

The Royal Society of Canada Expert Panel:
**Environmental and Health Impacts
of Canada's Oil Sands Industry**

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The Royal Society of Canada (RSC) • Executive Summary in Brief



Development of the oil sands of northern Alberta has become an issue of growing public interest in recent years, with highly polarized views being presented by different stakeholders, including First Nations, environmentalists, industries and governments, about the merits of oil sands development in relation to its environmental and health impacts. Regardless of what any individual chooses to believe about these divergent views, the scale of investment and development in the oil sands is a major factor in Canada's economy, making the issues involved of vital importance to Canadians.

On October 5, 2009, The Royal Society of Canada announced the commissioning of an Expert Panel, consisting of eminent Canadian scientists and chaired by Dr. Steve E. Hruddy, FRSC, Professor Emeritus, Analytical and Environmental Toxicology, University of Alberta. The Expert Panel was given a mandate to review and assess available evidence bearing on these issues and identify knowledge gaps to provide Canadians with a scientific perspective in a summary report.

Context for the Project

The oil sands (or tar sands) have become a focus of intense development in recent years, and production from the oil sands has raised the prospect of Canada being a substantial net exporter of petroleum products. The oil sands have become increasingly controversial because of environmental and health issues, including: overall greenhouse gas emissions (the oil sands contribute about 5% of Canada's total emissions, but are Canada's fastest growing source); major landscape disruption from surface mining; massive tailings ponds holding wastes toxic to fish and waterfowl; and major consumptive water use.

These features have drawn the attention of international environmental groups, some of which have labeled the product from this source as "dirty oil." The deaths of more than 1,600 ducks on a tailings pond in April 2008, and ongoing claims of a cancer cluster being caused by oil sands contamination in the downstream (predominantly aboriginal) community of Fort Chipewyan, have drawn media attention.

On the economic side, the oil sands have been a major source of investment in Canada, supporting not only Alberta but the federal government (through increased taxes), the Ontario manufacturing sector, and skilled tradespeople from across Canada who have migrated to Fort McMurray for employment.

The major findings in the report addressing health and environmental issues include, in brief:

Feasibility of reclamation and adequacy of financial security: Reclamation is not keeping pace with the rate of land disturbance but research indicates that sustainable uplands reclamation is achievable and ultimately should be able to support traditional land uses. Current practices for obtaining financial security for reclamation liability leave Albertans vulnerable to major financial risks.

Impacts of oil sands contaminants on downstream residents: There is currently no credible evidence of environmental contaminant exposures from oil sands reaching Fort Chipewyan at levels expected to cause elevated human cancer rates. More monitoring focused on human contaminant exposures is needed to address First Nation and community concerns.

Impacts on population health in Wood Buffalo: There is population level evidence that residents of the Regional Municipality of Wood Buffalo (RMWB) experience a range of health indicators, consistent with "boom town" impacts and community infrastructure deficits, which are poorer than those of a comparable Alberta region and provincial averages.

Impacts on regional water supply: Current industrial water use demands do not threaten the viability of the Athabasca River system if the Water Management Framework developed to protect in-stream, ecosystem flow needs is fully implemented and enforced.

Impacts on regional water quality and groundwater quantity: Current evidence on water quality impacts on the Athabasca River system suggests that oil sands development activities are not a current threat to aquatic ecosystem viability. However, there are valid concerns about the current Regional Aquatics Monitoring Program (RAMP) that must be addressed. The regional cumulative impact on groundwater quantity and quality has not been assessed.

Tailings pond operation and reclamation: Technologies for improved tailings management are emerging but the rate of improvement has not prevented a growing inventory of tailings ponds. Reclamation and management options for wet landscapes derived from tailings ponds have been researched but are not adequately demonstrated.

Impacts on ambient air quality: The current ambient air quality monitoring data for the region show minimal impacts from oil sands development on regional air quality except for noxious odour emission problems over the past two years. Control of NOx emissions and regional acidification potential remain valid concerns.

Impacts on greenhouse gas emissions (GHG): Progress has been made by the oil sands industry in reducing its GHG emission per barrel of bitumen produced. Nonetheless, increasing GHG emissions from growing bitumen production creates a major challenge for Canada to meet our international commitments for overall GHG emission reduction that current technology options do not resolve.

Environmental regulatory performance: The environmental regulatory capacity of the Alberta and Canadian Governments does not appear to have kept pace with the rapid expansion of the oil sands industry over the past decade. The EIA process relied upon by decision-makers to determine whether proposed projects are in the public interest has serious deficiencies in relation to international best practice. Environmental data access for cumulative impact assessment needs to improve.

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The Royal Society of Canada (RSC) • Executive Summary



The oil sands deposits in northern Alberta have become a focus of intense development in recent years. While oil production has reached international stature, the overall oil sands operations have become increasingly controversial because of several widely publicized environmental and health issues. The public discourse on these subjects has become increasingly strident, leaving the Canadian public to sort out who and what to believe. With this background, The Royal Society of Canada (RSC): The Academies of Arts, Humanities and Sciences of Canada, as a public service to Canadians, commissioned an expert panel to review publicly available evidence on the environmental and public health impacts of oil sands development from an independent perspective that is not captive to any of the stakeholders in the current public debate.

This report is organized into three major parts:

- 1. Background**
- 2. Major Environmental and Public Health Issues**
- 3. What Does It All Mean?**

PART 1: BACKGROUND

The rationale for this review is presented in Section 1.1 in relation to the current public debates about the merits and risks of oil sands development. Some realities regarding the magnitude of economic activity involved are summarized, with further details elaborated in Appendix A.1.

The panel's scope, including an explanation of practical limitations of the review, is outlined in Section 1.2 and the panel's terms of reference are provided in Section 1.3. The panel's process for undertaking the review, gathering and analyzing evidence, and writing this report is summarized in Section 2.1. A scenario for future development to 2020 (as far as credible projections allow) was developed and used as a general reference for considering future impacts (Section 2.2).

The history of the oil sands, beginning with the first recorded report of bitumen in 1719, is reviewed in Section 3.1. It covers pre-commercial background, early small scale developments attempting bitumen extraction from the 1920s through the Second World War, the modern era with the first commercial-scale plant opening in 1967, and a series of on-again-off-again proposals until the late 1990s and early 2000s when new oil sands mega-projects began. Some of the complex interactions among inventors, entrepreneurs, levels of governments, and international oil companies confronting the considerable technological challenges of extracting bitumen from the oil sands are summarized. The summary covers the interplay of tensions between the provincial and federal governments dealing with private sector investors amid changing oil supply and demand scenarios and a roller coaster of international oil prices. This history is intended to help the reader understand some of the behaviours of current players. For example, arguably governments have been focusing on encouraging oil sands development with less apparent emphasis on environmental management or orderly development. A brief history of major environmental problems with oil sands operations is provided in Section 3.2, including oil releases to the Athabasca River and recent deaths by oiling of more than 2,000 ducks on at least two occasions on various oil sands tailings ponds.

The physical environment ranging from subsurface geological conditions giving rise to the oil sands deposits, to the surface landscape of the boreal forest and its wildlife and water resources are summarized in Section 3.3. The human environment is summarized in Section 3.4 including that of First Nations inhabitants who are

now covered under Treaty 8, Métis inhabitants, and urban communities which now occupy the oil sands region.

Technology (Section 4) is a key element of current activity in the oil sands, making recovery of bitumen feasible and giving rise to a wide range of environmental issues. Current oil sands technology is reviewed in relation to surface (open pit) mining and in situ processes. Bitumen upgrading and emerging oil sands technology are reviewed. The by-products generated by these technologies are explained along with discussion of how they are managed and what prospects exist for recovering valuable products from these materials.

Both provincial and federal governments have a wide range of regulatory instruments to govern approval and development, and to control the environmental performance of projects. Section 5 provides an overview of the complex current regulatory framework for oil sands developments and summarizes some concerns in relation to regulatory issues. Appendix A.3 provides additional details relevant to legislation and regulation.

