Mercury Releases from Oil Sands

Implications for Teck Frontier

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Key Points

Mercury Releases from Oil Sands
Basic Facts

Mercury occurs in low concentrations in bitumen in all Alberta oil sand deposits
Range 100–700 parts per billion

Mercury Releases from Oil Sands
Hot Facts

Mercury is vaporized from bitumen at temperatures below 80°C
Peace River deposit bitumen is heated in vented tanks at 65–80°C
Athabasca deposit bitumen is processed by the 'hot' water method

Conclusion **Mercury is vaporized in the initial stages of bitumen recovery**

Mercury Releases from Oil Sands
Where has all the Hg gone?

In synthetic crude oil? **No** (it contains about 1 ppb)
In the environment? **Certainly** (around plants near Fort McMurray)
Disposed in tailings ponds etc.? **Yes** (National Pollutant Release Inventory)
Still in the plant? **Unknown**

Mercury Releases from Oil Sands
Health Facts - Peace River Example

Mercury is toxic and can accumulate in human tissues
Peace River: multiple adverse health symptoms were reported in 2009–2013
Alberta Energy Regulator concluded hydrocarbons and sulphur compounds to be the cause
Mercury data not required or provided, although its presence in bitumen was known

Mercury Releases from Oil Sands
Measuring the Mercury Footprint

Mercury concentration is low
Plant throughput is high
Multiply these two numbers to compare plants
(parts per billion mercury × 1000s of barrels per day)

Mercury Releases from Oil Sands
A Quick Comparison

Syncrude	200 000 barrels per day	82 ppb mercury	Impact number 16 400
Frontier	260 000 barrels per day	680 ppb mercury	Impact number 176 800

Frontier has a mercury footprint 10.8 times greater than that of Syncrude

Mercury Releases from Oil Sands

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ABOUT US

Brian Hitchon (B.Sc., Ph.D., P.Geol., F.G.S.) is a geochemist, retired after 32 years working for the Alberta Research Council (now InnoTech Alberta). His research is mainly concerned with the chemistry and flow of formation waters and how this information can be applied to processes such as CO_2 storage. Because formation water and crude oil are intimately interconnected he has also worked on trace elements in crude oils and bitumen in oil sand deposits. He is President of Hitchon Geochemical Services Ltd.
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OVERVIEW

We have prepared this report to highlight: (1) the under-recognized fact that bitumen in the Alberta oil sand deposits contains low concentrations but important quantities of mercury; and (2) potential large mercury emissions from the proposed Teck Frontier extraction of the Athabasca deposit.

Although the concentrations of mercury in oil sands are relatively small, the volumes processed are huge, and environmentally significant quantities of mercury are released by processing these oil sands. Mercury is vaporized from bitumen at temperatures at least as low as 80°C, which is the temperature range at which bitumen is processed commercially. Therefore, much or all of the mercury in the bitumen is released during initial processing, such that the mercury concentration is far lower in the final synthetic crude oil than in the original bitumen.

Our report follows the trail of knowledge of mercury from the laboratory to the largest oil sands project still under consideration (the Frontier mine of Teck Resources Ltd.). Along this path we summarize what is known and what needs to be known about mercury in Alberta's oil sands, and areas and populations impacted by emissions.

The evidence we reviewed suggests that the health of some Albertans may already be impacted by mercury released from bitumen. The importance of metals including mercury and cadmium was noted by Sears during the AER Peace River Proceeding No. 1769924, but no data on metals were required by the AER, nor provided by industrial parties. Symptoms described by local residents are consistent with vaporized mercury species as well as the acknowledged petrochemical toxicants. Mercury deposition elsewhere and bioaccumulation of methylmercury in the food chain is discussed below.

