

## FOCUSED STUDY ACTIVITY WORK PLAN

### General Information

<b>Work Plan Unique Identifier:</b>	WL-PD-10-1718																																														
<b>Focused Study Activity Title:</b>	NEW Wetland Ecosystem Monitoring																																														
<b>Focused Study Category:</b>	Monitoring Design and Method Improvement																																														
<b>Geographic Location</b> ( <i>choose from drop-down menu. If Project Location is in more than one area choose from second drop-down</i> )	Athabasca Oil Sands Region	More than 2 Locations (Described in Detailed Monitoring Plan)																																													
<b>Monitoring Site(s) Coordinates</b> ( <i>latitude and longitude</i> )	<p>A long-term wetland monitoring program will be developed over the next three years based on existing sites and the inclusion of new sites to meet monitoring objectives and include sites valued by local communities.</p> <p>The following wetland sites have been intensively monitored over the past 5 years and will be monitored under this program:</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>Site name</th> <th>Latitude</th> <th>Longitude</th> <th>Wetland type</th> </tr> </thead> <tbody> <tr> <td>JPH4</td> <td>57.1125</td> <td>-111.423056</td> <td>Bog</td> </tr> <tr> <td>McKay</td> <td>57.228056</td> <td>-111.703056</td> <td>Bog</td> </tr> <tr> <td>McMurray</td> <td>56.626944</td> <td>-111.19555</td> <td>Bog</td> </tr> <tr> <td>Anzac</td> <td>56.468889</td> <td>-111.042778</td> <td>Bog</td> </tr> <tr> <td>Mariana Lake bog</td> <td>55.896702</td> <td>-112.094611</td> <td>Bog</td> </tr> <tr> <td>Poplar Road Fen</td> <td>56.93852</td> <td>-111.549</td> <td>Fen</td> </tr> <tr> <td>Unnamed 1</td> <td>56.57392</td> <td>-111.276</td> <td>Fen</td> </tr> <tr> <td>Pauciflora Fen</td> <td>56.37542</td> <td>-111.235</td> <td>Fen</td> </tr> <tr> <td>Firebag Fen</td> <td>57.22433</td> <td>-110.898</td> <td>Fen</td> </tr> <tr> <td>Unnamed 2</td> <td>56.32108</td> <td>-111.65</td> <td>Fen</td> </tr> </tbody> </table> <p>Additional wetland monitoring sites will be added over the next three years.</p>			Site name	Latitude	Longitude	Wetland type	JPH4	57.1125	-111.423056	Bog	McKay	57.228056	-111.703056	Bog	McMurray	56.626944	-111.19555	Bog	Anzac	56.468889	-111.042778	Bog	Mariana Lake bog	55.896702	-112.094611	Bog	Poplar Road Fen	56.93852	-111.549	Fen	Unnamed 1	56.57392	-111.276	Fen	Pauciflora Fen	56.37542	-111.235	Fen	Firebag Fen	57.22433	-110.898	Fen	Unnamed 2	56.32108	-111.65	Fen
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<b>Project Leader:</b>	Danielle Cobbaert, Wetland Scientist, Alberta Environment and Parks																																														
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<b>Date Study initiated:</b>	<b>April 1, 2017</b>
<b>Monitoring Category:</b> <i>(From OSM long-term plan; choose from drop-down menu)</i>	Wetland Ecosystem Monitoring
<b>Strategic Objective of Focused Study:</b> <i>(From OSM long-term plan; choose from drop-down menu)</i>	Objective WE1: Detect and report changes in wetland ecosystem in relation to Oil Sands Developments and related Point and Non-point source emissions  <i>Evaluation and integration of wetlands monitoring across air, water and biodiversity studies.</i>
<b>Hypotheses:</b> <i>(Briefly outline the specific hypotheses that your focused study is aiming to address)</i>	<b>Background</b>  The primary goal of the project is to develop a wetland long-term monitoring (LTM) program, and clear mechanisms to integrate existing Oil Sands Monitoring (OSM) wetland Focus Studies (FS). There are currently eight OSM wetland monitoring FS work plans in 2017/18 OSM program, plus a biodiversity long-term monitoring (LTM) project that monitors biodiversity of wetlands across the oil sands region (see list below). There is a lack of integration across these wetland monitoring projects, which limits the power and utility of the data collected. An integrated wetland Long Term Monitoring program with clearly articulated scientific questions, testable hypotheses and associated study design and approach, and complementary methods is needed to understand the effects of oil sands activity on wetland ecosystems.  An integrated OSM wetlands monitoring program, informed by clearly articulated information needs for understanding wetland ecosystems, will support: <ul style="list-style-type: none"> <li>(i) better understanding of the effects of stressors associated with oil sands development activities on wetland ecosystems;</li> <li>(ii) better understanding of stressor effects on wetland ecosystem state and their inability to provide values and services;</li> <li>(iii) inclusion and application of Indigenous knowledge related to cultural wetland value and observations of ecosystem change;</li> <li>(iv) improved use of resources from the elimination of duplicate effort, cost-saving associated with shared infrastructure, and the efficient targeting of resources to areas of highest priority;</li> <li>(v) improved data-sharing and availability among monitoring projects resulting in increased program adaptability and improved access to information by stakeholders;</li> <li>(vi) increased awareness of key information gaps to understand:</li> </ul>

	<p>key drivers (anthropogenic and natural variability), stressors associated with oil sands development and their effects on wetland ecosystem state (includes those wetland indicators valued by local communities), and impacts; and</p> <p>(vii) development of standardized operating procedures (SOPs) including indigenous knowledge and western science, as appropriate.</p> <p>A coordinated, integrated and hypothesis-driven long-term wetlands monitoring program will allow an improved understanding of potential impacts to wetland ecosystems in the oil sands region and will ultimately provide the scientific information required to support regulators, policy makers, industry, stakeholders and other interested/affected parties.</p> <p>The development of the OSM integrated wetland monitoring program will follow the Framework for Ambient Environmental Monitoring of Oil Sands Development (draft document), which outlines an evidence-informed, risk-based, adaptive approach to assess and report on the extent to regulatory controls are adequately protective of the environment. Scientific credibility and relevance to local communities are key aspects of the Oil Sands Monitoring Program. The conceptual framework follows a Driver (Anthropogenic and Natural) – Environmental Stressor – Biotic Response pathway, which monitors indicators focused on detecting environmental ‘effects’ (i.e. biological or ecological impairment) of key ecosystem sentinel species through time. The need for surveillance monitoring to track the status and trends of select wetland variables will also be evaluated (e.g. as measure of system state, unanticipated effects, validation of predicted state, etc.).</p> <p>This project will build upon the Alberta Monitoring Institute’s (ABMI) 2017 report entitled ‘Knowledge Requirements – An integrated Wetland Monitoring Program for Alberta’s Oil Sands Region’, which focused on understanding information needs and desired uses. This project follows the report by developing an integrated wetland monitoring program led by AEP and Environment Canada and Climate Change (ECCC) scientists and supported by the participation of key external agencies and community stakeholders. This project will focus on reviewing existing OSM wetland monitoring studies, both focused and long term, plus other OSM biotic focus studies and OSM environmental monitoring programs (e.g. atmospheric deposition, water quality monitoring and groundwater monitoring) to develop an integrated wetland monitoring plan.</p> <p><b>The rationale for this study arose from the following sources:</b></p> <ul style="list-style-type: none"> <li>- Oil sands industry’s Environmental Protection and Enhancement Act operating approvals include conditions for a Wetland Monitoring Program to determine the potential</li> </ul>
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effect of dewatering and mine development on wetland communities.

- Indigenous communities have identified wetlands as culturally important and have expressed concerns regarding the loss and degradation of wetlands during engagement in the Lower Athabasca Regional Plan (LARP) (Government of Alberta (GOA) 2012) and currently during development of LARP environmental management frameworks.
- In November 2016 the Oil Sands Planning Coordination Committee identified the need to integrate the various wetland focus study funding proposals. This task was directed to Dr. Danielle Cobbaert as an objective of the Long-Term Wetland Monitoring Program Development Focus Study (Environmental Monitoring and Science Division (EMSD), Alberta Environment and Parks (AEP)).
- In January 2017 direction was provided to Dr. Danielle Cobbaert (AEP, EMSD) to submit the Long-Term Wetland Monitoring Program as a 3-year Focus Study on Monitoring Design and Method Improvement.
- In April 2017 direction was provided to Dr. Danielle Cobbaert that this work plan needed to including the following deliverables:
  1. A recommended plan for the future disposition of each of the activities identified below to have a single, integrated wetland monitoring activity.
  2. A recommended plan for standardization, rationalization and integration of WL-PD-10-1718 activities with complementary Oil Sands Monitoring activities (including, but not limited to; Deposition, Groundwater/Hydrology Monitoring and Benthos monitoring).