PART 2: MAJOR ENVIRONMENTAL AND PUBLIC HEALTH ISSUES

Greenhouse gas (GHG) emissions from the oil sands (Section 6) are a major environmental issue. Although substantial progress has been made in reducing the quantity of GHG emitted per unit of production (emissions intensity) by the oil sands industry, and future reductions in emissions intensity will occur, the rapid pace of growth in bitumen production means direct oil sands GHG emissions have grown substantially. With current and projected developments, direct GHG emissions will continue to grow at a time when Canada has accepted targets for substantial overall reductions in response to the Copenhagen Accord. Technological solutions, such as carbon capture and storage (CCS), will not be sufficient to eliminate projected GHG emission increases from oil sands operations over the next decade.

The impact of non-GHG emissions on air quality (Section 7) is an important issue for oil sands development because these operations are major emitters of air pollutants on local, regional, and national scales. Extensive regional air quality monitoring has confirmed recent problems with odorous emissions which must be resolved. Other regional ambient air quality issues are not evident, but concerns over acid-forming emissions (SO₂, NO_x) and polycyclic aromatic hydrocarbons (PAH) will need to be dealt with. There has been a policy of Alberta Environment (AENV) to require the best available technology economically achievable (BATEA) for emission controls. AENV must demonstrate consistent adoption of BATEA as its policy has long stated. In a national context, the oil sands industry in total is not the largest emitter in Canada for any air pollutant, nor will it become the largest emitter in any category under any foreseeable expansion scenario.

All aspects of oil sands development are dependent on water and Section 8 focuses on how current and anticipated activities impinge upon water quality and quantity issues. A management framework is in place to control water abstraction from the Athabasca River as this is the source of water for most surface mining operations and it is necessary to ensure minimum river flow rates are maintained at all times. In situ mining operations almost exclusively use groundwater but, in the absence of a regional hydrogeological framework, the regional cumulative impact of operations on groundwater quantity and quality still has not been assessed. The flow dynamics between groundwater and surface water, such as lakes and wetlands, need to be better understood. Oil sands process wastewaters stored in tailings ponds contain chemical constituents that are acutely toxic to aquatic organisms. While this toxicity declines with time, there is evidence of persisting negative effects on fish health from these constituents. Naphthenic acids (NA) are a constituent of particular concern; continuing research is required into more appropriate analytical methods and standards for this complex mixture, to understand their migration and persistence in groundwater, and to establish chronic biological effects of their different forms. Construction of end pit lakes (EPLs) has been approved in principle by Alberta's Energy Resources Conservation Board (ERCB) since 1993 as a reclamation measure for receiving large quantities of aqueous wastes from surface mining and processing operations subject to demonstrated success which has yet to be achieved. Given their large scale and potential to be a significant water quality hazard for the foreseeable future, high priority should be given to research that improves methods of assessment and possible remediation, including development of a receiving water standard for NA. Assessment of downstream effects of oil sands operations within the Regional Aquatics Monitoring Program (RAMP) indicates a minimal impact to date on water quality and responses of biota, but the RAMP program faces monitoring challenges to rigorously identify any possible impacts on the aquatic environment

by oil sands development. Because contradictory studies have been published, the current uncertainties that exist need to be resolved to restore public confidence in management of regional water resources.

Land reclamation (Section 9) is a major issue in oil sands development because of the huge land disturbance from surface mining operations and considerable land impact from in-situ mining operations. The pace of reclamation has been slow and is cause for concern. There is considerable uncertainty among stakeholders because of confusion over the meaning of terms related to reclamation; standardization needs to be introduced to remove this confusion. Greater clarity is needed among all stakeholders about end land use, equivalent land capability, and time frames for reclamation. Despite understandable scepticism about the ability to reclaim lands given the historically slow pace of reclamation, research to date indicates that there is a high potential for successful reclamation of upland ecosystems from soil and vegetation perspectives. Wet lands reclamation is more uncertain although there is promising research for this outcome. As noted in Section 8, tailings pond reclamation by EPLs is uncertain, but research shows interesting results such as toxicity reduction. Although impacts of oil sands operations on biodiversity have been the subject of speculation, few research data exist to substantiate or refute the concerns. There has been misunderstanding about the time frames involved for reclamation because the early landscape will not reflect the ultimate intended landscape, even though reclamation may be on a successful trajectory towards the target end land use.

Public health (Section 10) was reviewed first by evaluating a public health profile for the former Northern Lights Health Authority which largely coincides with the Regional Municipality of Wood Buffalo (RMWB) where the most intense oil sands development has occurred. Analysis revealed that for many indicators of community health, this region fares substantially worse than the provincial average. This disparity remains, even after considering that all health regions outside Calgary and Edmonton do not fare as well for these community health indicators. The problems identified are classic indicators of the “boom town” effect which have been well documented elsewhere. Such health disparities are difficult to reconcile with the wealth the region generates. The possibility that health problems might be caused by exposure to environmental contaminants was reviewed and it is unlikely that current levels of exposures will bring major health impacts. In particular, there is no credible evidence to support the commonly repeated media accounts of excess cancer in Fort Chipewyan being caused by contaminants released by oil sands operations.

Section 11 deals with a range of economic and policy issues recognizing that economic factors are major drivers in decision-making. The concept of environmental and health impacts being negative externalities in economic evaluation is explained and economic implications for Canadians are described. With water use being a major consideration from an environmental perspective, the reality is that water used by industry in Alberta is currently subject only to minor administrative fees, eliminating any economic incentive for minimizing water use. Financial security for reclamation obligations is a large issue regarding potential future liability for Albertans. A careful review of current practices aligns with repeated comments from the Auditor General of Alberta, that substantial improvements are needed to the current financial security arrangements to minimize potential liability to the public purse. Current practices in environmental impact assessment (EIA) were reviewed with regard to their coverage of socio-economic impact assessment; relevant topics are addressed by EIAs, but there is little evidence of rigorous analysis of socio-economic impacts compared with requirements for international development projects. The EIA process for approval of new oil sands projects has addressed human health only in relation to potential contaminants exposures; a broader health impact assessment approach addressing the full set of health determinants, in line with national and international best practice, has not been used in the EIA process. A more broadly defined cumulative impact assessment has been widely recognized as essential for the kind of massive development occurring in the oil sands, but while there are some encouraging developments, there is only limited evidence of tangible progress towards implementing these assessment tools.

PART 3: WHAT DOES IT ALL MEAN?

Section 12 includes a summary of panel findings on major issues; panel findings in relation to 12 questions which capture some of the current public debate over environmental and health issues concerning oil sands development, and general panel observations. The panel operated on the premise that the economic and strategic importance of the oil sands industry to Alberta and Canada is self-evident, so this report only summarizes the magnitude of some of these economic factors based on available credible evidence. The impact of the oil sands industry to the foregoing jurisdictions in the short-term can be adequately

demonstrated by fully answering the rhetorical question: What would the consequences be for Alberta and Canada if the oil sands industry was to shut down in the next year or the next five years? No further consideration of this rhetorical question is given here.

The panel findings on some major environmental and health impact issues are as follows.

