



Canadian Nuclear  
Safety Commission

Commission canadienne  
de sûreté nucléaire



# Regulating Uranium Mining and Production: Part of a National Nuclear Regulatory Statute

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October 4, 2017



# Outline

- Uranium market
- Regulating mines: old vs. new
- Environmental impact assessment
- Licensing process
- Oversight and compliance
- Regulating waste management
- Non-proliferation, safeguards
- Some conclusions



# Uranium in the “Front End” of the Fuel Cycle

## Mining



Rock containing on average 0.1–19% uranium (uranium ore) is extracted from the ground. The ore is transported to a regional mill.

## Milling



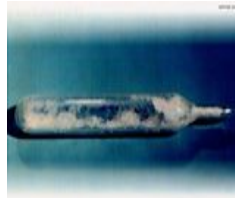
Uranium ore is ground and the uranium ( $U_3O_8$ ) is chemically separated from most other constituents. The uranium concentrate, containing approximately 98% uranium (yellowcake) is shipped to a refinery.

## Refining



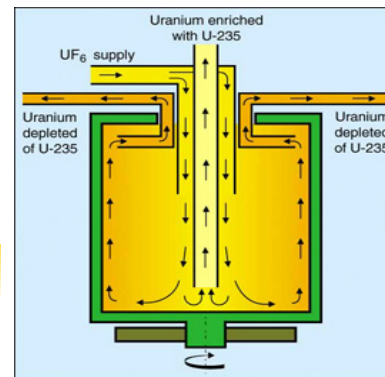
The remaining contaminants in the uranium concentrate are chemically separated from the uranium. The purified uranium ( $UO_3$ ) is shipped to a uranium conversion facility.

## Conversion



The chemical form of uranium is converted to  $UO_2$  (for CANDU reactor fuel) or to  $UF_6$  (for enrichment).

## Enrichment



## Fuel fabrication



## Fuel assembly



The fuel bundles are shipped to a nuclear generating station.

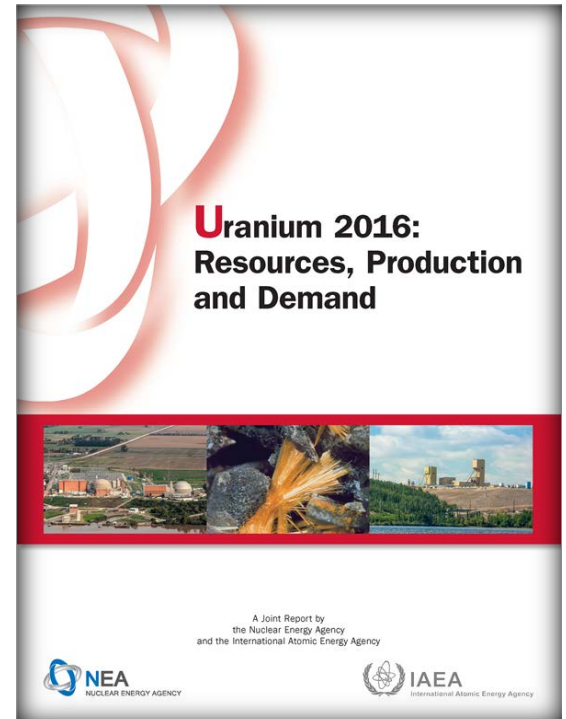


# Uranium Market Information and Data

- Resources, production, demand – the “Red Book”
- Uranium supply for energy security – statistical profile of the world uranium industry

## Resources:

- Identified resources are sufficient for “over 135 years of supply” for global nuclear power fleet
- But this depends on timely investment, and challenges remain in a market with “high levels of oversupply and inventories, resulting in continuing pricing pressures”
- Identified resources have changed little over 2 years – lower investment and exploration efforts
- Exploration and mine development expenditures up 10%, majority made by China