Project Identifier	Project Title	Wetland Monitoring sites including wetland class, number of sites, study area of interest
WL-CM-2-1718	Culturally Important Wetland Plants	<ul style="list-style-type: none"> <li>- 13 local communities across the Athabasca, Cold Lake, and Peace regions</li> <li>- Study areas of interest to be determined with communities</li> <li>- 1 'safe' site and one 'contaminated' site per interested community</li> </ul>
WL-MD-4-1718	Acquisition of Aerial High-Resolution Digital Ground Terrain Information in the Peace Athabasca	<ul style="list-style-type: none"> <li>- Ground-truth existing wetland monitoring sites in the Peace-Athabasca Delta. (EDIT: <i>Project not funded for 17-18 – Oil Sands Secretariat</i>)</li> </ul>

	Delta for Wetland Monitoring	
WL-PD-5-1718	Design of Deltaic Wetland Ecosystem Health Monitoring Program	12 shallow open water wetlands in the Peace-Athabasca Delta (see project plan for latitude/ longitude coordinates)
WL-MD-6-1718	Remote sensing wetland ecosystem change detection method development	Ground-truth existing wetland monitoring sites in Athabasca Region
WL-PD-10-1718	NEW Wetland Ecosystem Monitoring	2 new bog sites and 4 existing bog sites; previously funded by Cumulative Effects Management Association (CEMA) and the Wood Buffalo Environmental Association (WBEA); bog site locations listed below) 2 new fen sites and 5 existing fen sites; previously funded by COSIA; fen site locations listed below).
WL-LTM-E-3-1718	Waterfowl Effects-based Assessment	Various shallow open water wetlands across the Athabasca, Cold Lake and Peace oil sands regions
WL-IC-11-1718	Amphibian and Wetland Health: Investigation of Wetland Ecosystem Health	15 shallow open water wetlands in the Athabasca oil sands region
WL-IC-2-1718	Atmospheric deposition N-loading experiment on peatlands	Mariana Lake bog and poor fen. (EDIT: <i>Project not funded for 17-18 – Oil Sands Secretariat</i> )

**Specific hypothesis:**

- Oil sands development is significantly affecting wetland ecosystems compared to the range of natural variability of reference conditions.

**Key Objectives:**

- Develop a scientifically credible and efficient OSM Wetland Long-Term Monitoring (LTM) Program for stressor-response and cumulative effects monitoring.
- Integrate with OSM Wetland Focus Studies (see list above) to develop an integrated Wetland LTM Program.
- Integrate with other environmental OSM Long-term Monitoring Programs and other Biotic Focus Studies (FS) (e.g. Atmospheric Deposition FS; LTM Water quality; LTM

	<p>Groundwater; Biodiversity Monitoring) where appropriate to seek harmonization of monitoring efforts and results.</p> <ul style="list-style-type: none"> <li>- To support and create meaningful opportunities for indigenous community engagement in wetland monitoring including planning (e.g. defining key questions, site selection, and wetland indicators for monitoring), sharing results, and developing community-led wetland monitoring components (e.g. Berry health program in Fort MacKay). The ultimate objective is to develop a long-term wetland monitoring program with inherent value to indigenous communities.</li> </ul>
<p><b>Deliverables:</b></p> <p><i>What tangible goal (s) and/or product(s) will the monitoring produce and when?</i></p>	<p><b>Component 1: Evaluation and Integration of Wetland Studies</b></p> <p><b>Workshop</b> on “Designing an Integrated Long-term Wetlands Monitoring Program for the Oil Sands” (3 day workshop in November 2017, Edmonton). Experts will present key background materials, straw dog frameworks and opportunities for integration. Discussion and break out groups by workshop participants will provide input on a path forward for an integrated wetland monitoring program.</p> <p><b>OSM Wetland Monitoring Project study sites in 2017-2018.</b> GIS shapefile for public release.</p> <p><b>Development of Standards and Protocols for the “Evaluation and Integration of Wetland Studies”.</b> A report documenting Standards and Protocols of existing wetland projects (2017/2018) and recommendations for future work. To include a section on the collection of indigenous knowledge.</p> <p><b>Workshop final report</b> with recommendations for an OSM Integrated Wetland Monitoring Program Plan including: workshop proceedings and key outcomes, identification of a conceptual framework, assessment and synthesis of existing wetland Focal Studies, identification of any gaps in current monitoring, and recommendations (next steps, path forward) for implementing an integrated wetland monitoring program. The recommendations will be directed at the OSM Wetland Integration steering committee, which is responsible for developing an OSM Integrated Wetland Monitoring Program Plan in 2018-2019.</p> <p><b>Component 2: Wetland Monitoring including methods development</b></p> <p><b>Deliverables:</b></p> <ul style="list-style-type: none"> <li>- Monitoring six bog sites for effects of atmospheric</li> </ul>

	<p>deposition on bog ecosystems (co-PIs Drs. Kel Wieder, Melanie Vile and Dale Vitt).</p> <ul style="list-style-type: none"> <li>- Monitoring seven fens sites for effects of hydrologic alteration on fen ecosystems (co-PIs Drs. Rich Petrone and Jonathan Price).</li> <li>- Development of biotic indicators for effects of oil sands development on wetland ecosystems (co-PI Dr. Rebecca Rooney).</li> <li>- Methods Comparison Studies (led by Dr. Danielle Cobbaert) <ul style="list-style-type: none"> <li>o Wetland macroinvertebrate protocol comparison (ECCC's CABIN and ABMI wetland monitoring protocols)</li> <li>o Atmospheric deposition protocol comparison (WBEA's and Dr. Kel Wieder's protocols)</li> </ul> </li> <li>- Data published to OSM data portal throughout study.</li> <li>- At least 10 peer-review publications anticipated – details provided in Publications Table, plus Appendices D &amp; E.</li> <li>- Wetland LTM Program Manual - including objectives, key questions, hypotheses, study design, rationale for monitoring site selection and network optimization, rationale for stressor and biotic response indicators, standard operating procedures for field, remote sensing and laboratory measurements including quality assurance. Q4 2020 (upon completion of 3 year focus study).</li> </ul>
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## 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:

Wetlands, environmental effects monitoring, stressor, atmospheric deposition, hydrologic alteration, land clearing, biological indicators, vegetation, habitat, status and trends.

Describe how you will test your hypothesis:

### Component 1: Evaluation and Integration of Wetland Studies

**Workshop on 'Evaluation and Integration of Wetland Studies'** (November 2017, Edmonton). Discussion and break out groups to discuss background materials presented at workshop. Work towards consensus on defining a path forward for an integrated wetland monitoring program.

- **Review draft OSM wetland monitoring framework** that will be prepared and circulated by steering committee over the summer period, ahead of the fall face-to-face workshop.
- Identify of **key stressors** associated with oil sands development with the potential to affect wetland extent and ecological condition. Review key stressors monitored under existing OSM projects, annotated bibliography results to develop a rationale for key stressors. Based on the key stressors

develop a monitoring design and study approach. Finally, review various study designs, existing monitoring sites, and SOPs to monitor key stressors and identify the best path forward for implementation.

- Develop a rationale for a prioritized list of **key wetland environmental response indicators** associated with the key stressors. Review wetland responses currently monitored by OSM wetland monitoring projects and other biotic monitoring programs, plus the annotated bibliography findings to develop a rationale for key wetland responses. Finally, review various study designs, existing monitoring sites, and SOPs to monitor key wetland responses and identify the best path forward for implementation.
- The workshop will involve targeted discussions (likely in the format of breakout groups) to determine which OSM wetland questions have been answered (if any), what design components are working well, and potential monitoring adjustments/gaps that need to be addressed. The primary goal of the workshop is to identify a core wetland long-term monitoring (LTM) program, and clear mechanisms by which wetland monitoring focus studies can be integrated.
- Upon agreement and approval, a more detailed wetland integration plan will be developed after the workshop. A major deliverable from this workshop will be a final report describing the existing OSM wetland monitoring work, the rationale for this work, and recommendations for integration/adjustments, including consideration for the inclusion and application of indigenous knowledge. Depending on the extent of integration, a subsequent workshop in 2018/2019 may be required.

**Finalizing project outcomes and deliverables** including:

- GIS shapefile of 2017-2018 wetland monitoring site locations made publically available.
- Standards and Protocols for the 'Evaluation and Integration of OSM Wetland Studies'.
- Final workshop report including background workshop materials, webinar presentations, workshop presentations, recommended framework and next steps for developing an integrated wetland monitoring program.

