FOCUSED STUDY ACTIVITY WORK PLAN

General Information

Work Plan Unique Identifier:	*A-PD-4-1718*
Focused Study Activity Title:	Atmospheric Process Study - OS Air Pollution Emissions, Transformation, and Fate
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***)**	Athabasca oil sands region Cold Lake oil sands in situ facility region Edmonton East and Fort Saskatchewan Fort McKay, northwestern Saskatchewan Regional Municipality of Wood Buffalo
Monitoring Site(s) Coordinates *(latitude and longitude)*	Athabasca oil sands region Cold Lake oil sands in situ facility region Edmonton East and Fort Saskatchewan Fort McKay, northwestern Saskatchewan Regional Municipality of Wood Buffalo
Responsible Manager(s):	Stewart Cober Jaime Dawson
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Date Study initiated:	April 2016
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 A3: Investigate Sources and Atmospheric Transport Pathways
Hypotheses: *(Briefly outline the specific hypotheses that your focused*	H1) Characterizing and quantifying air pollutant emissions from in-situ operations, seasonal variabilities in surface mining facilities, and upgrading and refining facilities in east Edmonton/Fort Saskatchewan, using a combination of aircraft observations will

study is aiming to address)	address known gaps in emissions data estimates H2) Using an aircraft-based observational mass balance approach over large geographic regions downwind of the oil sands facilities will allow estimation of dry deposition estimates of sulfur and nitrogen H3) Aircraft-based measurements designed to identify the transformed products of oil sands emissions, and laboratory investigations of the chemical nature of the transformation products and their rates of formation will inform gaps in chemical transformation and speciation information H4) Using emission observations to improve model emission databases, particularly the under-estimation of emission rates and lack of speciation, integration with Continuous Emissions Monitoring Systems (CEMS) data, and inclusion of small emitters in the oil sands region will inform model emissions data H5) Validating new satellite data products from the following existing satellites TROPOspheric Monitoring Instrument (TropOMI), Visible Infrared Imaging Radiometer Suite (VIIRS), Moderate Resolution Imaging Spectroradiometer (MODIS), Greenhouse gases Observing SATellite (GOSAT), Orbiting Carbon Observatory 2 and 3 (OCO_2/OCO_3) and well as the next generation satellite Tropospheric Emissions: Monitoring of Pollution (TEMPO) using aircraft observations under typical Canadian conditions will enable space-based observations to fill gaps in monitoring H6) Impacts estimation and integration of observations, by improving model capabilities, through improved processes representation, and validation and improvement of emissions inputs, will lead to improved confidence in model predictions of pollutant fate and the associated impacts, and will lead to improved methods for assessing cumulative impacts H7) The transformation of mercury (Hg) occurs higher in the atmosphere closer to industrial activities and above the forest canopy, and measurements at the current location suggest that the deposition of mercury is being taken up by the overlying forest H8) Re-emission of Hg from forest fires deposition in the region impacts the reported atmospheric mercury deposition and concentration levels in the OS area
Deliverables: *What tangible goal (s) and/or product(s) will the monitoring produce and when?*	**1.1 Ambient air measurements from airborne platforms.** 1.1.1 A science plan for the airborne measurements will be completed to serve as guidance for the project in 2018. Expected: **June 2017**.

	1.1.2 Engagement workshop with industry for accessing industrial data (production, activities, etc.) for the 2018 study periods. Expected: **July 2017**. 1.1.3 Memorandum of Agreement (MOA) between ECCC and National Research Council (NRC) will be signed, entering both parties into a formal agreement for the use of the Convair-580 aircraft for deployment during spring-summer 2018. Expected MOA signing date: **Apr 2017** 1.1.4 Two airborne study planning workshops will be held in 2017. The first will be held in **Apr/May 2017**, and the second will be held in **Sep 2017**. 1.1.5 Instrument adaption/modification for installation on aircraft: on a continuing basis but with **quarterly reports on progress**. 1.1.6 Instrument installation on aircraft. This will take place in the period of **Jan-Mar 2018** 1.1.7 Test flights: **Mar 2018** 1.1.8 Logistic support activities for aircraft deployment in Alberta will be on a continuing basis but with **quarterly reports on progress.** 1.2 **Laboratory Studies on Oil Sands Pollutant Transformation.** 1.2.1 Acquisition of bitumen, unprocessed OS, solvents and tailings pond water samples: **Apr - Dec 2017** 1.2.2 Setup and development of improved lab facilities (chamber, flow-tube and instruments) for study of secondary organic aerosols (SOA) formation: on a continuing basis with quarterly progress reports 1.2.3 Laboratory study focusing on the SOA from unprocessed oil sand: **Jul 2017** 1.2.4 Laboratory study focusing on the SOA from Tailing pond water (TPW): **Sep 2017** 1.2.5 New information on the SOA formation rates and chemical composition from the hydroxal radical (OH) oxidation of unprocessed OS and OS-TPW: **Nov 2017** 1.2.6 Setup of laboratory experiments to study nighttime SOA formation (i.e.,: nitrate radical oxidation): **Mar 2018** 1.3 **Emission data compilation and synthesis** 1.3.1 In preparation for the 2018/19 monitoring intensive study activities will include (1) updating both United States (US) and Canadian bottom up inventories to 2014, (2) updating the volatile organic compounds and particulate matter speciation according to observations from the Summer 2013 study and the 2015 Stantec report, (4) incorporating forest fire emissions estimates from the ECCC Firework model product into oil sands emissions and (5) updating spatial allocation of emissions with new geographic information system and satellite observation data.

