Drilling DEEPER

THE IN SITU OIL SANDS REPORT CARD

JEREMY MOORHOUSE • MARC HUOT • SIMON DYER

March 2010

the PEMBINA institute
25 years
of Sustainable Energy Solutions

Oil SANDS Fever SERIES

Drilling Deeper

The In Situ Oil Sands Report Card

Jeremy Moorhouse
Marc Huot
Simon Dyer

March 2010

the PEMBINA institute
25 years
of Sustainable Energy Solutions

About the Pembina Institute

The Pembina Institute
Box 7558
Drayton Valley, Alberta, T7A 1S7
Phone: 780-542-6272
E-mail: info@pembina.org

The Pembina Institute is a national non-profit think tank that advances sustainable energy solutions through research, education, consulting and advocacy. It promotes environmental, social and economic sustainability in the public interest by developing practical solutions for communities, individuals, governments and businesses.

The Pembina Institute provides policy research leadership and education on climate change, energy issues, green economics, energy efficiency and conservation, renewable energy, and environmental governance. For more information about the Pembina Institute, visit **www.pembina.org** or contact **info@pembina.org**.

Acknowledgements

The Pembina Institute thanks the William and Flora Hewlett Foundation for its support of this work. The Pembina Institute would also like to acknowledge the support of Cenovus, Shell and Husky for participating in this process. Each of these companies graciously reviewed and commented on the data the Pembina Institute had collected for this analysis. Their comments and insights improved the quality of this report and the Pembina Institute's understanding of in situ operations.

About the Authors

Jeremy Moorhouse

Technical Analyst

Jeremy is a Technical Analyst with the Pembina Institute's Corporate Consulting team. He provides technical analysis for life cycle value assessments for decision-making. Jeremy's other projects include conducting research into practices and strategies for sustainability and evaluating the performance of current and proposed oil sands projects. Assessing and evaluating emerging technologies is also a key focus of Jeremy's work. His technical background includes experimental mining equipment design and production, as well as experimental data analysis. He has experience and knowledge in energy systems, water management and solid-waste management. Jeremy holds a bachelor's degree in mechanical engineering from McGill University.

Simon Dyer

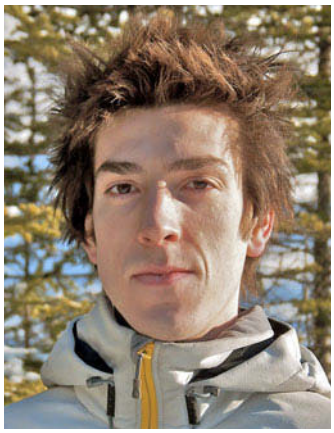
Oil Sands Program Director

Simon Dyer is a registered professional biologist and has worked on land use issues in western Canada since 1999. Simon represented the Pembina Institute on the Sustainable Ecosystems Working Group of the Cumulative Environmental Management Association (CEMA). Simon holds a Master of Science in environmental biology and ecology from the University of Alberta, and a Master of Arts in natural sciences from Cambridge University. Simon is the co-author of *Death by a Thousand Cuts: Impacts of In Situ Oil Sands Development on Alberta's Boreal Forest* and *Haste Makes Waste: The Need for a New Oil Sands Tenure Regime.*

Marc Huot

Policy Analyst

Marc Huot is a Policy Analyst with the Pembina Institute's Oil Sands Program. Marc is involved with researching and reviewing environmental impacts associated with oil sands development. His technical background includes knowledge of renewable energy, life cycle assessment methodology and energy systems. Marc holds a Bachelor of Science and a Master of Science in mechanical engineering from the University of Alberta.



Drilling Deeper: The In Situ Oil Sands Report Card

March 2010

Editor: Roland Lines
Layout: J&W Communications Inc
Cover Photo:
Courtesy of Husky Energy

Cover Photo / Inset:
David Dodge, The Pembina Institute

The Pembina Institute
Box 7558
Drayton Valley, Alberta
T7A 1S7 Canada

Phone: 780-542-6272
E-mail: info@pembina.org

Additional copies of this publication may be downloaded from our website, www.oilsandswatch.org.

the PEMBINA institute 25 years of Sustainable Energy Solutions

Table of Contents

List of Figures

List of Tables

Executive Summary

▲ *Forest fragmentation is one of the environmental impacts of in situ oil sands development.*

PHOTO: DAVID DODGE, THE PEMBINA INSTITUTE

Development of deep oil sands deposits using in situ (in place) extraction techniques is growing rapidly in Alberta, Canada. There is limited information and discussion about the environmental impacts and performance of in situ oil sands development. This report represents the first attempt to compare the environmental performance of in situ oil sands operations that were in operation in 2007 (the most recent period for which data was publicly available). The oil sands companies were asked to respond to questions in five categories: general environmental management, land, air emissions, water and climate change.

The average score for in situ operations in the survey was 44%. Suncor Firebag received the highest overall score of 60%, followed closely by Cenovus Foster Creek (57%), Imperial Oil Cold Lake (55%) and Suncor MacKay River (53%). Canadian Natural Primrose / Wolf Lake received the lowest overall score (25%).

Project	General Environmental Management (out of 3)	Land (out of 5)	Air Emissions (out of 3)	Water (out of 4)	Climate Change (out of 2)	Overall Score
Suncor Firebag	1.5	3	1.75	3	1	60%
Cenovus Foster Creek	2	2.75	2	2	1	57%
Imperial Oil Cold Lake	2.5	2*	1.25	2.5	0.5	55%
Suncor MacKay River	1.5	2.5	1.75	2.5	0.75	53%
AVERAGE	**1.83**	**2.36**	**1.06**	**1.56**	**0.50**	**44%**
Shell Peace River (demonstration)	3	3*	0	0	0	38%
Cenovus Christina Lake (pilot)	2	2	1.5	0	0.75	37%
Husky Tucker (start-up)	2	3	0	1	0	35%
JACOS Hangingstone (demonstration)	0.5	2*	0.5	2	0.5	34%
Canadian Natural Primrose/Wolf Lake	1.5	1	0.75	1	0	25%

▲ *Summary of project scores (*Imperial Oil Cold Lake, Shell Peace River and JACOS Hangingstone were scored out of four for land indicators because they were not scored on land use intensity.)*

Key Findings

1. CLEAR ROOM FOR IMPROVEMENT

The majority of in situ operators lagged in the following areas:

- Few projects have established absolute reduction targets for air emissions, water use and GHG emissions that go beyond government requirements.
- Few projects have invested in biodiversity offsets to compensate for the impacts associated with in situ development.
- Only three companies currently support regional biodiversity monitoring.
- Only two companies have third-party accredited environmental management systems for their projects.

2. POOR DISCLOSURE OF ENVIRONMENTAL PERFORMANCE DATA

The quality and quantity of project-specific environmental data makes comparing in situ projects a time-consuming enterprise. There is limited publicly available and accessible environmental impact data to inform discussion of in situ environmental performance.

3. IN SITU AND MINING PROJECTS BOTH HAVE SIGNIFICANT ENVIRONMENTAL IMPACTS

While the analysis shows that oil sands mining is more intensive on a per barrel basis in some environmental impact categories, such as land use, nitrogen oxide emissions and water intensity, a typical in situ project has more intensive greenhouse gas and sulphur dioxide emissions than mining. In addition, our land intensity assessment did not incorporate the impacts of fragmentation and upstream natural gas production associated with in situ operations.[1]

4. BEST PRACTICES ARE NOT WIDELY ADOPTED

The average project score of 44% clearly demonstrates the need for improvement. A fictional project designed from the best elements of each oil sands project could achieve a score of 85% in this assessment. In other words, in situ operators could achieve a score of 85% in this assessment by incorporating current industry best practices. A 100% score is also achievable by combining current in situ industry best practices with two best practices from other industries: setting public environmental targets to reduce absolute water use, air emissions and greenhouse gas emissions; and establishing biodiversity offsets.

5. CUMULATIVE IMPACTS ARE GENERALLY NOT CONSIDERED

This assessment considers the impacts and performance of in situ oil sands projects at the project level. Given the overall pace and scale of oil sands development – in both in situ and mining operations – there is an inadequate level of environmental management to ensure that the regional environment is protected from cumulative impacts.

Recommendations for Government

Government and industry both have clear roles in improving environmental performance in the oil sands. One of the main barriers to adopting leading environmental practices is a lack of incentive. Oil sands companies that adopt leading practices receive very little reward for their environmental initiatives, while laggard companies receive very little punishment. Government can help improve environmental performance in the oil sands by creating a competitive environment that rewards environmental stewardship and innovation while penalizing laggard companies.

1. Mandate environmental stewardship

Weak government requirements for environmental performance appear to be responsible for the inconsistent application of best practices across the industry. To correct this situation, government should do the following:

- Encourage companies to establish public reduction targets by providing some benefit to companies that set targets and punishing laggard companies that do not demonstrate continuous environmental improvement.
- Mandate compensatory offsets to mitigate the terrestrial impacts of in situ oil sands development, and develop conservation offset policies as recommended by the proposed wetland policy for Alberta[2] and *Responsible Actions: A Plan for Alberta's Oil Sands*.[3]

- Integrate mandatory financial support for the Alberta Biodiversity Monitoring Institute into existing and future approvals.
- Mandate third-party accreditation of environmental management systems for in situ projects.

2. Make oil sands environmental performance data more comparable and accessible

Project-specific and cumulative oil sands in situ environmental performance data needs to be available in an accessible and comparable format.

3. Limit in situ environmental impacts

In situ operations have significant cumulative and long-term impacts and should be submitted to rigorous environmental impact assessments, monitoring and regulation.

4. Create a regulatory system that rewards innovation

In situ operators have very little incentive to improve their environmental performance. Government must consider how harness the innovative capacity of the oil sands industry to address environmental issues.

5. Halt new approvals until environmental management systems are complete

Complete a regional management system to protect the ecological integrity of Alberta's ecosystems from the cumulative impacts of oil sands development before approving new projects.

Recommendations for Industry

Government action must be supported and matched by the oil sands industry.

1. Demonstrate leadership

- Establish project-specific absolute reduction targets for water use, air emissions and greenhouse gas emissions that go beyond government requirements.
- Invest in biodiversity offsets commensurate with the terrestrial impact of the in situ project.
- Financially support the Alberta Biodiversity Monitoring Institute and integrate its results into management planning.
- Implement a third-party accredited environmental management system for the in situ project.

2. Provide accessible public data

Project-specific environmental data should be disclosed publicly in a format that is comparable across the in situ industry.

3. Focus on the issues

In situ developments have significant environmental impacts and there is significant room for improvement across the industry. Seriously engage stakeholders and publicly discuss solutions to these issues.

4. Incorporate best practices and lead improvements

Adopt current best practices and continuously improve once best practices have been adopted.

5. Acknowledge cumulative impacts of in situ development

Take a leadership role in support of establishing regional environmental thresholds and of completing land use planning.

Introduction

People in Canada, in North America and around the world are searching for sustainable energy supplies for their growing energy demands. Sources of sustainable energy would allow people to meet their needs today without sacrificing the long-term needs of future generations. More specifically, a sustainable energy source provides the environmental services (clean water, air and land), social services (health, equal opportunity and rights) and economic services (wealth, profit and tax revenue) to satisfy our needs today without preventing future generations from receiving the environmental, social and economic services they need.

The oil sands are among the most controversial energy sources in Canada. The Pembina Institute's perspective is that in order to support a transition to a sustainable energy future, any development of the oil sands must occur in a responsible manner that addresses the need to make global reductions in greenhouse gas (GHG) pollution and protects regional ecosystems.

As a way of gauging the sustainability of mining-based oil sands operations and highlighting best practices, in 2008 the Pembina Institute and World Wildlife Fund Canada published a report that compared the environmental performance of 10 existing and proposed oil sands mines. That report,

▲ *Figure 1: In situ oil sands development has the potential to occur over a region 30 times larger than the mineable oil sands area north of Fort McMurray.* PHOTO: DAVID DODGE, THE PEMBINA INSTITUTE

Under-Mining the Environment: The Oil Sands Report Card,[4] found that given existing practices and available technologies, even the top performer had significant room for improvement.

The aim of this report is to conduct a similar analysis for in situ oil sands development. It provides quantitative information on the current environmental performance of in situ oil sands projects and attempts to define what responsible in situ oil sands development means at the individual project level. In doing so, it will clearly demonstrate which companies are leading and why, and offer suggestions on how poorly performing companies can improve their environmental performance. As with the 2008 assessment, it is the first of its kind.

The importance of objectively assessing the relative environmental performance of in situ operations is three-fold.

1. Although mining is currently the dominant form of oil sands production on a volume basis, and is projected to stay dominant until 2030, the majority of oil sands deposits are only accessible through in situ technologies. Understanding the differences in environmental performance between operations can help regulators and companies design projects with less impact on the environment than current ones.
2. The individual impacts of each in situ operation contribute to cumulative environmental impacts, which can lead to significant regional environmental impacts. In the 2006 report *Death by a Thousand Cuts: The Impacts of In Situ Oil Sands Development on Alberta's Boreal Forest*,[5] the Pembina Institute and the Canadian Parks and Wilderness Society concluded that in situ oil sands development itself is an intensive and long-lived form of unconventional energy development that has significant environmental impacts. This new report, *Drilling Deeper: The In Situ Oil Sands Report Card*, offers greater context for that finding. By presenting the environmental impacts of in situ production on a project-specific basis, it can serve as a resource for regulators, companies and stakeholders to more clearly assess, limit or decrease cumulative impacts.
3. Proponents of in situ oil sands development increasingly assert that in situ production has considerably lower environmental impacts than mine-based production. To date, no one has undertaken a definitive comparison of the two modes of production on an intensity basis (or some other relative indicator), which makes it difficult for stakeholders to adequately evaluate this claim. This report compares in situ production with mining production where possible to objectively highlight the relative benefits and drawbacks of each bitumen production method. It also provides a clearinghouse of in situ data for such a comparison where none previously existed, and can therefore aid a future, more robust comparison of oil sands mining versus in situ development.

Project Scope

This report ranks thermal in situ projects that were in operation for all of 2007, including both commercial and pilot projects. The Pembina Institute chose to include only these projects for a number of factors. Firstly, during the time of the assessment only 2007 data was publicly available for active in situ projects. The Pembina Institute requested more recent data from each of the companies including in this survey, but only three responded with data. Instead of providing performance data for different years, only 2007 data were used to provide a consistent comparison. Where possible, we have noted if a project's environmental performance has improved since 2007. Secondly, based on our experience with *Under-Mining the Environment*, it is more complex to compare active projects with planned projects. Finally, the nine projects included in the assessment represent the full range of commercial in situ technologies and producing regions.

▼ *Table 1: List of projects included in the assessment*

Lead Company	Project Name	2007 Status	2007 Average Production (bbl/day)	Technology
Canadian Natural (Canadian Natural Resources Limited)	Primrose/Wolf Lake	Commercial	61,050	CSS
Cenovus (Cenovus Energy Incorporated)[6]	Christina Lake	Pilot	5,295	SAGD
	Foster Creek	Commercial	49,258	SAGD
Husky (Husky Energy Incorporated)	Tucker	Commercial Start-up	1,672	SAGD
Imperial Oil (Imperial Oil Limited)	Cold Lake	Commercial	153,459	CSS
JACOS (Japan Canada Oil Sands Limited)	Hangingstone	Demonstration	7,069	SAGD
Shell (Royal Dutch Shell PLC)	Peace River	Demonstration	9,560	mix of techniques[7]
Suncor (Suncor Energy Incorporated)	Firebag	Commercial	36,893	SAGD
	MacKay River	Commercial	21,248	SAGD

Table 1 contains a list of all the projects included in the assessment. The two Canadian Natural projects – Primrose and Wolf Lake – are grouped together in this survey because that is how Canadian Natural reports the data in public submissions and applications.

In addition to its research and advocacy work, the Pembina Institute provides consulting services to industry, government, First Nations and environmental organizations. Since 2006, Pembina Corporate Consulting has completed work for Suncor Energy Ltd. and Shell Canada Ltd. This consulting work has influenced neither the development nor the results of this survey; rather it helped to provide the Pembina Institute with the appropriate technical knowledge to complete this comparative analysis.

Data Collection

The Pembina Institute first gathered information on all of the indicators from public data sources, primarily the Alberta Energy and Resources Conservation Board (ERCB) in situ oil sands progress reports, the National Pollutant Release Inventory (NPRI) and environmental impact assessments.

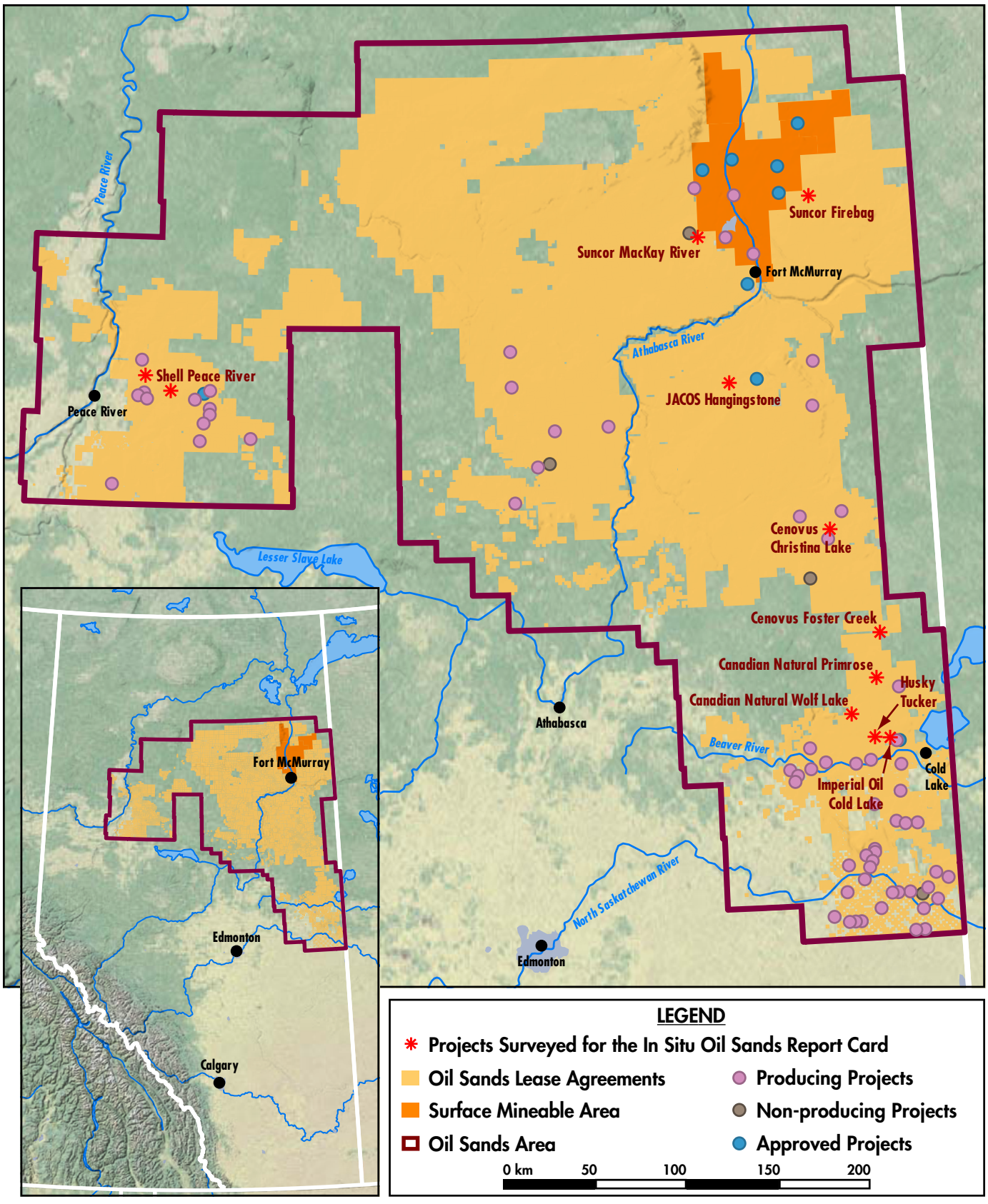
Disciplinary specialists in emissions, water, land management and industrial waste at the Pembina Institute created representative questions addressing environmental performance and commitments to continually minimize environmental effects. Although the survey does not address all aspects of environmental performance, the Pembina Institute is confident that the indicators selected are representative of the environmental management challenges facing in situ operators and comprehensive enough to meaningfully rank oil sands company commitments and environmental performance.

In June and July 2009 the Pembina Institute provided each company with a completed survey and a request for review and comments. Pembina Institute staff contacted each company by telephone and by electronic mail to solicit feedback on the accuracy of the data presented. Husky, Cenovus and Shell participated in the survey, reviewed the information and provided additional context and information to improve the analysis. The Pembina Institute incorporated their comments into the analysis and informed each of the participating companies about how their information was incorporated. Canadian Natural, Imperial Oil, JACOS and Suncor responded but declined to participate in the survey.

Performance Criteria

The Pembina Institute selected criteria to use by considering the following:

- ***Environmental issues and suitable performance criteria:*** Each criterion must first represent a potential environmental issue of concern in the oil sands region that in situ developments are contributing to. For example, the *Under-Mining the Environment* report on oil sands mining operations included volatile organic compound emissions because these emissions have potential environmental impacts and the tailings ponds at mining operations emit volatile organic compounds. In situ operations, in contrast,



▲ *Figure 2: Map of in situ oil sands projects included in this report.*

PROJECT DATA: ALBERTA ENERGY, DECEMBER 2008
MAP: ROLAND LINES, THE PEMBINA INSTITUTE

emit far fewer volatile organic compounds, so these emissions were not included in the performance survey.

- ***Global Reporting Initiative (GRI):*** Many companies are familiar with GRI indicators[8] because these indicators are often used in their sustainability reports. Wherever possible, the Pembina Institute used GRI indicators to increase the comparability of this report with current corporate social responsibility reporting practices and to reduce the reporting burden of the companies providing information for this report.
- ***Public data:*** The Pembina Institute only included indicators that could be determined using public data sources because not all companies had the time or interest in participating in the survey.
- ***External validation:*** Pembina Institute staff spoke with several industry and non-governmental organizations to ensure the indicators included in this report were of value and accurately and fairly compared projects. Each company being assessed was invited to participate in the survey process to ensure the purpose was understood and the best available data could be included.

The questions themselves can be split into two main categories: quantitative questions, which relate to criteria with a numerical value, such as air emission intensity, and qualitative questions, which relate to environmental management and public policy actions. Quantitative data is based on publicly available 2007 data and some information from environmental impact assessments. This assessment uses 2007 data because that is the most recent year where data exists for all projects considered in this assessment. Where possible we have indicated whether a specific project's performance has likely increased or decreased between 2007 and present.

The survey questions are grouped into five broadly recognized areas of environmental performance and management: general environmental management, land, air emissions, water and climate change.

General Environmental Management

This section concerns principles of environmental management that are valid for any natural resource–based company or project. These principles include the development of an effective environmental policy, a strong record of compliance with environmental regulations, third-party validation of environmental management systems and transparent public reporting of environmental data associated with a project.

What follows are the specific survey questions, the context for including the questions in the survey and the equivalent GRI indicators.

1. *Does your company have an environmental policy that commits to continuous improvement in environmental performance?*

Context: A company's published environmental policy is the public expression of its environmental management system and values.

The Pembina Institute supports companies that articulate a commitment to continuous environmental improvement because companies must now be held accountable. ISO 14001 also requires that companies include a commitment to continuous improvement in their policies.[9]

GRI Indicator: None applicable

▲ *Figure 3: Industrial development within caribou ranges is largely responsible for the decline of woodland caribou herds in Alberta.*
PHOTO: WAYNE LYNCH

2. Does your oil sands operation have an environmental management system that has been accredited by an independent third party, such as ISO 14001 or equivalent?

