THE JOURNEY TOWARDS SUSTAINABILITY

Over the course of the last decade, Alberta has experienced extraordinary economic growth due to the rapid expansion of the oil sands industry. Growth in the oil sands has also led to increased pressure on the province’s natural environment. Ensuring the protection of the environment while maximizing the social and economic benefits for Albertans from oil sands development is vital to the success of our province. To achieve this, we have in place strict standards and on-the-ground measures to protect our air, land, water and wildlife during oil sands development. But more can be done.

Developing non-renewable resources, such as the oil sands, is not inherently sustainable. This booklet outlines the potential environmental impacts of oil sands development, and explains how government, industry and communities are working together to ensure Alberta’s environment is protected throughout the development of the oil sands. Through these innovative plans and actions, and advancements in new technologies, we are on the journey towards sustainability.

ALBERTA’S OIL SANDS

Composition of Oil Sands

Each grain of sand is surrounded by a layer of water and a film of bitumen

Source: Canadian Centre for Energy Information
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As world demand for crude oil continues to grow, the oil sands deposits of northern Alberta represent one of the few reliable, long-term sources of supply. The oil sands reserves are larger than the reserves of Iran, Iraq or Russia, and are second only in size to those of Saudi Arabia.

The Alberta oil sands resource is estimated to contain as much as 1.7 trillion barrels of bitumen. The reserves - the amount that can be recovered economically with existing technology - are estimated to hold 170 billion barrels of recoverable bitumen, which would be enough to produce 3 million barrels per day for over 150 years.

The oil sands are contained in three major areas of northern Alberta beneath approximately 142,200 km² - an area similar in size as the state of New York, or twice the size of New Brunswick. Surface mining can only be used in a 4,800 km² area within the Athabasca oil sands - an area similar in size as the state of Rhode Island or smaller than the size of the Greater Toronto Area.
TWO WAYS TO RECOVER BITUMEN – SURFACE MINING AND IN-SITU

Surface mining is used when the oil sands are close to the surface, using huge trucks and power shovels. The oil sands are transported to a processing facility where hot water is used to separate the bitumen from the sands. About two tonnes of oil sands must be dug up, moved and processed to produce one barrel of oil. Only 20 per cent of the oil sands are shallow enough to be recoverable through surface mining and only in an area north of Fort McMurray along the Athabasca River Valley.

The remaining 80 per cent are recoverable through in situ technology. In situ is the Latin term for “in place”. In situ production recovers deposits that are deeper underground, using techniques that are similar to conventional oil production. The first commercial in situ extraction method was cyclic steam stimulation (CSS) in which the same wellbore is used for both steam injection and bitumen recovery. More recently, steam-assisted gravity drainage (SAGD) has gained popularity and is the most common method used in new projects. SAGD uses parallel horizontal wells, one above the other. Steam is injected into the upper well to heat and release the bitumen so that it can flow to the lower well and then be pumped up to the surface. In situ methods are used in all three major oil sands areas for deposits usually 400 metres below the surface.

Source: Canadian Centre for Energy Information
UPGRADING

Bitumen requires special processing or “upgrading” to make marketable commodities, such as gasoline, diesel and aviation fuel. Upgrading involves the use of temperature, pressure and catalysts to “crack” the big molecules into smaller ones. Adding hydrogen and/or removing carbon then creates hydrocarbon molecules like those in conventional light crude oil. Hydrogen is manufactured from natural gas and steam. Carbon removal is called coking. Further processing stabilizes the products and removes impurities such as sulphur. Upgrading and refining can be done remotely for both types of recovery. About half of the Alberta oil sands production in 2005 was upgraded into a “synthetic oil” product similar to conventional light crude oil, and the remainder was crude bitumen diluted for shipment by pipeline to refineries.

DEFINITIONS:

Bitumen: Petroleum that exists in the semi-solid or solid phase in natural deposits. Bitumen is best described as a thick, sticky form of crude oil, so heavy and viscous (thick) that it will not flow unless heated or diluted with lighter hydrocarbons. At room temperature, it is much like cold molasses and at 10 degrees celsius it is as hard as a hockey puck.

Oil Sands: Oil sands, sometimes referred to as tar sands, are naturally occurring mixtures of bitumen, sand, water, small amounts of heavy metals and other contaminants. Each grain of sand is surrounded by a layer of water and a film of bitumen. The oil sands are found mainly in the Athabasca, Peace River and Cold Lake areas of Alberta.

