FOCUSED STUDY ACTIVITY WORK PLAN

General Information

***Decision Pool C: Activity paused.**
* Activity paused pending outcomes of the Deposition Monitoring Integration Workshop
* It is a requirement that key members of the project team participate in a Deposition Monitoring Integration Workshop to be informed by the Oil Sands Monitoring Secretariat.
*Funding in 2018/19 is dependent upon the findings of the Deposition Monitoring Integration Review and Workshop.

Work Plan Unique Identifier:	*A-MD-2-1718*	
Focused Study Activity Title:	Atmospheric Process Research – Deposition and Effects	
Focused Study Category:	Monitoring Design and Method Improvement	
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	Remote Sites - Saskatchewan
	Cold Lake Airshed	Peace River Airshed
Monitoring Site(s) Coordinates *(latitude and longitude)*	See table below	

Monitoring Sites – Deposition and Effects (2018 – 2019)

Site ID	Description	CASA Google Earth		Converted Coordinates		Passive	PAS-DD	Active	Hg	N+S
Cold Lake (LICA) Stations:										
Fishing Lake		53.9029	-110.0762	53°54'10.62"N	110° 4'34.44"W	Y				
Fort George		53.8783	-110.7481	53°52'41.89"N	110°44'53.02"W	Y				
Frog Lake		53.8906	-110.3842	53°53'26.35"N	110°23'3.07"W	Y				
La Corey		54.4997	-110.8179	54°29'58.80"N	110°49'4.50"W	Y				
St. Lina		54.2160	-110.5033	54°12'57.46"N	111°30'11.89"W	Y				
Portable		54.2502	-110.6991	54°15'0.60"N	110°41'56.65"W	Y				
Peace River (PRAMP)Station:										
Station 842b		56.2741	-110.6991	56°16'26.76"N	116°58'55.20"W	Y				
Woof Buffalo Stations:										
JPL7	Jack Pine Low Deposition 7	57.8903	-111.4352	57°53'24.9"N	111°26'6.78"W	Y				
JP213	Jack Pine Meteorological Tower	57.0473	-109.7497	57°02'50.5"N	109°44'58.9"W	Y				
JP201	Jack Pine Meteorological Tower	57.0321	-113.7355	57°01'55.6"N	113°44'07.9"W	Y				
Continuous Sites (road access)										
AMS1	Fort McKay	57.1894	-111.6405	57°11'21.86"N	111°38'25.81"W	Y		Y		
AMS 4	Buffalo Viewpoint	56.9967	-111.5926	56°59'48.12"N	111°35'33.36"W			Y		
AMS 5	Mannix	56.9688	-111.4820	56°58'7.68"N	111°28'55.2"W	Y	Y			
AMS 6	Patricia McInnes	56.7514	-111.4766	56°45'4.99"N	111°28'35.75"W				Y	
AMS 11	Lower Camp	57.0269	-111.5007	57°1'36.73"N	111°30'2.7"W			Y		
AMS13	Syncrude UE-1	57.1492	-111.6424	57°8'57.12"N	111°38'32.64"W				Y	
AMS 14	Anzac	56.4489	-111.0381	56°26'56"N	111°2'17"W	Y	Y			
AMS 17	Wapasu	57.2592	-111.0386	57°15'33.1"N	111°02'18.9"W			Y		
AMS 18	Conklin	55.6323	-111.0789	55°37'56.4"N	111°04'43.9"W			Y		
CAPMoN										
PHL	Pinehouse Lake, SK	55.5122	-106.7245	55°30'43.9"N	106°43'28.2"W					Y
FLV	Flat Valley, SK	54.2946	-109.2092	54°17'40.6"N	109°12'33.1"W					Y

Notes: 1.)PACs are monitored at Passive, PAS-DD, and Active sites; 2.) Active sampling at AMS4 to begin in 2017/18; active sampling at AMS5 ended in 2016; and active sampling at site AMS 11 will end after 2018/19 resulting in a final network size of 4 sites 3.) Cold Lake and Peace River passive sampling sites are new and starting in 2018.	
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Date Study initiated:	November 2010: passive and active measurements at WBEA sites May 2018: passive sampling at Cold Lake and Peace River sites. August 2018: active sampling at Buffalo Viewpoint (AMS4) February 2015 (Pinehouse Lake, SK), February 2016 (Flat Valley, SK): Nitrogen (N) + Sulphur (S) measurements April 2015: Inferential deposition modelling
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 A2: Detect and report levels and trends of oil sands related chemical substances being deposited from the atmosphere
Hypotheses: *(Briefly outline the specific hypotheses that your focused study is aiming to address)*	Under this work plan, several projects investigating deposition from air in the oil sands (OS) region were combined into a single integrated project. This work to be carried out under the 'Deposition and Effects' work plan will contribute to and inform the 'Integrated Deposition Monitoring Design' project (A-MD-6-1718) that will be initiated in 2017/18 and will support the 'Causes and effects of atmospheric deposition of multiple pollutants' Synthesis Report planned for 2020-21 (under the R-1-1718 'Air Evaluation, Integration, Synthesis and Reporting' work plan). In 2017/18 two substantial integration and synthesis exercises were carried out: i) a PACs Air Synthesis Review (R-1-1718) and ii.) an Evaluation and Integration of Atmospheric Deposition Monitoring (A-MD-6-1718). These two activities although still in progress, have provided useful guidance on new science questions and integration opportunities. The draft recommendations from these reports have been incorporated into and are consistent with the current work plan under Deposition and Effects and will continue to guide work planning in future years. ***Component 1 of 5 - Passive monitoring of PACs in air:***

Monitoring Design and Method Improvement

H1) Passive air monitoring for PACs (Polycyclic Aromatic Compounds) at sites across the oil sands region combined with dispersion/inferential modeling can be used to generate maps of PAC deposition from air across the oil sands region in space and time

H2) Recently developed passive dry deposition samplers (PAS-DD) complement the data obtained from conventional PUF (polyurethane foam) disk type samplers and provide a comparable and direct measure of dry deposition that can be evaluated against model results

H3) Petcoke contributes significantly to PAC levels in air (and deposition) across the oil sands region

H4) PAC transformation products (e.g. oxy- and nitro-PAHs (polycyclic aromatic hydrocarbons)) are produced in the atmosphere of the oil sands region and are more widely distributed (away from the oil sands region) compared to parent PACs

Investigation of Cause or Potential Ecological Impact

H5) PAC transformation products result in enhanced in-vitro toxicity of air samples

Study to Reconstruct a Historical Environmental State

H6) Tree cores can be used to reconstruct historical trends for PACs in air across the oil sands region, including the pre-mining period, and to delineate the spatial range of the impacted region

Component 2 of 5 - Active monitoring of targeted multi-pollutants (PACs, metals, coarse (PM10-2.5) and fine (PM2.5) particulate matter (PM); PM2.5 speciation, VOCs (volatile organic compounds), polar and sulphur-containing VOCs) in air:

Monitoring Design and Method Improvement

H1) The geographical distribution and number of the active air monitoring sites for enhanced deposition can be used to collect ambient data of the targeted pollutants and generate deposition estimates

H2) Analytical methodologies will identify and detect potential chemical markers such as quinones and naphthenic acids, and can be used to derive ambient data for these new chemicals for later use in emission source attributions

Study to Establish the Current Environmental State

H3) Long term comprehensive multi-pollutant (PACs, metals, coarse (PM10-2.5) and fine (PM2.5) particulate matter; PM2.5 speciation, VOCs, polar and sulphur-containing VOC measurements will provide the data needed to fully assess the predominant primary emission sources impacting local and regional air quality including transport, transformation and deposition of target pollutants

H4) The active air monitoring data of targeted pollutants at selected sites across the oil sands combined with dispersion/inferential modeling will provide effective maps of atmospheric pollutant deposition across the region in space and time

