FACT SHEET
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Uranium Mining:
Nuclear Power's Dirty Secret

Pembina Institute's Life Cycle Study of Nuclear Power

This factsheet is part of series based on the findings of the Pembina Institute's groundbreaking analysis of the lifecycle impacts of nuclear power. Other factsheets in this series address the impacts of nuclear waste and look at nuclear power and climate change.

Proponents of nuclear power like to claim that it is a "clean" energy source. The reality, when looked at on a life-cycle basis, is very different. Nowhere in the process of producing nuclear energy is this more apparent than when it comes to the mining and milling of uranium, the basic fuel of nuclear reactors.

The environmental impacts of uranium mining and milling activities are severe. These impacts range from the creation of massive stockpiles of radioactive and toxic waste rock and sand-like tailings to serious contamination of surface and groundwaters with radioactive and toxic pollutants, and releases of conventional, toxic and radioactive air pollutants. In fact, the impacts of uranium mining have been so severe, that many jurisdictions around the world have adopted bans on the establishment of new uranium mines (a prominent example is Nunavut, where any proposal for a future uranium mine must be approved by referendum).

Canada is currently the world's largest uranium producer, extracting uranium from four Saskatchewan mines: McClean Lake, Key Lake, Rabbit Lake and McArthur River. While all current and proposed uranium mining and milling operations are based in northern Saskatchewan, there are uranium reserves in a number of Canadian provinces and territories. Historically, there have been uranium mines in both Ontario and the Northwest Territories.

Digging up more than just ore

Uranium mining is done using either open pit or underground operations. Currently, approximately 75 percent of Canadian uranium ore comes from open-pit operations.

Once mined, the ore is trucked or pumped as a slurry to the milling facility. At the mill, the ore is finely ground and mixed in either a highly acidic or alkaline solution to extract the uranium. Finally, the uranium is concentrated and dried into mixed uranium oxides called "yellowcake."

The tailings or wastes left by the milling process consist of ground rock particles, water, and mill chemicals, and radioactive and otherwise hazardous contaminants, such as heavy metals. In fact, up to 85 percent of the radiological elements contained in the original uranium ore end up in the tailings. Canadian uranium mines produce more than half a million tonnes of tailings each year. As of 2003, there were 213 million tonnes of uranium mill tailings in

Supplying a typical Canadian household with nuclear-generated electricity results in the production of 14 kg of toxic and radioactive mine tailings and up to 440 kg of waste rock every year.

the PEMBINA institute
Sustainable Energy Solutions

For more information,
please see the full report *Nuclear Power in Canada: An Examination of Risks, Impacts and Sustainability* at www.pembina.org

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storage at 24 tailings sites across Canada — enough material to fill the Toronto Rogers Centre (formerly the SkyDome) approximately 100 times.

Other mining methods, such as in-situ leaching, where powerful chemicals are injected into the ground to leach uranium out of the ore, are sometimes presented as a way of mining uranium without the need for milling operations. However, the practice is associated with groundwater contamination that is impossible to remediate.

Uranium mining operations also produce waste rock, which can contain both radionuclides and heavy metals, such as nickel, copper, arsenic, molybdenum, selenium and cadmium. Depending on the type of rock, these wastes may be acid generating, with the result that radionuclides and heavy metals may be leached out of the waste and contaminate surface and ground water. Surface mines can generate up to 40 tonnes of waste rock for very tonne of uranium ore produced, while underground mines produce about one tonne of waste rock per tonne of ore.

