Oil Sands Monitoring Program

Annual Report for 2016-2017

Alberta Government

Environment and Climate Change Canada / Environnement et Changement climatique Canada

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Preface

This report for the Oil Sands Monitoring (OSM) Program was prepared by Alberta Environment and Parks (AEP) and Environment and Climate Change Canada (ECCC). It presents highlights of program accomplishments as well as a technical annex summarising monitoring activities implemented from April 1, 2016 to March 31, 2017.

The OSM program is jointly managed by Alberta Environment and Parks (AEP) on behalf of the Government of Alberta and Environment and Climate Change Canada (ECCC) on behalf of the Government of Canada.

Executive Summary

Since February 2012, the governments of Alberta and Canada have worked as partners to implement a world-class environmental monitoring program for the oil sands that integrates air, water, land and biodiversity. The program strives to improve characterization of the state of the environment and enhance understanding of the cumulative effects of oil sands development activities in the oil sands area.

Building on existing monitoring, where possible, the approach to program implementation is adaptive to ensure that the program is responsive to emerging priorities, information, knowledge, and input from key stakeholders and Indigenous peoples. Canada and Alberta have made progress in strengthening program delivery, and in providing leadership to ensure that necessary monitoring and supporting scientific activities were conducted to meet program commitments and objectives. The Implementation Plan is funded by industry up to $50 million annually.

The 3 year Joint Oil Sands Monitoring Program (JOSM) was formally concluded in March of 2015. An external expert peer-review of the scientific integrity of the monitoring system was conducted at that time and concluded that the program was a substantial improvement over previous monitoring programs. The review also highlighted several learnings and areas for improvement.

Monitoring and science activities continued in 2015-2016 under the joint leadership of the two governments within the Oil Sands Monitoring agreement that succeeded JOSM. The annual work planning process was informed by a review of existing monitoring work and results, new and emerging priorities, as well as comments received through multi-stakeholder meetings. The 2015-2016 monitoring plan was approved for implementation by the Alberta Environmental Monitoring, Evaluation and Reporting Agency (AEMERA) Board and monitoring activities were implemented. In April 2016, AEMERA was dissolved returning the core function of environmental monitoring to the Government of Alberta with the intent of ensuring a credible and efficient system that is fully accountable to Albertans.

In June of 2016, the Office of the Chief Scientist and the Environmental Monitoring and Science Division (EMSD) were formally established in the Ministry of Environment and Parks through an amendment to Section 15 of the Environmental Protection and Enhancement Act (EPEA). The Chief Scientist was given a mandate to develop and implement an environmental science program to monitor, evaluate and report on the condition of Alberta's ambient environment. This mandate also included ongoing leadership of the Oil Sands Monitoring program in collaboration with Environment and Climate Change Canada, Indigenous communities and Organizations, and other stakeholders including industry.

The 2016-2017, the Ambient Environment Monitoring Plan for Oil Sands Development was informed by the external expert science review of JOSM, and also reflected lessons learned as well as identified existing gaps in monitoring. A total of 58 projects were approved for implementation in the 2016-2017 fiscal year. Approved monitoring activities were implemented according to the annual monitoring plan, and evaluation of the data collected in 2016-2017 is in progress.

The most significant factors influencing program implementation in 2016-2017 were the Fort McMurray wildfires, which delayed start up for a number of projects, and transitioning staff into their roles within EMSD. Overall most of the 58 projects approved for 2016-2017 fiscal year were delivered as approved; five (5) projects had ongoing deliverables which were transitioned into 2017-2018 for implementation.

Technical discussions and planning for 2017-2018 will consider monitoring results, gaps identified and future monitoring needs of the program.

Both governments remain committed to working with all partners to implement a robust, and scientifically credible environmental monitoring program for the oil sands.

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1. Introduction

The governments of Alberta and Canada recognize the oil sands are a strategic natural resource and a key driver of economic growth. The development of this resource requires greater understanding of associated cumulative environmental impacts to help guide effective and responsible management of this resource. This report presents highlights of program accomplishments as well as a technical annex summarising monitoring activities implemented from April 1, 2016 to March 31, 2017.

In February 2012, the governments of Canada and Alberta announced the Canada-Alberta Joint Oil Sands Monitoring (JOSM) Implementation Plan (Appendix A). The three-year (2012-2015) JOSM Implementation Plan outlined changes in monitoring design that would enhance and integrate environmental monitoring in the oil sands area. The overarching intent was that at the conclusion of the three-year Implementation Plan, monitoring of the impacts of development on the ambient environment would be more comprehensive, including more sampling at more sites, with greater frequency, using consistent scientific standards and protocols. The results from the monitoring and related evaluation efforts would help characterize the condition of the environment in the oil sands area, and provide an enhanced understanding of cumulative environmental effects as well as environmental change due to oil sands development activities.

The formal conclusion (March 2015) of the three-year Implementation Plan was announced at the February 2016 stakeholder forum; however, monitoring and science activities continued under the joint leadership of the two governments within the Oil Sands Monitoring agreement that succeeded JOSM.

Under JOSM, the governments of Canada and Alberta agreed to an external expert peer review of the monitoring system after year three (2015) of implementation, with subsequent review at five-year intervals to verify that scientific integrity is maintained. The key findings and recommendations of the first Science Integrity Review (see Appendix B for Panel Report) were presented at the Oil Sands Multi-stakeholder forum held in Edmonton, February 2016. The expert panel report concluded that JOSM was a substantial improvement over environmental monitoring programs that existed prior to 2012, and also highlighted key areas for additional improvement.

In line with federal and provincial goals for oil sands monitoring, the key commitments made by both governments in the Canada-Alberta Joint Oil Sands Monitoring (JOSM) Implementation Plan covered funding, accountable administration and review, adaptive management, as well as transparent and accessible results. These commitments (see Appendix A) contribute to a monitoring program that will:

- Support sound decision-making by governments, as well as stakeholders;
- Ensure transparency through accessible, comparable and quality-assured data;
- Enhance science-based monitoring for improved characterization of the state of the environment and collect the information necessary to assess cumulative effects;
- Improve analysis of existing monitoring data to develop a better understanding of historical baselines and changes, and;
- Reflect the trans-boundary nature of the issue and promote collaboration with the governments of Saskatchewan and the Northwest Territories.

2015-2016 Program Transitions

The governments of Alberta and Canada worked together from 2012-2015 to implement a phased and adaptive monitoring program. The Joint Canada/Alberta Implementation Plan for Oil Sands Monitoring (Implementation Plan) was designed to improve characterization of the state of the environment and enhance understanding of the cumulative environmental effects of development activities in the oil sands region.

In addition to the resources committed by both governments to environmental monitoring in the oil sands area, Canada and Alberta also worked with the oil sands industry through the Canadian Association of Petroleum Producers (CAPP) to ensure continued funding support for the monitoring program. The governments have reported publicly on administering this funding for each year since the monitoring program's inception.

The annual work planning process for 2015-2016 was informed by a review of existing monitoring work and results, new and emerging priorities, as well as stakeholder comments received through multi-stakeholder meetings. The 2015-2016 monitoring plan was approved for implementation by the Alberta Environmental Monitoring, Evaluation and Reporting Agency (AEMERA) Board in December 2014 and February 2015. Approved 2015-2016 monitoring activities were implemented according to the annual monitoring work plans with subsequent evaluation of the data collected.

Multi-stakeholder forums were held in June 2015 and February 2016 respectively, in accordance with the governments' commitment to engage with stakeholders. The purpose of the forums were to provide information on monitoring and program activities to date, and to seek stakeholder perspective on their issues, concerns and priorities for oil sands monitoring and reporting in the upcoming fiscal year. Media-specific Component Advisory Committees (CAC) also met throughout the year to discuss monitoring results, and identify gaps and future monitoring needs of the program. These discussions contributed substantially to the development of the 2016-2017 annual monitoring plan.

The governments of Canada and Alberta agreed to an independent expert peer-review of the monitoring system after year three (2015) of implementation, with subsequent reviews at five-year intervals to ensure that the program's scientific integrity is maintained. The first Science Integrity Review conducted by a panel of world-renowned science experts, concluded that the Joint Oil Sands Monitoring (JOSM) had been a substantial improvement over previous environmental monitoring programs that existed in the region prior to 2012. The panel also highlighted the main areas for additional improvement across the program. The key findings and recommendations (see Appendix B) of the Science Integrity Review Panel were presented at the February 2016 multi-stakeholder forum.

In June 2016, the Government of Alberta announced its decision to dissolve AEMERA with attendant impacts to the program, the most significant of which was the transfer of responsibilities for the Oil Sands Monitoring program to a new division (Environmental Monitoring and Science Division) of Alberta Environment and Parks (AEP).

The governments of Canada and Alberta have reiterated their commitment to working together to achieve a scientifically rigorous, comprehensive and integrated system of environmental monitoring in the oil sands region. A new Memorandum of Understanding and operational agreement on Oil Sands Monitoring between AEP and ECCC to guide future collaboration on oil sands monitoring is under development.

2. Reporting Against 2016-2017 Oil Sands Monitoring Program Commitments

This section reports on the progress made against key commitments and overall objectives for 2016-2017 fiscal year in the following areas: funding, accountable administration and review, adaptive management, and transparent and accessible results.

2.1 Funding

Since 2012, the governments of Canada and Alberta have worked with the oil sands industry to develop a sustainable, ongoing funding arrangement to support environmental monitoring of oil sands development. Oil sands industry members, through the Canadian Association of Petroleum Producers (CAPP), worked collaboratively with the Alberta government to allocate monitoring costs to oil sands operators up to $50 million annually through the *Oil Sands Environmental Monitoring Program Regulation*.

Consistent with the governments' commitment to ensure funding transparency by reporting on expenditure, a total of $48,691,285 of industry funding was approved for monitoring and science activities in 2016-2017 (see Table 1). Approved funds were distributed as per approved work plans to ECCC ($13,618,145), AEP/AEMERA ($12,561,429) and external monitoring organizations including but not limited to ABMI, LICA and WBEA ($22,511,711).

A total amount of $18,313,034 was spent by governments and $20,711,931 by the monitoring/delivery organisations. Variances in the budget summary tables represent the difference between amount approved and actual expenditure for 2016-2017. These variances reflect significant delays in monitoring activities due to external factors, such as the Fort McMurray wildfires, obtaining permits, transition from AEMERA back into the Government of Alberta, and availability of equipment. The surplus of $9,666,320 was deferred revenue extended into the 2017-2018 OSM program year. For further details please see Appendix C. In reconciling the funding at the end of each fiscal year, industry is only invoiced for the actual amount spent to deliver work done under the approved work plan.

2016-2017 Budget Summary			
	Planned	Expenditures	Variance
ECCC[1]	13,618,145	12,341,938	1,276,207
AEP/AEMERA[2]	12,561,429	5,971,096	6,590,333
Monitoring Organisations	22,511,711	20,711,931	1,799,780
Total	**48,691,285**	**39,024,965**	**9,666,320**

Table 1: Summary of 2016-2017 planned budget and expenditure

1 Environment and Climate Change Canada

2 Alberta Environment and Parks/ Alberta Environmental Monitoring Evaluation and Reporting Agency

2.2 Accountable Administration and Review

2.2.1 Alberta's Legislative and Regulatory Changes

In order to demonstrate that their facilities are in compliance with predefined performance objectives, industry is required by provincial and federal regulations to monitor and report on source emissions and other environmental impacts resulting from their operations. Accountability for this is effected through the regulatory system i.e. approval clauses, executed either by respective approval holders, or through third party monitoring organisations on behalf of industry.

In December 2013, the Government of Alberta passed the *Protecting Alberta's Environment Act* that established the Alberta Environmental Monitoring, Evaluation and Reporting Agency (AEMERA). When AEMERA was proclaimed on April 28, 2014, it became responsible for leading the province's involvement in Oil Sands Monitoring until its dissolution in June 2016.

On June 30, 2016, the Office of the Chief Scientist and the Environmental Monitoring and Science Division (EMSD) were formally established in the Ministry of Environment and Parks through an amendment to Section 15 of the Environmental Protection and Enhancement Act (EPEA). The Chief Scientist was given a mandate to develop and implement an environmental science program to monitor, evaluate and report on the condition of Alberta's ambient environment. This returned the core function of environmental monitoring to government with the intent of ensuring a credible and efficient system that is fully accountable to Albertans. Consistent with the Government of Alberta's commitment to scientific excellence and transparency, the Chief Scientist and the new Monitoring and Science Division in AEP leads Alberta's contribution to oil sands monitoring (Alberta Regulation 226/2013).

2.2.2 Joint Management of Monitoring Program

Monitoring arrangements through various independent organisations are continuing to be rationalized and better integrated into a single, government-led program under the joint management of the two governments.

In the spirit of continuous improvement, a new model for planning and implementing oil sands monitoring, that included improved stakeholder involvement in priority setting and planning for monitoring activities was presented at the February 2016 stakeholder meeting. Although the return of AEMERA back into government impacted the timing of implementation of the new model, it is important to acknowledge the invaluable contributions of stakeholders to building a strong foundation for environmental monitoring, evaluation and reporting in the oil sands region. Presently, discussions are ongoing between the governments, Indigenous leaders and stakeholders including industry to chart a new path forward regarding program governance and planning.

2.2.2.1 Program Delivery

In 2016-2017, approved activities under the oil sands program continued the monitoring implemented since 2012, under the 2012-2015 Canada-Alberta Joint Oil Sands Monitoring (JOSM) Implementation Plan. The 2016-2017 Ambient Environment Monitoring Plan for Oil Sands Development was informed by the external expert science review of JOSM, and also reflected lessons learned as well as identified existing gaps in monitoring. A total of 58 projects (see Appendix D) were approved for implementation in 2016-2017 fiscal year as shown below:

- Atmospheric Monitoring: 24 projects
- Watershed Monitoring: 7 projects
- Physical Disturbance Monitoring: 1 project
- Biotic Response Monitoring: 12 projects
- Indigenous Monitoring Program: 5 projects
- Wetland Ecosystem Monitoring: 4 projects
- Standards, Quality Assurance/Quality Control, Data Management: 3 Projects
- Program Administration: 2 projects

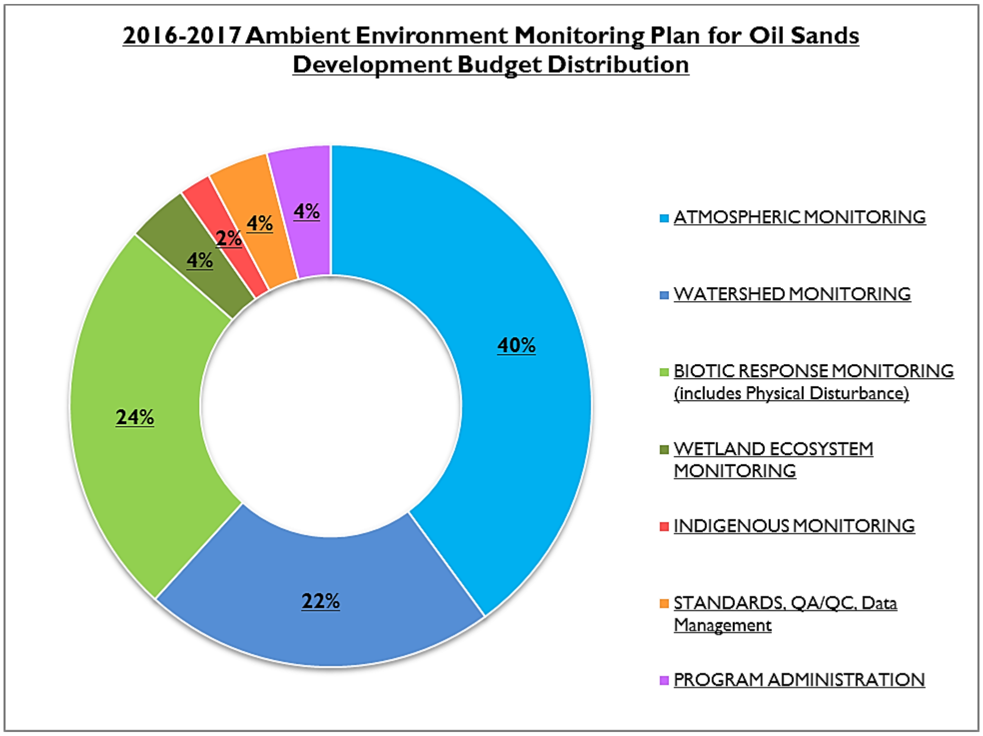

Figure 1: 2016-2017 Ambient Monitoring Plan for Oil Sands Development Summary

Approved OSM projects were classified as follows:

- Long-term Monitoring (LTM): refers to the routine monitoring of status and trends of physical/chemical/biological parameters related to oil sands development activities to detect and evaluate changes in the environment over a period of time, typically >5 years. Although these are long term projects, deliverables are subject to annual reviews for scientific soundness and cost effectiveness. 19 LTM projects were approved for implementation in 2016-2017.

