

# Tar Sands Crude Oil:

## Health Effects of a Dirty and Destructive Fuel

Three recent studies confirm that tar sands processing near Fort McMurray and Edmonton, Alberta is resulting in the release of cancer-causing chemicals.



Syncrude upgrader, Fort McMurray © Julia Kilpatrick, Pembina Institute

The boreal forest in Northern Canada lies atop massive tar sands deposits that are roughly the size of Florida. Crude oil produced from these tar sands is one of the world's dirtiest and most environmentally destructive sources of fuel. Today, energy companies in Canada are actively developing this dirty fuel and have plans to triple production in the coming years. As tar sands is strip-mined and drilled from beneath the boreal forest of Alberta, Canada, greater volumes of tar sands-derived crude oil will be transported through North America's communities. With more tar sands flowing through pipelines, moving on railcars, and being processed at refineries, there is mounting evidence that people and communities in the vicinity of tar sands activity face substantial health and safety risks. This report highlights a growing body of scientific research, and news reports about people directly impacted, showing that serious health risks and problems are arising all along this tar sands network, from northern Canada to refineries in California, the Gulf Coast, the Midwest and the Rocky Mountains, as well as from accidents and spills. Despite this deepening danger, to date, state and federal governments have done too little to address this threat to the public's health.



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This report is based on a review of recent scientific research looking at the potential impacts on human health that are associated with tar sands oil. The Natural Resources Defense Council undertook this effort out of concern about the growth of tar sands development and because tar sands oil is dirtier than conventional oil, and thus poses a greater risk to public health.

Today, people who live near tar sands strip-mining, drilling, and processing operations in Canada face health risks from additional air and water pollution, and there are reports of an increasing incidence of cancer. Transporting tar sands on rail and through pipelines pose other threats to public health, as do tar sands oil spills and the refining process. Not only does refining of tar sands increase hazardous air pollution, it also produces an especially dirty, carbon-intensive byproduct known as petroleum coke, which is often burned in a way similar to coal. Taken together, the myriad health threats from tar sands development, transportation and processing are far more significant than policymakers and governments have acknowledged to date.

## Upstream Health Effects: HEALTH RISKS IN AREAS CLOSE TO TAR SANDS DEVELOPMENT IN CANADA

### Pollutants in the air

After tar sands are mined and drilled from the ground, the resulting product is “upgraded” via chemical and heating processes that remove impurities and convert the resulting raw bitumen into synthetic crude oil.<sup>1</sup> Due to expanded tar sands activity, scientists are noting an increased presence of pollutants in the ambient air near Fort McMurray (the epicenter of tar sands development) and to the south near upgrading facilities just outside of Edmonton, Alberta.<sup>2,3</sup> Several recent studies show that these pollutants include toxic constituents that are carcinogens (cancer-causing chemicals). A 2009 study published by the National Academy of Sciences showed that the snow and water in an area extending outward 30 miles from upgrading facilities at Fort McMurray contained high concentrations of pollutants associated with fossil fuels, known as polycyclic aromatic hydrocarbons (PAHs).<sup>4</sup> These chemicals often present serious risks to human health—some are known to damage DNA, others are carcinogens, and many cause developmental impacts. They also typically accumulate and remain present in the environment over long periods of time, according to research published by the U.S. Environmental Protection Agency.<sup>5</sup> A follow up study in 2014, published by the National Academy of Sciences, modeled the PAH levels measured in the tar sands region and found that environmental impact studies conducted by the tar sands industry in support of further development have systematically underestimated PAH emission levels and thus did not adequately account for human health risks.<sup>6</sup>



In a landmark study published in the November 2013 issue of the journal *Atmospheric Environment*, scientists noted the presence of elevated levels of numerous hazardous air pollutants near major upgrading facilities just north of Edmonton. Among the pollutants found at elevated levels, many are carcinogens, including benzene and styrene.<sup>7</sup> The study also noted elevated rates of leukemia and other cancers of the lymph and blood-forming systems in areas surrounding upgrading and petrochemical manufacturing facilities just north of Edmonton.<sup>8</sup> Further, this study also noted that experts have found similar elevated risks in other populations living downwind of industrial facilities with similar emissions, which have also been linked to increased rates of leukemia and childhood lymphohematopoietic cancers.<sup>9</sup>

The impact of increased air pollutants and noxious odors from excavating tar sands has been the subject of significant attention in the remote community of Peace River.<sup>10</sup> There, the Alberta Energy Regulator is finally responding to years of reports by residents that emissions and odors from tar sands drilling and processing are making them sick.<sup>11</sup> According to news reports, public hearings began in early 2014 following complaints that the tar sands operations have caused nausea, headaches, skin rashes, memory loss, joint pain, exhaustion, and respiratory problems, and have forced several families to leave the area.<sup>12</sup>



Leaks from tailings ponds, emissions from tar sands upgraders, and evaporating PAHs are already contaminating water resources and pose significant future health risks.