The Teck health report submitted to the Environmental Assessment process indicates that mercury levels in edible fish in the Athabasca River are almost four times the acceptable limit, but the Joint Environmental Assessment Panel concluded that it is not anticipated that proposed extraction will increase environmental contamination with mercury or methylmercury.[1]

DETAILED SCIENCE AND IMPLICATIONS

1. Hitchon et al. 1975 data - mercury in bitumen

In 1975, Brian Hitchon, R.H. Filby and K.R. Shah published a paper on trace elements in crude oils of Alberta.[2] Included in that study, but not part of the paper, was an undocumented oil sand sample supplied by Syncrude Canada Ltd. As with all oil sand samples described here, the bitumen was extracted from the oil sand with reagent grade benzene at room temperature without exposure to air. The benzene-bitumen mixture was then cooled and centrifuged at 8°C and 7000 rev/min for 15 minutes to remove clay minerals and water. Following this, benzene was removed from the mixture by evaporation at room temperature, and residual benzene was removed in a desiccator under vacuum, to constant weight.

In the case of this particular sample of bitumen the benzene-bitumen mixture was split into two parts. The bitumen was recovered from the first part as described above. The second benzene-bitumen mixture was subject to mild heat (less than 80°C) to drive off the benzene, although we recognize that light hydrocarbons may also have been vaporized at that temperature. Filby and Shah determined trace elements in each bitumen sample by neutron activation analysis at the Nuclear Radiation Centre, Washington State University at Pullman, Washington. For mercury, the result was as follows.

Sample Preparation Temperature	Mercury Concentration in Bitumen
Room temperature	81.7 parts per billion
80°C	Below detection (less than 2 parts per billion)

Full details of these two bitumen samples were published in 1983 in Open File Report 1983-02 of the Alberta Research Council.[3]

This experiment shows two things. First, our laboratory processing technique removed at most minimal mercury from bitumen. Second, mercury is easily vaporized from bitumen at 80°C.

In the case of our laboratory experiment the mercury vapour was exhausted via the fume hood into the atmosphere (but note that our sample size for the experiment was only 200 grams).

2. Alberta Research Council screen of mercury in Alberta formations, 1973

Circa 1973, the Alberta Research Council undertook a major investigation to determine if there are significant vertical and lateral variations in the composition of bitumen in Alberta oil sand deposits. Below is a summary of mercury in 12 bitumen samples across the major oil sand deposits.[4]

Mercury in 12 bitumen samples across the major oil sand deposits in Alberta

Sample No.	Depth (metres)	Stratigraphic unit	Location	Mercury (ppb)
ATHABASCA DEPOSIT				
BH-426A	48.2 – 54.6	McMurray Fm.	6-6-103-12 W4 Mer	680
BH-435B	283.5 – 295.7	McMurray Fm.	6-25-95-16 W4 Mer	370
BH-435C	295.7 – 307.9	McMurray Fm.	6-25-95-16 W4 Mer	303
BH-438A	468.8 – 471.2	McMurray Fm.	10-23-80-13 W4 Mer	273
BH-438B	480.2 – 485.6	McMurray Fm.	10-23-80-13 W4 Mer	209
COLD LAKE DEPOSIT				
BH-434B	482.2 – 484.6	Sparky Sandstone	10-10-59-2 W4 Mer	360
BH-439C	489.7 – 492.7	Sparky Sandstone	10-25-58-5 W4 Mer	406
BH-439D	494.2 – 499.9	Sparky Sandstone	10-25-58-5 W4 Mer	380
PEACE RIVER DEPOSIT				
BH-429D	516.3 – 518.6	Bullhead Fm.	1-27-86-19 W5 Mer	5740
WABASCA DEPOSIT				
BH-437A	339.9 – 342.9	Wabiskaw Member	16-5-86-21 W4 Mer	845
BH-430A	501.1 – 502.9	Grand Rapids A	7-8-75-1 W5 Mer	768
BH-430F	671.5 – 679.7	Wabiskaw Member	7-8-75-1 W5 Mer	728

With respect to the extraordinary value from the Peace River deposit, the original report stated:

> "Elements of particular environmental interest include As, Hg, Se, Sb and Zn. Of these the most startling value, which needs confirmation based on other samples, is the 5740 ppb (5.74 ppm!) reported for Hg in sample BH-429D from the Peace River oil sand deposit. Contamination is suspected."

