01 will temporarily increase, thereby increasing the amount of time needed to QA/QC the new data. An appropriate level of staffing capacity and requisite resources is needed.

Sufficient time is required to gather a minimum of five years of quality data from each of the monitoring instrument platforms in order to draw firm conclusions about seasonal patterns and the relationship between local meteorology and movement of air pollutants.

Linkages:

There are a series of linkages between this project and other air component focus studies and long-term monitoring, including as follows:

H1, H2 and H3, detailed above, link with the ECCC/AEP led focus study, Ambient Air Monitoring Network Optimization (A-PD-3-1718), with the ECCC led focus study, OS Air Pollution Emissions, Transformation and Fate (A-PD-4-1718), and links with the ECCC/AEP led focus study, Develop Methods to Measure Tailings Ponds Emissions (A-MD-7-1718). The ground-based activities associated with H1, H2 and H3 will be enhanced in FY2018-19, particularly in relation to vertical profiles and VOC measurements, to complement the aircraft intensive campaigns in 2018. These activities will be detailed in the ECCC led focus study, OS Air Pollution Emissions, Transformation and Fate (A-PD-4-1718).

H4 and H5, detailed above, links with the AEP led focus study, Strengthen Community Reporting of Odours - Ambient Air Odour Study (A-CM-1-1718).

H4, detailed above, links with the ECCC/AEP led focus study, Develop Methods to Measure Tailings Ponds Emissions (A-MD-7-1718).

Outcomes of this focus study will be integrated in several of the proposed synthesis reports, under Air Evaluation Integration Synthesis and Reporting - Technical Audience (R-1-1718) including Synthesis report #3 – 2019/2020: Remote Sensing – ground- and satellite-based, and Synthesis report #7 – 2020/2021: Analysis of trends of criteria air contaminants from long-term and focused studies.

References:

Fioletov, V. E., C. A. McLinden, A. Cede, J. Davies, C. Mihele, S. Netcheva, S.-M. Li, and J. O'Brien, Sulphur dioxide (SO2) vertical column density measurements by Pandora spectrometer over the Canadian oil sands, Atmos. Meas. Tech, 9, 2961–2976, 2016.

McLinden, C. A., V. Fioletov, N. Krotkov, C. Li, K. F. Boersma, and C. Adams, A decade of change in NO2 and SO2 over the Canadian oil sands as seen from space, Env. Sci. Tech., 2016.

McLinden, C. A., V. Fioletov, K. F. Boersma, S. Kharol, N. Krotkov, P. A. Makar, R. V. Martin, J. P. Veefkind, and K. Yang, Satellite retrievals of NO2 and SO2 over the Canadian oil sands and comparisons with surface measurements, Atmos. Chem. Phys., 14, 3637–3656, 2014.

Shephard, M. W., C. A. McLinden, et al. Tropospheric Emission Spectrometer (TES) satellite observations of ammonia, methanol, formic acid, and carbon monoxide over the Canadian oil sands: validation and model evaluation, Atmos. Meas. Tech., 8, 5189-5211, 2015.

Sioris, C. E., C. A. McLinden, M. W. Shephard, M. W., V. E. Fioletov, and I. Abboud, Assessment of the aerosol optical depths measured by satellite-based passive remote sensors in the Alberta oil sands region, Atmos. Chem. Phys. Discuss., 17, 1931-1943, 2017 doi:10.5194/acp-17-1931-2017

Strawbridge, K.B. Developing a portable, autonomous aerosol backscatter lidar for network or remote operations, Atmos. Meas. Tech,. 6, 801-816, 2013.

Data Management

If this work generates data please summarize your project-level data management plan.

Deliverables	**Timeframe**
Data Collection Period: *CAM 1 Instrumentation* *LIDAR (ozone and aerosol)* *PANDORA* *windRASS* *CIMEL* *AMS 01 Syntech*	Start : 2017-04-01 End: 2021-03-31
Data Analysis Period: *Laboratory analysis and QA/QC of data* *LIDAR and windRASS data will be analyzed quarterly (e.g. , Q1 data will be analyzed and uploaded to the portal by the end of Q2)* *PANDORA spectrometer and CIMEL sunphotometer will be analyzed yearly (e.g. 2017 data will be analyzed by March 31, 2018)* *Syntech data will be analyzed yearly (e.g. 2016 data will be ready by March 31, 2018)*	Start : 2017-04-01 End: 2021-03-31
Data Release Date: *Weekly updates to the Portal of CAM 1 data* *Quarterly updates to the Portal for LIDAR and windRASS data* *Yearly updates to the portal for PANDORA spectrometer and CIMEL sunphotometer* *Yearly updates to the portal for AMS 01 Syntech data (1 year behind)*	Start : 2017-04-01 End: 2021-03-31