# Current Red Book Information – Production

- Production has decreased 4.1% since 2013, but still above 2011 level
- Production in 21 countries – top 6 have 90%:
  - Kazakhstan – 40%
  - Canada – 23%
  - Australia – 10%
  - Niger – 6%
  - Namibia – 6%
  - Russia – 5%
- Mining methods:
  - *In situ* leach – 51%
  - Underground – 27%
  - Open-pit – 14%
  - By-product – 7%
- World production has varied between 70 and 80% of production capability
- Environmental and social aspects of uranium production are of ever-increasing importance, especially for newer mining countries

# Current Red Book Information – Demand

Will uranium supplies be adequate for future needs of nuclear power?

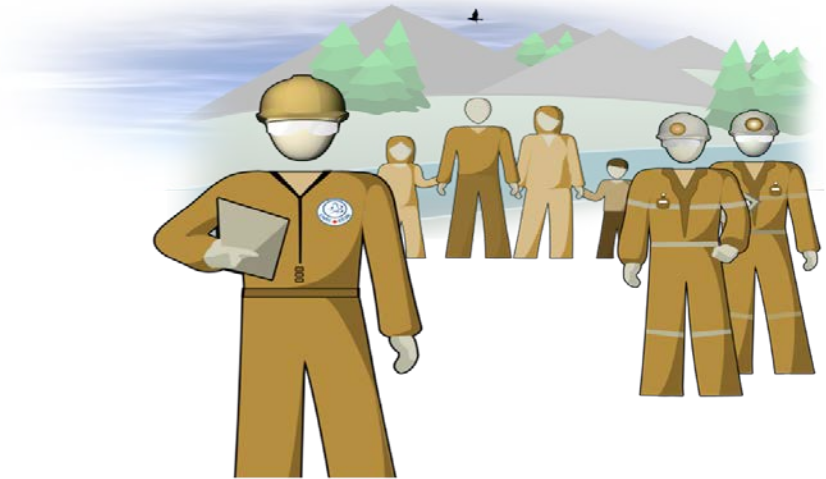
- The currently defined resource base – existing, committed, planned and prospective mines – will meet high case uranium demand, to 2035.
- Demand projections have a lot of uncertainty:
  - Capacity growth in Asia, Middle East will increase uranium demand
  - North America – capacity estimate between same and 11% increase
  - EU – capacity estimate between 48% decrease and 2% increase
- Market transition in future from supply-driven to demand-driven?

*“Regardless of the role that nuclear energy ultimately plays in meeting future electricity demand, the uranium resource base...is more than adequate to meet projected requirements for the foreseeable future. The challenge in the coming years is likely to be less one of adequacy of resources than adequacy of production capacity development due to poor uranium market conditions.”*

# Uranium Mining Regulation: Part of Nuclear Law

## Commonalities with other aspects of nuclear law:

- Safety and radiation protection – managing risks to workers, minimizing health impacts
- National interest in control over the resource
- Non-proliferation
- Environmental protection
- Radioactive waste
- Social acceptance





# “Old” vs. “New” Uranium Mining

- Legacy sites: old mining practices, Cold War secrecy, lack of remediation, no closure plans, worker exposures, minimal regulatory oversight
- Current sites: environmental stewardship, site rehabilitation, social responsibility, financial guarantees, internationalized standards, prevention and mitigation of risks to health, environment is highly regulated
- Canadian example:  
*Rio Algom v. Canada*, 2012 ONSC 550  
(Jan. 4, 2012 decision of the Ontario Superior Court)