	H5) Petroleum coke dust is a source of PACs and metals in the oil sands region *H6) PACs transformation products (e.g., quinones) are produced in the atmosphere of the oil sands* *H7) Naphthenic acids are present in ambient particulate matter in the oil sand region* ***Component 3 of 5 – Mercury air sampling and deposition:*** Investigation of Cause or Potential Ecological Impact *H1) Atmospheric mercury levels in the oil sands region are impacted by both industrial activities and natural emissions (e.g., forest fires). Differentiating the sources of mercury deposited from the atmosphere between these sources will improve understanding of overall impact of mercury deposition in the oil sands region* *H2) Differences in land use affect the mercury cycle in the oil sands region* Monitoring Design and Method Improvement *H3) Atmospheric mercury monitoring (including new passive sampling method to be prepared and implemented in 2018-19 and 2019-20, respectively) and mercury in wet deposition sampling combined with improved modeling capabilities can be used to improve understanding of the mercury cycle in the oil sands region.* ***Component 4 of 5 – Enhanced Measurements of Nitrogen and Sulphur Species at Ecosystem/Transformation Sites*** Investigation of Cause or Potential Ecological Impact H1) *Industrial emissions from the oil sands region (i.e., NO_x (nitrogen oxide), and SO_2 (sulfur dioxide)) can undergo long-range transport and transformation and impact ecosystems at significant distances downwind of emission sources* ***Component 5 of 5 - Inferential modelling of atmospheric deposition*** Monitoring Design and Method Improvement *H1) Dispersion modeling combined with monitoring data can be used to generate gridded concentrations in air for a variety of pollutants (e.g. PACs, elements, N and S) in the oil sands region, which will then improve the accuracy of deposition maps based on inferential modeling*
Deliverables: *What tangible goal (s) and/or product(s) will the monitoring produce and when?*	The following details deliverables are to be achieved in 2018/2019. Progress will be summarized in quarterly interim reports. Deliverables are presented looking forward to 2019/20 and 2020/21 and 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. ***Component 1 of 5 - Passive monitoring of PACs in air:*** 2017/2018:

	D1) Improved estimates of the atmospheric deposition of PACs across the region (1 publication in 2017-18) - completed D2) Assessment of the performance of PAS-DD samplers against PUF disk samplers and evaluation of the contribution of petcoke dust to PAC levels in air (1 publication in 2017-18) - completed D3) New information on the seasonality, spatial distribution, and in-vitro toxicity of PAC transformation products and passive air samples (PUF disk versus PAS-DD sampler) (1 publication in 2017-18) – ongoingD4) Historical trends of PACs in air across the oil sands region based on the analysis of tree rings (1 publication in 2017-18) - ongoing D5) Continued sample collection at 18 sites in 2017-18. Samples from 5 sites will be processed while remaining 13 sites will be archived for possible future analysis – completed / sampling reduced to 6 of these 18 sites in 2018/19. D6) Support ecosystem effects and biodiversity program through passive air sampling at pond study sites – link to WL-MD-11-1718, (Amphibian and Wetland Health: Investigation of Wetland Ecosystem Health) – completed/data analysis and reporting is ongoing in 2018/19 with possibility for continued collaboration. <u>2018/19 to 2020/21:</u> D7) Reduction in the number of passive sampling sites in Wood Buffalo airshed by 12 sites (i.e. from 18 to 6 sites) and addition of passive sampling sites to Cold Lake (n=6) and Peace River (n=1) airsheds. This updated network of 13 sites will provide broader coverage of the oil sands regions for assessing the composition and levels of PACs from different mining operations. D8) Assessing metals deposition across the oil sands region using PUF disk passive air samplers deployed at 13 passive sites (based on methods developed within ECCC-ASTD in 2017-18). Linkages to other deposition studies (e.g., snow, peat) and biodiversity studies will be explored during 2018-19 and building on existing linkages established for studies on PACs. (2017 to 2020 with 1-2 papers during this period) D9) Enhanced toxicity indicator mapping using passive air samplers for PACs and metals coupled with in vitro methods (based on improved assays currently being tested/developed with Health Canada under CCAP (Climate Change and Air Pollution)) (1-2 publications in 2019 and 2020) D10) Assessing the potential of air mixtures (gas and particulate phase) with OS origin in causing oxidative stress, and investigating whether atmospheric transport and oxidation of particulate matter (PM) and PACs from OS result in enhanced oxidative potential (OP) and toxicity. An OP assessment method is currently being developed by ECCC (ready in early 2018), which will be used for testing the air samples. Laboratory experiments on oxidation of PM and related OP are expected to start in the second half of 2018 – this component aims to investigate links between chemical composition of air samples and their OP (up to 2 publications in 2018-2019 period). D11) Support ecosystem effects and biodiversity program through passive air sampling for PACs and metals (see D8) (2018 to 2021)

	D12) Assessing PAC long term trends in air across the oil sands region from 2011 to 2018, based on passive air samples (1 publication in 2019/20) D13) Tree coring survey #2 (follow-up to the 2015 survey and paper from 2017) to delineate spatial trends of PACs in air. Survey #2 will address limitations realized from Survey #1 (e.g., detection issues) (2019 to 2021) ***Component 2 of 5 - Active monitoring of targeted multi-pollutants (PACs, metals, coarse (PM10-2.5) and fine (PM2.5) particulate matter; PM2.5 speciation, VOCs, polar and sulphur-containing VOCs) in air:*** 2017/2018: D1) Fully functional network of five enhanced deposition site (NOTE: It is recommended to keep AMS11 (Atmospheric Monitoring Site) while AMS4 is being prepared. AMS4 is now replacing AMS5. It is recommended to have overlap for AMS4 and AMS11.) – completed D2) Improved estimates of the atmospheric deposition of selected pollutants across the region (1-2 publications) D3) New information on the sources and spatial distribution of metals and PACs (2 publications) - completed D4) Assessing the impact of petroleum coke dust on PACs and metals (vanadium) levels in the oil sand region (1 publication, in progress) D5) New information on characterization of PACs and their transformation to the corresponding quinones (2 publications, completed) D6) New information on characterization of classical naphthenic acids in PM (1 publication, completed) 2018/19, 2019/20 and 2020/21: D7) Continue monitoring of targeted multi pollutants at the five active enhanced deposition sites in 2018/19 with the aim to discontinue sampling at site AMS11 at the end of 2018/19, following an evaluation/comparison of data from sites AMS4 and AMS11. Note: guidance for the number of sites required for the longer term will be provided by the PACs air synthesis report in 2017/18 under R-1-1718. D8) Examine long-term trends of PACs and metals (PM2.5 and PM coarse), based on active air samples (Timeline: 2018/19+ after the collection of 5-10 years of data). Linkages to other deposition studies (e.g. snow, peat) and biodiversity studies. D9) Examine long-term trends of PM2.5 and its chemical components, and VOCs based on active air samples (Timeline: 2018/19+ after the collection of 2-5 years of data) D10) Support ecosystem effects and biodiversity program through active air sampling (2018 to 2021) ***Component 3 of 5 – Mercury air sampling and deposition:*** 2017/2018: D1) QC/QA TGM (Total Gaseous Mercury) data for Fort McMurray – Patricia McInnes station (AMS 6) through 2017 D2) QC/QA TGM data for Fort McKay South (AMS 13) through 2017

D3) QC/QA Speciated Hg (Mercury) data for Fort McKay South (AMS 13) through 2017
D4) Install 1 mercury wet deposition collector samplers (under and outside the forest canopy) to quantify the amount of mercury deposited to the ground and collected in the forest. QC/QA (Quality Controlled/Quality Assured) Hg in wet deposition data for Fort McKay South (AMS 13) through 2017. Note – original intention was to deploy 2 samplers, however due to forest clearing (fire maintenance) it was not feasible to deploy a second sampler.

<u>2018/19 and 2019/20:</u>
D5) QC/QA TGM data for Fort McMurray – Patricia McInnes station (AMS 6) through 2018
D6) QC/QA TGM data for Fort McMurray – Patricia McInnes station (AMS 6) through 2019
D7) QC/QA TGM data for Fort McKay South (AMS 13) through 2018
D8) QC/QA TGM data for Fort McKay South (AMS 13) through 2019
D9) QC/QA Speciated Hg and wet deposition data for Fort McKay South through 2018
D10) Identify sampling locations and deployment of passive mercury samplers

Component 4 of 5 – Enhanced Measurements of Nitrogen and Sulphur Species at Ecosystem/Transformation Sites
<u>2017/18:</u>
Measurements were successfully conducted at both the Pinehouse Lake and Flat Valley sites in 2017/18 with regular site audits and minimal issues. In addition bi-weekly passive sampling of ammonia (NH3) were added to both sites (commenced March/April 2017) to be evaluated against the continuous measurements. Although the reporting of the previous year QA/QC final data has been delayed significant progress towards this was made in 2017/18. The majority of the project deliverables are dependent on having several years of available data.