Reporting and Publications

Provide information on the anticipated reports / publications. (Insert additional rows if needed)

Expected Subject/Titles of Publications or Reports	Short Description of Publication or Report	Expected Year of Publication
Results from a comprehensive air quality monitoring station in the OS Region of Alberta	Description of pollutant concentrations and ratios during the primary pollutant events, the presence of solvents in the air during the episodes.	2017
Novel method to monitor the total sulfur (TS) compounds in the troposphere	Describe the improvements in measuring TS by minimizing the inlet losses; new methodology to derive total reduced sulfur (TRS); comparison with the conventional TRS method.	2017
LIDAR plume measurements in the OS Region	LIDAR data are being analyzed for two sites (Mannix and Oski-otin) to look at when the plume is over the site and when it impacts the ground (time of day and seasonality).	2017
Vertical column density measurements (VCD) – What can we learn from them?	The study is about the link between VCDs and surface concentrations of NO2 and SO2 as a function of the wind speed and planet boundary layer (PBL) height.	2017
Planetary boundary layer: LIDAR, WINDRASS and Model comparison	Comparison between LIDAR derived PBL heights, WINDRASS and GEM-MACH model output. Waiting for the model runs.	2018
Anthropogenic atmospheric CH4 sources in the Alberta oil sands region	Paper would be based on using measurements made during the Alberta cold season from a small mobile platform to quantify CH4 emissions from various OS facility sources.	2019
Time Resolved VOC Measurements in the Fort McKay, AB area associated with oil sands activities	Summary of the summer campaign measurements taken at Oski-ôtin in 2018.	2018

Technical / Professional Roles and Responsibilities

Identify members of the monitoring team/organization, their roles and responsibilities. Identify monitoring organization leads if different from overall monitoring activity lead. (Insert additional rows if needed)

Role	Responsibilities	Resource Name/Organization
Project Management	ECCC OS Air Component Manager OS Air Coordinator	ECCC
Project Lead	Project coordination, reporting	ECCC
Project Investigators	Data IM/IT Site Technical support Site Program support Project Coordination	ECCC and AEP
Project Support	Instrument PIs	ECCC and AEP
Project Support	IM/IT	ECCC
Project Support	Laboratory analyses	ECCC

Deliverables (Year 1) If your Focus Study is longer than 1 year then complete **Appendix 3** for multi-year deliverables breakdown

Provide a summary of tangible quarterly deliverables. Identify major project areas (deliverables) and results that can be identified as a tangible goal. This could include: field work, lab work/ analysis, evaluation, data, reports, publications, SOPs etc. Do not define process as your Deliverable e.g. 'fly to Ft. McMurray to conduct fieldwork' or 'seek Director approval for report'.

Deliverable(s) (please provide enough information to support status reporting)
Q1 – April to June
A short interim report (1-2 pages) will document project progress including implementation of activities, ongoing observations, data analysis, submissions to the data portal, presentations, conference abstracts and publications.
CAM1 weekly updates of near real time data to the portal
LIDAR Ozone profiles for Q4 2016 delivered to data portal
LIDAR aerosol daily curtain images for Q4 2016 delivered to data portal
Q2 – July to September
A short interim report (1-2 pages) will document project progress including implementation of activities, ongoing observations, data analysis, submissions to the data portal, presentations, conference abstracts and publications.
CAM1 weekly updates of near real time data to the portal
LIDAR Ozone profiles for Q1 delivered to data portal
LIDAR aerosol daily curtain images for Q1delivered to data portal
Q3 – October to December
CAM1 final 2016 data delivered to the portal
A short interim report (1-2 pages) will document project progress including implementation of activities, ongoing observations, data analysis, submissions to the data portal, presentations, conference abstracts and publications.
CAM1 weekly updates of near real time data to the portal
LIDAR Ozone profiles for Q2 delivered to data portal
LIDAR aerosol daily curtain images for Q2 delivered to data portal
Q4 – January to March
A short interim report (1-2 pages) will document project progress including implementation of activities, ongoing observations, data analysis, submissions to the data portal, presentations, conference abstracts and publications.