## **Rio Algom v. Canada, 2012 ONSC 550 – not the law that’s interesting, but the Facts**

- **1954-1972:** Rio Algom sold >65M pounds of uranium oxide to a Canadian government-owned (Crown) corporation, which in turn (and for no profit), sold the uranium to the U.S. Atomic Energy Commission to build nuclear arsenal in the Cold War – the “Cold War contracts”
- Rio Algom made >\$72M on the contracts based on a formula that was meant to incentivize the industry and turn a profit for them – to create a uranium mining industry in Canada
- Price formula included cost of tailings management, but such management was rudimentary at the time
- **1990s:** new regulations – to remedy environmental harm caused by the radioactive waste, ineffectively treated mine tailings – Rio Algom complied
- **2000:** *Nuclear Safety and Control Act* – licence to decommission required, new standards for mine rehabilitation
- Rio Algom sues Canada – Canada indemnifying company as an implied term of Cold War contracts?
- Legal arguments fail – Rio Algom must hew to new environmental standards for mine rehabilitation, Canada is not required to indemnify it
- Rio Algom’s costs of managing tailings will continue **in perpetuity** – current estimate of future cost is approx. \$100M

# Decommissioning and Restoration

- Legacy sites in need of remediation are all over the world due to past inappropriate or non-existent standards
- Governments are financing necessary cleanup – e.g., European Bank for Reconstruction and Development fund for Central Asia sites established in 2015 at request of European Commission
- Remediation of former sites can be more technically challenging than new sites
- Acceptability of new mines may be judged according to how governments are perceived to have dealt with legacy sites
- These photos show a **modern** decommissioning project – Cluff Lake, Canada, where production ended in 2002



# *Regulating Uranium Mine Operations Today*





# Regulating Uranium Mining



## Protecting Workers

- Control of radioactive materials
- Control of workers' radiation doses
- Measurement of radiation
- Conventional health and safety



## Protecting the public

- Measure key parameters in the environment
- Estimate potential dose to the public



## Protecting the environment

- Control releases to the air, to surface water and to ground water
- Measure releases: effects
- Take action, when required





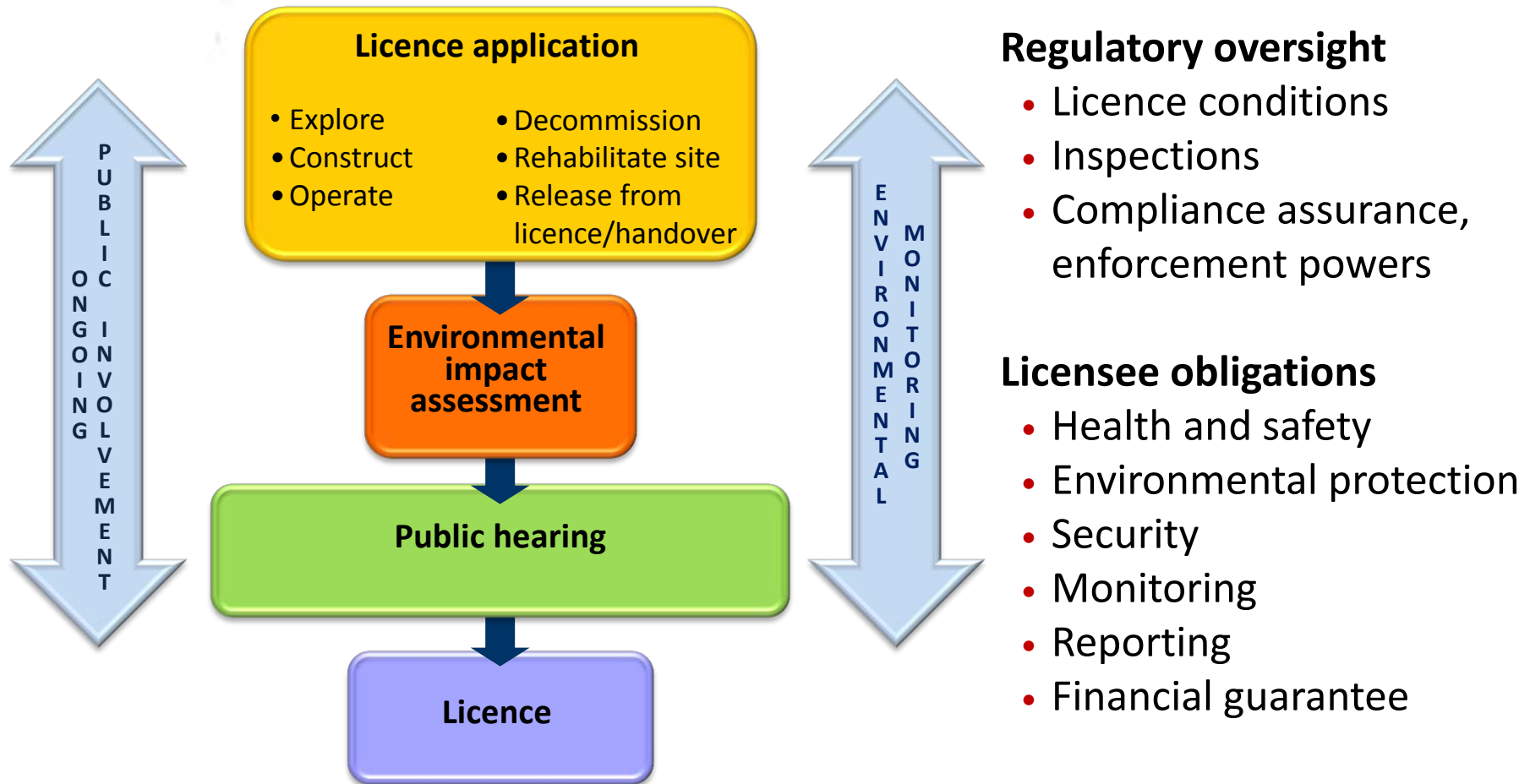
# Regulating the Nuclear Industry in Canada