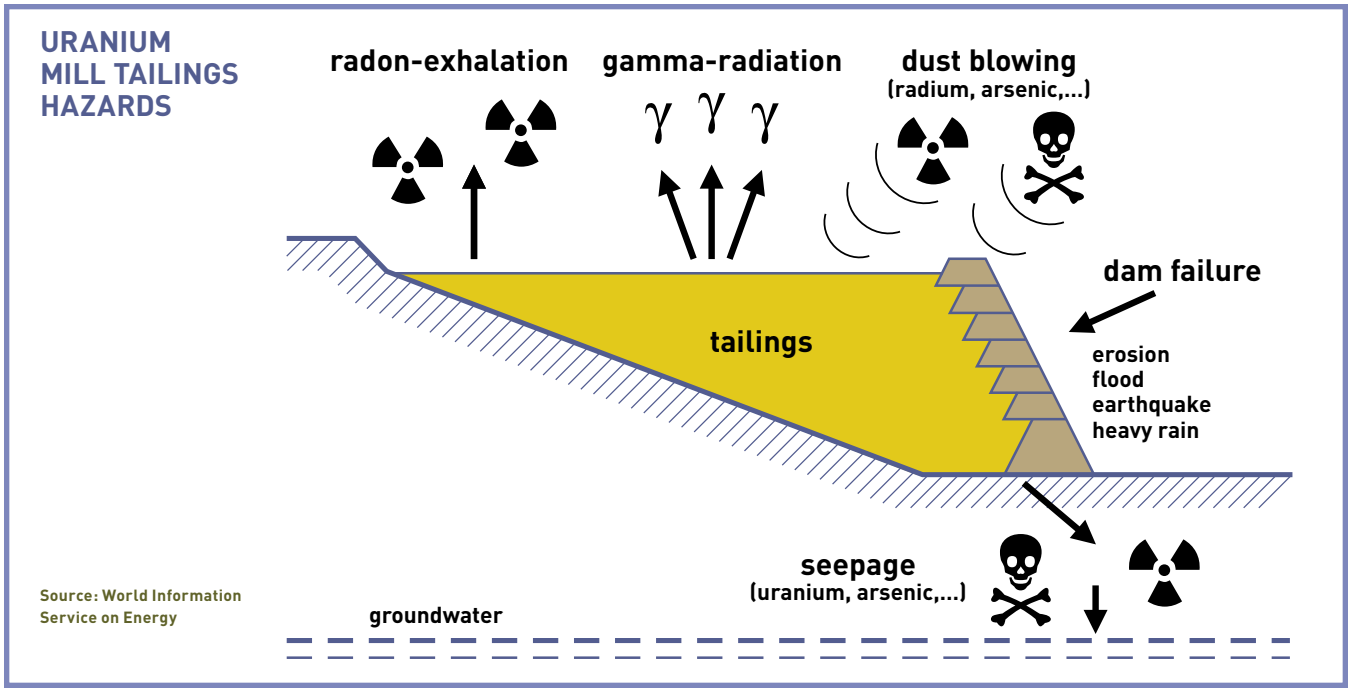
Because of their hazardous nature, uranium mine tailings and waste rock require perpetual care. Operating and now-closed uranium tailings management facilities have been associated with severe pollution of surface and ground water with radionuclides (principally uranium), heavy metals and conventional pollutants. Windblown dust from tailings facilities contains radionuclides, heavy metals and particulate matter. The facilities can also be significant sources of radon gas. Major failures of tailings management facilities have occurred in Canada (Rabbit Lake, Key Lake and Elliot Lake) and around the world (the United States, Australia, Germany, Hungary, Bulgaria, Kyrgyzstan, Kazakhstan).

Air impacts

In addition to the radionuclides, radon gas, heavy metals and particulate matter (PM) that can be released from underground ventilation systems, waste rock and tailings storage areas and surface mining operations, the uranium milling process is a significant source of air pollution. Milling operations release nitrogen oxides (NOx), volatile organic compounds (VOCs), carbon dioxide (CO_2) and PM. Acid plants producing acid for milling operations release large amounts of sulphur dioxide (SO_2) — a major contributor to acid rain.

Water impacts

In addition to the leaching of contaminants from tailings management facilities (TMFs) and waste-rock storage sites, uranium mines and mills release radio-



For local people, a major concern is indirect exposure through eating livestock or wildlife that has been exposed to radioactive contaminants that have entered the food chain as dust or effluent from uranium mines and mills.

Bruce Petersen

The caribou connection

The concentration of airborne radionuclides in lichens that are then eaten by caribou, which are in turn eaten by people, is considered one of the most serious threats to the health of those living in the area of uranium mining operations. A tissue study from 18 Wollaston Lake-area caribou concluded that an adult eating 100 g/day of caribou meat would receive annual effective radiation doses of 0.85 mSv/year. Additional eating of one liver and ten kidneys per year would double this dose to 1.7 mSv/year. A one-year-old child who consumed only 10 percent of the adult caribou intake would receive more than half the adult dose of radiation.

