Joint
Canada | Alberta
Implementation Plan
for Oil Sands Monitoring

The Joint Canada | Alberta Implementation Plan for Oil Sands Monitoring

First Annual Report: 2012–2013

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Table of Contents

I. Introduction

Responsible development of the oil sands resource is a priority for the governments of Canada and Alberta and needs to be informed by robust, reliable monitoring of the environmental impacts. Monitoring the environmental performance of the oil sands industry has been required by regulatory operating approvals, licences and permits since industrial extraction began in 1967. With the increased pace and scale of development, and based on recommendations from expert panels, the governments of Canada and Alberta jointly agreed to enhance and integrate existing environmental monitoring to better assess the cumulative environmental impacts of development.

On February 3, 2012, the federal and provincial environment ministers jointly announced the *Joint Canada-Alberta Implementation Plan for Oil Sands Monitoring* (the Implementation Plan), committing the two governments to implementing a scientifically rigorous, comprehensive, integrated and transparent environmental monitoring program for the region. The Implementation Plan describes a phased implementation of enhanced monitoring activities over three years (2012–2015), and the rationalization and integration of current monitoring arrangements into a single, government-led program under the joint management of the two governments. The result will be an improved characterization of the state of the environment in the oil sands area and an enhanced understanding of cumulative effects and environmental change.

The Implementation Plan also commits the governments to reporting annually on the progress made in carrying out the activities laid out in the Implementation Plan. This annual report highlights progress made during the first year of the Implementation Plan (2012–2013) and includes a brief summary of initial findings. Details of monitoring results, evaluation and reports can be found on the Canada-Alberta Oil Sands Environmental Monitoring Information Portal (the Portal) and links contained therein.

II. Implementing the Plan

Environment Canada and Alberta Environment and Sustainable Resource Development have worked collaboratively since the announcement of the Implementation Plan. Government co-leads and technical staff immediately began the management, planning and implementation needed to enhance, rationalize and integrate monitoring activities in the component areas of air, water, wildlife health and biodiversity.

Funding

Funding for monitoring in the first year of the three-year Implementation Plan (fiscal year 2012–2013) was collected from industry through Government of Alberta Ministerial Orders as a transition measure until appropriate legislation and regulations are put in place. The Ministerial Order enabled the Alberta government to set and collect fees from oil sands producers, identify the fee amount, hold the fees in a government fund, and distribute money for monitoring, evaluation and reporting purposes.

The orders were drafted specifically to address the monitoring outlined in the Implementation Plan, and the fees are structured in accordance with the specific activities conducted under the Implementation Plan and associated costs. The oil sands industry members of the Canadian Association of Petroleum Producers have collaboratively developed a funding formula to allocate costs up to the $50-million ceiling to oil sands operators for 2012–2013. Invoices were prepared and sent to companies in March 2013 based on this fee schedule. A total of $13,224,104 was invoiced through the Ministerial Orders, of which $12.2 million reimbursed federal efforts and $970,000 went to fund provincial activities. Alberta reimbursed Environment Canada for expenses through a bilateral funding agreement.

During the fiscal year 2012–2013, industry continued to directly fund regional organizations to conduct monitoring activities required under regulatory operating approvals, licences and permits, most of which support the Implementation Plan. Once legislation and regulations are in place, all monitoring activities under the Implementation Plan will be approved jointly by the two governments and will be funded through the Government of Alberta with monies collected from industry.

Accountable Administration and Review

Delivering the integrated, comprehensive cumulative-effects monitoring outlined in the Implementation Plan requires that existing monitoring arrangements currently delivered through various independent organizations be rationalized into a single government-led approach under the joint management of the two governments. This means implementing a common planning, monitoring, evaluation and reporting cycle to which all organizations performing regional cumulative-effects monitoring in the oil sands region would adhere. The governments of Canada and Alberta are taking care to integrate the entire suite of monitoring activities while not unduly compromising monitoring objectives required for regulatory purposes. In addition, the Implementation Plan approach is consistent with the planned developments in Alberta's province-wide monitoring system. Integration of the multiple monitoring arrangements will be completed by 2014 as governments and independent organizations work to harmonize technical and governance mechanisms. In addition, the monitoring system will undergo external expert peer review after year three, and at five-year intervals thereafter, to ensure that scientific integrity is maintained.

The Implementation Plan commits the two governments to engage stakeholders, including Aboriginal peoples, industry, independent scientists and existing monitoring organizations.

Multi-stakeholder engagement efforts in 2012–2013 included First Nations and Métis organizations, the governments of the Northwest Territories and Saskatchewan, industry, monitoring organizations in Alberta, and other stakeholders. Shortly after the Implementation Plan was announced, a May 2012 technical multi-stakeholder workshop was held to seek stakeholder perspectives on the Implementation Plan and to better understand which engagement mechanisms are most effective for different stakeholders. An overarching engagement strategy will be finalized in 2013–2014 to guide future engagement efforts.

Aboriginal Engagement

During 2012-2013, the governments of Canada and Alberta started engagement of representatives of the Athabasca Chipewyan First Nation, Chipewyan Prairie Dene First Nation, Fort McKay First Nation, Fort McMurray First Nation and Mikisew Cree First Nation. The goals of these engagement discussions were to share information and lessons learned; to build and sustain relationships; and to identify opportunities to advance common interests related to oil sands monitoring including communication, engagement, field operations and training.

Governments, First Nations and Métis collaborated on some early successes, including:

- Monitoring activities – Members of the Mikisew Cree First Nation participated in snow pack sampling, an Air Quality Monitoring Station was established within the Fort McKay First Nation, and numerous First Nations and Métis community members contributed harvested wildlife for tissue sampling. All activities were initiated based on environmental concerns of the First Nations.

- Training – The governments and the Mikisew Cree First Nation undertook a pilot Environmental Monitor Training Program in March 2013 with the intent to train First Nations and Métis individuals from the Fort Chipewyan area in basic monitoring skills and contribute to capacity building for local peoples.

We recognize that much work remains to engage Aboriginal Peoples and integrate Traditional Ecological Knowledge (TEK) into our work as described in the Joint Plan. Efforts continue to establish truly effective working relationships with First Nations and Métis people, organizations and communities. Additional effort will be required to fully include Aboriginal perspectives, information and traditional ecological knowledge in the planning, evaluation and reporting of monitoring activities.

Governments of Saskatchewan and the Northwest Territories Engagement

Reflecting the transboundary nature of the potential environmental impacts, and to promote collaboration, the Implementation Plan commits to engage with these governments, and efforts have included discussions with the Assistant Deputy Minister (ADM) of Saskatchewan Environment and the ADM of Environment and Natural Resources, Northwest Territories. Information is being shared with regard to the status of the Implementation Plan, and more fulsome engagement of these governments is planned as part of more permanent multi-stakeholder engagement mechanisms.

Environmental Non-governmental Organizations Engagement

Environmental non-governmental organizations were included in ongoing multi-stakeholder engagement mechanisms, including technical planning meetings and multi-stakeholder meetings.

Industry Engagement

In February 2012, a full-day workshop was held with industry representatives focused on the technical aspects and governance approaches in the Implementation Plan.

A government-industry Transition Working Group (TWG) was established to inform governments about industry practices and perspectives on the current regional cumulative-effects monitoring compelled by industry's regulatory approval conditions. The intent of the TWG is to learn from industry's experiences on ambient regional monitoring to facilitate the transition from multiple individual-approval requirements delivered through multiple independent organizations into a single government-led program under the joint management of the two governments.

Monitoring Organizations Engagement

Discussions were held with independent monitoring organizations that have a current role in delivering monitoring functions in the oil sands region. In early March 2012, a meeting was held with the leaders of these monitoring organizations to begin the process of integration. This has been followed by a series of more technical discussions between government monitoring leads and experts from monitoring organizations. As monitoring activities integrate into a single government-led process, it is expected that a number of these monitoring organizations will continue as service providers and contribute valued monitoring expertise.

Transparent and Accessible Results

Evaluating monitoring results and presenting them in a form suitable for decision makers is more than simply identifying levels of substances in the environment and changes over time. A particular challenge is that "correlation does not imply causation." In other words, evaluation of monitoring results does not always demonstrate a cause-and-effect relationship between observed levels and trends in monitored substances and an activity. The Implementation Plan identifies multiple approaches that might help to identify the cause of environmental changes or impacts. The design also recognizes that while acute biological effects may be almost immediately apparent, more subtle long term effects may require longer monitoring periods to detect. For this reason, the Implementation Plan explicitly recognizes the value of detecting levels and trends of substances and biological effects that inform management decisions on mitigation measures to forestall adverse effects.

Transparency and accessibility of results are the foundation of the integrated monitoring program. To ensure consistency and the ability to integrate data, standardized quality assurance and quality control procedures and standard operating protocols are being developed. The Implementation Plan will produce a data management framework that will allow information to be uploaded, organized and publicly available in a timely, standardized, coordinated manner so that it is transparent and freely accessible.