LAND USE AND RECLAMATION

FAST FACTS

OIL SANDS AREA

Alberta’s oil sands cover an area of 140,200 km², of which 2.4 per cent can be developed through surface mining. The rest of the oil sands deposits are much deeper, and must be extracted using in situ methods.

Less than one per cent of Alberta’s boreal forest could potentially be disturbed by oil sands surface mining.

As of December 31, 2007, there was 530 km² of land disturbed due to oil sands mine operations, which is about the size of the City of Edmonton.
LAND USE AND RECLAMATION

FAST FACTS
OIL SANDS AREA

Alberta’s oil sands cover an area of 142,200 km², of which 3.3 per cent can be developed through surface mining. The rest of the oil sands deposits are much deeper, and must be extracted using in situ methods.

Roughly 1.25 per cent of Alberta’s boreal forest could potentially be disturbed by oil sands surface mining.

As of March 31, 2009, there was 602 km² of land disturbed due to oil sands mine operations, which is about the size of the City of Edmonton.
Prior to mining activity: Before any mining begins, engineers and scientists develop closure plans outlining how the area will be reclaimed after mining. These plans are submitted to Alberta Environment, in order to obtain regulatory approval to begin mining.

Tree harvest: Oil sands mining occurs in a forested region; the first step is to clear all the trees and send them to forestry operations.

Overburden removal: The topsoil, muskeg and mineral material that sits on top of the oil sands deposit is referred to as overburden. The overburden must be removed and stored for later use.

Oil sands mining: Once the mine is operating, giant trucks and shovels may remove up to 720,000 tonnes of material a day. Oil sands surface mining can create a pit that is up to 80 metres deep.

Backfilling: After the mining is complete, the leftover sand, consolidated tailings and overburden are used to fill in the mine pit.

Recontouring: The overburden is reshaped into a working landscape that allows for surface water movement and drainage, and minimal erosion. Once the general shape of the landform is complete topsoil is placed on the surface.

Revegetation: Grasses, shrubs and trees that are indigenous to the area are planted. The topsoil contains nutrients, as well as seeds and roots, which under the right conditions will begin to grow.

Monitoring: Once reclamation is completed, monitoring begins. The soil is tested for various chemical and physical properties, and tree and shrub growth and health are monitored.

Certification: Reclamation certificates are issued when monitoring over time demonstrates the land is at least as ecologically productive as it was before the area was mined.
DEFINITIONS:
Reclamation: the process of converting disturbed land to a state where it is capable of supporting the same kinds of land uses as before the disturbance.
Remediation: The process of removing, reducing or neutralizing contaminants in soil, sediments or water to prevent or minimize any adverse effects on the environment now or in the future.

RECLAMATION REQUIREMENTS
Under Alberta’s legislation, companies must remediate and reclaim Alberta’s land so it can be productive again. Alberta Environment ensures the results of the company’s remediation and reclamation activities meet the department’s strict standards and requires all reclaimed land be able to support a range of activities similar to its previous use.

FINANCIAL SECURITY
Oil sands companies must also provide financial security for reclamation. By law, oil sands companies post security equivalent to the cost of reclamation into the Environmental Protection Security Fund. Security increases as additional land is disturbed, and is returned to the company as land is reclaimed. As of March 2009, Alberta Environment held over $820 million in reclamation security from oil sands mine companies.

RECLAMATION FACTS
Major oil sands companies have planted over 7.5 million trees as part of reclamation efforts.

Currently, over 67 km$^2$ of disturbed land have been reclaimed, but not yet certified.

In March 2008, Syncrude Canada received the first reclamation certificate for a 104 hectare parcel of land. Today the land is a forested area with hiking trails and lookout points.
Currently, oil sands related greenhouse gas emissions (GHG) account for five per cent of Canada’s total GHG emissions and less than one tenth of one per cent of the world’s GHG emissions (<0.1 %)

Oil sands projects have reduced their carbon dioxide emissions intensity by up to 33 per cent since 1990, and are working towards further reductions.
CLIMATE CHANGE OR WEATHER?
Climate change is a wide-scale change in average weather over at least 30 years whereas weather is what can be observed day-to-day.