While the study concluded that consumption of moose did not carry significant health risks, the consumption of caribou was found to increase the chance of developing cancer to as high as 0.6 per cent over a 70-year lifetime, which is equivalent to a rate of six cancers per 1,000 people. This far exceeds the U.S. Environmental Protection Agency (EPA) range of acceptable cancer risks of 1 in 10,000 to 1 in 1,000,000.

active (principally uranium), hazardous (e.g. heavy metals) and conventional (e.g. total suspended solids) contaminants to groundwater and surface water through discharges of mill and mine waters, and general run-off from mine sites. In fact, Environment Canada and Health Canada have concluded that effluent from uranium mining and milling operations in Canada meets the definition of a toxic substance for the purposes of the *Canadian Environmental Protection Act*.

Groundwater near the Cluff Lake mine site has been found, for example, to have arsenic concentrations 66 times higher than background levels and nickel levels 1,250 times higher (both of these metals are CEPA Toxics). Fish in waters receiving discharges from the Key Lake mine have been found to have heavy metal (e.g., nickel, cobalt, cadmium) concentrations up to 43 times higher than normal levels.

Health effects

For mine workers, uranium mining remains a risky business. While current uranium mining and milling operations in Canada are much more careful about ensuring that workers stay within radiation exposure limits, a number of studies have linked relatively low level radon and radiation exposure levels to cancers. International studies on the links between radiation exposure and health have found that health impacts occur over the long term, and that levels of lung cancer are two to five times higher than normal in uranium mine workers who have been exposed to high levels of radon or who have been exposed to lower levels over long periods of time.

For local people, a major concern is indirect exposure through eating livestock or wildlife that has been exposed to radioactive contaminants that have entered the food chain as dust or effluent from uranium mines and mills.

Care needed now — and for centuries to come

Once uranium ore reserves are exhausted, the mine, mill and TMF must be properly shutdown (decommissioned). Decommissioned mines must be managed essentially forever to prevent the release of contaminants from tailings and waste rock to the surrounding ecosystem and community.

While mine shutdown work seeks to undo some of the damage done to an area by mining operations, the physical landscape changes that are a part of mining operations, waste rock and tailings management areas (TMAs), and the ongoing presence of long-lived radionuclides and other contaminants at mine sites, makes returning these sites to a "natural" state impossible.

Major mining impacts:

Mining waste

- Nearly 600,000 tonnes of tailings and up to 18 million tonnes of waste rock each year. Of this total, approximately 90,000-100,000 tonnes of tailings and up to 3 million tonnes of waste rock can be attributed to domestic energy production. Uranium mine tailings and waste rock are typically acidic or potentially acid generating, and contain long-lived radionuclides, heavy metals and other contaminants.
- Canadian uranium mines and mills have already created 109 million tonnes of waste rock and 214 million tonnes of tailings.
- "In Canada a walk-away solution is not realistic for decommissioning most uranium tailings sites. Long-term storage requires long-term institutional care." – Auditor General of Canada.
- The mining of lower-grade ores would result in proportionally larger amounts of tailings, other wastes and emissions, as larger amounts of ore would have to be processed to produce the same amount of uranium concentrate.

Water contamination

- Severe contamination of groundwater with radionuclides, heavy metals, and other contaminants has occurred at tailings management facilities and waste rock storage areas.
- Surface water discharges from uranium mining and milling facility have resulted in the contamination of the surrounding environment with radionuclides and heavy metals. Effluent from uranium mines and mills has been classified as "toxic" for the purposes of the *Canadian Environmental Protection Act*.
- Uranium mining operations involve extensive pumping-out of groundwater (in excess of 16 billion litres per year).

Landscape and wildlife impact

- The natural environment and wildlife in the vicinity of uranium mines and mills have been contaminated with radionuclides, particularly through windblown dust from tailings sites and effluent discharges to surface waters.
- Uranium mining operations involve major disruptions of the surface landscape, and surface and groundwater flows.

Air impacts

- Uranium mines and tailings storage areas are significant sources of atmospheric releases of radon gas (which can continue for 1,600 years or more).
- In 2004, VOC emissions from the uranium milling operations were equivalent to the average annual emissions of more than 300,000 cars. The Rabbit Lake acid plant reported releases of 43,000 tonnes of SO_2 in 2004, ranking it among the largest sources of SO_2 emissions in Canada.
- GHG emissions arise from the operation of mining equipment, milling and tailings management processes, and mine site closure and post-closure care activities.

Human Health

- Workers at uranium mines and mills typically receive annual effective radiation doses higher than those considered acceptable for members of the general public. Increased incidences of lung cancer as well as deaths resulting from silica exposure are reported among uranium miners.
- Significant health risks, particularly increased risks of developing cancer, have been identified for regular consumers of caribou in the vicinity of uranium mine operations.