### Pollutants in the water

The majority of tar sands oil production takes place in close proximity to the north-flowing Athabasca River, which eventually flows into the Arctic Ocean (via the Peace, Slave, and MacKenzie Rivers).<sup>13</sup> According to a 2012 study published by the National Academy of Sciences, researchers confirmed through lake sediment sampling and modeling that the presence of elevated levels of toxic PAHs can be traced to the major expansion of tar sands production that began in the 1980s.<sup>14</sup> In particular, certain water bodies within the Athabasca watershed now exceed current Canadian standards for pollutants in sediment for seven PAHs, including benzo(a)pyrene, a chemical that has been linked to cancer, genetic damage, reproductive impacts including birth defects, and organ damage.<sup>15</sup>

In addition, scientists analyzed lake sediments and snow samples and found evidence that tar sands development is leading to increasing amounts of methylmercury in Alberta's waterways and landscape. Specifically, the researchers report an exponential increase in measured methylmercury levels within 30 miles of tar sands upgraders.<sup>16</sup> Methylmercury is a potent neurotoxin that causes developmental and behavioral problems, including lower IQ in children, as well as cardiovascular effects in adults.<sup>17</sup> Methylmercury is known to accumulate in the food chain and can result in unsafe exposures, particularly among populations who consume a lot of fish.<sup>18</sup> This increased presence of mercury in the Canadian landscape poses a unique threat to First Nations who rely on hunting and fishing for sustenance, and whose right to hunt and fish has been guaranteed by treaty and by the Canadian Constitution.<sup>19,20</sup>

Further health threats arise from ponds full of mining waste. These tailings ponds contain multiple toxic chemicals including arsenic, benzene, lead, mercury, naphthenic acid, and ammonia, according to a Pembina Institute analysis.<sup>21</sup> A 2008 study by Environmental Defence Canada, based on industry data, found that as much as 2.9 million gallons of water leaks from tar sands tailings ponds into the environment every day.<sup>22</sup> Another study, published by the National Academy of Sciences in 2014, shows that extreme concentrations of PAHs present in tailings may lead to the evaporation of those PAHs into the ambient air.<sup>23</sup> Further, the releases of PAHs into the ambient air from tar sands upgrading facilities discussed above are finding their way into the Athabasca River and its numerous tributaries.<sup>24</sup> While the tailings leakages suggest the possibility of a significant future threat to waterways, emissions from upgrading and evaporating PAHs from tailings ponds appear to already be contaminating water resources with carcinogens and other chemicals linked to negative human health effects.

### A concerning rise in cancer rates

In a 2009 study commissioned by the governments of Alberta and Canada, scientists studied the incidences of cancer found in the tiny community of Fort Chipewyan. Fort Chip, as it is commonly known, has 1,100 residents and is located where the Athabasca River empties into Lake Athabasca, 124 miles north (downstream) of the major tar sands developments in Fort McMurray. In the report, scientists noted a diagnosed cancer rate from 1995 to 2006 that was 30 percent higher than what would typically be expected for that period of time.<sup>25</sup> Further, certain types of cancers—biliary tract cancers, blood and lymphatic cancers, lung cancers in



Residents of Mayflower, Arkansas bore the full brunt of a tar sands oil pipeline rupture when diluted bitumen from the Canadian tar sands covered their neighborhood with crude oil.

women, and soft tissue cancers—all occurred at rates higher than expected, the government study showed.<sup>26</sup> Scientific studies have linked elevated levels of these specific cancers to exposure to certain constituents in petroleum products and the chemicals produced in petroleum manufacturing.<sup>27</sup> Fort Chip has also gained the attention of the media due in part to concerns raised by an Alberta physician, Dr. John O'Connor, who has called for further investigation of cancer incidences after noting the presence of at least three cases of cholangiocarcinoma in this small town within the past decade. Cholangiocarcinoma is a cancer that typically strikes only 1 in every 100,000 to 200,000 individuals.<sup>28</sup>

### Transport Health Effects: HEALTH RISKS ASSOCIATED WITH TAR SANDS CRUDE OIL SPILLS FROM PIPELINES AND RAILCARS

#### Toxic air emissions during transport and loading

A diluting agent is typically mixed with the semisolid bitumen from tar sands to allow the bitumen to be moved into and out of railcars and through pipelines.<sup>29</sup> Though the specific content of the diluting agent is proprietary information, most formulations include natural gas liquid condensate containing volatile hydrocarbons such as benzene, toluene, ethyl benzene and xylene.<sup>30</sup> The transport of diluted bitumen can involve a multistage process: loading and unloading railcars, pumping into and out of pipelines or loading and unloading barges. During transfers between transportation mechanisms, there is an increased likelihood that vapors will be released from the diluted bitumen, putting workers at particular risk.<sup>31</sup> The diluting agent, which evaporates quickly, contributes to greater unplanned, or fugitive emissions, of highly toxic and carcinogenic chemicals during loading, transport, and unloading than would be the case with conventional oil.<sup>32</sup>