CAM1 weekly updates of near real time data to the portal
LIDAR Ozone profiles for Q3 delivered to data portal
LIDAR aerosol daily curtain images for Q3 delivered to data portal
2016-AMS 01 VOC data to be posted to the data-portal
Data collection for column NO2, SO2 and Aerosol Optical Depth from April 1, 2017 to March 31, 2018 with final validated 2017 data to be delivered by March 31, 2018.
Greenhouse gas data delivered to data portal

Detailed Financial Breakdown – Year 1 of 3 (2017-2018)

Also complete **Appendix B** for the multi-year financial breakdown

Budget requirements – List areas that require budget expenditures: (ADD OR DELETE BUDGET CATEGORIES AS REQUIRED)	OS Funding	External Funding (*outside JOSM*)
O&M - Operations and Maintenance:		
Field Costs	$129,000 (ECCC-CAM1) $25,000 (ECCC-LIDAR) $10,000 (AEP)	$150,000 (ECCC)
Data Management	$2,500 (AEP)	$20,000 (ECCC)
Internal Lab Analysis	$24,000 (ECCC-CAM1)	$
Consumable Materials & Supplies	$41,000 (ECCC-CAM1) $30,000 (ECCC-LIDAR) $10,000 (ECCC-SAT) $36,600 (ECCC-VOC)	
Publication Costs	$2,500 (AEP)	$10,000 (ECCC)
Sub-Total	$194,000 (ECCC-CAM1) $55,000 (ECCC-LIDAR) $10,000 (ECCC-SAT) $36,600 (ECCC-VOC) $15,000 (AEP)	$180,000 (ECCC)
O&M - Travel		
Field Work	$90,000 (ECCC-CAM1) $35,000 (ECCC-LIDAR) $10,000 (ECCC-SAT) $4,000 (ECCC-VOC) $10,000 (AEP)	$
Conferences (*identify conference*)		$
Meeting (*identify meeting*)		$
Sub-Total	$90,000 (ECCC-CAM1)	$

Budget requirements – List areas that require budget expenditures: (ADD OR DELETE BUDGET CATEGORIES AS REQUIRED)	OS Funding	External Funding (*outside JOSM*)
	$35,000 (ECCC-LIDAR) $10,000 (ECCC-SAT) $4,000 (ECCC-VOC) $10,000 (AEP)	
O&M - External Contracts/PDFs :		
Goods and Services Contract (*describe contractor*)	$2,400 (ECCC-VOC) Contractor: WBEA	$
PDFs	$9,500 (ECCC-LIDAR) $63,000 (ECCC-SAT) $32,500 (ECCC-GHG)	
Sub-Total	$9,500 (ECCC-LIDAR) $63,000 (ECCC-SAT) $2,400 (ECCC-VOC) $32,500 (ECCC-GHG)	$
Salaries:		
Principal Investigator	**$**	$
Technical / Professional Assistants	$152,982 (ECCC-CAM1) $80000 (AEP)	$630,000 (ECCC)
Field Staff	$134,000 (ECCC-VOC) $10,000 (AEP)	$80,000 (ECCC)
Sub-Total	$152,982 (ECCC-CAM1) $134,000 (ECCC-VOC) $90,000 (AEP)	$710,000 (ECCC)
Total Salaries	**$376,982** $286,982 (ECCC) $90,000 (AEP)	$710,000 (ECCC)
Total O&M	**$565,859** $540,859 (ECCC) $25,000 (AEP)	$180,000 (ECCC)
2017-2018 GRAND TOTAL (*before other related costs)	**$827,841 (ECCC)** **$115,000 (AEP)**	$890,000 (ECCC)

* For ECCC, total Salary ($286,982) with other related costs is $394,658 in 2017-18. For AEP, total salary is $90,000 in 2017-18. For ECCC, total O&M in 2017-18 ($540,859) with other related costs is $600,342. For AEP, total O&M is $25,000 in 2017-18. The Grand Total for is **$1,110,000** (ECCC with other related costs the grand total is $985,000 and for AEP is $125,000).