D1) Deliver quality controlled dataset for the 2016 measurements conducted at the Flat Valley and Pinehouse Lake sites-ongoing
D2) Quantify the contribution of measured NO (Nitrogen Oxide), NO_2 (Nitrogen Dioxide), NO_y (total of oxidized forms of nitrogen), and NH_3 (ammonia) to dry and total deposition of N; thus, providing the necessary estimation of the N deposition input at these Ecosystem and Transformation sites (Timeline: 2017/18 to 2018/19+ after the collection of 2-5 years of data)- to commence in 2018/19 once sufficient data has been finalized
D3) Quantify the contribution of long-range /transboundary transport of oil sands emissions versus other emission sectors to N and S dry and total deposition in northwestern Canada and in particular over sensitive ecosystems located at long distances from the emission areas (Timeline: 2017/18 to 2018/19+ after the collection of 2-5 years of data) - to commence in 2018/19 once sufficient data has been finalized

D4) Examine trends of nitrogen and sulphur species air concentrations and deposition in light of the potential expansion of industrial activities in western Canada- to commence after 2021.
(Timeline: 2017/18 to 2025/26; i.e., after the collection of 7-10 years of data)
D5) Develop and evaluate chemical transport models (GEM-MACH (Global Environmental Multi-Scale – Modelling Air quality and CHemistry)) needed to interpolate between measurement sites
(Timeline: Ongoing as data is made available)- to commence in 2018/19 once sufficient data has been finalized
D6) Compare against satellite (TES (Technology Experiment Satellite), OMI (Ozone Monitoring Instrument), CrIS (Cross-track Infrared Satellite), TROPOMI (TROPOspheric Monitoring Instrument), TEMPO (Tropospheric Emissions: Monitoring of Pollution)) observations of NO_2, NH_3, and SO_2
(Timeline: Ongoing as data is made available)- ongoing

<u>2018/19:</u>
Measurements will continue to be conducted in 2018/19 with regular site audits at both the Pinehouse Lake and Flat Valley sites. The majority of the project deliverables are dependent on having several years of available data.
D1) Deliver quality controlled dataset for the 2016 and 2017 measurements conducted at the Flat Valley and Pinehouse Lake sites
D2) Quantify the contribution of measured NO (Nitrogen Oxide), NO_2 (Nitrogen Dioxide), NO_y (total of oxidized forms of nitrogen), and NH_3 (ammonia) to dry and total deposition of N; thus, providing the necessary estimation of the N deposition input at these Ecosystem and Transformation sites (Timeline: 2018/19 to 2019/20+ after the collection of 2-5 years of data
D3) Quantify the contribution of long-range /transboundary transport of oil sands emissions versus other emission sectors to N and S dry and total deposition in northwestern Canada and in particular over sensitive ecosystems located at long distances from the emission areas
(Timeline: 2018/19 to 2019/20+after the collection of 2-5 years of data)
D4) Examine trends of nitrogen and sulphur species air concentrations and deposition in light of the potential expansion of industrial activities in western Canada
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(Timeline: Ongoing as data is made available)
D6) Compare against satellite (TES (Technology Experiment Satellite), OMI (Ozone Monitoring Instrument), CrIS (Cross-track Infrared Satellite), TROPOMI (TROPOspheric Monitoring Instrument), TEMPO (Tropospheric Emissions: Monitoring of Pollution)) observations of NO_2, NH_3, and SO_2
(Timeline: Ongoing as data is made available)

<u>2019/20 and 2020/21:</u>

	In addition to the ongoing activities related to D2-D6 D7) Deliver quality controlled dataset for the 2018 measurements conducted at the Flat Valley and Pinehouse Lake sites D8) Deliver quality controlled dataset for the 2019 measurements conducted at the Flat Valley and Pinehouse Lake sites ***Component 5 of 5 - Inferential modelling of atmospheric deposition*** 2017/2018: D1) Concentration maps for PACs across the region (1 publication) - completed D2) Total atmospheric deposition maps for PACs across the region (1 publication) – completed 2018/19: D3) Estimated atmospheric dry deposition for trace metals at the three active sampling sites (1 publication) D4) Development of emission database for trace elements (1 publication) D5) Concentration and deposition maps for trace elements across the region (1 publication) 2019/20: D7) Publications of deposition estimation for other pollutants in future years D8) Improved results integration and model application with other deposition measurement studies carried out under the oil sands monitoring program

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:

Deposition, oil sands region, PACs, metals, PM, mercury, S and N, particulate matter, inferential modeling, tree cores

Describe how you will test your hypothesis:

Component 1 of 5 - Passive monitoring of PACs in air:

H1) Passive air monitoring for PACs at sites across the oil sands region combined with dispersion/inferential modeling can be used to generate maps of PAC deposition from air across the oil sands region in space and time

Results from passive air sampling for PACs over the period 2012-2015 at 15 to 18 monitoring sites will be analyzed and reported. These data will build on previously published results covering the period November 2010-June 2012 (Harner et al., 2013; Schuster et al., 2015) and will support an improvement to the current deposition modeling approach (Zhang et al., 2015) by combining dispersion modeling and inferential modeling to generate improved estimates of PAC deposition from air across the oil sands region (see component 5 of 5 for details on modeling). Note that starting with the 2016 samples, analysis of PACs will be reduced to the 5 monitoring sites where PAS-DD samplers are co-deployed (i.e., AMS5, AMS6, AMS9, AMS13, and AMS14). Samples will continue to be collected at all 18 sites and the samples that are not analyzed (i.e., from remaining 13 sites) will be archived for possible future analysis. **Updates:** In 2018/19 the passive sampling network for PACs will be reduced in number of sites (from 18 to 13) but increase in overall geographic coverage to include the Cold Lake and Peace River airsheds as shown in Table 1. In addition, trace metals will be measured in passive samplers during a one-period pilot study using new methodology developed at ECCC for measuring trace metals the PUF disk type passive air samplers. **Linkages:** In 2017/18 passive air sampling will be integrated with ecosystem effects studies / biodiversity work, under WL-MD-11-1718 (Amphibian and Wetland Health: Investigation of Wetland Ecosystem Health); and data analysis for passive air samples will continue in 2018/19; in 2018/19 measurements of PACs in air made under passive and active methods (components 1 and 2) and inferential modelling of PACs deposition (component 5) will be integrated with GEM-MACH modelling of PAHs in the oil sands region which is under A-MD-4-1718 (*OS Air Pollution Emissions, Transformation and Fate*) and the Atmospheric Pollutant Deposition Monitoring - Lakes and Snowpack study (A-MD-9-1718); results from PACs synthesis report under proposal R-1-1718 (*Air evaluation, integration, synthesis and reporting*) to be completed in 2017/18 will inform future passive and active sampling including the distribution and number of sites.

(Timeframe: 2017/18 to 2021+)

Background: Over the period 2011-2018, passive monitoring sites measuring PACs have ranged in number from 15 to 18. Based on recommendations stemming from a March 2016 “Deposition and Effects - Results and Planning Workshop” sample analysis was reduced to 5 sites because it was felt that several years of data for all 15-18 sites was adequate. However, sample collection continued at all 18 sites (samples from 13 of the 18 sites were archived) in case there was a need for future retrospective analysis. Cost of sample collection is relatively minor compared to the analysis of samples. In 2017/18, and based on expert discussions stemming from the PACs Air Synthesis Review (R-1-1718) a decision was made to optimize the passive sampling network and to expand it to include airsheds other than just Wood Buffalo, where different types of mining approaches are used e.g. in-situ. Starting in 2018/19 the passive sampling network will include 6 sites in the Wood Buffalo airshed, 6 in the Cold Lake airshed, and 1 in the Peace River airshed.