- Focused Study (FS): refers to a class of purposeful, requested projects with definite start and end dates (typically 3 years). FS projects are implemented as required for any of the following purposes:
    - To develop or validate a current monitoring design and/or protocols
    - To confirm or quantify an initial observation of significant effect
    - To investigate the potential cause of an observed adverse effect; and,
    - To characterize an undisturbed or minimally disturbed environmental state resulting from

human activity as distinct from a disturbed state relative to a particular natural environmental stressor.

In 2016-2017, 29 approved projects were Focused Studies.

The most significant risks to the delivery of approved projects in 2016-2017 were the Fort McMurray wildfires, which delayed start up for a number of projects, and resourcing as staff transitions on both federal and provincial sides also caused some delays in project delivery. Overall most of the 58 projects approved for 2016-2017 fiscal year were delivered as approved; there were however, five (5) projects with outstanding deliverables – these have now been moved into 2017-2018 for implementation. Project progress is tracked and reported to Program Executives quarterly.

The budget allocated to Program Administration funds the activities of the Oil Sands Secretariat that provides joint oversight of the program including project planning, implementation, and tracking; coordinating quarterly and annual reporting as well as managing stakeholder engagements. Program Administration is an ongoing funding area under the OSM program.

Highlights

A total of 58 projects approved for 2016-2017;

5 projects with ongoing deliverables – these have now been transitioned into 2017-2018 work plans.

The governments of Canada and Alberta recognize that monitoring in the oil sands region is a responsibility that has multi-generational implications for the province as well as the nation; both governments remain committed to working to ensure the environmentally sustainable development of the oil sands.

2.2.3 Engagement Activities

2.2.3.1 Multi-Stakeholder

The multi-stakeholder forums are one of the mechanisms through which the governments of Canada and Alberta share information and seek feedback from stakeholders on oil sands monitoring. These forums bring together representatives from the governments, First Nations, Métis organisations, oil sands industry, non-governmental organisations, and academia to share information and discuss progress made on oil sands monitoring activities.

As part of the commitment to ongoing stakeholder engagement, a two-day, multi-stakeholder forum was held in February 2016 in Edmonton. At the forum, stakeholders received an update on oil sands monitoring activities including an announcement of the formal conclusion of the Canada-Alberta Joint Oil Sands Monitoring (JOSM) Implementation Plan. Stakeholders also had an opportunity to participate in discussions regarding the future of the Oil Sands Environmental Monitoring Program.

JOSM called for an expert peer review of the program after year three of implementation to assess the scientific integrity of the monitoring system upon completion of the program's initial three-year term. The peer review panel consisted of six independent science experts; the Panel Chair, Dr. Phillip Hopke of

Clarkson University in Potsdam, New York, presented the Panel's findings and recommendations to stakeholders at the OSM multi-stakeholder forum in February 2016.

> **Highlights**
>
> Presentation of the findings and recommendations of the Science Integrity Review Panel. A key conclusion was that the program has been a substantial improvement over previous environmental monitoring programs.

The outcome of an independent governance review of the OSM program commissioned by AEMERA was also presented at the forum; it included a proposed governance structure and an operating model showing how First Nations, Métis organisations, scientific and technical experts, governments and working partners could be engaged in environmental monitoring in the oil sands regions. Discussions are ongoing between the governments, Indigenous leaders, industry and key stakeholders on a governance model for the oil sands monitoring program that addresses the planning process. Program executives also responded to questions on the working relationship between the federal and provincial governments with respect to oil sands monitoring.

A high-level summary of monitoring results from previous years was presented and participants had an opportunity to provide comments and have their questions addressed. Dr. Fred Wrona (AEP) and Dr. David Boerner (ECCC) led a discussion on priorities and processes for technical work planning under the Oil Sands Monitoring program from 2016-2017 and beyond. Interested parties were able to review and comment on the draft 2016-2017 science and technical work plans provided at the forum.

2.2.3.2 Indigenous Peoples

In 2017, the governments of Canada and Alberta invited Indigenous leaders to a series of meetings to propose a formal collaborative relationship for the purpose of jointly directing the ambient environmental monitoring of oil sands development including the incorporation of Traditional Ecological Knowledge and western science knowledge in ambient monitoring programs.

The intent is to co-develop and implement an inclusive arrangement that brings together Canada, Alberta, First Nations and Métis organisations, industry, and stakeholders in the oil sands region in strategic decision-making as part of an evidence-based, risk-based, adaptive approach to monitoring design and implementation.

Program science co-leads, Dr. David Boerner (Environment and Climate Change Canada) and Dr. Fred Wrona (Alberta Environment and Parks) led the discussions with interested parties in Peace River (March 28), Fort McMurray (March 29), and Edmonton (March 31). Overall, the meetings were well attended and there was a positive reception to the proposed collective path forward. Going forward, several rounds of meetings will be scheduled with Indigenous leaders and their representatives that will build upon the positive outcomes of the meetings.

2.2.3.3 Indigenous Peoples Training and Participation in Monitoring Activities

Indigenous communities in the oil sands region have expressed the desire to be equipped to participate in environmental monitoring and help answer their own questions about changes on the land. An Indigenous Environmental Monitoring Technician Training Program Pilot was launched in 2015 to enable more robust Indigenous peoples' participation in environmental monitoring in the oil sands region. A three-year collaborative initiative funded under the Oil Sands Monitoring program, the Pilot, focuses on building on technical skills of Indigenous peoples in environmental monitoring, and facilitate establishing working relationships between Indigenous peoples and scientists.

In 2016-2017, 90 percent of course participants successfully completed the 5-week training that took place in Edmonton (information session, presentations, and workshops) with hands-on field visits to surrounding areas (e.g. Rocky Mountain House). The training covered monitoring design and field monitoring techniques related to contaminants, water, fish and wildlife monitoring. It also included data management and reporting as well as first aid and safety training. See Appendix E for full report.

The training pilot was successfully delivered; feedback from participants was positive, and survey results indicate that the 2016-2017 program was well received. Indigenous peoples have participated in training and field activities since 2013, and it is expected that this will continue into the future.

Both governments remain committed to seeking opportunities for capacity building within Indigenous communities, and to working with Indigenous peoples to foster openness, transparency and the inclusion of Indigenous Knowledge into environmental monitoring of the oil sands region.

2.2.3.4 Industry Engagement

During 2016-2017, industry representatives participated in various engagement activities including the multi-stakeholder forums (February 2016) and Oil Sands Science Symposium (November 2016). In addition to the above, program executives from both governments met with industry representatives at various times to provide updates on the OSM program, and to receive feedback from industry on their perspectives on various issues affecting the oil sands program, including administering program funding, access to industry sites as well as ensuring ambient monitoring and facility performance monitoring are complementary rather than duplicative. Discussions are ongoing between OSM program executives and industry representatives through Canada's Oil Sands Innovation Alliance (COSIA) regarding aligning the technical design of the ambient regional monitoring program and regulatory requirements as specified under regulatory approvals issued to industry by the Alberta Energy Regulator. COSIA is an alliance of oil sands producers working to improve the environmental performance of its members; COSIA coordinates industry's involvement in the technical design and implementation of the oil sands environmental monitoring program.

2.2.3.5 Oil Sands Monitoring Symposium

The governments of Canada and Alberta have worked together since 2012 to monitor and report on environmental conditions in Alberta's oil sands region. With over four years of monitoring data collected, the Oil Sands Monitoring Symposium is part of a larger effort to engage with science and stakeholder communities to the share results and key learnings emanating from oil sands monitoring activities.

The second Oil Sands Monitoring Symposium was held in Calgary on November 22-23, 2016. The purpose was to share data and results from the program with scientists, governments, industry, non-governmental organisations, and others interested in environmental monitoring of oil sands activities. The two-day symposium was well attended with a total of 269 participants representing First Nations, Métis organisations, provincial and federal government departments, non-governmental organisations, oil sands companies, consultants, scientific experts, and academic institutions.

The 2016 Oil Sands Symposium explored key learnings about physical and chemical environmental stressors related to oil sands development with a focus on their fate in the environment and consequent impacts on human and ecosystem health. Integration was a central theme of the symposium, specifically the linkages between environmental media as well as between knowledge systems. Dr. Leroy Little Bear, who delivered the keynote address on the second day of the Symposium, discussed the interrelationship between Western and Indigenous science, while a joint presentation by Dr. Fred Wrona and Dr. David Boerner gave an overview of the Oil Sands Monitoring program, and also discussed the interactions between development activities and observed responses in the various environmental media (air, water, land).

The symposium provided various opportunities for participants to interact with scientists active in oil sands monitoring including panel discussions as well as questions and answer sessions. Dr. Brenda Parlee from the University of Alberta facilitated a panel discussion by Indigenous and western scientists involved in oil sands monitoring. Dr. Jill Baron, Chair of the Alberta Environment and Parks Science Advisory Panel discussed the interface between science and policy in her keynote address. She acknowledged that while scientific knowledge played a key role in understanding the consequences resulting from interactions of natural and anthropogenic drivers, it is only one of several factors contributing to resource management decisions. She indicated that managing natural resources required both the knowledge and correct application of science, and stressed the importance of objective interpretation of environmental data and its application in management and policy decisions. Dr. Baron also highlighted the importance of interactive exchange of information between scientists, managers, policy makers, and stakeholders in building credibility and increasing the influence of science in decision-making.

Highlights of commitment on Accountable Administration and Review:

– Completion of OSM Science Integrity Review by Expert Panel;
– Multi-stakeholder forum held in February 2016;
– Oil Sands Monitoring Symposium held in November 2016;
– Several meetings held with representatives of First Nations and Métis organisations for talks with Indigenous leaders regarding a formal collaboration with the governments of Canada and Alberta on jointly directing the Monitoring of Oil Sands Development
– Progress made in beginning to align ambient environmental monitoring program design with facility performance monitoring as required under regulatory approvals issued by the Alberta Energy Regulator.

Feedback from participants surveyed indicated that the information presented at the symposium was very relevant to their interests and work. Both governments remain committed to open and transparent sharing of results with all stakeholders.

2.3 Adaptive Management

In 2012, both governments committed to managing environmental monitoring in the oil sands region in an adaptive manner. A detailed plan was implemented as outlined in the Implementation Plan for 2012-2015. Consistent with adaptive management, the 2016-2017 monitoring plan and associated activities have evolved to incorporate lessons learned from monitoring results and input from subject matter experts from governments, Indigenous communities, industry, academia and NGOs.

The governments of Canada and Alberta agreed to an external expert peer review of the monitoring system after year three (2015) of implementation, with subsequent review at five-year intervals to ensure that scientific integrity of the program is maintained. The Panel concluded that the program had substantially improved environmental monitoring in the region but also highlighted areas for additional improvement; in response, Alberta and Canada accepted the panel's recommendations and expressed appreciation to the panel for their efforts in reviewing the program, and for their thoughtful recommendations. Key actions currently underway to address the panel's recommendations are highlighted in Table 3.

Recommendations from both the Expert Science Integrity Review Panel and Auditors General of Alberta and Canada were considered in the development and implementation of the 2016-2017 annual monitoring plan. Examples of this include rationalization of monitoring networks by science experts before significant changes are made to the network as well as clear identification of annual activities as either long-term monitoring or focused studies.

Adaptive management not only ensures the monitoring program is responsive to changes in environmental signals but also that program implementation is efficient and cost effective. The scope, operations and cost of the monitoring program have been jointly reviewed by the two governments as part of the annual planning process to ensure the monitoring program is cost effective.

Highlights of commitment on Adaptive Management:

- Exploring opportunities for integration of monitoring across media.
- Expert Panel recognition that the OSM program had substantially improved environmental monitoring in the region

Both governments remain committed to supporting the responsible development of oil sands resources through implementing a science-based monitoring program to better understand cumulative effects of oil sands activities.

	Recommendation	Actions Currently Underway to Address Recommendation
1	Better define and document specific policy and scientific goals of the governments of Canada and Alberta for the monitoring of the oil sands.	AEP and ECCC are working together to develop a long-term Agreement that will include longer-term planning with enhanced clarity for the policy and scientific objectives.
2	Conduct more comprehensive data analysis and interpretation.	Comprehensive data analysis of water results 2012-2015 has been completed and the OSM Water Monitoring Synthesis Report has been drafted for release in late 2017. A re-analysis of historical water quality data is planned. A series of atmospheric-focused synthesis reports was approved for production in 2016 at a rate of at least one report per year, on a specific priority theme (e.g., polycyclic aromatic compounds) with consideration for the evaluation, integration and synthesis of results from across OSM.
3	Take the necessary steps to enhance the integration of the monitoring within and across the four components.	A review of the air monitoring network design was done in 2016. Efforts initiated in 2016 towards integrating multiple atmospheric deposition projects will continue in 2017 towards informing an integrated deposition monitoring program for improved understanding of atmospheric deposition on environmental receptors including forests, wetlands, lakes, amphibians and birds.
4	Develop and document a uniform Quality Assurance (QA) approach that is implemented and tracked across all monitoring activities.	Approved project plans for 2015/16 included a project on "Establishing a uniform and consistent QA/QC approach across JOSM".
5	Make monitoring data and information more readily available and accessible to stakeholders.	Initial efforts have focused on making the JOSM scientific and technical data provided by all organizations accessible primarily through the OSM portal: https://www.canada.ca/en/environment-climate-change/services/oil-sands-monitoring.html

Table 2: Highlights of OSM Program response to the Science Integrity Review Panel's Recommendations

2.4 Transparent and Accessible Results

Open, transparent access to quality assured monitoring data within a management framework that allows information to be uploaded, organized and publicly-available in a timely, standardized, and coordinated manner is a key focus of the OSM program.

The Science Integrity Review Panel recommendations called for a more rigorous approach to the Quality Assurance (QA) process, including full independent auditing, better quality assurance documentation that includes an overall quality assurance plan, detailed standard operating procedures (SOPs). As part of comprehensive quality management, quality assurance and quality control activities were implemented program wide for 2016-2017. Examples of these include collating Standard Operating Procedures (SOP) from program areas to ensure all program contributors and the general public had access to the standards and protocols used in the oil sands monitoring program. This is intended to ensure that data and information generated by the program are of high quality and comparable. Other activities include, regular audits conducted on air monitoring networks in the oil sands region, double-blind Certified Reference Material Inter-Lab studies, analytical laboratory performance improvement exercises, and external scientific peer review on the draft groundwater SOPs. SOPs for air, water and biodiversity are posted at: http://environmentalmonitoring.alberta.ca/resources/standards-and-protocols/; 150 SOPs have been posted since 2015.

Historically, the program has relied on monitoring organisations for data management, including quality assurance and storage, with data collected through monitoring activities by delivery organisations available through the respective organisations' websites.

As part of program improvement, significant efforts were made in 2016-2017 to ensure that data collected under the program is publicly accessible through the Canada-Alberta Oil Sands Environmental Monitoring Information Portal launched in 2013 as they become available. Feedback from stakeholders has been informing improvements to the Portal.

Going forward, a federated model for data management will be implemented across the program.