**Future years' work plan:**

- Adapt work plans/monitoring according to workshop findings (e.g., co-locate receptor/stressor sites, add/remove sites, add/remove measurements)
- Follow-up workshop(s) to facilitate the above
- Data products, data sharing, and scientific papers
- Update the GIS database annually

**Component 2: Monitoring for Effects of Atmospheric Deposition on Bogs**

Oil sands development activities have led to **increased emissions of N and S** (notably NO<sub>x</sub>, SO<sub>2</sub>, and NH<sub>x</sub>) to the atmosphere, ultimately resulting in increasing N and S inputs to surrounding ecosystems through wet and dry atmospheric deposition (Wood et al. 2015; Nwaishi et al. 2015; Nwaishi et al. 2014; Wieder et al. 2016a,b). Bogs and poor fens are predicted to be highly sensitive to additional nutrient inputs owing to their oligotrophic status, whereas rich fens and swamps are predicted to be less responsive. Recent research in the oil sands mining area have identified potential ecological responses in bogs to N and S bulk deposition including correlations with N and S tissue concentrations for several lichen, vascular plant and moss species (Wieder et al. 2016a,b). These changes in plant and tissue concentrations may be indicative of early biogeochemical responses in bogs to N loading associated with oil sands mine development. Accumulation of N and S in peat also increased with proximity to the oil sands mine industrial centre (Wieder et al. 2016b). Continued monitoring is needed to follow the status and trends in these bogs, and to further develop wetland stressor and response indicators to determine the effects of oil sands mining on wetland health



under a broader wetland long-term monitoring program.

Key research and monitoring questions:

1. What are the effects of atmospheric deposition (specifically N and S) associated with the oil sands mines on the ecosystem health, integrity and function of bog ecosystems?
2. What (and how) are the best ecological indicators to monitor the effects of atmospheric deposition associated with oil sands development on bog ecosystems?

**Component 3: Monitoring for Effects of Hydrologic Alteration on Fens**

Oil sands mine development **alters surface and groundwater connectivity with wetlands**. Surface water flow and quality are altered due to land clearing, construction and early operational activities (Alexander and Chambers 2016), which may affect the ecological and hydrological conditions of nearby wetlands, especially those downstream of development. Additionally, mines typically withdraw significant quantities of shallow and basal groundwater during operations to prevent groundwater seepage into the mine pits, which can cause drying of wetlands in areas adjacent to the mines. Climate, geology and soils contribute to controlling hydrology and biogeochemical exchange mechanisms for wetlands on the Boreal Plains (Devito et al. 2005a). A preliminary hydrologic alteration stressor monitoring program will focus on evaluating whether surface water alterations and groundwater withdrawals due to mine development (Phase 1), are affecting the ecological condition of dominant wetland classes adjacent to the oil sands mines, beyond their range of natural variability.

The hydrologic function, connectivity and landscape role of the peatlands will be sensitive to disturbance within and adjacent to the individual systems (AEP, 1998; Global Forest Watch, 2000) that both directly (peat removal for oil sands extraction or infrastructure construction) and indirectly (adjacent land use change) affect peatland ecohydrological function (Petrone et al. 2015; Plach et al. 2016). These feedbacks are based on interactions among hydrology, ecology (biophysical processes) and regional/local climate, which are poorly understood since few studies have examined all factors in a single integrative framework (Waddington et al. 2015). As evapotranspiration (ET) is the dominant hydrological process that governs the ecohydrological functioning and resiliency of peatlands in the AOSR, understanding the abiotic and biotic controls on ET is critical to establishing baseline monitoring of the appropriate variables. Peatlands within the AOSR are strongly influenced by topography and geologic setting, which controls water exchanges between upland and peatland systems (Petrone et al. 2007; Brown et al. 2013; Petrone et al. 2015). Compared to shallow flow systems more common in eastern peatlands, AOSR peatlands are situated on deep, heterogeneous fine- to coarse-textured post-glacial layered deposits with varying thicknesses resulting in complex water flows and stores (Wells and Price, 2015; Devito et al., 2005a), and various degrees of connectivity between distinct hydrological units and local and deep flow systems (Plach et al. 2015; Wells and Price, 2015; Devito et al., 2012). The degree of groundwater connectivity between upland and wetland landscapes is sensitive to the 10-15-year climate cycle (Devito et al. 2005b), thus long-term monitoring of groundwater patterns is essential to be able to characterize their true range of responses.

Key research and monitoring questions:

1. What are the effects of hydrologic alteration (GW withdrawal and other hydrologic disturbances) associated with the oil sands mines on wetland ecosystem health, integrity and function?
2. What (and how) are the best hydrology indicators to monitor the effects of hydrologic alteration associated with oil sands development on wetland ecosystems?

#### Component 4: Development of Biotic Indicators

The long-term wetland monitoring program will **develop biomonitoring tools** (e.g. an index of biotic integrity) for dominant wetland classes that are sensitive to the variety of stressors associated with oil sands development. By integrating the response to multiple stressors, these biomonitoring tools will **efficiently provide early warning signs of wetland impairment**. ABMI's biodiversity and human footprint data have been collected at approximately 700 sites (approx. 350 using the open water wetland protocol, which captures marshes and shallow open water wetlands, and 350 using the terrestrial protocol which captures bogs, fens, and swamps) in the oil sands region. These data will be used to develop a biomonitoring tool for various wetland classes such as a vegetation-based index of biological integrity (IBI) (e.g. Rooney and Bayley 2012). Previous work has found bird and vegetation communities are concordant with numerous other taxonomic groups in Alberta, and therefore they are good bioindicators of overall wetland diversity (e.g., Rooney and Bayley 2012b; Rooney and Azeria 2015).

The resulting biomonitoring tool will be validated in 2018-2019 and 2019-2020. Validation will involve simultaneous direct measurement of ABMI biodiversity of a suite of taxa (e.g. birds, bryophytes and vascular plants) at 30-40 Stressor-Response Monitoring synoptic sites (e.g., N and S deposition, hydrologic characterization). A biomonitoring tool will identify biotic metrics that are highly sensitive to oil sands development stressors, including atmospheric deposition, hydrologic alteration and human footprint, which can then be used to develop a more focused and efficient long-term monitoring program. Using threshold analysis, the biomonitoring tool can be used to develop monitoring and management triggers which can be used as benchmarks of wetland ecological condition and trends over time (Arciszewski et al. 2017).

#### Key research and monitoring questions:

1. What (and how) are the best biotic indicators to monitor the effects of human disturbance associated with oil sands development on wetland ecosystem health, integrity and function?
2. How can the ABMI wetland monitoring program and network be optimized to meet OSM Wetland LTM Program objectives?

#### Component 5: Wetland Monitoring Methods Development

Finally, integration of various existing monitoring programs requires comparison of different sampling protocols for program alignment between historic datasets.

Two key priorities for methods comparison were identified for the 2017-2018 field season as follows:

##### a) **Wetland Macroinvertebrate Method Comparison Study**

The primary objective of the "Wetland Macroinvertebrate Method Comparison Project" is to quantify comparability of data describing macroinvertebrate community structure in wetlands using ABMI's method (ABMI 2017) with the method described by Canadian Aquatic biodiversity Monitoring Network (CABIN 2017, draft document). ABMI's method has been used in approximately 700 shallow open water wetlands in boreal Alberta and 100s of additional sites in parkland and prairie sites in southern Alberta. The draft CABIN method has been used in approximately 40 shallow open water wetlands in the Peace-Athabasca Delta since 2011 under the 'Design of the Deltaic Wetland Ecosystem Health Monitoring Program' (WL-PD-5-1718).

Briefly, the ABMI method samples 10 plots throughout the wetland using three simple sweeps up from the bottom that are then composited, whereas the CABIN method samples one plot near the shore for a 2 minute time-limited sweep. Additionally, funds are available through a different program for eDNA

samples from each of the wetlands, which will allow the results using DNA barcoding to be compared to the ABMI and CABIN morphology-based identification methods.

The sampling methods will be compared in 20-30 shallow open water wetlands in the Athabasca oil sands region in August. Results will be evaluated and reported in a peer-review publication and data will be made publically available on the OSM data portal.

Key research and monitoring question: How do macroinvertebrate community results differ between the ABMI protocol and the draft CABIN protocol?