Context: ISO 14001 is an internationally recognized standard for environmental management systems. It has clear requirements for establishing an environmental policy, determining environmental risks and setting goals to reduce environmental impacts. Third-party validation of an environmental management system provides external evidence of the rigour of the environmental management system. Although ISO 14001 does not provide standards for environmental performance, it does provide a globally recognized framework for developing an environmental management system.

GRI Indicator: None applicable

3. Do you publicly report project-specific environmental data for your project?

Context: Public reporting allows stakeholders to assess and compare the environmental performance of in situ operators. Industrial operators that provide detailed data on their operations encourage trust and assist in creating a transparent system from which environmental issues and solutions can be identified more quickly. In the context of this report card, public reporting is defined as project-specific environmental parameters that companies make directly available to the public through company websites, annual sustainability reports and government reports or websites.

GRI Indicator: None applicable

4. Please summarize all ambient air exceedances and all environmental enforcement actions (including warning letters, prosecutions, fines, etc.) in 2007 for this oil sands operation.

Context: Environmental regulations exist to ensure industrial operations do not unduly harm the natural environment. These regulations grant the government the authority to punish companies whose projects are exceeding the rules laid out in the regulation and may ultimately be causing harm to the natural environment. Companies with poor environmental compliance records are therefore more likely to cause environmental damages.

GRI Indicator: EN28. Monetary value of significant fines and total number of non-monetary sanctions for non-compliance with environmental laws and regulations.

Land

In situ development results in significant fragmentation and disturbance of boreal forest ecosystems. This section contains indicators relating to disturbance footprint, the monitoring of biodiversity impacts, strategies to offset terrestrial impacts and company leadership in supporting the establishment of protected areas in the boreal forest.

5. What is the total expected land disturbance including exploration and production footprints (m^2) for your oil sands operation?

Context: The majority of oil sands in situ development is or is planned to occur in relatively intact boreal forest. Any development in this environment results in an increased cumulative impact on species and ecological systems. Determining the exact impact of each facility requires specific knowledge of where it is being built and the techniques used for forest clearing and construction. However, because any clearing will have some impact on wildlife, the total project footprint was used for the calculations.

GRI Indicator: EN11. Location and size of land owned, leased, managed in, or adjacent to, protected areas and areas of high biodiversity value outside protected areas.

6. Please report and provide documentation of total hectares of biodiversity/conservation offsets established to compensate for terrestrial impacts of your oil sands project.

Context: In situ facilities have a residual impact on biodiversity regardless of a company's on-site mitigation measures. Biodiversity and conservation offsets offer a method to compensate for the residual, unavoidable harm to biodiversity caused by development projects, thereby aspiring to no net loss in biodiversity.[10] Biodiversity offsets attempt to mitigate ecosystem disturbance and habitat loss by restoring or conserving substitute forest areas so that no net loss of critical habitat is maintained in perpetuity. Conservation offsets compensate for development impacts as part of a complementary strategy involving significant new conservation and protected areas and enhancing mitigation practices and reclamation. The Government of Alberta is exploring the establishment of conservation offset policies to mitigate terrestrial impacts of oil sands development.[11] The Pembina Institute considers the voluntary establishment of conservation offsets an important indicator of environmental performance in the absence of regulated offset programs.

GRI Indicator: EN13. Habitats protected or restored.

7. Is your project lease area located in woodland caribou habitat as defined by Alberta Sustainable Resource Development?

Context: Woodland caribou are a threatened species in Canada and Alberta. Environment Canada has concluded that all woodland caribou herds in Alberta are considered to have non-self-sustaining populations.[12] Industrial development within caribou ranges is largely responsible for these declines.[13] It is recommended that habitat restoration is necessary if these populations are to be maintained, yet new in situ developments are proposed in the ranges of these declining herds. In the absence of a land use plan that identifies how woodland caribou habitat

is to be protected, any in situ oil sands development, regardless of mitigation measures, contributes to the decline of this threatened species.

GRI Indicator: None applicable

8. *Did your company support Cumulative Environmental Management Association recommendations for conservation planning, specifically the recommendation to permanently protect 20-40% of the Regional Municipality of Wood Buffalo from industrial development?*

Context: The Cumulative Environmental Management Association (CEMA) is a multi-stakeholder body charged with assessing cumulative impacts of development and making recommendations to improve environmental management in northeastern Alberta.[14] In 2008, CEMA recommended that between 20% and 40% of northeastern Alberta should be permanently protected from industrial development through the establishment of legally designated conservation areas.[15] This indicator reflects which companies have been constructive participants in supporting the establishment of conservation areas free of industrial activity.

GRI Indicator: None applicable

9. *Does your company provide financial support to the Alberta Biodiversity Monitoring Institute (ABMI) in order to provide meaningful, long-term information about changes in biodiversity in the oil sands region? Have you incorporated ABMI biodiversity monitoring protocols into your project-specific reporting requirements? If so, please describe this support.*

Context: Effective monitoring for changes in wildlife species is an essential component of oil sands management. An independent science advisory committee found the ABMI[16] to be "a comprehensive world-class program that Albertans can rely on for high quality monitoring and reporting on the state of biodiversity in Alberta."[17] It is capable of providing statistically rigorous information about regional-level changes in biodiversity and has protocols that can be adapted to determine site-specific changes at the level of a single oil sands project. Without a credible, regional program such as the ABMI, there is insufficient information to adequately assess changes to biodiversity in the region. The ABMI is supported by both government and voluntary industry funding but does not currently have sustainable long-term funding. Financial support for the ABMI is a key indicator of an oil sands companies' commitment to meaningful biodiversity monitoring until a comprehensive regulated approach to biodiversity monitoring is developed. (The Pembina Institute sits on the ABMI board as the representative for Alberta's environmental community.)

GRI Indicator: None applicable

Air Emissions

Oil sands projects are major emitters of many chemical pollutants. Air emissions of particular importance generated at in situ operations include nitrogen oxides (NOx) and sulphur dioxide (SO_2). Both emission types contribute to smog, have potential human health impacts and are contributors to acid rain. This section reports on project emission levels and voluntary company targets to reduce air pollution.

One of the goals of this survey was to quantify NOx and SO_2 emissions for each project in order to highlight best

practices. For this analysis to be meaningful the data collected for each project had to be comparable. To be comparable, the Pembina Institute incorporated life cycle emissions and allocated cogeneration emissions for air emissions. A more detailed explanation of the methodology is available in Life Cycle Approach and Cogeneration sections.

NOx are formed during the combustion of natural gas for heat and electricity at in situ sites. In situ operators use technologies, such as low NOx boilers, to reduce NOx emissions. Some of the lowest NOx intensities result from reduced natural gas consumption. Despite these technologies, in situ oil sands operations still result in the release of 9,752 tonnes NOx of each year.[18]

SO_2 is similarly formed during the combustion of natural gas and produced gas for heat and electricity used on-site at in situ facilities. Upstream natural gas production also produces relatively significant quantities of SO_2 during the natural processing phase. Operators can reduce their SO_2 emissions by reducing the quantity of natural gas combusted or by installing technologies, such as sulphur recovery units. Despite these technologies, in situ oil sands operations still result in the release of 9,043 tonnes SO_2 of each year.[19]

▲ *Figure 4: Growing acidifying emissions from oil sands development may pose a risk to northern lakes.*

PHOTO: DAVID DODGE, THE PEMBINA INSTITUTE

10. What are your overall project-specific nitrogen oxides (NOx) emissions in grams (g) per barrel (bbl)?

Context: NOx emissions contribute to the formation of ground level ozone and acid rain. Ground level ozone can irritate the respiratory system. Current acid deposition in Saskatchewan may exceed the buffering capacity of lakes and soils in regions close to the oil sands.[20] NOx are emitted in large quantities from in situ projects and have known human health impacts and impacts on the environment.[21] For the purpose of comparing projects, the GRI indicator was converted to a per barrel emissions intensity measure.

GRI Indicator: EN20. NOx and SO_2 and other significant air emissions by type and weight.

11. What is your 2007 average SO_2 emission intensity in grams (g) per barrel (bbl)?

Context: Once released into the atmosphere, SO_2 contributes to the formation of smog and haze. In high concentrations, SO_2 emissions can have a direct impact on human health, causing respiratory illness and aggravating pre-existing cardiovascular disease.[22] SO_2 is also the major component in the production of acid rain. As with NOx emissions, the GRI indicator was converted to a per barrel emissions intensity measure for the purpose of comparing projects.

GRI Indicator: EN20. NOx and SO_2 and other significant air emissions by type and weight.

12. Does your company have publicly reported targets to reduce or offset NOx or SO_2 beyond government regulations? If so, what are they?

Context: NOx and SO_2 emissions both contribute to acid rain and affect human health.[23] The Pembina Institute believes that oil sands projects should reduce their NOx and SO_2 emissions whenever possible, given their contribution to acid deposition and the potential for human health impacts in and around oil sands facilities. The Pembina Institute encourages companies to take a leadership role and commit to voluntary reduction targets because the Pembina Institute believes companies should be minimizing impacts where possible regardless of regulated limits. Companies that are able to achieve emission reductions above and beyond regulated limits encourage other companies to achieve similar results. This indicator is not included under the GRI guideline, but setting internal targets is considered to be an essential component of an environmental management plan.[24]

GRI Indicator: None applicable

▲ *Figure 5: Water treatment facilities at Husky Tucker.*

PHOTO: COURTESY OF HUSKY ENERGY

Water

Because of the cumulative scale of oil sands projects, in situ operations consume a considerable amount of water. This make-up water volume is in addition to water that is recycled through the processes. In situ facilities use either surface water or groundwater (fresh or saline), or any combination of these sources. In situ operators also produce waste products that are typically injected deep underground or shipped off-site to a waste treatment facility.[25]

This section compares projects on absolute water use, freshwater use, liquid waste production and public targets to reduce water use.

13. What is your project's 2007 average water consumption (brackish and fresh water) per barrel of bitumen produced?

Context: Withdrawing any type of water, even saline water, can have direct or indirect impacts on surrounding wetlands, lakes, aquifers and other water systems. However, groundwater monitoring and current data are insufficient to accurately judge potential impacts and safe withdrawal limits. The Pembina Institute believes that in the absence of sufficient data, operators with lower consumptive water use intensity pose a lesser risk to groundwater resources. The GRI indicator was converted to a per barrel intensity measure for the purpose of comparing projects.

GRI Indicator: EN8. Identify the total volume of water withdrawn from any water source that was either withdrawn directly by the reporting organization or through intermediaries such as water utilities.

14. What is the total volume of freshwater use in 2007?[26]

Context: Freshwater resources, which include rivers, streams, lakes and fresh groundwater, are defined as water with total dissolved solids (including sodium content) below 4,000 ppm.[27] With the large water demands required by in situ operations, it is essential that oil sands projects minimize their use of freshwater resources by making use of saline water resources when available.

GRI Indicator: None applicable

15. What is the average volume (bbl) of liquid waste produced per barrel (bbl) of bitumen for 2007?

Context: When in situ operators re-inject liquid waste products deep underground, there is a risk that the waste fluids will flow underground and contaminate other groundwater sources. To avoid this problem, operators limit the re-injection pressure, but the increased volumes of underground liquids risk future flow.[28] Some in situ facilities also ship solid and liquid waste off-site to a waste treatment facility. The GRI indicator was converted to a per barrel intensity measure for the purpose of comparing projects.

GRI Indicator: EN22. Total weight of waste by type and disposal method.

16. Does your company have publicly reported targets to reduce water intensity and consumption in your operations beyond government regulations? If so, what are your targets?

Context: Withdrawing any type of water, even saline water, can have direct or indirect impacts on surrounding water systems. Public targets ensure companies quantify their commitment to

continuous improvement, help spur technological innovation and application and lead to real reductions in water use. The ISO 14001 standard recognizes internal water reduction targets as a key component of a complete environmental management system.[29]

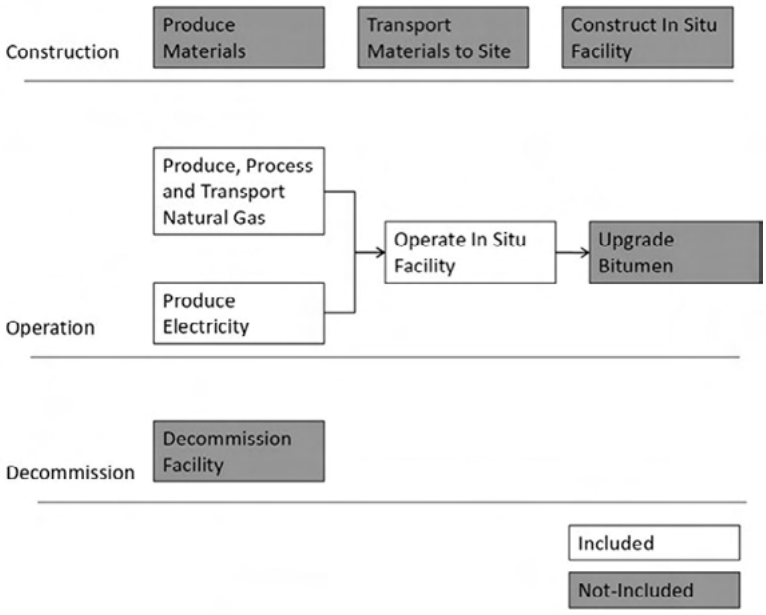
GRI Indicator: None applicable

Climate Change

Extracting bitumen from the oil sands is very energy intensive. As a result, in situ operations are major emitters of GHGs. The data used for this section of the report are derived in the same manner discussed in the air emissions section.

17. What is your 2007 average greenhouse gas emission intensity in kilograms (kg) per barrel (bbl) of bitumen?

Context: Over 44% of the increase in Canada's GHG emissions from 2006 to 2020 is projected to be a direct result of new oil sands development.[30] If Canada is to achieve the necessary deep reductions in overall GHG emissions, emissions must be reduced in absolute terms. However, GHG intensity is a useful way to compare the efficiency of oil sands operations. It is important to note that the emissions presented here are from the production of bitumen only.



▲ *Figure 6: Simplified life cycle activities included or excluded in this analysis.*

GRI Indicator: EN16. Identify direct emissions of GHGs from all sources owned or controlled by the reporting organization.

18. Does your company have publicly reported absolute greenhouse gas emission reduction targets beyond government regulations? If so, what are they?

Context: A public opinion poll conducted by Probe Research in 2007 showed that 92% of Albertans polled felt that oil sands companies should reduce greenhouse emissions at all their facilities. The same poll showed that 70% of Albertans felt that absolute reductions in GHGs were appropriate, compared to the 20% of Albertans polled that preferred targets that reduced only the intensity of GHG emissions per barrel.[31] Voluntary targets are recognized by ISO 14001 as a necessary component of an environmental management system.

GRI Indicator: EN18. Report quantitatively the extent GHG emissions reductions achieved during the reporting period as a direct result of the initiative(s) in tonnes of CO_2 equivalent.

Life Cycle Approach

Each in situ oil sands project is slightly different, but all projects require some similar types of equipment and energy

sources. To ensure a fair comparison of projects, this analysis uses a life cycle approach. Each project was compared on a per barrel of bitumen basis. Upgrading was not included in the assessment. Figure 6 identifies activities that were included or excluded in the analysis.

The main purpose of using a life cycle perspective is to ensure that projects that reduce on-site emissions are not transferring those impacts to other locations. For example, an in situ project with a cogeneration facility that produces its own electricity will likely have higher on-site emissions than one without. The project without a cogeneration facility still requires electricity, however, and the emissions from that electricity generation should be attributed to the project's bitumen production. Increases or decreases in off-site emissions are important to quantify to provide the fairest assessment of life cycle environmental impact.

Because applicable life cycle data does not exist for all indicators, only those with Alberta-specific life cycle data are included. Life cycle data is used for GHG, NOx and SO_2 emissions. There are also water and land impacts associated with natural gas production, but quality data on these indicators are not readily available.

Cogeneration

This survey includes air emissions (NOx and SO_2) and GHG emissions associated with off-site electricity and natural gas production. For facilities that have a cogeneration site, an on-site facility that produces both electricity and heat, additional methodologies were needed to ensure that those facilities were not unfairly disadvantaged. While cogeneration facilities produce heat, which is provided exclusively to the site, only a portion of the electricity they produce is used by the in situ operation. The remainder of the produced electrical power is redistributed to the electrical grid. It was therefore necessary to ensure that emissions associated with the portion of electricity redistributed to the grid were not allocated to the project.

Allocating cogeneration emissions was difficult due to a lack of publicly available data, but in general terms, a cogeneration allocation ratio was calculated and then applied to the total emissions value to determine what portion of the emissions should be allocated to the site.

Figure 7 depicts the cogeneration allocation methodology. The allocation ratio is simply the portion of produced heat and electricity used by the in situ facility (E1 and H1 in the diagram) divided by the total heat and electricity produced by the cogeneration facility (E1, E2 and H1 in the diagram). In this way, in situ operations that incorporate cogeneration facilities are not penalized for the air emissions associated with the production of electricity they do not use. In other words, the in situ operators are only responsible for the air emissions associated with the heat and electricity they use to produce bitumen at the site.

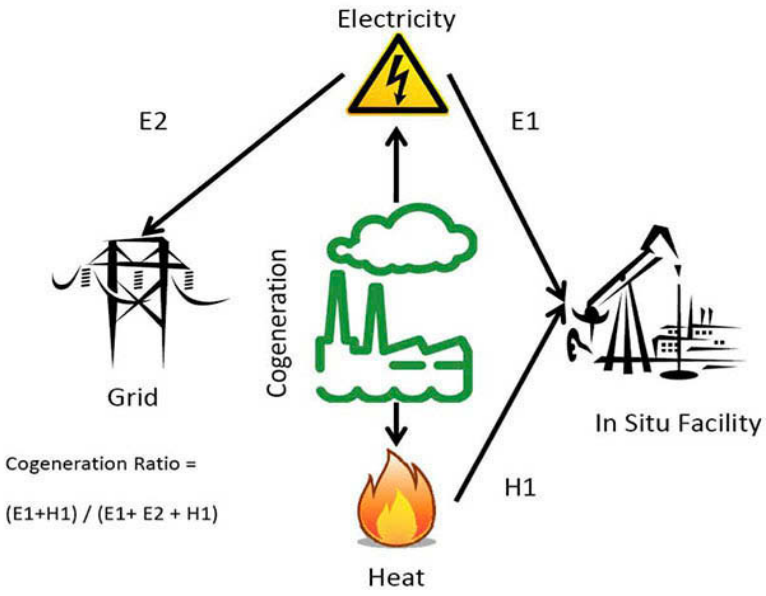


Figure 7: Cogeneration allocation methodology.

Scoring

For each environmental indicator we identify leaders and laggards and score the projects accordingly. For yes/no questions, a project receives either 1 or 0 points. In limited circumstances we provide 0.5 points for projects that partially achieve a yes/no indicator. For example, although all projects publicly report project-specific environmental indicators, this information is often difficult to find and inconsistent between projects. For this reason, most projects received only a 0.5 for public reporting instead of 1.

The yes/no questions were designed to determine which projects and companies demonstrate a progressive approach to environmental management by participating in exemplary management practices, such as independent performance verification, mitigation and monitoring efforts, and voluntary performance targets in the absence of clear regulatory requirements. An operation that has adopted a number of these management practices is clearly making an effort to implement systems to better manage its environmental impacts.

The remaining questions consider the environmental impact associated with the production of a barrel of bitumen from each operation, in terms of water use, air emissions, land impacts and GHG emissions.

For quantitative indicators, such as GHG emissions per barrel of bitumen, projects were ranked in quartiles from highest to lowest performer. Projects within 25% of the top performer were granted full points for that question. Projects performing within 25–50% of the top performer were granted 0.5 points, projects performing within 50–75% of the top performer were awarded 0.25 points and projects in the bottom quartile were awarded zero points. Using this relative scale clearly distinguishes the leaders and laggards among projects, but it does not indicate whether the best performer is truly a leader in an absolute sense. For example, the project with the lowest GHG intensity is awarded full marks under this methodology, but this does not mean that project should not be achieving better performance; it is simply the best relative to its peers.

We aggregated the scores within the five categories to facilitate comparisons among projects and among companies. We calculated an overall project score for each project as the percentage of the possible total for all questions. Where a project was scored as not applicable (n/a) on any question, that question was not included in the calculation of overall score.

Limitations

We believe that this report represents the most comprehensive and rigorous publicly available assessment of comparative environmental performance of in situ oil sands operations. This report focuses on current environmental performance of in situ oil sands operations only. It does not consider corporate governance issues, the health and safety of employees, or the adequacy of consultation and accommodation of aboriginal interests by oil sands companies. For information about other indicators, readers are encouraged to examine sources such as *Lines in the Sands: Oil Sands Sector Benchmarking by Northwest and Ethical Investments.*[32] That survey is based on a broad assessment of potential risks and company mitigation strategies.

The Pembina Institute attempted to compare in situ projects on as many environmental issues as possible. However, data are not available for some issues and for others the environmental issue is not fully addressed. For example, when high-temperature and high-pressure steam is injected underground, it creates a region where underground temperatures are significantly higher than normal conditions. This region, called a thermal plume, can slowly migrate underground with time.

The concern with this phenomenon is that naturally occurring minerals, such as arsenic, become highly concentrated in thermal plumes and, through migration, risk contaminating groundwater systems.[33] Another example is cumulative impacts. This report focuses on comparing individual in situ operations, but the combined existence of all in situ projects contributes to cumulative impacts that must be addressed differently than project-specific impacts.

This report should be considered a snap-shot of project-specific environmental performance, based on data that was available during our analysis period. Companies update their performance regularly. For example, most companies have subsequently updated their in situ performance reports for 2008.

The Pembina Institute attempted to appropriately credit facilities that have incorporated cogeneration. However, to do this correctly requires detailed natural gas and electricity generation and use values. This information is not available in the public domain. The Pembina Institute estimated emissions based on available information, and these calculations should only be considered as estimates. Our approach is discussed in detail in the Cogeneration section.

About In Situ Production

Alberta's Oil Sands

Oil sands are naturally occurring mixtures of sand or clay, water and tar-like bitumen. In an oil sands deposit, each grain of sand is covered by a thin layer of water and then by a layer of the highly viscous bitumen.[34] Bitumen is a heavy form of crude oil.

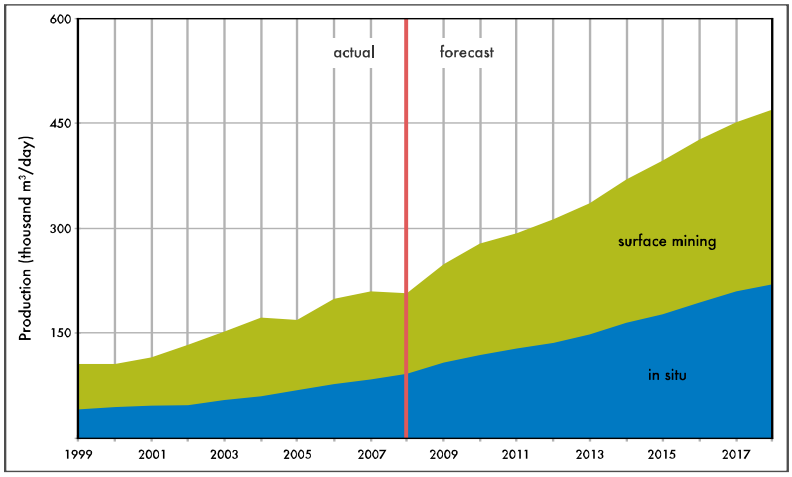
The Alberta oil sands contain an estimated 175 billion barrels of crude bitumen that can be recovered using current technology.[35] They are primarily found in three deposits – Athabasca, Cold Lake and Peace River[36] – and underlie approximately 140,000 km^2 (20%) of Alberta, which is an area about the size of Florida.[37] As of June 2009, the Alberta government had granted 84,000 km^2 of oil sands extraction leases,[38] which accounts for almost 60% of the total oil sands area.