	1.3.2 Activity (3), obtaining Continuous Emissions Monitoring data for the Summer 2018 aircraft observation period, and further updates to the emissions data will follow in subsequent fiscal years. 1.3.3 Activities 1, 2, 4, and 5 will be repeated subsequent to 2018/19 in order to achieve the best possible emissions data for the new monitoring intensive period. **Progress will be included in quarterly reports.** 1.4 **GEM-MACH (Global Environmental Multi-scale-Modelling Air Quality and Chemistry) Air Quality Model Prediction and Application** 1.4.1 Preparation of the model and input emissions for the 2018/2019 monitoring intensive. 1.4.2 Inclusion of updated model process parameterizations into the model code. 1.4.3 Generation of simulations and analysis of acid deposition with the most recent model version. 1.4.4 Comparison of new model parameterizations for ammonia bi-directional fluxes to observations. 1.4.5 Generation of simulations using updated (aircraft-based) emissions from the 2013 monitoring intensive, comparison of model results to observations to determine impact of the new information on model results. Quarterly progress reports on the above activities will be included in the reporting for the overall activities under this sub-project. 1.5 **Remote Sensing of Air Pollutants in the Oil Sands.** 1.5.1 Activities include acquisition and evaluation of satellite observations, further development of an Aerosol Optical Depth (AOD) product for the oil sands regions, and publication of the initial satellite-AOD study. Project progress will be reported on a quarterly basis. **1.6 Airborne and Ground-based measurement of Mercury** 1.6.1 Prepare instrumentation for atmospheric mercury measurements on the aircraft in winter 2017 1.6.2 Undertake the aircraft program field work in spring/early summer 2018 1.6.3 Data Quality Control (QC) and reporting of atmospheric mercury measurements in fall 2018 1.6.4 Analysis and interpretation of collected data in fall 2018 1.6.5 Implement data into the mercury part of the GEM-MACH model winter 2018 1.6.6 Preparation of journal publication in 2019/20 1.6.7 Reporting of results to stakeholders in 2019/20

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:

Airborne measurements, criteria air contaminants, greenhouse gases, emissions, transformation, transport, deposition, fate, oil sands region, air quality prediction model, satellite validation

Describe how you will test your hypothesis:

This project plan is for the second year of a 5-year investigation (2016-2021) that was proposed in 2016. The project focuses on understanding and characterizing the emission, transformation, transport and fate of oil sands air pollution. Broadly stated, the two primary objectives are:

1. *Providing emissions rates of criteria air contaminants (CACs) and greenhouse gases (GHGs) for oil sands facilities and refineries in East Edmonton and Fort Saskatchewan, quantifying the rates of change of the primary pollutants and formations of secondary pollutants in the atmosphere, and determining the deposition fluxes of primary and secondary pollutants onto downwind ecosystems using comprehensive aircraft and ground-based measurements as well as remote sensing.*
2. *Integrating knowledge gained, both from the first phase study and the proposed measurements, into a comprehensive numerical air quality prediction model, to improve the model simulation and prediction capability to assess downwind impacts on ecosystems and human health, with the assumption that the model will be a critical tool for cumulative effects assessment.*

The project includes aircraft and ground-based mobile measurements in a monitoring intensive campaign scheduled for the spring of 2018; laboratory investigations of transformation processes; improved satellite data retrieval methodologies; and improvements to and simulations using an advanced air quality numerical prediction model. The aircraft monitoring intensive will be focused on the spring and early summer period of 2018 in order to capture a different season in comparison to the 2013 monitoring intensive. In addition, emission characterization measurements associated with the upgrading and refining activities in Edmonton East/Fort Saskatchewan region are also proposed.

In the fiscal year 2017 to 2018 (the second year of the project), project activities will continue from those in fiscal year 2016-17, and starting preparatory activities to support the intensive airborne field campaign at the beginning of the fiscal year 2018-2019. The airborne field campaign is intended to address the gaps identified above.

This project will consist of the following components:

1.1. **Ambient air measurements from airborne platforms. These measurement activities provide data for testing and proving all hypotheses H1 to H8 as listed above.**

The National Research Council of Canada's Convair-580 aircraft will be deployed for the intensive study separately in April and June, 2018. Specific flights will be designed to tackle the following topics:

(1.1.1) Facility integrated emissions using the top-down approach. Measurements will be made with box/screen flight plans to apply the Top-down Emission Rate Retrieval Algorithm developed at ECCC to determine emission rates. Flights will be conducted over surface

mining facilities, in situ operations, and upgrading/refining facilities in Fort Saskatchewan and Edmonton East. Ground level measurements of particulate matter three-dimensional (3-D) distribution by a Differential Absorption Lidar will be made from a suitable site nearby to map the plume at the same time.

(1.1.2) Source characterization. Gridded tracks over the facilities will be flown to characterize the major sources within the main surface mining facilities and in selected in situ operations. Where possible there will be concurrent ground measurements to support the aircraft measurements.