**Licensees** are responsible for the protection of health, safety, security and the environment in the context of their licensed activities, and for respecting Canada's international commitments

The **regulator – the CNSC** – is responsible for regulating licensees: assessing whether applicants should be authorized; then verifying whether licensees are compliant with the statute, the regulations and the licence; and taking measures to ensure compliance

- The Commission makes independent, objective and risk-informed decisions on licensing – this means that regulatory actions/decisions are based on the level of risk.
- Under the statute, licensees are responsible for managing their licensed activities in a manner that protects health, safety, security and the environment, while respecting Canada's international obligations.
- The CNSC sets the requirements for licensees, and verifies compliance with those requirements.

# Licensing Uranium Projects – Lifecycle Approach



# Environmental Impact Assessment (EIA)

- Environmental protection: a tenet of nuclear law
- International conventions:
  - *Aarhus Convention* (access, public participation)
  - *Espoo Convention* (EA in transboundary context); *Kiev Protocol*
- EIA is a process to predict the environmental effects of proposals which involves:
  - assessing whether proposals would cause adverse effects: physical, biological and human environment
  - ensuring public discourse on a project
  - crafting monitoring programs, mitigation measures, remediation plans – lifecycle
- International environmental standards – Environmental Management System (ISO 14001) to measure and improve environmental impact





# EIA Components for Uranium Production

- Baseline data: topography, hydrogeology, flora, fauna, local air, water, soils, biota
- Detail of ore body and proposed mining method:
  - *in situ* recovery: inject leaching solution, recover uranium from solutions pumped to surface, \*impact on groundwater is an issue
  - open-pit: near-surface orebodies, high ratio of waste rock to ore
  - underground: vein-type deposits, costliest, risk of collapse
- Milling process: how to extract uranium from ore – acid leaching, solvent extraction, calcinations – to obtain yellowcake (uranium oxide concentrate)
- Socio-economic issues: need to include potential impacts on culture, potential positive economic effects, long-term plan for land



# Indigenous Rights and Uranium Mining

- **UN Declaration on the Rights of Indigenous Peoples:**
- 29(2): States shall take effective measures to ensure that **no storage or disposal of hazardous materials shall take place in the lands or territories of indigenous peoples without their free, prior and informed consent.**
- 32(2): States shall consult and cooperate in good faith with the indigenous peoples concerned through their own representative institutions in order to obtain their **free and informed consent prior to the approval of any project affecting their lands or territories and other resources, particularly in connection with the development, utilization or exploitation of mineral, water or other resources.**