In 2012–2013, standard quality management protocols and procedures were established for many oil sands monitoring activities. Standard Operating Procedures (SOPs) for core chemical analyses are being developed by the participating laboratories, and field sampling protocols being used in the monitoring program are being documented (e.g., Alberta Biodiversity Monitoring Institute). Any alterations of methods will be approved through an expert consultation process and include a period of inter-calibration with older methods. Where SOPs do not exist, they will be developed and will conform to existing standards developed by recognized international bodies whenever possible.

Governments worked to develop the Portal website, launched on April 22, 2013, by Canada's then Environment Minister Kent and Alberta Environment and Sustainable Resource Development Minister McQueen. The Portal provides access to information related to the Implementation Plan, including maps of the monitoring region, details of the monitoring sites, the recent data, and scientific analysis and interpretation of the data and results. As more data becomes available, the Portal will evolve with new updates and features and become more comprehensive.

Open, transparent and unrestricted access to all oil sands environmental results is a primary long-term goal. While much progress was made in 2012–2013, much work remains to finalize data management policies, integrate standards and protocols, and ensure a full and open data system.

III. Achieving the Overall Goal: Understanding Environmental and Cumulative Effects

Understanding Long-term Environmental Effects

In order to understand long-term environmental effects, including cumulative effects of oil sands development, monitoring should provide answers to specific ecologically relevant scientific questions. In answering these questions, information becomes integrated, and a picture of the environmental effects of oil sands development begins to emerge. The three-year Implementation Plan is just a beginning, and assembling, evaluating and reporting trends may take some time, particularly where trends and impacts may be subtle.

The Implementation Plan's scientific design addresses the following specific questions, which are key to understanding regional effects.

- ***What are the sources and types of substances being released?***
- ***How are these substances being distributed though air, water, and land?***
- ***What are the spatial and temporal trends in these substances?***

The primary substances of concern for the Implementation Plan in the oil sands region include: acidifying compounds (NO_X, SO_X); and substances related to the extraction and combustion of bitumen including monocyclic aromatics (BTEX – benzene, toluene, ethylbenzene, xylenes), polycyclic aromatic compounds, naphthenic acids, metals and particulate matter. The quantity of these substances can be estimated from industry emissions reports of their operations (as required under regulations), direct measurements in air, water, groundwater, snow, sediments, soils, and organisms, and from indirect measurements by satellite observations.

Understanding the concentration, exposure and impact of these substances is a scientific challenge because emissions can vary over time. Also, the substances can exist naturally in the environment, may be transformed into other substances once emitted, may enter or leave the region, or may accumulate locally. Integrating and validating the information collected to assess total emissions is very important to ensure the most complete picture of environmental effects possible.

- ***How are these substances being transported and transformed?***
- ***What happens to these substances in the environment?***

Emitted substances can be transported through the environment via a number of means and, once deposited, may be remobilized through natural erosion or human-induced changes to the landscape. In addition, substances can be transformed through chemical reactions or biological activity in the atmosphere, water and/or soil. The Implementation Plan identifies monitoring activities that quantify these transport and transformation mechanisms. This allows scientists to provide an overall accounting of the environmental fate of emitted substances.

- ***To what extent do these substances affect biological communities?***

It is possible that at certain concentrations and exposures, substances may impair the biological functioning of an ecosystem through impacts on aquatic and terrestrial plants, fish, amphibians, mammals and/or birds. Monitoring and supporting research activities identified in the Implementation Plan are designed to evaluate biological impacts at local and regional scales and at different levels in the aquatic and terrestrial food webs. Forensic investigations into the cause of these impacts are guided through the use of indicators of biological impairment. Using a range of indicators, biological communities and species will be sampled regularly to identify any biological, ecological and toxicological effects.

- ***To what extent does habitat disturbance impact biodiversity?***

Oil sands development physically disturbs habitat (e.g., forests and wetlands), which can directly impact dependent biodiversity. Monitoring activities will survey a broad variety of mammals, birds, amphibians, invertebrates, and vascular and non-vascular plants and lichens at hundreds of sites with a five-year rotational cycle. Changes to human footprint and habitats caused by disturbance will also be assessed. In addition, there will be complementary surveys for rare, at risk and harvested species to improve the ability to detect trends and monitor the impacts of habitat disturbance. This information will provide an improved understanding of the status and trend of species in the oil sands region and indicate the cumulative and individual effects of development on biodiversity, now and into the future.

Complementing and Enhancing Regulatory Monitoring

Industry is required by provincial and federal regulations to monitor source emissions or other environmental impacts of their operations to demonstrate that their facilities operate within predefined performance objectives. While not part of the Implementation Plan, industry continues to be responsible for all costs involved in monitoring their facility operations to ensure they remain compliant with their regulatory requirements.

Industry has also been responsible for assessing and evaluating the trends and levels of environmental change at the longer-term, regional scale, and this responsibility continues. Prior to the Implementation Plan, regional ambient monitoring approval conditions required individual industry operators to participate in independent monitoring organizations such as the Wood Buffalo Environmental Association (WBEA) or the Alberta Biodiversity Monitoring Institute (ABMI). Under the Implementation Plan, industry will fund the Implementation Plan to conduct regional ambient monitoring.

The enhanced monitoring of the Implementation Plan will help reveal any environmental or cumulative impacts resulting from long-term exposure to substances of concern and from the existence of multiple environmental stresses (substances of concern, nutrients in water, changing climatic conditions, etc.) due to oil sands development. Regional and facility performance monitoring activities are complementary, and exchange of information between the two types of monitoring can assist in the evaluation of potential cumulative impacts of the industry on the environment.

IV. 2012–2013: What We Have Learned

In the oil sands region, a particular challenge is that many of the substances found in the environment occur naturally as well as resulting from development activities. Separating the natural environmental effects from those that are introduced by human activities involves forensic work to establish cause and effect. Without clear cause-and-effect relationships, management actions meant to mitigate environmental impacts may be ineffective.

To date, monitoring and scientific study data show evidence of oil sands development on the surrounding environment, although generally not at levels that are cause for immediate concern. Concentrations of oil sands–related substances (i.e. polycyclic aromatic compounds, acidifying compounds and metals) in air, water, snow and sediments are highest at locations close to oil sands extraction and upgrading facilities. These concentrations decline with increasing distance from development sites, with the highest concentrations found within an approximately 50 km radius from the confluence of the Steepbank and Athabasca rivers.

Laboratory fish and invertebrates exposed to ground and surface waters and to sediment from sites located close to oil sands mining and upgrading facilities showed biological effects related to exposure. However, biological effects were also observed in fish and invertebrates exposed to water and sediments collected from areas of exposed natural bitumen deposits. The development sites also coincide somewhat with naturally exposed bitumen deposits, emphasizing the challenges associated with establishing clear cause-and-effect relationships between development and impacts.

Below in bullet form are some of the key findings based on existing data. The findings below are merely observations based on data, and have not been fully interpreted or evaluated for implications of impacts or cumulative effects. Supporting data and reports are available on the Portal.

Acidifying Compounds

- Atmospheric concentrations of NO_2 and SO_2 increase near the oil sands development areas and are comparable to, or less than, concentrations typically found near coal-fired power plants, mining smelters or metropolitan areas such as Edmonton.
- Satellite observations from the period 2005 to 2010 show an enhancement of NO_2 over an area of intensive surface mining. Further analysis will be done to assess potential impact and relevance.

Polycyclic Aromatic Hydrocarbons and Polycyclic Aromatic Compounds

- Polycyclic aromatic compound (PAC) atmospheric concentrations vary considerably across the region. On average, the PAC concentrations in air near mining and upgrading activities are twice as high as the concentrations at sites 50 to 100 kilometres away.
- Atmospheric deposition of polycyclic aromatic hydrocarbons (PAHs) recorded in lake sediments has steadily increased since oil sands development started in 1970, is detectable up to 100 km from the development.
- Lake sediment polycyclic aromatic hydrocarbon (PAH) concentrations found today are generally lower than those found in urban lakes or lakes near coal-fired generating plants. Canadian sediment quality guidelines for PAHs since the mid-1980s have only been exceeded in one (fish-free) lake located immediately adjacent to mining, extract and upgrading facilities.
- Pre-development PAH concentrations are typical of wood combustion (probably from forest fires), although PAHs typical of oil sources have increased since oil sands development began.

Metals

- Naturally high sediment loads reflecting erosion during the spring and summer cause total metal concentrations in the Athabasca River to exceed the Canadian Council of Ministers of the Environment (CCME) guidelines in these seasons.
- In almost all samples collected from water, the substance concentrations measured are below relevant environmental guidelines established by the CCME. As well, substance concentrations tend to decrease with increasing distance from oil sands mining and upgrading facilities.
- Hourly average measurements of total gaseous mercury made in Fort McMurray have not shown significant changes over time with concentrations similar to those found elsewhere in Canada.
- Snowpack analysis results show deposition patterns and levels consistent with earlier findings. Concentrations of PAHs and metals (As, Ag, Be, Cd, Cr, Cu, Hg, Ni, Pb, Sb, Se, Tl, Zn) were highest within 50 km of the major mining extraction and upgrading facilities and fall off with distance.
- Levels of iron and cadmium in some wetlands water samples at several sites exceeded established (CCME) safe limits for aquatic life, but there is no obvious spatial pattern associated with proximity to oil sands upgraders.