Greenhouse gases such as carbon dioxide, methane and nitrous oxide, have an important effect on the Earth's temperature, trapping heat in the atmosphere and causing global temperatures to rise, in what is called the greenhouse effect.

The natural greenhouse effect makes life on Earth possible. It is the excess of greenhouse gases that is a concern.

As temperature continues to increase in the coming years, at a global level we could see more heat waves, floods, droughts and rising sea levels. The impacts at a local level will vary, and work is currently underway to assess potential provincial impacts - risks, challenges and opportunities - resulting from a changing climate.

FROM WELLS TO WHEELS
Oil sands production and upgrading are more energy intensive than the production of conventional oil and as a result, create more greenhouse gas (GHG) emissions. Production and upgrading of the oil sands is one part of the process required to generate a barrel of oil. The complete process, also known as the life cycle, also includes refining, transporting and consumption of oil. GHG emissions are released at every stage of the life cycle. In fact, 80 per cent of total emissions come from the end-use consumption, such as emissions from burning fuel in a car or plane. When you compare the entire life cycle, oil produced from the oil sands stacks up closely to Saudi Arabian, Mexican and Nigerian oil, and actually results in fewer GHG emissions than Venezuelan oil.

GREENHOUSE GAS SOURCES IN ALBERTA
Oil sands are not the only industrial source of GHG emissions in Alberta. Coal-fired electricity plants, manufacturing and transportation industries, and other oil and gas production also create GHG emissions.
ALBERTA’S PLAN FOR THE FUTURE

In 2007, Alberta became the first in North America to legislate GHG reductions on large industrial facilities. Any facility, including oil sands facilities, that emits more than 100,000 tonnes of GHGs a year is required to reduce emissions intensity by 12 per cent.

Under this legislation, Alberta gave companies three options for meeting the emissions reduction by March 31, 2008:

- To make improvements that will reduce GHG emissions immediately,
- To buy carbon credits from other sectors that have reduced their emissions in the Alberta-based offset system, or
- To pay $15 for every tonne over their reduction target.

Results from 2008 show that companies made 10 million tonnes of actual reductions through operational changes and practices and investing in verified offsets created by other Alberta projects. In addition to emission reductions, $82.3 million was paid into the Climate Change and Emissions Management Fund in 2008, which is now worth $123.4 million. Money from this fund will be invested into developing and implementing technologies that will reduce GHGs and improve our ability to adapt to climate change.

THREE WAYS TO LOSE 200 MEGATONNES

In January 2008, the Alberta government released its new action plan to address climate change – Alberta’s 2008 Climate Change Strategy. Alberta is in a unique situation – it is experiencing extraordinary growth and is a major energy supplier for North America. The plan recognizes that GHG emissions will rise in the short-term until 2020, but as new industrial technology is implemented, overall emissions will decline.

Alberta’s emissions are projected to grow to 400 megatonnes (Mt) by 2050, largely due to forecast growth in the oil sands sector. The new plan will cut the projected 400 Mt in half by 2050, which equals a 14 per cent reduction below 2005 levels. These reductions will be achieved by using three different approaches, which are conservation and energy efficiency, carbon capture and storage and greening energy production. A bulk of the carbon capture and storage reductions are anticipated to come from activities related to projected growth in oil sands production, about 100 Mt. By using carbon capture and storage, emissions linked with a barrel of oil from oil sands productions will fall below the amount of emissions from a barrel of oil from conventional oil sources.

ALBERTA’S REDUCTION COMMITMENTS

![Diagram showing emissions targets and reductions](image-url)
CARBON CAPTURE AND STORAGE
Carbon capture and storage is a process that captures carbon dioxide emissions and stores them in geological formations one or two kilometres deep underground.

In July 2008, the Alberta government committed $2 billion to kick-start carbon capture and storage projects in Alberta. It is expected that by 2015, facilities in this initiative will capture and permanently store up to 5 million tonnes of carbon dioxide emissions per year.

Carbon capture and storage is supported by the United Nations Intergovernmental Panel on Climate Change and the International Energy Agency. Even former Vice President Al Gore supports implementing carbon capture and storage as one of the tools to address climate change. Experience from Canada and around the world has shown that carbon capture and storage is a safe technology that has positive environmental results.