There was no follow-up determination by our laboratory. Although this suggests that higher mercury concentrations are a possibility, in this work we limit considerations to a maximum mercury content of 680 parts per billion.

It is difficult to draw many conclusions from this limited data, though we can note that when bitumen was analyzed in two samples a few metres apart from the same well, the mercury values were relatively close. Also, of the twelve samples where we have values, most of the mercury values are in the range 200 to 700 parts per billion.

3. If companies presently processing oil sands have done any research to determine what happens to the mercury that is processed we are not aware that the results have been published. The research by Hitchon et al. (1975)[2] and Hitchon and Filby (1983)[3] on trace metals in crude oils (*but not the oil sands results reproduced above*, in Hitchon, 1993[4]) was cited in a 2009 report by the Alberta Research Council for the Petroleum Technology Alliance Canada.[5] The authors noted a paucity of data on mercury in heavy oil. As noted above, the Peace River Proceeding did not require from participants nor entertain data regarding mercury or other metals. Accordingly, the following is based only on our data, from historical work carried out by the Alberta Research Council.

4. Is there any evidence that extraction of bitumen from oil sands in Alberta may have produced untoward health effects that could possibly be attributed to mercury?

What follows in the next few paragraphs is summarized from a report from the Alberta Energy Regulator (AER) *Report of Recommendations on Odours and Emissions in the Peace River Area.*[6]

Items in brackets […] refer to individual sections in the AER report. Our comments are added, underlined.

> Just east of Peace River town in northern Alberta the oil sands of the Peace River deposit are extracted by a process known as CHOP (cold heavy oil production). In the CHOP process, wells are drilled to the oil sand zone and the reservoir energy then drives the oil, water, and gas (and sometimes sand) to the wellbore, from where the mixture is pumped to the surface … and hence to the production tanks to be heated to reduce viscosity and to allow separation of the oil, water, sand and gas in the tanks [92]. Shell Canada Limited noted that "the tank temperatures averaged 65 to 70 degrees Celsius depending on the water cut in the well" [103] and Baytex Energy Ltd. reported "heating the tanks to temperatures between 75 and 80 degrees Celsius" [112]. Note that both sets of temperatures are comparable to that used in our laboratory experiment to vaporize all the mercury in a sample of Athabasca oil sand.
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> Shell Canada Limited reported that it had "fully enclosed systems" for their tanks [102]. Other companies had various degrees of tank closure. Thus tank top gas was being vented to the atmosphere, flared, scrubbed using SulfaTreat scrubber to remove odours, used on site or off site, or various combinations of the above. What is clear is that mercury in the oil would be vaporized by heating and would be found in the atmosphere if vented or flared (possibly also if scrubbed).
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> Complaints from residents about hydrocarbon odours in the Three Creeks area began to increase in 2009, so that by late 2013 the AER had received 881 odour complaints, 80 percent of which were from areas with CHOP operations [6]. Symptoms included sinus congestion, headaches, tiredness, coughs, diarrhea, loss of balance, dizziness, loss of sleep, and nausea [38] and feeling clumsy, problems with balance, eye twitching, feeling faint, nervousness, clumsiness (in children), constipation, leg cramps, sensitization to other odours, hot and cold flashes, weakness in arms, night sweats and inflamed nasal passages [63]. The list of emissions generally associated with heavy oil operations [41] does not include heavy metals such as mercury.
>
> In her report to the AER, Dr. Sears noted the "gaps in the information available" to her [including data on toxic metals] and that "the measurement and identification of exposure levels were of single chemicals rather than complex mixtures" [57]. Further, she "emphasized that the exposures are chronic" with serious long-term effects, especially to susceptible populations such as children [58].

In addition to the above quotation, originating from interviews conducted by Sears, independent interviews of residents corroborated and expanded upon personal health problems. For example, one family reported loss of balance, short- and long-term memory loss, slurred speech, slowed thoughts, loss of hearing, metallic taste, and noted that their daughter, then two years old, "was unable to keep balance. She would fall off things–you know, one stair up, she'd fall off it. She'd fall off the couch, she'd fall off the chair when she was just sitting, eating supper" (Michael Toledano, Vice magazine, 2014-02-20).