H2) Recently developed passive dry deposition samplers (PAS-DD) complement the data obtained from conventional PUF disk type samplers and provide a comparable and direct measure of dry deposition that can be evaluated against model results

Co-deployed PUF disk and PAS-DD air samples collected over a one year period (October 2015-September 2016 at the 5 sites listed above) will be analyzed to compare the performance of the two passive sampling methods. The results of the PAS-DD sampler will be evaluated against new deposition model results. The results of the PAS-DD sampler comparison will inform future direction and application of the PAS-DD sampler. This could result in phasing out of the PAS-DD sampler or possibly even an expanded passive deposition network based solely on the PAS-DD as part of a focused study.
(Timeframe: 2017/18 to 2018/19)

H3) Petcoke contributes significantly to PAC levels in air (and deposition) across the oil sands region

PUF disk and PAS-DD air samples (mentioned above) will be evaluated for the presence of petcoke dust signature. This will involve the comparison of PAC residue profiles in petcoke samples (fluid and delayed petcoke) and by inspecting individual particles trapped on passive samplers using a novel SEM/EDS (Scanning Electron Microscopy / Energy-Dispersive X-ray) technique in collaboration with the University of Alberta. Similar to work addressing H2, the outcome of this work will inform the next steps and future focused studies and applications of new analysis tools such as SEM/EDS. **Linkages:** This work is also integrated with activities in ECCC-WSTD investigating heterocyclic aromatics in petcoke, snow, sediments, and air samples. (Timeframe: 2017-18 to 2018/19+)

H4) PAC transformation products (e.g. oxy- and nitro-PAHs) are produced in the atmosphere of the oil sands region and are more widely distributed (away from the oil sands region) compared to parent PACs
Results of the analysis of nitro- and oxy-PACs in passive air samples from ~16 monitoring stations over the period October 2013-April 2016 will be compared to results for PAHs to delineate difference in spatial and seasonal trends. Results from PAC transformation experiments (chamber study using flow tube reactor), which are ongoing, may contribute to the identification of key transformation products in air samples. Again, due to the results-based and incremental aspect of this work, future focused study work may be required to fully address the hypothesis.
(Timeframe: 2017-18 to 2018/19)

H5) PAC transformation products result in enhanced in-vitro toxicity of air samples
Samples from PAC transformation experiments will be used to assess changes in in-vitro toxicity resulting from oxidation of PACs in air. The in-vitro toxicity work will build on an ECCC-led recent publication (Jariyasopit et al., 2016) and will depend on ongoing collaboration with Health Canada on testing and developing new and sensitive in-vitro screening methods to link measurements of organics in air with a range of toxicity indicator endpoints. The ongoing work includes assessing the toxicity (oxidative potential, OP) of air samples from OS region (using the method currently being developed within ECCC), and potential OP increase due to atmospheric transport and oxidation of PM-bound PACs . Given the rapidly developing progress in the field of in-vitro testing, it is expected that this work will require additional time.
(Timeframe: 2017-18 to 2021)

H6) Tree cores can be used to reconstruct historical trends for PACs in air across the oil sands region, including the pre-mining period, and to delineate the spatial range of the impacted region
Based on a recent methodology developed and validated for measuring PACs in tree cores (Rauert and Harner, 2016) and experiments and new uptake model (Rauert et al., in prep), samples collected during July/August 2015 across 18 sites and analyzed for PACs during 2016-18 will be analyzed to delineate spatial and temporal trends of PACs across the oil sands region. We will also continue to work with Natural Resources Canada (NRCan) on the testing of isotope techniques that can be applied to PACs in tree bark and wood to differentiate sources, starting in 2017-18 and continuing in 2018-19.
(Timeframe: 2017-18 to 2018-19)

Assumptions and Constraints behind the hypothesis and the testing method:

- Some challenges have been experienced in 2017/18 with the flow tube reactor study to generate transformation products of PACs. The challenges relate to the stability of the system in generating consistent results which is most likely due to sorption of more polar products to chamber surfaces. This may impact/delay work under H4A and H4B above. The flow tube reactor study will be revisted in 2018/19.
- Characterization of petcoke is based on petcoke samples (fluid and delayed) provided by University of Alberta (Zhang et al., 2016). We assume that these samples are representative of petcoke across the oil sands region. Characterization of petcoke from other oil sands sources in 2018-19 will address this issue.
- Analysis of tree coring results to produce historical trends of PACs will be constrained by the current uncertainties in how gas- and particle-phase PACs deposit onto and accumulate in tree wood. This is an area of ongoing study.

Component 2 of 5 - Active monitoring of targeted multi-pollutants (PACs, metals, coarse and fine particulate matter (PM), PM2.5 speciation, VOCs, polar and sulphur-containing VOCs) in air:

H1) The geographical distribution and number of the active air monitoring sites for enhanced deposition can be used to collect ambient data of the targeted pollutants and generate deposition estimates
The previous project initiated under OSM included three pilot sites, AMS5, AMS11 and AMS13 (terminated in 2015), to measure PACs and PM2.5 metals. Additional multi-pollutant measurements (coarse and fine PM, PM metals, speciated PM2.5, and VOCs) were implemented at two additional enhanced deposition sites (AMS1, AMS18; started in 15-16) designated as "supersites". Under this new design for fiscal year 17-18, the third "supersite" (Buffalo Viewpoint, AMS4), planned to be in operation mid-year during fiscal year 16-17 (delays due to May 2016 Fort McMurray wildfires), will be operational at the beginning of fiscal year 17-18. At the same time, the pilot site (Mannix, AMS5) will be phased out in 17-18. This will complete the enhanced deposition network comprised of five integrated monitoring sites (AMS1, AMS4, AMS11, AMS17, and AMS18). - completed
Linkages: Under WL-MD-11-1718 (Amphibian and Wetland Health: Investigation of Wetland Ecosystem Health); starting in 2017/18 measurements of PACs in air made under passive and active methods (components 1 and 2) and inferential modelling of PACs deposition (component 5) will be integrated with GEM-MACH modelling of PAHs in the oil sands region which is under A-MD-4-1718 (*OS Air Pollution Emissions, Transformation and Fate*); results from PACs synthesis report under proposal R-1-1718 (*Air Evaluation, Integration, Synthesis and Reporting*) to be completed in 2017/18 will inform future and active and passive sampling including the distribution and number of sites; results from PM2.5 speciated measurements will be integrated with Component 4 and Component 5.
(Timeframe: 2017-18)

H2) Analytical methodologies will identify and detect potential chemical markers such as quinones and naphthenic acids, and can be used to derive ambient data for these new chemicals for later use in emission source attributions
Novel analytical methodologies developed in fiscal 16-17 to identify quinones and naphthenic acids in samples collected in oil sand region will be finalized and published in fiscal year 17-18.
(Timeframe: 2017-18; completed)

H3) Long term comprehensive multi-pollutant *(PACs, metals, coarse (PM10-2.5) and fine PM2.5; PM2.5 speciation, VOCs, polar and sulphur-containing VOCs)* measurements will provide the data needed to fully assess the predominant primary emission sources impacting local and regional air quality including transport, transformation and deposition of target pollutants

- Continuation of present atmospheric monitoring of multi-target pollutants at enhanced deposition sites: AMS1, AMS5 (to be replaced by AMS4), AMS11, AMS17, AMS18.
- The long term sampling strategy (e.g., number and distribution of sites) will also depend on the outcomes of the PACs air synthesis report expected in late 2018/19.
- Commence measurements at the third "supersite" (AMS4) and stop measurements at the AMS5 site
- Evaluation of data collected for at least one year at both AMS4 and AMS11 to formulate future recommendations on sampling at these two sites (the AMS4 site is already replacing AMS5).
- Data from active air sampling for metals and PACs over the period 2010-2016 at 3 pilot sites will be analyzed and results reported (2-3 publications; in progress).
- Initiate analysis of results for other target pollutants collected at AMS17 and the two enhanced deposition "supersites" AMS1 and AMS18.

(Timeframe: 2017-18 to 2018/19+)

H4) The active air monitoring data of targeted pollutants at selected sites across the oil sands combined with dispersion/inferential modeling will provide effective maps of atmospheric pollutant deposition across the region in space and time.
These data will support an improvement to the current deposition modeling approach by combining dispersion modelling and inferential modeling to generate improved estimates of PACs and metals

deposition from air across the oil sands region (1-2 papers). **Linkages:** This work is also integrated with activities under A-MD-4-1718 (*OS Air Pollution Emissions, Transformation and Fate*).
(Timeframe: 2017-18 to 2018/19+)

H5) Petroleum coke dust is a source of PACs and metals in the oil sands region
The 4-year datasets for PACs and metals in samples collected at three sites (AMS05, AMS11 and AMS13) will be used to: (1) characterize air pollutant levels with emphasis on benzo[a]pyrene (BaP) and vanadium; (2) assess to what degree the dust from petcoke is detectable in ambient air; and (3) provide informed evidence to support future AOSR (Alberta Oil Sands Region) management strategies
Linkages: Starting in 2017-18, this work will integrate with passive PACs evaluation for the presence of petcoke dust (Component 1) (1 publication).
(Timeframe: 2017-18; in progress)

H6) PACs transformation products (e.g. quinones) are produced in the atmosphere of the oil sands
Results of the analysis of gas-phase (GP) and particle-phase (PM) ambient air aerosol samples collected separately in 2013 summer intensive field campaign will be reported (2 publications). So far, data indicated that PAHs oxidizes faster in GP, and the level of transformation products (quinones) increases in the PM phase with time. Also, the temporal changes in the monitored concentrations suggest that a difference in the positional isomer or alkylation influences the generation and stability of quinones arising from the same parent PAH.
(Timeframe: 2017-18; completed)

H7) Naphthenic acids (NAs) are present in particulate matter (PM) in the oil sand region.
The results from the analysis of atmospheric PM samples by the developed method (H2) will be reported (1 publication). This preliminary study presents, to our knowledge, the first direct identification of classical NAs in atmospheric particulate matter.
(Timeframe: 2017-18; completed)

Assumptions and Constraints behind the hypothesis and the testing method:
Sample analysis, data interpretation and reporting might be delayed due to the implementation of the new national ECCC laboratory information management system (NLIMS), and in conjunction with laboratory renovations.