- Current Government of Alberta policy on financial security for reclamation liability leaves Albertans vulnerable for major financial risks which are exacerbated by the current rate of reclamation which is not keeping pace with the rate of land disturbance. Major improvements in tailings management have been made in the past decade and reclamation of uplands landscapes is clearly feasible based on extensive research despite the small scale of certified reclamation to date. Reclamation of wetlands landscapes is less certain and the feasibility of the EPL option for reclamation of tailings-filled mined out areas remains to be demonstrated despite having been approved-in-principle in 1993.
- There is currently no credible evidence of environmental contaminant exposures from oil sands developments reaching downstream communities at levels expected to cause elevated human cancer cases in the local population. Highly publicized media reports of downstream contamination from oil sands developments are likely amplifying the considerable concern among downstream residents about their health, particularly given the magnitude and visual impact of industrial development that is occurring. Current levels of concern in potentially affected communities make it important for previous environmental contaminant exposure studies, which have focused on air pollutant exposures, to be expanded. New exposure assessment studies need to address contaminant exposures in food and water. The prospects are not promising for reaching definitive answers about health impacts from contaminant exposures using only conventional epidemiological methods on such small populations. This reality makes documentation of contaminant exposures by rigorous and thorough exposure assessment which can be compared with other relevant populations not located in oil sands regions the best approach for addressing these ongoing concerns.
- There is population level evidence that residents of the Regional Municipality of Wood Buffalo (RMWB) experience a range of health indicators that are poorer than the provincial average, which is dominated by the urban populations of Calgary and Edmonton, and are also poorer than indicators for a more relevant comparison with residents of what was formerly Peace Country Health Region. These indicators are consistent with the “boom town” effect and likely reflect the consequences of strained health and social infrastructure in RMWB as a consequence of the rapid pace of oil sands development. The Government of Alberta has recognized some of the infrastructure funding shortfalls caused by the rapid growth and major additional funding has been directed to the region, but we could find no evidence of any specific public health interventions to address some of the serious population health issues. At least, some investigation to validate these health discrepancies is needed, with subsequent strategies developed based on validated need.
- The Environmental Impact Assessment (EIA) process that is relied upon by decision-makers (i.e., panels for Alberta’s Energy Resources Conservation Board, ERCB and in some cases the Canadian Environmental Assessment Agency, CEAA) to make a determination whether proposed projects are in the public interest is seriously deficient in formal health impact assessment (HIA) and quantitative socio-economic impact assessment (SEIA) as would be required for World Bank projects, for example. Currently, human health impacts are assessed only by quantitative health risk assessment that is focused on predicting environmental contaminant exposures while population health impacts as outlined in the third bullet above, human health risk from technological disasters and occupational health are not addressed. Socio-economic impacts of developments are addressed only in a general, qualitative manner and these assessments would not satisfy the requirements of the World Bank for funding international development projects. Despite long-standing commitments to cumulative impacts assessment there is little tangible progress evident in recent EIAs or current regulatory policy.
- Considerable progress has been made by the oil sands industry in reducing its greenhouse gas (GHG) emissions intensity (amount emitted per unit of production) over the past two decades. The Government of Alberta has implemented the first regulatory requirements in Canada to achieve reduced GHG emissions from all major Alberta GHG emitters, but these reductions in emissions intensity will not be sufficient to cause overall reductions in GHG emissions from the oil sands industry because of recent and projected growth in bitumen and synthetic crude oil (SCO) production. The oil sands are not Alberta’s

largest industrial source of direct GHG emissions, but they currently represent about 5% of Canada's total GHG emissions. Thus, the continued growth of oil sands direct GHG emissions will create a major challenge for Alberta and Canada to meet Canada's international commitments for reducing overall GHG emissions.

- Despite over 30 years of water quality monitoring in the oil sands region, assessment of water quality impacts on regional tributaries and the Athabasca River has been controversial. This is partly because of recently published studies which, albeit based on sparse data and showing very little measureable impact on water quality for industrial developments of this scale, do support a hypothesis of measureable impact arising from oil sands developments on river water concentrations of polycyclic aromatic compounds (PAC), including polycyclic aromatic hydrocarbons (PAH) and various trace metals. This water quality impact hypothesis has been represented as demonstrating inadequacy of the RAMP, an industry-funded program created in 1997 partly based on recommendations arising from Environment Canada river studies over several years in the oil sands region. The adequacy of RAMP has been, or is currently, the subject of three reviews, commissioned respectively by RAMP as its routine five year review, the federal Environment Minister, and the provincial Environment Minister. The timing of these reviews concurrent with our review has not allowed us to consider their findings.

However, based on our review we concluded RAMP does need:

- Ongoing external scientific oversight at a greater frequency than every five years, to demonstrate that it is using the best available monitoring methods with state-of-the-art detection levels.
- Assurance that its biological monitoring programs are at least equivalent to those used by the Environmental Effects Monitoring program for the pulp and paper industry.
- Data made publicly accessible similar to the public access provided to air quality data by the Wood Buffalo Environmental Association (WBEA).

The Government of Alberta needs to make the water quality monitoring reported under individual industrial approvals issued under the Environmental Protection and Enhancement Act (EPEA) publicly accessible, particularly for monitoring that EPEA approvals require to be reported for tailings pond dyke seepage and groundwater. Other related concerns are the current absence of a regional groundwater model and the implications for groundwater of any major difficulty encountered reclaiming wetlands.

- The current ambient air quality monitoring data for the region show minimal air quality impacts from oil sands development on regional air quality except for noxious odour emission problems over the past two years. These problems may have been associated with reclamation of the first oil sands tailings pond at Tar Island which was announced as completed in September 2010. Nonetheless, Alberta Environment (AENV) must demonstrate in a publicly credible manner that it is implementing its own stated policy of requiring best available technology economically achievable (BATEA) for emissions control, particularly when applicable BATEA is being demonstrated for similar industrial emissions such as the power generation industry. Ongoing controversies over water quality impacts of oil sands developments indicate a need to validate reporting of contaminant emissions to the National Pollutant Release Inventory (NPRI), including validated monitoring of fugitive emissions from surface mines and tailings ponds.
- A Government of Alberta report in 2006 called for major expansion of the regulatory capacity of AENV and Alberta Sustainable Resource Development (SRD) to cope with the growth of the oil sands industry. Notwithstanding announced increases in regulatory inspection capacity of the ERCB for dealing with oil sands operations, the necessary increase in regulatory capacity for the other two agencies is not evident, particularly in light of possible regulatory factors which may have contributed to more than 1600 ducks being killed by oiling on a tailings pond in April 2008. These agencies need to seriously review whether they have and can effectively maintain the specialized technical expertise needed to regulate industrial development of this scope and sophistication, particularly in a preventive manner that demands detailed industry-specific technical knowledge by its regulatory personnel. EPEA provides that designated directors will make regulatory approval decisions independent of influence from senior management or politicians. The people of Alberta must be able to have confidence that such regulatory decisions are being made by highly skilled, senior technical specialists based strictly on the merits of scientific, technical, and economic evidence free of political interference. There is an adequate mechanism under

Alberta legislation for the Minister to make the final decision about regulatory approvals and related decisions if they are appealed.

Our governments – federal and provincial – need to show some leadership in not only clearly demonstrating responsibility in how the oil sands are currently developed now and in the future, but also in beginning to look ahead to a time when an economy based on fossil fuels may no longer be viable.

The Public Debate

The panel sought to frame this assessment of the oil sands development in the context of issues and questions that are on the minds of Canadians. These questions have been distilled from a variety of recent documents produced by non-governmental organizations (NGOs), government and industry advocating positions both for and against the merits of the oil sands industry. The following questions are provided together with what the panel has found based on our review of the evidence.

1. Can technology solve all of the environmental challenges of oil sands development?

- Technology cannot reduce the environmental impacts/footprint to zero in the oil sands industry any more than it can in any other heavy industry (e.g., mining, smelting, forestry, power generation).
- There have been substantial improvements in the environmental performance of oil sands production including substantially reduced intensity (i.e., per unit of production) of GHG emissions (down by 39% since 1990 according to Environment Canada) and water use for both surface mining and in situ technologies. These include: slurry hydrotransport allowing substantial reductions in extraction temperature for surface mining bitumen extraction with consequent reductions in GHG emissions; recycling warm water from the tailings stream to extraction, reducing energy needs for heating otherwise cold water; paraffinic froth cleaning for bitumen extraction, reducing GHG emissions by reducing the need for energy intensive centrifugation, and widening the upgrading technology portfolio by inherent partial upgrading of bitumen; improved bitumen recovery by novel chemical additives, reducing energy intensity of production because less material is moved and processed; and use of shovels and trucks for mining contributing to a significant reduction in GHG emissions by eliminating old energy intensive conveyor belts for oil sands transportation after mining by bucket-wheels and draglines, and by providing flexibility of mining for optimal processing. These reductions in emission intensities achieved by improved operating and process technologies have been more than off-set by the rapidly growing rate of bitumen production and upgrading.
- Important technologies are under development which hold promise for continued improvement in overall environmental performance for reducing land disturbance, facilitating rapid land reclamation, and reducing emissions. Advances include: integrated technologies based on gasification of coke and asphaltenes, solvent-based in situ production to reduce GHG emissions by reducing or eliminating the need for steam and minimizing energy intensity of mobilizing bitumen by solvent injection and/or electro-thermal in situ recovery integrated with carbon capture and storage; CO₂-enhanced oil recovery (EOR) to reduce GHG emissions, partial catalytic in situ upgrading through in situ combustion to provide energy to mobilize bitumen and development of practical coagulants to consolidate tailings more rapidly and release pore water. For some new technologies there may be trade-offs such as reduced water use or land disruption vs. increased GHG emissions, and these trade-offs must be recognized.
- A number of important and substantial technological challenges remain.
 - Tailings reclamation including proposed end pit lakes (EPLs) remains a major question because no tailings pond has yet been completely reclaimed.
 - The first oil sands tailings pond adjacent to the Athabasca River had its mature fine tailings (MFT) removed, with surface reclamation in September 2010 but the removed MFT must continue to be processed at other locations.
 - GHG emissions per m³ of bitumen are highest for in situ oil sands production and as long as these methods are based on generating steam by burning fossil fuels this is likely to continue.