Ecosystem Impacts

- Athabasca River benthic (organisms that live at the bottom of rivers) communities are diverse and healthy, apparently not showing evidence of biological impairment.

- Zooplankton (tiny invertebrates that float freely throughout freshwater) community studies in lake sediments from the oil sands region show increases in primary productivity of biomass that may indicate climate-induced increases in light and temperature, and/or the addition of nutrients.
- Total phosphorus and nitrogen exceeded the Alberta surface water quality guidelines during periods of naturally high loads of suspended sediment–related precipitation-induced erosion.

V. Next Steps

Details on monitoring activities planned for 2013–2014 and 2014–2015 are found in the Implementation Plan Appendix Tables 1 through 4.

Efforts in 2013–2014 will focus on transitioning into a single government-led process, enhancing and improving engagement approaches, including a focus on improving Aboriginal relationships, working to better integrate the Traditional Ecological Knowledge into the Implementation Plan, and finalizing regulations to ensure sustainable funding of oil sands–related environmental monitoring.

VI. Technical Annex I: Activities and Results to Date

During the implementation phase, enhanced environmental monitoring progress is reported against the commitments found in the Implementation Plan Appendix. A direct comparison of progress against commitment is located in Technical Annex II of this report.

The monitoring activities in 2012–2013 of the Implementation Plan focused on enhancing our understanding of the following key questions:

- What are the levels, geographic extent and trends over time of atmospheric deposition of oil sands–related substances in snow in the lower Athabasca region?
- What were the historical levels of atmospheric deposition of PAHs and metals?
- What is the spatial pattern of the acidifying emissions in acid-sensitive lakes in the lower Athabasca region?
- What are the levels of oil sands–related substances from groundwater sources in the tributary and Athabasca River systems?
- What are the spatial and temporal trends in water quality and levels of oil sands–related substances associated with the spring freshet in the Athabasca River and tributaries?
- What is the status of surface water quality in the Peace-Athabasca Delta and other downstream receiving environments?
- What is the variation in flow/discharge in the Athabasca River and in key regional tributaries?
- What are the factors affecting regional hydrology, sediment transport and sediment dynamics?
- Are there observable impacts on the structure and function of terrestrial or aquatic ecosystems?
- Is there evidence of toxicological impairment in wildlife, fish and/or benthic invertebrates from environmental exposure to substances related to oil sands development?

Air Quality

The impact of oil sands extraction activities on air quality is addressed in a comprehensive way through the monitoring of point source emissions, ambient air and atmospheric deposition. This enables the evaluation of potential ecosystem and human health impacts. The geographic scope includes the immediate oil sands region, as well as upwind and downwind areas in Alberta, the Northwest Territories, Saskatchewan and Manitoba, reflecting the transboundary nature of air pollution and the predicted geographical extent of potential ecosystem impacts.

Air quality monitoring activities build upon existing local and national monitoring networks and involve collaborators from the Government of Canada, the Government of Alberta, regional environmental associations and monitoring organizations, Aboriginal communities, industry, and university academics. The monitoring approach incorporates various strategies to understand and quantify air emissions in the oil sands region, their chemical transformation in the atmosphere, and long-range transport and deposition to the local and regional environment (see figure below).

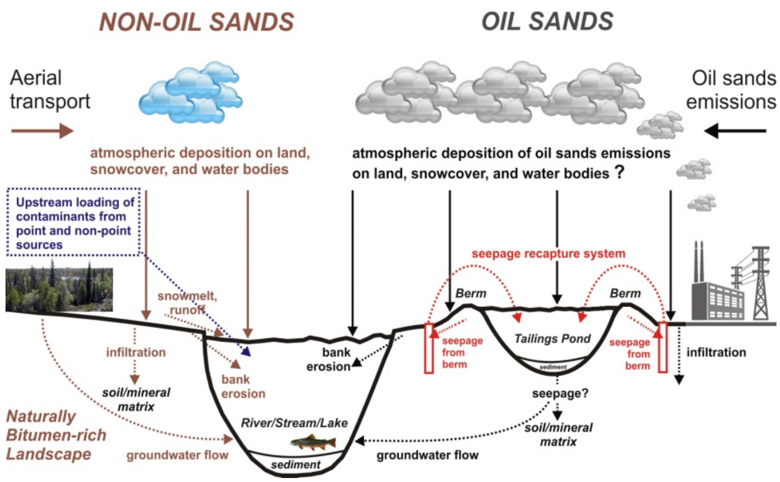

Figure 1 – Simplified schematic showing pathways of substances in the oil sands region

During 2012–2013, existing air quality monitoring activities were enhanced and improved by:

- Refining estimates of emission from development activities;
- Distinguishing between oil sands–specific sources of emissions and other sources such as natural and long-range transported emissions;
- Quantifying transport over a large spatial range from upwind sites to sites outside of Alberta;
- Establishing approaches that quantify atmospheric transformation mechanisms;
- Adding precision to mapping deposition patterns; and
- Integrating data into a predictive model that provides air quality and deposition data to water quality, acid-sensitive lakes, aquatic biota and wildlife components.

Ambient Air Quality

The objectives of the ambient air quality monitoring activities are to understand what substances are in the atmosphere and to establish the atmospheric fate (transport, transformation, deposition) of oil sands emissions. The data from the ambient air quality monitoring are essential for assessing cumulative impact of oil sands emission on air quality, atmospheric deposition, and ecosystem and human health.

Ecosystem monitoring sites are being established to quantify atmospheric wet and dry deposition on sensitive ecosystems and to define the long-range transport/transboundary influences of oil sands emissions. The data from these activities are also important inputs to the interpretation of aquatic observations of cumulative effects in relation to atmospheric deposition. The three primary sites are Pinehouse Lake, Saskatchewan, Island Falls, Saskatchewan, and Cross Lake, Manitoba. These are part of the Canadian Air and Precipitation Monitoring Network (CAPMoN) and are the first sites downstream of the oil sands region in western Canada.

In 2012–2013, measurements of precipitation chemistry were begun at Island Falls, construction of Pinehouse Lake is ongoing, and planning and site design are underway for Wood Buffalo National Park, Northwest Territories, Joussard, Alberta, Buffalo Narrows, Saskatchewan, and, Flat Valley, Saskatchewan. As well, site options were finalized for Beaverlodge, Alberta. An alternative monitoring site delivery option continues to be explored for Cross Lake, Manitoba.

In addition, a number of sites are being monitored within the existing WBEA ambient air monitoring network to fill in gaps in the types of chemicals measured in order to inform local and regional air quality evaluations. Also, continuous monitoring of gaseous mercury as well as BTEX substances is being completed at three existing WBEA-operated sites. The raw Total Gaseous Mercury (TGM) data is being streamed live to the WBEA website, and the first two years of quality-controlled TGM data from one site is posted to the Portal while detailed analysis continues.

Characterizing Emissions

A comprehensive emissions inventory for the region is necessary to understand all sources of emissions (i.e. oil sands–related and others). This inventory is the primary input for the air quality model that integrates emissions data and observational data to interpret the state of the atmospheric environment and to estimate the environmental and cumulative impacts of oil sands emissions on air quality, atmospheric deposition, and ecosystem and human health.

Initial efforts focused on compiling and assessing information from existing emissions inventories in order to develop an overall picture of what emissions data is currently available for the oil sands regions. This effort also allowed us to identify areas of overlap (duplicate sources, facilities, etc.), inconsistency (conflicting emission numbers, stack parameters, locations, etc.) and disconnect (different types of emissions, level of detail, etc.). The analysis supported the development of a comprehensive emissions inventory, which is needed as input to the air quality modelling associated with monitoring studies described later under Transport and Transformation. This analysis of the various existing inventories also identifies knowledge gaps, including what targeted measurements are needed for specific point sources, mobile sources (e.g., non-road vehicle fleets) and area sources (e.g., tailings ponds).

Large-haul trucks used in mining and highway coach buses that transport workers between communities and oil sands operation sites are thought to be two significant contributors of mobile sources of air emissions in the oil sands region. Characterization of emissions from the mine-vehicle fleet is ongoing, and new work has focused on monitoring emissions from highway coach buses. A methodology is being developed for conducting emission measurements under actual operational conditions, and measurements are to be continued in 2013–14.

Tailings ponds were also identified as a significant gap in the emissions inventories, as there is little public knowledge of what compounds are evaporating and at what rate. In 2012–2013, several new methods for measuring emissions of substances from the tailings ponds were tested and validated. A collaborative field project to measure emissions for 2013–2014 involving the two governments, industry and academic partners is under development.

Transport and Transformation

An important aspect of air quality monitoring efforts is determining the fate of substances from emission through transport and transformation until they are deposited into aquatic and terrestrial environments. Short-term intensive studies utilizing airborne and ground-based measurements of substances in the atmosphere will provide data on what is being introduced into the air from oil sands. This data is integrated into an air quality model that allows for region-wide tracking of air quality based on current measurements.

In 2012–2013, work began with the support of the Fort McKay First Nation to establish two ground-based monitoring sites in the Fort McKay region.