Component 3 of 5 – Mercury air sampling and deposition:
H1) Atmospheric mercury in the oil sands region is driven by background levels and wildfire events
Results from ongoing total gaseous mercury (TGM) monitoring and ongoing speciated atmospheric mercury (gaseous elemental mercury (GEM) + gaseous oxidized mercury (GOM) + particulate bound mercury (PBM)) monitoring in the oil sands region since 2014 will be analyzed and reported. These data will build on previously published results (Parsons et al., 2013) that covered October 2010 through May 2013, with the addition of speciated Hg data that were not available at the time of the previous publication. (Timeframe: 2017-20). TGM is being measured at 2 sites in the area (AMS6 and AMS13) for comparative purposes. AMS6 is considered an upwind site (not impacted by industrial activities, yet still within the region) and AMS13 is considered a downwind site (atmospheric mercury reaching this site has been impacted by the emissions to the atmosphere through industrial/mining activities). Once the processes studies (H2 and H3) have been completed, a location further removed from the oil sands primary industries to replace AMS6 would be warranted to represent a larger regional atmospheric mercury signature. At this time, the cost to continue measuring mercury at AMS6 is minimal (4K) and the value of this comparative data is well worth the cost.

H2) Differences in land use affect the mercury cycle in the oil sands region

Mercury has been shown to deposit from the atmosphere close to oil sands facilities (Kirk et al., 2014). Subtle differences in total gaseous monitoring (TGM) data collected at Fort McMurray – Patricia McInnes (AMS 6 station) compared to TGM data collected at Fort McKay South (adjacent to AMS 13 station) suggest that local land use may play a minor role influencing TGM concentrations observations (Parsons et al., 2016). The wet deposition sampler was installed October 2017 at AMS13 and will complement the ongoing atmospheric mercury measurements in the oil sands region. One sampler was installed because the area has been cleared for fire maintenance and thus not possible to undertake measurements through the forest at this location. Speciated mercury sampling will continue at AMS 13 as required, to supplement wet deposition sampling data. The number of atmospheric speciation sampler systems has been reduced to one. (Timeframe: 2017-2020)

H3) Atmospheric mercury monitoring and mercury in wet deposition sampling can be used to improve understanding of the mercury cycle in the oil sands region through improved modelling capabilities.

Mercury can be transformed in the atmosphere from a stable chemical to one that easily deposits to the ground (eventually making its way to the ecosystem). Chemicals released to the atmosphere from industrial activities can enable this transformation of mercury and subsequent deposition. Measurements of mercury in the snow around industrial activities show strong evidence of atmospheric mercury deposition but current ground measurements of mercury in the air (away from the activities) do not reflect this transformation and deposition. It is hypothesized that the transformation of mercury occurs higher in the atmosphere closer to industrial activities and above the forest canopy. It is also thought that measurements at the current location reflect that the deposition of mercury is being taken up by the overlying forest.

Overall, a primary goal of the mercury monitoring program is to better understand the mercury cycle within the oil sands region, including transport and deposition of atmospheric mercury, and subsequent transformation to methylmercury in terrestrial, aquatic, and biotic systems. Data from the atmospheric mercury monitoring program, including wet deposition sampling, will be used in conjunction with the other mercury programs (water and wildlife, e.g. Linkage with snow deposition study and the Aircraft 2018 project) to further develop overall mercury modelling currently being developed by ECCC staff scientists. The atmospheric component of the mercury cycle is necessary to understand/predict mercury deposition trends/forecasts. (Timeframe: 2017-2020)

Linkages: GEM-MACH Hg modelling and transformation processes of mercury under A-MD-4-1718 (*OS Air Pollution Emissions, Transformation and Fate)*; Hg deposition in snow under A-MD-9-1718 Atmospheric Pollutant Deposition Monitoring - Lakes and Snowpack and the Tailings Ponds Study of 2017.

Assumptions and Constraints behind the hypothesis and sampling of mercury in the air:

- Currently, speciated mercury (GOM and particle bound mercury) are operationally defined terms and thus we assume that the sum of GEM and GOM reflect total gaseous mercury (TGM).
- During the Fort McMurray wildfires the pumps on the instruments stopped running. Should there be additional wildfires in the near vicinity, we will likely face the same sample collection challenges.

Component 4 of 5 – Enhanced Measurements of Nitrogen and Sulphur Species at Ecosystem/Transformation Sites:

H1) Industrial emissions from the oil sands region (i.e., NO_x, and SO_2) can undergo long-range transport and transformation and impact ecosystems at significant distances downwind of emission sources

– Real time measurements of gaseous nitrogen and sulphur species (NO, NO_2, NO_y, NH_3 and SO_2) will continue to be monitored as an enhancement to routine Canadian Air and Precipitation Monitoring Network (CAPMoN) measurements at two Ecosystem/Transformation sites: Pinehouse Lake (SK) and Flat Valley (SK). The additional gas phase measurements are needed to estimate dry deposition of the most important nitrogen and sulphur species. Measurements began at Pinehouse Lake (PHL), SK in February 2015 and at Flat Valley (FLV), SK in February 2016 and both of these sites are part of CAPMoN. It is recommended that the

measurements continue for 5 years (period of time subject to review) in order to provide the required data to answer the science based questions related to long range transport, transformation, and deposition of oil sands emission sources.
– Data collected at these sites will undergo routine quality assurance/quality control and standard CAPMoN data management practices. For data collected each year, final review will begin at the end of the calendar year with data being made available via the Government of Canada data portal in the second quarter of the following fiscal year.
– Regionally-representative continuous gaseous NO, NO_2, NO_y, NH_3 and SO_2 data from this activity will be used to quantify air concentrations and dry deposition at sites downwind from the oil sands.

Linkages: The data collected as part of this project, combined with the existing nitrogen and sulphur species components of the air and precipitation measurements of CAPMoN, will enable the quantification of total nitrogen deposition at these sites (component 5 of A-MD-2-1718), which can be used to establish critical load maps (Trent University). The data will be used to estimate the influence of long-range/transboundary transport and transformation of emissions from the oil sands (A-MD-4-1718) relative to other western Canadian sources, examine trends in nitrogen and sulphur species, aid in the development and evaluation of chemical transport models (A-MD-4-1718), and assist in the validation of satellite measurements of NO_2 , NH_3, and SO_2 (A-MD-4-1718). Air concentration data will also be available for assessing the state of air quality in the region.
(Timeframe: 2017-18 to ~2022)

Background: The costs of daily operation of the PHL and FLV sites are covered under CAPMoN. The current work plan supports the enhanced N and S measurements (NO, NO_2, NO_y, NH_3, SO_2) needed to understand deposition of oil sands-related compounds in areas downwind of the industrial activities. These measurements are not part of the standard CAPMoN suite and complement the typical CAPMoN air tower (p-NO_3^- (particulate nitrate), p-NH_4^+ (particulate ammonium), HNO_3 (nitric acid), SO_2, and p-SO_4^{2-} (particulate sulfate)), and precipitation (NO_3^- (nitrate ion), NH_4^+ (ammonium ion), and SO_4^{2-} (sulfate ion)). With these enhanced measurements a more complete calculation of the total dry deposition of N and S species can be made and with the CAPMoN wet deposition total deposition and dry/wet comparisons can be accomplished. The data can also be used for the purpose of satellite and model validation.