- Carbon capture and storage (CCS) is appealing from the perspective of GHG policy as a whole but does not appear to be very feasible for oil sands production in general and in-situ in particular. Bitumen upgrading could provide a more promising source of applications for CCS. Substantial questions remain to be answered about the feasibility and reliability of CCS in all applications.

2. Is in situ bitumen recovery more environmentally benign than surface mining technology, recognizing that in situ will be the major source of bitumen production in the future?

- The nature of surface disturbance associated with in situ bitumen recovery is clearly different from surface mining. In situ operations involve clearing a smaller area (per m³ of bitumen production) including extensive linear developments, which if supporting developments like natural gas supply are accounted for, may be similar to surface mining in total quantity, but does not involve dewatering, overburden removal, tailings storage, and associated reclamation challenges faced by surface mining. The nature of reclamation for disturbances caused by in situ bitumen recovery poses no particular technological challenge; the types of reclamation activities needed for in situ production have been practiced successfully for many years in other applications (e.g., conventional oil production).
- Net water usage by in situ bitumen recovery is substantially lower than required by surface mining. In situ water use has involved a greater proportion of groundwater and extensive use of saline groundwater has been demonstrated.
- GHG emissions per m³ of bitumen produced are higher (10% to more than 20% on a well-to-wheels life cycle comparison) for in situ technologies currently in use compared with surface mining.
- Emissions of all air pollutants except for carbon monoxide (CO) are substantially lower for in situ bitumen recovery compared with surface mining bitumen recovery.
- There are uncertainties, which need better characterization, around potential groundwater contamination by in situ operations.
- Environmental impacts are different, and in some cases substantially less than surface mining, but in situ technologies are not free of environmental impacts.

3. Does oil sands water use and pollution threaten the viability of the Athabasca River system and downstream waters?

- Water use at current levels does not threaten viability of the Athabasca River system if the Water Management Framework developed by AENV with the federal Department of Fisheries and Oceans (DFO) to protect in-stream, ecosystem flow needs is fully implemented and enforced. Authority under the province's Water Act (WA) for water withdrawal licences issued to oil sands operators is adequate to achieve the protection required.
- Fresh surface water use is mainly associated with surface mining operations and although water demand is substantial, it is not an unsustainable fraction of available water flow in the Athabasca River. Water use for operating projects in 2008 was <0.7% of total annual flow that year and <0.5% of longer-term mean annual flow. Cumulative maximum allowable use is restricted to <10% of the lowest 5th percentile weekly flow by the Athabasca River Water Management Framework. Water actually used was about 23% of the maximum water allocated to the oil sands industry, an allocation which was <5% of total water allocations in Alberta, compared to 43% of Alberta's total water allocations for irrigation, for example.
- Concerns expressed about water withdrawals during low flow conditions in the Athabasca River (typically in winter) can be addressed effectively by implementing additional industrial off-stream water storage to capture water during seasonal high flow in spring. Substantial reductions in Athabasca River flow resulting from climate change would drive implementation of this option to a greater degree.
- Current evidence on water quality impacts on the Athabasca River system suggests oil sands development activities are not a current threat to aquatic ecosystem viability. However, there are valid concerns about the structure of the current RAMP that need to be addressed regarding appropriateness

of data collected, public access to RAMP data, independent scientific oversight, and verification of results.

4. Does oil sands development threaten regional groundwater resources or pose a threat to transfer process contaminants to surface waters?

- Potential threats to groundwater are commonly mentioned in individual project environmental impact assessments (EIA), but these concerns are typically addressed to local groundwater resources, and there needs to be greater attention directed to regional groundwater resources.
- The regional groundwater resource is not well characterized so it is difficult to judge the nature of the groundwater resource that may be at risk. Groundwater flow velocities are much smaller than surface water flow velocities, e.g. groundwater typically moves at a rate of 1 meter per year (m/y) in permeable aquifers compared to water velocities of metres per second (m/s) in the Athabasca River. Therefore, the time scale for groundwater pollution is much longer than it is for surface water, taking decades or more for groundwater pollutants to migrate from a source to a receptor.
- Seepage from tailings dykes is an intentional design feature to assure stability of dykes constructed with permeable sand. That seepage, which contains substantial quantities of dissolved organic carbon, largely NA, must be collected and returned to the inventory of process-affected waters on the operating plant site. Only a few published studies present seepage measurements and track groundwater contamination from tailings ponds. These studies indicate seepage rates highly depend on local geological materials, including those underlying dykes, and transport of NA in groundwater is poorly characterized.
- Successful reclamation of the original Tar Island tailings pond which had its inventory of mature fine tailings removed and replaced by sand completed in 2010 will be an important demonstration of what can be expected for impact on groundwater and surface waters from tailings dyke seepage from a reclaimed tailings pond in the long-term.
- Modifications to groundwater regimes which are feeding regional wetlands, such as dewatering before landscape clearing and mining, have potential to reduce the proportion of wetlands that will occur in a fully reclaimed regional landscape.
- The unresolved challenge of demonstrating long-term reclamation success of wetland landscapes poses a concern for groundwater regimes.

5. Will all disturbed land ultimately be restored to a natural state by oil sands developers?

- Alberta legislation requires that all disturbed lands must be reclaimed to an equivalent land capability. Contrary to popular belief, the legislation and regulations do not require reclamation to boreal forest ecosystems, although this expectation has evolved over time with applications to operate and subsequent approvals.
- Reclaimed conditions will resemble and function as natural landscapes, provided that the legislated requirements are fully implemented, but reclaimed conditions will not be identical to the pre-disturbance state.
- If developers cannot (or will not) undertake the needed reclamation activities, provisions are in place to protect the public from financial liability (see Question 7). In such cases, however, responsibility for insuring the needed reclamation activities are undertaken and funded would rest with the Government of Alberta rather than the developer. Since the associated reclamation costs are likely to exceed the amount of financial security held by the province, such cases would create a financial liability for the Government of Alberta.
- Use of standardized definitions for terms such as equivalent land capability, reclamation, and restoration are critical for establishing end land use goals, expectations, and requirements.

- Functional upland landscapes (soil and vegetation) can be reclaimed with current reclamation strategies, although some potential groundwater issues related to leaching salts require attention. The use of leaf, fibric, humic material (LFH) has substantially enhanced biodiversity in reclaimed uplands.
- The potential for successful reclamation of wetlands, particularly peatland, has not been well demonstrated in the research to date although studies elsewhere indicate more feasibility than generally believed.
- The reclamation of tailings ponds and the EPL approach raise many questions about feasibility because no tailings pond has yet been fully reclaimed (see Questions 1 and 4 above).

6. Are traditional Aboriginal land uses adequately recognized in authorizing oil sands development activities?

- For the duration of surface mining operations and reclamation, which are likely to last for three or more generations (50–100 years), the affected landscapes are not available for traditional Aboriginal use. As of March 2009, 602 km² have been disturbed by oil sands mining operations, an area equivalent to a square 24.5 km x 24.5 km or about 90% of the area of the City of Edmonton. The total potentially surface-mineable area of the oil sands deposit is about 4,800 km² (about two-thirds of the greater Toronto metropolitan area) mainly in the Athabasca River valley downstream from Fort McMurray. For comparison, the James Bay hydroelectric project flooded at least 9,715 km² of boreal forest in northern Quebec.
- If reclamation is successful, which is more certain for uplands than for wetlands, traditional land uses should be possible in the future.
- Judging the magnitude of negative impacts of the landscape area impacted by disturbance is not possible without up-to-date studies on the current traditional activity patterns and current attitudes towards development among potentially affected First Nations and Métis populations.
- Cumulative negative effects through cultural and demographic stress for regional First Nations and Métis populations are likely to be more severe if imposed without consultation, reasonable accommodation and creative, meaningful engagement in sharing benefits of developments.