We stress here that during the Proceeding, all these health symptoms were reasonably related to hydrocarbons and sulphur compounds. This review was limited because no participant of the AER inquiry had been provided data on mercury in oil sands bitumen, despite the fact that this information had been requested by Sears, and in fact in the public domain since the Alberta Research Council reports of 1983 [3] and 1993.[4]

5. Toxicity of mercury, as related to the health problems reported in the Peace River area.
During the Peace River Proceeding, interviewees indicated a number of symptoms that may be attributed to mercury exposure, as well as to sulphur-containing and other petrochemicals. With overlaps in symptoms from chemicals in the complex emissions mixture, it is impossible to attribute symptoms to a single component. Nevertheless, elemental mercury vapour as well as organic mercury (most commonly methylmercury, though other compounds are possible [7]). The following are symptoms summarized in a large Canadian Institutes for Health Research (CHIR) scoping review conducted by Dr. Sears, and Dr. Riina Bray MD, Medical Director of the Environmental Health Clinic, Women's College Hospital, University of Toronto. Many of these symptoms were reported by residents. A comprehensive review of health effects of mercury and compounds, as well as an interaction profile for chlorpyrifos, lead, mercury and methylmercury was published by the U.S. Agency for Toxic Substances and Disease Registry (ATSDR).[8,9]

Acute exposure may cause fever, altered blood pressure (depending upon type of mercury compound), tachycardia, inflammation of mouth and gums, salivation and swelling of salivary glands, metallic taste, tremors of eyelids, airway irritation and cough; weakness, cramping and twitching; decreased urine output, ejaculatory pain. Skin symptoms and delayed systemic symptoms are possible with dermal organic mercury exposures.

Chronic exposure would also have been experienced in Alberta communities impacted by mercury-containing bitumen emissions. Mercury causes permanent damage to nerves in the brain as well as peripheral nervous system. Symptoms include hearing loss, tinnitus and deafness; tremors of the eyelid, jerky visual tracking (nystagmus), narrowing of visual field, increase in size of "blind spot" in retina; nasal irritation and disturbed sense of smell; excess salivation, change in sense of taste and other oral and airway symptoms seen with acute exposure; allergic skin reactions and rash; photophobia, cramps, chills, perspiration, irritability, sleeplessness, progression of atherosclerosis (negating the benefits of fish consumption), anemia and other abnormalities in blood cells reflecting effects on bone marrow; cough and lung damage; nausea, gastrointestinal symptoms, liver damage, weight loss; kidney damage; weakness, muscle cramps, developmental regression; and other symptoms similar to amyotrophic lateral sclerosis (ALS), that may be reversible.

6. We now turn our attention to the Athabasca oil sand deposit, the most commercially important oil sand deposit in Alberta. Although (1) there is a wealth of information on the deposit and its environmental impact, and (2) mercury has received much attention, we still do not know the answers to such fundamental questions as: (1) How much mercury is there in the oil sands/raw bitumen inputs to the processing plants? (2) What is the fate of mercury species within the processing plants? (3) How much mercury is in the environment outside the processing plants and where is it found? Mercury releases reported to the National Pollutants Release Inventory (NPRI), on site and off site, to air, water and soil, may be searched online.[10] The majority of mercury from Syncrude is deposited in tailings; however, questions remain as to long term fate of mercury.

There are five well documented analyses of bitumen from three cores from across the Athabasca oil sand deposit (see table on page 3). Average values are summarized below.

Sample No.	Average depth (m)	Location	Average mercury (ppb)
BH-426A	51.4	6-6-103-12 W4 Mer	680
BH-435B/C	295.7	6-25-95-16 W4 Mer	337
BH-438A/B	477.2	10-23-80-13 W4 Mer	241

None of the cores is close to the operating plants, so we do not know the true content of mercury in the bitumen being mined at the various sites across the deposit. The only value available is 81.7 ppb mercury in the undocumented sample from Syncrude Canada Ltd.