Assumptions and Constraints behind the hypothesis and the testing method:

- It is assumed that detectable ambient air concentrations of gaseous N and S pollutants will be observed at ecosystem sites and that the measured levels will be significant enough for evaluating chemical transport models and validating satellite observations. – over the past couple of years most species have been found at detectable concentrations with notable events that may be associated with long range transport of emissions from the oil sands region.
- It is assumed that pollutants emitted in oil sands region may be transported long distances to sensitive ecosystems downwind.
- Some challenges to date that we have experienced have been due to forest fires. Measurements at both sites have been impacted by forest fires either upwind or locally and these may pose additional uncertainties in the deposition estimates.

Component 5 of 5 - Inferential modelling of atmospheric deposition
H1) Dispersion modeling combined with monitoring data can be used to generate gridded concentrations in air for a variety of pollutants (e.g. PACs, elements, N and S) in the oil sands region, which will then improve the accuracy of deposition maps based on inferential modeling
– An air dispersion model has been modified and run for the year 2011. The simulated concentrations have been compared with monitored air concentrations of PACs at the 17 passive sampling sites. Gridded

concentrations, once evaluated and adjusted based on available measurements, will be used to produce dry and total deposition estimates.
– Work will also be started to estimate dry deposition of 40+ trace elementals at the three monitoring sites. A literature survey of particle size distribution of trace elementals will first be conducted. A particle dry deposition model, forecasted meteorology, particle size distribution, and monitored air concentration will then be coupled together to obtain dry deposition estimation of all trace elements at locations they are monitored. Emission database and deposition maps will also be developed for trace elements.
– The work planned for PACs has been finished by the end of fiscal year 17/18. Similar products to PACs will be generated for trace elements in FY2018/19. Estimation of dry deposition of other pollutants can be done in a similar approach in future years (as documented in other project components, e.g., CAPMoN monitoring of nitrogen species). As evidence supporting the proposed approach, the mercury dry deposition framework developed by Zhang et al. has been adopted in the U.S. National Atmospheric Deposition Program - the Atmospheric Mercury Network (NADP/AMNet) since 2009. The first six-year mercury dry deposition results have now been published (Zhang et al., 2016) and data produced from this project will also soon be online on the NADP website. (Timeframe: 2017-18)

Linkages: The inferential dry deposition framework developed in this component applies to various pollutants and makes use of the air concentration data monitored in the other four components of this project. Deposition results from this project component will be compared with deposition estimates stemming from aircraft campaign under A-MD-4-1718 (*OS air pollution emissions, transformation and fate*). Deposition estimates from this project will also be integrated with ecosystem effects studies / biodiversity work (multiple projects under water and biodiversity components), and will be used for the synthesis report “Causes and effects of atmospheric deposition of multiple pollutants” under R-1-1718 and inform the work plan A-MD-6-1718 Integrated Deposition Monitoring Design.
(Timeframe: 2017/18 to 2021+)

Assumptions and Constraints behind the hypothesis and the testing method:
Uncertainties in dry deposition estimation are typically on the order of a factor of 2.0 for seasonal or annual averages of the highly-studied pollutants, such as inorganic sulphur and nitrogen species. Uncertainties for other pollutants such as PACs, trace elements and heavy metals are expected to be larger than those of sulfur and nitrogen species due to the greater challenges in measuring and modeling dry deposition of these pollutants.

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Data Management

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

Deliverables	**Timeframe**	
Data Collection Period:		
PAC passives:		
- Collection of passive air samples – ongoing	Start : 2010-11-01	End: 2021-03-31
- Development and application of in-vitro toxicity testing based on collected passive air samples	Start : 2017-04-01	End: 2021-03-31
PACs, metals and other target pollutants:		
- On-going collection of active air samples at 5 sites using the NAPS (National Air Pollution Surveillance) program one-day-in-six schedule (all samplers, all sites) and one-day-in-three schedule (for PM2.5 speciation and dichotomous samplers at the three supersites, AMS1, AMS4 and AMS18	Start : 2017-04-01	End: 2021-03-31
Atmospheric Mercury:		
- Collection of continuous TGM data at 2 sites – ongoing	Start : 2017-04-01	End: 2020-03-31
- Collection of semi-continuous Speciated Hg at 1 site – ongoing	Start : 2017-04-01	End: 2020-03-31
-Collection of weekly wet deposition samples at 1 site – new	Start : 2017-06-01	End: 2020-03-31
-Design of study (18-19) and deployment of mercury passive samplers (19-20)	Start : 2018-12-03	End: 2020-03-31
Enhanced Measurements of Nitrogen and Sulphur Species at Ecosystem/Transformation Sites: *Collection of continuous NO, NO_2, NO_y, NH_3, and SO_2 data from two sites (Pinehouse Lake and Flat Valley, SK)*	Start : 2017-04-01	End: 2021-03-31
Data Analysis Period:		
<u>Laboratory analysis and QA/QC of data:</u>		
PAC passives:		
PAC passives data (2011 to 2015)	Start : 2017-02-01	End: 2018-04-30
Tree core data	Start : 2016-04-01	End: 2018-04-30
PAC/trace metals passives data from updated network of 13 sites, covering 3 airsheds	Start : 2018-06-01	End: 2019-03-31
Toxicity and OP of passive air sample mixtures	Start : 2018-06-01	End: 2019-03-31
PACs, metals and other target pollutants:		
PM2.5 metals (up to mid of 2016) - completed	Start : 2016-04-01	End: 2017-05-31
Active (high volume) PACs (up to end of 2016) – in progress	Start : 2016-04-01	End: 2017-06-30
PM Speciation (2015-16) – in progress	Start : 2016-04-01	End: 2017-12-30
VOC (2015-16) – in progress	Start : 2016-04-01	End: 2017-12-30
	Start : 2018-04-03	*End: 2018-12-31*

	PM2.5 metals at AMS01, AMS11, AMS17, AMS18 (up to end of 2017) *PM2.5 metals at AMS05 (mid-end 2016; replaced by AMS04)* *PM10-2.5 metals at AMS01, AMS04, AMS17, AMS18 (up to end of 2017)* *Active (high volume) PACs at AMS01, AMS05, AMS11, AMS17, AMS18 (up to end of 2017)* *PM Speciation at AMS01, AMS04, AMS18 (up to end of 2017)* *VOC at AMS01 and AMS18 (up to end of 2017)* ***Atmospheric Mercury:*** *-TGM data at 2 sites (2018)* *-Speciated Hg data at 1 site (2018)* *-Wet Deposition Hg data at 1 site (2018)* ***Enhanced Measurements of Nitrogen and Sulphur Species at Ecosystem/Transformation Sites:*** *NO, NO$_2$, NO$_y$, NH$_3$, and SO$_2$ data for both the Pinehouse Lake and Flat Valley sites collected during the 2016 and 2017 calendar years.*	Start : 2018-04-03 *End: 2018-06-30* Start : 2018-04-03 *End: 2018-12-31* Start : 2018-04-03 *End: 2018-12-31* Start : 2018-04-03 *End: 2018-12-31* Start : 2018-04-03 *End: 2018-12-31* Start : 2018-01-01 End: 2020-03-31 Start : 2018-01-01 End: 2020-03-31 Start : 2017-04-01 End: 2020-03-31 Start : 2017-01-01 End: 2018-06-30	
	Data Release Date: *Metadata and data consistent, complete and meet basic standard format for publication in Open Data; on or linked to JOSM portal* ***PAC passives:*** *PAC passive data from 2012 to 2015* *PAC/trace metals passives data from new 13 sites* ***PACs, metals and other target pollutants:*** *Active PACs, metals (up to end-of-2014)* *Other target pollutants:* *Active PACs, metals (up to end-of-2016)* *Other target pollutants (up to end-of-2016):* ***Atmospheric Mercury:*** *TGM data at 2 sites (2018)* *Speciated Hg data at 1 site (2018)* *Wet Deposition Hg data at 1 site (2018)* ***Enhanced Measurements of Nitrogen and Sulphur Species at Ecosystem/Transformation Sites:*** *NO, NO$_2$, NO$_y$, NH$_3$, and SO$_2$ data for both the Pinehouse Lake and Flat Valley sites collected during the 2016 calendar year.*	2018-04-30 2018-04-30 2019-04-30 2017-06-30 2018-03-31 2018-07-31 2018-07-31 2020-03-31 2020-03-31 2020-03-31 2018-06-30	