7. Is financial security for oil sands disturbed land reclamation adequate?

- Financial security for surface mining oil sands operations is administered by AENV; no financial security is collected for associated processing plants (upgraders and extraction plants) which will require remediation and reclamation.
- For financial security purposes, some mining operations are governed by previous legislation that sets financial amounts according to production, not estimated reclamation liability.
- Evidence in Canada and the U.S. for coal and hard rock mining suggests financial security requirements have been chronically underestimated.
- Financial security requirements for in situ operations are administered by the ERCB and differ from those applicable to surface mines. Overall, although processing plants are included and provisions are made for remediation and reclamation, the approach adopted for in situ operations is such that security deposits will be a smaller proportion of assessed environmental liability than for surface mining operations.
- The Auditor General of Alberta has commented on the situation for surface mines and noted the current system lacks a reasonable, systematic risk management approach to avoid claims on the public purse arising from inadequate financial security. The same concern applies to in situ projects.
- For oil sands operations, financial security deposits typically take the form of irrevocable letters of credit issued by financial institutions. In the event of failure to perform on the part of oil sands operators, liability, as determined by the size of the letter of credit, reverts to the issuing institution.

- The ability of financial institutions authorized to issue letters of credits to deliver payment on major reclamation liability is a concern.
- Responsible government management of this issue must be demonstrated better than has been demonstrated to date.

8. Does oil sands development cause serious human health effects in regional communities?

- Environmental contaminants at current levels of exposure are unlikely to cause major health impacts for the general population. Projected additional emissions from expanded operations are not likely to change this expectation. In particular, there is no credible evidence to support the commonly repeated media accounts of excess cancer in Fort Chipweyan being caused by contaminants released by oil sands operations, notably polycyclic aromatic hydrocarbons (PAH) and arsenic. In particular, common references to PAHs in relation to human cancer risk have been loose and inconsistent with the scientific understanding of human cancer risk from this class of compounds.
- Notwithstanding the evidence, there appears to be a strong and recurring perception of potential cumulative health risks by many community members, which itself can lead to stress-related health issues in the affected communities.
- There are commonly perceived beneficial impacts of oil sands developments related to increased income and employment.
- As is commonly the case in boom-town style developments, there are major negative effects on community health due to several simultaneous pressures on individuals, families, and infrastructure. These include general price inflation, extreme housing shortages, labour shortages in most sectors, family stress, drug and alcohol abuse, increased crime, and other social negative impacts related to inadequate public health and municipal services. Community health status in the oil sands region is lower than the provincial average, which is dominated by Calgary and Edmonton data, but also poorer than that in the more comparable Peace Country region which has had its own, less intense, economic boom.
- Despite extensive searching of publicly accessible documents, no assessment could be found related to oil sands development for occupational health status in the industry or human health risks from technological disasters.

9. Are cumulative human and environmental impacts of oil sands development being adequately managed (including monitoring and data access) by the current regulatory system?

- Cumulative environmental impact assessment has been repeatedly raised as a concern in hearings addressing individual project EIAs and has been acknowledged as a priority need for regulatory reform by the Government of Alberta.
- A basic requirement for effective cumulative environmental assessment is easily accessible environmental data, preferably accessible in a central registry. Currently, relevant data are only readily accessible for air quality from the Wood Buffalo Environmental Association (WBEA) and air emissions from the National Pollutant Release Inventory (NPRI) database. Data collected by RAMP, Cumulative Environmental Management Association (CEMA), environmental monitoring for regulatory approvals, and individual project EIA studies are not uniformly and readily accessible.
- Cumulative impact assessment can only be achieved if these environmental data are analyzed on an ongoing basis.
- Cumulative environmental assessment requires determination of the ecological capacity in the region to identify limits that need to apply to individual project approvals.
- Water withdrawal limits developed in the Water Management Framework are based on historical flow data and an assessment of ecological in-stream flow needs by AENV in collaboration with DFO and ongoing work is required to validate these assumptions.

- Regional air quality and cumulative air emissions have been addressed to some degree in individual project EIAs, but better overall coordination of ongoing analysis is needed.
- There is strong indication that community health is being impacted cumulatively by the boom-town effect, but there is no specific program evident to address this problem.
- Access to environmental data and the associated transparency are essential to public confidence in environmental management.
- Government needs to take leadership to enable coordination and data access that is necessary and efforts to date fail to meet the scale of the challenge.
- In recent years a practice has emerged that does not support a cumulative environmental assessment approach by the Government of Alberta. AENV and SRD have not been participating in the ERCB public hearings which are held to inform the public interest decision which the ERCB must make concerning individual projects. This practice means the ERCB must make its public interest decision without benefit of input from Alberta's primary environmental regulators. AENV, in turn, is faced with issuing environmental approvals and licenses (EPEA, WA) to projects that have been approved by the ERCB without benefit of publicly accessible AENV input at the hearing stage.
- Despite many clear issues of valid federal interest, the profile of relevant federal agencies has been low.
- The purpose statements of EPEA and WA (see Section 5.3.3) provide clear guidance to the Government of Alberta about what needs to be achieved in managing environmental impacts from oil sands development; the government simply needs to respect the letter of its own legislation in this regard.

10. Is the oil sands industry collectively Canada's largest emitter for air pollutants other than greenhouse gases?

- The summary in Section 7.2 (Table 7.2) shows that for the major criteria air pollutants (PM_{2.5}, SO_x, NO_x, VOC, and CO), the contribution of the oil sands industry to the total of all Canadian industrial sources plus electric power generation utilities in 2007 and 2008 ranges from a low of 1.7% for CO to a maximum of 9.2 % for VOC. The oil sands industry ranked among major industrial categories plus electric power generation utilities for emissions in 2007 and 2008 from a low of twelfth for PM_{2.5} to a high of third for VOC and NO_x. To become the largest industrial emitter in Canada, in 2007 or 2008 the oil sands industry would have to increase by more than five-fold for SO_x and VOC or by more than seven-fold for any other category of criteria air pollutants.
- For the four categories of toxic air pollutants (carcinogenic PAH, Pb, Cd, Hg) summarized by NPRI for major industrial categories in 2007, the contribution of the oil sands industry to the total Canadian industrial sources plus electric power generation utilities in 2007 and 2008 range from a low of 0.01% for carcinogenic PAH to a maximum of 2.0% for mercury. The oil sands industry ranked among major industrial categories plus electric power generation utilities for emissions in 2007 and 2008 from a low of eighth for lead to a high of fifth for mercury. In 2007 and 2008 the oil sands industry would have to increase emissions by more than 15-fold to become the largest industrial emitter in Canada for any category of the four toxic air pollutants available in NPRI for comparison. 2008 was the most recent industry data summary available which allowed a cross-industry comparison.
- The proportion of air emissions from the oil sands industry is expected to grow over the next decade, but, as noted above, will not lead to the oil sands industry being the worst polluter in any category.
- The 2007 NPRI data do not cover volatile organic compounds (VOC) from tailings ponds, a source that is important and should be reflected in future NPRI summaries. The 2008 NPRI data show about a three fold overall increase in VOC from 2007 driven by a major increases in reported fugitive emission, presumably from tailings ponds. These estimates would allow judgement of the degree of improved air pollution control that will be necessary.
- The odour emissions problems experienced over the past two years need to be resolved.

- The expeditious and consistent adoption of current BATEA used by the power generation industry by oil sands operation for NO_x and other air pollutants is necessary.