#### **b) Atmospheric Deposition Method Comparison Study**

The primary objective of the 'Atmospheric Deposition Method Comparison study is to compare the bulk deposition measurements using Kel Wieder's and WBEA's methods to see if the results are comparable. Bulk deposition has been measured at open sites by Kel Wieder's team at eight bog sites and one industrial site since 2011 (Wieder et al. 2016) and by WBEA at 10 industrial sites and 14 jack pine forest sites since 2008 (Fenn et al. 2015). Annual deposition values from the two monitoring programs were compiled and used to estimate bulk deposition in the region in a recent study (Wieder et al. 2016), however there was no comparison of methods at joint-sites to see if the results are comparable.

Bulk atmospheric deposition (ion exchange resins) for nitrogen, sulphur and base cations will be monitored using both methods at six bog sites (see Table 1) in 2017-2018. Passive air samplers will also be deployed using WBEA's standard operating procedures. Results will be evaluated and reported in a peer-review publication and data will be made publically available on the OSM data portal.

Key research and monitoring question: How do atmospheric deposition measurements differ between Kel Wieder's and WBEA's protocols?

#### **Assumptions and Constraints behind the hypothesis and proposed approach:**

- Assumption: Atmospheric deposition, hydrologic alteration and land clearing are the key stressors affecting wetland ecosystems in the oil sands region (Ciborowski et al. 2012).
- Assumption: Bogs and poor fens are predicted to be highly sensitive to atmospheric deposition (principally N and S) owing to their oligotrophic status, whereas rich fens, swamps, marshes and shallow open water wetlands will be less responsive. In general, most pristine peatlands in the Boreal zone are N-limited and only some very wet rich fens may be P-limited (Wieder & Vitt, 2006).
- Assumption: Fens, marshes, swamps and shallow open water wetlands will be more responsive to hydrologic alteration associated with oil sands development compared to bogs, which are ombrotropic and receive all of their water from precipitation.
- Assumption: The natural climatic cycle in the Boreal Plains is typically 15-20 years (Devito et al. 2005b). Thus long-term monitoring of sentinel wetland sites is critical for understanding the full range of natural variability and eventually will allow us to come up with simpler cause-effect relationships and biometric indices.
- Constraints: Timely availability of funds to purchase and obtain equipment and hire qualified personnel for 2017-2018 field season.

## References:

Alberta Environment and Parks. 1998. Alberta Water Quality Guidelines for the Protection of Freshwater Aquatic Life – Mercury and Methylmercury. Standards and Guidelines Branch, Environmental Assessment Division. Alberta Environmental Protection. Edmonton. 53 pp + Appendices.

Alexander, A.C. Chambers, P.A. 2016. Assessment of 7 Canadian Rivers in relation to Stages in Oil Sands Industrial Development, 1972 to 2010. Environmental Reviews.

Arciszewski, T.J., Munkittrick, K.R., Scrimgeour, G.J., Dube, M.G., Wrona, F.J. , and R.R. Hazewinkel. Submitted. Operationalizing adaptive principles and mechanisms to achieve meaningful environmental monitoring. Integrated Environmental Assessment and Management.

Brown, S., Petrone, R.M., and K.J. Devito. 2013. Atmospheric and Vegetation Controls on Evapotranspiration From a Sub-Humid Western Boreal Plain Peatland. *Hydrological Processes*, DOI: 10.1002/hyp.9879.

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## Data Management

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

AEP will collate OSM wetland monitoring site locations into a GIS database. This information will be made publically accessible.

A new Wetland Database will be created.

Deliverables	Timeframe
Data Collection Period:  <i>Field work</i>  <i>OSM Wetland study site locations compiled from OSM Wetland project PIs</i>	Start : 2017-05-01      End: 2017-10-31
Data Analysis Period:  <i>Laboratory analysis and quality assurance of data</i>  <i>QA/QC of GIS data</i>	Start : 2017-09-04      End: 2017-12-31
Data Release Date:  <i>Metadata and data consistent, complete and meet basic standard format for publication in Open Data; on or linked to OSM portal</i>	2018-03-31

## Reporting and Publications

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

Expected Subject/Titles of Publications or Reports	Short Description of Publication or Report	Expected Year of Publication
Workshop final report – OSM integrated wetland monitoring program plan	Led by Danielle Cobbaert (AEP) and Bruce Pauli (ECCC)  Provides conceptual framework and implementation plan for an integrated wetland monitoring program including study design, site	March 2018

	selection criteria, key stressors, key biotic responses and SOPs.	
OSM Wetland Monitoring Project study sites	Led by Danielle Cobbaert (AEP) GIS shapefile for public release of OSM Wetland Monitoring Project study sites Updated annually	March 2018
Summary of Standards and Protocols for wetlands monitoring in the oil sands	Led by Long Fu (AEP) <ul style="list-style-type: none"><li>- Describes various OSM Wetland Monitoring Project SOPs based on 2017-2018 project plans.</li><li>- Describes key OSM Environmental Monitoring Program SOPs based on 2017-2018 project plans.</li><li>- Recommends SOPs for an Integrated Wetland Monitoring Program (best SOPs or path forward where more work is needed).</li><li>- Includes considerations for the collection and application of indigenous knowledge.</li><li>- Evergreen document</li></ul>	March 2018
Annual Report: OSM LTM Wetland Monitoring Program Development Progress Report	Three annual scientific and operational reports, containing cumulative results	2018, 2019, and 2020
Effects of oil sands development on wetland ecosystem health: Synthesis of 3-years monitoring program results	Manuscript submitted to peer-review journal	2021-2022
Development of Biotic Indicators of Wetland Ecosystem Health in Oil Sands Development Areas	Manuscript submitted to peer-review journal	2020-2021
State of the Science: Wetland Remote Sensing in the Oil Sands Mining region (also identified as a deliverable under Wetland	Manuscript submitted to peer-review journal	Autumn 2017



Remote Sensing FS)		
State of the Science: Wetland Monitoring and Research in the Oil Sands Mining region (may be broken into multiple topic areas)	Manuscript submitted to peer-review journal	Winter 2017

## 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
<b>NEW Wetland Ecosystem Monitoring Program Lead</b>	<ul style="list-style-type: none"> <li>- OSM Wetland Monitoring Program Steering Committee Chair</li> <li>- Coordinate integration between various Wetland Monitoring Focus Studies and Wetland LTM program development.</li> <li>- Manage monitoring program implementation with external partners.</li> <li>- Participate in Indigenous Community engagement.</li> <li>- Supervise and assist with field work as required</li> <li>- Supervise and conduct analyses, write scientific manuscripts</li> </ul>	Danielle Cobbaert, Wetland Scientist, Alberta Environment and Parks, Environmental Monitoring and Science Division
<b>Evaluation and Integration of Wetland Studies Component co-lead</b>	<ul style="list-style-type: none"> <li>- Evaluation and Integration of Wetland Studies Component co-lead</li> <li>- Manage and coordinate ECCC staff participation and process as required for project delivery</li> <li>- Principal Investigator for Amphibian and Wetland Health FS ; seek integration and alignment between OSM wetland monitoring programs</li> </ul>	Bruce Pauli, Chief, Ecosystem Health Research, National Wildlife Research Centre, Environment and Climate Change Canada
<b>Atmospheric Science Co-Principal Investigator</b>	<ul style="list-style-type: none"> <li>- OSM Wetland Monitoring Program Steering Committee member</li> <li>- Coordinate Wetland Monitoring Program with various JOSM Atmospheric Deposition Monitoring Programs (Forest Health,</li> </ul>	Greg Wentworth, Atmospheric Scientist, Alberta Environment and Parks, Environmental Monitoring and Science Division