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
Component 1 of 5 - Passive monitoring of PACs in air:		
Factors influencing the long-term concentrations of PACs in air across the Athabasca oil sands region	As per the expected subject/title	2017/18 – in prep. (expected in early 2018)
Comparing PUF disk and PAS-DD samplers for measuring PACs and petcoke dust contributions in air samples across the oil sands region	As per the expected subject/title	2017 – completed *(Jariyasopit et al., 2018)*
Oxy- and nitro-PACs in air across the oil sands region: seasonal trends, spatial distribution, and in-vitro toxicity	As per the expected subject/title	2017/18 – in prep. (will be combined with PAC trend paper above)
Historical trends of PACs in air across the oil sands regions derived from tree-ring cores	As per the expected subject/title	2017/2018 – in prep. (expected in early 2018)
Spatial distribution of PACs and trace metals in air across the oil sands region.	This will be the first paper from the updated passive sampling network of 13 sites that span the Wood Buffalo, Cold Lake, and Peace River airsheds. It will likely include data on PACs and trace metals from consecutive sampling periods.	2019
Toxicity of air mixtures from oil sands mining: oxidative potential in gas and particulate phases	This paper will employ in vitro assays and methods for assessing oxidative potential to passive air samplers from across the oil sands region.	2019
Component 2 of 5 - Active monitoring of targeted multi-pollutants		
Sources of Particulate Matter in the Athabasca Oil Sands Region: Investigation through a Comparison of Trace Element Measurement Methodologies	As per the expected subject/title	2017/18 - completed (Phillips-Smith et al., 2017)
Application of ultrahigh-performance liquid chromatography–quadrupole time-of-flight mass spectrometry (UPLC/QTOF-MS) for the characterization of organic	As per the expected subject/title	2017/18 - completed (Yassine and Dabek-Zlotorzynska, 2017)

aerosol: searching for naphthenic acids		
Contribution of Petroleum Coke to Benzo[a]pyrene and Vanadium Levels in Atmospheric Aerosols in the Athabasca Oil Sands Region	As per the expected subject/title	2017/18 – in progress
Characterization of 19 non-derivatized quinones in ambient air: Gas-particle phase partition, distributions and daytime-nighttime variability	As per the expected subject/title	2017/18 - completed (Wnorowski and Charland, 2017)
Characterization of the ambient air content of parent polycyclic aromatic hydrocarbons and their transformation into the corresponding quinones	As per the expected subject/title	2017/18 – completed (Wnorowski, 2017)
Polycyclic Aromatic Compounds in the Lower Athabasca Region of Oil Sands in Albert – 2010-2014 Characterization and Trends	As per the expected subject/title	2017/18 – in progress (Wnorowski et al., 2017)
Using ultrahigh pressure liquid chromatography coupled with ion mobility-time of flight mass spectrometry to characterize naphthenic acids	As per the expected subject/title	2018/19
PACs, metals, VOC: spatial and seasonal trends (from active measurements)	As per the expected subject/title	2018 and later years
Comprehensive chemical composition of $PM_{2.5}$ and associated gaseous pollutants in the Athabasca Oil Sands Region	As per the expected subject/title	2018 and later years
Component 3 of 5 – Mercury air sampling and deposition:		
Atmospheric mercury monitoring in the oil sands region	As per the expected subject/title	2018 or 2019 – delayed due to the later than planned installation of the wet deposition sampler. Data now needs to be collected for at least 1 year

Component 4 of 5 – Enhanced Measurements of Nitrogen and Sulphur Species at Ecosystem/Transformation Sites:		
Estimation of the impact of oil sands emissions on the total deposition of N and S species observed at downwind ecosystems.	This paper will attempt to estimate the fraction of N and S deposition that can be attributed to oil sands emission in relation to other sources. Estimation will be based on calculated deposition at each site and employ back trajectories to determine origin of air mass.	2019/2020
Component 5 of 5 - Inferential modelling of atmospheric deposition		
Model simulations of PACs air concentrations with existing and revised emission inventory and comparison with measurements	The purpose of this paper is to improve the PACs emission inventory to produce air concentration maps for subsequent dry deposition estimation	2017
Mapping atmospheric deposition of PACs	As per the expected subject/title	2017
Estimates of dry deposition of trace elements	As per the expected subject/title Potential publications on other pollutants in future years if monitored air concentration data are available	2017 2019 and later years

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	Project coordination and principal investigator (passives)	ECCC
Project Co-lead	Project coordination	ECCC
Project Co-Lead / Principal Investigator	Project Co-lead and principal investigator (deposition modelling)	ECCC
Principal Investigator	Principal Investigator (Enhanced deposition)	ECCC
Principal Investigator	Principal Investigator (Mercury air sampling and deposition)	ECCC
Principal Investigator	Principal Investigator (N and S deposition)	ECCC
Oil Sands Senior Support (air monitoring component)	Provide coordination and liaison within ASTD, and with the Oil Sands Secretariat and OSM partners	ECCC
Section Manager / Air Component Lead	Air program OS overall management lead	ECCC
Component 1 of 5 - Passive monitoring of PACs in air:		

Science / Technical Support	Logistics, shipping and sample/instrumental analysis for PAC passive samples	ECCC
Science / Data Support	Process studies on PACs and data analysis including QA/QC for passive sampling for PACs	ECCC
Science Specialist	Process studies on PAC uptake by trees and data analysis for tree core studies	ECCC
Science Specialist	Data analysis, QA/QC and reporting for passive air monitoring results for PACs	ECCC
Science Specialist	Coordination of new passive sampling sites in Cold Lake and Peace River airsheds starting in 2018.	AEP
Science / Technical Support	WBEA contact and support for passive sampling for PACs at WBEA sites	AEP / WBEA
Component 2 of 5 - Active monitoring of targeted multi-pollutants		
Principal Investigator	Overseeing integrated sampling network, data analysis and reporting, and coordination with other projects / components.	ECCC
Science Specialist	QA/QC - field operations	ECCC
Science Specialist	Media/field sample handling and reporting	ECCC
Science Specialist	PM metals and PM speciation analysis, and reporting	ECCC
Science Specialist	Analysis of VOCs, polar and sulphur VOCs and reporting	ECCC
Science Specialist	Sample preparation and analysis of PACs, and reporting	ECCC
Data Specialist	Data validation and reporting	ECCC
Science / Technical Support	Management of Ambient Air Technical Program and Terrestrial Environmental Effects Monitoring Program	AEP / WBEA
Technical Support	Field Technical Support	AEP / WBEA
Project coordination	Overall project logistics, O&M, capital and field operations; liaisons with OS industry and local communities	AEP / WBEA
Component 3 of 5 – Mercury air sampling and deposition		
Science Specialist	Overseeing Hg sampling, data analysis and reporting	ECCC
Technical Support	Field Technical Support	ECCC
Technical Support	Field Technical Support	ECCC
Technical Support	Data analysis support	ECCC
Technical Support	Field Technical Support	ECCC
Component 4 of 5 – Enhanced Measurements of Nitrogen and Sulphur Species at Ecosystem/Transformation Sites:		

Science / Data Specialist	Oversee field operations; QA/QC of data	ECCC
Field Technician	Perform maintenance, repairs, and conduct quarterly audits on measurement instrumentation; Daily review of incoming data to ensure instrumentation and data acquisition is functioning properly; Provide training and support for site operators.	ECCC
Component 5 of 5 - Inferential modelling of atmospheric deposition		
Project Co-Lead / Project Investigator	Project coordination and principal investigator (Inferential modeling of atmospheric deposition)	ECCC
Data Support	Coding and data processing	ECCC

Detailed Financial Breakdown – Year 2 of 3 (2018-2019)

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	$	$
Internal Lab Analysis (PDF and coop students) (passives)	$20 310	$
Consumable Materials & Supplies (passive)	$60 000	$
Instrument / capital costs (GC/MS/MS; ASEs; reactions chamber; passive samplers) (passive)		$ 55 000
Operations cost for enhanced deposition sites (n=5, Stony Mountain, Buffalo Viewpoint, Fort McKay and Wapasu enhanced deposition sites. Note: does not include AMS11.) (AEP-WBEA) (active)	$140 000	$
Consumable Materials & Supplies (active)	$195 000	$
Instrument / capital costs (Lab equipment: ICs, XRF, ICP-MS, OC/EC, GC-MS's, HPLC, LC-MS/MS, etc.) (active)		$ 125 000
Field Costs (mercury)	$4 500	$
Consumable Materials & Supplies (mercury)	$11 700	$
Instrument Costs (wet deposition samplers) (mercury analyzers)	0	$243 500
Data management (N+S)	$12 100	$
Consumable Materials & Supplies (N+S)	$25 000	$
Instrument / capital costs (N+S)		$ 34,800
Sub-Total	**$468 610**	**$458 300**
O&M - Travel		
Conferences (Dioxin 2017, Vancouver) (passive)	$2000	$2000
Field Work (QA/QC) (active)	$7000	$
Field Work (mercury air + wet dep)	$11 500	$
Conferences (NADP 2018 Fall Meeting, Albany, NY) (mercury)	$2 000	$
Field Work (QA/QC) (N+S)	$18 000	$
Sub-Total	**$40 500**	**$2000**
O&M - External Contracts :		
Goods and Services Contract (analytical instrument) (active)	$45 000	$75 000
Goods and Services Contracts (WBEA field support, Data QA/QC) (mercury)	$14 800	$