11. Are greenhouse gas emissions from the oil sands industry being adequately controlled?

- In response to the Copenhagen Accord, the Government of Canada has made an economy-wide commitment to reduce GHG emissions by 17%, relative to 2005 levels, by 2020.
- The current proportion of Canada's total direct GHG emissions attributable to the oil sands industry is about 5%, compared with 16% for fossil fuel-fired power generation and 27% for transportation, based on 2008 Environment Canada data.
- Canada's GHG emissions have been rising over the period covered by the Kyoto Protocol, an overall increase of 142 million tonnes (24%) from 1990 to 2008. More than 80% of that increase in Canada's GHG emissions was independent of the growth in GHG emissions from the oil sands industry. The total 2008 GHG emissions related to the oil sands were about 37 million tonnes in 2008 and the increase in GHG emissions from the oil sands from 1990 to 2008 was roughly 20 million tonnes because of the growth in bitumen production.
- In 2008, oil sands direct GHG emissions were about 19% of total Canadian transportation GHG emissions. About two-thirds of total oil demand in North America (i.e., the demand driving oil sands production) arises from the transportation sector.
- There are some important technological initiatives reducing oil sands GHG emissions and there is some promise for further reductions in GHG emissions intensity (GHG emitted per unit of production) as noted in Question 1 above. The oil sands industry has reduced its GHG emissions intensity by 39% from 1990 to 2008 according to Environment Canada.
- GHG emissions intensity is currently higher for in situ than surface mining projects and in situ bitumen production is expected to grow more than surface mining bitumen production.
- In 2003 Alberta adopted the first legislated system in North America for regulating GHG emissions. Regulations in effect for large industry (established emitters of more than 100,000 tonnes of CO₂e per year in any of 2003 to 2006) are required to reduce their emissions intensity beginning in 2007 by 12% based on the average emissions intensity from 2003 to 2006. Emitters who miss their GHG emission targets can purchase credits to meet their regulated limit at the rate of \$15/tonne of CO₂e with the funds collected managed by a Government of Alberta agency investing in research into technology for reducing GHG emissions.
- The Government of Alberta has committed a \$2 billion investment towards CCS industrial demonstration projects. Although CCS may achieve a major reduction in Alberta GHG emissions, the geology of the oil sands region of northeastern Alberta is not a good candidate for CO₂ storage. Overall, CCS is likely a better technology for coal-fired power generation than for oil sands production.
- The predicted future of GHG emissions from the oil sands industry pose a major and growing challenge to Canada's ability to meet national GHG emission reduction targets in keeping with international GHG reduction targets.

12. Is the oil sands industry the most environmentally destructive project on earth, as has been suggested by some media and declared critics of the industry?

- Based on our review of the publicly accessible evidence, a claim of such global magnitude is not accurate. Despite the lack of evidence to support this particular view, it has gained considerable traction with the media and it now pervades the internet. This depiction is clearly aided by the photographs of ugly surface-mined landscapes, but the claims of global supremacy for oil sands environmental impacts do not accord with any credible quantitative evidence of environmental damage.

- Based on the most recently available summary data (2007 and 2008) from Environment Canada's NPRI database, the oil sands industry is no higher than third in industrial categories for air emissions of major criteria air pollutants.
- Likewise the oil sands industry ranks in the major industry categories for toxic emissions as fifth for mercury, sixth for cadmium, eighth for lead, and eighth for the four carcinogenic PAH available for summary comparison.
- In all cases for both criteria air pollutants and toxic emissions, at least a five-fold increase in emissions would be necessary for the oil sands industry to become the first ranked industrial emitter in Canada, meaning that no foreseeable oil sands growth scenario could lead to the oil sands industry being the largest category of industrial emitters in Canada, let alone the world, for any pollutant.
- The current proportion of Canada's total direct GHG emissions attributable to the oil sands industry is about 5% compared with 16% for fossil fuel-fired power generation and 27% for transportation, based on 2008 data. Oil sands GHG emissions are currently 0.08% of estimated global GHG emissions.
- Elimination of oil sands GHG emissions will not eliminate or substantially lessen the immense challenge facing the world to reduce GHG emissions. Notwithstanding that reality, GHG emissions from the oil sands industry pose a major and a growing challenge to Canada being able to meet national GHG emission reduction targets in keeping with international commitments.
- As of March 2009, 602 km² have been disturbed by oil sands mining operations in the past 40 years, with a major acceleration in the rate of mining over the past 10 years. The cumulative area disturbed by oil sands surface mining is equivalent to about 90% of the area of the City of Edmonton (population 782,000).
- The ultimate total potentially surface-mineable area of the oil sands deposit is about 4,800 km², which is about two-thirds of the greater Toronto metropolitan area (population over 5.5 million).
- Mines were estimated to occupy about 3,700 km² of the United States in 1980 and 20,000 km² of China in 1989, with an estimated rate of addition of 200 km² mining-affected land per year in China. For other comparisons of major human activities causing land impact, the James Bay hydroelectric project flooded at least 9,700 km² of boreal forest in northern Quebec and the cumulative net area of forest loss in the five years between 2000 and 2005 was 1,010 km² in North America, 40,400 km² in Africa, and 42,510 km² in South America. Surface mining and tailings ponds in the oil sands are concentrated in one area which may increase the local impact.
- Open pit mining in any application causes a substantial impact and the areal extent of oil sands open pit surface mining is considerable. Conventional tailings ponds are a visual blot on the landscape and pose a continuous threat to migratory waterfowl. There is clearly scope and need for more rapid reclamation of disturbed areas than has been implemented to date.
- Preliminary NPRI 2009 reporting of tailings and waste rock from mines and mills indicates oil sands mines total 10% of total tailings and waste rock produced in Canada compared with 54% for metal ore mining and 25% for iron ore mining.
- Fresh surface water use is mainly associated with surface mining operations and although water demand is substantial, it is not an unsustainable fraction of available water flow in the Athabasca River (further details in response to Question 3 above and in Section 8.2.1).
- Consistent evidence the oil sands industry is a major polluter of surface waters has not been demonstrated. Pollution of groundwater is less certain, but there is no evidence potential pollution of local or regional groundwater is substantial on national or global scales.
- The claim by some critics of the oil sands industry that it is the most environmentally destructive project on earth is not supported by the evidence. However, for Canada and Alberta, the oil sands industry involves major environmental issues on many fronts which must be addressed as a high priority.

Panel Observations on Closing the Gap

Our mandate was not to judge the economic benefits of oil sands development but to document them as a relevant matter of background. The magnitude of economic development of the oil sands and its contribution to the Albertan and Canadian economies largely speaks for itself. Our evaluation of environmental and health impacts has been addressed to a moving target; many things are happening while we have been doing our evaluation. Consequently, we cannot claim to know everything that is currently underway or which has been achieved (see Section 1.2).

Some of the challenges involved in managing environmental and health issues associated with oil sands development arise from the large physical scale, rapid rate of expansion, the long project life, and involvement of multiple developers. These circumstances all contribute to challenges in achieving a coordinated and integrated environmental management approach. An overall theme of fragmentation vs. integration is a recurring challenge, particularly for cumulative impact assessment, an objective that is almost universally recognized as essential.

The Government of Alberta has reviewed many aspects bearing on health and social impacts of oil sands development, including seeking stakeholder perspectives on these issues. In response to the stakeholder survey, the Government of Alberta has proposed six strategies (Gov AB 2009a) to pursue regarding oil sands.

1. Develop Alberta's oil sands in an environmentally responsible way.
2. Promote healthy communities and a quality of life that attracts and retains individuals, families, and businesses.
3. Maximize long-term value for all Albertans through economic growth, stability, and resource optimization.
4. Strengthen our proactive approach to Aboriginal consultation with a view to reconciling interests.
5. Maximize research and innovation to support sustainable development and unlock the potential of Alberta's oil sands.
6. Increase available information, develop measurement systems, and enhance accountability in the management of the oil sands.

A number of actions were identified to implement the strategies. These actions are mainly process recommendations, which while valuable, do not specify end targets. In our review, we have identified specific needs for improvement that are generally, and in some cases specifically, applicable to these strategies. Although we may emphasize different elements, many of our findings should not come as a surprise, given the stakeholder feedback which is already reflected in the Government of Alberta plan for environmentally responsible oil sands development. The important issue, given the pace of oil sands development which has occurred, is how quickly meaningful action will be taken. As of the time of writing this report, there was little evidence available to us that implementation of meaningful improvements has begun or will be achieved in an adequately rapid time frame.