Appendix 1 – Approvals

Project Submitted by:

Name: Stewart Cober		
Organization: ECCC	Signature:	Date:

Project Approved by:

Dr. Monique Dubé (AEP)		**Dr. Kevin Cash (ECCC)**
Signature 		Signature 
Date		Date

APPENDIX 2 – Detailed Multi-year Financial Breakdown (Complete the following detailed financial breakdown; add or delete categories as required)

Budget requirements	Year 1 (2017- 2018) APPROVED		Year 2 (2018- 2019) ESTIMATE, PENDING APPROVAL		Year 3 (2019- 2020) ESTIMATE, PENDING APPROVAL		Year 4 (2020- 2021) ESTIMATE, PENDING APPROVAL	
	Cash	In-kind	Cash	In-kind	Cash	In-kind	Cash	In-kind
1) Salaries and benefits								
a) Investigators								
b) Technical/professional assistants	$232,982 ($152,982 ECCC; $80,000 AEP)	$630,000	$232,982 ($152,982 ECCC; $80,000 AEP)	$630,000	$232,982 ($152,982 ECCC; $80,000 AEP)	$630,000	$232,982 ($152,982 ECCC; $80,000 AEP)	$630,000
c) Field Staff	$144,000 ($134,000 ECCC; $10,000 AEP)	$80,000	$144,000 ($134,000 ECCC; $10,000 AEP)	$80,000	$144,000 ($134,000 ECCC; $10,000 AEP)	$80,000	$144,000 ($134,000 ECCC; $10,000 AEP)	$80,000
2) Operations and maintenance								
a) Facilities								
b) Equipment								
c) Lab analysis	$24,000 (ECCC)		$24,000 (ECCC)		$24,000 (ECCC)		$24,000 (ECCC)	
d) Data management	$2,500 (AEP)	$20,000 (ECCC)	$2,500 (AEP)	$20,000 (ECCC)	$2,500 (AEP)	$20,000 (ECCC)	$2,500 (AEP)	$20,000 (ECCC)
e) Field work	$164,000 ($154,000 ECCC;	$150,000 (ECCC)	$164,000 ($154,000 ECCC;	$150,000 (ECCC)	$164,000 ($154,000 ECCC;	$150,000 (ECCC)	$164,000 ($154,000 ECCC;	$150,000 (ECCC)

	$10,000 AEP)		$10,000 AEP)		$10,000 AEP)		$10,000 AEP)	
3) Consumable Materials and supplies								
a) Consumables	$117,600 (ECCC)		$119,600 ($117,600 ECCC; $2,000 AEP)		$119,600 ($117,600 ECCC; $2,000 AEP)		$119,600 ($117,600 ECCC; $2,000 AEP)	
b)								
4) Travel								
a) Conferences and meetings			$7,000 ($2,000 ECCC; $5,000 AEP)		$7,000 ($2,000 ECCC; $5,000 AEP)		$7,000 ($2,000 ECCC; $5,000 AEP)	
b) Field work	$149,000 ($139,000 ECCC; $10,000 AEP)		$149,000 ($139,000 ECCC; $10,000 AEP)		$149,000 ($139,000 ECCC; $10,000 AEP)		$149,000 ($139,000 ECCC; $10,000 AEP)	
c) Project-related travel								
5) Dissemination & Engagement								
a) Publications/Reports	$2,500 (AEP)	$10,000	$2,500 (AEP)	$10,000	$2,500 (AEP)	$10,000	$2,500 (AEP)	$10,000
b) Translation (if required)								
c) Communications								
d) Stakeholder Engagement								

e) Indigenous Peoples Engagement								
6) External Contracts								
a) Goods and Services Contract	$2,400 (ECCC)		$3,300 (ECCC)		$3,300 (ECCC)		$3,300 (ECCC)	
7) Postdoctoral Fellows								
Postdoctoral Fellows	$48,300 (ECCC)		$189,000 (ECCC)		$189,000 (ECCC)		$189,000 (ECCC)	
Grand Total (*before other related costs)	**$952,841** **($827,841 ECCC;** **$115,000 AEP)**	**$890,000 (ECCC)**	**$1,037,882** **($915,882 ECCC;** **$122,000 AEP)**	**$890,000 (ECCC)**	**$1,037,882** **($915,882 ECCC;** **$122,000 AEP)**	**$890000 (ECCC)**	**$1,037,882** **($915,882 ECCC;** **$122,000 AEP)**	**$890,000 (ECCC)**

* For ECCC, total Salary ($286,982) with other related costs is $394,658 in 2017-18. For AEP, total salary is $90,000 in 2017-18. For ECCC, total O&M in 2017-18 ($540,859) with other related costs is $600,342. For AEP, total O&M is $25,000 in 2017-18. **The Grand Total for is $1,110,000** (ECCC with other related costs the grand total is $985,000 and for AEP is $125,000).