At present, monitoring data and information is available on the OSM program portal https://www.canada.ca/en/environment-climate-change/services/oil-sands-monitoring.html, and through the following sources:

- Air Data Warehouse - http://airdata.alberta.ca
- AEMERIS - http://aemeris.alberta.ca
- Wood Buffalo Environmental Association - www.wbea.org
- Lakeland and Industry Community Association - www.lica.ca
- RAMP - www.ramp-alberta.org/ramp/data.aspx
- ABMI - www.abmi.ca

Work done under data management in 2016-2017 contributed to the goal of providing publicly accessible, comparable and quality-assured data on oil sands monitoring.

3. Summary and Next Steps

The governments of Alberta and Canada have worked together since 2012 to implement a phased and adaptive monitoring program for the oil sands region intended to generate information on the cumulative effects of oil sands development activities.

Both Canada and Alberta committed to an independent expert peer review of the monitoring system for scientific integrity after year three of the Implementation Plan. A panel of independent internationally recognised science experts conducted an extensive review of the program and presented their findings and recommendations (see Appendix A) at the February 2016 multi-stakeholder forum in Edmonton. The scope, operations and cost of the monitoring program have been jointly reviewed by the two governments as part of the annual planning process to ensure the monitoring program remains efficient and cost effective.

The development of the annual monitoring activities plan for 2016-2017 was informed by the outcome of a review of monitoring and evaluation completed since the program started in 2012. This focused on what was learned and the additional monitoring needed, recommendations of the Science Integrity Review Panel as well as comments received through past multi-stakeholder meetings.

Monitoring activities for 2016–2017 have been completed and evaluation of the data collected is in progress. It is expected that the results will be shared at a future oil sands symposium.

The implementation of a new more robust planning model announced at the oil sands monitoring forum held in February 2016 was impacted by the Government of Alberta's decision to dissolve the agency charged with overseeing Alberta's contribution to oil sands monitoring in June of 2016. The intent was to ensure a credible and efficient system that is fully accountable to Albertans, and return the core function of environmental monitoring to government. The agency became a division within Alberta Environment and Parks and continues to lead Alberta's contributions to oil sands monitoring. Discussions are ongoing between the two governments, Indigenous leaders and key stakeholders on jointly directing the program; it is expected that these discussions will culminate in a formal governance arrangement and operational model for the oil sands monitoring program.

Participation and engagement of Indigenous peoples has been ongoing since 2012 through various mechanisms including regional forums specific to communities in the oil sands region, multi-stakeholder forums as well as elder and community sessions, although it was recognized that significant improvement was still required. To this end, in 2016, the governments of Canada and Alberta expressed a desire to work with Indigenous peoples in directing the oil sands monitoring program through respective Ministers for the Environment. To this end, in 2017, there have been concerted efforts to engage with Indigenous leaders, and representatives from communities within the oil sands region and key stakeholders including industry to propose a collaborative relationship between the parties on oil sands monitoring. Program scientific co-leads, Dr. David Boerner, Environment and Climate Change Canada and Dr. Fred Wrona, Alberta Environment and Parks met to discuss the proposed collaboration with interested parties in Peace River (March 28), Fort McMurray (March 29), and Edmonton on (March 31).

The formal collaboration will enable the governments, Indigenous peoples, and key stakeholders to jointly direct oil sands monitoring including the application of Traditional Ecological Knowledge and western science in monitoring. The active participation of Indigenous peoples is a vital part of oil sands monitoring. Community-based monitoring activities will continue to focus on enhancing relationships with Indigenous peoples with the intent of ensuring approved monitoring activities effectively respond to the interests and concerns of Indigenous communities.

Following the expiration of the existing Memorandum of Understanding (MOU) in 2015, Canada and Alberta have been actively engaged in developing a new agreement between Alberta Environment and Parks (AEP) and Environment and Climate Change Canada (ECCC) for future collaboration on oil sands monitoring. It is expected that a new MOU outlining the Canada-Alberta relationship on oil sands monitoring will be announced by both Federal and Provincial Ministers of Environment in late 2017. The new MOU will be supported by a collective operational agreement that will define how both governments, Indigenous peoples and key stakeholders including industry, other government departments and agencies will work together to inform and direct oil sands monitoring.

In conclusion, monitoring in the oil sands region is a responsibility that has multi-generational implications. The valuable work completed since the program was announced in 2012 has built a strong foundation for environmental monitoring, evaluation and reporting on oil sands development activities in the region under the Oil Sands Monitoring (OSM) Program. The Government of Canada and the Government of Alberta remain committed to working collaboratively with Indigenous groups in the region, and key stakeholders to ensure the responsible and sustainable development of this important resource through implementing a comprehensive, integrated, and scientifically rigorous environmental monitoring program.

4. Appendices

A. Joint Canada-Alberta Implementation Plan for Oil Sands Monitoring

B. Assessing the Scientific Integrity Of The Canada-Alberta Joint Oil Sands Monitoring (2012-2015) Expert Panel Review

C. OSM 2016-2017 Work Plan - Year End Report

D. The 2016-2017 Ambient Environmental Monitoring Plan For Oil Sands Development

E. Environmental Monitoring Technician Training For First Nations and Métis Communities in the Oil Sands Regions, Alberta Program Report 2016-2017 Pilot Year (Released July 2017)

5. References

- Bill 18, *An Act to Ensure Independent Environmental Monitoring,* 2nd Session, 29th Leg, Alberta, 2016.

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- Environment Canada and Alberta Environment. 2013. *Joint Canada/Alberta Implementation Plan for Oil Sands Monitoring Data and Results Sharing and Release Principles and Protocols*.

- Environment Canada and Alberta Environment. 2013. Joint Canada-Alberta Implementation Plan for Oil Sands Monitoring – Charter.

- Environmental Protection and Enhancement Act Oil Sands Environmental Monitoring Program Regulation Alberta Regulation 226/2013

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6. Acronyms

AAAQOs	Alberta's Ambient Air Quality Objectives
ADPC	Acoustic Doppler Current Profiles
AEMERIS	Alberta Environmental Monitoring, Evaluation and Reporting Information Service
AQHI	Air Quality Health Index
CEW	Canadian Eco-toxicology Workshop
EFDC	Environmental Fluid Dynamics Code
EPEA	Environmental Protection and Enhancement Act
FME	Feature Manipulation Engine
GEM-MACH	Global Environmental Multi-scale - Modelling Air quality and Chemistry
HYDAT	Hydrometric Data
LC/GC-QToF	Liquid and Gas Chromatography time-of-flight mass spectrometry
LICA	Lakeland Industry and Community Association
LiDAR	Light Detection and Ranging
NADP	National Atmospheric Deposition Program
NMHC	Non-methane Hydrocarbon
PRAMP	Peace River Area Monitoring Program
PYLET	Pacific Yukon Lab for Environmental Testing
RAMP	Regional Aquatics Monitoring Program
SAGD	Steam Assisted Gravity Drainage
SensorML	Sensor Model Language
SFC-Orbitrap	Supercritical Fluid Chromatography
SPMD	Semipermeable Membrane Device
TEK	Traditional Ecological Knowledge
VIC	Variable Infiltration Capacity
WBEA	Wood Buffalo Environmental Association
WSC	Water Survey of Canada

7. Technical Annex

A summary of the results from monitoring activities implemented in 2016-2017 is presented in this section under the following categories Atmospheric Monitoring, Watershed Monitoring, Biotic Response Monitoring, Wetland Ecosystem Monitoring, Indigenous Monitoring Program, Standards, Quality Assurance/Quality Control, and Data Management.

The information presented in this section of the report was provided and reviewed for completeness and accuracy by the project leads representing the respective OSM project delivery organisations.

Atmospheric Monitoring		
Objective A1: Detect and report concentration levels and trends of atmospheric substances that are likely to cause adverse human and/or environmental health effects.		
Strategy: Determine current levels and trends of SO_2, NOX, O_3, $PM_{2.5}$, H_2S and compare these against established Ambient Air Quality Standards		
Oil Sands Monitoring Activities	Key Targets	Outcomes
Ambient Air Monitoring: Athabasca Oil Sands	– Operate and maintain continuous monitoring stations and integrated samplers – Produce quality assured near real - time data – Provide open access to data – Provide data for air modelling and AQHI – Produce monthly data reports	– Exceedances of Alberta's Ambient Air Quality Objectives (AAAQOs) were measured for sulphur dioxide, carbon monoxide, nitrogen dioxide, ozone, hydrogen sulphide and particulate matter. Most of these exceedances occurred in May and were associated with the Horse River wildfire. All AAAQO exceedances for carbon monoxide, nitrogen dioxide, ozone occurred in May. Exceedances of AAAQOs for hydrogen sulphide occurred occasionally throughout the year with a notable high number of exceedances (69) in August. There were 3 exceedances of the AAAQOs for sulphur dioxide at all stations throughout the year. Exceedances of AAAQOs for hydrogen sulphide and sulphur dioxide are likely due to processes associated with industrial facilities.

		– Data is reported in real-time on the Alberta Environment and Parks and WBEA web sites. Quality controlled data is available from the WBEA web site and Alberta Airdata.
Ambient Air Monitoring: Cold Lake Oil Sands	– Operation of continuous, passive, and integrated monitoring – Produce QC data monthly – Produce real-time air quality data	– Alberta's Ambient Air Quality Objectives for hydrogen sulphide were exceeded at the Bonnyville portable station. These were associated with Jesse Lake located in the immediate vicinity of the monitoring station. Fine particulate matter levels ($PM_{2.5}$) were also elevated at monitoring stations in the Cold Lake region and primarily associated with wildfire smoke. Hydrocarbon concentrations were elevated (greater than 2.5 ppm) at all continuous monitoring stations. Elevated hydrocarbon concentrations are likely caused by industrial and domestic (e.g. automobiles) sources in the region. LICA collected air samples when elevated hydrocarbon concentrations were recorded by continuous monitors. These samples were analyzed for individual volatile organic compounds. – Data is reported in real-time on the Alberta Environment and Parks and LICA web sites. Quality controlled data is available from the LICA web site and Alberta Air data.
Ambient Air Quality Surveillance: Peace Oil Sands	– Produce real-time air quality data – Produce monthly quality controlled data – Produce quarterly public newsletter – Participate in the annual AER continuous air monitoring audits	– Alberta's Ambient Air Quality Objectives were not exceeded at air monitoring stations in the Peace River oil sands region (based on data from October 1, 2016 to March 31, 2017). However, elevated hydrocarbon concentrations (> 2.5 ppm) were reported at two monitoring stations. These were associated with methane concentrations and likely related to nearby industrial sources and, in some cases, natural sources. PRAMP collected air samples when elevated hydrocarbon concentrations were recorded by continuous monitors. These samples were analyzed for individual volatile organic compounds. – Data is reported in real-time on the Alberta Environment and Parks web site. Quality controlled data is available from Alberta Air data.

Ambient Air Quality Surveillance: Beaver River Valley	– Install field equipment – Produce monthly data summaries on QA/QC meteorological data	– The installation of the Beaver River Valley meteorological station was deferred due to lack of resources within LICA to deliver the project.
Remote Ozone Monitoring	– Routine surveillance, data validation, data review, and reporting	– Remote ozone monitoring is conducted at three locations in the Athabasca oil sands region to obtain high time resolution data during the growing season. Because of the Horse River wildfire, deployment was delayed until Q2. Data reports for 2016-2017 have been prepared and are available on request from WBEA. It is expected that the data reports will be available on the WBEA website by the end of November.
Instrumented Meteorological Towers	– Operation of instrumented meteorological towers – Public release of real-time data via WBEA website and monthly QA data reporting	– Instrumented meteorological towers are deployed at six Jack Pine monitoring sites in the Athabasca oil sands region. The data is collected on 30 metre towers following the U.S. Environmental Protection Agency's CASTNET (Clean Air Status and Trends Network) Multi-layer Model requirements. In 2016-2017, operation and maintenance was conducted for all sites. Quality controlled data is available at www.wbea.org
Strategy: Determine current levels and spatial and temporal trends of substances emitted specifically by Oil Sands development activities to estimate human and ecosystem exposures		
Ambient Air Passive Monitoring - Athabasca Oil Sands	– Operation of passive monitoring network in the Athabasca oil sands region – Public release of data via WBEA website	– Bi-monthly samples for sulphur dioxide, nitrogen dioxide, ozone, nitric acid and ammonia are collected using passive sampling systems at 30 sites in the Athabasca oil sands region. This program also includes deployment of ion exchange resin samplers and Plant Root Stimulators (PRS) soil probes. In 2016-2017, there was some disruption in the data collection due to the Horse River wildfire. These sample analysis and data quality control for the passive systems are currently ongoing.
Ambient Air Passive Monitoring - Cold Lake Oil Sands	– Operation of passive monitoring network – Public release of data via LICA website and monthly QA data reporting	– Passive monitoring for sulphur dioxide, nitrogen dioxide, ozone and/or hydrogen sulphide is conducted bi-monthly at 27 sites in the Cold Lake oil sands region. The data are used to determine the spatial variability in air quality, determine long-term trends at remote locations and estimate dry deposition of air pollutants. Results for 2016-

		2017 show higher concentrations of pollutants such as hydrogen sulphide and sulphur dioxide in areas with more industry.
Ambient Odour Study	– Quantification and identification of oil sands related odour causing compounds – Data processing and modelling using Air Mapping Tool – Data synthesis and reporting	– The odour monitoring program in 2016-2017 included the testing and use of trigger-based adsorbent tube technology for volatile organic compounds and reduced sulphur compounds at two locations. The samplers were successfully tested at two locations and will be incorporated into future odour monitoring for the Athabasca oil sands region. The Community Odour Monitoring Program was evaluated and revised in 2016-2017 and will be implemented in 2017-18. – An integration report for 2015 odour data was released in November 2016. (http://www.wbea.org/resources/reports-and-publications/human-exposure-monitoring-reports)
Strategy: Optimize the effectiveness and efficiency of the regional air monitoring network design to detect spatial patterns and trends of emissions		
Ambient Air Monitoring Network Optimization (AEP/AEMERA)	– Conduct correlation study, removal bias assessments, and sensitivity analysis – Validate modelled against measured data – Produce technical report summarizing methods and results	– Validated the locations and coordinates of WBEA air monitoring stations in the air mapping tool and conducted removal bias analysis using air mapping tool modeling. Removal bias provides an indication of the usefulness of the monitoring station. – Conducted correlation study and assessed level of dissimilarity against the distances between air monitoring stations including sensitivity analysis. – Validated the modeled data against the passive monitoring data. The modeled data provided a reference for the performance of the passive monitors. – Prepared an interim report and presented the results at two scientific meetings with participation of government, industry, scientific researchers and stakeholders.

Ambient Air Monitoring Network Optimization (ECCC)	– Conduct hierarchical clustering dissimilarity analysis of Alberta continuous and passive air quality monitoring network data, using Kolmogorov-Zurbenko filtering and employing correlation coefficient and Euclidean distance metrics to assess the degree of station time series similarity between stations – Produce summary diagrams (i.e., dendrograms), tables, and maps based on dissimilarity analysis of data	– In its first year, this project delivered on a scientific methodology and its application to Alberta air quality continuous and passive monitoring data with the intent provide a component of the science necessary to inform recommendations for the optimization of the air monitoring networks in the oil sands region. – Conducted an evaluation of the proposed methodology (Kolmogorov-Zurbenko filtering of observation time series and hierarchical clustering of the filtered time series following the work of Solazzo and Galmarini (2015), which resulted in modifications to the original published approach for time filtering of observation station data. – Obtained continuous monitoring data (hourly measurements of NO, NO_2, O_3, SO_2, $PM_{2.5}$, NMHC, THC, TRS, CH_4 for the period August 1, 2013 through July 31, 2014) from AEP. Used the revised methodology to analyze Alberta continuous monitoring station data to define station similarity. Results were presented to AEP and OSM stakeholders at the Air Network Optimization Science Meeting (24 March 2017; Edmonton, AB). – Five years of AEP passive monitoring data for NO_2 and SO_2 were obtained, along with continuous monitoring for the same 5 year period. Continuous data used in the analysis is available from Alberta Airdata (http://airdata.alberta.ca/). Passive data is available on request from Alberta Environment and Parks. – Continuous and passive SO_2 and NO_2 data were analysed using hierarchical clustering with 1-R (correlation coefficient) and Euclidean distance metrics for the analysis. – Produced maps of station dissimilarity at different levels of the metrics generated, as well as dendrograms relating stations on basis of 1-R (correlation coefficient) and Euclidean distance. Results of this analysis, including the maps, will be presented in a technical report and/or peer-reviewed publication in 2017-18.