#### Diluted bitumen spills

Large quantities of diluted bitumen were spilled following pipeline ruptures in Marshall, Michigan, in 2010 and Mayflower, Arkansas in 2013.<sup>33,34</sup> These spills, of at least 1.15 million gallons and 210,000 gallons, respectively, have proved extremely difficult to clean up.<sup>35</sup> The tar sands oil that spilled in Michigan entered the Kalamazoo River, leading to the most expensive oil pipeline cleanup in U.S. history (now totaling more than \$1 billion).<sup>36</sup> After the spill in Michigan, the state Department of Public Health set up a broad surveillance effort that determined 320 people suffered adverse health effects, including cardiovascular, dermal, gastrointestinal, neurological, ocular, renal, and respiratory impacts.<sup>37</sup> Similarly, following the Arkansas spill, air monitoring data showed significantly increased levels of benzene in the ambient air, and residents living close to the spill reported increased headaches, nausea, and respiratory problems.<sup>38</sup> Despite these health concerns, the federal government has failed to promulgate guidelines for dealing with chemical exposure at oil spills and has not commissioned any studies regarding the long-term human health impacts of these spills.<sup>39</sup>

#### Train derailments and railcar explosions

Public concern over the safety of transporting crude oil by rail has risen dramatically following a number of serious accidents in the United States and Canada.<sup>40</sup> While tar sands have largely been absent from the crude-by-rail boom that began in 2008, the amount of tar sands moving via rail on the U.S. East and West Coasts, based on forecasts by the Canadian Association of Petroleum Producers, is expected to increase as companies seek to access new markets that have limited pipeline capacity.<sup>41</sup> This increased movement of tar sands by rail poses the threat of additional train derailments that can cause deadly explosions and leave behind residues containing toxic heavy metals and diluted bitumen.<sup>42</sup> Additionally, a derailment over open water could result in a spill and pose potential health risk to the public.

## Refining Health Effects: HEALTH RISKS ASSOCIATED WITH INCREASED AIR POLLUTION AND TOXIC BY-PRODUCTS OF THE REFINING PROCESS

### Refinery emissions

When diluted tar sands crude oils arrive at U.S. refineries, they bear little similarity to conventional crude oils.<sup>43</sup> Not only does the bitumen portion of the diluted mixture contain 102 times more copper, 11 times more nickel, and 5 times more lead than conventional crude oils, but the added diluting agent contains high concentrations of hazardous pollutants such as benzene.<sup>44</sup> All of these chemicals may be released as air pollutants during the refining process.<sup>45</sup> Vapor or “fugitive” emissions may escape through leaks in piping and equipment throughout the refining process, and the presence of highly volatile diluting agents makes it likely that more carcinogenic pollutants will be released into the air.<sup>46</sup> In addition, tar sands crudes require greater use of heaters, boilers, hydro-treating, and cracking, which are likely to increase emissions of toxic and smog- and soot-forming air pollutants.<sup>47,48</sup> These pollutants have been tied to increased cancer risks, increased respiratory issues including asthma, cardiovascular illness, developmental delays, and other negative health effects.<sup>49</sup>

### Noxious odors

In addition to toxic air pollutants, tar sands bitumen contains as much as 11 times more sulfur than conventional crude oils; diluted bitumen contains even higher levels due to the presence of sulfur compounds in diluting agents.<sup>50</sup> Diluted bitumen from the tar sands also has notably high levels of certain sulfur compounds called mercaptans, which are highly volatile and produce strong odors at very low concentrations.<sup>51</sup> Mercaptans have also been linked to central nervous system problems and can irritate the eyes, skin, and upper respiratory system.<sup>52</sup> Due to the extreme volatility of mercaptans, experts have found it likely that they could be released, along with other highly volatile compounds, during the refining of crude oil.

