5- YEAR LONG-TERM MONITORING OR OPERATIONAL ACTIVITY WORK PLAN

Changes to this Work Plan are only accepted via an Approved Addendum.

General Information		
Monitoring Category: *(From OSM long-term plan; choose from drop-down menu)*	Atmospheric Monitoring	
Strategic Monitoring Objective: *(From OSM long-term plan; choose from drop-down menu)*	Objective: Detect and report levels and trends of oil sands related chemical substances being deposited from the atmosphere	
Work Plan Unique Identifier:	*A-LTM-S-4-1718*	
Monitoring Activity Title:	Meteorological Network	
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	Athabasca Oil Sands Region
Monitoring Site(s) Coordinates *(latitude and longitude)*	JE306 – 57.6218°, -110.9184° JE308 – 57.0847°, -112.8507° JE312 – 56.8299°, -110.4345° JE316 – 56.3484°, -110.1213° JE323 – 56.8358°, -111.1131° JP104 – 57.1180°, -111.4249° JP107 – 57.8911°, -111.4348° JP201 – 57.0328°, -113.7345° JP213 – 57.0470°, -109.7494° JP311 – 56.5655°, -111.9485° JP316 – 56.3528°, -110.1182° R2 – 57.1144°, -111.4289	
Monitoring Organization and Responsible Manager:	Wood Buffalo Environmental Association	Sanjay Prasad Bob Myrick
Date Monitoring initiated:	**2013**	
Specific Monitoring Objective: *(State the monitoring objective addressed through this monitoring)*	1) Provide meteorological data at 6 paired forest health monitoring sites to improve meteorology fields in air dispersion models. 2) Calculate NO_2, SO_2, O_3, HNO_3 and NH_3 dry deposition at each site using data collected by co-located samplers.	
Deliverables (Annual):	1. Continuous data from the meteorological towers is available on the WBEA web site.	

What Data Reports will be produced and when?	2. Annual report calculating monthly dry deposition of NO_2, HNO_3, SO_2, NH_3 and HNO_3 at each site and assessing the influence of anthropogenic emissions. Determine whether deposition exceeds the forest critical loads for nutrient N and acidifying compounds 3. Five year report calculating deposition trends and multi-year comparison to modelled deposition (from e.g. CMAQ, CALPUFF)

Monitoring Plan Summary: *Please summarize the monitoring including relevant information such as background, objectives, monitoring area, methods/monitoring design, assumptions, outcomes, and references. These should align with the information provided in Appendix 1: Annual Monitoring Schedule.*

Background

Recent studies have examined bulk deposition (Fenn et al., 2015; Watmough et al., 2014), dry deposition (Hsu et al., 2016; Zhang et al., 2015), and wet deposition (Lynam et al., 2015) of various pollutants in the Athabasca Oil Sands Region (AOSR). Dry deposition is difficult to measure on a long-term basis so it must be inferred from modelling calculations. High quality meteorological data (wind speed, wind direction, RH, air temperature, leaf area index (LAI), and solar radiation) along with co-located measurements of the pollutant(s) of interest is required to calculate dry deposition. Clair and Percy (2015) estimated that >70% of S and N deposition in the AOSR is from dry deposition. The same report (in Chapter 11) studied 10 boreal forest sites and found that all 10 sites receive N deposition in excess of the critical load for nutrient N.

Despite dry deposition being the dominant pathway of S and N deposition to forests surrounding the AOSR, robust dry deposition estimates are hindered by a lack of forest sites with co-located measurements of meteorology and pollutants. Dry deposition is calculated using meteorological data from instrumented towers and tripods and ambient concentration data collected at remote forest health monitoring sites.

The WBEA's network of instrumented meteorological stations is comprised of six 30m tall instrumented towers ("met towers") and six 3m tall instrumented tripods ("met tripods") that provide continuous, hourly measurements of meteorological conditions throughout the Wood Buffalo region. Each met tower is located at a Forest Health Monitoring (FHM) interior stand site and monitors air temperature, relative humidity, wind speed, wind direction, and solar radiation at four levels within and above the jack pine canopy, precipitation and barometric pressure at ground level, and temperature and volumetric water content within the forest soil. Each met tripod is located on the open wetland adjacent to a FHM edge site and monitors air temperature, relative humidity, wind speed, wind direction, solar radiation, and barometric pressure. Data from these stations is manually downloaded during bi-monthly site visits.