Ground-based remote sensing and satellite monitoring are being used to provide critical information on the distribution and concentration of particles and gases at high resolution across the region over the four seasons. A Light Detection and Ranging (LiDAR) system installed in Fort McKay in November 2012 has been providing near-continuous measurements of fine particulate matter (PM) or liquid droplets in a vertical profile through the atmosphere from near ground level to altitudes of 15 km. The data from this monitoring provides direct measurements of the emissions in the region and how they are transported through the atmosphere. This information supports the collection of short-term intensive measurements, and together they enable the refinement of the atmospheric models for predicting the deposition across the entire oil sands region. A LiDAR system capable of measuring carbon dioxide (CO_2), methane (CH_4) and PM levels was acquired by the Alberta government in 2012 and was tested in the oil sands region during the summer of 2013.

The satellite monitoring is complementary to surface and aircraft measurements, especially in areas where ground access is limited. Satellite observations between 2005 and 2010, verified using ground-based monitoring data, produced high-resolution air pollutant maps that showed distinct concentrations of nitrogen dioxide (NO_2) and sulphur dioxide (SO_2) over an area roughly 30 km x 50 km of intensive oil sands surface mining (McLinden et al 2012).

The amount of nitrogen dioxide over the region of surface mining increased at 10% each year between 2005 and 2010.

Deposition Patterns

Five new monitoring sites will be installed in the oil sands mining area to actively sample more substances in air and in precipitation than are sampled in typical air quality measurements. This monitoring will quantify the dry and wet atmospheric deposition rates of oil sands emissions and enhance existing monitoring by providing spatially and temporally resolved data on organic PACs and inorganic (trace metals and acidifying species) substances.

In 2012–2013, the site selection criteria and infrastructure and instrument requirements were developed and the potential sites for enhanced monitoring were surveyed. The selected sites will be phased in over the next two years. Under the pilot project, measurements of PACs and selected trace metals/elements have been ongoing since December 2010 at three sites operated by the WBEA. The data are undergoing quality control review and will be posted on the data portal in spring 2014.These pilot sites will be phased out as the Implementation Plan's enhanced deposition sites are installed.

While these new sites are being established, monitoring has been conducted under a second pilot project that utilizes two approaches. The first approach uses active sampling technologies, which require infrastructure and electricity services to support powered instrumentation. The second approach is passive sampling technologies, where samplers do not require electricity and can be placed in more remote areas providing the geographic coverage necessary in the oil sands region. Measurements of atmospheric PACs using the passive sampling technique were made at 16 sites since November/December 2010. These results will be integrated with measurements of PACs accumulated in the snowpack made at various locations around the oil sands upgraders (described below under Water Quality and Quantity). In addition, PAC measurements were made near bird nesting boxes to investigate linkages between avian species health and local air quality (described under Wildlife Contaminants and Toxicology).

Modelling and Data Integration

The sites at which the atmospheric distribution of substances can be directly measured are quite limited (generally only at logistically accessible locations on the surface of the earth). Hence, atmospheric modelling is used to understand the atmospheric fate (transport, transformation, deposition) of oil sands emissions at a regional scale and across different timelines (current, past or future). The Global Environmental Multi-scale – Modelling Air Quality and Chemistry (GEM-MACH) model is being used to integrate emissions and monitoring data and to predict air quality and deposition over the entire region. A predictive air quality model also allows the concentration and exposures over the entire region to be entered into cumulative effects assessments.

GEM-MACH has been enhanced to work with 2.5 km resolution and to generate information on deposition to ecosystems, values for the Air Quality Health Index, and values to compare the model to satellite data, and air quality forecasts.

Water Quality and Quantity

The implementation of water quality, water quantity and aquatic biological monitoring activities follows the principles and objectives outlined in the Integrated Oil Sands Environmental Monitoring Plan (2011); the Lower Athabasca Water Quality Monitoring Plan – Phase 1 (2011); an Integrated Monitoring Plan for the Oil Sands – Expanded Geographic Extent for Water Quality and Quantity, Aquatic Biodiversity and Effects, and Acid-Sensitive Lake Component (2011); and the Joint Canada-Alberta Implementation Plan for Oil Sands Monitoring (2012). These documents are all available on the Portal.

During 2012–2013, existing water monitoring was enhanced and improved by:

- Increasing geographic extent of monitoring, increased frequency of sampling and inclusion of sediment monitoring;
- Increasing the number of monitoring sites on the Athabasca River and tributaries;
- Increasing the frequency of monitoring from annual to monthly for many river and tributary sites;
- Increasing the sensitivity and limits of detection for a broad suite of substances related to oil sands activities, including metals, polycyclic aromatics and naphthenic acids;
- Expanding monitoring of fish health, benthic community health, and fish and invertebrate toxicology;
- Refining a sampling program to assess the hydrological conditions and ecosystem health of the Peace-Athabasca Delta;
- Improving the ability to identify and quantify sources (air, surface water and groundwater), transport, loadings, fate, types of oil sands–related substances and their effects on key aquatic ecosystem components in the Athabasca River system;
- Enhancing regional sampling of substances deposited from the atmosphere in snow and in sediments of regional lakes; and
- Improving the quantification of historical trends.

Atmospheric Deposition and Effects on Regional Water Quality

Snow is an efficient collector of atmospheric material, as deposited substances accumulate in the snowpack over time. Environment Canada and Alberta Environment expanded the coverage of previous work (Kelly et al. 2009, 2010) to quantify the deposition of PAHs, metals and methylmercury in local terrestrial and aquatic ecosystems. The snowpack was sampled at the time of the maximum snowpack depth (March 2012) at approximately 90 sites. Peace-Athabasca Delta snowpack samples were collected with the help of members from the Mikisew Cree First Nation of Fort Chipewyan. Data from previous collections were combined to calibrate data and allow data comparisons among different years.

Historical records of atmospheric deposition can be at least partially recovered by studying the sequential accumulation of substances over time in lake sediment layers. Similarly, fossil remains of zooplankton and/or aquatic bottom dwellers (benthic community) may also be preserved in these same sediment layers and can indicate whether atmospheric deposition and organism health might be correlated. To collect undisturbed lake sediments, several small lakes were selected and showed minimal evidence of direct human disturbance, and sampling was started in late winter 2013. Sediment cores recovered during coring were analyzed to determine the concentrations of substances of concern, including PAHs and metals, and to examine aquatic biota fossils.

Lake acidification because of atmospheric deposition, primarily of NO_X and SO_X, is particularly important in lakes that have limited ability to neutralize the acidifying material. There are three tiers of monitoring:

- Activity in 2012–2013 focused on regional lake surveys repeated every 5 to 10 years to establish current acidification status and monitoring a subset of approximately 50 lakes, sampled twice annually, to identify trends in lake acidification.
- In northeastern Alberta, southern Northwest Territories and Saskatchewan north of Lake Athabasca, 326 lakes were sampled in 2012–2013.
- In addition, 22 lakes sampled previously by the Regional Aquatics Monitoring Program (RAMP) were sampled for intercomparison to integrate historical data records. A database containing all the field and laboratory information collected from this survey is under construction.

Groundwater Effects on Surface Water and Ecosystem Health

The groundwater investigations in the oil sands region are meant to identify and assess the role of groundwater in maintaining and affecting river water quality and ecosystem health.

Groundwater monitoring was conducted in the Lower Athabasca River to assess groundwater discharge impacts on surface water quality and river discharge (i.e., quantity) in selected river systems. Large-scale (10–100 km) analysis of the geochemistry of major tributaries was completed on four major tributaries (Ells, Steepbank, Firebag and MacKay rivers).

In addition, groundwater quality samples were collected near tailings impoundments adjacent to river systems to document the geochemical signature of the local aquifers and to check for the presence of substances that might seep from the tailings ponds. Groundwater samples collected will also be analyzed for toxicological effects on aquatic biota to assess surface-groundwater interactions.

Spatial and Temporal Trends in Water Quality and Quantity

Snow and ice melt in the spring “freshet” is a significant event in northern latitudes, as it represents a large pulse of water flow over a short time period that can transport substances deposited in the terrestrial environment (e.g., snow) into the aquatic environment.

In spring 2012, an extensive and intensive campaign to sample the spring freshet was initiated. Surface water samples were collected daily at the initiation of spring freshet conditions from the Steepbank, Ells, Muskeg, Mackay and Firebag tributaries and weekly (May–June) at long-term water quality monitoring sites on the Athabasca River. Water samples are being analyzed for general water quality parameters and for substances of concern.

Six tributary sites were sampled intensively starting in April 2012, and this number was increased to 9 by late summer 2012. In addition, monitoring of more than 50 tributary sites continued in 2012 to assess status and trends. Passive sampling devices were deployed throughout the lower Athabasca region to collect time-integrated samples of hydrocarbons. Automated water quality measurements were taken at key tributary water quality monitoring sites. In addition, more than 700 water samples are being analyzed, with approximately 40% of these samples generated during freshet conditions (April–June 2012). Laboratory analytical results are being validated and will subsequently be used to spatial patterns and local trends.

Surface water quality samples were collected monthly in the Peace-Athabasca Delta starting in April of 2012. Samples are being analyzed for core water quality parameters and oils sands–related substances of concern.