	– Present results to AEP and JOSM stakeholders. – Commence writing of report on analysis	– Tables summarizing monitoring station data similarity levels, and a protocol for their use in assessing potential station redundancies were generated. Results of this analysis, including the tables, will be presented in a technical report and/or peer-reviewed publication in 2017-18. – Results from this work were presented at a multi-stakeholder meeting in Edmonton in March 2017. – Writing of summary report on the work (Stages 1 and 2 of the 4 stage project) has been initiated and is on schedule for completion in 2017/18.
Objective A2 : Detect and report levels and trends of oil sands related chemical substances being deposited from the atmosphere		
Strategy: Quantify the amount of chemical substances being deposited from the atmosphere to the ambient terrestrial and aquatic environment		
Cold Lake Soil Acidification Monitoring Program	– Collect mineral soil and leaf litter samples for analysis – Data analysis, synthesis, and reporting	– Four sites that were determined to be sensitive to acid deposition are monitored in the Cold Lake oil sands region using Alberta Environment and Parks protocol. In 2016-2017, soil sampling was conducted at the Tucker Lake sub-sites. Analysis of the samples has been completed and data has been provided to Alberta Environment and Parks for inclusion in the provincial repository.
Operation of Enhanced Deposition Sites	– Produce air quality and deposition data following ECCC requirements – Provide monthly quality assured data for continuous measurements	There are four sites that have been upgraded with enhanced deposition monitoring equipment in the Athabasca oil sands region (Stony Mountain, Wapasu, Bertha Ganter and Buffalo Viewpoint). Enhanced deposition equipment was installed at Buffalo Viewpoint in 2016-2017. These sites are operated by WBEA and sample analysis is conducted by ECCC.
Athabasca Oil Sands Dry Deposition	– Produce deposition data at remote locations in the Athabasca oil sands region – Provide quality assured data	– Solar powered dry deposition samplers are implemented at four sites in the Athabasca oil sands region. In 2016-2017, the sites were operated and maintained by WBEA. Analysis

		and quality control of dry deposition data collected in 2016-2017 is ongoing.
Deposition and Effects	– Completion of integrated enhanced deposition monitoring network of 5 sites – Continue measurements of PACs and metals; additional and comprehensive measurements of coarse and fine PM, PM2.5 speciation, and VOCs at the 3 “supersites” Continue a continuous (high time resolution) measurement of total PAHs at AMS1 – Data analysis, assessment of temporal and spatial trends in PACs and metals levels, and data portal submission for active monitoring data for PACs and metals – Preliminary assessment of the impact of petroleum coke dust on PACs and metals levels in the AOSR	– Building on measurements and analysis conducted during the first phase of JOSM, this focus study continued to enhance the integration of monitoring and process studies related to the deposition of pollutants, for the purpose of assessing ecosystem health and cumulative environmental effects associated with the mining activities. – Pollutants targeted include polycyclic aromatic compounds (PACs), mercury (Hg), other elements including lead isotope ratios, additional and comprehensive measurements of coarse and fine particulate matter (PM), $PM_{2.5}$ speciation, and volatile organic compounds (VOCs) including polar and sulphur-containing VOCs, nitrogen (N) and sulfur (S). – The transition of the enhanced deposition network from 3 pilot sites to 5 better-located and longer term sites was completed. Measurements under the network continued for PACs and metals (including lead isotopes), and additional and comprehensive measurements of coarse and fine PM, $PM_{2.5}$ speciation, and VOCs including polar and sulphur-containing VOCs continued at the 3 “supersites” – AMS1, AMS18 and AMS4. – Data analysis and assessment of temporal and spatial trends in PACs and metals (including lead isotopes) continued including submission of data to the JOSM portal. – The impact of petroleum coke dust on PACs and metals levels in air was performed based on 4-years of monitoring data from 3 pilot sites. – New analytical methodologies and first evaluation of the presence of chemical markers, such as quinones and naphthenic acids, in air. This work resulted in a series of papers submitted for publication: (1) “Characterization of

	– Finalize development of analytical methodologies and first evaluation of the presence of chemical markers in ambient air in the AOSR	the ambient air content of parent polycyclic aromatic hydrocarbons in the Fort McKay region (Canada)", Wnorowski (accepted for publication in May 2017; (2) "Profiling quinones in ambient air samples collected from the Athabasca region (Canada)", Wnorowski et al. (accepted for publication in December 2017); (3) Application of ultrahigh-performance liquid chromatography-quadrupole time-of-flight mass spectrometry for the characterization of organic aerosol: Searching for naphthenic acids", Yassine et al. (accepted for publication in August 2017).
	– Downsize the passive sampling network for PACs from 16 sites to 5 strategic long-term sites	– Analysis of samples from the passive sampling network for PACs was downsized from 16 sites to 5 strategic long-term sites (sample collection continues at all sites); the strategy will be re-assessed based on the outcomes of the PACs Synthesis Review to be completed in 2017/18.
	– Assess transformation products for alkylated PAHs through chamber studies	– Transformation products for alkylated PAHs and their toxicity were assessed using reaction chamber experiments and in vitro toxicity assays.
	– Continue special study using PAS-DD (passive deposition) samplers co-deployed at 5 sites	– PAS-DD (passive deposition) samplers were successfully tested and validated for PACs through deployment at 5 sites.
	– Continue special studies involving use of tree cores to assess historic trends and the application of in vitro methods for linking the air mixture with ecosystem health effects	– Methodology for using tree cores to assess historical trends of PACs in air was further developed and characterized.
	– Data analysis and data portal submission for passive monitoring data for PACs	– Data analysis continues with 4.5 years of passive monitoring data for PACs to be submitted to the JOSM data portal in 2017/18.
		– Monitoring of total gaseous mercury (TGM) continued at AMS 6, TGM at AMS 13, and speciated mercury at AMS 13 with $PM_{2.5}$ and PM_{10} inlets; these data for 2015 were finalized for submission to the JOSM data portal.

	– Continuation of atmospheric monitoring, analysis and submission to the JOSM portal of total gaseous mercury (TGM) at AMS 6, TGM at AMS 13, speciated mercury at AMS 13 with PM2.5 and PM10 inlets – Inclusion of any mercury wet deposition data into the GEM-MACH mercury model – Installation of mercury wet deposition samplers in open air and canopy at AMS 13 – Continue measurements, data analysis and submission to the JOSM portal of NO, NO_2, NO_y, NH_3, and SO_2 at Pinehouse Lake, SK and Flat Valley, SK sites of the Canadian Air and Precipitation Monitoring Network (CAPMoN) – Run the air-dispersion model and couple with monitored passive PACs data to produce gridded air concentrations for PACs	– Installation of mercury wet deposition samplers in open air and canopy through fall at AMS 13 was deferred to 2017/18 due to logistical issues. – Measurements of NO, NO_2, NOy, NH_3, and SO_2 continued at Pinehouse Lake, SK and Flat Valley, SK sites of the Canadian Air and Precipitation Monitoring Network (CAPMoN). Data analysis for 2015 samples continues with submission to the JOSM data portal in 2017/18. Once completed, these data will be used to estimate total N and S deposition and used to assess chemical transport models and satellite measurements. – Dispersion modeling was completed to generate gridded concentrations of PACs in air using data from the 17 passive sampling sites and three enhanced deposition pilot sites.
Atmospheric Deposition to Lakes and Snowpack Monitoring	– PAC source identification – Publish metadata records and data files – Data analysis, evaluation/interpretation	– Processing, laboratory analysis, and partial data analysis of snow and sediments collected in March 2015 were completed. Sample extracts were sent to PYLET for PACs analysis. Sediments were submitted to NLET for multi-element analysis. Work has commenced on the processing of the March 2016 snow sample collection. – 2014 PACs, mercury, and multi-element data for snowpack's and lake sediments have been uploaded to the JOSM Data Portal. This included: approved context note, 100% of data properly formatted and prepared in CSV

	– Create Contaminant Deposition Maps using geostatistical interpolation	format, and all data files reformatted according to new Data Mart 2.0. – A manuscript on mercury and metals in lake sediment cores (Cooke et al.) completed, approved in ECCC and AEP internal review, and accepted for publication in Environmental Research Letters. Progress made on manuscript on PACs in sediment cores (Muir et al). – Partial creation of winter 2014-2015 contaminant deposition maps using geostatistical interpolation including presentation of 2014 kriging maps for total PACs and methylmercury at the Oil Sands symposium in Calgary in November 2016. Full creation of 2015 deposition maps is on hold due to issues with contracting which are expected to be resolved soon. – Snow sampling campaign completed March 10th 2017 involving 50 sites in the OS region. This will extend the temporal trend for snow deposition of contaminants to 7 consecutive years. Sediment coring comparing lakes impacted by the FMM fire with un-impacted lakes completed March 14 2017
Acid Sensitive Lakes study	– Regional assessment of the status and trends in regional lake acidification	– Water and biological (zooplankton) samples were collected from 50 acid sensitive lakes in Northeastern Alberta. Water chemical analyses to identify spatial and temporal trends in key water quality parameters. – Biological samples were shared with ECCC for analysis. – Initiated new evaluation and reporting activities focused on summarizing the limnology of monitored lakes and on understanding drivers of spatial patterns in mercury concentrations within the lakes.
Evaluation and Integration of Deposition Studies	– Air mapping tool modelling and compare modelled data to satellite remote sensing data. – Assessing existing SOPs and relevant passive samplers.	– Conducted Air Mapping tool modeling in conjunction with wildfire investigation and compared the results to satellite remote sensing data. – Reviewed the deposition work plans and identified SOPs to be documented. Received SOP documents from ECCC for

		documentation. – Assessed the performance of passive monitors. Results were presented at a stakeholder science meeting.
Wet Precipitation Study (NADP Protocol)	– Credible data on deposition to ecosystems and for use in cumulative effects measurement	– An NADP (National Atmospheric Deposition Program) site was established at Fort McKay (Bertha Ganter). Data from this site will be used to compare against precipitation quality data collected using Alberta Environment and Parks sampling protocol. The station was implemented in 2016-2017 and data collection has started.
Objective A3: Investigate Sources and Atmospheric Transport Pathways		
Strategy: Quantify the amounts of chemical substances being emitted, how these substances are transported, and whether they undergo chemical transformation in the atmosphere after emission		
Tailings Pond Emissions Study	– Provide access to quality assured tailings pond emission data through the OSM data portal	– The field study had to be postponed due to the summer of 2016 wildfires in Fort McMurray.
Studying OS Air Pollution Emission Transformation and Fate	– Analysis of data and results from the 2013 aircraft campaign – Preparations for the 2018 aircraft campaign, including securing the use of National Research Council aircraft platform, memorandum of agreement in place between ECCC and NRC, as well as instrument modification for the 2018 aircraft campaign	– This focus study continued building on intensive measurements and significant numerical modelling development carried out during the first phase of JOSM. The multi-year project focuses on a comprehensive set of activities to address gaps in understanding the emission, transformation and fate of pollutants. Improved monitoring, regulatory development and understanding cumulative impacts are potential benefits. – Analyses of the summer 2013 airborne measurement results have reached several milestones, with several scientific papers being prepared as a result of the data analyses activities, including the following papers submitted for publication: (1) "*Differences between Measured and Reported Volatile Organic Compound Emissions from Oil Sands Facilities in Alberta, Canada*" by Shao-Meng et al. (accepted for publication in March 2017); and (2) *Understanding the Primary Emissions and Secondary Formation of Gaseous Organic Acids in the Oil Sands*

		Region of Alberta, Canada", by John Liggio et al. (accepted for publication in June 2017). – Additional analyses of the 2013 results continue, with at least two more manuscripts expected. Papers are complemented by a series of presentations at national and international fora. – The National Research Council aircraft was secured for the 2018 airborne measurement campaign, and the collaboration documented in a Memorandum of Agreement between the NRC and ECCC. Instrument modification was initiated building on the methodology utilized in 2013 and towards achieving the science plan established for 2018.
	– Model (GEM-MACH) studies making use of aircraft study results and surface monitoring network data, including evaluation of new emissions data impacts on model results	– Modelling work continued, with comparisons between model predictions, monitoring network observations and aircraft observations. A series of papers were initiated with the intent to be submitted in 2017-18 for the Atmospheric Chemistry and Physics oil sands special issue. Topics include acidifying deposition, ammonia chemistry, impacts of updates to volatile organic compounds and particulate matter emissions from aircraft observations on model results, among several others.
	– Lab study and method development to inform improved understanding of the transformation of air pollutants	– Authentic samples of bitumen, tailings pond water, solvent, and oil sand were received from industry for use in laboratory studies investigating the secondary organic aerosol (SOA) potential of these materials. The results will improve the modelling of SOA formation (GEM-MACH).
	– Prepare and conduct the tailings pond emissions study	– The tailings pond field study had to be postponed due to the summer of 2016 wildfires in Fort McMurray.

Monitoring to Understand Atmospheric Sources Process and Impacts Oski-ôtin Monitoring Site	– Operation of a comprehensive suite of measurements at the Oski-ôtin site in Fort McKay, AB – Annual delivery of data from the comprehensive suite of measurements to the JOSM Portal – Optimization of the approach to semi-continuous VOC measurements, specifically to address the overlap currently in place due to similar measurements being taken less than 1 km apart in Fort McKay – Development and implementation of a system for weekly or better delivery of preliminary data to the oil sands portal and possibly real-time graphical displays to enhance the transparency of the monitoring work and value to stakeholders – Reconfiguring/enhancing vertical measurements through replacement of the two Light Detection And Ranging (LIDARs) instruments in the region with one aerosol and ozone LIDAR at Oski-ôtin and installation of a Multi axis differential optical absorption spectroscopy (max-DOAS) system. – Improvements to the total reduced sulphur measurement method following up on the promising results obtained from the new methods tested to date.	– This focus study collected a third year of comprehensive air pollutant and meteorological monitoring data in central Fort McKay in partnership with the community. – The complete second year (2015) of final monitoring data was posted on the OSM portal, thus providing 2.3 years (August 2013 to December 2015) of complete data for analysis. – Key sets of measurements from Oski-ôtin for this time period were utilized in two scientific (peer-reviewed) publications. Liggio, J., Li, S.-M., Hayden, K., Taha, Y.M., Stroud, C., Darlington, A., Drollette, B.D., Gordon, M., Lee, P., Liu, P., Leithead, A., Moussa, S.G., Wang, D., O'Brien, J., Mittermeier, R.L., Brook, J.R., Lu, G., Staebler, R.M., Han, Y., Tokarek, T.W., Osthoff, H.D., Makar, P.A., Zhang, J., Plata, D.L., Gentner, D.R. Oil sands operations as a large source of secondary organic aerosols. 2017. Nature. 534 (7605), pp. 91-94 Fioletov, V. E., McLinden, C. A., Cede, A., Davies, J., Mihele, C., Netcheva, S., Li, S.-M., and O'Brien, J. *Sulphur dioxide (SO2) vertical column density measurements by Pandora spectrometer over the Canadian oil sands (*Atmos. Meas. Tech., 2016, 9, 2961-2976). – The real-time particulate matter chemical speciation measurements at Oski-ôtin showed that the bitumen-related secondary organic aerosol reported on in the Nature publication (Liggio et al., 2016) is frequently observed on the ground in the region and not solely from aircraft measuring in downwind plumes. – The Oski-ôtin vertical column measurements of sulphur dioxide and nitrogen dioxide were examined by Fioletov et al. (2017) to provide new insight into approaches to develop climatology of elevated air pollutant levels that pass over Fort McKay, but do not impact the surface. This information is being used to evaluate and improve the air