Unlike conventional crude oil, bitumen is too thick and viscous to flow naturally or to be pumped out of the ground unless it is heated or diluted with a solvent. Before it can be refined into useable petroleum products, bitumen must be upgraded into synthetic crude oil.[39]

The two primary extraction techniques for oil sands are mining and in situ (Latin for "in place"). Mining, which is currently the dominant form of oil sands extraction, accounted for 55% of oil sands production in Alberta in 2008.[40] However, as over 80% of Alberta's oil sands resource is too deep for surface mining, in situ extraction will become increasingly important in coming decades. Oil sands suitable for in situ extraction underlie about 135,000 km^2 – nearly 30 times the 4,800 km^2 of oil sands that is potentially surface mineable. Figure 8 displays the actual and forecast contribution of bitumen production from mining and in situ sources.

In Situ Production Technologies

Oil sand deposits that are more than 100 m below the surface are generally recovered using in situ techniques. In situ extraction involves drilling several wells into the deposit and then heating or diluting the oil sands underground so the bitumen can flow to a well and be pumped to the surface.[42] Most in situ oil sands deposits are more than 400 m below the surface.[43]



▲ *Figure 8: Actual and forecast bitumen production volumes from in situ and mining sources in Alberta.*

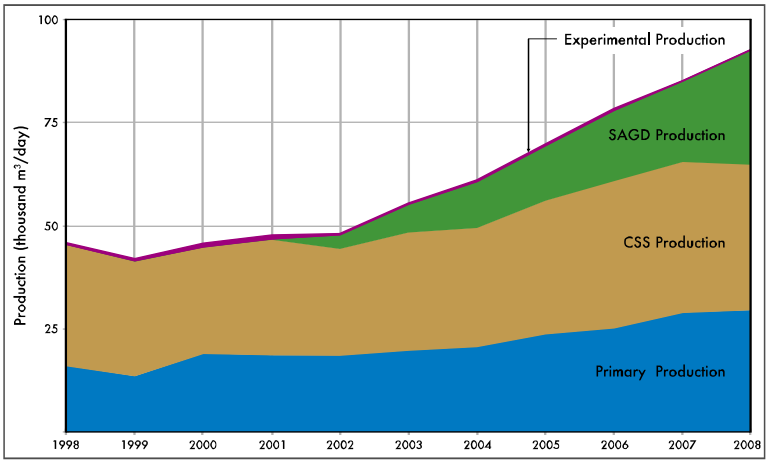
SOURCE: ERCB [41]

The two main types of thermal in situ technology are steam assisted gravity drainage (SAGD) and cyclic steam stimulation (CSS). Bitumen is also produced using water injection, but that production technique is not included in this report because of the greater pace and scale of thermal in situ development and its known environmental intensity. Figure 9 shows historical in situ bitumen production by technology type.

CYCLIC STEAM STIMULATION (CSS)

The CSS process requires a caprock and overburden of more than 300–400 m to withstand the high pressure created by the steam.[45] CSS has been used in the Cold Lake and Peace River areas for more than 20 years.[46]

In the CSS process, high-pressure steam is injected into the bitumen-bearing formation through a combination of vertical and horizontal wells, as can be seen in Figure 11. After a period of soaking, the warmed bitumen flows toward the well bore and is pumped to the surface through the same well bore that injected the steam. Then the whole process starts again, with the "huff and puff" cycle continuing until oil recovery is no longer economical.[47] The recovered bitumen is diluted with condensate (pentanes and heavier liquid hydrocarbons obtained from natural gas production) and shipped by pipeline.



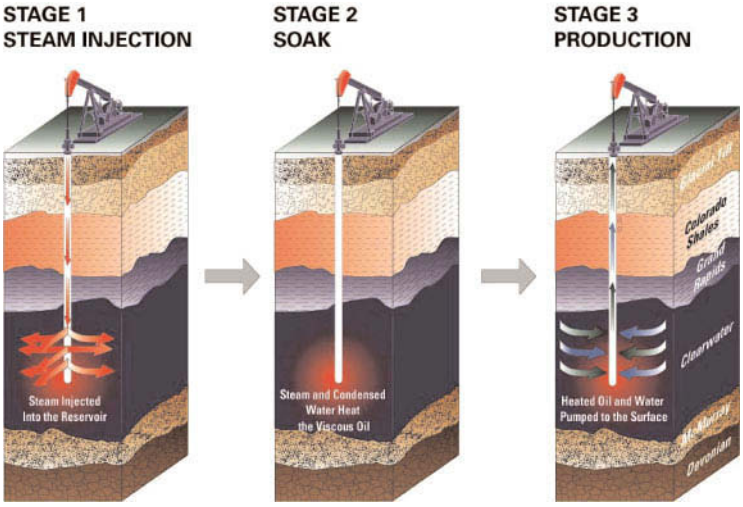
▲ *Figure 9: In situ oil sands production by technology type, including water injection, cyclic steam stimulation, steam assisted gravity drainage and experimental technologies.* SOURCE: ERCB [44]

▲ *Figure 10. SAGD wellpads at Suncor Firebag.* PHOTO: SUNCOR ENERGY

The steam condenses in the formation, and most of it will be pumped to the surface with the fluidized bitumen. In most situations this produced water is de-oiled and treated so it can be recycled to generate steam for the next injection cycle. Additional water is needed to replace water lost in the formation and treatment process.

STEAM ASSISTED GRAVITY DRAINAGE (SAGD)

The government-led Alberta Oil Sands Technology and Research Authority and the oil sands industry developed the SAGD process after more than a decade of research.[49] SAGD is used to extract



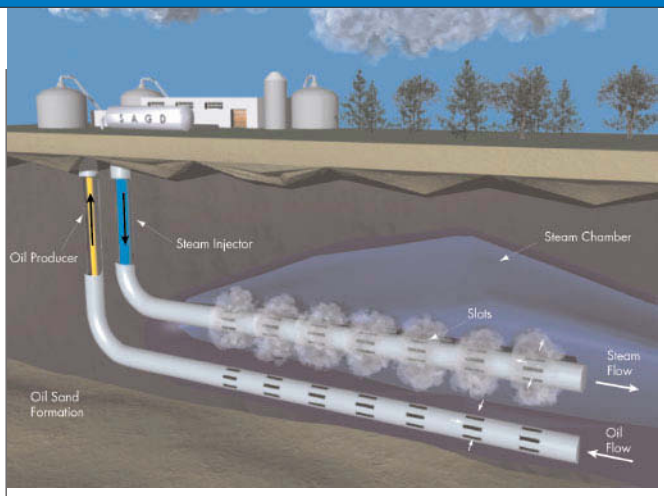
▲ *Figure 11: Cyclic steam stimulation.*

SOURCE: IMPERIAL OIL [48]

bitumen in areas where mining is not possible but where the bitumen is not deep enough for high-pressure CSS techniques to work.[50] In the SAGD process, steam is continuously injected underground through one set of pipes and the heated, fluidized bitumen and water (from the condensed steam) are collected and pumped to the surface through a lower, parallel set of pipes. The bitumen is recovered and in most cases the produced water is de-oiled and treated so that it can be reused. Several wells are drilled from a single well pad, and a SAGD project can have many pads over an extensive areas.

EMERGING IN SITU TECHNOLOGIES

Entrepreneurs are researching and testing a range of in situ technologies, such as toe-to-heel air injection (THAI), vapour extraction and electric induction. While proponents claim these technologies can economically produce bitumen with fewer environmental impacts, none has yet been demonstrated at a commercial scale. The analysis in this report includes only existing commercial technologies.



▲ *Figure 12: Steam assisted gravity drainage.*

ILLUSTRATION: J&W COMMUNICATIONS, THE PEMBINA INSTITUTE

Mining

Although oil sands mining is not a focus of this report, a brief description of mining operations is warranted because this report compares the environmental impacts of a typical oil sands mine with average in situ environmental performance.

In mining operations, bitumen-laden oil sands are mined using trucks and shovels. The trucks transport the oil sands to a preparation plant, where the oil sands are crushed and mixed with water before being transported to the bitumen extraction plant. At the bitumen extraction plant the bitumen is separated from the water and sand. The bitumen is then sent to be upgraded into synthetic crude oil. The waste material, called tailings, is sent for further processing before being disposed of in tailings ponds, which in 2009 covered 130 km^2 and held 720 billion litres of tailings waste.

The Pembina Institute and World Wildlife Fund Canada ranked environmental performance of 10 proposed and operating oil sands mines in the 2008 report ***Under-Mining the Environment: The Oil Sands Report Card****. It is available for download at www.oilsandswatch.org/pub/1571.*

Survey Results

This section provides the results of the survey per issue area for all of the in situ projects included in the assessment. Scores are provided on a per indicator basis, on a 0 to 1 scale. The environmental indicators are organized into five general categories: general environmental management, land, air emissions, water and climate change.

For each indicator the in situ projects are divided into leaders, middle and laggards. For yes/no questions, projects that receive a 1 are considered leaders and those with a 0 are laggards. In some circumstances a project will receive a 0.5 and be placed in the middle category. For questions that are scored on a relative scale, such as GHG intensity, projects that are better than average are considered leaders, those close to the average are middle and those worse than the average laggards.

▲ *Figure 13: Seismic lines cross-cut the boreal forest near Fort McMurray.*

General Environmental Management

This category assesses the following indicators of a sound approach to general environmental management:

1. development of an environmental policy that commits to continuous environmental improvement
2. validation of the environmental management system by a third party
3. transparent public reporting of environmental data associated with the project
4. strong compliance with environmental regulations

Project scores for this category are summarized in Table 2. Question 4 (regulatory compliance) was not scored.

▼ *Table 2: Summary of general environmental management scores per project.*

Project	Continuous Improvement	Third-Party Validation	Public Data Reporting	Total Score
Shell Peace River (demonstration)	1	1	1	**3**
Imperial Oil Cold Lake	1	1	0.5	**2.5**
Cenovus Christina Lake (pilot)	1	0	1	**2**
Cenovus Foster Creek	1	0	1	**2**
Husky Tucker (start-up)	1	0	1	**2**
Canadian Natural Primrose/Wolf Lake	1	0	0.5	**1.5**
Suncor Firebag	1	0	0.5	**1.5**
Suncor MacKay River	1	0	0.5	**1.5**
JACOS Hangingstone (demonstration)	0	0	0.5	**0.5**

1 CONTINUOUS IMPROVEMENT

Does your company have an environmental policy that commits to continuous improvement in environmental performance?

CONTEXT

A company's published environmental policy is the public expression of its environmental management system and values. The Pembina Institute supports companies that articulate a commitment to continuous environmental improvement because companies must now be held accountable. ISO 14001 also requires that companies include a commitment to continuous improvement in their policies.[52]

✪ LEADERS

Canadian Natural Primrose/Wolf Lake, Cenovus Christina Lake, Cenovus Foster Creek, Husky Tucker, Imperial Oil Cold Lake, Shell Peace River, Suncor Firebag, Suncor MacKay River

All the in situ operators above have comprehensive environmental policies that commit to continuous environmental performance improvement.

✦ MIDDLE

None

✣ LAGGARDS

JACOS Hangingstone

JACOS is the only company that does not appear to have an environmental policy that makes a commitment to continuous environmental improvement.

2 THIRD-PARTY VALIDATION

Does your oil sands operation have an environmental management system that has been accredited by an independent third party, such as ISO 14001 or equivalent?

CONTEXT

ISO 14001 is an internationally recognized standard for environmental management systems. It has clear requirements for establishing an environmental policy, determining environmental risks and setting goals to reduce environmental impacts. Third-party validation of an environmental management system provides external evidence of the rigour of the environmental management system. Although ISO 14001 does not provide standards for environmental performance, it does provide a globally recognized framework for developing an environmental management system.

✪ LEADERS

Imperial Oil Cold Lake, Shell Peace River

Imperial Oil Cold Lake has an operations integrity management system that has been registered by a third party as meeting the intent and requirements of ISO 14001. Shell Peace River is ISO 14001 registered.

✦ MIDDLE

None

✣ LAGGARDS

Canadian Natural Primrose/Wolf Lake, Cenovus Christina Lake, Cenovus Foster Creek, Husky Tucker, JACOS Hangingstone, Suncor Firebag, Suncor MacKay River

None of these projects provided evidence of an independently accredited environmental management system.

3 PUBLIC DATA REPORTING

Do you publicly report project-specific environmental data for your project?

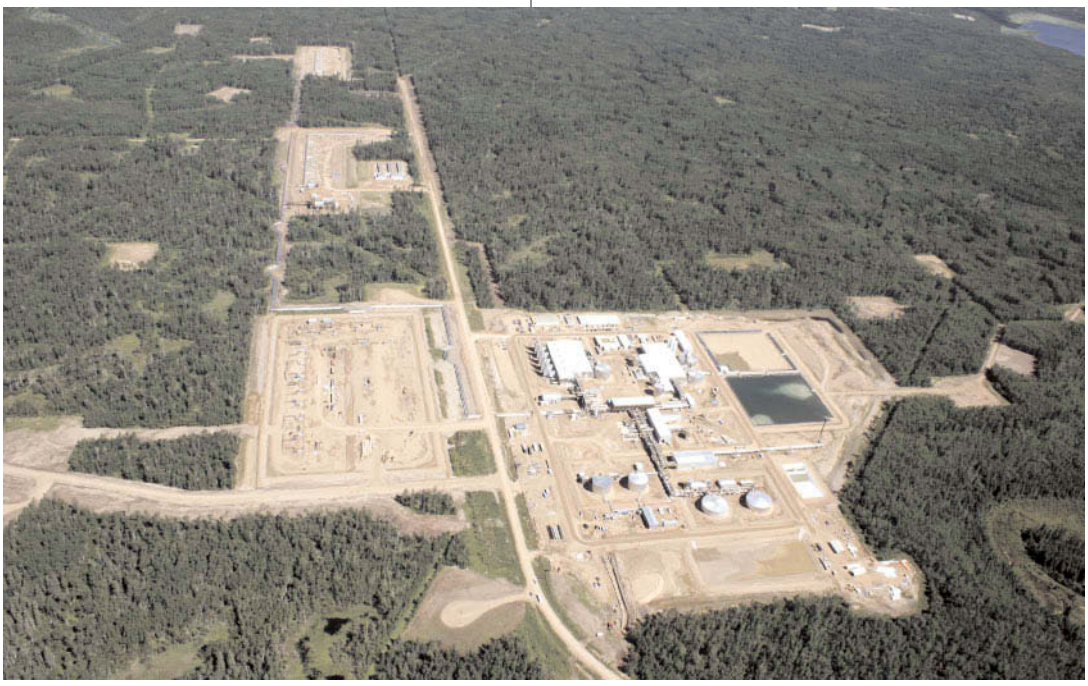
CONTEXT

Public reporting allows stakeholders to assess and compare the environmental performance of in situ operators. Industrial operators that provide detailed data on their operations encourage trust and assist in creating a transparent system from which environmental issues and solutions can be identified more quickly. In the context of this report card, public reporting is defined as project-specific environmental parameters that companies make directly available to the public through company websites, annual sustainability reports and government reports or websites.

✪ LEADERS

Cenovus Christina Lake, Cenovus Foster Creek, Husky Tucker, Shell Peace River

Cenovus, Husky and Shell all participated in the survey for this report and provided clarifications to public data the Pembina Institute had collected. The assistance of Cenovus, Husky and Shell staff reduced the effort required to analyze the public data and improved the accuracy of the final conclusions. For several other projects, the Pembina Institute had to estimate values based on publicly available information.



▲ *The Husky Tucker project (shown), along with the Cenovus and Shell projects, participated in the survey for this report.* PHOTO: COURTESY OF HUSKY ENERGY

3 PUBLIC DATA REPORTING

✦ MIDDLE

Canadian Natural Primrose/Wolf Lake, Imperial Oil Cold Lake, JACOS Hangingstone, Suncor Firebag, Suncor MacKay River

All in situ oil sands operators provide annual performance updates to the ERCB. These reports include operational data, such as sulphur emissions, water consumption, wastewater production and bitumen production. Some companies produce sustainability reports that summarize environmental impacts on a project-by-project basis, but many companies aggregate their environmental performance data into other operations. For example, Suncor reports some indicators for the Firebag facility independently, but reports other indicators only for Suncor's facility as a whole, which includes mining, upgrading and in situ operations. In situ operators are required to report annual GHG and air emissions to government agencies, such as Environment Canada.

The Pembina Institute found it difficult to compare in situ projects because the in situ operators provided data in different formats and used different methodologies to generate the data. For example, companies used different start and end dates for data reporting periods. In addition, while companies publicly report much of their performance data, no company reported all of the data needed for this report. In some cases, data crucial to a comparison of operational performance was unavailable and information provided in project applications and environmental impact assessments was used to fill the gaps. Project applications often do not represent actual performance.

✤ LAGGARDS

None

▲ *Lack of consistency in reporting between oil sands operators and a shortage of comparative information provided by Government makes it challenging to compare the environmental performance of oil sands projects.*

PHOTO: DAVID DODGE, THE PEMBINA INSTITUTE

4 REGULATORY COMPLIANCE

Please summarize all ambient air exceedances and all environmental enforcement actions (including warning letters, prosecutions, fines, etc.) in 2007 for this oil sands operation.

CONTEXT

Environmental regulations exist to ensure industrial operations do not unduly harm the natural environment. These regulations grant the government the authority to punish companies whose projects are exceeding the rules laid out in the regulation and may ultimately be causing harm to the natural environment. Companies with poor environmental compliance records are therefore more likely to cause environmental damages.

Evaluating projects according to this parameter proved to be more challenging than anticipated. In some cases, regulators found that a given company exceeded compliance requirements and the regulator asked that the company rectify the situation. In other cases companies self-reported compliance issues and then rectified them without any government action. In a few cases regulators fined companies for operating out of compliance for extended periods of time.

▲ *Meeting all applicable laws is a key component of environmental management.*

PHOTO: THE PEMBINA INSTITUTE

4 REGULATORY COMPLIANCE

The Pembina Institute could not develop a fair metric to compare projects on this indicator. The variation in the level of accountability and response is not clearly identified in all data sets, making it difficult to rank projects against one another. As such, there is no scoring for this environmental performance indicator. However, the compliance record for each company is provided below in Table 3 for reference. The data is organized into the following five compliance infraction types:

1. self-disclosed incidents that resulted in no release of material to the environment
2. non-disclosed incidents (such as those discovered by an ERCB facility audit) that resulted in no release the environment
3. self-disclosed incidents that resulted in a release of material to the environment
4. non-disclosed incidents that resulted in a release of material to the environment
5. fines for compliance infractions

▼ *Table 3: Summary of compliance records by in situ operator for 2007.*[52]

Project	1) No release, self-disclosed	2) No release, non- disclosed	3) Release, self-disclosed	4) Release, non-disclosed	5) Fines
Canadian Natural Primrose/Wolf Lake	1		1	1	1
Cenovus Christina Lake (pilot)	1	1	4		
Cenovus Foster Creek					
Husky Tucker (start-up)			1		
Imperial Oil Cold Lake			1		
JACOS Hangingstone (demonstration)		5			
Shell Peace River (demonstration)		2		9	
Suncor Firebag	2		1	1	
Suncor MacKay River		2		8	

▲ *The seismic lines, roads, well pads and other facilities associated with in situ development contribute to direct habitat loss and fragmentation.* PHOTO: DAVID DODGE, THE PEMBINA INSTITUTE

Land

The seismic lines, roads, pipelines, power lines, well pads and facilities associated with in situ oil sands development contribute to direct habitat loss and the fragmentation of additional habitat. This section contains indicators relating to project land use, conservation offsets to mitigate biodiversity impacts, development in threatened woodland caribou habitat, support for conservation targets through protected areas planning, and monitoring of impacts on biodiversity.

▼ *Table 4: Summary of land scores per project. (*Imperial Oil Cold Lake, JACOS Hangingstone and Shell Peace River were not scored on land use intensity, therefore their total score is out of four instead of five.)*

Project	Footprint	Conservation Offsets	Caribou Habitat	Conservation Planning	Biodiversity Monitoring	Total Score
Shell Peace River (demonstration)	n/a	0	1	1	1	**3***
Husky Tucker (start-up)	1	0	1	1	0	**3**
Suncor Firebag	0.5	0.5	0	1	1	**3**
Cenovus Foster Creek	0.75	0	0	1	1	**2.75**
Suncor MacKay River	0	0.5	0	1	1	**2.5**
Imperial Oil Cold Lake	n/a	0	1	1	0	**2***
JACOS Hangingstone (demonstration)	n/a	0	1	1	0	**2***
Cenovus Christina Lake (pilot)	0	0	0	1	1	**2**
Canadian Natural Primrose/Wolf Lake	1	0	0	0	0	**1**

5 FOOTPRINT

What is the total expected land disturbance including exploration and production footprints (m^2) for your oil sands operation?

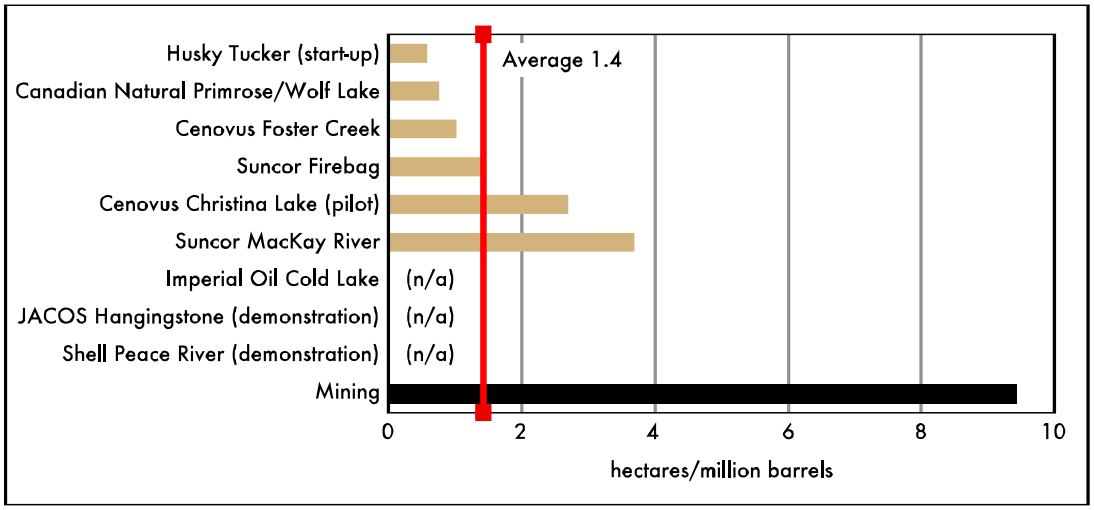
CONTEXT

The majority of in situ oil sands development is or is planned to occur in relatively intact boreal forest. Any development in this environment results in an increased cumulative impact on species and ecological systems. Determining the exact impact of each facility requires specific knowledge of where it is being built and the techniques used for forest clearing and construction. However, because any clearing will have some impact on wildlife, the total project footprint was used for the calculations.

However, an adjustment has been made to this metric in order to account for project production rates. It is necessary to acknowledge that a project that produces more bitumen per unit area of footprint than another, is making more efficient use of land. The metric for this indicator is footprint (m^2) per barrel of bitumen production, where the footprint is the total disturbance over the life of the project and bitumen production is the total expected production associated with that footprint. The metric was converted to the more appropriate units of hectares per million barrels.