APPENDIX 3 –Years 2 and 3 Deliverables (Complete the following detailed breakdown. Provide a summary of tangible quarterly deliverables. Identify major project areas (deliverables) and results that can be identified as a tangible goal.)

Year 2 (2018- 2019)
Deliverable(s) (please provide enough information to support status reporting)
The following deliverables are based on projected activities at the present time. On an annual basis, updated deliverables and budget estimates will be provided depending on the previous years' progress and new science questions that arise.
Q1 – April to June
A short interim report (1-2 pages) will document project progress including implementation of new activities, ongoing observations, data analysis, submissions to the data portal, presentations and publications.
CAM1 weekly updates to the data portal
LIDAR Ozone profiles for Q4 2018 delivered to data portal
LIDAR aerosol daily curtain images for Q4 2018 delivered to data portal
2017 QC'd MSC GCMS Data released to the portal
Q2 – July to September
A short interim report (1-2 pages) will document project progress including implementation of new activities, ongoing observations, data analysis, submissions to the data portal, presentations and publications.
CAM1 weekly updates to the data portal
LIDAR Ozone profiles for Q1 delivered to data portal
LIDAR aerosol daily curtain images for Q1delivered to data portal
Assessing feasibility for the deployment of TRS monitoring technology based on results from 2017/2018 project. (AEP)
Q3 – October to December
A short interim report (1-2 pages) will document project progress including implementation of new activities, ongoing observations, data analysis, submissions to the data portal, presentations and publications.
CAM1 weekly updates to the data portal
LIDAR Ozone profiles for Q2 delivered to data portal
LIDAR aerosol daily curtain images for Q2 delivered to data portal

CAM1 final 2017 data delivered to the portal
Q4 – January to March
A short interim report (1-2 pages) will document project progress including implementation of new activities, ongoing observations, data analysis, submissions to the data portal, presentations and publications.
CAM1 weekly updates to the data portal
LIDAR Ozone profiles for Q3 delivered to data portal
LIDAR aerosol daily curtain images for Q3 delivered to data portal
2017 QC'd AMS 01 VOC data released to portal
Data collection for column NO2, SO2 and Aerosol Optical Depth from April 1, 2018 to March 31, 2019 with final validated 2018 data to be delivered by March 31, 2019.
Posting data collected after QA/QC (AEP)
Greenhouse gas data delivered to data portal

Year 3 (2019- 2020)
Deliverable(s) (please provide enough information to support status reporting)
The following deliverables are based on projected activities at the present time. On an annual basis, updated deliverables and budget estimates will be provided depending on the previous years' progress and new science questions that arise.
Q1 – April to June
A short interim report (1-2 pages) will document project progress including implementation of new activities, ongoing observations, data analysis, submissions to the data portal, presentations and publications.
CAM1 weekly updates to the data portal
LIDAR Ozone profiles for Q4 2019 delivered to data portal
LIDAR aerosol daily curtain images for Q4 2019 delivered to data portal
Q2 – July to September
A short interim report (1-2 pages) will document project progress including implementation of new activities, ongoing observations, data analysis, submissions to the data portal, presentations and publications.
CAM1 weekly updates to the data portal

LIDAR Ozone profiles for Q1 delivered to data portal
LIDAR aerosol daily curtain images for Q1delivered to data portal
Q3 – October to December
A short interim report (1-2 pages) will document project progress including implementation of new activities, ongoing observations, data analysis, submissions to the data portal, presentations and publications.
CAM1 weekly updates to the data portal
LIDAR Ozone profiles for Q2 delivered to data portal
LIDAR aerosol daily curtain images for Q2 delivered to data portal
CAM1 final 2018 data delivered to the portal
Q4 – January to March
A short interim report (1-2 pages) will document project progress including implementation of new activities, ongoing observations, data analysis, submissions to the data portal, presentations and publications.
CAM1 weekly updates to the data portal
LIDAR Ozone profiles for Q3 delivered to data portal
LIDAR aerosol daily curtain images for Q3 delivered to data portal
Data collection for column NO_2, SO_2 and Aerosol Optical Depth from April 1, 2019 to March 31, 2020 with final validated 2019 data to be delivered by March 31, 2020.
Posting data collected after QA/QC (AEP)
Greenhouse gas data delivered to data portal