		quality model, to better understand the fate of oil sands related emissions and when and why some events are seen at some sites and not others. – Nearly the full suite of Oski-ôtin measurements can be accessed in real-time by the community providing quick feedback regarding how air quality is behaving in Fort McKay. The community has continued to use these data to help explain the occurrence of odour and to help in dialogue with the surrounding industry and the Province of Alberta. Knowledge gained from these data helped stimulate and subsequently inform the Alberta Energy Regulator's (AER) consideration of the recurring odour complaints. – Early in 2016 the Fort McMurray forest fire occurred and Oski-ôtin was measuring during the periods smoke plumes impacted Fort McKay helping to support ongoing research into the modelling of forest fire related air quality. After the fires were extinguished and the oil sands industries were resuming operation AER was provided with real-time access to Oski-ôtin data. The recognized value of the Oski-ôtin measurements, such as with the AER cooperation, and the requests from all stakeholders to make the data available much more frequently than yearly portal releases, sparked an initiative in 2016-17 to develop a system for weekly release of preliminary Oski-ôtin data. The result was that at the end of the fiscal year a graphical template was developed and the system to automatically plot the data and initiate cross-checks with the measurement experts was designed and beta-tested. – During 2016-17 improvements to measurements being taken at Oski-ôtin were accomplished. – The newly-developed method for total reduced sulphur (TRS), which has been pioneered at Oski-ôtin, was upgraded. As a result, the measurements are more sensitive at low levels and the system is much more robust thereby greatly reducing downtime. This is allowing the advancement of this research methodology to a possible

		routine monitoring option and/or for additional research applications given its proven capabilities. – A newly developed LiDAR for ozone vertical profiles was installed in October 2016 and has revealed new features of the dynamical variability of tropospheric ozone above Oski-ôtin. Of interest was the observation of several stratospheric intrusion events during each month of operation since installation. – The measurement of volatile organic compounds (VOCs) was enhanced at the nearby AMS01 site of the Wood Buffalo Environmental Association (WBEA). There is now much greater consistency between AMS01 and Oski-ôtin in the species being measured (10-11) with increased capability to explore VOC events potentially related to the impact of naphtha releases from the surrounding industry. – To reduce redundancy at Oski-ôtin, the measurement of nitrogen dioxide and nitric oxide was reduced to the use of the standard monitoring instrumentation. This streamlining of the monitoring was supported by the 2+ years of Oski-ôtin direct, high sensitivity measurements of nitrogen dioxide, which demonstrated that the quantity of more oxidized forms of nitrogen is relatively small and thus poses a minimal artifact on the standard monitoring approach.
Workshop to Develop New Monitoring Methods Using Satellite Data	– Focus on measurements of wetland, greenhouse gases, and air quality, host a workshop of developers and potential clients of satellite remote sensing products to collectively identify opportunities for satellite remote sensing deployment in subsequent years – Consideration of the outcomes of the workshop to inform how satellites can be used to improve the scientific value, rigour, and confidence of	– From March 8-9, 2017, AEP and ECCC hosted a workshop on Current and Emerging Methods for Satellite Monitoring of the Oil Sands at the ECCC Downsview building (Toronto, ON). The workshop was very well attended, with upwards of 50 participants representing both levels of government, industry, academia and private industry joining in person or remotely via WebEx. – With the purpose to bring together developers, scientific experts, users, and potential clients of satellite remote sensing products to discuss opportunities and applications, the program was designed to allow for both presentation and discussion across the themes of air quality, greenhouse gas, and wetlands.

	monitoring and optimization of monitoring results	– Presentations were aimed at informing a wider audience on current and emerging space-based capabilities, and how satellite products could be used to inform monitoring in the oil sands region. The afternoon of March 9 was reserved for facilitated discussion on specific opportunities and applications for satellite monitoring of the oil sands, and potential integration or exchange across the three themes. – A report, which synthesizes the presentations and the facilitated discussion, was completed to inform future consideration of satellite monitoring in support of oil sands monitoring.
Objective: Integration and Synthesis		
Air Evaluation, Integration, and Synthesis	– Air monitoring data evaluation, integration, and synthesis	– This project was deferred to 2017-18 to ensure sufficient time to scope objectives and deliverables, and for required resources to be identified.

Watershed Monitoring

Objective W1: Detect and report concentration levels and trends of chemical substances of concern in the aquatic environment that are likely to cause adverse human and/or environmental health effects.		
Strategy: Focus monitoring in the areas of highest known or expected disturbance, and expand, if warranted		
1. Determine current levels and trends of metals, organics and physical parameters and compare these against established Water Quality Standards		
Oil Sands Monitoring Activities	**Key Targets**	**Outcomes**
Water Level and Flow Monitoring	– Produce near real-time data (e.g. river water levels and flows, lake levels and meteorological data) to establish a long-term hydrometric data records in oil sands area to assess watershed hydrology and trends; to support the interpretation of water quality and aquatic ecosystem based measures; and to support predictive modelling activities.	– The current JOSM Hydro-climatic network consist of 55 Hydrometric stations, 5 climate stations and 4 snow-course survey geographic areas in the Alberta oil sands regions, and in downstream receiving environments. – *Hydrometric Monitoring*: River/lake water levels were monitored at key nodes throughout the lower Athabasca River system. These nodes represent the core hydrometric network which has been integrated with all elements of the core water monitoring program. Water levels were recorded at 55 hydrometric stations (43 hydrometric stations operated by AEP and 12 hydrometric stations operated by WSC). Water level data are transmitted via satellite or cellular telemetry and are available in near-real time through Alberta Environment and Parks (AEP) and Water Survey of Canada (WSC). Water level data were used to calculate river and stream discharges. Near-real time discharge reporting is also being phased in throughout the lower Athabasca River system. – *Meteorological Monitoring*: Near Real Time (NRT) meteorological monitoring was also conducted at 5 climate stations to inform the interpretation of hydrometric data and to support modelling. The oil sands meteorological monitoring program supplements existing meteorological monitoring in the province. – *Snow Surveys*: Three snow-course surveys were conducted in following four distinct geographical regions: • CANR - Canterra Road. This is an area in the Muskeg River watershed near Kearl Lake;

		• NEX - This is an area in the Christina watershed on the Nexen lease area; • CNRL - This is an area in the Tar River watershed on the CNRL lease area; and • MCLL - This is an area in the Firebag watershed near McClelland Lake. – Each geographical region has following four terrain types (landuse/ landcover): • JP - Jackpine forested terrain; • MD - Mixed Deciduous forested terrain; • FL - Flat, low-lying terrain; and • OP - Open land/lake terrain. – *Data Availability:* All monitoring data collected under hydro-climatic network are regularly validated and QA/QC and publically available from the sources listed below – *Stations Operated by Water Survey of Canada:* Near Real Time Data: Data is made available through Water Survey of Canada's Water Office and can be downloaded in CSV format from the link below: https://wateroffice.ec.gc.ca/mainmenu/real_time_data_index_e.html – *Historical Data*: Historical hydrometric data can be downloaded from the link below: https://wateroffice.ec.gc.ca/mainmenu/historical_data_index_e.html – All historical hydrometric data is archived in the HYDAT database and can be downloaded from the link below: https://www.canada.ca/en/environment-climate-change/services/water-overview/quantity/monitoring/survey/data-products-services/national-archive-hydat.html – *Metadata:* Completed new or update metadata &/or monitoring site records including station metadata can be found at:

		https://wateroffice.ec.gc.ca/mainmenu/station_and_network_data_index_e.html – *Stations Operated by AEP:* Near Real Time and all historical data: Data is made available through former RAMP public website and can be downloaded in CSV format from the link below: http://www.ramp-alberta.org/ramp/data.aspx

Water Quality Monitoring	– Produce and release quality assured water quality monitoring data and associated metadata	– As per the 2016-17 workplan for water quality under the Joint Oil Sands Monitoring Plan, the program included sampling at sites in the Lower Athabasca River (M0-M9) from the Town of Athabasca (M0) to just upstream of the Athabasca River Delta (M9). In addition, water quality was monitored in the downstream expanded geographical area (EGA) at M11A, M12, M10, SL1, SL2, BI1, RI1, QU1, MC1, BU1, and BU2. Pending a review of the recommendations from the Joint OS Water Quality reports, some frequency and sites were adjusted for 2016-17 sampling year. Sampling achieved from April 2016-March 2017 was as follows:
		  – For mainstem Athabasca River sites, 162 samples were taken from 5 sites; M2, M3, M4, M5 and M6.
		  – For the EGA downstream 155 samples were taken from 11 sites; M11A, M12, M10, SL1, SL2, BI1, RI1, QU1, MC1, BU1, BU2.
		  – Due to the Fort McMurray Wildfire in the spring and early ice events in October 2016, some samples were not able to be taken as planned.
		
		– Water quality samples collected during 2016-17 were analyzed at the laboratory and a quality assurance-quality control review of the data initiated.
		
		– Presentations Given
		  – C-L. Epp, L. Levesque, N. Glozier, Data Methods and Quality Control Measures for a Passive Water Quality

		Monitoring Program in the Oil Sands Region of Alberta, Canada, CEW September 26-28 2016 Edmonton AB – K. Pippy and N.E. Glozier. Surface Water Quality Monitoring under the Joint Oil Sands Monitoring Program in the Lower Athabasca River and Downstream Receiving Environments. CEW September 26-28 2016 Edmonton AB – L. Levesque, N. Glozier, C-L Epp, and K. Pippy Passive Sampling Advances Knowledge of Water Chemistry in Rivers of Canada's Oil Sands Region. SETAC November 6-10 2016 Orlando, FL – D.B. Baird, N.E. Glozier, L. Levesque, M. McMaster, D. Peters, K. Pippy, G. Tetreault. Monitoring of Water Quality, Fish and Deltaic Wetland Ecosystem Health in Relation to Upstream Development in the Peace Athabasca and Slave River Watersheds. Presentation to UNESCO mission in Fort Chipewyan, AB November 2016. – N.E. Glozier, K. Pippy, L.M. Levesque, A. Ritcey, B. Armstrong, O. Tobin, C.A. Cooke, M. Conly, L. Dirk, C. Epp, A. Gue, R. Hazewinkel, E. Keet, D. Lindeman, J. Maines, J. Syrgiannis, M. Su, V. Tumber. Surface Water Quality Monitoring under the Joint Oil Sands Monitoring Program in the Lower Athabasca River and Downstream Received Environments. Poster presentation at OS Symposium November 22-23, 2016, Calgary. – Reports N.E. Glozier, K. Pippy, L. Levesque, A. Ritcey, B. Armstrong, O. Tobin, C.A. Cooke, M. Conly, L. Dirk, C. Epp, A. Gue, R. Hazewinkel, E. Keet, D. Lindeman, J. Maines, J. Syrgiannis, M. Su, V. Tumber. (in press). Surface Water Quality of the Athabasca, Peace and Slave rivers and riverine waterbodies within the Peace-Athabasca Delta: A synthesis report prepared for the Canada-Alberta Joint Oil Sands Monitoring Plan – The draft report for Assessing Water Quality of the Athabasca and EGA was completed and sent for review. Results were

		presented at several venues including the CEW workshop in Edmonton and the OS Science Symposium in Calgary. – Deployed water quality sondes at key monitoring stations to record near real-time water quality information. Deployed semi-permeable membrane devices at key mainstem and tributary monitoring stations to understand dissolved PAC concentrations and loadings.
Groundwater Monitoring	– Technical report detailing field activities, data analysis and findings	– A draft technical report has been produced that details the results of two groundwater monitoring and sampling events in the fall of 2016 and spring of 2017 in the North Athabasca Oil Sand (NAOS) and South Athabasca Oil Sand (SAOS) regions respectively. The report also includes results of statistical analyses comparing historical to contemporary geochemistry and recommendations for improving the existing monitoring well network. The report is expected to be finalised in late 2017/early 2018.
2. Determine current levels and trends of substances associated specifically by Oil Sands development activities to estimate human and ecosystem exposures		
Modelling- regional Hydrology/Climatology	– Transitioning of data/numerical models to AEP – Generation of digital elevation model for Lower Athabasca River. – Continue refining and enhancing the hydrological, sediment transport and water quality models for lower Athabasca River. – Publication of journal articles	– AEP has established a shared cloud server and all the data and numerical models (e.g. VIC hydrology model; Mike11 and EFDC water quality models) have been transferred to the EMSD/AEP from ECCC. EMSD is using the cloud server as the modelling platform to build and run the required simulation in addition to archiving all the models and model data sets. – All available bathymetry data (GeoSwath, cross-sections and ADPC) and LIDAR data has been integrated to generate the latest high resolution bathymetric data for the Lower Athabasca River. A technical report entitled: “Use of Bathymetric and LiDAR Data in Generating Digital Elevation Model over the Lower Athabasca River Watershed” has been produced under the OSM technical series. The following open-access paper has also been published: Chowdhury, E.H., Hassan, Q.K., Achari G, and Anil Gupta (2017). *Use of Bathymetric and LiDAR Data in Generating Digital Elevation Model over the Lower Athabasca River*

		Watershed in Alberta, Canada. Journal: Water, Manuscript ID: Water 2017, 9(1), 19. – Hydrology model (VIC) was reviewed and a need of recalibration of the model was identified. A finer model grid (~2km x 2 km) has been created and the model recalibration/ verification work is under progress. The water quality model (EFDC) was also reviewed. EFDC model was updated with the newly generated Athabasca River bathymetry. EFDC model requires recalibration and this work is also in progress.
3. Evaluation of the effectiveness and efficiency of the regional watershed monitoring design to detect spatial patterns and trends of releases		
Rationalization of the Watershed Monitoring Network -Effectiveness and Efficiency Optimization	Rationalization of the Water Monitoring Network's effectiveness	– A workshop was held November 28-30, 2016 to review and optimize the water monitoring network. – The workshop participants included representatives from the Environmental Monitoring and Science Division (EMSD) of Alberta Environment and Parks (AEP), and the Water Science and Technology Directorate (WSTD) and National Hydrological Services, Water Survey of Canada (NHS-WSC) of Environment and Climate Change Canada (ECCC). – Outcomes included a new decision framework to guide long-term monitoring activities, recommendations for changes to long-term monitoring stations, sampling frequency, and sampling methodologies. – In addition, new focused studies were also recommended to answer new questions and/or to test new monitoring approaches. – An initial draft of the workshop report was completed and is due to be released in the 2017/18 fiscal year.
Objective W2: Aquatic Contaminant Source Identification		
Strategy: Develop means of uniquely identifying industrial sources of aquatic contamination		
Uniquely Identifying Industrial Sources of Aquatic Contamination	– Data analysis and publications in peer reviewed journals	– Work with the Rowland lab from the UK (U. Plymouth) has resulted in a new publication on OSPW temporal/spatial variations in acid extractable organics (Frank et al. 2016). – Data required to refine Oil Sands Process Water (OSPW) seepage toolbox for tracking OSPW migrations in groundwater was completed, statistical analyses were initiated.

		– Completed chemometric data-mining of LC/GC-QToF analyses of oil sands samples, resulting in a new short list of unknowns unique to OSPW that will be characterized further using SFC-Orbitrap under a new collaboration with the Martin lab at the U of Alberta. – Method development to improve acid and neutral organic yields has been completed and work with authentic standards as a final phase was initiated to finalize a new preparative extraction method for water soluble bitumen-derived organics from oil sands matrices (Bauer et al. 2017 in prep). This method is being transferred to National Laboratory for Environmental Testing (NLET) for production of NA reference materials and is part of project under S1 below. – A new method for NA quantification was developed and a paper published (Brunswick et al. 2016a), with a subsequent follow up manuscript on a traceable standard (Brunswick et al. 2016b). – A comprehensive manuscript on the toxicology of OSPW extracts and NA mixtures in multiple invert species was compiled and submitted (Bartlett et al. 2017). – A manuscript on parasites in wild fish from the Athabasca was accepted and published (Blanar et al. 2016). – A manuscript on the genetic profiles in walleye embryos incubated with our OSPW extracts was prepared, submitted and published (Marentette et al. 2017). – A new collaboration with Exxon was initiated where they are testing extracts with their models for predicting toxicity. A new manuscript is planned on this work (Redman et al. 2017). – The results from the collaboration with U. Windsor on gamma irradiation as a remediation tool for NAs are in and 2 manuscripts are now planned on this work (Milestone et al. 2017, Weisener et al. 2017).