Insufficient data exists in the public realm to estimate land use intensity for Imperial Oil Cold Lake, JACOS Hangingstone and Shell Peace River. Therefore, those projects were not scored on this indicator.

RESULTS



▲ *Figure 14: Project land use intensity based on footprint area and bitumen production volumes over the total project lifetime.*

5 FOOTPRINT

✪ LEADERS

Canadian Natural Primrose/Wolf Lake, Cenovus Foster Creek, Husky Tucker

The land disturbance intensities for Canadian Natural Primrose/Wolf Lake and for Husky Tucker, as measured by the total expected land disturbance over the lifetime of the project divided by the total expected production, are lower than for most other projects.

Cenovus Foster Creek has the next smallest land use intensity. This project reduced its land use intensity by using underground storage caverns to replace aboveground storage, by reorganizing its well pads to reduce their footprint, and by using the "Mega Bin" 3D system to lower seismic impact.

✦ MIDDLE

Suncor Firebag

✣ LAGGARDS

Cenovus Christina Lake, Suncor MacKay River

Both Cenovus Christina Lake and Suncor MacKay River have considerably larger land disturbance intensities than the other in situ facilities.

HOW DOES MINING COMPARE?

At first glance, oil sands mining operations show an almost six times greater direct footprint intensity compared with in situ oil sands projects. However, this metric only includes direct land disturbances like roads and well pads and not the impact of reduced use of habitats adjacent to in situ developments through forest fragmentation. Other studies have shown that when land disturbance and fragmentation effects associated with natural gas production are considered, the influence on wildlife habitat of in situ operations can reach levels that are equal to and sometimes greater than oil sands mining.[53] The land impact and subsequent wildlife impact of mines and in situ projects are different and require different mitigation approaches.

6 CONSERVATION OFFSETS

Please report and provide documentation of total hectares of biodiversity/conservation offsets established to compensate for terrestrial impacts of your oil sands project.

CONTEXT

In situ facilities have a residual impact on biodiversity regardless of a company's on-site mitigation measures. Biodiversity and conservation offsets offer a method to compensate for the residual, unavoidable harm to biodiversity caused by development projects, thereby aspiring to no net loss in biodiversity.[54] Biodiversity offsets attempt to mitigate ecosystem disturbance and habitat loss by restoring or conserving substitute forest areas so that no net loss of critical habitat is maintained in perpetuity.

Conservation offsets compensate for development impacts as part of a complementary strategy involving significant new conservation and protected areas and enhancing mitigation practices and reclamation. The Government of Alberta is exploring the establishment of conservation offset policies to mitigate terrestrial impacts of oil sands development.[55] The Pembina Institute considers the voluntary establishment of conservation offsets an important indicator of environmental performance in the absence of regulated offset programs.

▲ *Figure 15: Conservation offsets can compensate for the residual, unavoidable harm to biodiversity caused by development projects.* PHOTO: DAVID DODGE, CPAWS

6 CONSERVATION OFFSETS

✪ LEADERS

None

None of the in situ operators demonstrated an investment in biodiversity or conservation offsets to fully mitigate terrestrial impacts related specifically to their in situ operations.

✦ MIDDLE

Suncor Firebag, Suncor MacKay River

Suncor has invested in the protection of nearly 600 ha of boreal forest in northern Alberta under its "Boreal Habitat Conservation Initiative" program.[56] However, as noted in its sustainability report, this conservation effort helps offset the environmental footprint of all Suncor operations and does not specifically relate to the Firebag in situ operation. In 2007, Petro-Canada committed to establish conservation offsets on 194 ha of forest to partially offset impacts associated with what is now the Suncor Mackay River expansion project.[57]

✣ LAGGARDS

Canadian Natural Primrose/Wolf Lake, Cenovus Christina Lake, Cenovus Foster Creek, Husky Tucker, Imperial Oil Cold Lake, JACOS Hangingstone, Shell Peace River

None of the other companies have made investments in biodiversity or conservation offsets to mitigate the land use impacts from their in situ operations.

Shell invested in conservation offsets as part of the Albian Sands Energy Muskeg River Mine Expansion Project. Albian Sands Energy signed a commitment with the Alberta Conservation Association to provide $200,000 per year for 10 years to purchase conservation offsets.[58] This commitment does not extend to offsetting impacts associated with the Peace River project.

7 CARIBOU HABITAT

Is your project lease area located in woodland caribou habitat as defined by Alberta Sustainable Resource Development?

CONTEXT

Woodland caribou are a threatened species in Canada and Alberta. Environment Canada has concluded that all woodland caribou herds in Alberta are considered to have non-self-sustaining populations.[59] Industrial development within caribou ranges is largely responsible for these declines.[60] Habitat restoration is necessary if these populations are to be maintained, yet new in situ developments are proposed in the ranges of these declining herds. In the absence of a land use plan that identifies how woodland caribou habitat is to be protected, any in situ oil sands development, regardless of mitigation measures, contributes to the decline of this threatened species.

✪ LEADERS

Husky Tucker, Imperial Oil Cold Lake, JACOS Hangingstone, Shell Peace River

These four in situ operations are all located outside of the regions in Alberta identified as woodland caribou habitat.

✦ MIDDLE

None

✣ LAGGARDS

Canadian Natural Primrose/Wolf Lake, Cenovus Christina Lake, Cenovus Foster Creek, Suncor Firebag, Suncor MacKay River

The remainder of the in situ facilities are located in areas defined as caribou habitat and risk further diminishing this already threatened species.

8 CONSERVATION PLANNING

Did your company support Cumulative Environmental Management Association recommendations for conservation planning, specifically the recommendation to permanently protect 20–40% of the Regional Municipality of Wood Buffalo from industrial development?

CONTEXT

The Cumulative Environmental Management Association (CEMA) is a multi-stakeholder body charged with assessing cumulative impacts of development and making recommendations to improve environmental management in northeastern Alberta.[61] In 2008, CEMA recommended that between 20 and 40% of northeastern Alberta should be permanently protected from industrial development through the establishment of legally designated conservation areas.[62] This indicator reflects which companies have been constructive participants in supporting the establishment of conservation areas free of industrial activity.

Land use planning is currently underway in northeastern Alberta.[63] Without an effective land use plan that identifies conservation areas and sets cumulative limits on disturbance, criticism of in situ land use impacts will continue to grow.

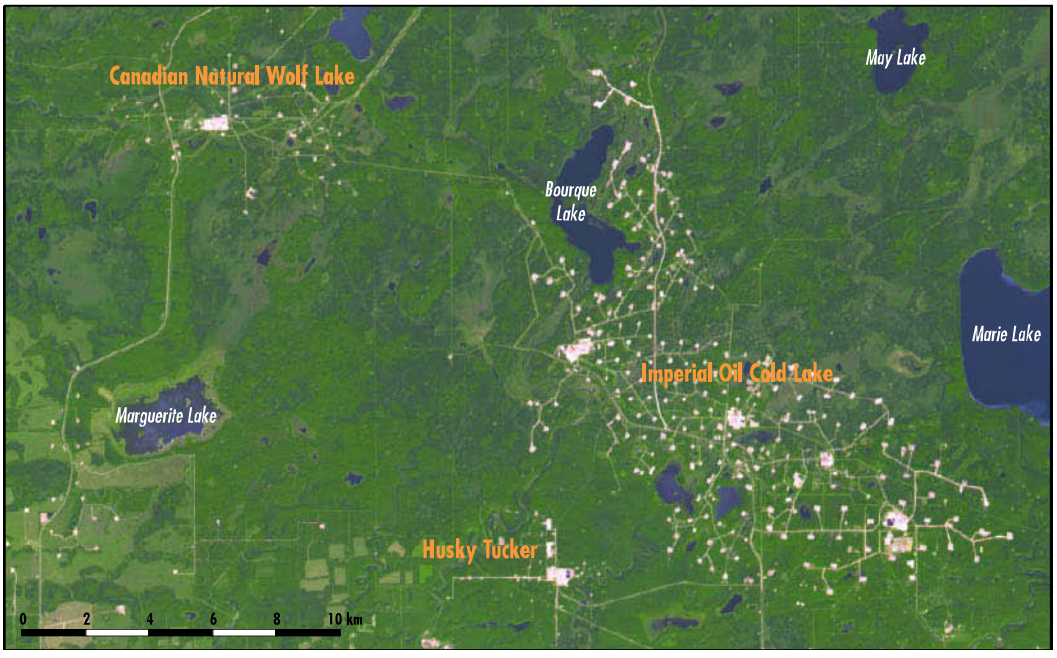


Figure 16: The cumulative impacts of in situ oil sands projects need to be included in land use planning.

MAP: ROLAND LINES, THE PEMBINA INSTITUTE.
SATELLITE DATA: NATURAL RESOURCES CANADA, 2006

8 CONSERVATION PLANNING

✪ LEADERS

Cenovus Christina Lake, Cenovus Foster Creek, Husky Tucker, Imperial Oil Cold Lake, JACOS Hangingstone, Suncor Firebag, Suncor MacKay River, Shell Peace River

According to CEMA's online documentation, all of the above companies responded in support of the recommendations for conservation planning.[64] Suncor is a member of the Boreal Leadership Council, whose members are signatories to the Boreal Forest Conservation Framework, which identifies the need to protect 50% of Canada's boreal forest from industrial activity in perpetuity.[65]

✦ MIDDLE

None

✤ LAGGARDS

Canadian Natural Primrose/Wolf Lake

Canadian Natural provided a response to CEMA stating that it would be unable to support the conservation planning framework. Canadian Natural noted that the framework would directly affect 44,000 ha of its mineral leases and wished to have further discussion on many of the key requirements.[66]

9 BIODIVERSITY MONITORING

Does your company provide support (financial or other) to the Alberta Biodiversity Monitoring Institute (ABMI) in order to provide meaningful, long-term information about changes in biodiversity in the oil sands region? Has it incorporated ABMI biodiversity monitoring protocols into your project-specific reporting requirements? If so, please describe this support.

CONTEXT

Effective monitoring for changes in wildlife species is an essential component of oil sands management. An independent science advisory committee found the ABMI[67] to be "a comprehensive world-class program that Albertans can rely on for high quality monitoring and reporting on the state of biodiversity in Alberta."[68] It is capable of providing statistically rigorous information about regional-level changes in biodiversity and has protocols that can be adapted to determine site-specific changes at the level of a single oil sands project.

Without a credible, regional program such as the ABMI, there is insufficient information to adequately assess changes to biodiversity in the region. The ABMI is supported by both government and voluntary industry funding but does not currently have sustainable long-term funding. Financial support for the ABMI is a key indicator of an oil sands companies' commitment to meaningful biodiversity monitoring until a comprehensive regulated approach to biodiversity monitoring is developed. (A Pembina Institute employee sits on the ABMI board as a representative for Alberta's environmental community.)

9 BIODIVERSITY MONITORING

✪ LEADERS

Cenovus Christina Lake, Cenovus Foster Creek, Shell Peace River, Suncor Firebag, Suncor MacKay River

All of the above companies are listed as current sponsors of the ABMI.[69] However, no information was available on the value of contributions, so it was not possible to differentiate companies according to their level of commitment.

✦ MIDDLE

None

✣ LAGGARDS

Canadian Natural Primrose/Wolf Lake, Husky Tucker, Imperial Oil Cold Lake, JACOS Hangingstone

Canadian Natural, Husky, Imperial Oil and JACOS were not listed as current or past ABMI sponsors and no information was available in their sustainability reports to suggest otherwise.

Air Emissions

Air emissions from the oil sands region have the potential to affect human and environmental health. For example, current acid deposition in Saskatchewan, which is partially caused by NOx and SO_2 emissions from the oil sands, may exceed the buffering capacity of lakes and soils in regions close to the oil sands.[70] This means that lakes and soils in Saskatchewan could become more acidic, which would present risks to the health of plant and animal species. NOx and SO_2 are both produced at in situ facilities. This section reports on project emission levels and voluntary company targets to reduce air pollution.

The Pembina Institute calculated both on and off-site emissions associated with the in situ operations. On-site emissions were calculated using company reported emissions available in the NPRI or ERCB reports. Off-site emissions associated with electricity generation and the production of natural gas required for the operation of the in situ facility were calculated using generic emissions factors. For facilities with cogeneration units that provide power to both the grid and the in situ operation, emissions were allocated using the cogeneration allocation methodology described in the introduction.

▼ *Table 5: Summary of air emission scores per project.*

Project	NOx Emissions	SO_2 Emissions	Reduction Targets	Total Score
Cenovus Foster Creek	1	1	0	**2**
Suncor Firebag	0.75	0.5	0.5	**1.75**
Suncor MacKay River	0.75	1	0	**1.75**
Cenovus Christina Lake (pilot)	1	0.5	0	**1.5**
Imperial Oil Cold Lake	0.5	0.75	0	**1.25**
Canadian Natural Primrose/Wolf Lake	0	0.75	0	**0.75**
JACOS Hangingstone (demonstration)	0.5	0	0	**0.5**
Husky Tucker (start-up)	0	0	0	**0**
Shell Peace River (demonstration)	0	0	0	**0**

10 NITROGEN OXIDES EMISSIONS

What are your overall project-specific nitrogen oxides (NOx) emissions in grams (g) per barrel (bbl)?

CONTEXT

NOx emissions contribute to the formation of ground level ozone and acid rain. Ground level ozone can irritate the respiratory system. Current acid deposition in Saskatchewan may exceed the buffering capacity of lakes and soils in regions close to the oil sands.[71] NOx are emitted in large quantities from in situ projects and have known human health impacts and impacts on the environment.[72] For the purpose of comparing projects, the GRI indicator was converted to a per barrel emissions intensity measure.

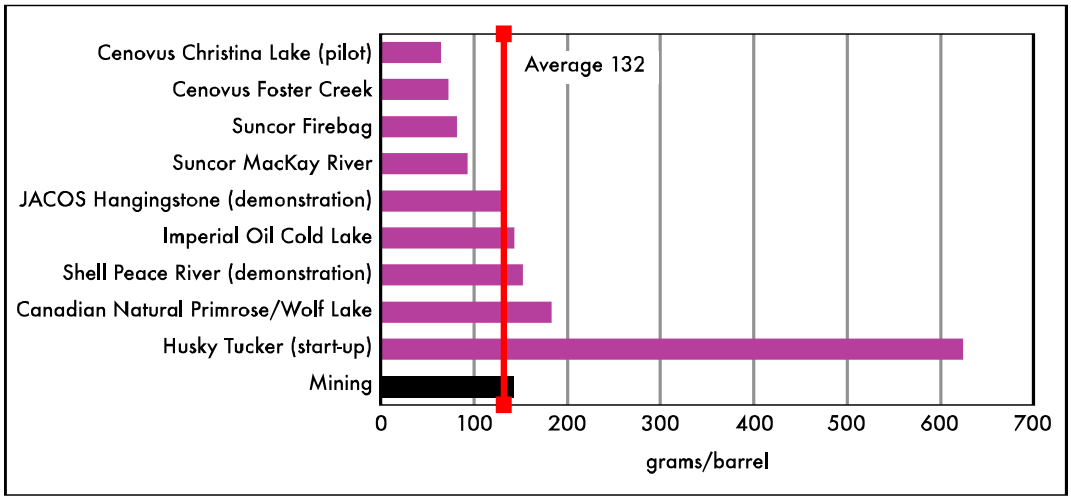
✪ LEADERS

Cenovus Christina Lake, Cenovus Foster Creek, Suncor Firebag, Suncor MacKay River

These projects have NOx emissions that range between 82 g and 130 g per barrel of bitumen (g/bbl). These projects create NOx emissions by combusting natural gas to produce steam. Natural gas production itself also generates NOx emissions. Reducing the amount of natural gas per barrel of bitumen produced is one of the best ways a project can reduce NOx emissions. One indication of a project's natural gas intensity is its steam-to-oil ratio. The steam-to-oil ratio is a measurement of the total volume of steam required per unit of bitumen production. As natural

RESULTS

▼ *Figure 17: NOx emissions per barrel of bitumen produced.*



10 NITROGEN OXIDES EMISSIONS

gas is used to heat water for steam production, a higher steam-to-oil ratio means more natural gas consumption. Christina Lake, Foster Creek, Firebag, and MacKay River all have relatively low steam-to-oil ratios between 2.4:1 and 3.3:1.[73] In addition, each of these projects has a cogeneration facility. Cogeneration is a more efficient way of producing heat and electricity (rather than producing heat and electricity separately) that reduces NOx emissions per barrel of bitumen produced.

✦ MIDDLE

Imperial Oil Cold Lake, JACOS Hangingstone, Shell Peace River

These projects have NOx emissions that range between 130 g and 150 g per barrel of bitumen (g/bbl).

✤ LAGGARDS

Canadian Natural Primrose/Wolf Lake, Husky Tucker

These projects have NOx emissions that range between 180 g and 620 g per barrel of bitumen (g/bbl). Canadian Natural Primrose/Wolf Lake and Husky Tucker have the second highest and highest steam-to-oil ratios, respectively. The Husky Tucker facility noted a steam-to-oil ratio that was three times as high as the average steam-to-oil ratio from the nine projects surveyed.[74] Both of these projects consume significantly more natural gas per barrel of bitumen produced than the other projects.

STEAM-TO-OIL RATIO

The steam-to-oil ratio is a measurement of the total volume of steam required per unit of bitumen production. The steam-to-oil ratio is an easy way to compare projects and provides a superficial indication of an in situ operation's technical and environmental performance. Operations with high steam-to-oil rations tend to require more water and combust more natural gas than operations with low steam-to-oil ratios. In general an in situ operator will aim to reduce its project's steam-to-oil ratio to reduce operating costs. A low steam-to-oil ratio has the added benefit of reducing the project's environmental impact by reducing water requirements and air emissions.

Determining why one company's steam-to-oil ratio is lower or higher than another's can be very difficult. It is determined by a number of factors, such as reservoir characteristics, operator experience, extraction technology and operating procedures. In this report the Pembina Institute often refers to the steam-to-oil ratio as a justification for leading or lagging environmental performance on specific indicators. However, the steam-to-oil ratio is really an indication of the ability for an in situ operator to optimize its reservoir, the operator's experience, the extraction technology, the operating procedures and in some instances luck.

11 SULPHUR DIOXIDE EMISSIONS

What is your 2007 average SO_2 emission intensity in grams (g) per barrel (bbl)?

CONTEXT

Once released into the atmosphere, SO_2 contributes to the formation of smog and haze. In high concentrations, SO_2 emissions can have a direct impact on human health, causing respiratory illness and aggravating pre-existing cardiovascular disease.[75] SO_2 is also the major component in the production of acid rain. As with NOx emissions, the GRI indicator was converted to a per barrel emissions intensity measure for the purpose of comparing projects.

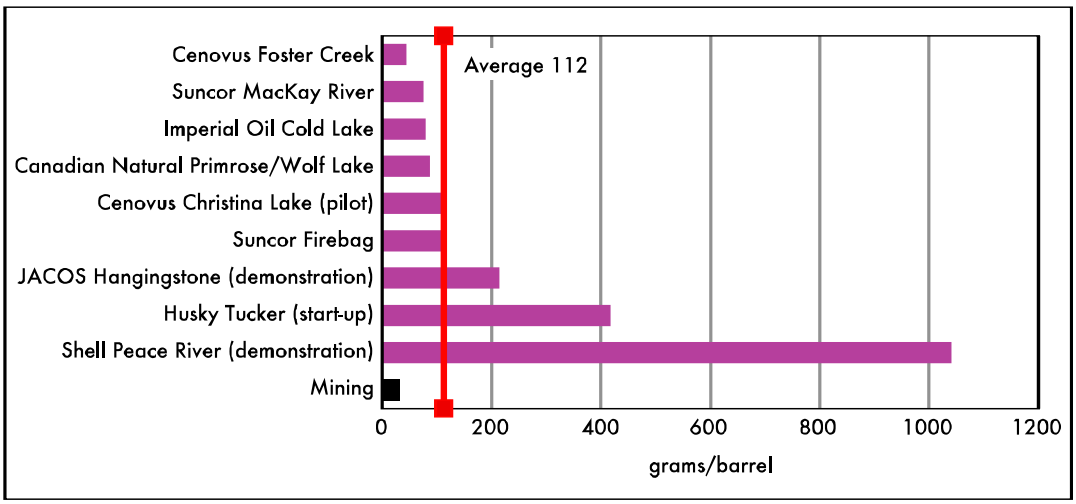
✪ LEADERS

Canadian Natural Primrose/Wolf Lake, Cenovus Foster Creek, Imperial Oil Cold Lake, Suncor MacKay River

These projects have SO_2 emissions that range between 44 g and 86 g per barrel of bitumen (g/bbl). Like NOx emissions, SO_2 emissions are also linked to steam-to-oil ratios. Generally, a higher steam-to-oil ratio means more natural gas consumption, which in turn would suggest more SO_2 emissions associated with the upstream production of natural gas and from the on-site combustion emissions. Cenovus Christina Lake, Suncor MacKay River and Cenovus Foster Creek have the three lowest steam-to-oil ratios, which could in part explain why these projects have low SO_2 emission intensities. Additionally, most

RESULTS

▼ *Figure 18: SO_2 emissions per barrel of bitumen produced.*



11 SULPHUR DIOXIDE EMISSIONS

in situ facilities make use of sulphur recovery technologies to reduce on-site SO_2 emissions resulting from natural gas combustion. Produced gas is another factor that influences SO_2 emissions. In situ operations combust purchased natural gas where sulphur has been removed during the processing phase. However, produced gas, which is produced during bitumen production and combusted to produce heat, can contain varying amounts of sulphur depending on reservoir characteristics.

✦ MIDDLE

Cenovus Christina Lake, Suncor Firebag

These projects have similar SO_2 emission intensities of around 110 g per barrel of bitumen (g/bbl).

✤ LAGGARDS

Husky Tucker, JACOS Hangingstone, Shell Peace River

These projects have SO_2 emissions that range between 214 g and 1,000 g per barrel of bitumen (g/bbl). Husky Tucker's relatively high sulphur intensity is a result of off-site natural gas production. Because Husky Tucker's operation requires relatively high amounts of natural gas for each barrel, a relatively high amount of sulphur is emitted to produce the natural gas used at the facility. JACOS Hangingstone is currently a pilot project. Its absolute emissions (tonnes of SO_2 per day) fall below its regulated sulphur emission limit. However, because JACOS has not installed sulphur recovery technology, its SO_2 emissions intensity is relatively high. Shell Peace River has the highest SO_2 emission intensity of projects examined because its operations do not include sulphur recovery technology. Because the project's sulphur emissions are below the 14 tonnes per day licence limit, it is not required by law to install sulphur recovery technology.[76]

HOW DOES MINING COMPARE?

The sulphur intensity of mining operations, excluding upgrading, are well below the average sulphur intensity of in situ operations and are approximately 30% lower than the lowest sulphur intensity in situ facility, Cenovus Foster Creek. Mining operations use primarily commercial grade natural gas to produce steam and electricity, which has a lower sulphur content. The trucks used to transport bituminous sands use diesel, which emits sulphur, but the resulting SO_2 emission intensity per barrel is lower than for an in situ facility.

12 REDUCTION TARGETS

Does your company have publicly reported targets to reduce or offset NOx or SO_2 beyond government regulations? If so, what are they?

CONTEXT

NOx and SO_2 emissions both contribute to acid rain and affect human health.[77] The Pembina Institute believes that oil sands projects should reduce their NOx and SO_2 emissions whenever possible, given their contribution to acid deposition and the potential for human health impacts in and around oil sands facilities. The Pembina Institute encourages companies to take a leadership role and commit to voluntary reduction targets because the Pembina Institute believes companies should be minimizing impacts where possible regardless of regulated limits. Companies that are able to achieve emission reductions above and beyond regulated limits encourage other companies to achieve similar results. This indicator is not included under the GRI guideline, but setting internal targets is considered to be an essential component of an environmental management plan.[78]

✪ LEADERS

Suncor Firebag

Suncor has committed to reducing absolute air emissions from its oil sands facilities, including Firebag, by 10% by 2015.[79] The actual reduction of NOx and SO_2 emissions are unclear.