Verified and validated water quality data from the summer and fall of 2012 (June through September) was collected at the Slave River at Fitzgerald site (data is available on the Portal). Measurements are reported for water temperature, turbidity, dissolved oxygen, pH and specific conductance at 1 m and 4 m depths every two hours. Weather observations (air temperature, wind speed and direction, barometric pressure, precipitation, and relative humidity) are collected every 15 minutes.

Regional Hydrology, Sediment Transport and Sediment Dynamics

In 2012, the frequency of Water Survey of Canada measurements of flow, water level and sediment concentration was increased at eight tributary monitoring sites (Clearwater, Steepbank, Mackay, Muskeg, Firebag, Christina, Beaver and Hangingstone). More than 50 river discharge measurement sites are being operated throughout the region.

Understanding the mechanisms that transport and transform substances in the aquatic environment requires modelling the climate, water dynamics and sediment transport in the Lower Athabasca drainage basin. Substances can accumulate in sediments and may be remobilized and transported as a result of sediment erosion and riverbed scouring during ice breakup. Substances may be either attached to suspended sediments in the water column or dissolved, and both mechanisms are important for understanding biotic exposure.

Regional Hydrology

- Modelling was initiated on snowpack data on selected tributaries of the Lower Athabasca to assess the importance of snow transport and deposition processes.

- An analysis of extreme hydro-climatic events affecting the Athabasca River is underway and will include information on the effects of extreme precipitation events that affect stored water systems and floods.

Sediment Transport

- Sampling and hydraulic modelling programs have been initiated to increase knowledge about sediment transport characteristics in the Athabasca River.
- An integrated study of river-ice and sediment dynamics associated with spring river-ice breakup is underway.
- Laboratory experiments were conducted to understand sediment erosion, transport and deposition in the Ells River.

Bed Sediment

- Stretches of river bed have been surveyed via multi-beam side-scanning sonar (total length of river surveyed to date is 30 km) to calibrate/validate the sediment/bitumen erosion, transport and deposition models. The acquired data is undergoing quality assurance/quality control (QA/QC) reviews.
- A field survey was conducted during low flow conditions to determine key areas where substances may be deposited within the main stem of the Athabasca River.
- Bed sediment and water were collected from two locations on the Ells River for sediment dynamics assessment.

Suspended Sediment Quality

- Samples were collected at four locations on the Athabasca River at high flow, low flow and under ice conditions to assess for substances of concern.
- Time-integrated suspended sediment sampling devices were installed on the Athabasca, Ells and Steepbank rivers to assess the concentration of substances of concern. The samplers performed poorly on the high flow conditions of the Athabasca River, resulting in limited data collection, but performed reasonably well on the tributaries.

Aquatic Ecosystem Health

Fish, benthic invertebrates, algae and other biological samples and associated environmental information were collected at 11 sites in the Athabasca River, 50 tributary sites in the Steepbank, Ells, Mackay, Muskeg and Firebag rivers, and 16 wetland sites in the Peace-Athabasca Delta.

Detecting and quantifying any biological and ecological impairment in aquatic biota resulting from exposure to substances released from oil sands development activities is a key objective of the Implementation Plan. Achieving this goal requires establishing and demonstrating causal relationships between environmental exposure of organisms to physical-chemical stressors and biological impairment. The toxicology program under the Implementation Plan is focused on improving our understanding of whether measured environmental concentration levels of substances, such as mercury, naphthenic acids (NA) and PAHs, are producing discernible physiological and ecological effects.

During 2012–2013, aquatic ecosystem health monitoring activities included:

- Laboratory-based bioassays were conducted to assess the biological significance of exposure to atmospheric deposition of oil sands–related substances in snow.
- In September 2012, sediment samples were collected from 16 tributary sites and are currently being assessed for toxicity to aquatic biota.
- Groundwater samples from near tailings ponds, remote from tailings ponds and from off the bitumen deposit were assessed for toxicity to aquatic biota.
- Patterns of substances in surface and groundwater are being further assessed by isolating different chemical components of PAHs and NAs to determine if chemical profiles correlate with observed toxicity.
- Bioassays of mussels caged in the waters of the Athabasca mainstream and tributaries at seven distinct sites (Ells, MacKay, Muskeg and Steepbank): mussels were brought back to the laboratory, and biomarker analyses are underway to evaluate whether their immune systems were affected, and to evaluate whether DNA in the cells participating in immune system reactions was damaged.

Benthic Invertebrates

The age distribution, species composition and overall health indicators of bottom-dwelling organism communities (benthic invertebrates) are sensitive indicators of overall ecosystem health. Benthic macro-invertebrate community structure and function are being assessed and compared over a range of conditions from sites adjacent to oil sands development areas to sites in essentially undisturbed areas. In addition, more detailed studies were performed at a series of tributary sites in the Ells and Steepbank rivers at varying distances from natural exposed oil sands deposits. This data will be on the Portal in the fall of 2014.

Sampling for biota and water quality with increased frequency was conducted at 16 wetland sites (6 perched basin wetlands, 1 oxbow lake, 1 connecting channel and 8 marl ponds) in the Peace-Athabasca Delta and the Slave River Drainage, in addition to ongoing sampling at 5 regional lakes. This data will be on the Portal in the fall of 2014.

Airborne-based remote sensing monitoring of the Peace-Athabasca Delta wetlands was initiated in August 2012 with LiDAR coverage of ~300 km^2 to improve understanding of the complex hydrological flow pathways in the delta. This information is being used to assess changes in water availability and to better delineate the fate and distribution pathways of oil sands–related substances in the delta environment.

Wild Fish

Wild fish were collected at five sites on the Athabasca River, and fish health is being assessed in white sucker (*Catostomus commersonii*) at all sites. Indicators of reproductive function is also being assessed, including analysis of plasma for circulating steroids and vitellogenin and measuring *in vitro* steroid production and secondary sexual characteristics. Liver tissue was collected for evaluation as part of a liver tumour survey and to assess exposure to PAHs (using oxygenase activity). Additional liver samples were collected for contaminant analysis and studies of anomalous protein production that might indicate stress. Bile was collected to evaluate the presence of PAH compounds. Muscle tissue was collected for chemical analysis, and bodies were studied to document anomalies in the fish parasite community.

In addition, 10 tributary sites were assessed for fish health in slimy sculpin (*Cottus cognatus*) using the same protocols as for the white sucker. Temperature recorders were deployed at all wild fish sites in early spring to help develop predictive relationships for cumulative effects.

At a subset of fish sampling sites, water and sediment samples were collected for laboratory-based toxicity tests, and freshwater amphipods (*Hyallela*) were left caged at the site for a two-week period to evaluate exposure to substances of concern and possible effects. Benthic invertebrate sampling was also conducted at these same sites to provide multiple lines of evidence on causal relationships.

Fish Community Studies

Studies of fish community structure were conducted at 19 Athabasca River sites and at 6 tributary sites (Muskeg, MacKay, Steepbank, Tar, Ells and Jackpine) during the spring, summer and fall by characterizing the occurrence of fish species and their abundance, as well as any external abnormalities.

Wildlife Contaminants and Toxicology

This component focuses on understanding the levels of chemical substances found in the wildlife and flora of the oil sands region and the effects of those substances on these species. To do this, targeted activities are conducted to increase this understanding and to provide information on the health of the ecosystem in the area.

Wild Bird Health and Contaminants

Repeated censuses of and egg collections from colonial water birds (California Gulls *Larus californicus*, Herring Gulls *Larus argentatus*, Ring-billed Gulls *Larus delawarensis*, Caspian Terns *Hydroprogne caspia* and Common Terns *Sterna hirundo*) in the oil sands region can be analyzed for chemical substance trends, sources and changes in sources through time.

During 2012–2013, colonial water bird eggs were collected from nesting sites in Lake Athabasca and in Wood Buffalo National Park. Mercury concentrations were measured in individual eggs and are known to indicate concentrations in the local prey of these birds, particularly small fish. Polychlorinated dibenzodioxins (PCDDs) and dibenzofurans (PCDFs) were measured in eggs to evaluate the possible influence of forest fires on egg mercury concentrations. Measurements of other metals, such as arsenic, cadmium and lead, are currently being conducted, and the PAH and PCDD/PCDF data are currently being interpreted.

Avian Toxicology

Tree swallows (*Tachycineta bicolor*) are being used as biomonitors of the levels and effects of airborne emissions. Airborne substances may affect reproduction, growth of nestlings, immune function, thyroid function (important for appropriate development, metabolism and timing of reproduction by adults) and the stress response of the birds. Tree swallow nest boxes were set up at locations near active mine sites and at reference sites, along with passive air samplers to measure PACs deposited over the breeding season. Tree swallow adults lay eggs in the nest boxes, and nestlings that have hatched in the nest boxes are monitored for growth and survival. Tissues are collected and sent to laboratories for assessments of the presence and concentration of substances and assessments of biomarkers (measures conducted in certain tissues that can indicate disruptions of biological health). Fecal samples (in 2012) and fecal samples plus liver tissue (in 2013) of tree swallow chicks are being analyzed for PACs and metabolites to confirm exposure of the nestlings to the substances measured by the air samplers.