		– Presentations at COSIA-led workshops on OSPW sampling for reference materials were provided. Manuscripts Completed in 2016-2017 1. Blanar, C., M. Hewitt, M. McMaster, J. Kirk, Z. Wang, W. Norwood and D. Marcogliese. 2016. Parasite community similarity in Athabasca River trout-perch (*Percopsis omiscomaycus*) varies with local-scale land use and sediment hydrocarbons, but not distance or linear gradients. *Parisitol. Res.* **10**: 3853-3866. 2. Frank R.A., Milestone C., Kavanagh R.J., Headley J.V., Rowland S.J., Scarlett A.G., West C.E., Peru K.M. and L.M. Hewitt. 2016. Assessing variability of acid extractable organics within two containments of oil sands process-affected water. *Chemosphere*, **160**: 303-313. 3. Brunswick, P., L.M. Hewitt, R.A. Frank, G. van Aggelen, M. Kim and D. Shang,. 2016. Specificity of high resolution analysis of naphthenic acids in aqueous environmental matrices. *Anal. Methods*. **8**: 6764-6773. 4. Marentette, J.R., K. Sarty, A.M. Cowie, R.A. Frank, L.M. Hewitt, J.L. Parrott, and C.J. Martyniuk. 2017. Molecular responses of Walleye (*Sander vitreus*) embryos to naphthenic acid fraction components extracted from fresh oil sands process-affected water. *Aquat. Toxicol*. **182**: 11-19. 5. Brunswick, P., L.M. Hewitt, R.A. Frank, G. van Aggelen, M. Kim and D. Shang. 2017. A traceable reference for direct comparative assessment of total naphthenic acids concentrations in commercial and acid extractable organic mixtures derived from oil sands process water. *Environ. Sci. Health A*. **52**: 274-280. 6. Bartlett A.J., Frank R.A., Gillis P.L., Parrott J.L Marentette, J., Headley J.V., Peru, K. and Hewitt L.M. 2017. Toxicity of naphthenic acids to invertebrates: Extracts from oil sands process-affected water versus commercial mixtures. *Environ. Poll*. **227**: 271-279.

		7. Vignet C., Frank R.A., Yang, C., Wang, Z.Shires, K., Bree, M., Sullivan, C., Norwood, W.P., Hewitt, L.M., McMaster, M.E. and Parrott J.L. 2017. Long term effects of an early exposure of fathead minnow to oil sands sediments. Part I: survival, deformities and growth. Submitted to *Environmental Pollution*, August 2017. <u>Manuscripts in preparation, data analysis completed.</u> 8. Hewitt, L.M., Roy J.W., Frank, R.A., Bickerton G., Rowland S.J., Scarlett A.G., West, C.E., De Silva A., Headley J.V., Peru K.M., Milestone, C.B., and L. Grapentine. 2018. Analytical methodologies to identify industrially influenced groundwater in the McMurray Formation of northern Alberta, Canada (Expected submission to *Environmental Science and Technology*, 2017). 9. Milestone, C.B, Sun, A., Roy, J.W. Bickerton, G., Martin, J., Frank R.A. and L.M. Hewitt. 2018. Untargeted profiling of bitumen influenced waters and identification of tracers of oil sands processed water (OSPW) migrations in the Athabasca watershed of Alberta Canada. (Expected submission to *Environmental Science and Technology*, 2017). 10. Bauer, A.E., R.A. Frank, J.W. Roy, G. Bickerton, C.B. Milestone, D.G. Dixon and L.M. Hewitt. 2018. A preparative method for the isolation and fractionation of dissolved organics from bitumen-influenced waters. (Expected submission to *Science of the Total Environment*, 2017). 11. Bauer, A.E., R.A. Frank, J.L. Parrott, A. Bartlett, P. Gillis, L.M. Hewitt, L. Deeth, M.D. Rudy, R. Vanderveen, L. Brown, A. Farwell and D.G. Dixon. 2018. Toxicity of aged oil sands process-affected water fractions to a suite of aquatic species. (Expected submission to *Aquatic Toxicology*, 2017). 12. Redman AD, Parkerton TF, Butler JD, Letinski DJ, Frank R, Parrott, J., Bartlett, A., Gillis, P., Hewitt M, Hughes S, Guest R, Bekele A, Morandi G, Martin J, Giesy J. 2018. Application of Target Lipid Model and passive samplers to characterize

		toxicity of organic chemicals in oil sand process water. (Expected submission to *Environmental Toxicology and Chemistry*, 2017). 13. Parrott J.L., J.R. Marentette, L.M. Hewitt, M.E. McMaster, P. Gillis, W.P. Norwood, J.L. Kirk, K.M. Peru, J.V. Headley, Z. Wang, C. Yang and R.A. Frank. 2018. Fathead minnow chronic exposures to snow and freshet from the oil sands region of Alberta. (Expected submission to *Environmental Pollution*, 2017). 14. Bauer, A.E., J.L. Parrott, A. Bartlett, P. Gillis, L.M. Hewitt, L. Deeth, M.D. Rudy, R. Vanderveen, L. Brown, A. Farwell, D.G. Dixon and R.A. Frank. 2017. Assessing the toxicity of groundwater proximate and distal to a tailings pond to a suite of aquatic species. (Expected submission to *Aquatic Toxicology*, 2017). 15. Frank, R.A., A.E. Bauer, J.V. Headley, S.J. Rowland, A. Scarlett, C.E. West, K. Peru, D.G. Dixon and L.M. Hewitt. 2018. Chemical analyses of groundwater fractions proximate and distal to a tailings pond. (Expected submission to *Environmental Toxicology and Chemistry*, 2017).
Objective W3: Integration and Synthesis		
Strategy: Integrate all monitoring and study results to establish multiple lines of evidence and to identify and resolve any apparent differences		
Data Integration, Synthesis, and reporting	– Water Monitoring Synthesis Reports	Synthesis reports on aerial deposition, tributary water quality, groundwater, regional modelling, benthos and fish health completed and sent for external review. It is anticipated that these reports will be made available to the public in early 2018.
Synthesis and Interpretation of Tributary Water Quality and of Groundwater/Surface Water interactions	– Water Monitoring Synthesis Reports	*Groundwater* – *Assessing Risks of Shallow Riparian Groundwater Quality Near an Oil Sands Tailings Pond* published in the July-August 2016 (Vol. 54 No. 4) edition of the journal Groundwater (Roy et al. 2016)

		– Final draft version of synthesis report, *Assessments of Groundwater Influence on Select* River *Systems in the Oil Sands Region of Alberta*, submitted for external review on Aug 29, 2016. – External review returned April 21, 2017. Revised version in progress. – A separate manuscript on source attribution techniques validated on a known OSPW groundwater plume is no longer planned. This data is now being included in a more encompassing method validation study (i.e. manuscript 8. in Objective W2: Aquatic Contaminant Source Identification preparation by Hewitt et al.) Surface Water: – Alexander A.C., Chambers P.A., & Jeffries D.S . 2017. Episodic acidification of 5 rivers in Canada's oil sands during snowmelt: a 25-year record. *Science of the Total Environment 599-600: 739-749.* – 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 24: 484-494.* – Chambers P.A., Alexander A.C., Kirk J., Manzano C. Cooke C. & Hazewinkel R. (in press) Surface water quality of tributaries to the lower Athabasca River. A synthesis report prepared for the Canada-Alberta Joint Oil Sands Monitoring Plan
Establishing a data management system for watershed data	– Assessment and compilation of key pre- and post JOSM environmental monitoring data and other required watershed data sets.	– All the pre- and post- JOSM water quality, hydrology and climate data has been compiled[3]. A preliminary assessment of data has been completed to validate data quality and completeness, and identify gaps. This data is currently available through the Regional Aquatic Monitoring Program website. The process of transferring all RAMP (pre and Post

[3] Currently all these data are available through the Regional Aquatic Monitoring Program (RAMP) website. The process of transferring all data from RAMP (pre and Post JOSM) to the AEP Kisters data system has begun; it is envisaged that this work will be completed by March 2018.

	– Analysis of environmental data to identify trends, patterns and "hot spots".	JOSM) to the AEP Kisters Data System has been initiated and is expected to be completed by March 2018. – A customized "R" program has been developed for data visualization and analysis. Using the developed "R" program, a thorough statistical analysis has been completed. More advanced data analysis (e.g. machine learning) as well as results interpretation and reporting work will continue in next fiscal year.

Biotic Response Monitoring

Objective B1: Detect and report biotic response in relation to Oil Sands Developments		
Strategy: Assess the status and trends of ecological effects of physical landscape disturbance and contaminants from oil sands developments on terrestrial ecosystem structure and function		
Oil Sands Monitoring Activities	**Key Targets**	**Outcomes**
Core Biodiversity Monitoring	– Trend monitoring of species, habitats and human footprint indicators in the OSM region; – Correlative and causative inference between land-use, species and habitat; – Baseline information on biodiversity, habitat, and footprint used to support regional and sub-regional planning, policy and management; – Oil Sands monitoring is fully integrated with oil sands monitoring across Alberta; – Close integration with existing provincial monitoring programs; – Augments to monitoring systems to address unique regional and sub-regional knowledge requirements; – Compliant with a suite of recommendations arising from the provincial and federal governments and Royal	– Trend monitoring of species is ongoing. Estimates of temporal change for species in the Oil Sands region are presently being determined, with results updated each year based on information collected during the previous year. Reliable estimates of trend are expected by 2020 for common species that have high detectability and low inter-annual variability. For species that are less common, have moderate detectability, and have moderate inter-annual variability, reliable estimates of trend are expected after the third round of surveys are completed at Oil Sands sites (completion in the eastern Oil Sands region is anticipated by 2025). For rare species, and species with high inter-annual variability, additional monitoring cycles will be required to determine reliable estimates of trend. – Trend monitoring of human footprint is also ongoing. Between 1999 and 2015, the total human footprint in the Athabasca Oil Sands Area increased by 3.7% (from 4.8% to 8.4%). This change was mainly due to the creation of new forestry footprint (+2.0%) and energy footprint (+0.9%). – Correlative and causative inference between land-use, species and habitat were made from models of species habitat relationships. Field and geospatial data from 2015-16, and updated models of species habitat relationships, were uploaded to a public website (www.abmi.ca) – Baseline information on biodiversity, habitat, and footprint was acquired. Field data were acquired from 91 sites in the provincial (20 km systematic grid) network in the OSM region using standard biodiversity monitoring protocols. In addition, 1:15,000 human footprint data across the Oil Sands Region (2014 conditions) were acquired, updated and enhanced. Finally, 1:5:000 land cover data

	Society of Canada reports on oil sands monitoring; – Integrated with legislative requirements associated with the Environmental Protection and Enhancement Act; – Enhancements in vegetation and human footprint monitoring.	from 38 3x7 km sites on the provincial network in the OSM region.
Core Ungulate Monitoring	– Estimate the population trends of moose and deer within the oil sands region	– Completed surveys to estimate the population of moose and deer in 5 of 7 planned Wildlife Management Units (WMU 502, 514, 516, 540, and 544) within the oil sands region. Surveys in two WMUs (516, 544) were deferred to 2017-18 due to unsuitable weather conditions. – Uploaded survey reports to a public website (aep.alberta.ca/fish-wildlife/fishing-hunting-trapping/aerial-wildlife-survey-reports.aspx)
Effects-based Assessment -Land Birds	– Revisit sites to gather additional data on old-forest specialists. – Re-evaluate the ability of existing efforts to assess status and trend for species of concern.	– Completed ARU-based point-count surveys at sites targeting old-forest specialists. – Completed a report assessing how changes in ABMI sampling design and methods influenced the statistical power to detect changes in population trends with emphasis on listed, rare and difficult-to-monitor species. For most species, power to detect trend under the new protocol was similar to the previous protocol. Power under the new protocol was increased for some species with higher detection rates. However, old-forest species still require supplemental monitoring off the ABMI core grid to adequately estimate trend. A potential bias in trend estimation warrants further study. • Toms, J.D. 2017. The impact of changes in survey methods and design on the ability to detect trends in landbird populations within the oil sands areas and the need for supplemental monitoring programs. Phase 1: Power analysis. Environment and Climate Change Canada. Available by request. – Completed a draft manuscript comparing the models. • Leston, L., E. Bayne, C.L. Mahon, P. Solymos, J. Ball, J. Schieck, F. Schmiegelow and S. Song. 2016. Comparing and Contrasting Different Assessments of Cumulative Forestry

	– Compared three existing models of landbird responses. – Continue efforts to integrate automated recording unit data into landbird models. Use targeted studies to understand landbird responses to physical disturbance.	and Energy Sector Effects on Boreal Birds. – Assessed technical differences between bird surveys conducted by Automated Recording Units (ARU) and human observers. Also evaluated the effect of multiple visits to survey points on status and trend estimation. Developed approaches to standardize data from ARUs and human observers. • Shonfield, J. and E. M. Bayne. 2016. *Autonomous recording units in avian ecological research: current use and future applications.* Avian Conservation and Ecology 12:14. https://doi.org/10.5751/ACE-00974-120114 • Bayne, E., M. Knaggs, and P. Solymosl. 2017. *How to Most Effectively Use Autonomous Recording Units When Data are Processed by Human Listeners.* Report published by University of Alberta and Alberta Biodiversity Monitoring Institute. http://ftp.public.abmi.ca/home/publications/documents/489_Bayne_etal_2017_EffectiveUseofARUsandHumanDataProcessing_ABMI.pdf • Yip, D.A., E.M. Bayne, P. Solymos, J. Campbell and D. Proppe. 2017. *Sound attenuation in forest and roadside environments: Implications for avian point-count surveys.* Condor 119:73-84. https://doi.org/10.1650/CONDOR-16-93.1 • Yip, D. A., L. Leston, E. M. Bayne, P. Sólymos, and A. Grover. 2017. *Experimentally derived detection distances from audio recordings and human observers enable integrated analysis of point count data.* Avian Conservation and Ecology 12(1):11. https://doi.org/10.5751/ACE-00997-120111 – An assessment of the impacts of energy-sector disturbances on landbirds within young forests, as well as the evaluation of the effect of vegetation regrowth on reclaimed well pads on landbird response was conducted as part of this work. Results indicate that all landbird species associated with young forests avoided non-vegetated disturbances but individuals were less likely to avoid or began to use

	– Targeted studies of behavioural responses of landbirds to specific oil sands features using spot-mapping and sound triangulation	disturbed areas once vegetation within disturbances regenerated to shrub and tree-dominated phases. • Wilson, S. 2017. Use of an Acoustic Location System to Understand Songbird Response to Vegetation Regeneration on Reclaimed Wellsites in the Boreal Forest of Alberta. M.Sc. thesis, University of Alberta, Edmonton. • Toms, J.D., and T. Carpenter. 2017. Community and species-level responses to energy-sector disturbances within regenerating forests: preliminary results, 2016 field season. Environment and Climate Change Canada. Available by request.
	Additional work: Evaluate how estimates of landbird response to energy sector-related development changes with the spatial scale of assessment	– Abundance of six lowland-associated landbird species was modelled as a function of landcover structure and area, area of disturbance, and distance to disturbance at lease and regional scales. At the larger regional scale, variation in abundance was best explained by landscape context, with disturbance improving model fit for two of six species. At the smaller lease scale, variation in abundance was best explained by forest stand height, with disturbance improving model fit for four of six species. Preliminary recommendations include evaluating the effects of development at multiple scales to better describe impacts on landbird populations. Our ongoing “Big Grid” program is assessing impacts at multiple spatial scales by surveying birds across entire SAGD leases. • Mahon, C.L. G.L. Holloway, T. Carpenter, T. Mahon and J. Keim. Assessing impacts of Steam Assisted Gravity Drainage (SAGD) disturbance on lowland boreal landbirds using regional and lease data within the Athabasca Oil Sands Area in Northern Alberta, Canada. Environment and Climate Change Canada. Available by request. – Addressed the challenges of estimating large-scale impacts from local-scale studies. Results from this work highlight the need for more intensified sampling at larger scales around SAGD and mine facilities. • Bayne, E., L. Leston, C.L. Mahon, P. Solymos, C. Machtans, H. Lankau, J.R. Ball, S.L. Van Wilgenburg, S.G. Cumming, P. Fontaine, F.K.A. Schmiegelow, and S.J. Song. 2016. Boreal bird abundance estimates within different energy sector