Budget requirements – List areas that require budget expenditures: (ADD OR DELETE BUDGET CATEGORIES AS REQUIRED)	**OS Funding**	**External Funding** (*outside JOSM*)
Goods and Services Contract (Wet deposition Hg lab analyses) (mercury)	$15000	$
Goods and Services Contract (estimated site operations) (N+S)	$	$50 000
Goods and Services Contract (dispersion/inferential modeling)	$25 000	$
Sub-Total	**$99 800**	**$125 000**
Salaries:		
Principal Investigator (passives)	$	$50 000
Technical / Professional Assistants (passives)	$	$65 000
Data Management (passive)	$50 000	$
Principal Investigators (active)	$	$37 000
Technical / Professional Assistants (active)		$284 843
Technical / Professional Assistants (active)	$239 776	$
Principal Investigator (mercury)	$	$
Technical / Professional Assistants (mercury)	$128 600	$179 600
Principal Investigator (N+S)	$	$48 000
Technical / Professional Assistants (N+S)	$64 724	$
Principal Investigator (modeling)	$	$50 000
Post-doctoral Fellow (modeling)	$64 690	
Post-doctoral Fellow (passives)	$64 690	
Post-doctoral Fellow (mercury)	$21 563	
Sub-Total	**$637 380**	**$704 443**
Total Salaries	**$634 043**	**$714 443**
Total O&M	**$608 910**	**$585 300**
2017-2018 GRAND TOTAL* (BEFORE OTHER RELATED COSTS)	**$1 242 953**	**$1 299 743**

Appendix A - Approvals

Project Submitted by:		
Name: Stewart Cober		
Organization: ECCC	Signature:	Date:
Project Approved by:		

Signature		Signature
Date		Date

Activity Planning Review and Evaluation

To be completed by OSM Administration

Date Completed	**Review type**	**Validated by** (insert name and title)
	Program Management review completed	

APPENDIX B – 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) 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		270 000		185 000		185 000		185 000
b) Technical/professional assistants	479 716	454 943	483 100	529 443	540 551	432 343	541 300	432 343
c) Post-doctoral Fellows			150 943		157 796		164 640	
2) Operations and maintenance (O&M)								
a) Facilities (operation of 4 enhanced deposition sites) (AEP-WBEA)	187 800		140 000		140 000		140 000	
b) Equipment (Hg wet dep sampler.)	20 000							
c) Lab analysis (PDF and coop students) (passives)	85 000		20 310		17 373		14 440	
d) Data management	12 100		12 100		12 100		12 100	
e) Field work costs	3 100		4 500		4 500		4 500	
f) Mercury passive sample analysis					3 000	35 000	3 000	35 000
g) Instrument capital costs (passive; active; N+S)		258 300		214 800		258 300		258 300
h) Mercury instrument capital costs (Tekrans, DMA)		200 000		243 500		235 000		235 000
3) Consumable Materials and supplies								
a) Passive sampling and analysis	60 000		60 000		60 000		60 000	
b) Air sampling and analysis consumables (active)	195 000		195 000		195 000		195 000	
c) Mercury consumables +	20 600		11 700		20 000		15 000	

Mercury passive samplers								
d) N+S consumables	25 000		25 000		25 000		25 000	
4) Travel								
a) Conferences and meetings	2 000	2 000	4 000	2000	6 000	2 000	6 000	2 000
b) Field work	44 000		36 500		42 000		42 000	
c) Project-related travel								
5) Dissemination & Engagement								
a) Publications/Reports								
b) Translation (if required)								
c) Communications								
d) Stakeholder Engagement								
e) Indigenous Peoples Engagement								
6) External Contracts								
a) Goods and services (instrument; Active)	45 000	75 000	45 000	75 000	45 000	75 000	45 000	75 000
b) WBEA field support and data QA/QC (Hg)	18 000		14 800		14 800		14 800	
c) Lab analysis (Hg, wet dep.)	35 000		15 000		16 000		17 000	
d) Site operations (CAPMoN)		50 000		50 000		50 000		50 000
e) Dispersion modelling	25 000		25 000		25 000		25 000	
Grand Total (*before other related costs)	1 307 316	1 110 243	1 242 953	1 299 743	1 324 120	1 272 643	1 324 780	1 272 643

*** Total salary costs for ECCC ($634,043) in 2018-19 with other related costs are $871,936. Total O&M costs for ECCC ($468,910) in 2018-19 with other related costs are $570,561. Total O&M costs for AEP in 2018-19 are $140,000. The Grand Total for ECCC (with other related costs) and AEP in 2018-19 is $1,582,497.**

* Total salary costs for ECCC ($479,716) in 2017-18 with other related costs are $659,705. Total O&M costs for ECCC ($639,800) in 2017-18 with other related costs are $728,395. Total O&M costs for AEP in 2017-18 are $187,800. **The Grand Total for ECCC and AEP in 2017-18 is $1,575,900.**

APPENDIX C –Years 1 to 4 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 1 (2017- 2018)
Deliverable(s) (please provide enough information to support status reporting)
Q1 – April to June
An interim report (~2 to 3 pages) will document project progress including implementation of activities, sample collection, sample and data analysis, publications, presentations, and submissions to the data portal.
Q2 – July to September
An interim report (~2 to 3 pages) will document project progress including implementation of activities, sample collection, sample and data analysis, publications, presentations, and submissions to the data portal.
Q3 – October to December
An interim report (~2 to 3 pages) will document project progress including implementation of activities, sample collection, sample and data analysis, publications, presentations, and submissions to the data portal.
Q4 – January to March
An interim report (~2 to 3 pages) will document project progress including implementation of activities, sample collection, sample and data analysis, publications, presentations, and submissions to the data portal.

Year 2 (2018 - 2019)
Deliverable(s) (please provide enough information to support status reporting)
Q1 – April to June
An interim report (~2 to 3 pages) will document project progress including implementation of activities, sample collection, sample and data analysis, publications, presentations, and submissions to the data portal.
Q2 – July to September
An interim report (~2 to 3 pages) will document project progress including implementation of activities, sample collection, sample and data analysis, publications, presentations, and submissions to the data portal.
Q3 – October to December
An interim report (~2 to 3 pages) will document project progress including implementation of activities, sample collection, sample and data analysis, publications, presentations, and submissions to the data portal.
Q4 – January to March
An interim report (~2 to 3 pages) will document project progress including implementation of activities, sample collection, sample and data analysis, publications, presentations, and submissions to the 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 (~2 to 3 pages) will document project progress including implementation of new activities, sample collection, sample and data analysis and submissions to the data portal.
Q2 – July to September
A short interim report (~2 to 3 pages) will document project progress including implementation of new activities, sample collection, sample and data analysis and submissions to the data portal.
Q3 – October to December
A short interim report (~2 to 3 pages) will document project progress including implementation of new activities, sample collection, sample and data analysis and submissions to the data portal.
Q4 – January to March
A short interim report (~2 to 3 pages) will document project progress including implementation of new activities, sample collection, sample and data analysis and submissions to the data portal.

Year 4 (2020 - 2021)
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 (~2 to 3 pages) will document project progress including implementation of new activities, sample collection, sample and data analysis and submissions to the data portal.
Q2 – July to September
A short interim report (~2 to 3 pages) will document project progress including implementation of new activities, sample collection, sample and data analysis and submissions to the data portal.

Q3 – October to December
A short interim report (~2 to 3 pages) will document project progress including implementation of new activities, sample collection, sample and data analysis and submissions to the data portal.
Q4 – January to March
A short interim report (~2 to 3 pages) will document project progress including implementation of new activities, sample collection, sample and data analysis and submissions to the data portal.