WATER

WATER USE – FAST FACTS
Currently, the average oil sands surface mine uses roughly between two to five barrels of fresh water to produce a barrel of oil. The average in situ project uses roughly half a barrel of fresh water to produce a barrel of oil. Some in situ methods use water to produce steam to inject into the ground in order to heat the bitumen and pump it to the surface. In situ projects often use deep-well salt water as an alternative to freshwater where possible.
Currently, the average oil sands surface mine uses roughly between two to four barrels of fresh water to produce a barrel of oil. The average in situ project uses roughly half a barrel of fresh water to produce a barrel of oil. Some in situ methods use water to produce steam to inject into the ground in order to heat the bitumen and pump it to the surface. In situ projects often use deep-well salt water as an alternative to freshwater where possible.
WATER QUALITY

Water quality in the Athabasca River, Cold Lake/Beaver River and Peace River watersheds will continue to be protected during oil sands development. Extensive monitoring systems are in place to ensure water quality remains protected during oil sands development.

Currently, oil sands operators in the Athabasca region are required to run monitoring programs on their land, and the Regional Aquatics Monitoring Program operates over 100 water quality stations in the region.

The Athabasca River region is unique due to naturally occurring oil sands that the river runs through. Sediment from the banks of the river is caught in the current and deposits naturally occurring contaminants in the water. Data from ongoing monitoring shows there has been no increase in concentrations of contaminants as oil sands development has progressed. The main contaminants of concern are mercury, arsenic and polycyclic aromatic hydrocarbons (PAH). Stringent monitoring has shown mercury and arsenic concentrations are well below the Alberta water quality standards. The standards for PAHs are in development; however, there is evidence that PAH concentrations have been lower in recent years than they have been historically.

PROTECTING THE WATER

Protecting the waterways during oil sands development is of utmost importance to the Alberta government. The Athabasca, Peace and the Cold Lakes/Beaver Rivers are important, as they provide habitat for many plants and animals, and the Athabasca also serves as a transportation route for boaters. Water from the Athabasca River is used for community drinking water, agriculture and industrial development. Alberta Environment has set strict limits on how much water oil sands companies can remove from the Athabasca River under the Water Management Framework for the Lower Athabasca River. A Cold Lake-Beaver River Water Management Plan is in place for the basin to protect surface water and groundwater quantity and quality.

The Water Management Framework for the Lower Athabasca River sets a world standard by placing a high degree of protection on a waterway to avoid future environmental impacts. This framework puts a weekly cap on how much water oil sands companies can remove, based on the natural and seasonal changes in river flow. During periods of low river flow, water consumption is limited to the equivalent of 1.3 per cent of annual flow. This means industrial users could be restricted to less than half of their normal requirement. Limiting withdrawals encourages each oil sands operation to conserve water and ensures healthier aquatic ecosystems. The next phase of this framework is currently in the works, and will put emphasis on the river’s ecosystem protection.
WATER USE IN AN OIL SANDS MINING OPERATION

Trucks dump raw oil sands into crushers.

Crusher breaks oil sands into smaller pieces.

Slurry Preparation Vessel: Hot water is added and mixed with oil sands.

Primary Separation Vessel: More hot water is added to slurry to separate bitumen.

Froth Treatment Vessel: Water & solvents added to further separate bitumen.

Bitumen froth floats to top & is skimmed off & sent for froth treatment.

Oil sands slurry sent to extraction plant via Hydrotransport pipelines.

Bitumen froth sent to upgrading.

Tailings Pond

Recyclable clear water from tailings pond.

Waste water mixed with clay, sand & excess bitumen, pumped into tailings ponds.

Fresh river water.

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All current and approved oil sands facilities are allocated less than three per cent of the average annual flow of the Athabasca River.

**WATER MANAGEMENT - FAST FACTS**

Oil sands companies are continuing to improve their water usage. Roughly 85 per cent of the water used during mining can be recycled depending on how long the facility has been operating and the process it uses. It is possible for in situ operations to use 100 per cent recycled and deep-well salt water in their facilities, and not withdraw any freshwater.

**WATER USE – FAST FACTS**

Oil sands actual water use is less than one per cent of the Athabasca River’s average annual flow.
TAILINGS PONDS

FAST FACTS

The average 100,000 barrel a day facility processes about 195,000 tonnes of oil sands per day, creating almost 20,000 m³ of fine tailings. This is enough to fill over 8 Olympic-size swimming pools.