	– Additional publications completed	disturbances vary with point count radius. Condor 118:376-390. https://doi.org/10.1650/CONDOR-15-126.1 • Mahon, C.L., G. Holloway, P. Solymos, S.G. Cumming, E.M. Bayne, F.K.A. Schmiegelow and S.J. Song. 2016. Community structure and niche characteristics of upland and lowland western boreal birds at multiple spatial scales. Forest Ecology and Management 361:99-116. https://doi.org/10.1016/j.foreco.2015.11.007 • Lankau, H, E. Bayne, S. Morrison, D. Farr and A. MacPhail. 2016. Developing Standard Methods for Bioacoustic Data Collection and Processing. Report published by University of Alberta and Alberta Biodiversity Monitoring Institute. http://bioacoustic.abmi.ca/wp-content/uploads/2016/03/Morrison_POSTER.pdf All publications and reports are either available from the journal and/or at http://bioacoustic.abmi.ca/resources/reports/ or http://ace-lab.org/3G/publications.php.
Effects-based Assessment -Rare Plants	– Assess persistence of rare plant populations in the oil sands region by re-visiting historical locations. – Predict rare plant occurrence at the scale of individual energy leases using LiDAR-based terrain and vegetation metrics – Evaluate the success of translocation (effectiveness monitoring) as a viable approach to mitigate the impacts of oil sands development on rare plants – Assist with updates on rare plant status via the Alberta	– Completed a summary report: Nielsen, S.E., Dennett, J., Denny, C., Kohler, M. & Farr, D. 2017. *Terrestrial vascular plant monitoring project for the Lower Athabasca (2012-2016)*, 166 pages) that included the following key findings: – Field observations indicated approximately 30% of historic rare plant populations had been extirpated and that the likelihood of persistence declined with increasing proximity to disturbance. These findings suggest re-visitation surveys in disturbed landscapes such as the oil sands area should be encouraged to both improve the accuracy of the provincial rare plant database and to understand how oil and gas-related activities may threaten plant populations. Source: Dennett, Kohler, Farr and Nielsen. 2017. *Persistence of historic rare vascular plant populations in the oil sands region of Alberta*. Pp. 80-91. – Vascular plant data from 283 quarter-hectare (50 m × 50 m) plots in the Oil Sands Region was used to evaluate the potential for Airborne Laser Scanning-derived metrics to explain species richness patterns for vascular plants, as well as for four growth forms: herbaceous

	Conservation Information Management System – Complete an implementation plan for regional rare plant monitoring that supports both regulatory and ambient monitoring requirements	(including forbs and graminoids) and woody plants. Laser-derived canopy height was found to be the most consistent and important factor positively related to local patterns in vascular plant richness. Multivariate regression models of laser-derived metrics explained 20% to 35% of the variation in species richness among vascular plant and the four subclasses. When considering the current distribution of in-situ oil sands leases in the region, vascular plant richness inside of the leases are higher than those outside of the leases. Areas delineated for woodland caribou conservation had lower average plant richness suggesting that caribou conservation will do little to protect hotspots of plant diversity in Alberta's boreal forest. Results highlight the value of using fine-scale measures of laser-derived vegetation structure to explain, predict, and potentially monitor local plant diversity for a high latitude forested ecosystem. Source: Mao et al. 2017. *Using airborne laser scanning to predict plant species richness and assess conservation threats in the oil sands region of Alberta's boreal forest*. Pp. 28-55. – Experimental translocations in the oil sands region were used to evaluate mitigative translocation as a conservation tool and to inform future mitigation efforts. Results indicate high transplant survival for two fen species and little variation between recipient sites despite differences in major nutrients. *Sarracenia purpurea* transplants had consistent high survival and flowering rates, while *Carex oligosperma* transplants had reduced growth and survival. Translocations are most often conducted under time and logistical constraints and may be most effective if employed on species known to have broad environmental tolerances. Source: Dennett and Nielsen. 2017. *Evaluating translocation of rare species in peatlands as a mitigation technique*. Pp. 69-79. – An implementation plan for regional rare plant monitoring that supports both regulatory and ambient monitoring requirements was not completed. Additional input from regulators is required to understand the regulatory requirements related to the occurrence and persistence of rare plant populations.

DNA Methods for Boreal Caribou	– Trial sight-resight methods for determining caribou population size and composition estimates through the collection of caribou fecal pellet samples. – Partner with Trent University's Natural Resources DNA Profiling and Forensic Centre (NRDPFC) to perform genetic analysis. – Estimate caribou population size and structure within the caribou populations that overlap the oil sands region.	– Completed sight-resight surveys in the Red Earth caribou range. 1,800 fecal pellet samples were collected from 209 sites from January to March, 2017. – Trent University continues to perform the genetic analysis for this project through a grant issued with AEP. – Sample processing, genetic analysis, and reporting for determining the Red Earth population size and structure is ongoing at Trent University.
Wildlife Contaminants and Toxicology	– Analysis of Gull and Tern eggs – Analysis of hunter and trapper harvested samples	– Eggs were collected and analysed from Egg Island (Lake Athabasca) and from Mamawi Lake in Wood Buffalo National Park. Eggs were not collected from sites near Fort McMurray because the nesting sites were impossible to access as a result of the Fort McMurray wildfire. However, additional eggs were collected from other sites farther removed from Fort McMurray where access to nesting sites was possible. All eggs were processed and samples distributed to analytical laboratories for required analyses. For instance, stable nitrogen isotopes in individual eggs were analyzed at the University of Ottawa and amino acid-compound specific nitrogen isotope analysis was completed on selected pooled egg samples at the University of Hawaii. Prey fish, collected to examine contamination of bird diet, were processed: prey fish samples collected during 2013-2015 from locations on the Athabasca River (4 sites) downstream to the Peace-Athabasca Delta/Lake Athabasca (5 sites) were sorted according to species and species-specific samples and processed for mercury and stable isotope analyses. Hunter and trapper harvested wildlife samples were successfully collected during the 2016/17 trapping season from registered fur management areas located inside and outside the oil sands surface mineable region. Furbearer carcasses were subsequently dissected and samples were prepared and submitted for the analysis of contaminants of concern, specifically metals, including mercury, and polycyclic aromatic compounds

	– Develop Synthesis Report	(PACs). The analysis of fisher and American marten carcasses revealed detectable levels of rodenticides; results are published in the Journal of Biological Conservation (Thomas, et al., 2017). Three years of otter population genetics data from 2 trap lines (one north of Lac La Biche, the other in Fort McMurray) were analysed and the methods developed published in the European Journal of Wildlife Research. Population structuring data were also presented to stakeholders, including at the Oil Sands Science Symposium which was held in Calgary in November 2016. – An approach to completing the synthesis report for wildlife health has been developed. The synthesis report will serve to compile and assess all of the data generated during the JOSM wildlife contaminants and toxicology program and provide recommendations for further activities. The approach to the data assessment has been summarized and has been presented in several fora as a "peer-review" of the approach being proposed. Input and comments from this process are being incorporated for the development of a revised and final approach for the completion of the synthesis report.
Forest Health Monitoring	– Conduct insect and disease survey at Forest Health sites – Complete detailed TEEM (deposition) data discovery and cataloguing exercise	– The annual insect and disease survey was conducted at all Jack Pine interior and exterior forest health sites. Insects, disease and drought conditions are confounders when assessing the impact of atmospheric deposition on forest function. Also, site maintenance was conducted at all sites in 2016-2017. This included improving security at several sites to prevent damage caused by local wildlife.
Strategy: Assess the status and trends of ecological effects of physical landscape disturbance and contaminants from oil sands developments on aquatic ecosystem structure and function		
Monitoring Benthic Macro-Invertebrates in Rivers and Tributaries	– Data collection, analysis and reporting on Benthic Macro Invertebrates	SAMPLING CONDUCTED Mainstem Athabasca River The nine core cobble sites (M0, M1, M2, M3, M3B, M4, M6, M8 and M9) were sampled with 5 replicate samples taken per reach. In addition, two reference sites were added (M1A and M2A) to better resolve confounding effects. The performance of these new sites is currently being assessed. Samples collected:

		• Benthic invertebrate samples (55 samples analyzed as for 2012-2015 FY JOSM assessment) • Water quality / YSI grab samples (as per 2012-2015 FY JOSM) • Sediment quality grab samples (as per 2012-2015 FY JOSM) • SPMD samples (August-September sampling at the 9 core reaches as per 2013-2015 FY JOSM data, plus the 2 new sites that were used) Tributaries – Athabasca and Birch Mountains and Peace River A total of 61 erosional tributary locations were sampled in the OS Minable Area, Birch Mountains and Peace River areas in 2016/17 as described below. • In tributaries of the Athabasca River 18 core reference sites and 21 core test sites in catchments with a high proportion of disturbance. These included, 7 new sites which were established to address spatial gaps for reference and test areas • In the Birch Mountains area 17 reference sites were sampled including 6 new sites, bringing the total of established sites in the area up to 26. • 5 new sites in the Peace River catchment were established along with additional reconnaissance of potential sites. Samples collected: • Benthic invertebrate samples (61 samples analyzed as for 2012-2015 FY JOSM assessment) • Water quality / YSI grab samples (as per 2012-2015 FY JOSM) • Sediment quality grab samples (as per 2012-2015 FY JOSM) • SPMD samples (August-September sampling at 25 reaches as per 2013-2015 FY JOSM data) Presentations Given: 1) R.B., Brua, J.M. Culp, D.J. Baird, N.E. Glozier, M.E. McMaster, J.L. Parrott, C.J. Bennett, R. Casey, C.B. Choung, T. Clark, C.J. Curry, M. Evans, R.A. Frank, D. Halliwell, E. Keet, H. Keith, B. Kilgour, J. Kirk, J. Ings, J. Lento, E. Luiker, D.L. Peters, A.L. Ritcey, C. Suzanne , G.R. Tetreault, F. J. Wrona. 2017.

		Assessment of biological condition: Lower Athabasca River tributaries and mainstem. CABIN Science Forum, 28 February-1 March 2017. Edmonton, Alberta, Canada. 2) R.B., Brua, J.M. Culp, E. Luiker, N.E. Glozier, and D. Halliwell. 2017. *Habitat-specific effects of taxonomic sufficiency on detecting environmental change in larger rivers.* CABIN Science Forum, 28 February – 1 March 2017, Edmonton, Alberta, Canada. 3) J.M. Culp, D.J. Baird, N.E. Glozier, M.E. McMaster, J.L. Parrott, R.B. Brua, C.J. Bennett, R. Casey, C.B. Choung, T. Clark, C.J. Curry, M. Evans, R.A. Frank, D. Halliwell, E. Keet, H. Keith, B. Kilgour, J. Kirk, J. Ings, J. Lento, E. Luiker, D.L. Peters, A.L. Ritcey, C. Suzanne , G.R. Tetreault, F. J. Wrona. 2016. *Assessment of biological condition: Lower Athabasca River tributaries and mainstem*. Oil Sands Science Forum, November 2016. Calgary, Alberta, Canada 4) N.E. Glozier and A. Ritcey. *Patterns in Stream Invertebrate Communities in Reference Areas within the Alberta Oil Sands Region*. Society of Freshwater Science, Annual Meeting Sacramento California, May 2016 5) N.E. Glozier, A. Ritcey, E. Keet, J. Maines, L. Levesque, L. Dirk, C-L Epp. *Patterns of Stream Invertebrate Communities in Reference Areas within the Alberta Oil Sands Region*. CABIN Science Forum, 28 February-1 March 2017. Edmonton, Alberta, Canada. Reports Produced 1) Culp, J.M., N.E. Glozier, D.J. Baird, F. J. Wrona, R.B. Brua, A.L. Ritcey, D.L. Peters, R. Casey, C.B. Choung, C.J. Curry, D. Halliwell, E. Keet, B. Kilgour, J. Kirk, J. Lento, E. Luiker, and C. Suzanne. (in press). Assessing ecosystem health in benthic macroinvertebrate assemblages of the Athabasca River main stem, tributaries and Peace-Athabasca Delta. A synthesis report prepared for the Canada-Alberta Joint Oil Sands Monitoring Plan. <u>Manuscripts in preparation</u>

		1) Culp, J.M., R.B. Brua, E. Luiker, and D. Halliwell. 2018. Ecological causal assessment of benthic condition in the oil sands region, Athabasca River, Canada. Expected submission in early 2018 Science of the Total Environment. 2) Brua, R.B., J.M. Culp, E. Luiker. 2018. Habitat-specific effects of taxonomic sufficiency on detecting environmental change in larger rivers. Expected submission in mid-2018 Hydrobiologia
Peace-Athabasca Delta Ecosystem Health Study	– Collect baseline data and generate model for effects assessment in the Peace Athabasca Delta	– We continued analysis of newly acquired hydrological/geophysical data to support baseline models for effects assessment. – Newly acquired hydrological information were incorporated into i) assessments of elevation/connectivity of monitored wetlands, ii) initial development of relevant hydrological indicators, iii) effects assessment models and iii) manuscripts in progress. – Baseline data was collected at 24 wetland sites in the Peace-Athabasca Delta, comprising water quality (including contaminants and mercury), macroinvertebrates and algae to support biomonitoring model development. – Completed report on ecological risk assessment from sediment-borne contaminants. It is anticipated that the report will be publicly available in 2018.
Monitoring Fish Health and Community	– Develop a science-based framework for the monitoring and assessment of the environmental health of the AOSR through the use of fish health assessments, fish assemblage monitoring, and contaminants levels – Collection of baseline information on fish populations/communities – Establish linkages between fish health and benthic invertebrates within the oil sands development region and	– Members of the Fish Subgroup met twice in 2016 to develop a science based strategic plan for fish monitoring in the oil sands that was divided into Long Term Monitoring, Focused Studies and Baseline Monitoring. This program integrated the existing JOSMP fish health program with parts of the earlier RAMP fish assemblage and community monitoring program. Details were examined to expand our current fish contaminants program and to integrate where possible the fish program with community led monitoring initiatives being developed. – All the planned wild fish health and tissue contaminants related monitoring was completed in Athabasca main stem (six reaches along the Athabasca River) and tributaries (18 tributary reaches). Ageing structures were analysed and liver samples were shipped to ECCC for laboratory analysis. – All the planned fish community monitoring was completed as

	downstream receiving environments – Publication on fish liver tumor assessment.	identified in work plan. All the data entry and QA/QC activities for the fish community monitoring component were completed. Data collected for the fish community monitoring component were uploaded to AEP's Fisheries and Wildlife Management Information System (FWMIS). – All the AEP QA/QC fish data are available through RAMP website: http://www.ramp-alberta.org/data/Fisheries/default.aspx – All fish health baseline monitoring on the Peace River was completed at the five locations identified. Samples for estimating exposure were completed and samples for contaminants were submitted and analysis received. Fish health data input and evaluation is ongoing. A publication from the fish health work to date (see below) is now available. Blanar, C., M. Hewitt, M. McMaster, J. Kirk, Z. Wang, W. Norwood and D. Marcogliese. 2016. *Parasite community similarity in Athabasca River trout-perch (Percopsis omiscomaycus) varies with local-scale land use and sediment hydrocarbons, but not distance or linear gradients*. Parisitol. Res. 10: 3853-3866. As part of the reporting for the 2012-2015 JOSMP program, a number of reports are being prepared. A Fish Health and Toxicology report has been completed and is with drafting for final formatting. Similar reports were created for the Benthic programs as part of JOSMP and a final report integrating all aspects of the program including Fish Health and Benthic communities has been prepared. These documents are set to be released in late 2017. – Liver tumor assessments have been conducted on white sucker within the Athabasca River over the 3 years of baseline fish health collections. Assessment of liver tumor presence was then conducted with community involvement in Lake Athabasca in the fall of 2015. Liver tumors from this assessment have just returned from the final histological assessment by Dr. Gary Marty of the BC Ministry of Agriculture and data are now being prepared for publication.
Objective B2: Investigate the causal mechanisms of a known important biotic relationship in relation to Oil Sands Developments		
Strategy: A hypothesis-driven focused study to respond to evidence of a known important biotic change		