A controlled laboratory study with captive American kestrels (*Falco sparverius*) was completed to better understand the potential effects of specific airborne substances (benzene, toluene, NO_2, SO_2) on avian health. Chemical analyses and biomarker assessments of the kestrel tissues are underway.

Hunter/Trapper-Harvested Wildlife Contaminants and Toxicology

This activity focuses on analyzing oil sands–related substances in wildlife tissue samples taken from carcasses donated by local hunters, trappers, and Métis and First Nations community members and from dead and moribund birds collected in or near tailings ponds in the oil sands area.

The 2012–2013 trapping season concluded with the donation from local trappers of 568 fur-bearing mammals from across northern Alberta (142 lynx, 107 fishers, 289 American martens, 6 river otters, 9 beavers, 1 fox, 4 minx, 6 muskrats and 4 wolverines). In addition, 11 ducks from the area surrounding Hines Creek, Alberta, and 19 from the vicinity of Fort Resolution, Northwest Territories, were also collected. All mammal and duck carcasses have been dissected, and tissues are being assessed for the presence of substances of concern. A goal of the tissue assessment of fur-bearing mammals is to identify a single indicator species, best suited for monitoring oil sands–related substances. Localized and intensive sampling of waterfowl and mammals will continue in 2013–2014.

During 2012–2013, no birds were collected or submitted from tailings ponds. Collaborations with partner agencies to determine and ensure the availability of these birds are being established.

Plant Health

The aim of this activity is to monitor the effects of oil sands–related substances on native wetland and upland plant species. The overall goal is to identify sentinel plant species and determine the health of wetland plant communities in the oil sands region. This activity also tests phytotoxicity, that is, whether native plants are able to grow in oil sands soils and sediments under controlled conditions in a greenhouse. In the field, vegetation assessments (species composition, diversity and richness) are undertaken at various locations along the Athabasca River and in remote areas.

In 2012–2013, soil was collected in the Fort McMurray area and is being analyzed for metals, PAHs and NAs. A phytotoxicity study using augmented selenium and salt was also conducted to examine phytotoxic responses. A field reconnaissance trip was conducted to identify sites of interest and to collect plant samples. In total 26 sites were visited. Using specific criteria, 10 sites were identified for thorough study in 2013.

The potential impact of oil sands–related substances on native plants will require further study in order to assess the effects of substance classes (PAHs, NAs, metals). During field studies, indicator plant species collected from several sites included *Vaccinium* spp (blueberry), *Ledum groenlandicum* (Labrador tea), *Arctostaphyllos uva-ursi* (common bearberry), *Cornus canadensis* (bunchberry) and *Picea* spp (spruce) for substance analyses. Most of these species are used by Aboriginal peoples for traditional medicine or food. Additionally, metal elements detected in oil sands soil need to be further examined as the significance of the levels detected remains uncertain.

As most of the substances being studied in this activity would be the result of airborne deposition, air modelling activities and air monitoring will be important to integrate overall ecosystem impacts into this activity. The concentration of substances measured in soil and eventually in plants (as primary producers) can be assessed in terms of the potential effects on consumers of the plants, as well as on ecosystem “health,” which depends on a fully functioning plant community.

Amphibian Health, Toxicology and Contaminants

Amphibians are at the interface of terrestrial and aquatic food webs as a result of their complex life cycles. As a result, amphibians are important biomonitoring species used to evaluate overall ecosystem health. Key parameters investigated in this activity include amphibian population biology, rates of malformations, infectious disease dynamics, stress responses, and levels of metals, NAs and PAHs in amphibian breeding ponds and amphibian tissues.

Amphibian samples were collected from ponds in the Fort McMurray area and at increasing distances from Fort McMurray. In addition, laboratory studies are used to assess impacts of pond water quality on amphibian growth and development.

The common amphibian diseases (ranavirus and chytrid fungus) were detected in several populations across the study region; also recorded were recurrent ranavirus-related die-offs at some wetlands. Amphibian tissue analyses for metals, PAHs and NAs are currently underway. Rates of malformations in the region were typically less than 5%, and abnormalities are currently being characterized with radiography and histopathology techniques; causes are also being investigated. The ranavirus-related die-offs that have taken place at some sites have had no apparent impact on population size or structure, whereas at other sites there has been complete loss of all young-of-the-year frogs, and the population structure has shifted to one of large adults only. Analyses are ongoing to understand relationships between ranavirus infections and environmental stressors such as contaminant levels and proximity to highways and mining operations.

Pond water samples have been analyzed for metal, PAH and NA concentrations. Finally, the majority of amphibian sites in this project were included in the 2013 snow sampling campaign. The snow sampling activity is monitoring concentrations of substances that accumulate over winter in snow and then wash into water bodies during the spring melt. This information will indicate the possibility of a spring "pulse" exposure of amphibian breeding sites to substances deposited from the atmosphere in the oil sands region.

Terrestrial Biodiversity and Habitat Disturbance

The thousands of species found in Canada's oil sands region have important ecological roles that promote a dynamic and resilient ecosystem. The scope and geographic breadth of biodiversity monitoring activities in the oil sands region expanded significantly in 2012 to cover the full extent of the oil sands deposits, providing valuable information on the status and trends of species ranging from soil mites to woodland caribou. This information provides the foundation needed to understand the causes of biodiversity change, including the cumulative and individual effects of oil sands development. Information will inform land-use planning, environmental assessment, conservation and recovery planning, and can be used to assess the efficacy of mitigation efforts.

The vast area, the diversity of habitat types, and the great variety of species that inhabit and interact throughout the area represent significant challenges to implementing a comprehensive biodiversity monitoring program.

In 2012–2013, the Implementation Plan's biodiversity component was jointly delivered by the following organizations:

- Alberta Biodiversity Monitoring Institute (ABMI);
- Alberta Environment and Sustainable Resource Development (ESRD);
- Environment Canada (EC); and
- Ecological Monitoring Committee for the Lower Athabasca (EMCLA).

During 2012–2013, biodiversity monitoring was enhanced and improved by:

- Increasing by more than 50% the level of core biodiversity monitoring activity in the region compared with 2011;
- Implementing full monitoring at 64 sites and partial monitoring at 7 other sites;
- Completing spring surveys to measure land birds, ecological site conditions, trees, downed woody material and soil arthropods;
- Completing summer surveys to measure vascular plants, moss and lichens;
- Completing wetland surveys to measure vascular plants, aquatic invertebrates and water physio-chemistry;
- Completing winter surveys to measure mammals; and
- Completing remote sensing surveys to measure vegetation cover and human footprint in 21 km^2 areas surrounding each monitoring installation.

Related activities completed included:

- Created a GIS inventory of human footprint and vegetation for the entire oil sands region. Products are available on the ABMI website for download by all stakeholders.
- Worked with the Royal Alberta Museum to identify and curate field samples.
- Conducted quality control on all data collected during 2012 and prepared data for public release. Released 2011 data is available at the ABMI website and the Portal website.
- Worked with stakeholders and land managers to secure access to all monitoring installations scheduled to be surveyed during the 2013–2014 operational year.
- Conducted data analyses to support the creation of biodiversity status reports for areas in and around the oil sands region.
- Released a status report on the *Status of Landbirds in Alberta's Boreal Plains Ecozone* that also profiled the status of human footprint and landbirds in the oil sands region.

Core biodiversity monitoring delivered in 2012–2013 was supplemented by intensive monitoring of key wildlife species. The number of aerial surveys of moose and deer within the oil sands region was increased to provide critical information on the population size, distribution and trends. Aerial ungulate surveys were conducted in five wildlife management units (512, 517, 518, 528 and 541). The expanded survey effort also enabled an examination of the impacts of harvesting, predation or other disturbance on ungulate populations.

Additional monitoring was conducted in 2012 to assess cause-effects relationships between birds and oil sands disturbance; avian point-count surveys were conducted at over 1100 sites in upland and lowland habitats with a focus on habitats previously undersampled. This work was complemented by the design of conceptual models for migratory birds, which articulates the potential pathways through which oil sands development can affect birds. Models will be peer-reviewed in 2013–2014 and used to direct future monitoring efforts.

Woodland Caribou are of increasing concern in the oil sands region. Enhanced caribou monitoring in 2012–2013 has resulted in better techniques to estimate the population size of this elusive species and has assessed the genetic diversity and relationships among sub-populations in the oil sands region. In coordination with the provincial caribou program, composition surveys and caribou collaring occurred in the East Side of the Athabasca River caribou population and in the Cold Lake, Richardson, West Side of the Athabasca, Red Earth and Nipisi caribou populations. In addition, a study on caribou movement that evaluated the effects of simulated future in situ oil sands development patterns on simulated caribou movements was completed.

Barred owls were also identified as a key species for monitoring activities, as they are a good indicator for the health of old-growth boreal forests. In 2012–2013, ESRD expanded the validation of a resource selection habitat model for barred owls to include the oil sands area. This involved the generation of 579 sampling sites for northeastern Alberta to conduct owl occupancy surveys. Field work began in March 2013 and included radio-tagging a subset of owls found on occupied territories. These surveys continued into the fall of 2013.