*Fond du Lac Denesuline First Nation et al. v. Canada (Attorney General)*  
2012 FCA 73  
March 2012 Federal Court of Appeal  
(see NLB 2012/1, No. 89)



# Regulatory Framework for Uranium Mining

- Regulatory body: regulates to protect workers, the public and environment from risks of uranium production; licensing system; transparent decisions; lifecycle authority
- Applicant requirements: design information; closure plan before mine begins construction; practices proposed to minimize radiation exposure and protect workers, to protect water resources and to manage wastes
- Licensee obligations: safe operation; financial assurance for remediation; monitoring; records and reporting requirements; public consultation and information

**Regulating may require different regulators to collaborate, to ensure adequate oversight without gaps or overlap**



# Licensing a New Mine or Mill

Licence application process (details in regulations):

- EIA process and results: environmental monitoring plan, water management
- Mining process and milling process
- Safety: radiation protection, conventional worker safety, transport, emergency preparedness/planning
- Public consultation/outreach
- Onsite security: physical protection for transport
- Waste generation and disposal, tailings management
- Disclosure/reporting requirements
- Financial assurance for site closure
- Long-term plan for institutional control and release

**Social responsibility is important**





# International Guidance and Tools

- *Managing Environmental and Health Impacts of Uranium Mining* (NEA, 2014)  
<http://www.oecd.org/publications/managing-environmental-and-health-impacts-of-uranium-mining-9789264216044-en.htm>
- *Lessons Learned from Environmental Remediation Programmes* (IAEA Nuclear Energy Series No. NW-T-3.6, 2014) <http://www-pub.iaea.org/books/IAEABooks/10509/Lessons-Learned-from-Environmental-Remediation-Programmes>
- *Sustaining Global Best Practices in Uranium Mining and Processing: Principles for Managing Radiation, Health and Safety, Waste and the Environment* (WNA policy document, 2010)  
<http://www.world-nuclear.org/our-association/publications/position-statements/best-practice-in-uranium-mining.aspx>

“This document holds the status of a policy and ethical declaration by the full WNA membership... In the category of uranium miners, the WNA membership includes all major uranium mining and processing companies as well as many mid-size and junior companies. The principles affirmed here are supported by key relevant international organizations, including the International Atomic Energy Agency. Indeed, these principles have been affirmed as an outgrowth of an IAEA cooperation project aimed at encouraging expanded exchanges between professionals from governments and industry. These principles are also supported by the global mining community through relevant international and national associations that cover uranium mining and processing.”

# Construction – Cigar Lake Mine





# Operation – McArthur River Mine



# Mining – Drill and Blast



A person operates a scoop tram remotely to scoop up the muck

## Radiation protection

- Distance – the person maintains a line of sight with the scoop tram but is far away from the muck pile
- Shielding – the walls are covered with cement
- Reduction – the muck pile is kept damp to reduce dust
- Dilution – the tunnel where the worker is working is ventilated with fresh air

## Health and safety

- The orange plates and screening provide ground support
- Personal protective equipment