	<p>Wetlands, Acid Lakes, etc.).</p> <ul style="list-style-type: none"> <li>- Co-PI on atmospheric deposition component of Wetland Monitoring Program including SOP development</li> </ul>	
<b>Watershed Science Co- Principal Investigator</b>	<ul style="list-style-type: none"> <li>- OSM Wetland Monitoring Program Steering Committee member</li> <li>- Coordinate various JOSM Watershed Monitoring Programs (surface water quality, groundwater etc.)</li> <li>- Co-PI on Watershed component of Wetland Monitoring Program.</li> </ul>	Vacancy, Hydrologist/ Hydrogeologist, Alberta Environment and Parks, Environmental Monitoring and Science Division
<b>Indigenous Community Co- Principal Investigator</b>	<ul style="list-style-type: none"> <li>- OSM Wetland Monitoring Program Steering Committee member</li> <li>- Co-PI for the Wetland Monitoring Program - Indigenous Community component.</li> <li>- Coordinate Wetland Monitoring Program with various JOSM Indigenous Community Monitoring Programs (Berry Health, Fish etc.).</li> <li>- Act as a bridge between FN's communities, industry, and professional/ technical project staff</li> </ul>	Tracy Howlett, Knowledge Translation, Alberta Environment and Parks, Environmental Monitoring and Science Division
<b>OSM Biodiversity Monitoring Program Collaborator</b>	<ul style="list-style-type: none"> <li>- OSM Wetland Monitoring Program Steering Committee member</li> <li>- Lead for OSM Biodiversity Monitoring Program; seek integration and alignment between OSM biodiversity and wetland monitoring programs</li> </ul>	<ul style="list-style-type: none"> <li>- Vacant, Biodiversity Scientist, Alberta Environment and Parks, Environmental Monitoring and Science Division</li> </ul> <p>Dan Farr, Biodiversity and Ecosystem Health Director (interim member)</p>
<b>OSM Wetland Monitoring Program Development Collaborator</b>	<ul style="list-style-type: none"> <li>- OSM Wetland Monitoring Program Steering Committee member</li> <li>- PAD Wetland Monitoring FS co-lead (including remote sensing project)</li> </ul>	<ul style="list-style-type: none"> <li>- Donald Baird, Senior Research Scientist, Environment and Climate Change Canada</li> </ul>
<b>OSM Wetland Monitoring Program Development Collaborator</b>	<ul style="list-style-type: none"> <li>- OSM Wetland Monitoring Program Steering Committee member</li> <li>- PAD Wetland Monitoring FS co-lead (including remote sensing project)</li> </ul>	<ul style="list-style-type: none"> <li>- Daniel Peters, Research Scientist, Watershed Hydrologist, Watershed Hydrology &amp; Ecology Research Division, Water Science and Technology Directorate, Environment and Climate Change Canada</li> </ul>
<b>OSM Wetland Monitoring Program Development Collaborator</b>	<ul style="list-style-type: none"> <li>- OSM Wetland Monitoring Program Steering Committee member</li> <li>- Co-PI for Wetland Habitat FSs ; seek</li> </ul>	<ul style="list-style-type: none"> <li>- Samantha Song, Manager, Wildlife and Habitat Assessment Section, Canadian Wildlife Service, Environment</li> </ul>

	integration and alignment between OSM wetland habitat monitoring programs	and Climate Change Canada
Co-Principal Investigator, <b>Atmospheric Deposition Component</b>	<ul style="list-style-type: none"> <li>- External contract to implement Atmospheric Deposition component at 6 sentinel sites over 3 years (ongoing work previously funded by WBEA as component of Forest Health Program).</li> <li>- Atmospheric Deposition component advisor for LTM wetland program development including study design, SOP development, indicator selection, quality assurance, and network optimization.</li> </ul>	<ul style="list-style-type: none"> <li>- Kel Wieder, Professor, Villanova University</li> <li>- Melanie Vile, Assistant Professor, Villanova University</li> <li>- Dale Vitt, Emeritus Professor, University of Illinois</li> <li>- Plus technicians and students</li> </ul>
Co-Principal Investigator, <b>Hydrologic Alteration Component</b>	<ul style="list-style-type: none"> <li>- External contract to implement Hydrologic Alteration component at 14 sentinel sites (6 mine test sites, 2 <i>in situ</i> development test sites, and 6 reference sites) over 3 years (4 sites previously funded by COSIA fen reclamation project).</li> <li>- Hydrologic Alteration component Advisor on LTM wetland program development including study design, SOP development, indicator selection, QUALITY ASSURANCE, and network optimization.</li> </ul>	<ul style="list-style-type: none"> <li>- Rich Petrone, Professor, University of Waterloo</li> <li>- Jonathan Price, Professor, University of Waterloo</li> <li>- Plus technicians and students</li> </ul>
<b>Wetland Scientist, Collaborator</b>	<ul style="list-style-type: none"> <li>- Co-Advisor with Danielle Cobbaert for PhD student and post-doc for biotic indicator program development including rationale and approach for biotic indicator selection, SOP development, QUALITY ASSURANCE, and network optimization.</li> </ul>	<ul style="list-style-type: none"> <li>- Rebecca Rooney, Assistant Professor, University of Waterloo</li> </ul>
<b>LTM Wetland Monitoring Program Development Technicians and support staff</b>	<ul style="list-style-type: none"> <li>- Field sampling (4 person crew for synoptic sampling campaigns in August) (0.5 x 2 FTEs)</li> <li>- GIS technician and analyst (0.5 FTE)</li> <li>- Database developer (0.25 FTE)</li> <li>- Project coordinator (0.5 FTE)</li> </ul>	<ul style="list-style-type: none"> <li>- TBD, 3 technicians, EMSD Monitoring Team staff</li> </ul>

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

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

Deliverable(s) (please provide enough information to support status reporting)
<b>Q1 – April to June</b>
<ul style="list-style-type: none"> <li>- Grant agreements with external partners signed off.</li> <li>- Ongoing monitoring (previously funded by COSIA and CEMA and WBEA) of fens and bogs continues.</li> <li>- Site selection and reconnaissance of new and existing monitoring sites initiated.</li> </ul>
<b>Q2 – July to September</b>
<p><b>Component 1: Evaluation and Integration of Wetland Studies</b></p> <p><b>Prepare background materials for workshop.</b> The materials will form the basis of the Final Workshop Report summarizing existing wetland studies and providing recommendations for future work plan integration (2018/2019).</p> <ul style="list-style-type: none"> <li>- A <b>series of webinars</b> held during September 2017 to gain familiarity of various OSM wetland monitoring project work plans. The webinars will provide the basis for a draft framework to be prepared and circulated by project leads over the summer period, ahead of the fall face-to-face workshop.</li> <li>- A <b>straw dog OSM Integrated Wetland Monitoring framework will be developed by the Steering Committee.</b> It will summarize key points of the webinar presentations and review of OSM monitoring project plans, and propose an integration strategy that will be discussed and finalized at the workshop.</li> </ul>
<p><b>NEW Wetland Monitoring including methods development</b></p> <ul style="list-style-type: none"> <li>- <b>Atmospheric Deposition Bog Sites</b> (led by Drs. Kel Wieder and Melanie Vile, U. of Villanova, and Dale Vitt, University of Southern Illinois) <ul style="list-style-type: none"> <li>o Continue existing Atmospheric Deposition monitoring program at 4 existing bog sites.</li> <li>o Identify 2 new bog sites and conduct preliminary monitoring.</li> <li>o Develop and test key SOPs, key stressor variables, and biotic indicators as appropriate.</li> <li>o Provide Status Update to Wetland Steering Committee</li> </ul> </li> <li>- <b>Hydrologic Alteration Fen Sites</b> (led by Drs. Richard Petrone and Jonathan Price, U. Waterloo) <ul style="list-style-type: none"> <li>o Continue existing Hydrologic Alteration monitoring program at 5 existing fen sites.</li> <li>o Identify 2 new fen sites and conduct preliminary monitoring.</li> <li>o Develop and test key SOPs, key stressor variables, and biotic indicators as appropriate.</li> </ul> </li> </ul>

- Provide Status Update to OSM Wetland Monitoring Steering Committee
- **Development of Biotic Indicators** (co-led by Drs. Danielle Cobbaert and Rebecca Rooney)
  - Secure post-doctoral fellow to conduct study
  - Obtain ABMI wetland datasets
- **Methods Comparison Studies** (led by Dr. Danielle Cobbaert)
  - Wetland macroinvertebrate methods comparison (compares sampling protocols of ECCC's CABIN and ABMI monitoring programs). Conduct monitoring program.
  - Atmospheric deposition bulk deposition methods comparison study (compares sampling protocols of WBEA and Kel Wieder's monitoring program) and addition of dry deposition monitoring to bog monitoring program. Conduct monitoring program.

### Q3 – October to December

#### Component 1: Evaluation and Integration of Wetland Studies

**Workshop on “Designing an Integrated Long-term Wetlands Monitoring Program for the Oil Sands”** (December 2017, Edmonton). Discussion and break out groups to discuss background materials presented at workshop. Work towards consensus on defining a path forward for an integrated wetland monitoring program.

#### NEW Wetland Monitoring including methods development

- **Atmospheric Deposition Bog Sites** (led by Drs. Kel Wieder and Melanie Vile, U. of Villanova, and Dale Vitt, University of Southern Illinois)
  - Retrieve Passive Air samplers
  - Monitoring data management including quality assurance
- **Hydrologic Alteration Fen Sites** (led by Drs. Richard Petrone and Jonathan Price, U. Waterloo)
  - Retrieve and download data from mini-met stations and water level loggers
  - Monitoring data management including quality assurance
  - Provide Status Update to OSM Wetland Monitoring Steering Committee.
  - Provide Status Update to Wetland Steering Committee
- **Development of Biotic Indicators** (co-led by Drs. Danielle Cobbaert and Rebecca Rooney)
  - Conduct preliminary analysis of dataset
  - Conduct literature review of biotic indicator approaches and methods for status and trend monitoring.
- **Methods Comparison Studies** (led by Dr. Danielle Cobbaert)
  - Database management including quality assurance
  - Conduct analyses of dataset

### Q4 – January to March

#### Component 1: Evaluation and Integration of Wetland Studies

- **OSM Wetland Monitoring Project study sites in 2017-2018.** GIS shapefile for public release.