✦ MIDDLE

None

✤ LAGGARDS

Canadian Natural Primrose/Wolf Lake, Cenovus Christina Lake, Cenovus Foster Creek, Husky Tucker, Imperial Oil Cold Lake, JACOS Hangingstone, Shell Peace River, Suncor MacKay River

No other companies reviewed in this assessment have public voluntary air emission reduction targets. Suncor's targets were made for Suncor oil sands facilities before it acquired MacKay River in the merger with Petro-Canada.

Water

Lack of information on impacts on groundwater is a major concern associated with groundwater use for in situ operations. On January 30, 2008, the Alberta Water Council noted that "there was a concern that research and technology support is unable to sustain the planning envisioned by the Alberta *Water for Life Strategy*." It further referenced the need for more mapping of quality and quantity of groundwater.[80] Without sufficient data, government agencies and other institutions are unable to assess the risk posed by large sale in situ developments.

In situ operators heat water to produce steam, which is then injected into the reservoir to liquefy the viscous bitumen. Wastewater is often disposed of in deep disposal wells. When considering the scale of in situ operations (213 million barrels of bitumen in 2008), the annual water withdrawals are significant. However, given the lack of data, the potential risks of current operations and planned expansions cannot be determined.

This section concerns in situ operator water use, the management of liquid wastes and voluntary company targets to reduce water consumption.

▼ *Table 6: Summary of water scores per project.*

Project	Water Intensity	Freshwater Targets	Liquid Waste Intensity	Targets	Total
Suncor Firebag	1	0.75	0.75	0.5	**3**
Imperial Oil Cold Lake	0.75	0.75	1	0	**2.5**
Suncor MacKay River	1	0.5	1	0	**2.5**
Cenovus Foster Creek	0.5	1	0.5	0	**2**
JACOS Hangingstone (demonstration)	0.75	0.5	0.75	0	**2**
Canadian Natural Primrose/Wolf Lake	0.5	0	0.5	0	**1**
Husky Tucker (start-up)	0	1	0	0	**1**
Cenovus Christina Lake (pilot)	0	0	0	0	**0**
Shell Peace River (demonstration)	0	0	0	0	**0**

13 TOTAL WATER CONSUMPTION

What is your project's 2007 average water consumption (brackish and fresh water) per barrel of bitumen produced?

CONTEXT

Withdrawing any type of water, even saline water, can have direct or indirect impacts on surrounding wetlands, lakes, aquifers and other water systems. However, groundwater monitoring and current data are insufficient to accurately judge potential impacts and safe withdrawal limits. The Pembina Institute believes that in the absence of sufficient data, operators with lower consumptive water use intensity pose a lesser risk to groundwater resources. The GRI indicator was converted to a per barrel intensity measure for the purpose of comparing projects.

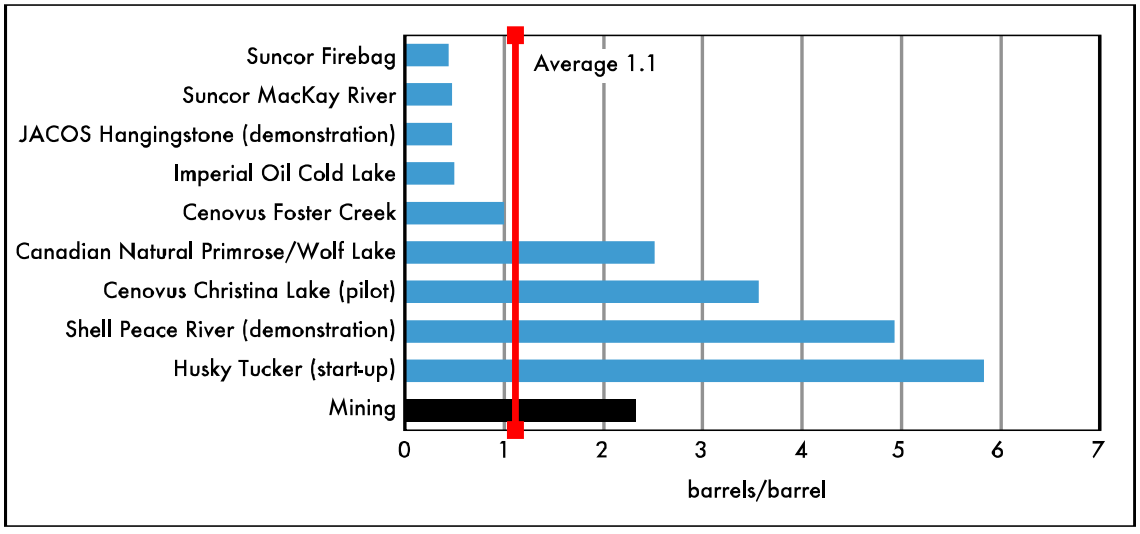
RESULTS

✪ LEADERS

Imperial Oil Cold Lake, JACOS Hangingstone, Suncor Firebag, Suncor MacKay River

These projects' total water use intensities range from 0.4 bbl to 0.5 bbl water per barrel of bitumen. The primary drivers of water use intensity are a project's steam-to-oil ratio and its recycle rates. Projects with low steam-to-oil ratios use less water to produce a barrel of bitumen. Projects must also recycle water to further reduce water use intensity. All three leading projects have both relatively low steam-to-oil ratios and recycle produced water.

▼ *Figure 19: Total water consumption per barrel of bitumen produced.*



13 TOTAL WATER CONSUMPTION

✦ MIDDLE

Cenovus Foster Creek

Cenovus Foster Creek requires just under 1 bbl water per barrel of bitumen produced.

✤ LAGGARDS

Canadian Natural Primrose/Wolf Lake, Cenovus Christina Lake, Husky Tucker, Shell Peace River

These projects' total water use intensities range from 2.5 bbl to just under 6 bbl water per barrel of bitumen produced. These relatively high water intensities are driven by two different factors. In the cases of the Christina Lake and Peace River projects, Cenovus and Shell, respectively, have not installed water recycling facilities. Water that is injected into the reservoir returns to the surface with the bitumen and is then disposed in deep disposal wells. Both these projects have to replace every barrel that is sent to deep disposal wells accounting for the high water use. Cenovus installed water recycling facilities at its Christina Lake facility in 2008 and Shell plans to recycle produced water as part of the Carmon Creek expansion project.[81] Both Canadian Natural and Husky have installed water recycling facilities. However, both these projects have relatively high steam-to-oil ratios that outweigh the water reduction capacity of the recycling facilities. In addition, Husky Tucker was in start-up phase during this assessment. Water use intensity will decrease as the project matures.

HOW DOES MINING COMPARE?

This assessment shows that in situ operations use on average 1.1 bbl water for every barrel of bitumen produced. However, actual water intensities vary by project from 0.5 bbl to just under 5 bbl water for every barrel of bitumen produced. This additional water is sourced from either fresh or saline sources. The average oil sands mine uses over twice as much water as the average in situ operation per barrel of bitumen produced. Imperial Oil Cold Lake, JACOS Hangingstone and Suncor MacKay River and Suncor Firebag all use significantly less water per barrel of bitumen than a mining operation. However, Canadian Natural Primrose/Wolf Lake, Cenovus Christina Lake, Shell Peace River and Husky Tucker all use more water than an average mining operation. There are other distinctions as well. Mining operations use water primarily drawn from the Athabasca River, whereas in situ operations tend to use groundwater sources and are increasingly using saline sources.

14 FRESHWATER CONSUMPTION

What is the total volume of freshwater use in 2007? [82]

CONTEXT

Freshwater resources, which include rivers, streams, lakes and fresh groundwater, are defined as water with total dissolved solids (including sodium content) below 4,000 ppm.[83] With the large water demands required by in situ operations, it is essential that oil sands projects minimize their use of freshwater resources by making use of saline water resources when available.

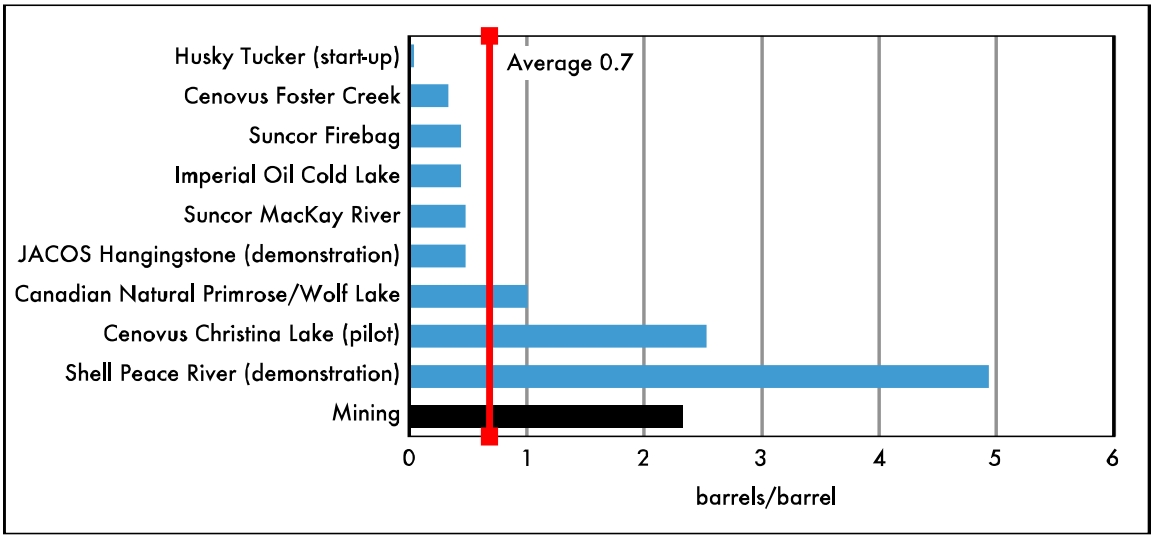
RESULTS

✪ LEADERS

Husky Tucker

Husky Tucker's freshwater use intensity is the lowest of the projects included in this survey at 0.04 bbl fresh water per barrel of bitumen. The volume of fresh water used at an in situ facility will depend on the availability of saline water resources and company priority or preference. At the Husky Tucker facility, fresh water is used only for domestic and cleaning purposes, resulting in the lowest freshwater use intensity among operations surveyed.[84]

▼ *Figure 20: Freshwater consumption per barrel of bitumen produced.*



14 FRESHWATER CONSUMPTION

✦ MIDDLE

Cenovus Foster Creek, Imperial Oil Cold Lake, JACOS Hangingstone, Suncor Firebag, Suncor MacKay River

All five projects have freshwater intensities below the weighted average. These projects' freshwater use intensities range from 0.4 bbl to 0.5 bbl fresh water per barrel of bitumen.

✣ LAGGARDS

Canadian Natural Primrose/Wolf Lake, Cenovus Christina Lake, Shell Peace River

These projects' freshwater use intensities range from 1 bbl to 5 bbl fresh water for every barrel of bitumen produced. As discussed in the water intensity section, these projects have higher water use intensities because of high steam-to-oil ratios for Canadian Natural Primrose/Wolf Lake and no water recycling facilities for Cenovus Christina Lake and Shell Peace River. However, all companies will need to use increasing amounts of saline water to comply with the ERCB draft directive *Requirements for Water Measurement, Reporting, and Use for Thermal In Situ Oil Sands Schemes*. In this draft directive, fresh water may only account for 10% of makeup water for in situ schemes that require more than 500,000 m^3 of makeup water per year.[85]

HOW DOES MINING COMPARE?

After accounting for recycling, oil sands mines use approximately four times as much fresh water on a per barrel basis as the average in situ operation. Oil sands mines use fresh water drawn mainly from the Athabasca River. Much of this water is trapped in the mature fine tailings at oil sands facilities. Some in situ operators use saline water, which reduces their freshwater intensity.

15 LIQUID WASTE

What is the average volume (bbl) of liquid waste produced per barrel (bbl) of bitumen for 2007?

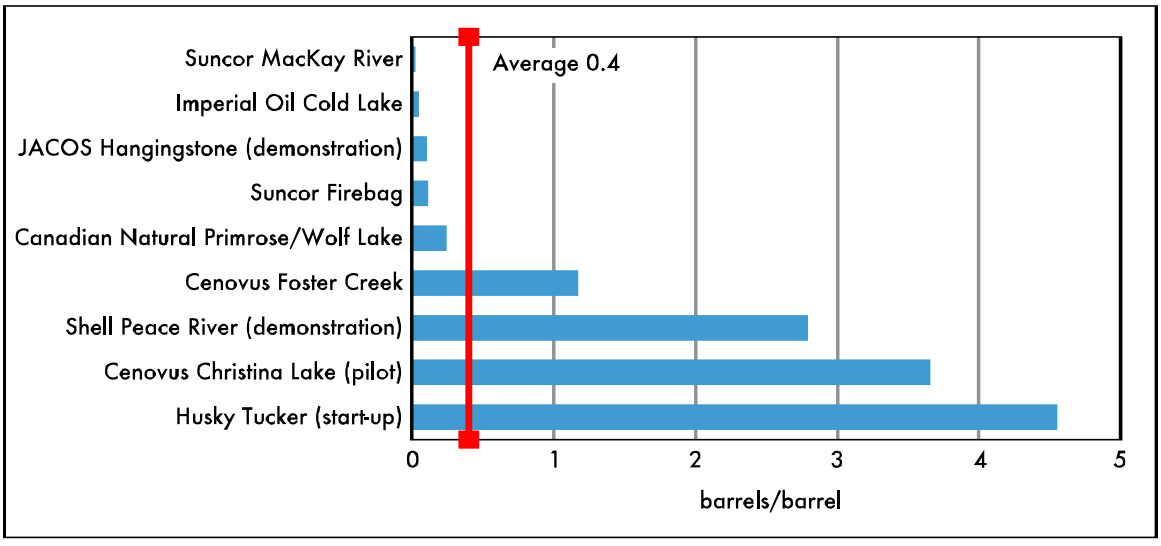
CONTEXT

When in situ operators re-inject liquid waste products deep underground, there is a risk that the waste fluids will flow underground and contaminate other groundwater sources. To avoid this problem, operators limit the re-injection pressure, but the increased volumes of underground liquids risk future flow.[86] Some in situ facilities also ship solid and liquid waste off-site to a waste treatment facility. The GRI indicator was converted to a per barrel intensity measure for the purpose of comparing projects.

RESULTS

The results illustrated in Figure 21 include volumes of liquid waste from several sources, such as lime sludge, waters from softeners, brine, any form of re-injected wastes and produced water that cannot or is not treated. Liquid waste intensities are difficult to calculate because it is uncertain whether all liquid wastes are reported equally for all operations.

▼ *Figure 21: Liquid waste production per barrel of bitumen produced.*



15 LIQUID WASTE

✪ LEADERS

Canadian Natural Primrose/Wolf Lake, Imperial Oil Cold Lake, JACOS Hangingstone, Suncor Firebag, Suncor MacKay River

These projects' liquid waste intensities range from 0.005 bbl to 0.2 bbl disposed water per barrel of bitumen. All the projects with low liquid waste production have both low steam-to-oil ratios and water recycling facilities. These two points lead to less wastewater production. The combination of Suncor MacKay River's relatively low steam-to-oil ratio and its zero liquid discharge process account for its leadership position in liquid waste intensity.[87] In a zero liquid discharge system, evaporators and a crystallizer are used to essentially eliminate wastewater production. However, a concentrated salt byproduct must be disposed in a landfill.

✦ MIDDLE

Canadian Natural Primrose/Wolf Lake

Canadian Natural Primrose/Wolf Lake's wastewater disposal is below the average disposal value at 0.2 bbl disposed water per barrel of bitumen produced.

✤ LAGGARDS

Cenovus Christina Lake, Cenovus Foster Creek, Husky Tucker, Shell Peace River

These projects' liquid waste intensities range from 1 bbl to 4.5 bbl disposed water per barrel of bitumen production. As noted for question 13, neither Shell Peace River nor Cenovus Christina Lake had water recycling facilities installed at their facilities. Because Husky Tucker has the highest water use intensity, it also has a high liquid waste intensity. It is unclear why Cenovus Foster Creek's wastewater intensity is higher than the average. The facility has a relatively low steam-to-oil ratio and incorporates water recycling.

16 REDUCTION TARGETS

Does your company have publicly reported targets to reduce water intensity and consumption in your operations beyond government regulations? If so, what are your targets?

CONTEXT

Withdrawing any type of water, even saline water, can have direct or indirect impacts on surrounding water systems. Public targets ensure companies quantify their commitment to continuous improvement, help spur technological innovation and application and lead to real reductions in water use. The ISO 14001 standard recognizes internal water reduction targets as a key component of a complete environmental management system.[88]

✪ LEADERS

Suncor Firebag

Suncor states a target to reduce water intake by 12% by 2015.[89] However, this target is applied to its oil sands operations as a whole, not specifically to the Suncor Firebag facility.

✦ MIDDLE

None

✤ LAGGARDS

Canadian Natural Primrose/Wolf Lake, Cenovus Christina Lake, Cenovus Foster Creek, Husky Tucker, Imperial Oil Cold Lake, JACOS Hangingstone, Suncor MacKay River, Shell Peace River

None of these operators have committed to absolute water reduction targets for their in situ facilities. Suncor's targets were made for Suncor oil sands facilities before it acquired MacKay River in the merger with Petro-Canada.

Climate Change

Oil sands are the fastest growing source of GHG emissions in Canada.[90] According to Environment Canada projections, oil sands operations will account for about 44% of the increase in Canada's GHG emissions from 2006 to 2020.[91] "Reference case" projections from this study show oil sands contributions to national emissions rising from 4% of Canada' emissions in 2006 to 12% in 2020.

This rate of growth in emissions stands as a potential barrier to Canada's commitments through the Kyoto accord. According to international law, as of 2005, Canada entered a legally binding commitment to set emissions targets to reduce its average annual greenhouse emissions 6% below 1990 levels between 2008 and 2012.[92] If the international community is to succeed at limiting global GHG emissions, it is necessary for developed countries such as Canada to rapidly reduce emissions. For this to take place, Canada would need to address the large and growing volume of emissions that are derived from oil sands operations.

In situ operators consume large quantities of natural gas to produce steam. The combustion of natural gas creates carbon dioxide, a significant contributor of GHG emissions. This section examines GHG intensity and company targets to reduce absolute amounts of GHG pollution.

The methodology used to derive the on-site, off-site and allocation of cogeneration emissions presented in this section is the same as that discussed in the Air Emissions section.

▼ *Table 7: Summary of climate change scores per project.*

Project	GHGs	Targets	Total
Cenovus Foster Creek	1	0	**1**
Suncor Firebag	1	0	**1**
Cenovus Christina Lake (pilot)	0.75	0	**0.75**
Suncor MacKay River	0.75	0	**0.75**
Imperial Oil Cold Lake	0.5	0	**0.5**
JACOS Hangingstone (demonstration)	0.5	0	**0.5**
Canadian Natural Primrose/Wolf Lake	0	0	**0**
Husky Tucker (start-up)	0	0	**0**
Shell Peace River (demonstration)	0	0	**0**

17 GHG EMISSIONS

What is your 2007 average greenhouse gas emission intensity in kilograms (kg) per barrel (bbl) bitumen?

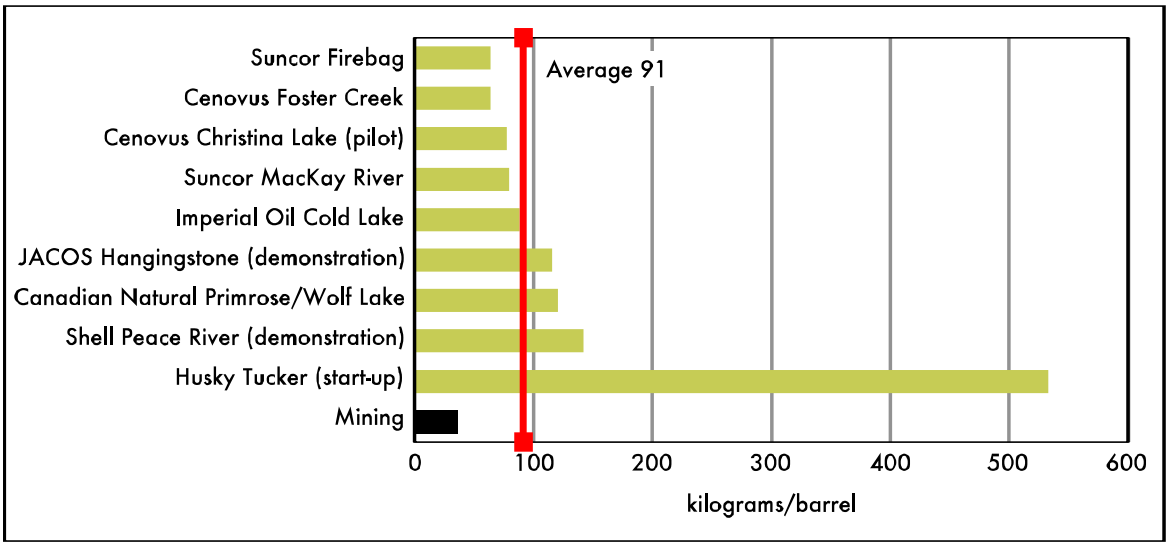
CONTEXT

Over 44% of the increase in Canada's GHG emissions from 2006 to 2020 is projected to be a direct result of new oil sands development.[93] If Canada is to achieve the necessary deep reductions in overall GHG emissions, emissions must be reduced in absolute terms. However, GHG intensity is a useful way to compare the efficiency of oil sands operations. It is important to note that the emissions presented here are from the production of bitumen only.

Note: This survey includes on-site as well as off-site emissions, including those associated with upstream natural gas production. Reporting GHG emissions associated with upstream natural gas production is not a standard practice but is included here because of the considerable amount of natural gas used by in situ operators and to enable a fair comparison between oil sands operations.

RESULTS

▼ *Figure 22: Greenhouse gas emissions per barrel of bitumen produced.*



17 GHG EMISSIONS

✪ LEADERS

Cenovus Christina Lake, Cenovus Foster Creek, Suncor Firebag, Suncor MacKay

Similar to NOx emissions, GHG emissions are closely tied to steam-to-oil ratios. All three of these projects have relatively low steam-to-oil ratios that explains their low GHG emission intensities. Three of these operations have also incorporated cogeneration into their facilities.

✦ MIDDLE

Canadian Natural Primrose/Wolf Lake, Imperial Oil Cold Lake, JACOS Hangingstone, Shell Peace River, Suncor MacKay River

In comparison with the Husky Tucker facility, all of these operations have relatively lower steam-to-oil ratios, and therefore combust less natural gas and produce fewer GHG emissions. However, all of these projects have higher steam-to-oil ratios than the leading projects.

✣ LAGGARDS

Husky Tucker

As noted previously, the Husky Tucker steam-to-oil ratio in 2007 was three times as high as the average steam-to-oil ratio from the nine projects surveyed.[94] This explains why Husky Tucker's GHG emissions are so high in comparison with the other projects.

HOW DOES MINING COMPARE?

The average in situ operation generates two and half times more GHGs per barrel of bitumen produced in comparison with oil sands mining operations. The lowest GHG intensity in situ operations, Cenovus Foster Creek and Suncor Firebag, generate just under twice the GHG emissions per barrel of an average oil sands mining project. The explanation for this difference at the most basic level is energy requirements. Each barrel of bitumen produced in situ requires more energy than a corresponding barrel of mined bitumen. Since the energy used in oil sands operations is from fossil fuel sources, primarily natural gas, an increase in energy use leads to a corresponding increase in GHG emissions.