The footprint of current tailings facilities is about 130 km², which represents 22 per cent of the 602 km² disturbed by oil sands mines as of March 2009.

The first tailings pond is scheduled to be partially reclaimed by 2010.
The oil sands tailings are a mix of water, sand, clay, small amounts of bitumen, and chemicals that are of concern from an environmental perspective, such as polycyclic aromatic hydrocarbons (PAHs), naphthenic acids, heavy metals and mineral ions that increase salt levels. Over time the tailings separate into layers within the tailings ponds.

1. Coarse sands settle to the bottom rapidly.
2. Finer solids, such as clay and silts, remain in a floating layer called fluid fine tailings. Over a few years, excess water settles out of the fluid fine tailings and the solids sink down into the mature fine tailings layer.
3. Mature fine tailings are heavier than the fluid fine tailings because they contain more solid materials; therefore, they settle underneath the fluid fine tailings. Mature fine tailings are a great concern because it may take anywhere from a few decades to 150 years to fully settle. Recent technology has led to the invention of consolidated tailings, which can separate out excess water in a relatively short time span (3-5 years).
4. Clear water separates out of the tailings and rises to the top of the tailings pond.
5. This water is pumped out of the tailings pond and reused in the extraction process, allowing companies to use less fresh water from the Athabasca River.
6. Some remaining bitumen will separate from the tailings and float to the surface of the tailings pond in the form of an oily slick, which can be a significant threat to birds if they land on the surface. Deterrence systems are mandatory to prevent birds from landing on the tailings ponds.
WHY DO TAILINGS PONDS EXIST?
Fluid tailings are produced because water is used to extract bitumen from the oil sands. One key reason for tailings ponds is that provincial law strictly prohibits the release of water that has been in contact with bitumen, into water bodies off the mine site, including the Athabasca River. The ponds serve four important functions:

1) a disposal area for coarse and fine tailings
2) a settling pond (allowing water to separate from solid waste materials)
3) a place to store water for recycling
4) a place to hold contaminants

MANAGEMENT OF TAILINGS PONDS
Tailings management remains one of the most difficult challenges for the oil sands mining sector to address. Any proposal to construct a new tailings pond is thoroughly examined by technical experts from the Alberta government.

Every effort is made to ensure the design and proposed location of a pond is suitable from an environmental, resource conservation, public safety and economic point of view.

All tailings ponds are constructed with groundwater monitoring and seepage capture facilities. Monitoring ensures seepage is minimized and that surface water is not impacted. As an added level of protection, ditches are constructed around the tailings ponds to intercept any seepage from entering regional groundwater systems or waterways. Research and development is key to ensuring tailings are reclaimed quicker, and that future tailings are built more environmentally friendly. New technologies under development are focusing on consolidated tailings, dry tailings, and enhanced water use to reduce the need for and the size of tailings ponds.

In 2008 and 2009, the Alberta government provided over $4.5 million towards furthering tailings research.

In June 2008, the Alberta government released a set of guidelines that require oil sands companies to follow a tougher set of rules for managing tailings. The guidelines lay out specific enforcement actions if the rules are not followed.

Suncor’s research demonstrates the reclamation potential of wetlands containing consolidated tailings and recycled water.
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AIR QUALITY

The burning of any type of fossil fuel results in air emissions that have the potential to affect human and environmental health.

Air quality is monitored 24 hours a day, every day of the year in the oil sands region.

Improved pollution controls and regulations, plus new technologies such as flue scrubbers, have reduced the emissions intensity of pollutants that can cause smog and acid rain.

FAST FACTS

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The Air Quality Index (AQI) is a way of measuring the cleanliness of outdoor air, also known as ambient air. Alberta Environment measures the concentrations of five major air pollutants—carbon monoxide, fine particulate matter, nitrogen dioxide, ozone and sulphur dioxide—and averages those readings to an AQI number every hour. The higher the AQI number, the greater the level of pollution:

<table>
<thead>
<tr>
<th>GOOD AIR QUALITY</th>
<th>FAIR AIR QUALITY</th>
<th>POOR AIR QUALITY</th>
<th>VERY POOR AIR QUALITY</th>
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<tbody>
<tr>
<td>0-25</td>
<td>26-50</td>
<td>51-100</td>
<td>100+</td>
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**SULPHUR DIOXIDE (SO₂)**
A colourless gas with a pungent, rotten egg odour. Natural gas, oil sands plants and upgraders as well as power plants are major sources of sulphur dioxide in Alberta. Other minor sources include gas plant flares, oil refineries, pulp and paper mills and fertilizer plants.