- **Development of Standards and Protocols for the “Evaluation and Integration of Wetland Studies”.** A report documenting Standards and Protocols of existing wetland projects (2017/2018) and recommendations for future work. Includes a section on the application of indigenous knowledge.
- **Workshop final report** with recommendations for an OSM Integrated Wetland Monitoring Program Plan including: workshop proceedings and key outcomes, identification of a conceptual framework, assessment and synthesis of existing wetland FS, identification of any gaps in current monitoring, and recommendations (next steps, path forward) for implementing an integrated wetland monitoring program.

#### **NEW Wetland Monitoring including methods development**

- **Atmospheric Deposition Bog Sites** (led by Drs. Kel Wieder and Melanie Vile, U. of Villanova, and Dale Vitt, University of Southern Illinois)
  - o Contribute 2017-2018 data to Wetland Monitoring database.
  - o Provide Annual Report to Wetland Steering Committee.
  - o Review and update 2018-2019 Project work plan.
- **Hydrologic Alteration Fen Sites** (led by Drs. Richard Petrone and Jonathan Price, U. Waterloo)
  - o Contribute 2017-2018 data to Wetland Monitoring database.
  - o Provide Annual Report to Wetland Steering Committee
  - o Review and update 2018-2019 Project work plan.
- **Development of Biotic Indicators** (co-led by Drs. Danielle Cobbaert and Rebecca Rooney)
  - o Conduct preliminary analysis of dataset
  - o Conduct literature review of biotic indicator approaches and methods for status and trend monitoring.
- **Methods Comparison Studies** (led by Dr. Danielle Cobbaert)
  - o Publish results of comparison studies in peer-review journal or government report as appropriate.
  - o Publish data on OSM data portal.

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

Also complete **Appendix 2** 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)
<b>O&amp;M - Operations and Maintenance:</b>		
Workshop hospitality (30 participants * \$20/ person (breakfast and lunch) * 3 days)	\$1,800	
Workshop venue (GOA venue to be provided)	\$0	
Field work - Accommodation and food (3 field crew from EDM to FMM 4 flights * \$600/ flight + 20 days * 2 person crew * Hotel \$200/ day * GOA per diems \$50/day)	\$17,600	
Field transportation including truck rental (1 month use of Biodiversity and Ecosystem Health team vehicle pool rentals at \$1017/month) + fuel (\$2500) + boat rental in PAD (1 day = \$1000) + misc. (\$200)	\$3,717	
Benthic taxonomy identification (30 sites * 2 samples/ site * \$325/ sample) + \$750 for reference collection.	\$20,250	
Field equipment and shipping costs (e.g. waders, preservatives, collection bottles, PPE, kick nets, wash nets, misc.)	\$2,870	
Water quality and sediment quality sample laboratory analysis (AEP amendments to existing contracts) for 6 bog sites and 7 fen sites in August Plus macroinvertebrate comparison study water quality and sediment quality analyses	\$85,000 \$9,980	
<b>Subtotal Operations and Maintenance</b>	<b>\$141,217</b>	
<b>O&amp;M - Travel</b>		
<b>Wetland Steering committee meetings</b> <ul style="list-style-type: none"> <li>- 3 meetings in Edmonton (June - planning; November workshop, February wrap-up)</li> <li>- AEP = 1 staff *3 days * local flight* hotel * per diems = \$1500 * 3 trips)</li> <li>- ECCC = 3 staff*3 days*flights*hotel*per diems = \$6000* 3 trips)</li> <li>- Community members = 2 participants * 3 days * local</li> </ul>	\$4,500 (AEP)  \$18,000 (ECCC)  \$4,500 (community participants)	

flight* hotel * per diems = \$1500 * 3 trips)		
<b>Workshop</b> - 3 days in Edmonton, flights, hotel, per diems = est. \$ 2000/ person within AB, \$ 2500/ person outside AB - AEP staff (2 participants) - ECCC (4 participants) - Community participants (6 participants)	\$3,000 (AEP) \$10,000 (ECCC) \$12,000 (Communities)	
Conferences (DC to travel to 1 international science conference per year - e.g. SETAC, AGU)	\$4,000	
<b>Subtotal Travel</b>	<b>\$56,000</b>	
<b>O&amp;M - External Contracts :</b>		
Annotated bibliography on wetland stressors and responses associated with oil sands development - contract	\$20,000	
Workshop facilitation including planning, workshop facilitation and follow-up – contract	\$5,000	
Monitor six bog sites for effects of atmospheric deposition on bog ecosystems - Grant to Drs. R. Kelman Wieder, Professor (Villanova University), Melanie Vile (Villanova), and Dale Vitt (University of Illinois) for ongoing monitoring since 2011. Collaborator on wetland LTM program development. Deliverables – SOPs, datasets after publication, submission of annual technical reports and peer-review manuscripts (details provided in Appendix D).	\$414,854	\$204,882
Monitor seven fen sites for effects of Hydrologic Alteration on fen ecosystems- Grant to Profs. R. Petrone and J. Price, (UWaterloo) and research team for ongoing monitoring of 5 fen sentinel sites and establishment of 2 new fen sentinel sites. Collaborator on wetland LTM program development. Deliverables – SOPs, datasets after publication, submission of annual technical reports and peer-review manuscripts (details provided in Appendix E).	\$285,729	\$573,000
Develop biotic indicators for effects of oil sands development on wetlands – Grant to Dr. Rebecca Rooney (U. Waterloo) to co-supervise a post-doctoral fellow (\$81,000 including benefits) with Dr. Danielle Cobbaert (adjunct professor at U. Waterloo) plus additional costs for travel (\$3,000) and computer and software (\$2,000), overhead to university (15%).	\$100,000	
WBEA contract to conduct 2017 bulk and dry deposition monitoring work at the 6 bog sites including materials (\$4,400), analysis (\$32,900), labour (\$49,700), travel (\$3,000) and administration (\$16,200).	\$106,200	



<b>Subtotal External Contracts</b>	<b>\$931,783</b>	<b>\$777,882</b>
<b>Salaries</b>		
<b>AEP Project Coordinator</b> (temporary wage position) – <i>Workshop planning logistics, OSM Project Plan review and preliminary synthesis, and survey with PIs, assist with preparation of background materials and preparation of final workshop report.</i>	\$25,583	
<b>AEP GIS Technician</b> (temporary wage position) - <i>Compilation of OSM Wetland Monitoring site locations in 2017-2018 and other key OSM monitoring sites location (e.g. GW monitoring) to facilitate co-location and integration of monitoring sites. Apply wetland monitoring site selection criteria to identify future integrated wetland monitoring sites and extract environmental covariables.</i>	\$25,000	
<b>ECCC Project Coordinator</b> - Technical / Professional Assistants - <i>Workshop planning, OSM Project Plan review and synthesis and survey with PIs, assisting with preparation of background materials)</i>	\$25,000 (ECCC)	
<b>Indigenous Community Coordinator(s)</b> - <i>Workshop planning logistics, OSM Project Plan review and preliminary synthesis, and survey with PIs, assist with preparation of background materials and preparation of final workshop report.</i>	\$ 25,000	
<b>Sub-Total Salaries</b>	<b>\$100,583</b>	<b>\$50,000</b>
<b>Grand Total</b>	<b>\$1,229,583</b>	<b>\$827,882</b>

## Appendix 1 - Approvals

<b>Project Submitted by:</b>		
Name: Danielle Cobbaert, Wetland Scientist		
Organization: Alberta Environment and Parks	Signature:	Date: August 10, 2017
<b>Project Approved by:</b>		
Dr. Monique Dubé (AEP)		Dr. Kevin Cash (ECCC)
Signature 		Signature 
Date		Date