Based on our review of publicly available evidence, we offer the following observations.

Environmental Assessment

We have identified deficiencies in environmental assessment practices compared with international best practice guidance from guidelines promoted by Canadian agencies, international agencies, and industrial associations (e.g., IAIA, IPIECA, OECD, OGP, ICMM, World Bank). Notably, there has generally been inadequate overall risk assessment for technological and natural disasters, assessment of community health impacts (negative and positive), integrated and cumulative ecological impact assessment, and assessment of regional socio-economic impacts.

The cumulative impact assessment challenge requires much better integration of data gathering and assessment than is evident under current practices. Water issues are being addressed by RAMP, air issues

by WBEA, and these and other environmental issues by CEMA. These activities require effective stakeholder input, coordinated cross-media data analyses, and meaningful scientific oversight to assure continuous improvement in scientific methods, analyses, and ultimately to project approvals and environmental protection practices. These needs suggest that some agency must ultimately be responsible for integrating all of these monitoring and analytical activities towards the overall goal of assuring environmentally responsible development. The credibility of this agency and transparency of its activities are vital.

Tangible improvements could be achieved by:

- Undertaking a thorough comparison of current practices in environmental assessment against international practices, including health, social, economic, environmental, and sustainable development components, with a view to identifying international best practices. This evaluation must be done in an open manner. The findings should establish a benchmark for these assessments and must be updated regularly and be publicly accessible.
- Implementing a central repository of regional environmental, community health, and infrastructure data that provides effective public access.
- Implementing cumulative assessment, which requires the foregoing and a coordinated effort to review, analyze, and interpret regional data to set targets with a publicly accessible process that define cumulative capacity limits, as has been done with water use.

Community Health Disparities

We identified major community health disparities for the oil sands region compared to the provincial average and a similar resource development region of the province. We were unable to identify any public health intervention programs specifically targeted towards resolving these conditions that are largely symptomatic of boom-town conditions. A coordinated public health effort needs to be organized to address the evident health disparities. In particular, the Government of Alberta undertook a major review of needs for dealing with the oil sands development boom with the Radke report (Gov AB 2006) and many actions have been taken to implement its wide-ranging recommendations. Given the evidence for substantial community health disparities in the oil sands region, a current review of the evidence and community health needs would be valuable for developing meaningful and timely responses.

Role of Governments and Regulatory Agencies

The current visibility of relevant provincial and federal agencies, in particular, in dealing with the major environmental challenges is low and is generally not in line with the scale of those challenges. The Government of Alberta has a government-wide portal on its website to address oil sands, but the current content is largely public relations documents regarding the industry. There is a need for a substantive, publicly accessible, cross-government source where evidence on identifying problems and tangible government progress in dealing with those issues can be tracked.

Albertans clearly own the oil sands resource, thus their elected government, as the agent of the owners, has a critical leadership responsibility and role in determining how and under what conditions that resource will be developed. Recently, there have been some important steps taken to demonstrate the leadership required, notably as itemized in the Implementation Plan (Gov AB 2009b) for the strategies outlined in Responsible Actions (Gov AB 2009a). A key test moving forward will be in how effectively and quickly these actions are implemented regardless of the pressure arising from oil sands development applications that will be driven by market demand.

In view of the growing international, national, and local attention oil sands development is attracting, the public interest determination required of the ERCB in judging the next round of oil sands project approvals is becoming more challenging. Based on the specific deficiencies that we have identified and the important lack of cumulative analysis on many environmental and social issues, the ERCB faces difficult public interest determinations on future projects unless these information deficiencies, especially on cumulative impacts, are corrected. Accordingly, the necessary studies need to be completed with highest priority to assure a sound

evidence basis for the public interest decisions that the ERCB's enabling legislation obliges it to make for the people of Alberta on project applications.

First Nations and Métis Issues

Concerns about health risks from traditional Aboriginal land use need to be addressed by a focused data gathering exercise on potential contaminant exposure from traditional lifestyles, rather than performing health risk assessments with inadequate local data which drive those assessments towards over-reliance on models and assumptions.

Judging the magnitude of negative impacts requires studies on current traditional activity patterns and current attitudes towards development among potentially affected First Nations and Métis populations. Recent projects have conducted extensive traditional use studies and maintained substantial consultations with affected First Nations and Métis populations. Consultations need to achieve meaningful agreements that will allow First Nations and Métis populations affected by developments to participate tangibly in benefits of development, rather than simply having to adapt to negative impacts.

Financial Security

The need for new policy to protect Albertans from financial liabilities from reclamation of oil sands operations has been recognized by the Provincial Auditor General and more recently by the Government of Alberta (2009). For many reasons, the Government of Alberta should proceed with efforts to enhance financial liability management programs applicable to *both* oil sands surface mining and in situ projects. Such efforts are especially needed in light of evidence of widespread insufficient financial security in mining cases elsewhere in Canada and in the United States. A systematic approach to determining liability and the required financial security should be actively considered, recognizing that the approach adopted must be flexible enough to accommodate differences in the relevant aspects of surface mining and in situ activities.

The process leading to adoption of new policy in this area should be the subject of broad stakeholder and public consultation. The approach ultimately adopted and implemented should be the subject of detailed, publicly available documentation to assure Albertans their valid interests are truly protected.

Given the nature of activities and existing policy in this area, the following issues of particular relevance to surface mining activities should be addressed. Financial security should apply to remediation (contaminant clean-up) and reclamation (already the case for in situ operations). Extraction plants and upgraders should be subject to financial security requirements (already the case for in situ operations). All oil sands mining operations should be subject to financial security requirements that are related to reclamation and remediation liabilities and not to production volume as is currently the case for some older mines. Given the substantial magnitude of financial risks involved, there appears to be a compelling need to develop and implement an overall financial risk management approach to address this risk to the public purse.

GHGs

There is a clear challenge for Canada to meet overall GHG emission reduction targets while oil sands industry GHG emissions rise because of growth in production even while the industry has achieved reduced GHG emissions intensity. The provincial and federal governments need to recognize that the tangible commitments evident to date are likely still inadequate for Canada to meet its economy-wide GHG emissions target.

Air Quality

Given the major air emissions associated with oil sands operations, AENV needs to rigorously maintain a requirement for BATEA in all operating approvals issued. This is not a decision that industry can simply veto, it must be a responsibility of a competent environmental regulator. This means there must be the political will demonstrated to support technical decisions made by the regulator's technical personnel. The odour problems encountered in recent years are substantial issues that must be similarly understood and effectively resolved.

Oil Sands Lexicon

Developing common definitions for key technical and policy terms, such as reclamation vs. restoration, equivalent land capability, and “in the public interest,” is clearly required to minimize the negative impacts of differing interpretation of these terms among all stakeholders. Consideration will have to be given to how these terms can be standardized and clearly delineated for existing projects that are based on older and variable interpretations of the terms.

Progressive Reclamation

The real barriers to progressive land reclamation need to be explained. Intuitively, most would agree that reclaiming land soon after it is disturbed is a good thing which needs to be encouraged. Various reasons are given for not implementing progressive reclamation, but a full analysis of the barriers has not been done. Regardless, there appears to be more opportunity to implement progressive reclamation than past practices have demonstrated and the need to do better is compelling.

Protection of Waterfowl

The current practices for protecting waterfowl from the lethal risks posed by tailings ponds has been shown by the April 2008 and October 2010 incidents to be seriously inadequate. A new integrated approach focusing on doing more to prevent bitumen from reaching the tailings ponds, more to recover floating bitumen and more to segregate bitumen from the majority of the tailings pond surface needs to be pursued in light of these recent environmental failures. Even without the unacceptable toll of waterfowl deaths occurring, such measures are surely within the mandate of the ERCB because avoiding loss and maximizing recovery of bitumen is clearly conserving an energy resource. For the operators, lost bitumen represents lost income.

Industry Leadership

The oil sands industry can demonstrate leadership in developing future project proposals by implementing health impact assessment (HIA) guidelines as proposed by their international peer group. They should produce better consideration of cumulative impacts on community health, including the economic quantification of negative impacts and infrastructure spending.