**OZONE (O₃)**
Ozone is a gas that occurs both in the Earth’s upper atmosphere and at ground level. Ozone can be “good” or “bad” for people’s health and for the environment depending on its location in the atmosphere.

In the air closest to the Earth’s surface, ground-level or “bad” ozone is a pollutant that is a significant health risk, especially for children with asthma. It also damages crops, trees and other vegetation. It is a main ingredient of urban smog. Ozone is not usually emitted directly into the air, but at ground-level is created by a chemical reaction between oxides of nitrogen (NOx) and volatile organic compounds (VOC) in the presence of sunlight.

**NITROGEN DIOXIDE (NO₂)**
Nitrogen dioxide is a reddish-brown gas with a pungent odour and is partially responsible for the “brown haze” observed near large cities. Transportation (automobiles, locomotives and aircraft) is the major source of nitrogen dioxide in Alberta, and other major sources include industrial sources (oil and gas industries) and power plants. Smaller sources include natural gas combustion, heating fuel combustion, and forest fires. Nitrogen dioxide is also formed when oxides of nitrogen react with ozone in the atmosphere.

**PARTICULATE MATTER (PM₂.₅)**
Particulate matter refers to the particles in the air. Particles less than 2.5 micrometers in diameter (PM₂.₅) are referred to as “fine” particles and are believed to pose the greatest health risks. Because of their small size (approximately 1/50th the average width of a human hair), fine particles can lodge deeply into the lungs.

**CARBON MONOXIDE (CO)**
Carbon monoxide is a colourless, odourless gas that reduces the ability of blood to absorb and deliver oxygen to cells in the body. Carbon monoxide is a gas formed when carbon-based fuels such as gasoline, natural gas and wood are incompletely burned.
HYDROGEN SULPHIDE

In addition to pollutants included in the AQI, other key pollutants are carefully monitored in the oil sands regions, including oxides of nitrogen (NOx), volatile organic compounds (VOCs) and hydrogen sulphide (H₂S). Hydrogen sulphide is a colourless gas with a rotten egg odour. Industrial sources include emissions from petroleum refineries, tank farms for unrefined petroleum products, natural gas plants, petrochemical plants, oil sands plants, sewage treatment facilities and some pulp and paper plants. Natural sources include sulphur hot springs, sloughs, swamps and lakes.

Concentrations of hydrogen sulphide remain well below Alberta Environment’s guidelines most of the time, but there have been a number of instances when some measurements are elevated and exceed guidelines. This is usually the result of conditions or events at processing facilities/oil sands plants. Alberta Environment is notified every time there is a guideline exceedance, and takes action to correct the problem if necessary.

PROTECTING OUR AIR

Air quality is protected in Alberta by:

• Requiring companies to use the best technology possible in order to reduce air emissions and odours from industry.
• Making sure companies meet air quality standards. This can be done by monitoring air quality, having regulators visit sites and inspect what is happening, and by giving fines or environmental protection orders if companies aren’t meeting the standards.
• Monitoring local air quality around the oil sands and nearby communities through partnerships made up of the Alberta government, industry, First Nations, and community members.

FAST FACTS

The air quality in Fort McMurray, the closest urban area to the Athabasca oil sands, was rated good 98 per cent of the time during 2008.

Air quality in the oil sands region is consistently rated better than major Canadian cities, such as Vancouver or Montreal.

Since 1995, monitoring in the oil sands region indicates four out of the five key air quality pollutants used to calculate the Air Quality Index show an improvement or no change in long-term air quality trends. Only nitrogen dioxide demonstrated an increasing trend. As well, air monitoring has shown increases in hydrogen sulphide exceedances in the Fort McMurray area and near oil sands upgraders.
For more information contact Alberta Environment’s Information Centre at (780) 427-2700 (toll free, dial 310-0000)

You can also visit the Alberta government’s oil sands website: www.oilsands.alberta.ca