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

Budget requirements	Year 1 (2017- 2018)		Year 2 (2018- 2019)		Year 3 (2019- 2020)	
	Cash	In-kind	Cash	In-kind	Cash	In-kind
<b>1) Salaries and benefits</b>						
a) Lead Investigator - Dr. Danielle Cobbaert, AEP Wetland Scientist (0.5 FTE)		\$55,000	\$90,200		\$92,455	
b) Dr. Greg Wentworth, AEP Atmospheric Scientist (0.25 FTE)		\$27,500	\$28,188		\$28,892	
c) Dr. Cynthia MacClain, AEP Hydrogeologist (0.25 FTE)		\$27,500	\$28,188		\$28,892	
d) Tracy Howlett, AEP Knowledge Translation Expert (0.25 FTE)		\$27,500	\$28,188		\$28,892	
e) Vacant, AEP Biodiversity Scientist (Dan Farr for interim) (0.25 FTE)		\$15,000	\$28,188		\$28,892	
f) AEP GIS technician and analyst (0.3 FTE, \$75K salary)	\$25,000		\$27,675		\$28,367	
g) Field Staff - AEP field technicians to monitor synoptic sites in spring, mid-summer, and autumn (2*0.5 FTE at \$45K salary)		\$25,000	\$45,000		\$46,125	
h) AEP Project coordinator and database developer (0.3 FTE, \$75K salary)	\$25,583		\$18,450		\$18,911	
i) Indigenous community coordinator Workshop planning logistics, OSM Project Plan review and preliminary synthesis, and survey with PIs, assist with preparation of background materials and preparation of final workshop report.	\$25,000					
j) ECCC Project Coordinator - Technical / Professional Assistants - Workshop planning, OSM Project Plan review and synthesis and survey with PIs, assisting	\$25,000					

with preparation of background materials)						
<b>Subtotal Salaries and Benefits</b>	<b>\$120,583</b>		<b>\$294,075</b>		<b>\$301,427</b>	
<b>2) Operations and maintenance</b>						
a) Workshop hospitality (30 participants * \$20/ person (breakfast and lunch) * 3 days)	\$1,800					
b) Workshop venue - GOA venue to be provided	\$0					
c) Field work - Accommodation and food (3 field crew from EDM to FMM 4 flights * \$600/ flight + 20 days * 2 person crew * Hotel \$200/ day * GOA per diems \$50/day)	\$17,600		\$14,900		\$14,900	
d) Field transportation (1 month use of Biodiversity and Ecosystem Health team vehicle pool rentals at \$1017/month) + fuel (\$2500) + boat rental in PAD (1 day = \$1000) + misc. (\$200)	\$3,717		\$4,068		\$4,068	
e) Benthic taxonomy identification (30 sites * 2 samples/ site * \$325/ sample) + \$750 for reference collection.	\$20,250					
f) Field equipment and shipping costs (e.g. waders, preservatives, collection bottles, PPE, kick nets, wash nets, misc.)	\$2,870					
g) Water quality and sediment quality sample laboratory analysis (AEP amendments to existing contracts) for 6 bog sites and 7 fen sites in August. Macroinvertebrate comparison study water quality and sediment quality analyses for 20-30 additional sites.	\$85,000 \$9,980					
<b>Subtotal Operations and Maintenance</b>	<b>\$141,217</b>		<b>\$178,968</b>		<b>\$178,968</b>	
<b>3) Travel</b>						

a) Wetland Steering committee meetings 3 meetings in Edmonton (June - planning; September planning workshop, February wrap- up) - AEP staff = 1 staff *3 days * local flight* hotel * per diems = \$1500 * 3 trips) - ECCC staff = 3 staff*3 days*flights*hotel*per diems = \$6000* 3 trips) - Community participants = 2 participants * 3 days * local flight* hotel * per diems = \$1500 * 3 trips)	\$4,500 (AEP)  \$18,000 (ECCC)  \$4,500 (community participants)		\$15,400		\$15,400	
b) Workshop - 3 days in Edmonton, flights, hotel, per diems = est. \$ 2000/ person within AB, \$ 2500/ person outside AB - AEP staff (2 participants) - ECCC (4 participants) - Community participants (6 participants)	\$3,000 (AEP) \$10,000 (ECCC) \$12,000 (Communities)		\$4,000		\$4,000	
c) Conferences - DC to travel to 1 international science conference per year - e.g. SETAC, AGU)	\$4,000					
<b>Subtotal Travel</b>	<b>\$56,000</b>		<b>\$19,400</b>		<b>\$19,400</b>	
<b>4) Dissemination &amp; Engagement</b>						
a) Science communications (Public access to science journals)		\$5,000	\$5,000		\$5,000	
<b>Subtotal Dissemination and Engagement</b>	<b>\$0</b>		<b>\$25,000</b>		<b>\$25,000</b>	
<b>Subtotal AEP Component</b>	<b>\$367,217</b>		<b>\$746,421</b>		<b>\$753,773</b>	
<b>5) External Contracts</b>						
a) Annotated bibliography on wetland stressors and responses associated with oil sands development - contract	\$20,000					

b) Workshop facilitation including planning, workshop facilitation and follow-up – contract	\$5,000						
c) Monitor six bog sites for effects of atmospheric deposition on bog ecosystems - Grant to Drs. R. Kelman Wieder, Professor (Villanova University), Melanie Vile (Villanova), and Dale Vitt (University of Illinois) for ongoing monitoring since 2011. Collaborator on wetland LTM program development. Deliverables – SOPs, datasets after publication, submission of annual technical reports and peer-review manuscripts (details provided in Appendix D).	\$414,854	\$204,882	\$445,870	\$210,004	\$457,017	\$215,254	
d) Monitor seven fen sites for effects of Hydrologic Alteration on fen ecosystems- Grant to Profs. R. Petrone and J. Price, (UWaterloo) and research team for ongoing monitoring of 5 fen sentinel sites and establishment of 2 new fen sentinel sites. Collaborator on wetland LTM program development. Deliverables – SOPs, datasets after publication, submission of annual technical reports and peer-review manuscripts (details provided in Appendix E).	\$285,729	\$573,000	\$399,947	\$73,000	\$399,947	\$73,000	
e) Develop biotic indicators for effects of oil sands development on wetlands – Grant to Dr. Rebecca Rooney (U. Waterloo) to co-supervise a post-doctoral fellow with Dr. Danielle Cobbaert (adjunct professor at U. Waterloo)	\$100,000		\$191,188	\$24,000	\$191,188	\$24,000	
f) WBEA contract to conduct 2017 bulk and dry deposition monitoring work at the 6 bog sites including materials (\$4,400),	\$106,200		\$191,498	\$52,000	\$175,490	\$51,500	

analysis (\$32,900), labour (\$49,700), travel (\$3,000) and administration (\$16,200).						
<b>Subtotal External Contracts</b>	<b>\$931,783</b>	<b>\$777,882</b>	<b>\$80,000</b>			
<b>Grand Total</b>	<b>\$1,229,583</b>	<b>\$827,882</b>	<b>\$2,054,923</b>	<b>\$359,004</b>	<b>\$1,977,414</b>	<b>\$363,754</b>

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

<b>Year 2 (2018- 2019)</b>	
<b>Deliverable(s)</b> (please provide enough information to support status reporting)	
<b>Q1 – April to June</b>	
-	<p><b>LTM Wetland Program Coordination and Development</b> (OSM Wetland Monitoring Steering Committee led by Dr. Danielle Cobbaert)</p> <ul style="list-style-type: none"> <li>o Wetland Steering Committee meeting.</li> <li>o Oversee development of the 'OSM Wetland LTM Program Manual'.</li> <li>o Host annual OSM Wetland Monitoring Field Planning Workshop (1-2 day workshop) in Edmonton in Spring (April or May).</li> </ul>
-	<p><b>Wetland Synoptic Sites</b> (AEP staff led by Dr. Danielle Cobbaert)</p> <ul style="list-style-type: none"> <li>o Reconnaissance to select 20-40 synoptic sites at a variety of wetland classes, plus assist with selecting new sentinel sites.</li> <li>o Deploy instrumentation and monitor key stressor variables including mini-meteorological stations (ppt, rh, temp), water wells (water quality) and water level loggers, and passive air samplers (primarily N and S).</li> <li>o Develop and test key SOPs as appropriate, key stressor variables, and biotic indicators (e.g. vegetation, macroinvertebrates, birds and amphibians with Acoustic Recording Units).</li> <li>o Provide Status Update to OSM Wetland Monitoring Steering Committee.</li> <li>o Contribute to the development of the 'OSM Wetland LTM Program Manual'.</li> </ul>
-	<p><b>Hydrologic Alteration Sentinel Sites</b> (led by Drs. Richard Petrone and Jonathan Price, U. Waterloo)</p> <ul style="list-style-type: none"> <li>o Reconnaissance to select 2 new sentinel field sites (2 new mine exposed sites, 2 existing reference sites, 2 existing in situ exposed sites) to monitor hydrologic alteration stressor and ecological response.</li> <li>o Installation of hydrologic monitoring instruments at new sites (eddy covariance towers, piezometers, wells etc.).</li> <li>o Continue existing Hydrologic Alteration monitoring program at 6 sentinel sites.</li> <li>o Develop and test key SOPs, key stressor variables, and biotic indicators as appropriate. Work with AEP science team to develop and align SOPs between synoptic and sentinel sites.</li> <li>o Contribute to the development of the 'OSM Wetland LTM Program Manual'.</li> <li>o Provide Status Update to the Wetland Steering Committee</li> </ul>
-	<p><b>Atmospheric Deposition Sentinel Sites</b> (led by Drs. Kel Wieder, U. of Villanova, and Dale Vitt, University of Southern Illinois)</p> <ul style="list-style-type: none"> <li>o Continue existing Atmospheric Deposition monitoring program at 6 sentinel sites.</li> <li>o Develop and test key SOPs, key stressor variables, and biotic indicators as appropriate. Work with AEP science team to develop and align SOPs between synoptic and sentinel sites.</li> <li>o Contribute to the development of the 'OSM Wetland LTM Program Manual'.</li> <li>o Provide Status Update to the Wetland Steering Committee</li> </ul>
<b>Q2 – July to September</b>	
-	<p><b>LTM Wetland Program Coordination and Development</b> (OSM Wetland Monitoring Steering Committee led by Dr. Danielle Cobbaert)</p> <ul style="list-style-type: none"> <li>o Wetland Steering Committee meeting.</li> <li>o Oversee development of the 'OSM Wetland LTM Program Manual'.</li> <li>o Planning for Annual OSM Wetland Monitoring Program Integration Session (1-2 day session in autumn).</li> </ul>
-	<p><b>Monitor Synoptic Wetland Sites</b> (AEP staff led by Dr. Danielle Cobbaert)</p> <ul style="list-style-type: none"> <li>o Develop and test key SOPs as appropriate, key stressor variables, and biotic indicators (e.g. vegetation, macroinvertebrates).</li> </ul>