18 REDUCTION TARGETS

Does your company have publicly reported absolute greenhouse gas emission reduction targets beyond government regulations? If so, what are they?

CONTEXT

A public opinion poll conducted by Probe Research in 2007 showed that 92% of Albertans polled felt that oil sands companies should reduce greenhouse emissions at all their facilities. The same poll showed that 70% of Albertans felt that absolute reductions in GHGs were appropriate, compared to the 20% of Albertans polled that preferred targets that reduced only the intensity of GHG emissions per barrel.[95] Voluntary targets are recognized by ISO 14001 as a necessary component of an environmental management system.

✪ LEADERS

None

✦ MIDDLE

None

✣ LAGGARDS

Canadian Natural
Primrose/Wolf Lake,
Cenovus Christina Lake,
Cenovus Foster Creek,
Husky Tucker,
Imperial Oil Cold Lake,
JACOS Hangingstone,
Shell Peace River,
Suncor Firebag,
Suncor MacKay River

None of these companies have publicly reported targets to reduce absolute GHG emissions.

Conclusions

Table 8 summarizes the project scores by category for each project. It also includes the average score across all projects.

As Table 8 indicates, Suncor Firebag, Cenovus Foster Creek, Imperial Oil Cold Lake and Suncor MacKay River are above average in overall environmental performance compared to their in situ peers. These operations have several features in common. Each project is a commercial scale operation that is performing at or slightly below expected rates. They all have relatively low steam-to-oil ratios, which helps account for relatively lower intensities for air and GHG emissions, total and fresh water use, and liquid waste production. A low steam-to-oil ratio results from the quality of the reservoir and the production choices of the in situ facility operator. All four projects include cogeneration, which further reduces their air and GHG emission intensities. Each of the operating companies also perform relatively well

Project	General Environmental Management (out of 3)	Land (out of 5)	Air Emissions (out of 3)	Water (out of 4)	Climate Change (out of 2)	Overall Score
Suncor Firebag	1.5	3	1.75	3	1	60%
Cenovus Foster Creek	2	2.75	2	2	1	57%
Imperial Oil Cold Lake	2.5	2*	1.25	2.5	0.5	55%
Suncor MacKay River	1.5	2.5	1.75	2.5	0.75	53%
AVERAGE	**1.83**	**2.36**	**1.06**	**1.56**	**0.50**	**44%**
Shell Peace River (demonstration)	3	3*	0	0	0	38%
Cenovus Christina Lake (pilot)	2	2	1.5	0	0.75	37%
Husky Tucker (start-up)	2	3	0	1	0	35%
JACOS Hangingstone (demonstration)	0.5	2*	0.5	2	0.5	34%
Canadian Natural Primrose/Wolf Lake	1.5	1	0.75	1	0	25%

▲ *Table 8: Summary of project scores (*Imperial Oil Cold Lake, Shell Peace River and JACOS Hangingstone were scored out of four for land indicators because they were not scored on land use intensity.)*

on environmental management, regional commitments and, in Suncor's case, published reduction targets for air emissions and water use. The project scores range from 53% to 60%.

Canadian Natural Primrose/Wolf Lake, Cenovus Christina Lake, Husky Tucker, JACOS Hangingstone and Shell Peace River all score below the average environmental performance. The reasons for these lower scores are mixed. The Shell, Cenovus and JACOS projects were all pilot or demonstration projects during 2007. Pilot and demonstration projects do not often incorporate technologies like produced water recycling and sulphur recovery technologies and tend to have higher steam-to-oil ratios compared with commercial projects leading to lower overall scores. The Husky and Canadian Natural projects were designed as commercial projects but still performed below the average score. Husky Tucker experienced a number of challenges associated with its operation and was in start-up phase in 2007. The project was performing well below its designed bitumen production rate. Canadian Natural Primrose/Wolf Lake has a relatively high steam-to-oil ratio, leading to high water use and disposal, and air and GHG emission intensities. Canadian Natural also scored poorly on environmental management and commitments to regional initiatives such as the ABMI and public support for conservation planning.

There are a number of important conclusions that can be drawn from Table 8 and the report in general. These conclusions are outlined below.

There is substantial room for environmental improvement

The average score in our survey was 44%, suggesting there is substantial room for improvement in the environmental performance and management of in situ oil sands projects. The highest-ranked project was Suncor Firebag, with a score of 60%. The lowest-ranked project was Canadian Natural Primrose/Wolf Lake, with 25%. Most projects demonstrate leadership in some areas of project-specific environmental performance and most have an environmental policy that commits to continuous improvement.

Projects scored consistently poorly on four indicators:

1. ***Reduction Targets:*** Very few in situ operators have established absolute reduction targets for air emissions, water use and GHG emissions that go beyond regulated requirements. Only Suncor has absolute reduction targets for air emissions and water use. Despite the significant GHG emissions of the oil sands industry, no operators have voluntary targets to reduce GHG emissions.
2. ***Biodiversity Offsets:*** Suncor was also the only company to invest in biodiversity offsets to compensate for the impacts associated with in situ oil sands development, and even here level of commitment is not commensurate with the level of terrestrial impacts. The purpose of a biodiversity offset is to mitigate impacts associated with habitat loss and the disturbance of ecosystems by restoring or conserving substitute

forest areas so that no net loss of critical habitat is maintained in perpetuity.

3. ***Biodiversity Monitoring:*** Only three companies, Suncor, Cenovus and Shell, financially support the Alberta Biodiversity Monitoring Institute.
4. ***Third-party Accredited Environmental Management:*** Only Imperial Oil and Shell have third-party accredited environmental management systems.

Disclosure of environmental performance data is not accessible or comparable

Husky, Cenovus and Shell fully participated in this assessment and provided the Pembina Institute with environmental data and detailed explanations regarding their operations. However, the Pembina Institute found it difficult to compile comparable data for all projects using public data sources. The data are distributed over a number of different databases and are often not reported in a consistent manner across or within those databases. For example, the ERCB in situ progress reports contain significant information on water use and wastewater disposal. However, each company reports data slightly differently and it can take a significant amount of time to calculate water use values that are comparable between projects. Weak public disclosure of environmental impact data weakens transparency and risks undermining public understanding and confidence in the sector.

Both in situ and mining projects have significant environmental impacts

We compared an average mining project against the in situ projects on land use, air (NOx and SO_2) and GHG emissions, water use and freshwater use intensities. As one might imagine, the average oil sands mine disturbs more land, emits more NOx and is more water intensive than the average in situ project. However, in other categories in situ projects are more environmentally intense. For example, the average mining operation is less GHG and SO_2 intense than all in situ projects surveyed. Some of the poor performing in situ projects were more NOx and water intense than the impacts associated with an average oil sands mine. In addition, our land intensity assessment did not incorporate the impacts of fragmentation and upstream natural gas production associated with in situ operations.[96]

Best practices are not widely adopted

There is a wide variation in performance between in situ operators. If a fictional in situ operation, in this assessment, took the aspects of the best project in each category it could achieve a score of 85% on this survey. That is to say that any project could achieve a score of 85% simply by incorporating the best practices of the leading in situ operator into its own operations. This result suggests substantial room for improvement. Given that many in situ operators have not

voluntarily adopted viable strategies to address some of the environmental risks posed by in situ oil sands development, more consistent regulation by the Alberta and federal government could also drive the kind of environmental outcomes that are possible.

To achieve 100% on this survey would require in situ operators to improve upon policies and actions that are also already being implemented by in situ operators. The only questions where no project received full points were on establishment of GHG emission, water and air targets and biodiversity offsets. Setting environmental targets is a policy widely used by industries around the world to demonstrate a commitment to continuous improvement. Suncor has already established environmental performance targets for its facilities as a whole. There are also numerous examples of biodiversity offset programs. Both Suncor and Shell have invested in these programs. An in situ operator that incorporated the best practices in the industry and established GHG reduction targets and biodiversity offsets could achieve 100% on this survey.

Cumulative impacts are generally not considered

This assessment considers the impacts and performance of in situ oil sands projects at a project level. Although important, given the overall pace and scale of oil sands development, both in situ and mining, there is an inadequate level of environmental management to ensure that the regional environment is protected.

Recommendations

Government

To date the government has failed to establish regional environmental thresholds that will ensure the oil sands are developed in manner that protects the ecological integrity of the region. Government has also failed to create an atmosphere that encourages oil sands companies to continuously improve their environmental performance.[97] There is still time to establish these limits and encourage continuous environmental improvement. The oil sands are a financially valuable energy resource that some of the world's largest energy companies are competing to develop. As demonstrated in the analysis of this report, there are examples of leading performance for the majority of environmental indicators in this report. However, no single project has incorporated all the best practices available in the industry. The Government of Alberta is in a unique position to leverage the international interest in the oil sands to mandate application of best practices and innovation in environmental practices and technologies.

1 Mandate environmental stewardship

Most companies have not developed project-specific reduction targets, invested in biodiversity offsets, biodiversity monitoring through ABMI or third-party accredited environmental management programs. It appears that weak government requirements for environmental performance are responsible for the inconsistent application of best practices across the industry.

Specific policy improvements include the following:

- ***Absolute environmental reduction targets:*** Most companies have not defined their commitment to continuous environmental improvement by setting public reduction targets. Government should encourage setting public reduction targets by providing some benefit to companies that set and meet public targets. Government could equally support leaders by penalizing laggards who are not adopting the technologies and practices that leading companies are employing. The EnviroVista Leaders is an example of a policy that provides some benefit to environmental leaders.
- ***Biodiversity offsets:*** Government should make compensatory offset mitigation of terrestrial impacts of in situ oil sands development mandatory, and develop conservation offset policies as recommended by the proposed wetland policy for Alberta[99] and *Responsible Actions: A Plan for Alberta's Oil Sands.*[100]
- ***Biodiversity monitoring:*** Government should integrate mandatory financial support for the ABMI and mandatory reporting using ABMI protocols into existing and future approvals for in situ oil sands development projects.

- Third-party accredited environmental management: Only two in situ operators have implemented third-party accredited environmental management systems at their facilities. Given the significant environmental impacts of in situ oil sands projects the Government of Alberta should make this a mandatory requirement for all oil sands facilities.

2 Make oil sands environmental performance data more comparable and accessible

It remains difficult to find and compare environmental data for in situ projects and for the oil sands region as a whole. As the regulator, the Government of Alberta already receives environmental data for each of the in situ operators. The Government of Alberta should help disseminate this information by providing environmental performance indicators, similar to those used in this report, on a project by project basis. For example, while the ERCB in situ progress reports provide a wealth of information on in situ operations, they only include information on select environmental indicators and the data is difficult to find and aggregate for each project.

3 Halt new approvals until environmental management systems are complete

Leading in situ oil sands projects need to operate within a regulatory system that sets cumulative thresholds or limits to protect the environment. Although Alberta has committed to a new approach to the management of cumulative effects, this remains a work in progress. Necessary elements include a land use plan, requirements for GHG emissions reductions and a framework for water management. These regulatory gaps mean that expanded in situ oil sands development is risky from both an investment[101] and an environmental perspective. Given that many of the elements in management of cumulative environmental impacts in the oil sands are either absent or under development, it is appropriate to pause approval of new oil sands developments until appropriate environmental management systems and regulations are implemented.

4 Create a regulatory system that rewards innovation

Best environmental practices are not widely adopted between in situ operators. The Government of Alberta should catalyze innovation and the adoption of best practices in the in situ industry. Most oil sands applications are for the two primary in situ technologies, SAGD and CSS, and promise no improved environmental performance relative to already producing commercial operations. The Government of Alberta could encourage innovation and technology development by requiring each new proposed project to perform better than the present best in class project. Such a policy would encourage new technology development and the adoption of proven best practices to continuously raise the bar in environmental performance. Once a new bar is set, regulations similar to Directive 74

(The Tailings Directive) and the draft water directive, *Requirements for Water Measurement, Reporting, and Use for Thermal In Situ Oil Sands Schemes*, could set performance requirements to ensure improvements in existing projects for all elements of air, water, land and GHG management.

Industry

Industry must acknowledge the real and significant project-specific and cumulative impacts of in situ oil sands development. While there is a clear need for government leadership in many areas industry can support government by demonstrating leadership on a project by project basis and displaying a sincere effort to address environmental impacts by incorporating best practices, supporting progressive public policy and innovating environmental practices and technologies.

1 Demonstrate leadership

There are four specific environmental indicators that very few projects scored well on: reduction targets, biodiversity offsets, biodiversity monitoring and third-party accredited environmental management. There are already examples of in situ oil sands operators that have implemented policies or practices in these four areas. Suncor has set absolute reduction targets for water use and air emissions, has invested in biodiversity offsets and supports the ABMI. Both Shell and Imperial have third-party accredited environmental management systems.

2 Provide accessible public data

The level of reporting on environmental indicators required by government is insufficient to accurately assess and compare in situ oil sands projects. Reporting frameworks, such as the GRI, do exist that provide a clear list of social, environmental and economic reporting indicators that can be compared across projects. In situ operators should report on project-specific environmental indicators similar to the indicators included in this report. A recent report by Northwest and Ethical Investments, *Lines in the Sands: Oil Sands Sector Benchmarking*, also concluded that oil sands operators must significantly improve their public disclosure to provide investors with a "true picture of oil sands risk."[102]

3 Focus on the issues

In situ operators should acknowledge the real environmental impacts of in situ development, both cumulative and project specific, and describe their strategies for addressing these impacts over time. Only this approach will lead to increased environmental performance overtime and create an atmosphere conducive to collaboration and constructive dialogue between government, industry and external stakeholders.

4 Incorporate best practices and lead improvements

Our assessment demonstrates that any oil sands in situ operator could achieve a score of 85% on this survey simply by adopting current best practices for each environmental indicator. At a minimum in situ operators should be incorporating the best practices of their peers.

Those operators that are already leading in specific indicators, such as Cenovus, Suncor and Imperial Oil, should continue to build upon their leadership position by innovating new technology and practices to continually reduce their environmental impact. Achieving 100% on this assessment in the future is possible by incorporating best practices in the in situ oil sands industry and supplementing those practices with common practices from other industries. For example, the only indicators for which no in situ project received full marks are environmental targets and biodiversity offsets.

As the analysis in this report demonstrates, there is also clear link between environmental performance on some indicators (water use, air emissions and GHG emissions) and a project's steam-to-oil ratio. Minimizing a project's steam-to-oil ratio reduces environmental impact and delivers cost savings.

5 Acknowledge the cumulative impacts of in situ development

Many of the most serious impacts of in situ oil sands development are a result of the cumulative impact of in situ operations. It is the role of government to establish regional environmental thresholds that protect the ecological integrity of the oil sands region. Oil sands in situ owners and operators should acknowledge the extent of current and projected cumulative impacts in the oil sands region and take a leadership role in support for the establishment of regional environmental thresholds and completed land use planning.

6 Follow the best practice in situ development checklist

An in situ oil sands operator can satisfy all of the points above by ensuring its project follows the best practice in situ development checklist in Table 9. The numerical targets represent the top quartile of 2007 performance of the projects included in this assessment.

An in situ operation that ranks well on this checklist is a leading in situ facility relative to its peers. However, in the absence of regional regulations to protect the ecological integrity of the oil sands region, even a leading project may contribute to unacceptable cumulative impacts in the oil sands region. Further, as this is a relative assessment a leading project today. Improvements in environmental performance are expected to continually reduce per barrel impacts.

General Environmental Management

- ❑ An environmental policy that commits to continuous improvement in environmental performance
- ❑ An environmental management system that has been accredited by an independent third party, such as ISO 14001 or equivalent
- ❑ Publicly reported project-specific environmental data
- ❑ A strong legal compliance record

Land

- ❑ Land use intensity below 0.5 hectares per million barrels, measured by total expected disturbance over the life of the project divided by total expected production
- ❑ Compensation for the terrestrial impacts of the in situ project by establishing biodiversity/ conservation offsets equivalent to the area affected by the in situ oil sands project
- ❑ In the absence of a land use plan that shows how woodland caribou will be conserved in northeastern Alberta, no operations in threatened woodland caribou habitat
- ❑ Public policy support for establishing large conservation areas free of industrial development to provide habitat for wildlife affected by in situ oil sands development
- ❑ Financial support Alberta Biodiversity Monitoring Institute in order to provide meaningful, long-term information about changes in biodiversity in the oil sands region

Air Emissions

- ❑ NO_x intensity below 0.08 kg/bbl (including off-site electricity and natural gas production)
- ❑ SO_2 intensity below 0.08 kg/bbl (including off-site electricity and natural gas production)
- ❑ Publicly reported targets to reduce absolute NO_x or SO_2 emissions beyond government regulations

Water

- ❑ Total saline water use intensity below 0.5 bbl/bbl bitumen
- ❑ No freshwater consumption except for domestic use
- ❑ Publicly reported absolute water reduction targets beyond government regulations

Climate Change

- ❑ Greenhouse gas emissions intensity below 78 kg/bbl bitumen
- ❑ Public absolute greenhouse gas reduction targets beyond government regulations

▲ *Table 9: Best practice in situ development checklist.*

Summary of Conclusions and Recommendations

Conclusion	Government Recommendations	Industry Recommendations

Substantial room for improvement
There is substantial room for environmental improvement in the following areas:
▮ Reduction targets
  ▮ Water use
  ▮ GHG emissions
  ▮ Air emissions
▮ Biodiversity offsets
▮ Biodiversity monitoring
▮ Third-party accredited environmental management
	Mandate environmental stewardship
	Government must provide incentives or regulate as needed to encourage action in the four areas on the left. Specific recommendations are as follows:
	▮ Provide some benefit to companies that have voluntary targets such as reducing regulatory hurdles or providing financial incentives. Supplement incentives with a clear message that continuous improvement is expected.
	▮ Make compensatory offset mitigation of terrestrial impacts in situ oil sands development mandatory.
	▮ Integrate mandatory financial support for the ABMI into existing and future approvals.
	▮ Make third-party accredited environmental management systems mandatory for in situ projects.
		Take the lead
		Industry leaders must demonstrate their capacity to implement reduction targets, biodiversity offsets and monitoring and third-party accredited environmental management. Specific recommendations are as follows:
		▮ Establish specific absolute reduction targets or water use, air emissions and GHG emissions.
		▮ Invest in biodiversity offsets commensurate with the terrestrial impact of the in situ project.
		▮ Support the Alberta Biodiversity Monitoring Institute and integrate its results into management planning.
		▮ Implement a third-party accredited environmental management system for the in situ project.

Conclusion	Government Recommendations	Industry Recommendations
Disclosure The Pembina Institute found it difficult to compile comparable data for all projects using public data sources. Weak public disclosure of environmental impact data weakens transparency and risks undermining public understanding and confidence in the sector.	**Make oil sands environmental performance data accessible** Make project-specific and cumulative oil sands in situ environmental performance data available in an accessible and comparable format.	**Provide accessible public data** Disclose project-specific environmental data in a format that is comparable across the in situ industry.
Mining vs. in situ On some important environmental indicators, like NOx and GHG emissions, in situ operations are more intensive than mining operations. In addition, our land use intensity assessment did not incorporate the impacts of fragmentation and upstream natural gas production associated with in situ operations.[103]	**Mining vs. in situ** In situ operations have significant, cumulative and long-term impacts and should be submitted to rigorous environmental impact assessments, monitoring and regulation.	**Focus on the issues** In situ developments have significant environmental impacts and there is substantial room for improvement across the industry. In situ operations should seriously engage stakeholders and publicly discuss solutions to these issues.

The In Situ Oil Sands Report Card *SUMMARY*

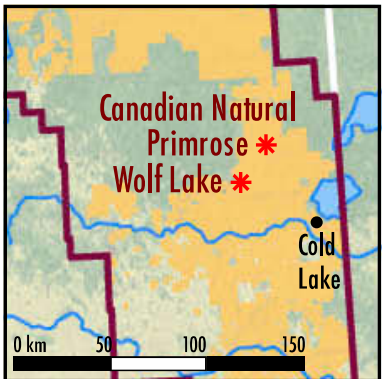
Conclusion	Government Recommendations	Industry Recommendations
Best practices There is a wide variation in performance between in situ operators. All projects could achieve 85% on this survey by incorporating already existing best practices.	**Create a competitive atmosphere for innovation** There is very little incentive for in situ operators to improve environmental performance. Government must consider how harness the innovative capacity of the oil sands industry to address environmental issues.	**Incorporate best practices and lead improvements** Adopt current best practices and continuously improve once best practices have been adopted.
Cumulative impacts There is an inadequate level of environmental management to ensure that the regional environment is protected.	**Halt new approvals until environmental systems are complete** Complete regional management of cumulative impacts from oil sands development that protects the ecological integrity of the Alberta's ecosystem before approving new projects.	**Acknowledge cumulative impacts of in situ development** Take a leadership role in support for the establishment of regional environmental thresholds and completing land use planning.

Appendix: Project Summaries

The previous sections summarized performance by indicator to identify leading practices in each category. This section provides information on a project by project basis. The purpose of this section is to highlight where each company is doing well, why the project is doing well and what challenges the project has experienced. The section also summarizes, where possible, actions that each company is taking to resolve outstanding environmental issues. The Pembina Institute provided each project summary to participating companies to ensure a fair representation of each company's performance and plans to resolve outstanding environmental issues.[104]

Canadian Natural Primrose/Wolf Lake: 25%

Canadian Natural's Primrose and Wolf Lake projects are located about 55 km north of Bonnyville, Alberta. Canadian Natural wholly owns and operates both projects. Canadian Natural started Wolf Lake operations in 1985, and then added Primrose South in 1998 followed by Primrose North in mid-2006. Canadian Natural's operations also include a cogeneration unit.

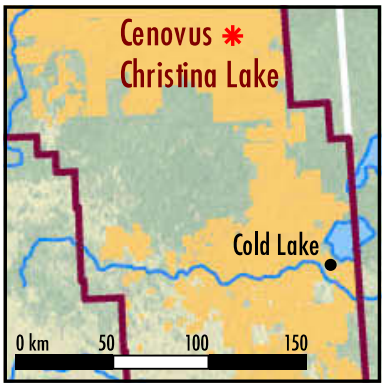


SCORE	RANK	
General Environmental Management		
1.5/3	Below Average	Canadian Natural Primrose/Wolf Lake's environmental management score is on par with other projects. To improve its performance in this area Canadian Natural should implement a third-party management system.
Land		
1/5	Below Average	Canadian Natural Primrose/Wolf Lake scores well below the average in the land category because the Pembina Institute found no evidence that Canadian Natural supports CEMA, the ABMI or has purchased biodiversity offsets. Canadian Natural's project is also located in caribou habitat.
Air Emissions		
0.75/3	Below Average	Canadian Natural Primrose/Wolf Lake outperforms other operations on its SO_2 emission intensity. However its NO_x emissions are relatively higher than other projects. NO_x emissions are strongly correlated to the steam-to-oil ratio of the project. Canadian Natural could reduce its NO_x emissions by reducing its steam-to-oil ratio. Canadian Natural could also create public emission reduction targets to achieve a better score in this category.
Water		
1/4	Below Average	Canadian Natural Primrose/Wolf Lake's water use intensity, freshwater use intensity and wastewater production is higher than the average in situ project. A relatively high steam-to-oil ratio of about 5:1[105] is partially responsible for this result. Canadian Natural is also behind its peers in incorporating brackish water into its water use profile. However, Canadian Natural is aiming to reduce freshwater use by 73% by 2013 in response to the ERCB's draft directive.[106]
Climate Change		
0/2	Below Average	Canadian Natural Primrose/Wolf Lake's GHG intensity is one of the highest in the industry, and Canadian Natural currently has no public emission reduction targets above and beyond government regulations. GHG emissions are strongly tied to steam-to-oil ratio, so reducing steam-to-oil ratio should lead to better GHG performance. Public targets could help to drive this change internally. Canadian Natural is focusing on technology such as follow up production with SAGD or solvents and in situ combustion schemes to increase production. These technologies may have environmental benefits as well because they require less energy production per barrel of bitumen produced.
Overall		
4.25/17 25%	Below Average	Canadian Natural Primrose/Wolf Lake is the lowest-scoring project reviewed in this assessment. Its project has a relatively high steam-to-oil ratio, which results in higher water use, air emissions and GHG emissions relative to other projects. In addition Canadian Natural has not supported initiatives, such as the ABMI and CEMA, which most other operators have participated in. Public targets to reduce absolute air emissions, water use and GHG emissions would also help increase the score of Canadian Natural Primrose/Wolf Lake.