Field work was also initiated to evaluate improvements in monitoring methods for two groups of rare species: rare vascular plants and rare vocalizing animals. The rare plants project initiated an adaptive sampling model that targets habitat with a high potential to support rare plants, and the rare vocalizing animals project tested the efficacy of using automated recording units for monitoring. Rare plant fieldwork resulted in the collection of 6408 plant observations, 73 of which were rare species.

Technical Annex II: Progress on Key Commitments

Implementation Plan Activities	**Commitments made in the Implementation Plan for FY 2012–2013**	**Progress Against Commitments for FY 2012–2013**
Table 1 – Air Quality Implementation Plan Activates (p. 17 in the original plan)		
Element – Ambient Air Quality		
Ambient Air Monitoring	Continuation and expansion of ambient monitoring network, consistent with the Integrated Monitoring Plan.	• 2012–2013 commitment met.
Fixed Platforms	Installation of three ecosystem sites downwind of oil sands region.	• 2012–2013 commitment met.
	Enhanced measurements at a site in vicinity of sources.	• 2012–2013 commitment met.
	Additional Progress	• New and archived data from existing sites posted to the Joint Canada-Alberta Oil Sands Monitoring data portal.
Monitoring Pollutant Transformation	Seasonal campaign via mobile labs and/or aircraft.	• Work began with the support of the Fort McKay First Nation to establish two ground-based monitoring sites in the Fort McKay region. • Summer 2013 airborne campaign planned. • Two portable instrument trailers for deployment to the Fort McKay sites, and a third mobile laboratory for various locations in the oil sands region have been fully equipped.
Remote Sensing and Modelling	Use remote sensing to produce maps of sulphur dioxide and nitrogen dioxide; use models to produce high-resolution air pollutant maps.	• 2012–2013 commitment met. • Additional work is being done with the National Center for Atmospheric Research to use satellite remote sensing and air mapping tools to improve detailed mapping for air quality in the oil sands region.
Focused Studies	Continued nitrogen and oxygen isotopic fingerprinting from non-oil sands sources.	• 2012–2013 commitment met.
Element – Source Emissions Monitoring		
Emissions Inventories	Compile all existing emissions databases.	• 2012–2013 commitment met.
	Continued emissions inventory development for modelling.	• An assessment of the data was performed for application to air quality models and identifying of potential information gaps.

Implementation Plan Activities	**Commitments made in the Implementation Plan for FY 2012–2013**	**Progress Against Commitments for FY 2012–2013**
	Initiate and validate methods to derive activity and topography data and emissions locations from satellite photos.	• Satellite-based emissions estimates of sulphur dioxide and nitrogen dioxide were obtained over the entire surface mining region.
Point Sources (stacks and fugitive)	Initiate process to request additional stack emissions parameters.	• Initiated.
	Obtain satellite-based emissions estimates of sulphur dioxide and nitrogen dioxide over the entire surface mining region.	• 2012–2013 commitment met.
Tailings Ponds	Continuation of intensive studies of tailings ponds including LiDAR technology.	• Alberta ESRD led a contract with the University of Alberta to test and validate several methods from measuring emissions of chemical substances from the tailings ponds. • Planning for an intensive measurement program was initiated to characterize emissions from the ponds.
Mobile and Area Sources	Study design and initial testing of on-road vehicle fleet.	• Test methodology was developed for conducting emission measurements of highway coach buses under actual operational conditions. • A large fleet operator was identified as project partner. • The test planning is continuing.
	Source characterization of dust from mines, roads, coke piles.	• 2012–2013 commitment met.
Element – Deposition		
Ecosystem Exposure	Measurement of pollutions in ecosystem settings to determine deposition and exposure. Link to wildlife monitoring below.	• Initiated.
Forest Critical Loads	Continuation of critical load studies; measurements of forest soils.	• 2012–2013 commitment met.
Enhanced Deposition	Continue measurement of polycyclic aromatic compounds and particulate metals at three sites.	• 2012–2013 commitment met.
Deposition Modeling	Continuation of deposition modelling. Modelling to understand emission, transport and fate of air pollutants.	• 2012–2013 commitment met.

Implementation Plan Activities	Commitments made in the Implementation Plan for FY 2012–2013	Progress Against Commitments for FY 2012–2013
Table 2 – Water Implementation Plan Activities (p. 19 in the original plan)		
Element – Surface Water Quality/Surface Water Quantity/Sediment		
Mainstem Water Quality	Continue to monitor items in FY 2011–2012.	• Increased to 7 sites with 5 sites monitored 12/year and 2 sites monitored quarterly.
	Initiate quarterly sampling at three sites.	• 2012–2013 commitment met (M3, M6, M7).
	Initiate detailed method comparison and quality management of field methods and data comparability studies between AEW [ESRD] and EC. Also review ongoing role for one AEW [ESRD] LTRN site.	• 2012–2013 commitment met including full sampling at site M2.
	Conduct technical workshops with appropriate parties to address the technical/logistical details to operationalize the Implementation Plan.	• 2012–2013 commitment met (e.g., EC, ESRD, RAMP).
	Align current RAMP program with this joint Implementation Plan, and reflecting the Integrated Monitoring Plan.	• Initiated.
Tributary Water Quality	Conduct monthly sampling at 26 tributary sites.	• 2012–2013 commitment met. • Conducted monthly sampling at 27 tributary sites.
	Continue Benthos/CABIN and fish work supporting water quality.	• 2012–2013 commitment met.
	Add three additional monitoring sites on the tributaries, including the MacKay.	• 2012–2013 commitment met.
	Additional Progress	• Modelling was initiated, utilizing snow-contaminant data to assess snow transport/deposition processes on selected tributaries of the lower Athabasca.
Expanded Geographic Extent (PAD; Slave River; Lake Athabasca)	Increase number of locations; establish sampling frequency.	• Increased the number of locations from five to nine. • Surface water sampling at nine locations. • Sampled monthly except during river freeze-up and break-up periods. • Open water passive sampling increased from one to three locations. • Under Ice passive sampling increased from two to three locations. • Automated continuous monitoring initiated at one location.

Implementation Plan Activities	**Commitments made in the Implementation Plan for FY 2012–2013**	**Progress Against Commitments for FY 2012–2013**
Event-based Sampling	Initiate sampling sites and monitoring frequency.	• Initiated an intensive and extensive tributary spring freshet (snowmelt) monitoring program. • Increased sampling frequency to weekly during spring freshet (snowmelt) at M4 and M5.
Passive Sampler Program	Increased sampling frequency at existing sites.	• Deferred to 2013–2014; high flow conditions in the Lower Athabasca mainstem and tributaries hampered successful deployment and retrieval of passive samplers.
Groundwater Quality	Continue monitoring program as per Baseline year.	• 2012–2013 commitment met.
Water Quantity	Mainstem: Continue core monitoring (four sites); enhance current AEW [ESRD] water level sites.	• 2012–2013 commitment met.
	Undertake detailed planning and budgeting (locations, operating periods, manual measurements) for expansion of hydrometric network.	• 2012–2013 commitment met. • New hydrometric monitoring station added to the Ells River in 2013.
	Initiate validation of comparability of RAMP Climate and Hydrology Program methods.	• Initiated.
	Trib sites and Expanded Geographic Extent: evaluate as part of detailed planning and budgeting exercise.	• 2012–2013 commitment met.
River Ice Modelling	Establish sites and monitoring frequency.	• 2012–2013 commitment met.
Sediments	Benthos/CABIN and fish work to generate supporting sediment quality data.	• 2012–2013 commitment met.
	Collect five more sediment cores from lakes for paleo-analyses.	• 2012–2013 commitment met. • Seven additional sediment cores were obtained from lakes.
	Initiate sediment sampling using historical WSC methods at one site.	• 2012–2013 commitment met.
	Initiate sediment sampling research/surveillance studies.	• 2012–2013 commitment met.
	Process-based sediment monitoring in mainstem/tribs: initiate sampling program.	• 2012–2013 commitment met.
Element – Benthic Invertebrates		
Mainstem	Mainstem – implement up to 10 sites.	• 2012–2013 commitment met; implemented 11 sites.