<ul style="list-style-type: none"> <li>o Sample water, soil, vegetation tissues, vegetation and macroinvertebrates communities (test key SOPs as appropriate)</li> <li>o Retrieve Acoustic Recording Units</li> <li>o Swap out Passive Air samplers</li> <li>o Download data from mini-met stations and water level loggers</li> <li>o Submit water, soil and tissue samples to laboratories for analysis.</li> <li>o Provide Status Update to OSM Wetland Monitoring Steering Committee</li> </ul>
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<p><b>Q3 – October to December</b></p>
<ul style="list-style-type: none"> <li>- <b>LTM Wetland Program Coordination and Development</b> (OSM Wetland Monitoring Steering Committee led by Dr. Danielle Cobbaert) <ul style="list-style-type: none"> <li>o Wetland Steering Committee meeting.</li> <li>o Oversee development of the 'OSM Wetland LTM Program Manual'.</li> <li>o Host annual <b>OSM Wetland Monitoring Program Integration Workshop</b></li> </ul> </li> </ul>
<ul style="list-style-type: none"> <li>- <b>Monitor Synoptic Wetland Sites</b> (AEP staff led by Dr. Danielle Cobbaert) <ul style="list-style-type: none"> <li>o Retrieve Passive Air samplers</li> <li>o Retrieve and download data from mini-met stations and water level loggers</li> <li>o Update relevant sections of the 'OSM Wetland LTM Program Manual'.</li> <li>o Provide Status Update to OSM Wetland Monitoring Steering Committee</li> </ul> </li> </ul>
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<p><b>Q4 – January to March</b></p>
<ul style="list-style-type: none"> <li>- <b>LTM Wetland Program Coordination and Development</b> (OSM Wetland Monitoring Steering Committee led by Dr. Danielle Cobbaert) <ul style="list-style-type: none"> <li>o Wetland Steering Committee meeting.</li> <li>o Oversee development of the 'OSM Wetland LTM Program Manual'.</li> <li>o Deliver Final Report on <b>OSM Wetland Monitoring Program Integration Workshop</b> (fall 2018).</li> <li>o Review and update 2019-2020 Project work plan.</li> <li>o Plan upcoming Annual OSM Wetland Monitoring Field Planning Workshop (1-2 day workshop) in Edmonton in</li> </ul> </li> </ul>

spring (April or May).
<ul style="list-style-type: none"> <li>- <b>Synoptic program components</b> (AEP staff led by Dr. Danielle Cobbaert) <ul style="list-style-type: none"> <li>o Contribute 2018-2019 data to Wetland Monitoring database.</li> <li>o Update relevant sections of the 'OSM Wetland LTM Program Manual'.</li> <li>o Provide Status Update to OSM Wetland Monitoring Steering Committee.</li> <li>o Review and update 2019-2020 Project work plan.</li> </ul> </li> </ul>
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Year 3 (2019- 2020)	
Deliverable(s) (please provide enough information to support status reporting)	Budget
<b>Q1 – April to June</b>	
<ul style="list-style-type: none"> <li>- <b>LTM Wetland Program Coordination and Development</b> (OSM Wetland Monitoring Steering Committee led by Dr. Danielle Cobbaert) <ul style="list-style-type: none"> <li>o Wetland Steering Committee meeting.</li> <li>o Oversee development of the 'OSM Wetland LTM Program Manual'.</li> <li>o Host annual OSM Wetland Monitoring Field Planning Workshop (1-2 day workshop) in Edmonton in Spring (April or May).</li> </ul> </li> </ul>	
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in autumn).	
<ul style="list-style-type: none"> <li>- <b>Monitor Synoptic Wetland Sites</b> (AEP staff led by Dr. Danielle Cobbaert) <ul style="list-style-type: none"> <li>o Develop and test key SOPs as appropriate, key stressor variables, and biotic indicators (e.g. vegetation, macroinvertebrates).</li> <li>o Sample water, soil, vegetation tissues, vegetation and macroinvertebrates communities (test key SOPs as appropriate)</li> <li>o Retrieve Acoustic Recording Units</li> <li>o Swap out Passive Air samplers</li> <li>o Download data from mini-met stations and water level loggers</li> <li>o Submit water, soil and tissue samples to laboratories for analysis.</li> <li>o Provide Status Update to OSM Wetland Monitoring Steering Committee</li> </ul> </li> </ul>	
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<b>Q4 – January to March</b>	
<ul style="list-style-type: none"> <li>- <b>LTM Wetland Program Coordination and Development</b> (OSM Wetland Monitoring Steering Committee led by Dr. Danielle Cobbaert) <ul style="list-style-type: none"> <li>o Wetland Steering Committee meeting.</li> <li>o Deliver final draft of 'OSM Wetland LTM Program Manual' for publication.</li> <li>o Deliver Final Report on <b>OSM Wetland Monitoring Program Integration Workshop</b> (fall 2018).</li> <li>o Review and update 2019-2020 Project work plan.</li> <li>o Plan upcoming Annual OSM Wetland Monitoring Field Planning Workshop (1-2 day workshop) in Edmonton in spring (April or May).</li> </ul> </li> </ul>	
<ul style="list-style-type: none"> <li>- <b>Synoptic program components</b> (AEP staff led by Dr. Danielle Cobbaert) <ul style="list-style-type: none"> <li>o Contribute 2018-2019 data to Wetland Monitoring database.</li> <li>o Contribute final sections of the 'OSM Wetland LTM Program Manual'.</li> <li>o Provide Status Update to OSM Wetland Monitoring Steering Committee.</li> <li>o Review and update 2019-2020 Project work plan.</li> </ul> </li> </ul>	
<ul style="list-style-type: none"> <li>- <b>Hydrologic Alteration Sentinel Sites</b> (led by Drs. Richard Petrone and Jonathan Price, U. Waterloo) <ul style="list-style-type: none"> <li>o Contribute 2018-2019 data to Wetland Monitoring database.</li> <li>o Contribute final sections of the 'OSM Wetland LTM Program Manual'.</li> <li>o Provide Status Update to OSM Wetland Monitoring Steering Committee.</li> <li>o Review and update 2019-2020 Project work plan.</li> </ul> </li> </ul>	
<ul style="list-style-type: none"> <li>- <b>Atmospheric Deposition Sentinel Sites</b> (led by Drs. Kel Wieder, U. of Villanova, and Dale Vitt, Illinois University) <ul style="list-style-type: none"> <li>o Contribute 2018-2019 data to Wetland Monitoring database.</li> <li>o Contribute final sections of the 'OSM Wetland LTM Program Manual'.</li> <li>o Provide Status Update to OSM Wetland Monitoring Steering Committee.</li> <li>o Review and update 2019-2020 Project work plan.</li> </ul> </li> </ul>	
<b>Total Annual Budget</b>	