# Operation – Key Lake Mill



# Operation – McClean Lake Mine and Mill





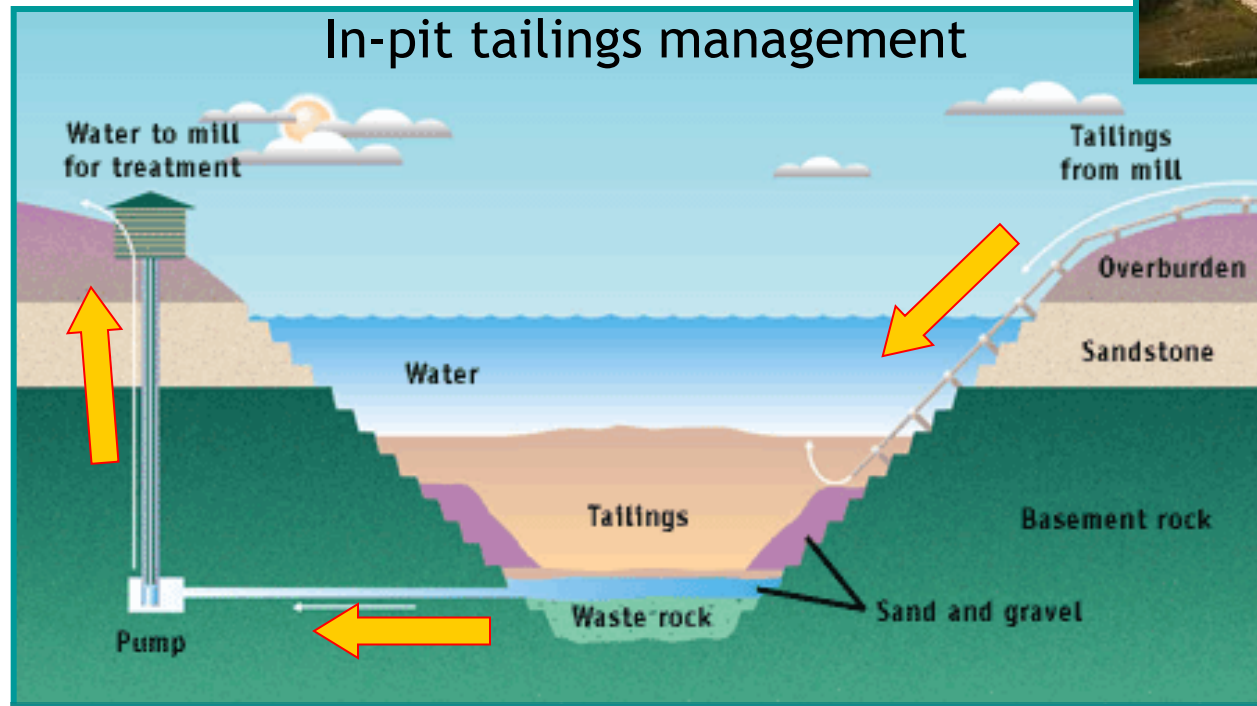
# Waste Produced by Uranium Mines and Mills

## Remember: high volume, low activity

- **Clean waste rock and waste rock:** Mining produces both clean waste rock and waste rock that must be removed to retrieve the uranium ore. Clean waste rock is not harmful to the environment and is placed in surface rock piles for future use. Waste rock is usually found close to the ore body and contains low concentrations of radionuclides or heavy metals (mineralized waste). These must be managed during operations and properly disposed of so that contaminants are not released to the environment.
- **Tailings:** Milling uranium ore produces tailings. Tailings are what are left over once the uranium has been removed from the ground rock and resemble fine sand. They contain long-lived radionuclides (such as thorium-230 and radium-226) produced from the decay of uranium, as well as trace metals like arsenic and nickel. They also contain chemical residues from the milling process.



# Mine Waste Management





# Waste Management for Mines and Mills

- The *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management* sets general safety requirements (article 11).
- Article 3(2) notes that the Convention does not apply to “naturally occurring radioactive material ... that does not originate from the nuclear fuel cycle unless ... declared as radioactive waste ... by the Contracting Party.” Contracting Parties have agreed to include mine and mill waste in reporting.