### Petroleum coke

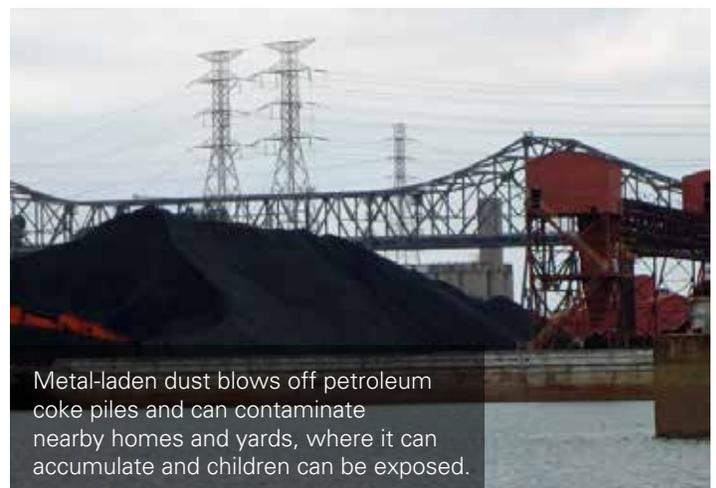
Petroleum coke is an oil refining by-product composed predominantly of carbon.<sup>53</sup> Though the refining of all crude oils results in the production of petroleum coke, the refining of tar sands-derived crudes yields a significantly larger amount of coke than does conventional crude.<sup>54</sup> To counteract the increases in refining costs caused by the large quantities of by-product in tar sands-derived crudes, refiners often use “fuel grade” petroleum coke as a fuel for their boiler systems or resell it as a fuel on the open market.<sup>55,56</sup> In its marketed form, petroleum coke resembles coal and shares many of coal’s physical qualities, including a similar chemical composition.<sup>57</sup> In addition, fuel-grade petroleum coke

contains relatively high concentrations of metals including mercury, lead, arsenic, chromium, selenium, vanadium, and nickel, which people are exposed to when they breathe dust blown from petroleum coke piles.<sup>58</sup>

As refining of Canadian tar sands-derived crudes has increased in the United States, large piles of petroleum coke have appeared within the urban areas of Detroit and Chicago, sometimes leading to black dust clouds entering the surrounding air.<sup>59</sup> Metal-laden dust blows off petroleum coke piles and can contaminate nearby homes and yards, where it can accumulate and children can be exposed. This dust is primarily composed of particulate matter, a pollutant recognized by the U.S. Environmental Protection Agency as contributing to a number of negative human health effects including heart attacks, asthma, decreased lung function, and even premature death.<sup>60</sup> Further, many of these metals are carcinogens and have been linked to a number of other health problems, including developmental and cardiovascular impacts, according to government health experts.<sup>61</sup>

### Increased risk of refinery accidents

The diluted bitumen transported from Canada that arrives in U.S. refineries is more corrosive than conventional crude oils and may lead to increased risk of refinery accidents.<sup>62</sup> Diluted bitumen has very high Total Acid Numbers (TAN), driven primarily by high levels of naphthenic acid.<sup>63</sup> Naphthenic acid, in combination with elevated levels of sulfur compounds, has been shown to significantly increase the corrosive properties of crude oil at the high temperatures commonly reached during the refining process.<sup>64</sup> In fact, low-quality crudes, like tar sands, were found by the U.S. Chemical Safety Board to be a contributing factor in a major accident at the Chevron refinery in Richmond, California, in August 2012, which sent 15,000 residents to area hospitals and endangered the lives of 19 workers.<sup>65</sup> This is a serious concern given the advanced age and poor maintenance record of many U.S. refineries.<sup>66</sup>



Metal-laden dust blows off petroleum coke piles and can contaminate nearby homes and yards, where it can accumulate and children can be exposed.

Tar sands petroleum coke pile, Chicago, Illinois  
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## CONCLUSIONS AND RECOMMENDATIONS

Canadian oil producers, including many multinational oil companies, are producing a growing amount of tar sands oil, and have goals to triple production in the near future. As they continue to look for ways to develop markets and increase sales to Canada and the United States, it is incumbent on health and environmental agencies to protect the public from potential harm. We recommend a number of actions that would provide better safeguards for the public in the coming years:

- Federal agencies such as the U.S. Environmental Protection Agency, provincial agencies such as Health Canada, as well as state and provincial bodies should undertake research to evaluate all of the potential health impacts of tar sands crudes and make that information available on public websites. This information is needed because studies cited in this report, and others, make it clear that pollution from tar sands development is already harming public health.
- Canadian officials should conduct comprehensive, independent investigations into the health impacts from existing operations, particularly on locally affected communities such as Fort McMurray, Fort Chipewyan, and Edmonton, Alberta.
- Any new proposals by U.S. and Canadian officials at the federal, state, and provincial levels that affect tar sands development should include evaluations of potential human health impacts.
- During review, these federal, state, and provincial agencies must seriously consider impacts arising from new pipelines, upgrading facilities, rail terminals, refineries, and other infrastructure facilities that allow for major growth of this industry.

Even without additional health monitoring data, enough is known now about this environmentally destructive and dangerous fuel source that the tar sands oil industry's plans to triple production by 2030 should be halted.

The bottom line is that until there is a better understanding of how these projects will cumulatively impact human health, efforts to expand the tar sands industry should cease. In the meantime, clean and safe energy options should be pursued much more vigorously, because they offer an alternative that better protects the environment, public safety, and human health.

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