Objectives

Provide high-quality meteorological data, co-located with samplers, which will be used to drive dispersion models (e.g. CALPUFF) and calculate gaseous dry deposition of both N-containing and acidifying compounds at six forest health monitoring (FHM) sites.

Rationale

There are very few sites with high-quality meteorological measurements at multiple heights which hinder

accurate estimates of gaseous dry deposition. Uncertainties in gaseous dry deposition lead to direct uncertainties on how forest and ecosystem health respond to industrial emissions.

Monitoring Area

Six paired FHM sites within a 120-km radius of the Athabasca Oil Sands mining area. These towers and tripods are strategically placed at FHM sites to enable stakeholders to make informed decisions about the interactions between emissions, deposition, and forest health.

Monitoring Methods

Meteorological towers conform to those used by the U.S. EPA's CASTNet to monitor dry deposition in the United States. Passive samplers will be deployed using the same methodology outlined in Hsu et al. (2016).

Assumptions

Reliable meteorological and passive sampler data on an adequate spatial scale is required to properly calculate acid and N deposition, as well as transport processes, which feed into cause-and-effect studies on forest/ecosystem health.

In previous years, the WBEA has proposed an increase to the number of instrumented meteorological towers from 6 to 8, as per their original plan. However, this increase cannot be justified since, to our knowledge, the data has not yet been used for its intended purpose. It is recommended that AEP assess the data from the instrumented meteorological tower against its intended purpose (e.g. calculation of dry deposition) prior to adding or removing stations. The scientific validity of adding or moving existing wet deposition monitors to be co-located at selected met tower/dry deposition sites should be considered.

Outcomes

Long-term continuous dataset of meteorology and gaseous dry deposition in the Boreal Forest. This data set will be used to assess whether industrial emissions are linked to potential exceedances of forest critical loads for: 1) acidifying compounds and 2) nitrogen compounds (as a nutrient).

Contribution OSM component areas

Meteorological data collected at instrumented towers is used with ambient concentration data to calculate dry deposition. Dry deposition calculations can then be used to determine the loading to forest ecosystem and wetlands. Wet deposition data collected at other locations in the oil sands region can be used to estimate the wet component of deposition to these ecosystems.

References: see Appendix 1

Appendix 1 – Annual Monitoring Schedule

(Please provide detailed information on the specifics of your monitoring schedule including – **locations, schedule, methods, SOPs, QA/QC data release, references**)