The Environment Canada report *Mercury in Crude Oil Refined in Canada* [11] describes two samples (CCCN66 and CCCN67) as 'synthetic' crude oils created by upgrading bitumen from the Alberta oil sands. Sample CCCN43 is "a bitumen produced from oil sands that has not been upgraded upstream of the refinery". There is no further documentation of these samples. Average values from Table 8 of the report are given below.

Sample ID	Density (g/mL)	Sulphur (% w/w)	Total Mercury (ng/g) [University of Ottawa]
CCCN66 synthetic oil	0.8559	0.2	0.3
CCCN67 synthetic oil	0.8679	0.1	1.1
CCCN43 bitumen, not upgraded	0.9072*	3.1	6.6

* This density looks very low for unprocessed bitumen. Most have density greater than 1.0 g/mL.

Let us, simplistically, assume that one barrel of bitumen yields about one barrel of synthetic crude oil. Then our input and output concentrations of mercury are about 82 ppb and an average of 0.7 ppb (above tables), respectively. This means that we need to account for about 81 ppb of mercury. Syncrude Canada Ltd. recently announced that as of mid-October 2019 they had produced a total of 3 billion barrels of crude oil (read synthetic oil?) since the start of operations 41 years ago. This is an average of 200 000 barrels per day from a plant with 82 ppb in the starting material. That represents a large amount of mercury to be accounted for – roughly 40 000 kg over the lifetime of the plant.

Where might this mercury be found? The hot water flotation method is the basis of the present commercial extraction process for mined oil sand. The mined oil sand is crushed and mixed with hot water forming an aerated slurry. This means that the initial process results in effective removal of mercury from the raw bitumen. Mercury may also be in the bitumen froth (which is de-aerated with steam … more heat applied). The final bitumen stream is upgraded by a variety of processes such as fluid coking, delayed coking, and hydrotreating before being sent to refineries for final upgrading. Wastes include gases, and material sent to tailings ponds. There are thus many places in which the 'missing' mercury may appear.

One pathway for mercury to enter the surface environment is by atmospheric deposition. This may be investigated through either deposition onto plants or through precipitation. The plant of choice for some studies of heavy metals in northern Alberta is *Sphagnum* moss from ombrotrophic (rain-fed) bogs but there appears to be only one study with respect to atmospheric mercury deposition on *Sphagnum* moss.[12] Bill Shotyk and Chad Cuss collected samples of moss from twenty-two bogs near open pit mines and upgraders, and analyzed for mercury by two different methods. The results were compared to a control site at Utikuma (in northwest Alberta). Although the authors noted that the analytical findings were "contradictory" they nevertheless indicated mercury accumulation rates of 5.8–7.5 μg/m^2/yr (micrograms per square metre per year) versus 5.7–6.1 μg/m^2/yr for the control site. Dissipation from "hotspots" can be expected, as mercury is a "global pollutant" by virtue of its long range transport via re-volatilization. This required global actions,[13] and Canada is a signatory and has ratified the Minamata Convention – a global treaty to protect human health and the environment from mercury releases.[14]

In spring 2013, Jane Kirk and co-authors [15] sampled the 2012 accumulated winter snowpack at sites located at varying distances from major developments in the Athabasca oil sands area (about 20 000 km^2). They found that 79 ± 12% of the total mercury was bound to particles, with loads reaching up to 1000 ng m^{-2} (nanograms per square metre) near major developments. More important, there was a parallel increase in methylmercury (MeHg) loads, reaching up to 19 ng m^{-2} near major developments. The total mercury and methylmercury values were significantly correlated. By comparing the mercury data with other data they had they suggested "that oil sands developments are a direct source of MeHg [methylmercury] to local landscapes and water bodies." As noted previously, and worth repeating, methylmercury is a neurotoxin which bioaccumulates through foodwebs, and can reach levels in fish and wildlife that pose health risks to human consumers.