(1.1.3) Transformation and transport. Aircraft flights will follow air pollutant plumes downwind of surface mining and in situ operations to determine the chemical transformation rates of primary pollutants and formation of products as a function of downwind distance and atmospheric conditions.

(1.1.4) Dry deposition determination. The aircraft will conduct measurements in specifically designed flight patterns to allow mass balance analysis for dry deposition fluxes of the oil sands air pollutant plume as it is transported downwind.

(1.1.5) Remote sensing and data product validation. Conduct validation flights for retrieval products from the *TropOMI*, *Cross-track Infrared Sounder (CrIS)*, *VIIRS*, *MODIS*, and *GOSAT* satellites, and obtain measurements of actinic flux radiance/irradiance and infra-red aerosol optical depth. Ground level mapping of 3-D particulate matter at a suitable location in the oil sands region will help aid the satellite data comparison.

1.2 Laboratory Studies on Oil Sands Pollutant Transformation. These studies provide data to test and prove hypotheses H2, H3, and H6.

A series of samples will be collected from the oil sands, including raw oil sand, unprocessed bitumen, processed/extracted bitumen, upgraded synthetic crude oil, tailing ponds water and solvents. The gases evolved from these samples will be analyzed for the volatilities and molecular structure of semi-volatile and intermediate volatile organic compounds to determine the key species (or range of species) responsible for secondary organic aerosol (SOA) formation and their SOA potential. The evolved semi-volatile and intermediate volatile organic compounds will be further studied in smog chambers and flow-tubes which will simulate processing in the atmosphere. The relevant processes important to SOA formation in OS plumes to be studied include: (1) the effect of different oxidants on SOA yield/formation rates and chemical composition, (2) The effect of various OS precursor sources (TPW, Bitumen, solvents) on the SOA formation rates and composition, (3) the effect of co-emitted inorganic species (e.g., sulfur dioxide (SO_2) and nitrogen oxides (NOx)) on the formation rates and composition of SOA, and (4) the effect of processes 1-3 above on the chemical speciation of the gas-phase reaction products. The results of these studies will be compared with the 2018-19 aircraft field campaign gas and aerosol measurements for consistency and to identify previously unaccounted for processes leading to SOA which will be incorporated into subsequent year laboratory studies. Finally, results of the laboratory studies will be used to improve regional modelling descriptions and predictions of SOA in the oil sands, through improved SOA formation parameterizations.

1.3 Emission data compilation and synthesis. These activities provide inputs to test and prove hypotheses H1, H2, H4, H5, and H6.

In addition to emissions updates using aircraft-derived values, other updates are planned under this project. The plan includes (1) updating both US and Canadian bottom up inventories to 2014, (2) updating the volatile organic compounds and particulate matter speciation according to observations from the Summer 2013 study and the 2015 Stantec report, (3) obtaining Continuous Emissions

Monitoring data for the Summer 2018 aircraft observation period, (4) incorporating forest fire emissions estimates from the ECCC Firework model product into oil sands emissions, and (5) updating spatial allocation of emissions with new geographic information system and satellite observation data. Work will include activity data and emission report gathering, compiling, unification, and synthesis with the proposed and past aircraft observations, for the successive years 2016-2018.

1.4 GEM-MACH Air Quality Model Prediction and Application. These activities provide outcomes for testing all hypotheses, H1 to H8.

A series of tasks have been identified for the model prediction and applications to the oil sands region.

- **1.4.1** **Conduct** real-time air-quality forecasts during the spring/summer 2018 aircraft-monitoring intensive, to aid in daily decision making and flight planning for the aircraft team.
- **1.4.2** **Evaluate** hypotheses explaining the observations, including impacts of improved emissions data on model performance, improved process representation for organic aerosol formation, gas-phase chemistry, Hg, bidirectional ammonia (NH_3) emissions, polyaromatic hydrocarbons, deposition of acidifying gases and particles, photolysis rate improvements, and forest canopy chemistry, and transport.
- **1.4.3** **Evaluate** the model using existing surface monitoring network data, and monitoring intensive data, for concentrations and wet deposition, for both intensive and multi-year periods.
- **1.4.4** **Estimate** deposition for multi-year simulations, including improved estimates and parameterization for base cation emissions and deposition. These will be compared to aircraft data, as well as long-term surface observations.
- **1.4.5** **Estimate** the frequency of Air-Quality Health Index events on a multi-year basis.
- **1.4.6** **Compare** with satellite data products, and apply to improve satellite retrieval algorithms.
- **1.4.7** **Conduct** simulation experiments at very high model resolution to evaluate the model's ability to capture local events.
- **1.4.8** **Improve** emission inventory. The value of the improved emissions inventories under 1.3 above will be demonstrated through model performance evaluation using the new emissions.

1.5 Remote Sensing of Air Pollutants in the Oil Sands. These activities provide products to test and prove hypotheses H5.

Assuming that key satellites will be available for the duration of the study period and new satellites will be successfully deployed, this work will include obtaining and validation of data products for aerosols (particulate matter) and for gases (nitrogen dioxide (NO_2), SO_2, formaldehyde (HCHO), NH_3, methane (CH_4), carbon monoxide (CO)), and possibly airborne measurements for data retrieval validation pending the outcome of a feasibility study. Geographic scope will include all of Alberta/Saskatchewan.