Sampling Locations/Sites	**Sampling Schedule** (*timing/frequency*)	**Compounds to be Analyzed**	**SOPs to be Consulted** (*hyperlinks accepted*)	**QA/QC Complete & Date Data to be Released**
JE306 57.6218, -110.9184	1) Continuous (reported as 1-hour averages) 2) Passive samplers (every 2 months)	1) wind speed, wind direction, air temperature, RH, dewpoint, solar radiation, photosynthetically active radiation each at 2m, barometric pressure at 1m. 2) NO_2, SO_2, O_3, NH_3, HNO_3 at 2m	SOPs to be determined by July 2017	Released annually by the end of every March for the previous year
JE308 57.0847, -112.8507	1) Continuous (reported as 1-hour averages) 2) Passive samplers (every 2 months)	1) wind speed, wind direction, air temperature, RH, dewpoint, solar radiation, photosynthetically active radiation each at 2m, barometric pressure at 1m. 2) NO_2, SO_2, O_3, NH_3, HNO_3 at 2m	SOPs to be determined by July 2017	Released annually by the end of every March for the previous year
JE312 56.8299, -110.4345	1) Continuous (reported as 1-hour averages) 2) Passive samplers (every 2 months)	1) wind speed, wind direction, air temperature, RH, dewpoint, solar radiation, photosynthetically active radiation each at 2m, barometric pressure at 1m. 2) NO_2, SO_2, O_3, NH_3, HNO_3 at 2m	SOPs to be determined by July 2017	Released annually by the end of every March for the previous year
JE316 56.3484, -110.1213	1) Continuous (reported as 1-hour averages) 2) Passive samplers (every 2 months)	1) wind speed, wind direction, air temperature, RH, dewpoint, solar radiation, photosynthetically active radiation each at 2m, barometric pressure at 1m. 2) NO_2, SO_2, O_3, NH_3, HNO_3 at 2m	SOPs to be determined by July 2017	Released annually by the end of every March for the previous year
JE323 56.8358, -111.1131	1) Continuous (reported as 1-hour averages) 2) Passive samplers (every 2 months)	1) wind speed, wind direction, air temperature, RH, dewpoint, solar radiation, photosynthetically active radiation each at 2m, barometric pressure at 1m. 2) NO_2, SO_2, O_3, NH_3, HNO_3 at 2m	SOPs to be determined by July 2017	Released annually by the end of every March for the previous year
JP104 57.1180°, -111.4249°	1) Continuous (reported as 1-hour averages) 2) Passive samplers (every 2 months)	1) wind speed, wind direction, air temperature, RH, dewpoint each at 2m, 6m, 21m, 29m; photosynthetically active radiation (PAR) at 2m, 6m, 21m; solar radiation at 29m; barometric pressure and	SOPs to be determined by July 2017	Released annually by the end of every March for the previous year

		precipitation at 1m; soil temperature and moisture at 10cm and 50cm below ground level 2) NO_2, SO_2, O_3, NH_3, HNO_3 above the canopy		
JP107 57.8911°, -111.4348°	1) Continuous (reported as 1-hour averages) 2) Passive samplers (every 2 months)	1) wind speed, wind direction, air temperature, RH, dewpoint each at 2m, 6m, 21m, 29m; photosynthetically active radiation (PAR) at 2m, 6m, 21m; solar radiation at 29m; barometric pressure and precipitation at 1m; soil temperature and moisture at 10cm and 50cm below ground level 2) NO_2, SO_2, O_3, NH_3, HNO_3 above the canopy	SOPs to be determined by July 2017	Released annually by the end of every March for the previous year
JP201 57.0328°, -113.7345°	1) Continuous (reported as 1-hour averages) 2) Passive samplers (every 2 months)	1) wind speed, wind direction, air temperature, RH, dewpoint each at 2m, 6m, 21m, 29m; photosynthetically active radiation (PAR) at 2m, 6m, 21m; solar radiation at 29m; barometric pressure and precipitation at 1m; soil temperature and moisture at 10cm and 50cm below ground level 2) NO_2, SO_2, O_3, NH_3, HNO_3 above the canopy	SOPs to be determined by July 2017	Released annually by the end of every March for the previous year
JP213 57.0470°, -109.7494°	1) Continuous (reported as 1-hour averages) 2) Passive samplers (every 2 months)	1) wind speed, wind direction, air temperature, RH, dewpoint each at 2m, 6m, 21m, 29m; photosynthetically active radiation (PAR) at 2m, 6m, 21m; solar radiation at 29m; barometric pressure and precipitation at 1m; soil temperature and moisture at 10cm and 50cm below ground level 2) NO_2, SO_2, O_3, NH_3, HNO_3 above the canopy	SOPs to be determined by July 2017	Released annually by the end of every March for the previous year
JP311 56.5655°, -111.9485°	1) Continuous (reported as 1-hour averages) 2) Passive samplers (every 2 months)	1) wind speed, wind direction, air temperature, RH, dewpoint each at 2m, 6m, 21m, 29m; photosynthetically active radiation (PAR) at 2m, 6m, 21m; solar radiation at 29m; barometric pressure and precipitation at 1m; soil temperature and moisture at 10cm and 50cm below ground level	SOPs to be determined by July 2017	Released annually by the end of every March for the previous year