# Corporate Social Responsibility (CSR) and Accountability

- Canada’s *Corruption of Foreign Public Officials Act* - “bribery” vs. “facilitation payments”
- Bilateral trade treaties may refer to the promotion/enforcement of internationally recognized standards of (CSR) as exception to trade liberalization
- U.S.: *Alien Tort Claims Act, Foreign Corrupt Practices Act*
  - Global companies need to have robust anti-bribery, anti-corruption policies in place
  - It is not enough to simply adopt such policies
  - Need to verify that compliance tools are put to use, and that employees are disclosing complete and accurate information – making policies effective in practice
- Canada’s *Extractive Sector Transparency Measures Act*
  - “publish what you pay” on commercial development of oil, gas and minerals
  - to deter corruption in extractive sector – making government revenues transparent
- *Choc v. Hudbay Minerals*, 2013 ONSC 1414 (July 22, 2013):
  - Does a Canadian mining (not uranium) company owe a duty to protect Guatemalan Mayan Q’eqchi from human rights abuses by the company’s subsidiaries?
  - June 2015 motion decision ordering production of documents – on security at other mine projects; community relations activities; corporate control documents

# Protecting the Environment

## Control releases to

- air
- surface water
- groundwater

## Measure and monitor

- releases
- effects

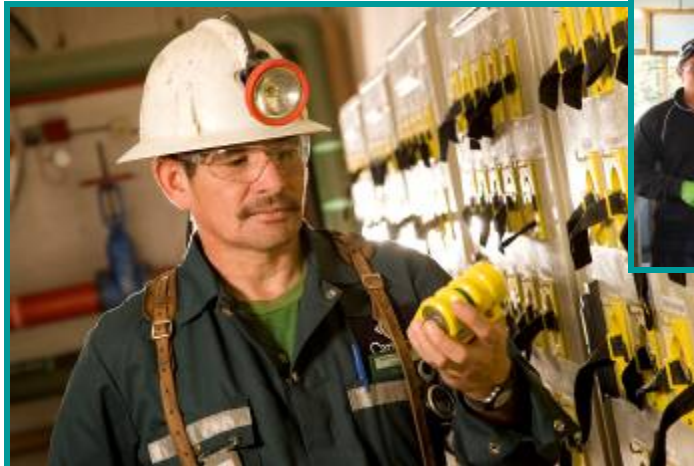
## Take action, when required





# Radiation Protection: Workers

- Management
- Control of radioactive materials
- Control of worker doses
- Measurement of radiation





# Radiation Protection: Public

- Measure radiation in the environment
- Calculate potential dose to members of the public



# Transportation

**Producing vs. using countries + complexity of fuel cycle = a lot of shipments, different stages**

- IAEA regulations
- Packaging requirements
- Security requirements, physical protection
- Use of reliable carrier
- Secure storage in transit
- Driver communications
- Emergency planning
- Security response
- Shipment notification





# Uranium Mining and Safeguards

## ***Treaty on the Non-proliferation of Nuclear Weapons (NPT):***

- Non-nuclear weapon states forego nuclear weapons, accept safeguards; nuclear trade – for peaceful purposes – is done under safeguards

## Starting point of safeguards (INFCIRC/153):

- “Nuclear material of a composition and purity suitable for fuel fabrication or for being isotopically enriched” (art. 34)
- Safeguards procedures for mining and milling: import and export reporting, keeping track of materials
- Accountancy and verification procedures apply to nuclear material at the next stage of the fuel cycle after mining – ore concentrate for nuclear purposes, conversion, enrichment, fuel fabrication
- Additional Protocol (INFCIRC/540) obligations include providing information on mining activities, stocks of source material, concentration plants, import/export, R&D



# Some General Takeaways

- As a “strategic resource” that is important for energy security, uranium is of both national and global importance
- For health and safety, radiation protection, environmental stewardship and non-proliferation, control of uranium production and trade is an important part of national and international nuclear law
- It makes sense to include the regulation of uranium mining activities in a national nuclear regulatory statute with the same regulatory oversight as other nuclear activities
- The evolution of environmental standards distinguishes current mining from “legacy” practices, but the perception of environmental damage must still be addressed; lifecycle management is key to current regulatory schemes
- Mine operators need to be aware of corporate social responsibility imperatives and project-related social acceptability issues – transparency is key



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