- **1.5.1** Remote sensing of aerosols. Application of aerosol optical depth data products from the MODIS, Multi-angle Imaging SpectroRadiometer (MISR), POLarization and Directionality of the Earth's Reflectances (POLDER), and Along-Track Scanning Radiometer (A-ATSR) satellites to provide information on emissions of particulate matter. Publication of satellite aerosol optical depth product assessment, maps, and trend study in the peer-reviewed literature.
- **1.5.2** Algorithm development. Refine an ECCC-developed aerosol optical depth retrieval algorithm and test using measurements from a near-IR (infrared) spectrometer obtained from existing oil sands overflight measurements for potential application to FY (fiscal year) 18/19 flights.
- **1.5.3** Satellite validation. Evaluate the TropOMI satellite products for NO2, SO2, HCHO, CH4, and CO including (1) a determination of their usefulness for products for oil sands monitoring, (2) exploiting higher spatial resolution to improve emission information, (3) estimate surface

concentrations. Validation of the CrIS NH3 data product using surface in-situ and remote sensing instrumentations.

1.5.4 Provide support for the planning of satellite validation flight segments, including projections of satellite observation times and locations for optimizing measurement co-incidences

1.6 Airborne measurements of mercury. Activities in this component provide data to test and prove hypotheses H7, and H8.

Atmospheric mercury (Hg) measurements will be undertaken from the aircraft flights around the OS activities and background regions. Gaseous elemental Hg will be measured using a Tekran 2537 X instrument. Focused study will be conducted on Hg transformation in the atmosphere from a stable chemical to one that easily deposits to the ecosystem possibly enabled by air chemicals released from oil sands industrial activities. Measurements of atmospheric Hg species on the aircraft will provide important information to assess the vertical, horizontal and breadth of Hg levels around the oil sands activities. Where aircraft logistics allows it, particle samples will be collected for Hg and its isotopic fractionation analyses to help understand impacts of land use changes on atmospheric Hg burdens in the OS region.

Measurements of atmospheric Hg over the region will be used to test hypothesis H8 that re-emissions of Hg deposited on forest canopy in the oil sands region from historic forest fires can impact the reported atmospheric Hg deposition and concentration levels in the oil sands region. Measurements of Hg on the aircraft around forest fires will provide information to assess the relative impact of fires on the Hg budget in the OS area.

Assumptions and Constraints behind the hypothesis and the testing method:

Assumptions

- It is assumed that the National Research Council aircraft will be available during 2018 (already confirmed) and that increased funding (from JOSM) to support an intensive airborne measurement program will be forthcoming in 2017 and 2018 as required.
- It is assumed that industries will be operating under normal operating procedures during the period of the intensive measurements proposed in 2018.
- The project assumes that knowledge generated from the measurements and the satellite observations will be sufficient to fill the known gaps in emissions data, and reduce uncertainties in the air quality model.
- The in situ operations are assumed to be large sources of Criteria Air Contaminants based on estimates of emissions from data on gas use, venting, and flaring. Currently emission reports indicate small emissions but might not include all sources, and may be low due to reporting thresholds. However, an underlying assumption is that individual in-situ facilities create high enough concentrations to be observable by the aircraft.
- It is assumed that Hg measurement instruments are suitable for deployment on the aircraft and can measure suitable concentrations for testing Hypotheses H7 and H8. While instruments for gaseous Hg have been deployed from aircraft previously, the speciated Hg instrument needs to examined for suitability for aircraft deployment.
- It is assumed that industries will report on hourly emissions and will identify unusual events that will be used to assist analyses of data from the aircraft campaign.
- Air space south of Fort McMurray is assumed to be available for the mission flights.

Constraints

Time: Time allocation in preparation for the various platforms can pose a challenge. Given the various

partners involved in the project, and the long lead times required for planning and coordination an early approval of the project is essential. An early approval will remove potential scheduling obstacles arising from coordination between ECCC and National Research Council, since the logistics of aircraft design, fabrication, and system integration need to fit into the NRC Convair-580 aircraft schedule, and will enable early coordination between ECCC, AEP (Alberta Environment and Parks), and industry for aircraft flight planning. Prioritization of tasks is necessary to carefully manage the progress towards the deployment goals. Steps are already being undertaken assuming that approval will be forthcoming.

Cost: To obtain a representative dataset for the different facilities, and to obtain a sufficiently representative dataset for transformation processes and for deposition studies, a sufficient number of flight hours need to be allocated. Cutting back on the aircraft hours will dictate a necessary downscaling of the project activities and objectives, affecting the ability to deliver on the project objectives. Furthermore, there are fixed costs for aircraft scheduling, instrument installation, and test flights. Mission flight hours are incremental to these fixed costs and as such, reduced funding will lead to disproportionately large reduction in mission flight time. Much of the model preparation work (scenario studies, emissions preparation) depends on funding for additional staff time to carry out tasks which would otherwise be lower priority.