		2) NO_2, SO_2, O_3, NH_3, HNO_3 above the canopy		
JP316 56.3528°, -110.1182°	1) Continuous (reported as 1-hour averages) 2) Passive samplers (every 2 months)	1) wind speed, wind direction, air temperature, RH, dewpoint each at 2m, 6m, 21m, 29m; photosynthetically active radiation (PAR) at 2m, 6m, 21m; solar radiation at 29m; barometric pressure and precipitation at 1m; soil temperature and moisture at 10cm and 50cm below ground level 2) NO_2, SO_2, O_3, NH_3, HNO_3 above the canopy	SOPs to be determined by July 2017	Released annually by the end of every March for the previous year
R2 57.1144°, -111.4289	1) Continuous (reported as 1-hour averages) 2) Passive samplers (every 2 months)	1) wind speed, wind direction, air temperature, RH, dewpoint, solar radiation, photosynthetically active radiation each at 2m, barometric pressure at 1m. 2) NO_2, SO_2, O_3, NH_3, HNO_3 at 2m	SOPs to be determined by July 2017	Released annually by the end of every March for the previous year

References:

Clair, T. A., and K. E. Percy (Editors) 2015. Assessing forest health in the Athabasca Oil Sands Region. WBEA Technical Report. 2015-05-25, 180 pp +Appendices.

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

Hsu, Y.-M., Bytnerowicz, A., Fenn, M. E., and Percy, K. E.: Atmospheric dry deposition of sulfur and nitrogen in the Athabasca Oil Sands Region, Alberta, Canada, Sci. Total Environ., 568, 285-295, 2016.

Lynam, M. M., Dvonch, J. T., Barres, J. A., Morishita, M., Legge, A., and Percy, K.: Oil sands development and its impact on atmospheric wet deposition of air pollutants tp the Athabasca Oil Sands Region, Alberta, Canada, Environ. Pollut., 206, 469-478, 2015.

Watmough, S. A., Whitfield, C. J., and Fenn, M. E.: The importance of atmospheric base cation deposition for preventing soil acidification in the Athabasca Oil Sands Region of Canada, Sci. Total Environ., 493, 1-11, 2014.

Zhang, L., Cheng, I., Wu, Z., Harner, T., Schuster, J., Charland, J.-P., Muir, D., and Parnis, J. M.: Dry deposition of polycyclic aromatic compounds to various land covers in the Athabasca oil sands region, J. Adv. Model. Earth Sys., 7, 1339-1350, 2015.

Appendix 2 – Detailed Multi-Year Financial Breakdown: if changes are to be made then an Addendum must be Complete and Approved.

(Complete the following detailed financial breakdown; add or delete categories as required)

Budget requirements	Year 1 (2017- 2018)		Year 2 (2018- 2019)		Year 3 (2019- 2020)		Year 4 (2020- 2021)		Year 5 (2021- 2022)	
	OSM Funding	External Funding	OSM Funding	External Funding	OSM Funding	External Funding	OSM Funding	External Funding	OSM Funding	External Funding
1) Salaries and benefits										
a) Appendix 3 – Totals	0.05 FTE ($5000)		0.05 FTE ($5000)		0.05 FTE ($5000)		0.05 FTE ($5000)		0.05 FTE ($5000)	
2) Operations and Maintenance										
a) Vehicles and Transportation										
b) Helicopter										
c) Lab analysis										
d) Data management										
e) Field work										
3) Consumable Materials and supplies										
a) (*Describe Consumable Supply*)										
4) Travel										
a) Conferences and meetings (*identify conference/meeting*)										
b) Field work – travel										

c) Project-related travel										
5) External Contracts										
a) (WBEA – See Appendix 5)	$203,623	$0	$245,700	$0	$257,985	$0	$481,572	$0	$505,651	$0
Grand Total	$208,623	$0	$250,700	$0	$262,985	$0	$486,572	$0	$510,651	$0

Appendix 3 – Staffing Plan

(Complete the following detailed staffing plan; add or delete categories as required)