▲ *Table 10: Summary of Canadian Natural Primrose/Wolf Lake's 2007 environmental performance.*

Cenovus Christina Lake: 37% *(PILOT)*

Cenovus's Christina Lake project is approximately 75 km north of its Foster Creek project. Like Foster Creek, Christina Lake is owned 50/50 by Cenovus and ConocoPhillips and operated by Cenovus. Christina Lake operations began in 2003, and it uses SAGD to recover the bitumen. Cenovus Christina Lake became a commercial project in 2008, and it made operational changes that are not reflected in this survey.

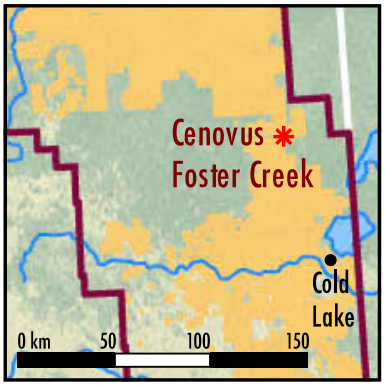


SCORE	RANK	
General Environmental Management		
2/3	Average	Cenovus Christina Lake's environmental management score is on par with other operations. It publicly reports project-specific data and has an environmental policy that commits to continuous improvement. It could achieve a higher score by implementing a third-party certified environmental management system.
Land		
2/5	Below Average	Cenovus supports the ABMI, and provided conditional support to the CEMA TEMF recommendation regarding biodiversity conservation in the Regional Municipality of Wood Buffalo.[107] However, Christina Lake is located in caribou habitat and the land use intensity of the project is relatively high compared to other in situ projects. To improve its score in this category Cenovus should reduce the land use intensity of the project and invest in conservation offsets.
Air Emissions		
2/3	Below Average	Cenovus Christina Lake's NO_x and SO_2 emissions are relatively low compared to other operations because it has a relatively low steam-to-oil ratio. Although SO_2 emissions are within regulated limits, Cenovus could further reduce SO_2 emissions by incorporating a sulphur recovery unit. Cenovus has approval to incorporate a sulphur recovery facility once additional production trains come online.[108] To score better in this category Cenovus should develop public absolute reduction targets.
Water		
0/4	Below Average	Cenovus Christina Lake received a zero score in the water category because in 2007 it required relatively high amounts of water, high amounts fresh water and produced high amounts of wastewater.[109] In addition, the brackish wells that Cenovus was using to supply water to its facility fell below the threshold of 4,000 ppm total dissolved solids, changing their classification to fresh water.[110] Since 2007, Cenovus has optimized its boilers and installed a water recycling facility at Christina Lake. It has also drilled new saline water wells. Together, these efforts are likely to enhance the project's water use performance.
Climate Change		
0.75/2	Above Average	As with air emissions, Cenovus Christina Lake's relatively low steam-to-oil ratio means the project has a relatively low GHG intensity. However, to improve in this area Cenovus should develop absolute GHG targets.
Overall		
6.25/17 37%	Below Average	To improve its score Cenovus should create public targets committing to reducing absolute air and GHG emissions and water use. These commitments would help to quantify Cenovus's commitment to continuous improvements. Cenovus would also show leadership in establishing biodiversity offsets to offset the impact of its operations in the boreal forest. Christina Lake has transitioned from a pilot to commercial project since this report was written. The Pembina Institute looks forward to scoring its commercial operations during the next report card period.

▲ *Table 11: Summary of Cenovus Christina Lake's 2007 environmental performance.*

Cenovus Foster Creek: 57%

Cenovus Foster Creek, located 75 km north of the city of Cold Lake, Alberta, uses SAGD technology to extract bitumen. The project is co-owned by Cenovus and ConocoPhillips in a 50/50 partnership and operated by Cenovus. The Foster Creek operation was the first commercial SAGD facility. Commercial operation started in 2001, and it produced just under 50,000 bbl/day on average in 2007, making it the largest SAGD bitumen producer. Cenovus Foster Creek incorporates a cogeneration unit and has one of the lowest steam-to-oil ratios in the in situ industry.

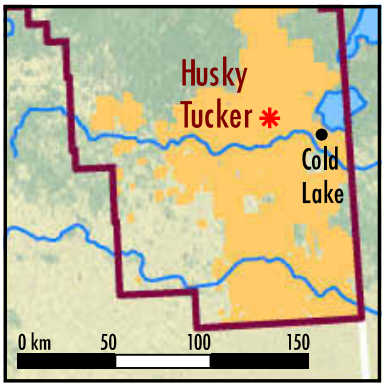


SCORE	RANK	
General Environmental Management		
2/3	**Average**	Cenovus Foster Creek's environmental management score is on par with other operations. It publicly reports project-specific data and has an environmental policy that commits to continuous improvement. It could achieve a higher score by implementing an externally verified environmental management system.
Land		
2.75/5	**Above Average**	Cenovus has reduced the land use intensity at Foster Creek by using underground storage caverns to replace aboveground storage, reorganizing their well pads to reduce footprint, and has lowered the seismic impact by using the "Mega Bin" 3D system. Although Cenovus supports the ABMI, its Foster Creek project is located in an area with nearby caribou herds,[111] reducing a portion of its land score. Cenovus could improve its score by investing in conservation offsets.
Air Emissions		
2/3	**Above Average**	Cenovus Foster Creek's NO_x and SO_2 intensities are among the lowest of the in situ facilities scored in this assessment. The primary driver for these two indicators is the project's relatively low steam-to-oil ratio. Cenovus Foster Creek also uses a cogeneration facility, further reducing NO_x and SO_2 intensities. Although Cenovus Foster Creek has delivered reductions in its emission intensity, to remain a leader in this area requires continuous reductions in absolute air emissions and public air emission reduction targets.
Water		
2/4	**Above Average**	Cenovus Foster Creek has among the lowest fresh and total water use intensities of the compared projects. In addition, Cenovus Foster Creek is currently piloting a re-boiler which will recycle a portion of the facility's blowdown water further reducing water make up requirements.[112] However, its wastewater production is considerably above the average in situ project.[113] To score better in this category Cenovus should strive to reduce its liquid waste production and develop public water use reduction targets that go beyond government regulated water reduction targets.
Climate Change		
1/2	**Above Average**	Cenovus Foster Creek's GHG intensity is among the lowest of the compared in situ projects. Foster Creek achieves this relatively low GHG intensity by maintaining a relatively low steam-to-oil ratio and by generating heat and electricity using cogeneration. To achieve a better score in this category Cenovus should publicly state absolute GHG emission reduction targets.
Overall		
9.75/17 57%	**Above Average**	Overall Cenovus Foster Creek's environmental performance is among the best in the industry. Its operations are performing well technically which results in reduced environmentally impact. To Cenovus's credit it is investing in new technologies to more efficiently produce bitumen and further reduce the environmental impact intensity of its operations. For example, Cenovus has developed and is implementing wedge wells and is experimenting with second stage "once through steam generation," which together are likely to improve the energy efficiency of its operations. Cenovus could invest in several areas to maintain its lead in environmental performance, including setting public targets and investing in land offsets.

▲ *Table 12: Summary of Cenovus Foster Creek's 2007 environmental performance.*

Husky Tucker: 35% *(START-UP)*

Husky Tucker, located 30 km northwest of the city of Cold Lake, Alberta, uses SAGD technology to extract bitumen from the Clearwater formation. Husky has 100% interest in the project. Steam injection commenced in late August 2006, and first production was achieved in late November 2006. However, average production was 1,700 bbl/day in 2007, well below the 30,000 bbl/day design capacity. Well production issues at Husky Tucker have resulted in a very high steam-to-oil ratio of about 14:1 in 2007.[114]

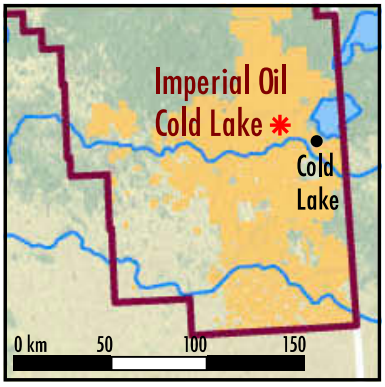


SCORE	RANK	
General Environmental Management		
2/3	Average	This project's environmental management system score is similar to other operations' scores. Husky publicly reports project-specific data and has an environmental policy that commits to continuous improvement. To achieve full marks in this category, Husky should implement an environmental management system certified by a third party.
Land		
3/5	Above Average	The land use intensity for Husky Tucker is lower than for most other projects. To improve its score in this category, Husky should invest in biodiversity offsets and provide support to the ABMI. It has committed to financially support the ABMI in 2010.[115]
Air Emissions		
0/3	Below Average	Husky Tucker underperforms compared with other operations in NO_x and SO_2 emissions. This project's high NO_x and SO_2 intensities are both linked to its high steam-to-oil ratio. If Husky Tucker reduced its steam-to-oil ratio to the design level (3:1) then it would likely compare well with other projects on air emissions. Husky is considering different production strategies, such as changing the pre-heat strategy in new wells and potentially re-drilling existing wells or drilling infill wells between current wells to enhance production.[116]
Water		
1/4	Below Average	Husky Tucker's overall water use is very high compared with other projects because of its high steam-to-oil ratio. Water with total dissolved solids of about 19,000 mg/L is treated for use as process make-up water. Husky Tucker uses very little fresh water compared to other projects – fresh water at the Tucker site is reserved for domestic and cleaning purposes, so it is independent of the project's steam-to-oil ratio.
Climate Change		
0/2	Below Average	As with air emissions and water use, Husky Tucker's GHG emissions are tied to its steam-to-oil ratio. Because this project has a high steam-to-oil ratio, its GHG emissions are also high. Husky Tucker does not have any publicly available targets.
Overall		
6/17 35%	Below Average	Overall, the Husky Tucker project scores poorly because of poor bitumen production. Absolute emissions are well within regulatory limits for the operations, but the relatively high intensities of water use, air emissions and GHG emissions reflect the project's poor performance. Environmental data reported for 2008 shows improvement from 2007, and Husky expects the Tucker project's performance to improve in 2009.[117] Nonetheless, Husky should invest in several actions, such as air, water and climate targets, and supporting the ABMI, while improving the technical performance of its project.

▲ *Table 13: Summary of Husky Tucker's 2007 environmental performance.*

Imperial Oil Cold Lake: 55%

Imperial Oil Cold Lake, located approximately 25 km northwest of the city of Cold Lake, Alberta, was among the first attempts at thermal oil production. The commercial pilot began production in 1975, followed by phases 1 to 10 between 1985 and 1994 and then phases 11 to 13, which included a cogeneration facility in 2002. Imperial Oil Cold Lake produced just under 50% of the in situ produced bitumen, making it the single largest in situ project. It uses CSS technology.

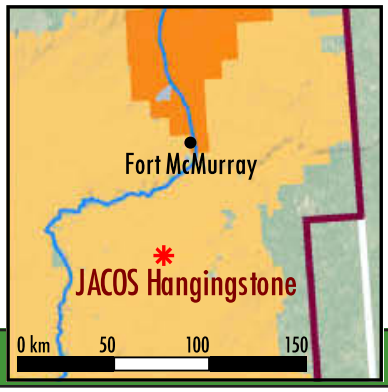


SCORE	RANK	
General Environmental Management		
2.5/3	**Above Average**	Imperial Oil Cold Lake scored above average with 83% in the environmental management category. The only difference between Imperial Oil's project and most other projects is that the Cold Lake facility is ISO 14001 certified.
Land		
2/4	**Average**	Imperial Oil Cold Lake scores average in the Land category because it is not located in caribou habitat and Imperial Oil supported the CEMA recommendation to preserve 20–40% of the Regional Municipality of Wood Buffalo. However, it could improve its score further by investing in conservation offsets and supporting the ABMI. In addition there was insufficient information in the public realm to calculate Imperial Oil Cold Lake's footprint intensity so this project was not evaluated on this metric.
Air Emissions		
1.25/3	**Average**	Imperial Oil Cold Lake scores average in this category because its SO_2 emission intensity is relatively low compared to other projects, its NO_x emission intensity is on par with other projects, and Imperial Oil has not generated public targets to reduce air emissions. Because this project already has a relatively low steam-to-oil ratio and a cogeneration unit, reducing these emission intensities will likely be difficult. Fortunately Imperial Oil is already experimenting with solvents to further reduce energy use, water use and air emissions. The results to date show an increase in bitumen recovery.[118] If Imperial Oil Cold Lake can reduce its NO_x emission intensity and publish public targets it will improve its score in this category.
Water		
2.5/4	**Above Average**	Imperial Oil Cold Lake scores well in this category because it has a relatively low water and freshwater use intensity and low liquid waste disposal intensity. The primary driving forces behind these lower intensities are Imperial Oil Cold Lake's relatively low steam-to-oil ratio and recycling of produced water. To score better in this category Imperial Oil should develop public water use reduction targets for the Cold Lake facility.
Climate Change		
0.5/2	**Average**	Imperial Oil Cold Lake scores average in the climate change category mainly for not incorporating GHG emission reduction targets into its operations. Imperial Oil could also improve its score slightly in this category by reducing its GHG intensity.
Overall		
8.75/16 55%	**Above Average**	Overall Imperial Oil Cold Lake scores relatively well in this survey because of a combination of good environmental management and technical performance which results in relatively good environmental performance. However, Imperial Oil can still improve significantly by setting public targets, investing in conservation offsets and further reducing its NO_x and GHG intensity.

▲ *Table 14: Summary of Imperial Oil Cold Lake's 2007 environmental performance.*

JACOS Hangingstone: 34% *(DEMONSTRATION)*

JACOS Hangingstone, located 50 km southwest of Fort McMurray, started as a pilot project in 1999 at 2,000 bbl/day production. It expanded to 4,000 bbl/day in 2000 and by another 4,000 bbl/day in 2002. In 2007, JACOS Hangingstone produced just over 7,000 bbl/day.



SCORE	RANK	
General Environmental Management		
0.5/3	**Below Average**	JACOS Hangingstone's environmental management score is well below the average of the projects compared for this assessment. JACOS does not appear to have an environmental policy that commits to continuous improvement and the Hangingstone operation does not have a third-party certified environmental management system.
Land		
2/4	**Average**	JACOS Hangingstone scores around average in the land category because the facility is not located in caribou habitat and JACOS has agreed to the CEMA recommendation to conserve 20-40% of the Regional Municipality of Wood Buffalo. It could improve its score by investing in biodiversity offsets and supporting the ABMI. In addition insufficient information existed in the public realm to calculate JACOS' footprint intensity.
Air Emissions		
0.5/3	**Below Average**	JACOS Hangingstone's air emission intensities are well above average. JACOS Hangingstone's NO_x emissions are strongly correlated to steam-to-oil ratio, so reducing steam-to-oil ratio will also lead to a corresponding decrease in NO_x emissions. For sulphur JACOS Hangingstone is currently performing within its regulated sulphur emission limit; however, it could reduce its sulphur intensity by reducing its steam-to-oil ratio as well as installing a sulphur recovery unit. JACOS Hangingstone should be able to increase its score in this category by decreasing its steam-to-oil ratio, investing in sulphur recovery technology and establishing air emission reduction targets.
Water		
2/4	**Above Average**	JACOS Hangingstone has a relatively low water use intensity in comparison with other projects. This project recycles its produced water which is rare for a pilot project. The other two pilot projects, Christina Lake and Peace River, do not recycle produced water. JACOS Hangingstone has also been able to achieve a relatively low steam-to-oil ratio of 3.24 which keeps its water use intensity low. Despite JACOS Hangingstone's relatively good water performance the project experienced a number of challenges in 2007. Its zero liquid discharge system did not perform as expected leading to increased total liquid waste from the project. It also experienced lower steam quality and reduced blowdown recycling than designed.[119] JACOS Hanginstone's score will likely improve in the future if it is able to rectify some of these challenges.
Climate Change		
0.5/2	**Average**	JACOS Hangingstone's score in this category is average relative to the compared projects. JACOS Hangingstone has a relatively low steam-to-oil ratio which results in a relatively low GHG intensity for a pilot project. It could improve its score in this category by further reducing its GHG intensity and developing public GHG emission reduction targets.
Overall		
5.5/16 34%	**Below Average**	As a pilot project, JACOS Hangingstone scores quite well in the water category. However, to increase its score JACOS Hangingstone will need to implement air and GHG emission and water use targets, improve its environmental management score and further reduce its steam-to-oil ratio to reduce its NO_x, SO_2 and GHG emissions.

▲ *Table 15: Summary of JACOS Hangingstone's 2007 environmental performance.*

Shell Peace River: 38% *(DEMONSTRATION)*

The Shell Peace River complex is located 40 km northeast of the town of Peace River, Alberta. Shell began operations there in 1986. Today the Peace River operation is defined as a demonstration project.

It produced at 9,130 bbl/day in 2007. Shell has experimented with a number of technologies at this site, including SAGD, CSS and J-Wells.

SCORE	RANK	
General Environmental Management		
3/3	Above Average	Shell Peace River is the only project to score 100% in the environmental management category. The only difference between the Shell Peace River and most other projects is that the Peace River facility is ISO 14001 certified.
Land		
3/4	Above Average	The project does quite well in the land section. The project is not in caribou habitat and Shell provides support to both CEMA and the ABMI. To improve this score further Shell should invest in biodiversity offsets specifically for the Peace River complex.
Air Emissions		
0/3	Below Average	The project is among the worst projects from air emission intensity standpoint. Shell Peace River's relatively high air emissions are tied to its relatively high steam-to-oil ratio at 5.8. This high steam-to-oil ratio means Shell combusts significantly more natural gas relative to other projects to produce a barrel of bitumen at Peace River. In addition, Shell Peace River is currently licensed to emit a maximum of 14 t/d SO_2 and does not have sulphur recovery at the facility. However, the SO_2 waiver will expire at the end of 2010. Shell has recently submitted a regulatory application for the Three Creeks project (see reference below), which will decrease SO_2 emissions to 2 t/d by the end of 2010. Sulphur recovery is planned for the Carmon Creek project.[120] To improve its score in this area Shell will need to significantly reduce the NO_x and SO_2 intensity of its facility and provide public absolute reduction targets.
Water		
0/4	Below Average	Shell Peace River currently only uses freshwater sources and does not recycle produced water. These two points combined with a high steam-to-oil ratio results in the Peace River complex being among the worst projects in terms of water use. Shell is planning to rectify these concerns in a number of ways. In the proposed Carmon Creek project that was filed in January 2010, Shell plans to recycle produced water and use brackish water as the primary make-up water source, which would be aligned with the draft ERCB directive.[121, 122] These two actions should reduce Peace River's water use intensity, freshwater intensity and wastewater intensity. However, Shell will have to reduce its steam-to-oil ratio as well to compare well against other projects.
Climate Change		
0/2	Below Average	Like air emissions Shell Peace River has a high GHG emission intensity because of its high steam-to-oil ratio. In addition Shell does not have public emission reduction targets for the Peace River facility. The proposed Carmon Creek project includes several GHG abatement measures, including heating integration, cogeneration and acid gas injection. Shell would score better in this category if it could significantly reduce the GHG intensity of its Peace River facility and develop public GHG emission reduction targets.
Overall		
6/19 38%	Below Average	Shell Peace River is a demonstration project and so underperforms relative to its peers. Shell will have to significantly reduce its air and GHG emissions and well as water and freshwater use and liquid waste production as part of its Carmon Creek expansion to perform well relative to other projects.

▲ *Table 16: Summary of Shell Peace River's 2007 environmental performance.*

Suncor Firebag: 60%

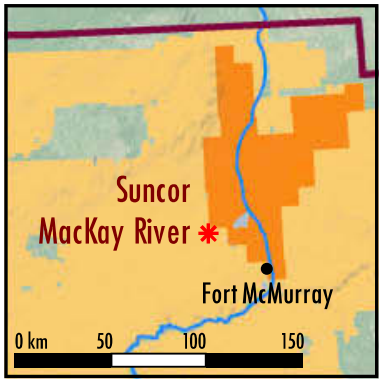
Suncor Firebag is located 65 km northeast of Fort McMurray, Alberta. Suncor started stage one of Firebag in 2004, followed by stage two in 2006. Both phases use SAGD to recover bitumen. The project also includes a cogeneration facility to produce electricity and steam for the SAGD operation. Production during 2007 averaged 37,000 bbl/day, well below the 70,000 bbl/day capacity. Suncor Firebag's production was lower than expected because of plant turnaround, chamber pressure restrictions imposed by the ERCB, pump failures and downsizing of pumps.[123]

SCORE	RANK	
General Environmental Management		
:1.5/3	Below Average	Suncor Firebag's environmental management score is on par with the in situ operations compared in this assessment. To improve its score Suncor should invest in a third-party certified environmental management system.
Land		
3/4	Above Average	Suncor Firebag scores relatively well in the land category for a number of reasons. Suncor supports both the ABMI and the CEMA recommendation to preserve 20-40% of the Regional Municipality of Wood Buffalo. Suncor also receives partial credit for protecting nearly 600 ha of boreal forest in northern Alberta.[124] However Suncor's facility is located in caribou habitat so loses a portion of its score on this indicator.
Air Emissions		
1.75/3	Above Average	Suncor Firebag's low steam-to-oil ratio means Suncor combusts less natural gas, producing fewer NO_x and SO_2 emissions per barrel of bitumen produced. The cogeneration facility produces steam and electricity more efficiently than producing steam on-site and importing electricity, which also reduces emissions. Suncor has also established absolute air emission reduction targets which help improve its score in this category as well.
Water		
3/4	Above Average	Suncor's relatively high score in this category can be attributed to Firebag's relatively low steam-to-oil ratio, water recycling and public water use reduction targets. Suncor recycles 90% of its water and the water used at Firebag is itself primarily sourced from reverse osmosis reject stream from Suncor's base facility.
Climate Change		
1/2	Above Average	Suncor Firebag's GHG intensity is among the lowest of the compared in situ projects. Firebag has a relatively low steam-to-oil ratio and also uses cogeneration to produce heat and electricity. Both of these factors result in Firebag's low GHG intensity. However, to improve its score further Suncor should develop public targets to reduce absolute GHG emissions.
Overall		
10.25/17 60%	Above Average	Suncor Firebag scores the highest of all the compared projects; however there is still considerable room to improve. Suncor could increase its environmental performance and score on this survey by providing absolute GHG reduction targets, expanding its biodiversity offsets program to account for new developments and by implementing a third-party audited environmental management system.

▲ *Table 17: Summary of Suncor Firebag's 2007 environmental performance.*

Suncor MacKay River: 53%

Suncor MacKay River is located 60 km northwest of Fort McMurray. Petro-Canada (now part of Suncor) first steamed the MacKay River operations in September 2002 and first produced bitumen in November of the same year. The project uses SAGD to produce bitumen, and it has a cogeneration unit operated by TransCanada to produce heat and electricity. In 2007, Suncor MacKay River averaged 21,248 bbl/day bitumen production.