Scope: While emission rates from the surface mining facilities can be well determined from the large surface mining facilities using the top-down approach, the success of the methodologies for in situ operations is less well assured since this will be such first deployment of the aircraft to measure in situ operations. Furthermore, some new measurement systems will be tested for performance for aircraft deployment even though they have the needed specs at ground level; hence test flights are critical to determine their airborne performance. Refinements to the GEM-MACH model are based on validation against data and on resulting understanding of processes specific to the oil sands region. These are crucial for building confidence in the accuracy of further applications of the model for integrating data and assessing the cumulative ecosystem impacts of oil sands activities. Modifications in scope to either the provision of data and information used to inform and validate the model (e.g., slowing down/stopping analysis of information derived from this focused monitoring study), or to development of the model itself (e.g., slowing down/stopping model development work) would impact on the ability to deliver enhancements to the model and delay deployment of the model for informing ecosystem impacts.

Linkages

There are linkages of this project to multiple focused studies being proposed.

First, there is a direct linkage to the *A-MD-2-1718 – Atmospheric Process Study - Deposition and Effects* project. One of the objectives of this proposal is to obtain dry deposition fluxes of criteria air contaminants, in particular acidifying substances (SO_2+$SO_4^=$ (sulfate), NO_X, and organic acids), over large downwind region of the oil sands facilities, directly determined from aircraft measurements using a mass balance approach. Such results will provide comparison with dry deposition determined using inferential models study proposed in the *Deposition and Effects project* but the aircraft measurement will expand the geographic coverage for dry deposition determination. Linkage to the project will also include the airborne Hg measurements, which are part of the *Deposition and Effects* project.

The second linkage is to the Oski-otin project (A-PD-5-1718 *Enhanced Ground-based Monitoring – Oski-otin Monitoring Site*). The present project will likely produce source information for the observations made at the Oski-otin site under appropriate meteorological conditions.

The third linkage is to the R-1-1718 *Air Evaluation, Integration, Synthesis and Reporting*. Airborne studies, modelling studies, and satellite data studies from this project and from the first aircraft focused study in

2013 will provide results on the emissions, transformation, and fates of many criteria air contaminants from the oil sands facilities. These results will be synthesized in a chapter dedicated to the topic of aircraft measurements. Contributions to other chapters in the Synthesis Reports, such as deposition, are envisioned.

The fourth linkage is to provide modelling analysis of pollutants. The model output will be in support of all air component focused studies and the Synthesis Report.

The fifth linkage is to *A-MD-7-1718 Develop Methods to Measure Tailings Ponds Emissions*, where a targeted study on tailings pond emissions is planned in collaboration with Alberta partners. This study will investigate the chemical characteristics of pollutants emanating from tailings ponds, quantify the emission rates using micrometeorological methods, evaluate operational flux chamber methods against the micrometeorological methods, and evaluate the feasibility of various methods for compliance monitoring, and quantify pond-to-pond and seasonal variability of emission rates. The resulting emissions estimates will be compared to GEM-MACH model predictions, with the model being used to determine the emission levels required to reproduce the observed concentrations. The emission results will be incorporated into the emissions data of Component 1.3 of this project.

The results from the project will reveal how much criterion air contaminants and Hg are emitted from the oil sands facilities, how they are transported and transformed downwind, and the quantities of deposition to downwind ecosystems. The information is crucial in understanding the quantities of acidifying pollutants to the ecosystem and whether/how critical loads of the downwind ecosystem are exceeded and to what extent geographically. It will also provide information on the potentials for secondary pollution formation from the primary emissions from the oil sands that may be harmful to human beings and the ecosystem. Such information can be useful for monitoring activities in various water and biodiversity components of the Oil Sands Monitoring program.

References:

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Data Management

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

Deliverables	**Timeframe**
Data Collection Period:	Start : 2017-06-01 End: 2017-10-27 *This time frame is for the laboratory study component of the project. For the aircraft study, the dates are shifted (delayed) by 9 months to April-June 2018. For the modelling studies and the satellite studies, the dates will be approximately 0.5 - 1 year after the aircraft study is completed.*
Data Analysis Period: *Laboratory analysis and QA/QC of data:*	Start : 2017-09-01 End: 2018-12-31 *This time frame is for the laboratory study component. For the aircraft study, the dates are shifted (delayed) by 9 months. For the modelling studies and the satellite studies, the dates will be approximately 0.5 - 1 year after the aircraft study is completed.*
Data Release Date: *Metadata and data consistent, complete and meet basic standard format for publication in Open Data; on or linked to JOSM portal:*	2018-09-30 For the laboratory study: *one year after study is completed. For the aircraft study, the dates are shifted (delayed) by 9 months.*

For the aircraft measurement activities, the following data management activities will be carried out as appropriate.

1) Project quality assurance plan will be prepared for each measurement to be conducted in the project. This will consist of two stages. The first stage will be prior to the actual start of the

measurements to document the preparation of the measurements, and the second stage will be after the completion of the measurements to document the actual measurements.

2) Data quality control will consist of two steps. First, detailed field quality control logs will be collected while the measurements are conducted. Second, post study quality control logs will be made. The quality control logs will be kept to document how the data were collected, calibrations made, unusual observations that may affect the collection and data interpretation, unusual environmental conditions for the observations, etc.

3) Standard operating procedures for each instrument and lab analysis will be documented and be part of data submission.