	Year 1 – Budget Allocation		Year 2 – Budget Allocation		Year 3 – Budget Allocation		Year 4 – Budget Allocation		Year 5 – Budget Allocation	
Responsible Role	OSM Funding	External Funding	OSM Funding	External Funding	OSM Funding	External Funding	OSM Funding	External Funding	OSM Funding	External Funding
Science Expertise	0.05 FTE ($5,000)		0.05 FTE ($5,000)		0.05 FTE ($5,000)		0.05 FTE ($5,000)		0.05 FTE ($5,000)	
Technical/Field Staff										
Administrative and Program Coordination										
Grand Total (*inserted into Appendix 2*)	**0.05 FTE ($5000)**		**0.05 FTE ($5000)**		**0.05 FTE ($5000)**		**0.05 FTE ($5000)**		**0.05 FTE ($5000)**	

Appendix 4 - Approvals

Project Submitted by:		
Name:		
Organization:	Signature:	Date:

Project Approved by:		
Dr. Monique Dubé (AEP)		**Dr. Kevin Cash (ECCC)**
Signature 		Signature 
Date		Date

Appendix 5 – Detailed Budget for External Contractor (WBEA)

Budget requirements	Description	Year 1 (2017- 2018)	
		OSM Funding	External Funding
1) Salaries and benefits			
a) Technical and Field Staff	4 Full time Technical and 1 Summer Student	$ 30,281	
b) Administrative and Program Coordination	Portion of 7 Administration staff and 2 contracts	$ 19,081	
c) Science Expertise	Science and Technical consultation	$ -	
2) Operations and Maintenance			
a) Vehicles and Transportation	Leased vehicles, repairs, insurance, gas	$ 1,626	
b) Helicopter	Flight costs + landing fees	$ 70,000	
c) Lab analysis	Lab analysis of semi-continuous parameters and shipping		
d) Data management	Data reporting, QAQC validation, Data Translation, Software License, IT infrastructure and support services, website reporting, rss feeds AQHI, emergency response, data backups, data security, data hosting and publications	$ 5,738	
e) Station and Site Maintenance	Station infrastructure and site access repairs	$ 242	
f) Data Telemetry and cell phone costs	Station modems, data plans, cell phone and satellite phone plans, emergency response data feeds	$ 3,125	
g) Station and Facilities Expenses	Station Insurance, Tower Lease, Land Agreements, Utilities, Office Equipment Lease and expenses	$ 936	
h) Building Leases and Occupancy Costs	Taiganova bays lease and occupancy costs	$ 6,260	
i) Quality Assurance	Data Audits, Documentation Management, QAP, Site Documentation -AMD)		

j) Safety	Site Access training, PPE, general safety training, Certificate of Recognition (COR), Health and Safety Policies	$ 1,162	
k) Shipping	General shipping fees, brokerage fees, freight charges		
l) Emergent Items	Unplanned emergency items that needs to be resolved within fiscal year. Requires special resolution and approval to be spent.	$ 2,217	
3) Consumable Materials and supplies			
a) Support Gases	Reference standards, calibration gases, support gases		
b) Materials and Consumables	Critical parts, spare parts, pump rebuild kits, pumps, scrubbing materials, tubing, inlet filters, tools, sample lines, electrical wires, etc.	$ 26,450	
4) Travel			
a) Field work – travel	Fort Chipewyan - air travel, accommodation and vehicle rental, per diems		
b) Program work - travel		$ 1,546	
c) Conferences, training and meetings	Staff Development, Presentations, Air - specific workshops, conferences	$ 1,116	
5) External Contracts			
a) External Professional Fees	External Contract fees for Technical Specialists, Software License, Alarm Monitoring, Data Analysis Level 3 QA, University Research grants for post graduate work	$ 31,600	
b) Stakeholder Honorariums	Honorariums for Indigenous and ENGO involvement	$ 1,135	
c) Financial Audit and Legal	Perform financial audits and legal reviews of contracts and human resource matters	$ 783	
6) Capital Expense			

a) Capital - Spare Parts	Critical and Spare parts over $1000 in value		
b) Capital - Equipment	Equipment Replacement and new Inventory		
c) Capital - Support Equipment	Computers, modems, data loggers, IT related		
d) Capital - Office Equipment	Office Equipment - Program related	$ 326	
Grand Total		$ 203,623	