Implementation Plan Activities	**Commitments made in the Implementation Plan for FY 2012–2013**	**Progress Against Commitments for FY 2012–2013**
Tributaries	Tributaries – implement up to 6 additional sites (36 sites in total).	• 2012–2013 commitment met; implemented 50 tributary sites.
	Initiate detailed comparison of existing and proposed monitoring programs and integrate where appropriate for both mainstem and tributary sites.	• 2012–2013 commitment met.
Deltaic Ecosystem Health	Biota/WQ/Sediments continue at Base sites; increase sample frequency.	• 2012–2013 commitment met. • Increased sampling sites from 8 to 16 sites; twice/year.
Element – Snow/Wet Precipitation (Acid Deposition to Acid-Sensitive Lakes and Snowpack		
Snow and Atmospheric Deposition	Continue to monitor items identified 2011–2012 year.	• 2012–2013 commitment met.
	Expand coverage of all snow sites on mainstem, tributary and landscape locations.	• 2012–2013 commitment met.
	Wet precipitation sites co-located with three WBEA sites: continue.	• 2012–2013 commitment met.
Element – Fish Health/Toxicology/Contaminant		
Wild Fish Health	Mainstem: increase to six sites.	• Initiated: wild fish collections attempted at six sites, collections made at five sites, extremely high water levels prevented fish collection at one location.
	Tributaries: increase to eight sites.	• 2012–2013 commitment met: collections made at 10 tributary sites.
Wild Fish Communities / Species Diversity	Continue Mainstem and Tributary monitoring as per 2011–2012.	• 2012–2013 commitment met.
	Align RAMP fish program with the program under the Integrated Monitoring Plan.	• 2012–2013 commitment met.
Fish Toxicology	Tributaries – implement all sites.	• 2012–2013 commitment met.
	Snow – maintain current sampling (8 sites; 1/yr).	• 2012–2013 commitment met. Snow was sampled at 18 sites (6 sites replicated 3x to assess consistency of atmospheric deposition).
	Ponds – ponds, seeps and groundwater to be determined.	• 2012–2013 commitment met.
Riverine In-situ Bioassays	Establish sampling program as per the Integrated Monitoring Plan.	• 2012–2013 commitment met.
Lake Health (Fish/Invertebrates)	Establish sampling program as per the Integrated Monitoring Plan.	• 2012–2013 commitment met.

Implementation Plan Activities	**Commitments made in the Implementation Plan for FY 2012–2013**	**Progress Against Commitments for FY 2012–2013**
Element – Acid-Sensitive Lakes		
Acid-Sensitive Lakes	Sample more than 250 lakes.	• 2012–2013 commitment met; sampled over 340 lakes in AB, NT and SK.
	Continue to monitor lakes in RAMP program.	• 2012–2013 commitment met.
	Initiate assessment of existing lake data to support long-term lake monitoring.	• 2012–2013 commitment met.
	Conduct an extensive survey of lake in NE Alberta to identify additional lakes for long-term acid deposition monitoring.	• 2012–2013 commitment met.
Element – Focused/Site-specific Assessments		
Representative Sub-basin Studies (REPS)	Representative Sub-basin Studies (REPS) – analyses/integration of REP work in Muskeg River Basin: water hydrology, sediments, groundwater and atmospheric deposition.	• 2012–2013 commitment met.
Maintstem – paired buoys	Deploy buoys with multiple WQ, sediment, hydraulic instruments at two sites, open-water season.	• Deferred.

Implementation Plan Activities	Commitments made in the Implementation Plan for FY 2012–2013	Progress Against Commitments for FY 2012–2013
Table 3 – Wildlife Contaminants and Toxicology Monitoring Program Implementation Plan Activities (p. 23 in the original plan)		
Element – Wild Bird Health and Contaminants		
Colonial Water Bird Health and Contaminants	Gulls and Terns: Eggs collected at Rocky Point (WBNP), Mamawai Lake (WBNP) and Egg Island (Lake Athabasca).	• 2012–2013 commitment met at Mamawi Lake (WBNP), Egg Island (Lake Athabasca) and Dalmead Reservoir (reference site near Calgary). • Reconnaissance complete for other egg collection locations.
Insectivorous Bird Health and Contaminants	Swallows: Eggs collected N and S of Fort MacKay, S of Fort McMurray	• 2012–2013 commitment met at Fort Chipewyan. • Reconnaissance complete for other egg collection locations.
Element – Amphibian Health/Toxicology/Contaminants		
Wild Amphibian Health Contaminants	Amphibian samples collected from ponds in the Fort McMurray area and from ponds over an expanded geographical area at increasing distances from Fort McMurray.	• 2012–2013 commitment met.
Amphibian Laboratory Exposures and Effects	Assessing impacts of water quality on amphibians using pond water.	• Deferred to 2013 amphibian breeding season.
Element – Bird Health and Toxicology		
Laboratory Exposure and Effects – Air Emissions	Exposures of laboratory birds to VOCs and SO_2.	• 2012–2013 commitment met.
Field Exposure and Effects – Air Emissions / PAHs	Nest boxes installed radially around three processing plant and in reference location.	• 2012–2013 commitment met.
Element – Wild Bird and Hunter/Trapper Harvested Wildlife Toxicology and Contaminants		
Dead and Moribund Bird Contaminants and Toxicology	Birds collected from tailings ponds near Fort McMurray (event-based).	• Deferred. Collaboration is being established to retrieve these birds in the future.
Hunter/Trapper Harvested Wildlife Contaminants and Toxicology	Animals harvested/trapped at various locations processed for contaminants and toxicology.	• 2012–2013 commitment met.
Element – Plant Health and Contaminants		

Laboratory Phytotoxity and Contaminants	Greenhouse exposures to NA_2SO_4, and naphthenic acids.	• 2012–2013 commitment met.
Field Vegetation Assessment/Contaminants	Vegetation assessments undertaken at various locations along the Athabasca River.	• 2012–2013 commitment met.

Implementation Plan Activities	Commitments made in the Implementation Plan for FY 2012–2013	Progress Against Commitments for FY 2012–2013
Table 4 – Biodiversity and Land Disturbance Monitoring Implementation Plan Activities (p. 25 in the original plan)		
Element – Core Terrestrial Biodiversity Monitoring		
	Enhancement of monitoring effort into other oil sands areas and all areas within the Lower Athabasca regional planning area (70–80 sites).	• 2012–2013 commitment met: ABMI terrestrial spring, terrestrial summer and wetland surveys at 99 sites.
	Periodic population or trend assessments of key provincial species (e.g., moose, deer, wolf).	• 2012–2013 commitment met: aerial moose and deer surveys conducted over southern and western portions of the oil sands region.
Element – Cause-effects Monitoring		
	Cause-effects monitoring of key migratory songbirds.	• Initiated: Statistical evaluation of the precision of major bird trend monitoring programs operating within the oil sands region.
	Design of cause-effects monitoring program for wetland-associated birds.	
Element – Measurement Harmonization		

	Development of an approach to integrate biodiversity monitoring effects in the oil sand areas by industry and other stakeholders (biodiversity monitoring data by oil sands developers, universities, etc.)	• Initiated:
		  ◦ Monitoring protocols and techniques for rare plants, wetland birds, owls and bats investigated.
		  ◦ Industry partners beginning to implement autonomous recording units using a methodology that is harmonized with the core biodiversity monitoring system.

Element – Species at Risk (SAR) and Rare/Difficult Species Monitoring		
	Annual caribou tracking and assessment of recruitment.	• 2012–2013 commitment met: aerial surveys. • Assessment of recruitment initiated: Caribou fecal pellet samples were obtained from 150 sites for DNA analysis to estimate herd size.
	Monitoring of Whooping Crane.	• 2012–2013 commitment met; monitoring migration over oil sands region.
	Design of augmented biodiversity core program to address gaps in status and trend and cause-effects monitoring of species at risk and rare/difficult species (e.g., increase detection probability of key species).	• 2012–2013 commitment met.

Element – Human Disturbance Footprint Monitoring		
	Mapping of human disturbance footprint at 3 x 7 km survey panels and coarse scale wall-to-wall mapping.	• Initiated.
	Augmented fine-scale wall-to-wall footprint mapping for oil sands regions and other reference areas, with participation of cooperating agencies.	
Element – Habitat Monitoring		
	Collection of vegetation and other ground-based habitat data.	• Initiated programs to: • Develop and test methods to monitor vegetation recovery on seismic lines, well sites and in cut blocks. • Develop and test methods to create a predictive ecosite map for the oil sands region. • Fill gaps in oil sands enhanced wetland layer and enhanced upland vegetation cover.
	Expand core land cover monitoring, with participation of cooperating agencies and initiatives to collect remote-sensed and high-resolution photo data.	• Initiated.
	Continue work to assess potential of remote-sensed and high-resolution photo data for biodiversity prediction. Assess ability to interpret and classify data sources to provide key habitat features relevant to key species that are the focus of cause-effects monitoring.	• Initiated.

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VII. Abbreviations

Organizations

ABMI	Alberta Biodiversity Monitoring Institute
CCME	Canadian Council of Ministers of the Environment
EC	Environment Canada
RAMP	Regional Aquatic Monitoring Program
ESRD	Alberta Ministry of Environment and Sustainable Development, formerly Alberta Environment and Water (AEW)
WBEA	Wood Buffalo Environmental Association

Substances

Elements		Compounds	
As	Arsenic	BTEX	Benzene, Toluene, Ethylbenzene, Xylene
Ag	Silver	CH_4	Methane
Be	Beryllium	CO_2	Carbon dioxide
Cd	Cadmium	NA	Naphthenic acid
Cr	Chromium	NA_2SO_4	Sodium sulfate
Cu	Copper	NO_x	Oxides of nitrogen
Hg	Mercury	PAC	Polycyclic aromatic compounds
Ni	Nickel	PAH	Polycyclic aromatic hydrocarbons
Pb	Lead	PCDD	Polychlorinated dibenzodioxins
Sb	Antimony	PCDF	Polychlorinated dibenzofurans
Se	Selenium	SO_x	Oxides of sulphur
Tl	Thallium	TGM	Total gaseous mercury
Zn	Zinc	VOC	Volatile organic compounds