4) Each data point will be flagged appropriately through a series of quality control checks and per quality control logs. Final quality assured and quality controlled data will be formatted as per the Oil Sands Monitoring program requirements using the NATChem data exchange format. Metadata will be part of the data file also as per the data format requirement.

5) Final data will be submitted to the appropriate data portal (primarily the Joint Oil Sands Monitoring Data Portal).

Analysis of the data will be made available through publications in peer-reviewed literature.

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
Differences between Measured and Reported Volatile Organic Compound Emissions from Oil Sands Facilities in Alberta, Canada	This paper describes the emission rates of 73-90 volatile organic compounds from four oil sands surface mining facilities determined from the 2013 aircraft measurements. Comparisons of these results with the emission reports of total volatile organic compound (VOC) and single VOC species by the facilities to the National Pollutant Release Inventories are made. This will be a peer-reviewed scientific publication.	2017
Gaseous Organic Acids in the Oil Sands Region of Alberta, Canada: From Primary Emissions to Secondary formation	This paper describes the emission rates of organic acids from the oil sands surface mining facilities, and the secondary formation rates from primary oil sands pollutants as they are transported downwind. The results are based on aircraft measurements made in 2013. This will be a peer-reviewed scientific publication.	2017

Reports on laboratory study of oil sands primary pollutant transformation	Internal preliminary reports to ECCC and AEP partners on the laboratory study on the transformation of primary oil sands pollutants	2017/18
Open datasets from the laboratory study	QA/QC'd (Quality Assured / Quality Controlled) datasets from the laboratory study will be published in online data portal	2018/19
Open datasets from the 2018 aircraft study	QA/QC'd datasets from the 2018 aircraft study will be published in online data portal.	2019/20

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 Lead/Principal Investigator	Principal Investigator and project coordination	ECCC
Project Co-Lead	Modeling and forecasting	ECCC
Principal Investigator	Sharing of results with partners and Air CAC members	AEP
Principal Investigator	Communication of results with other components of oil sands monitoring, partners and Air CAC members	ECCC
Science specialist	Airborne measurements of NH3	ECCC
Science specialist	Leading the lab studies, also fast oxygenated volatile organic compounds measurements	ECCC
Airborne program coordinator/Science specialist	Airborne program coordination and aerosol chemical measurements	ECCC
Project IM/IT coordinator/Science specialist	Information Management / Information Technology support	ECCC
Science specialist	Hg measurements	ECCC
Atmospheric mercury specialist	Hg measurements	ECCC
Science specialist	Acids measurements	ECCC
Science specialist (ECCC)	Satellite retrieval products	ECCC
Science specialist	VOC measurements, airborne	ECCC

Science specialist	Aerosol measurements, airborne	ECCC
Science specialist	NOX/SOX/O3 (ozone) measurements, airborne	ECCC
Science specialist	Airborne volatile organic compound/oxygenated volatile organic compound measurements	ECCC
Science specialist	Modeling and forecasting	ECCC
Science specialist	Modelling; emission inventories	ECCC
Science specialist	Modeling; Hg	ECCC
Science specialist	Modeling; cloud impact	ECCC
Science specialist	Modelling: simulation infrastructure and comparisons to observations	ECCC
Science specialist	NH3 bidirectional flux modelling and polyaromatic hydrocarbon modelling	ECCC
Science specialist	Mercury modelling	ECCC
Science specialist	Model forecast infrastructure, model forecasts	ECCC
Emission inventory specialist	Emission Inventory Synthesis	ECCC
Science specialist	GHG measurements	ECCC
National Research Council-Institute of Aerospace Research	Manager of the Convair 580 Research Aircraft, coordinator of National Research Council Institute for Aerospace Research activities	National Research Council
Oil Sands Senior Support (air monitoring component)	Provide coordination and liaison within ASTD, and with the Oil Sands Secretariat and OSM partners	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
Ambient air measurements from air borne platforms: • A science plan for the airborne measurements will be completed to serve as guidance for the project in 2018. • Signed memorandum of agreement between ECCC and the NRC for the use of the Convair-580 aircraft for deployment during spring-summer 2018. • Airborne study planning workshop
A short interim report (1 page) will document project progress including for: • Ambient air measurements from airborne platforms • Laboratory studies on oil sands pollutant transformation • Emission data compilation and synthesis • GEM-MACH Air Quality Model Prediction and Application • Remote sensing of air pollutants in the oil sands • Airborne and ground-based measurement of Mercury
Q2 – July to September
Ambient air measurements from air borne platforms: • Engagement workshop with industry for accessing industrial data for the 2018 study periods. • Airborne study planning workshop
A short interim report (1 page) will document project progress including for: • Ambient air measurements from airborne platforms • Laboratory studies on oil sands pollutant transformation • Emission data compilation and synthesis • GEM-MACH Air Quality Model Prediction and Application • Remote sensing of air pollutants in the oil sands • Airborne and ground-based measurement of Mercury
Q3 – October to December
A short interim report (1 page) will document project progress including for: • Ambient air measurements from airborne platforms • Laboratory studies on oil sands pollutant transformation • Emission data compilation and synthesis • GEM-MACH Air Quality Model Prediction and Application • Remote sensing of air pollutants in the oil sands • Airborne and ground-based measurement of Mercury
Q4 – January to March
Ambient air measurements from air borne platforms:

• Instrument installation on aircraft and test flights
A short interim report (1 page) will document project progress including for: • Ambient air measurements from airborne platforms • Laboratory studies on oil sands pollutant transformation • Emission data compilation and synthesis • GEM-MACH Air Quality Model Prediction and Application • Remote sensing of air pollutants in the oil sands • Airborne and ground-based measurement of Mercury

Detailed Financial Breakdown – Year 1 of 3 (2017-2020)

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:		
Helicopter Costs	**$**	**$**
Field Costs	**$**	
Data Management	**$10,000** (Data)	**$50,000**
Internal Lab Analysis		
Consumable Materials & Supplies	**$100,000** (Aircraft) **$500,000** (Aircraft) **$54,000** (Aircraft) **$15,000** (Model) **$55,000** (SOA) **$31,000** (Mercury) **$10,000** (Satellite) **$35,000** (Aerosol)	**$3,105,000**
Sub-Total	**$806,000**	**$3,155,000**
O&M - Travel		
Field Work	**$135,000** (Aircraft) **$10,000** (Data)	**$**
Conferences (*identify conference*)	**$5,000** (SOA) **$10,000** (Aerosol/VOC) **$5,000** (model)	**$12,000**
Meeting (*expert meetings with partners to inform project plan*)	**$10,000** (Aircraft) **$5,000** (model) **$2,000** (GHG) **$2,000 (AQRD management)**	
Sub-Total	**$184,000**	**$12,000**
O&M - External Contracts / Students / PDFs :		
Goods and Services Contract (*TBIP contract*)	**$50,000** (Aircraft) **$135,000** (Model) **$35,000**	**$**

Budget requirements – List areas that require budget expenditures: (ADD OR DELETE BUDGET CATEGORIES AS REQUIRED)	OS Funding	External Funding (*outside JOSM*)
	(IVOC/SVOC/VOC component)	
External Lab Analysis	**$**	**$**
Students / PDFs	**$30,000 (Aircraft)** **$22,000 (IVOC/SVOC/VOC component)** **$75,000 (Model)** **$63,000 (SOA)** **$31,500 (GHG)** **$46,500 (satellite)** **$30,000 (Data)**	
Sub-Total	**$518,000**	
Salaries:		
Principal Investigators		**$872,000**
Technical / Professional Assistants	**$42,460 (Aircraft)** **$78,522 (SOA)** **$95,000 (aerosol)** **$32,000 (OS support)**	**$924,000**
Field Staff	**$35,000 (Aircraft)**	
Sub-Total	**$282,982**	**$1,796,000**
Total Salaries	**$282,982**	**$1,796,000 (ECCC)**
Total O&M	**$1,512,061**	**$3,167,000 (ECCC)**
2017-2018 GRAND TOTAL* (BEFORE OTHER RELATED COSTS)	**$1,795,043**	**$4,963,000 (ECCC)**

* Total salary costs for ECCC ($282,982) in 2017-18 with other related costs is $389,157. Total O&M for ECCC ($1,512,061) in 2017-18 with other related costs is $1,610,843. The Grand Total for ECCC in 2017-18 is $2,000,000.

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	
	Cash	In-kind	Cash	In-kind	Cash	In-kind
1) Salaries						
a) Investigators	$ 95,000	$ 870,200	$ 97,000	$ 973,800	$ 98,000	$ 829,200
b) Technical/professional assistants	$ 152,982	$ 924,000	$ 443,287	$ 988,000	$ 455,411	$ 851,000
c) Field Staff	$ -	$ -	$ -	$ -	$ -	$ -
d) Student (O&M)	$ 105,000	$ 70,000	$ 119,000	$ -	$ 110,000	$ -
e) Overtime	$ 35,000	$ -	$ 105,000	$ -	$ 46,000	$ -
2) Operations and maintenance						
a) Facilities	$ -	$ 1,180,000	$ -	$ 1,180,000	$ -	$ 1,105,000
b) Equipment	$ 94,000	$ 1,920,000	$ 64,000	$ 1,920,000	$ 67,000	$ 1,730,000
c) Lab analysis	$ 21,000	$ 50,000	$ 36,000	$ 10,000	$ 49,000	$ -
d) Data management/software	$ 20,000	$ 50,000	$ 30,000	$ 50,000	$ 35,000	$ 50,000
e) Field work	$ 515,000	$ -	$ 1,655,00	$ -	$ 10,000	$ -
3) Consumable Materials and supplies						
a) Parts	$ 70,000	$ 40,000	$ 97,000	$ -	$ 80,000	$ -
b) Consumables	$ 75,000	$ -	$ 50,000	$ -	$ 12,000	$ -
4) Travel						
a) Conferences and meetings	$ 30,000	$ 12,000	$ 38,000	$ 12,000	$ 38,000	$ 12,000
b) Field work	$ 115,000	$ -	$ 657,000	$ -	$ 87,000	$ -
c) Project-related travel	$ 29,000	$ -	$ 23,000	$ -	$ 23,000	$ -