Whooping Crane Study	– Monitor behaviour and habitat use of whooping cranes during spring and fall migration through the oil sands region (OSR) – Monitor juvenile survival during fall migration through the oil sands region (OSR)	– Monitored 10 whooping cranes previously marked with satellite telemetry devices: 10 during spring migration (Apr-May) and nine during fall migration (Aug-Nov). Preliminary results from 2010 to present indicate most of the oil sands region (OSR) and all of the mineable oil sands area (MOSA) are contained within the whooping crane migration corridor; that density of whooping crane locations can be high within the OSR and the MOSA, especially in spring when cranes may be at higher risk of landing on tailings ponds during inclement weather; that cranes can be in the OSR as early as 16 April and as late as 1 November; that almost all cranes migrate through the OSR, most migrate through the MOSA, and a smaller number land or stop over for one or two nights including at industrial sites such as tailings ponds. During stopovers in the OSR, cranes select locations with more wetlands and with less anthropogenically-modified habitat. – Re-sighted 31 individual whooping cranes previously marked with coloured leg bands: 12 re-sighted during nesting surveys in May, 17 re-sighted during fledging surveys in Aug in and near Wood Buffalo National Park, north of the OSR, and 24 re-sighted during staging surveys in Sept-Nov in Saskatchewan, south of the OSR. We used these data to estimate apparent juvenile survival during the period of fall migration, including migration through the OSR. All banded adult cranes observed with chicks in Aug were later observed with chicks in Sept-Nov, so apparent survival during this period was 100%. This outcome is consistent with data collected since 2014 that indicates survival of juvenile cranes during this period is high. – Bidwell, M., J. Conkin, and J. Rempel. 2016. *Monitoring of Whooping Cranes during Migration through the Oil Sands Region.* Annual Operational Report for 2016-17. Available by request from Environment and Climate Change Canada.

Wetland Ecosystem Monitoring		
Objective WE1: Detect and report changes in wetland ecosystem in relation to Oil Sands Developments and related Point and Non-point source emissions		
Strategy: Assess the ecological effects of physical landscape disturbance and contaminants from oil sands developments on wetland ecosystem structure and function		
Oil Sands Monitoring Activities	Key Targets	Outcomes
Wetland Condition and Biodiversity	– Estimate the status and trend of Yellow Rails and Canadian Toad, by monitoring at targeted wetland sites to understand the potential impacts of oil sands development on these species at risk. – Assess the impacts of industrial development on wetland species by monitoring before and after oil sands development to assess industrial impacts. – Develop an Implementation plan for long-term monitoring of wetland species in the oil sands region.	Key findings are summarized as follows: – Passive acoustic monitoring with autonomous recording units were used to maximize detections of uncommon and common species of Canadian toads (*Anaxyrus hemiophrys*) and boreal chorus frogs *Pseudacris maculata*. We found that the presence of Canadian Toads is associated with fen wetland and upland edge habitat, along with the occurrence of coarser soils that allow toads to dig below the frost line during winter months. A positive relationship between presence and the proximity of roads was seen in the model, indicating that suitable habitat for toads exists near roads. Our model of Canadian Toad distribution had good predictive capacity and accuracy, and would be an effective tool for locating additional breeding locations for this species of concern. Source: Annich, N. 2017. *Use of bioacoustic technology to evaluate habitat use and road effects on two anuran amphibians in the boreal region of northeastern Alberta*. M.Sc. Thesis, University of Alberta. Available http://bioacoustic.abmi.ca – Detections of Common Nighthawk (*Chordeiles minor*), were extracted from a large bioacoustic database using automated signal recognition software. We found that home range selection was primarily explained by landscape scale geographic and climate variables and some avoidance of wetland areas. Territory selection was also strongly influenced by landscape scale climate variables, proportion of seismic lines, and areas with minimal poor fen. Our findings provide wildlife managers with guidance on where Common Nighthawks may be found in the boreal forest during the breeding season, with selection for cold, dry, northern landscapes, pine forests, and avoidance of wetland areas which is contrary to results for other biomes. Source: Knight, E. and E. Bayne. 2017. Habitat selection at different scales for a declining

		aerial insectivorous bird as determined by autonomous recording technology. Available http://bioacoustic.abmi.ca – An Implementation plan for long-term monitoring of wetland species in the oil sands region was not completed. However, we completed a review of acoustic recording as an emerging technology to monitor vocalizing species in wetlands and other environments. Acoustic recorders enable researchers to do more repeat visits with less time spent in the field, with the added benefits of a permanent record of the data collected and reduced observer bias. They are useful in remote locations and for targeting rare species. Drawbacks of acoustic recorders include the cost of equipment, storage of recordings, loss of data if units fail, and potential sampling trade-offs in spatial vs. temporal coverage. ARUs generate large data sets of audio recordings, but advances in automated species recognition and acoustic processing techniques are contributing to make the processing time manageable. ARUs have the potential to make significant advances in avian ecological research and to be used in more innovative ways than simply as a substitute for a human observer in the field. Source: Shonfield, J., and E. M. Bayne. 2017. Autonomous recording units in avian ecological research: current use and future applications. Avian Conservation and Ecology 12(1):14. – A wetland scientist was identified and recruited to lead the Oil Sands Wetlands Monitoring Program. The key accomplishment of the program area for 2016-17 was the development of an integrated wetlands monitoring plan for the oil sands region.
Waterfowl Effects-based Assessment	– Enhance science-based monitoring of waterfowl pair abundance and productivity by developing a better understanding of which stressors should be monitored and where breeding waterfowl populations may be most vulnerable to development	– A total of 46 unique plots were surveyed twice over two quarters and satellite imagery was acquired for all plots. Satellite imagery was used to calculate density of and distance to linear features within each plot for data analyses. – The report on field activities and preliminary analyses of 2013-2016 data was completed in March 2017. Preliminary analyses suggest that although pair counts increased in areas with higher linear feature density (i.e. roads and seismic lines) for some nesting guilds, cavity and upland nesting species may have lower

	– Provide benchmarks for interpreting future monitoring results – Permit assessment of both changes in relationships between waterfowl populations and energy sector development, and more clear identification of in situ development effects	productivity in these areas. – All field data from the 2016 surveys have been transcribed into our digital database and archived at Ducks Unlimited. We have also retained hard copies of data. These data have been proofed to assure accuracy during data collection and transcription. – Preliminary analyses suggest that the strongest potential cause and effect relationship exists between increased seismic line density and decreased waterfowl productivity. Early results were less robust for other linear features. This pattern is most consistent with a top-down, predation hypothesis. Overall, our work suggests that to be most effective, a waterfowl monitoring program in the OSA should assess both pair abundance and productivity.
Amphibian and Wetland Health	– Provide an assessment of the exposure and effects of chemicals of concern in sentinel wildlife species – Establish long-term program for monitoring wetland health in the region to assist in the monitoring of potential oil sands environmental impacts.	– For an assessment of the exposure and effects of chemicals of concern in the sentinel wildlife species being used in the amphibian and wetland health project, samples of wood frog tadpoles from seven wetland study sites (a reduced number because of the Fort McMurray wildfires) were pooled, processed and analysed for chemicals of concern by both ECCC and commercial laboratories. In addition, for an assessment of potential exposure and effects, 30 samples from semi-permeable membrane devices deployed in study ponds were analysed for polycyclic aromatic compounds and extracts made available for toxicity assessments and for the examination and development of a biomarker of exposure for wood frogs exposed to oil sands chemicals of concern. – Discussions with partners and stakeholders took place over 2016-17 to establish the mechanism and process by which a long-term program for monitoring wetland health in the region could be established. This commenced with the establishment of working group that was tasked with gathering information to first conduct a needs assessment, and then to produce a proposed design for a long-term program for monitoring wetland health in the region. A work plan was developed in 2016-17 so that this process could be effectively conducted over 2017-18. This included the identification of the necessary scientific support for study planning and

		coordination, of a process for "peer review" of the proposed design, and a means of establishing support for the eventual implementation of the proposed long-term monitoring program for wetlands in the region.

Indigenous Monitoring Program

Objective F1: Potential Impacts on Ecosystem Components Valued by Indigenous communities		
Strategy: Quantify the types and amounts of impacts on ecosystem components valued by Indigenous Communities.		
Oil Sands Monitoring Activities	Key Targets	Outcomes
Community Led Fish Monitoring	– Identify contractor for community led monitoring development. – Initiate collection of fish for community based monitoring program. Initiate F5 Evaluating a possible fishery effect in Lake Athabasca on white sucker and walleye spawning migrations and size distribution in the mainstem Athabasca. – Complete collection of fish for program. – Review field data, data evaluation and reporting.	– Initiated discussions with Indigenous communities in the three oil sands regions (Peace River, Athabasca, Cold Lake regions) to confirm interest in participating in a community-led fish health pilot project. – Cold Lake First Nation (CLFN) confirmed as project partner; CLFN established a community-led steering committee to guide the work, and began working with Alberta Environment and Parks scientific staff on a fish monitoring design. – University of Saskatchewan confirmed as collaborator in development of community-led monitoring project. U of S completed an inventory of provincial, national and international Community Based Monitoring Programs (CBMP). These CBMPs are being mapped and geo-referenced for point and click access. Pertinent information includes: Program description, funding source, target area (e.g., fish, water), contact information, related publications.
Real-time water quality Monitoring - Lake Athabasca	– Collect real-time water quality monitoring data in Lake Athabasca	Project was not implemented in 2016-2017
Enhanced Ground based Monitoring to understand sources, process and impacts - Oski-ôtin monitoring site	*See Atmospheric (Monitoring to Understand Atmospheric Sources Process and Impacts Oski-ôtin Monitoring Site)	*See Atmospheric (Monitoring to Understand Atmospheric Sources Process and Impacts Oski-ôtin Monitoring Site)
TEK Berry Health	– Evaluate the quality and availability of berries and validate findings with Elders/Focus Group – Produce report	– Fort McKay First Nation completed their fourth year of monitoring at select sites in the Fort McMurray area. – The field season was cut short as a result of the Fort McMurray fires and the community expressed concerns about the impacts of the fire.

		– In November, the Fort McKay Elders Focus Group met to discuss the results and plan for the 2017-2018 season. Findings of this year of monitoring were consistent with years prior. – At the fall meeting, the group agreed to share their methodology with other communities in the Fort McMurray area to potentially expand the project. – Discussions with additional communities began in the latter part of 2016.
Indigenous Monitoring and Science Coordination	– Establish an Indigenous Monitoring and Science Program – Building Indigenous capacity and relationships through training activities.	– Efforts in 2016/2017 focused on initiating small scale projects to pilot collaborative approaches to monitoring that address local Indigenous community concerns and interests. – Pilot project initiated on fish health (*See Community Led Fish Monitoring) – Five-week training program completed. Nine individuals from eight First Nation and Métis communities participated. – A workshop was held in March to gather communities in the Athabasca region to talk about the importance of wetlands and begin the development of a wetlands monitoring program. An historical scan of engagement efforts in the Oil Sands was partially completed in 2016/17. Work on this scan will continue in 2017/18.

Standards, Quality Assurance/Quality Control, Data Management		
Objective S1: Inventory existing field and laboratory-based standard operating procedures for monitoring data acquisition and analyses		
Strategy: Implement a randomized standard trial approach to ensure consistent QA/QC programs		
Oil Sands Monitoring Activities	Key Targets	Outcomes
Inventory Existing Standard Operating Procedures and Validation of their Application	– Establish program wide Standard Operating Procedures (SOPs) Inventories for Oil Sands Monitoring. – Implement uniform Quality Management Plan across program	– Conducted double-blind Certified Reference Material Inter-Lab study. Followed up with relevant analytical laboratories for performance improvement. Study report circulated for review and comments. The final report has been posted on EMSD's public facing web site. – Received additional air deposition SOPs from ECCC for inventory updates. – Conducted an external scientific peer review on the draft groundwater SOPs. The comments and recommendations will inform future ground water SOP development and formulation. – A summary for the ISO 17025 requirements for the analytical labs was prepared and circulated to the members of the analytical working group for review. A process map for QA/QC accountabilities was prepared and presented to the EMSD Science Advisory Panel. – Posted the AEP QA/QC Guidance Document for short term air studies online. – Regular audits were conducted on air monitoring networks in the Oil Sands region.
Development of a Naphthenic Acid Standard	– Create Certified Standard and Reference Materials for Quantitative Analysis of Naphthenic Acids	– More robust, quality assured analytical method to quantify Naphthenic Acids in Oil Sands related matrices. Requirements to make it more robust and useable for operational labs involved in testing for Oil Sands related samples are the following: – Use of relevant reference materials that are being prepared for ensuring the labs have proper methodology that uses these Certified Reference Materials (CRM). These CRMs include Oil

		Sands Processed Water (OSPW), surface water from the Athabasca River area, ground water from sites near the Oil Sands. With Matrix effects these CRMs will improve the quality of the results and in the current methodology being used. – Primary NA Standard synthesized by Queens University to be tested by ECCC laboratories involved in Naphthenic Acid (NA) analytical testing and then be a critical part of the requirement for labs involved in analyzing for NAs. This internal standard that is being synthesized by Queens University is one of the family isomers that have been identified as being present in current OSPW samples and it will be used as a key internal standard to calibrate and help in the quantitation of Total NAs. – Macro Scale Reference Materials are being prepared by a certified RM produced within ECCC; Information Quality Management (IQM) of the Environmental Science & Technology Laboratories Division (ESTL). Current RMs are being prepared for Oil Sands Processed Waters (OSPW) and for relevant Ground Water (GW) in the Oil Sands area. These RMs will be available for laboratories involved in analytical testing for NAs.
Objective S2: Establish and Maintain an Integrated Data Management System for Archiving and Retrieval of Oil Sands Monitoring Program data.		
Strategy: Design and operate and open, federated oil sands data system that allows for archiving of environmental data and search and download capabilities.		
Oil Sands Data Management and Dissemination	– Develop the data management framework and rigor required to manage data generated under the Oil Sands Monitoring program. – Provide public access to OSM data through web portal.	– Directly supported OSM Secretariat in updating, reorganizing and completing discovery metadata, and entered it into the ECCC Data Catalogue. Also directly supported reorganizing file structures and standardizing metadata within data files, and moved updated data to Data Mart 2 data access environment. – Started defining relationships between new Data Catalogue/Data Mart 2 datasets and 1000 + identified monitoring sites, as well as redefining how SensorML and Harmonized North American Profile (HNAP) records interact and link for OSM records. Began remodeling monitoring site metadata and tweaking Extract, Transform, Load (ETL) processes to transform

		the metadata used to update the geodatabase which populates the OSM Portal mapping interface. – Tested and standardized on Safe's FME Extract, Transform, Load (ETL) platform. Service contract for Safe's FME server is active and will be continuing through next fiscal. Contract includes training and business process analysis to help set up generic data modelling and ETL processes. – The 2016-2017 outcomes for this project consisted of discovery of the current state of: processes, data, documentation and standards. Gaps were identified and all the details gathered will be utilized in the 2017-18 planning and execution of a data management program (blue print) and the data management system for data collection, validation and accessibility.

8. OSM Publications in 2016-2017

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