Total mercury and methylmercury have also been measured in waters from fifty lakes throughout the Athabasca oil sands region over a five year period.[16] The mean amount of total mercury in the lake waters (0.4–5.3 ng L^{-1}) and methylmercury (0.01–0.34 mg L^{-1}) were similar to those of other boreal lakes. An atmospheric chemical transport model was used to show that <2% of all mercury deposited to the sampled lakes was emitted from oil sands activities. However, the authors did not relate the mercury values in specific lakes and their drainage basins with the atmospheric deposition data of Kirk and co-authors.[15] This might have been a more meaningful correlation (though it is recognized that input from surface runoff and groundwater inflow would have to be taken into account).

Organic mercury in bitumen that is released during separation of bitumen from sand and water may include other organic forms. Some of these are even more toxic than methylmercury. As reported for lighter fluids (condensates), mercury molecules with one or two methyl (single carbon), or ethyl (2-carbon chain) groups are possible, but not all may be detected in analyses.[7]

What may we conclude from the above? First, only a mass balance with defined input and output determinations will tell us where mercury goes when it is processed in an oil sands plant. Second, there is strong evidence that both total mercury, methylmercury and other forms of organic mercury came from existing oil sand plants. Third, that very toxic organic mercury is emanating from oil sand plants, is in the air, and is being deposited on the ground and making its way into waterways and thereby the food chain.

7. Potential mercury impacts from Teck Frontier mining and processing of oil sands. The most northerly of the determinations of mercury in bitumen in the Athabasca oil sand deposit has the highest value for mercury (680 ppb) in the deposit. The location of this sample is outside but near the northern end of the Frontier lease of Teck Resources Ltd. Equally important, it is located less than 20 km from the southern border of Wood Buffalo National Park … the largest national park in Canada and a UNESCO World Heritage Site that is under threat with the maximum number of threats (9) of any Canadian World Heritage Site.

In the submission of Teck Resources Ltd. under the Canadian Environmental Assessment Act (CEAA) Report 7 (Health)[17] concluded that health risks are low to negligible, based on estimates of low exposures to three known carcinogens (arsenic, benzo(a)pyrene and hexachloro-1,3-butadiene [the latter does not originate in oil sands]), among dozens of toxic substituents. Mercury was acknowledged as a renal, developmental, reproductive and neurological toxicant, and was included in a chronic oral exposure assessment of risks to human health. Oral intake is via fish. Very briefly, it was postulated on behalf of Teck, and accepted by the review panel,[1] that the fish in the Athabasca River are already contaminated with mercury (as would be expected for a mobile pollutant such as mercury), but that this would not increase substantially as a result of the Frontier development. Few recommendations from Environment and Climate Change Canada regarding mercury research and surveillance were accepted by the Review Panel.[1]

Ongoing environmental mercury loading from Teck Frontier versus Syncrude

A critically important aspect is the scaled-up amount of mercury involved, compared with current emissions, as represented by Syncrude Canada Ltd. The comparison is given below.

Producer	Production (barrels per day)	Mercury in input bitumen (part per billion)	Relative Impact Number (ppb × 1000 bbl/day)
Teck Resources Ltd. (Frontier mine)	260 000	680	176 800
Syncrude Canada Ltd. (41-year average)	200 000	82	16 400

With respect to mercury, this means that the Teck Resources Ltd. operation at the Frontier mine will have an ongoing impact 10.8 times greater than the impact of mercury at the operations of Syncrude Canada Ltd.

An impact that is more than one order of magnitude greater at the Frontier mine than at mines operated by Syncrude Canada Ltd. is sufficiently large that the Frontier mine should not be approved until the full impact of mercury in all oil sands processing is evaluated, mitigation devised, and deemed safe by independent experts.

SUMMARY

We divide our comments into three groups: (1) what we know, (2) what we think are possible links between mercury in bitumen and the environment, and (3) the significance of these links with respect to the application of Teck Resources Ltd. for the Frontier mine.

What we know.