5) Dissemination & Engagement						
a) Publications/Reports	$ 25,000	$ 5,000	$ 15,000	$ 9,000	$ 30,000	$ 5,000
b) Translation (if required)	$ -	$ -	$ -	$ -	$ -	$ -
c) Communications	$ -	$ -	$ -	$ -	$ -	$ -
d) Stakeholder Engagement	$ -	$ -	$ -	$ -	$ -	$ -
e) Indigenous Peoples Engagement	$ -	$ -	$ -	$ -	$ -	$ -
6) External Contracts						
a) Various contracts for services	$ 220,000	$ -	$ 52,000	$ -	$ 50,000	$ -
7) Postdoctoral Fellow						
a) Postdoctoral Fellow	$ 193,000	$ -	$ 439,500	$ -	$ 283,500	$ -
Grand Total (*before other related costs)	$ 1,795,043	$ 5,121,200	$ 3,920,787	$ 5,142,800	$ 1,473,911	$ 4,582,200

* Total salary costs for ECCC ($282,982) in 2017-18 with other related costs is $389,157. Total O&M for ECCC ($1,512,061) in 2017-18 with other related costs is $1,610,843. **The Grand Total for ECCC in 2017-18 is $2,000,000.**

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. Essentially these will be a continuation of the work described for 2017-18, with an intensive aircraft campaign planned in 2018-19. 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
Completion of a data visualization tool for aircraft deployment during the aircraft study (April 2018)
Aircraft study data QA plans and SOPs (Standard Operating Procedures) completed
Aircraft study Phase 1 completed (April 2018)
Laboratory study on SOA formation Phase 1 (conducted in the 2017/18 fiscal year) data QA/QC completed (May 2018)
Modelling team production of forecast for aircraft study Phase 1 and 2
Aircraft study Phase 2 started (June 2018)
Acquisition of satellite data products for aerosols, gases (NO2, SO2, HCHO, NH3, CH4, and CO)
Q2 – July to September
Aircraft study Phase 2 completed (July 2018)
Modelling team production of forecast for aircraft study Phase 2 (July 2018)
A manuscript on SOA formation from laboratory study Phase 1 completed for internal review and submission to a scientific journal
Acquisition of satellite data products for aerosols, gases (NO2, SO2, HCHO, NH3, CH4, and CO)
Q3 – October to December
QC of Hg data from the aircraft measurements completed.
Data QA/QC for aircraft measurements for Phase 1 measurements completed.
GEM-MACH model input database assembled on emissions and new processes.
Updated emission data Phase 1 (inclusion of the 2013 aircraft study results and 2015 Stantec report) completed.
Development of ECCC AOD retrieval algorithm

Q4 – January to March
Post-study QA Plans for aircraft study completed (March 2019)
Data QA/QC for aircraft measurements for Phase 2 measurements completed (March 2019)
Completion of metadata for aircraft studies Phase 1 and Phase 2 measurements (March 2019)
Laboratory study Phase 2 on SOA formation completed, new data acquired and QA/QC'd (March 2019).
New data on the SOA formation rate and composition derived nitrate radical oxidation of IVOCs (Intermediate Volatile Organic Compounds) in lab studies (March 2019)
Emission data updated for oil sands facilities (March 2019)
New GEM-MACH model simulations on new emissions and new processes input.
Satellite data product validation

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
Multiple aircraft measurement data sets in the NATChem data exchange standard (DES) ready for submission to oil sands data portal (June 2019)
Laboratory study Phase 2 data in the NATChem DES format ready for submission to oil sands data portal (June 2019)
Updated emission data Phase 2 (compilation of continuous emission monitoring data from industry for the 2018 aircraft study periods) completed. Emission data ready for model use.
GEM-MACH model new scenario predictions on new emission and process information
Convening a joint data analysis workshop on oil sands air monitoring studies
Q2 – July to September
Laboratory study, Phase 3, on the effect of inorganic seed composition on SOA formation from OS precursors, new data acquired and QA/QC'd
Submissions of multiple data sets from all measurements to OSM data portal
GEM-MACH model new scenario predictions on new emission and process information
Convening a special science symposium on oil sands monitoring results organized at the Chemical

Society of Canada (or other Canadian scientific conference)
First presentations on project components delivered at a conference(s)/symposium
Presentations to partners and stakeholders, on results of individual components of the project, Phase 1
Q3 – October to December
Laboratory study Phase 3 data in NATChem DES format ready for submission to the OSM data portal
Multiple presentations on results from various components of the project, from aircraft measurement, laboratory studies, emission information compilation, modelling studies, to satellite retrieval and validation studies delivered at conference(s)
Multiple manuscripts on results from various components of the project, from aircraft measurement, laboratory studies, emission information compilation, modelling studies, to satellite retrieval and validation studies, ready for internal review and submission to scientific journals
Presentations to partners and stakeholders, on results of individual components of the project, Phase 2
Q4 – January to March
Multiple presentations on results from various components of the project, from aircraft measurement, laboratory studies, emission information compilation, modelling studies, to satellite retrieval and validation studies delivered at conference(s)
Multiple manuscripts on results from various components of the project, from aircraft measurement, laboratory studies, emission information compilation, modelling studies, to satellite retrieval and validation studies, ready for internal review and submission to scientific journals
Presentations to partners and stakeholders, on results of individual components of the project, Phase 3