SCORE	RANK	
General Environmental Management		
1.5/3	Average	Suncor MacKay River's environmental management score is on par with the in situ operations compared in this assessment. To improve its score Suncor should invest in a third-party certified environmental management system.
Land		
2.5/4	Average	Suncor MacKay River scores average in this category because it provides support to the ABMI, supports the CEMA recommendation to conserve 20–40% of the Regional Municipality of Wood Buffalo, and has invested in conservation offsets. However, MacKay River is located in caribou habitat and has a relatively high footprint intensity. To improve its score in this category Suncor should reduce the footprint intensity of MacKay River and invest in biodiversity offsets specifically for the MacKay River project.
Air Emissions		
1.75/3	Above Average	Suncor MacKay River scores well in this category because its air emission intensity is quite low relative to other projects. MacKay River's steam-to-oil ratio is relatively low compared to other in situ projects which helps explain the low air emission intensity. Suncor could score better in this category by providing air emission reduction targets for the MacKay River. It is unclear whether Suncor's published targets for its oil sands facilities also apply to the MacKay River complex.
Water		
2.5/4	Above Average	From a water perspective, Suncor MacKay River uses a zero liquid discharge system which essentially eliminates the need for wastewater disposal and increases recycle rates at the operation. Its low steam-to-oil ratio also means the facility requires less water per barrel of bitumen produced than other facilities. To improve its score in this category Suncor should reduce freshwater consumption at the MacKay River project and provide public water reduction targets for the facility.
Climate Change		
0.75/2	Above Average	Suncor MacKay River's GHG emission intensity is among the lowest of the compared projects. Its relatively low steam-to-oil ratio and the incorporation of cogeneration explain this relatively low GHG intensity. However, Suncor could score better in this category by developing public absolute GHG emission reduction targets.
Overall		
9/17 53%	Above Average	Suncor MacKay River is performing well technically as suggested by its low steam-to-oil ratio, but to improve its score further, Suncor MacKay River must quantify its commitment to continuous improvement by establishing public targets to reduce absolute air, GHG emissions and water use. Suncor MacKay River also has one of the larger footprints of the operations reviewed and is located in caribou habitat, which further reduces its score.

▲ *Table 18: Summary of Suncor MacKay River's 2007 environmental performance.*

Endnotes

1 Sarah Jordaan, David Keith and Brad Stelfox. 2009. Quantifying land use of oil sands production: a life cycle perspective. *Environmental Research Letters*, 4 (2009) 024004, www.iop.org/EJ/article/17489326/4/2/024004/erl9_2_024004.pdf.

2 Available at www.albertawatercouncil.ca/Portals/0/pdfs/WPPT%20Policy%20web.pdf.

3 Available at www.treasuryboard.alberta.ca/docs/GOA_ResponsibleActions_web.pdf.

4 Simon Dyer, Jeremy Moorehouse, Katie Laufenberg and Rob Powell, *Under-Mining the Environment: The Oil Sands Report Card* (Drayton Valley, AB: The Pembina Institute, 2008), www.oilsandswatch.org/pub/1571.

5 Richard Schneider and Simon Dyer, *Death by a Thousand Cuts: The Impacts of In Situ Oil Sands Development on Alberta's Boreal Forest* (Drayton Valley, AB: The Pembina Institute, 2006), www.oilsandswatch.org/pub/1262.

6 Cenovus was formed on December 1, 2009, when EnCana Corporation formally split into an integrated oil company (Cenovus) and a natural gas company (EnCana).

7 Shell has tried a number of bitumen production techniques at its Peace River operations, including SAGD, J-wells, multi-lateral legs and HayBob.

8 Global Reporting Initiative, *Environment: Performance Indicators* (Amsterdam, The Netherlands: Global Reporting Initiative, 2008). Information about specific indicators can be found at www.globalreporting.org/ReportingFramework/G3Online/PerformanceIndicators/.

9 Northwest and Ethical Investments, *Lines in the Sand: Oil Sands Sector Benchmarking* (Vancouver, BC: 2009), www.ethicalfunds.com/SiteCollectionDocuments/docs/lines_in_the_sands_full.pdf.

10 Kerry ten Kate, Josh Bishop and Ricardo Bayon, *Biodiversity Offsets: Views, Experience, and the Business Case* (Washington, DC: 2004), 13, www.forest-trends.org/publication_details.php?publicationID=660 (accessed November 27, 2009)

11 Government of Alberta, *Responsible Actions: A Plan for Alberta's Oil Sands* (February 2009), 19.

12 Environment Canada, *Scientific Review for the Identification of Critical Habitat for Woodland Caribou* (Rangifer tarandus caribou), *Boreal Population, in Canada* (Ottawa: Environment Canada, 2008), vi.

13 Ibid., 145.

14 www.cemaonline.ca

15 *Terrestrial Ecosystem Management Framework for the Regional Municipality of Wood Buffalo*, prepared by the Sustainable Ecosystems Working Group of the Cumulative Environmental Management Association, June 2008, 3.

16 abmi.biology.ualberta.ca

17 Jari Kouki, Jeremy Kerr, Reed Noss, John Reynolds, Jim Schiek and Stan Boutin, "World-Class Biodiversity Monitoring Makes Alberta a World Leader," (2008).

18 Environment Canada (NPRI), "2006 Air Pollutant Emissions for Canada Version 1," (April 2008), www.ec.gc.ca/pdb/websol/emissions/2006/2006_canada_e.cfm (accessed April 2009).

19 Ibid.

20 Julian Aherne, "Critical Load and Exceedance Estimates for Upland Forest Soils in Manitoba and Saskatchewan," (2008).

21 U.S. Environmental Protection Agency, "Health Effects of Pollution," www.epa.gov/Region7/programs/artd/air/quality/health.htm (updated November 2007).

22 Ibid.

23 Environment Canada (NPRI), "National Pollutant Release Inventory 2007 Summary — 3.1.1.1 Criteria Air Contaminants," www.ec.gc.ca/inrp-npri/default.asp?lang=En&n=0D743E97-1, (last modified May 14, 2009).

24 Global Environmental Management Initiative, "ISO 14001 Environmental Management System Self Assessment Checklist," www.gemi.org/docs/PubTools.htm (accessed August 29, 2007).

25 Mary Griffiths, Amy Taylor and Dan Woynillowicz, *Troubled Waters, Troubling Trends: Technology and Policy Options to Reduce Water Use in Oil and Oil Sands Development in Alberta* (Drayton Valley, AB: The Pembina Institute, 2006), www.pembina.org/pub/612.

26 In response to industry recommendations, this indicator has been modified from its original format. The survey question initially read: What ratio of water use is derived from fresh water, as compared to saline water, for 2007? As noted in the survey responses, using the ratio method allows projects with very high water consumption rates to use more fresh water while still maintaining a low ratio. Adjusting the metric to focus on total volumes of fresh water removed this potential for misleading results and provides a comparison according to the key issue, which is to promote conservation of fresh water.

27 Government of Alberta, Water (Ministerial) Regulation, Chapter/Regulation: 205/1998 (Edmonton, AB: Queen's Printer, 1998), section 1, 1(z), www.qp.alberta.ca/index.cfm.

28 Mary Griffiths, Amy Taylor and Dan Woynillowicz, *Troubled Waters, Troubling Trends: Technology and Policy Options to Reduce Water Use in Oil and Oil Sands Development in Alberta* (Drayton Valley, AB: The Pembina Institute, 2006), www.pembina.org/pub/612.

29 Global Environmental Management Initiative, "ISO 14001 Environmental Management System Self Assessment Checklist," www.gemi.org/docs/PubTools.htm (accessed August 29, 2007).

30 Environment Canada, *Turning the Corner: Detailed Emissions and Economic Modelling* (Ottawa, ON: 2008), 42, www.ec.gc.ca/doc/virage-corner/2008-03/pdf/571_eng.pdf.

31 Probe Research, *Albertans' Perceptions of Oil Sands Development Poll: Part I, Pace and Scale* (Drayton Valley, AB: The Pembina Institute 2007), www.pembina.org/pub/1446.

32 Northwest and Ethical Investments, *Lines in the Sand: Oil Sands Sector Benchmarking*, (Vancouver, BC: 2009), www.ethicalfunds.com/SiteCollectionDocuments/docs/lines_in_the_sands_full.pdf.

33 Ibid.

34 Energy Resources Conservation Board, "Oil Sands," www.ercb.ca/portal/server.pt?open=512&objID=249&PageID=0&cached=true&mode=2 (accessed May 14, 2009).

35 Ibid.

36 Alberta Energy, "What Is Oil Sands" (last revised June 11, 2009), www.energy.gov.ab.ca/OilSands/793.asp.

37 Energy Resources Conservation Board, "Oil Sands," www.ercb.ca/portal/server.pt?open=512&objID=249&PageID=0&cached=true&mode=2 (accessed March 30, 2009).

38 Alberta Energy. June 24, 2009. *Alberta's Leased Oil Sands Area*. www.energy.alberta.ca/OilSands/pdfs/OSAagreesStats_June2009vkb.pdf.

39 Alberta Energy, "What Is Oil Sands," revised June 11, 2009, www.energy.gov.ab.ca/OilSands/793.asp.

40 Imperial Oil. *Cold Lake Approvals 8558 and 4510 2008 ERCB Annual Performance Review*. Calgary: ERCB; 2008, www.ercb.ca/portal/server.pt/gateway/PTARGS_0_0_321_256_0_43/http%3B/ercbcontent/publishedcontent/publish/ercb_home/industry_zone/industry_activity_and_data/in_situ_progress_reports/2008/.

41 Energy Resources Conservation Board, ST98: Alberta's Energy Reserves 2008 and Supply/Demand Outlook 2009–2018, (Calgary, AB: ERCB, 2009), Figure 2-13, www.ercb.ca/docs/products/STs/st98-2009.pdf.

42 Energy Resources Conservation Board, "Oil Sands: Development," www.ercb.ca/portal/server.pt/gateway/PTARGS_0_0_312_249_0_43/http%3B/ercbContent/publishedcontent/publish/ercb_home/public_zone/oil_sands/development/ (accessed August 2009).

43 Alberta Energy, "What Is Oil Sands," www.energy.gov.ab.ca/OilSands/pdfs/FactSheet_OilSands.pdf (accessed May 14, 2009).

44 Energy Resources Conservation Board, ST98: Alberta's Energy Reserves 2008 and Supply/Demand Outlook 2009–2018, (Calgary, AB: ERCB, 2009), Figure 2-12, www.ercb.ca/docs/products/STs/st98-2009.pdf.

45 Alberta Chamber of Resources. *Oil Sands Technology Roadmap: Unlocking the Potential. Final Report* (2004), 28, www.acr-alberta.com/projects/Oil_Sands_Technology_Roadmap/OSTR_report.pdf.

46 Imperial Oil's first pilot project in the Cold Lake area started near Ethel Lake in the 1960s. Its first commercial project was approved in 1983. Shell started operations in the Peace River area 25 years ago, using a variant of the CSS process referred to as the "radial soak" method that has a vertical well with four horizontal arms that extend into the bitumen.

47 The ultimate recovery rate with CSS is expected to be 20–35% compared to 40–70% for SAGD. Alberta Chamber of Resources, *Oil Sands Technology Roadmap: Unlocking the Potential, Final Report* (2004), 28–29, www.acr-alberta.com/Projects/Oil_Sands_Technology_Roadmap/PSTR_report.pdf.

48 Imperial Oil. Cold Lake Approvals 8558 and 4510 2008 ERCB Annual Performance Review (Calgary, AB: ERCB, 2008), www.ercb.ca/portal/server.pt/gateway/PTARGS_0_0_321_256_0_43/http%3B/ercbcontent/publishedcontent/publish/ercb_home/industry_zone/industry_activity_and_data/in_situ_progress_reports/2008/.

49 Alberta Oil Sands Technology and Research Authority, *History of AOSTRA and Accomplishments*. (2002), www.aeri.ab.ca/sec/new_res/docs/history_on_the_web_020130.pdf.

50 Alberta Energy Research Institute, Steam Assisted Gravity Drainage (SAGD) (2002) www.aeri.ab.ca/sec/suc_sto_001_2.cfm.

51 Northwest and Ethical Investments, *Lines in the Sand: Oil Sands Sector Benchmarking*, (Vancouver, BC: 2009), www.ethicalfunds.com/SiteCollectionDocuments/docs/lines_in_the_sands_full.pdf.

52 The information in this table is sourced from ERCB monthly progress reports for 2007, from sustainability reports and responses from the companies to our surveys.

53 Sarah Jordaan, David Keith and Brad Stelfox, "Quantifying land use of oil sands production: A life cycle perspective," *Environmental Research Letters* 4 (2009), 024004, www.iop.org/EJ/article/1748-9326/4/2/024004/erl9_2_024004.pdf.

54 Kerry ten Kate, Josh Bishop and Ricardo Bayon, *Biodiversity Offsets: Views, Experience, and the Business Case* (Washington, DC: 2004), 13, www.forest-trends.org/publication_details.php?publicationID=660 (accessed November 27, 2009).

55 Government of Alberta, *Responsible Actions: A Plan for Alberta's Oil Sands* (February 2009), 19.

56 Alberta Conservation Association, www.ab-conservation.com.

57 Petro-Canada, personal correspondence to the Oil Sands Environmental Coalition, September 25, 2007.

58 Shell, personal correspondence, 2009.

59 Environment Canada, *Scientific Review for the Identification of Critical Habitat for Woodland Caribou* (Rangifer tarandus caribou), *Boreal Population, in Canada* (Ottawa: Environment Canada, 2008), vi.

60 Ibid., 145.

61 CEMA. 2009. Cumulative Environmental Management Association (CEMA). www.cemaonline.ca.

62 *Terrestrial Ecosystem Management Framework for the Regional Municipality of Wood Buffalo*, prepared by the Sustainable Ecosystems Working Group of the Cumulative Environmental Management Association, June 2008, 3.

63 Lower Athabasca Regional Plan, www.landuse.alberta.ca/RegionalPlans/LowerAthabasca/Default.aspx.

64 Cumulative Environmental Management Association, CEMA Responses Received on TEMF Recommendation (CEMA, 2008), www.cemaonline.ca/component/option,com_docman/task,doc_download/gid,1438/.

65 www.borealcanada.ca/framework-e.php

66 Cumulative Environmental Management Association, CEMA Responses Received on TEMF Recommendation (CEMA, 2008), www.cemaonline.ca/component/option,com_docman/task,doc_download/gid,1438/.

67 abmi.biology.ualberta.ca

68 Jari Kouki, Jeremy Kerr, Reed Noss, John Reynolds, Jim Schiek and Stan Boutin, "World-Class Biodiversity Monitoring Makes Alberta a World Leader," (2008).

69 Alberta Biodiversity Monitoring Institute, Previous Sponsors, www.abmi.ca/abmi/sponsor/sponsors.jsp (accessed June 2009).

70 Julian Aherne, "Critical Load and Exceedance Estimates for Upland Forest Soils in Manitoba and Saskatchewan," (2008).

71 Ibid.

72 U.S. Environmental Protection Agency, "Health Effects of Pollution," www.epa.gov/Region7/programs/artd/air/quality/health.htm (last updated November 2007).

73 From reported valuables for each of the projects available in their ERCB progress reports.

74 Husky Tucker's steam-to-oil ratio is 14:1. The average steam-to-oil ratio is (including Husky Tucker in the calculations) is 4.6:1.

75 U.S. Environmental Protection Agency, "Health Effects of Pollution," www.epa.gov/Region7/programs/artd/air/quality/health.htm (last updated November 2007).

76 Shell Canada Energy, Peace River In Situ Oilsands Progress Report Commercial Scheme Approval 81431, 2008,135, www.ercb.ca/portal/server.pt/gateway/PTARGS_0_0_303_263_0_43/http%3B/ercbContent/publishedcontent/publish/ercb_home/industry_zone/industry_activity_and_data/in_situ_progress_reports/2008/.

77 Environment Canada (NPRI), "National Pollutant Release Inventory 2007 Summary – 3.1.1.1 Criteria Air Contaminants," www.ec.gc.ca/inrp-npri/default.asp?lang=En&n=0D743E97-1, (last modified May 14, 2009).

78 Global Environmental Management Initiative, "ISO 14001 Environmental Management System Self Assessment Checklist," www.gemi.org/docs/PubTools.htm (accessed August 29, 2007).

79 Suncor Energy, *Summary Report on Sustainability* (2009), www.suncor.com/pdf/2009_Report_on_Sustainability_Summary.pdf.

80 Alberta Water Council, Water for Life recommendation for renewal, Appendix A (2008), 30.

81 Shell. Shell Canada Peace River In Situ Expansion: Carmon Creek Project (2009), 17, www-static.shell.com/static/can-en/downloads/aboutshell/our_business/e_and_p/carmon_creek_disclosure_mar16_09.pdf.

82 In response to industry recommendations, this indicator has been modified from its original format. The survey question initially read: What ratio of water use is derived from fresh water, as compared to saline water, for 2007? As noted in the survey responses, using the ratio method allows projects with very high water consumption rates to use more fresh water while still maintaining a low ratio. Adjusting the metric to focus on total volumes of fresh water removed this potential for misleading results and provides a comparison according to the key issue, which is to promote conservation of fresh water.

83 Government of Alberta, Water (Ministerial) Regulation, Chapter/Regulation: 205/1998 (Edmonton, AB: Queen's Printer, 1998), section 1, 1(z), www.qp.alberta.ca/index.cfm.

84 Husky Energy Inc., Husky Oil Operations Limited: Tucker Thermal Project Commercial Scheme 9835.; 2008:144, www.ercb.ca/docs/products/osprogressreports/2008/2008ColdLakeHuskyTuckerSAGD9835.pdf.

85 ERCB. Draft Directive: Requirements for Water Measurement, Reporting, and Use for Thermal In Situ Oil Sands Schemes. 2009.

86 Mary Griffiths, Amy Taylor and Dan Woynillowicz, *Troubled Waters, Troubling Trends: Technology and Policy Options to Reduce Water Use in Oil and Oil Sands Development in Alberta* (Drayton Valley, AB: The Pembina Institute, 2006), www.pembina.org/pub/612.

87 Suncor Energy, Report to the Community 2007–2008, Opportunities Tomorrow. Performance Today (2008), 17, 19.

88 Global Environmental Management Initiative, "ISO 14001 Environmental Management System Self Assessment Checklist," www.gemi.org/docs/PubTools.htm (accessed August 29, 2007).

89 Suncor Energy, 2009 Summary Report on Sustainability.

90 The ecoENERGY Carbon Capture and Storage Task Force, Canada's Fossil Energy Future (Natural Resources Canada, 2008), www.nrcan-rncan.gc.ca/com/resoress/publications/fosfos/fosfos-eng.php.

91 Environment Canada, *Turning the Corner: Detailed Emissions and Economic Modelling* (Ottawa, ON: 2008), 42, www.ec.gc.ca/doc/virage-corner/2008-03/pdf/571_eng.pdf.

92 Canada ratified the Kyoto Protocol on December 17, 2002. (maindb.unfccc.int/public/country.pl?country=CA).

93 Environment Canada, *Turning the Corner: Detailed Emissions and Economic Modelling* (Ottawa, ON: 2008), 42, www.ec.gc.ca/doc/virage-corner/2008-03/pdf/571_eng.pdf.

94 Husky Tucker SOR = 14, Average SOR (with Tucker in calculations) = 4.57

95 Probe Research, *Albertans' Perceptions of Oil Sands Development Poll: Part I, Pace and Scale* (Drayton Valley, AB: The Pembina Institute 2007), www.pembina.org/pub/1446.

96 Sarah Jordaan, David Keith and Brad Stelfox. 2009. Quantifying land use of oil sands production: a life cycle perspective. *Environmental Research Letters*, 4 (2009) 024004,www.iop.org/EJ/article/1748-9326/4/2/024004/erl9_2_024004.pdf.

97 Pembina compared an application for approval for a new in situ oil sands facility against the operating facilities in this report. On all metrics that could be measured (NOX, SO2, GHG, land use and water use) the project scored in the middle of the pack.

98 Alberta Environment, EnviroVista, www.environment.alberta.ca/867.html.

99 Available at www.albertawatercouncil.ca/Portals/0/pdfs/WPPT%20Policy%20web.pdf

100 Available at www.treasuryboard.alberta.ca/docs/GOA_ResponsibleActions_web.pdf

101 Northwest and Ethical Investments, *Lines in the Sand: Oil Sands Sector Benchmarking* (Vancouver, BC: 2009), www.ethicalfunds.com/SiteCollectionDocuments/docs/lines_in_the_sands_full.pdf.

102 Ibid.

103 Sarah Jordaan, David Keith and Brad Stelfox. 2009. Quantifying land use of oil sands production: a life cycle perspective. *Environmental Research Letters*, 4 (2009) 024004, www.iop.org/EJ/article/1748-9326/4/2/024004/erl9_2_024004.pdf.

104 Husky, Shell and Cenovus provided comments. However, the Pembina Institute produced the final summary. The companies consulted do not necessarily agree with the provided summaries.

105 Canadian Natural has a number of well pads all with different steam-to-oil ratios.

106 ERCB, Draft Directive: Requirements for Water Measurement, Reporting, and Use for Thermal In Situ Oil Sands Schemes (2009).

107 Cenovus responded that it supports the TRIAD philosophy outlined in the TEMF, however believes that specific numerical designation of intensive, extensive and protected areas is premature prior to a complete analysis of the environmental, economic and social aspects of such land designations.

108 Cenovus Energy, EnCana Christina Lake In-situ Oil Scheme 2009 Update, 2009:272, www.ercb.ca/docs/products/osprogressreports/2009/2009AthabascaEncanaChristinaLakeSAGD8591.pdf.

109 This conclusion is uncertain due to the lack of verifiably consistent data on liquid waste disposal across the projects.

110 Cenovus, personal correspondence, 2009.

111 While the Cold Lake Air Weapons range that hosts it has not officially been designated as caribou habitat, there is a nearby herd, and the Foster Creek project has developed a Caribou Management Plan for the area.

112 Cenovus, personal correspondence, 2010.

113 This conclusion is uncertain due to the lack of verifiably consistent data on liquid waste disposal across the projects.

114 Husky, personal correspondence, 2009.

115 Husky, personal correspondence, 2010.

116 Husky, personal correspondence, 2009.

117 Husky, personal correspondence, 2010.

118 Imperial Oil, Cold Lake Approvals 8558 and 4510 2008 ERCB Annual Performance Review (Calgary, AB: ERCB, 2008), www.ercb.ca/portal/server.pt/gateway/PTARGS_0_0_321_256_0_43/http%3B/ercbcontent/publishedcontent/publish/ercb_home/industry_zone/industry_activity_and_data/in_situ_progress_reports/2008/.

119 ACOS. Thermal In-Situ Scheme Progress Report: HANGINGSTONE DEMONSTRATION PROJECT 2007 (2008), www.ercb.ca/docs/products/osprogressreports/2008/2008AthabascaJACOSHangingstoneSAGD8788.pdf.

120 Shell Canada Energy, *Three Creeks 8-11-86-19 W5 Underground Gas Storage Scheme Requirements – Directive 65 application submitted to the ERCB*, 2009.

121 ERCB, Draft Directive: Requirements for Water Measurement, Reporting, and Use for Thermal In Situ Oil Sands Schemes (2009).

122 Shell, Shell Canada Peace River In Situ Expansion: Carmon Creek Project (2009), 17, www-static.shell.com/static/can-en/downloads/aboutshell/our_business/e_and_p/carmon_creek_disclosure_mar16_09.pdf.

123 Suncor Energy, 2008 ERCB Annual Review Suncor Firebag (2008), www.ercb.ca/docs/products/osprogressreports/2008/2008AthabascaSuncorFirebagSAGD8870.pdf.

124 Alberta Conservation Association, www.ab-conservation.com.