Research Needs

Although research money is being invested in keeping with Strategy 5 of Responsible Actions (Gov AB 2009a), there is a need to ensure that research addresses the critical issues and is effectively published to ensure current and future research will benefit from work that has already been completed. A more intensive, time-sensitive, and integrated approach is needed to address the management of the critical issues, as follows:

- There is a need for a commitment to and emphasis on studying long-term effects (notably in reclamation and groundwater) beyond what is currently evident in published research.
- Continued efforts need to be directed at developing and improving alternative bitumen-recovery technologies that have a smaller environmental footprint and entail lower energy and water use.
- A regional groundwater framework to define a baseline for water quality and quantity is required. More research is needed to better understand and quantify interactions between groundwater and surface water.
- Reclamation of wet landscapes poses challenges which require intensive and coordinated research. There appears to be a need to simultaneously develop feasible process-affected water treatment vs. the EPL option for managing residual process water as a given project reaches termination. Regulatory decisions on water management are ultimately going to be necessary. Given the long time lines involved, developing discharge criteria for treated, process-affected waters should not be delayed any longer.

- All levels of government should establish a research capacity to monitor and investigate independently the current health impacts of oil sands projects. This initiative needs to be appropriately and adequately funded on a continuing basis by the developments generating the issues and be conducted under independent scientific guidance.
- Monitoring of health impacts should be undertaken on both health outcomes and health determinants. Health outcomes should include, for example, incidence of infectious and chronic diseases and mental health, incidence of physical injury and poisoning, and occupational health; while key health determinants should include, for example, effects on local health and social care services.
- Specific public health interventions should be determined and designed for the Regional Municipality of Wood Buffalo and other nearby regions found to be affected by oil sands development, to address the current health disparities described in Section 10.

The Royal Society of Canada (RSC) • Expert Panel Members



Members of the Panel (in alphabetical order)

Dr. Pierre Gosselin

Dr. Gosselin was trained as a physician (Université Laval) and in environmental health (University of California at Berkeley). He has been involved in environmental and occupational health for the last 30 years in various organisations. He is clinical professor at the Faculty of Medicine of Laval University and senior researcher at the Research Centre of Quebec City University Hospital (CHUQ), where he has been director of the WHO-PAHO Collaborating Centre on Environmental and Occupational Health since 1998. He has frequently advised the Pan American Health Organization and other WHO regional offices and headquarters, the International Joint Commission, the North American Commission for Environmental Cooperation, Health Canada and the Public Health Agency of Canada on environmental health matters. He works mostly out of the Quebec Public Health Institute (INSPQ), where he coordinates the joint Ouranos-INSPQ research program in climate change and health. He recently began coordinating the Health component of the Quebec Action Plan on Climate Change (2007-2012).

Dr. Steve E. Hrudey, FRSC (Chair)

Dr. Hrudey is currently Professor Emeritus, Analytical and Environmental Toxicology Division in the Faculty of Medicine and Dentistry at the University of Alberta with over 35 years in the environmental health sciences. He has chaired three and served on several expert panels including chairing the RSC panel to Review the Socio-Economic Models and Related Components Supporting the Development of Canada-Wide Standards for Particulate Matter and Ozone, serving the Research Advisory Panel to the Walkerton Inquiry, the Assessment of Health Risks Related to Trihalomethanes for Health Canada, Safe Drinking Water for First Nations for the Minister of Indian and Northern Affairs, Groundwater Management in Canada for the Council of Canadian Academies, Turbidity and Microbial Risk for the B.C. Minister of Health and most recently the Future Treatment Alternatives Study for the U.S. Army Corps of Engineers concerning drinking water for Washington, D.C. Dr. Hrudey was elected a Fellow of the International Water Association in 2010, a Fellow of the Society for Risk Analysis in 2007 and a Fellow of the Academy of Sciences, Royal Society of Canada in 2006.

Dr. M. Anne Naeth

Dr. M. Anne Naeth, P.Ag., P.Biol., is currently Professor of Land Reclamation and Ecological Restoration, in the Faculty of Agricultural, Life, and Environmental Sciences, and Vargo Distinguished Teaching Chair, at the University of Alberta with almost 35 years in the environmental sciences. Dr. Naeth has served on several expert advisory panels and boards for Alberta Sustainable Resource Development and Environment Canada (greenhouse gases), Canadian Wildlife Service (biodiversity), Alberta Environment (pipeline soils handling), Ducks Unlimited, North American Waterfowl Management Plan, Parks Canada, and the Nature Conservancy of Canada. She is currently leading development of an international graduate school in land reclamation. Dr. Naeth was elected a Fellow of the Canadian Society of Soil Science in 2007, and a Fellow of the Society for Teaching and Learning in Higher Education in 1997. She was awarded the Canadian Land Reclamation Association Noranda Award for outstanding contributions to the field of land reclamation in Canada in 1996.

Dr. André Plourde

André Plourde is currently Professor in the Department of Economics at the University of Alberta. He has previously held academic appointments at the University of Toronto and the University of Ottawa. To date, his career has also included two periods of service in leadership roles in the federal government departments of Finance and Natural Resources Canada. In 1994, he chaired the Task Force on Economic Instruments and Disincentives to Sound Environmental Practices for the federal ministers of Environment and Finance. Dr. Plourde has also served on the National Advisory Council on Energy Efficiency, the Energy Sector Sustainability Table (Environment Canada), and the Environmental Protection Advisory Committee (Alberta Minister of Environment), among others. In 2007, he was President of the International Association for Energy Economics and served as a member of the Government of Alberta's Royalty Review Panel.

Dr. René Therrien

Dr. Therrien has a PhD in hydrogeology from the University of Waterloo and is currently professor and chair of the Department of Geology and Geological Engineering at Université Laval. He has served on the expert panel on the Sustainable Management of Groundwater in Canada for the Council of Canadian Academies and is currently member of the commission examining the sustainable development of the shale gas industry in Québec within the Bureau d'audiences publiques sur l'environnement. He is also the current chair of the Healthy Environment and Ecosystems Panel within the Natural Science and Engineering Research Council's Strategic Projects Program. He was previously member of the Minister's National Advisory Board for the Earth Sciences for Natural Resources Canada and a member of the Canadian Geotechnical Research Board.

Dr. Glen Van Der Kraak

Dr. Glen Van Der Kraak is a Professor in the Department of Integrative Biology and the Associate Dean for Research in the College of Biological Science at the University of Guelph. He has published over 250 refereed journal articles, reviews and book chapters and has written or edited 4 books. He has extensive experience in the testing of chemicals and complex effluents for effects on the reproductive physiology of fish and amphibians. Dr. Van Der Kraak won the Award for Excellence in Research by the University of Guelph chapter of Sigma Xi in 2002. He has served on two panels of the World Health Organization's International Program on Chemical Safety evaluating risks posed by endocrine disrupting chemicals and methods of integrating human health and ecological risk assessments. He has frequently served as an advisor to the U.S. Environmental Protection Agency including serving as a member of the Endocrine Disruptors Methods Validation Sub Committee, the Endocrine Disruptors Methods Validation Advisory Committee and the Board of Scientific Counsellors that reviewed the US EPA's Endocrine Disruptors Research Program.

Dr. Zhenghe Xu

Dr Xu is Teck Professor in the Faculty of Engineering at University of Alberta and he has authored or coauthored 220 refereed journal articles, 50 technical conference proceeding papers, 9 invited book chapters and he holds 2 U.S. patents. His research expertise includes interfacial phenomena, oil sands engineering, surface engineering with emphasis on nano materials technology and mesoporous nanocomposites, mineral and materials processing and recycling, coal cleaning technology, waste management and pollution control. Dr. Xu held an NSERC/EPCOR/AERI Industry Research Chair in Advanced Coal Cleaning and Combustion Technology from 2002 to 2007, and he was appointed as a Canada Research Chair (Tier I) in Mineral Processing in 2006 and a NSERC Industry Research Chair in Oil Sands Engineering in 2008. He was elected a Fellow of the Canadian Academy of Engineering in 2008 and a Fellow of the Canadian Institute of Mining, Metallurgy and Petroleum in 2010.