- Mercury is present in bitumen in all oil sand deposits in Alberta.
- Amounts of mercury in bitumen from Alberta oil sands are in the general range 100 to 700 ppb (parts per billion), although higher concentrations are possible.
- The processing techniques used to recover bitumen from oil sand removes mercury from bitumen.
- Heating bitumen at temperatures as low as 80 degrees Celsius causes vaporization of effectively all the mercury.
- The cold heavy oil production (CHOP) method used to produce some oils in the Peace River oil sand deposit includes heating the bitumen-gas-water-sand mixture in tanks at temperatures in the range 65 to 80 degrees Celsius. The hot water flotation method developed by Dr. Karl Clark at the Alberta Research Council is the basis of the present commercial extraction process for mined oil sand in the Athabasca oil sand deposit. The temperature of the hot water is not specified here but is certainly less than 100°C.
- Mercury in bitumen is reported as total mercury (often identified as THg).
- Methylmercury is an organic mercury compound that is extremely toxic and bioaccumulates in humans, fish, wildlife and the environment. We did not determine it in oil sand bitumen. Bitumen may contain other organic mercury chemicals that are also very toxic.
- A study of total mercury and methylmercury in accumulated winter snowpack in the Athabasca oil sand area showed greater loads near oil sand developments, and a significant correlation between these two forms of mercury. This suggests that oil sands developments are a direct source of methylmercury to local landscapes and water bodies.
- Medical problems reported by some residents in the Peace River oil sand area were reviewed for Alberta Energy Regulator (AER) and attributed to venting hydrocarbon and sulphur vapours from

heated bitumen processing tanks. Although symptoms were consistent with mercury exposure, no data pertaining to mercury exposure was included in the materials under consideration by the AER experts.

- The highest reliably measured content of mercury in bitumen from the Athabasca oil sand deposit is 680 ppb. The sample came from core in a well near the northern end of the proposed development of Teck Resources Ltd. and less than 20 km from the southern boundary of Wood Buffalo National Park, a UNESCO World Heritage Site that is under threat with the maximum number of threats (9) of any Canadian World Heritage Site.
- As far as we know, a mass balance for mercury has never been carried out in any oil sand plant or similar oil sand operation. Such a mass balance would identify the amount and location of all mercury that will be input from the mined oil sand, and its environmental fate. The mercury content of synthetic crude oil is about 1 ppb, so there is much mercury to be accounted for.
- For comparative purposes, one way to estimate the order of magnitude of the mercury footprint is to multiply the mercury content of the input bitumen by the volume of oil processed per unit time. When this is done for Syncrude Canada Ltd. and the proposed Teck Resources Ltd. Frontier operation, the Frontier plant will have a relative impact more than 10 times greater than that of Syncrude Canada Ltd.

What we think are possible links.

- We suggest that in the Peace River oil sand area where CHOP is the bitumen recovery method, the hydrocarbon vapours emanating from the heated tanks also include mercury.
- Based on some of the symptoms reported by residents, we suggest that both elemental and organic mercury were vented from the heated bitumen tanks, and were harmful.

Significance of these links.

- In the Peace River oil sands area two questions need answers. First, have former and current residents been subject to contact with mercury from oil sand operations, and if so, how should they be medically treated? Second, how will the Alberta Energy Regulator ensure that mercury from oil sands operations will not be a problem in the future?
- In the Athabasca oil sands area it has already been shown through a study of atmospheric deposition that both elemental and methylmercury have been and are probably currently being vented from the oil sands processing plants. What is required is a mass balance of all forms of mercury from the oil sands in the open pit mine, through all activities within the processing plant (including the finished products), to the local environment (including all 'waste' streams, tailings ponds, and venting).
- Knowing the sources and pathways of mercury, only then can technological mercury recovery solutions be devised, tested and implemented.
- The proposed Frontier mine of Teck Resources Ltd. has the potential over its lifetime to be the foremost emitter of both carbon dioxide and mercury in Alberta. Although it has been approved by the Joint Provincial-Federal Review Panel as "in the public interest" the potential emissions of carbon dioxide and mercury are certainly not in the public interest. To date, only carbon dioxide emissions have been the focus of attention. The project should not be approved until it can be shown that both carbon dioxide and mercury emissions are within safe limits, both in the short- and long-term, bearing in mind global warming, Alberta's environment, and human health.

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