

Potential Consequences of a Transportation Incident Involving Uranium Ore Concentrate (UOC)

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Study Objective & Approach



- **Overview/summarize steps of the assessment**
- **Consequences**
- **Summary and Conclusion**
- **Use in ERAP training and outreach**

Results of Risk Assessment

Risk = Accident probability x Accident consequences

<i>Scenario Description</i>	<i>Probability Rating</i>	<i>Consequence Rating</i>	<i>Risk</i>
<i>Spill of UOC into major rivers</i>	<i>Highly Unlikely</i>	<i>Moderate</i>	<i>Negligible Risk</i>
<i>Spill of UOC into a generic small lake</i>	<i>Highly Unlikely</i>	<i>Catastrophic</i>	<i>Moderate Risk</i>
<i>Spill of UOC into larger lakes</i>	<i>Unlikely</i>	<i>Major *</i>	<i>Moderate Risk</i>
<i>Spill of UOC on land from truck accident</i>	<i>Unlikely</i>	<i>Minor</i>	<i>Negligible Risk</i>
<i>Spill of UOC on land followed by airborne release (truck accidents)</i>	<i>Unlikely</i>	<i>Minor</i>	<i>Negligible Risk</i>
<i>Spill of UOC on land followed by fire and airborne release (truck accidents)</i>	<i>Unlikely</i>	<i>Minor</i>	<i>Negligible Risk</i>

*For the majority of large lakes the consequence of releases are moderate, for other lakes the risk is negligible.

Assessment Steps

- 1. Describe key attributes of each transportation route**
- 2. Develop appropriate accident scenarios**
- 3. Define the probability of an accident**
- 4. Identify appropriate receptors**
- 5. Model the fate and transport**
- 6. Determine the consequence**
- 7. Rate the risk**

1. Transportation Routes



2. Accident Scenarios

- **major river**
 - Assiniboine, N Sask; Mississippi
- **generic small lake**
- **larger lake**
 - Wollaston; Lac La Ronge; Lake of the Woods; Lake St. Louis
- **on land**
 - Points North
- **on land followed by airborne release**
- **on land followed by fire and airborne release**



3. Define the Probability

of a release = (Probability of accident) \times (conditional probability of damage to the containment)

Probability of an transportation incident occurring resulting in a release of yellowcake is unlikely to highly unlikely

- **Probability of accidents involving transportation of dangerous goods is smaller than that of general transportation accidents***
- **Annual probability of a transportation incident on our routes**
 - near surface water 1.9×10^{-4} to 4.8×10^{-3}
 - in the vicinity of population centres ranged from 9.5×10^{-4} to 2.6×10^{-2}
- **Annual probability of release of UOC**
 - to surface water ranged from 2×10^{-4} to 5×10^{-3}
 - to land in the vicinity of population centres ranged from 1×10^{-3} to 3×10^{-2}

*Canada-wide, Province of Saskatchewan & United States transportation statistics for both general transport and dangerous goods

4. Identify the Receptors

● Aquatic Environment

- Aquatic plants
- Benthic invertebrates
- Fish, amphibians



● Wildlife considered for an aquatic spill

- Sandpiper
- Lesser Scaup
- Merganser
- Mallard
- Muskrat
- Barn swallow



● Terrestrial Environment

- Grouse
- Deer
- Meadow Vole
- Squirrel
- Barren-ground Caribou
- Woodland Caribou



● Human Receptors

- Workers
 - Emergency response personnel
 - Clean-up personnel
- Members of the public

UOC Characteristics

- **Dry powder**
- **Low specific radioactivity (low radioactivity)**
- **Not flammable**
- **Not explosive**
- **Soluble in water (non-calcined product)**
- **Very low solubility (calcined product)**
- **Stable form of uranium**
- **Generally handled as other heavy metals**
- **Very heavy / very dense**



Non-calcined Yellowcake



Calcined Yellowcake

5. Fate and Transport -Aquatic

- **Following accident**

- Assume release of 25% of contents
- Use UOC characteristics (solubility, particle size distribution) to model transport

- **Initial Release**

- Short-term was defined as the time from the spill until surface water met the WQ guideline for U based on dilution
 - Days to weeks depending on the system *

- **Long-term from residual solids**

- Remediation effective but not perfect
- Estimate long-term impact on sediment, water and biota post remediation

5. Fate and Transport -Terrestrial

- **Following accident**

- Assume release of 50% of contents
- Use UOC characteristics (source material and density) to model air dispersion
- Release on land can be contained and remediated efficiently
 - not considered to result in long-term exposure

- **Effect of fire on airborne release of UOC particles**

- Impact on air quality for public

6. Determine Consequence

Criteria for assessing consequences

Category	ConsequenceRating			
	1	2	3	4
Health & Safety Risk	<p>Minor:</p> <p>Nuisance and irritation, ill health leading to temporary discomfort, first aid treatment, minor cuts and bruises, eye irritation from dust, area exceeds internal administrative level.</p>	<p>Moderate:</p> <p>Some loss of hearing, dermatitis, asthma, upper limb disorder, minor disability, medical aid required, lacerations, burns, concussions, serious sprains, minor fractures, area exceeds a Threshold Limit Value</p>	<p>Major:</p> <p>Deafness, ill-health leading to major disability, medical aid required, lost limb injury, amputation, major muscle strain, major fracture, poisoning, multiple injuries, area routinely exceeds a Threshold Limit Value</p>	<p>Catastrophic:</p> <p>Life-shortening diseases, acute fatal diseases, ill health leading to permanent disability, fatality, area exceeds a Threshold Limit Value and causes harm to individual.</p>
Radiation Exposure Risk	<p>Minor:</p> <p>Area exposure rate or dose exceeds an internal administrative level.</p>	<p>Moderate:</p> <p>Area exposure rate or dose exceeds regulatory action levels.</p>	<p>Major:</p> <p>Area exposure rate or dose exceeds regulatory dose limit.</p>	<p>Catastrophic:</p> <p>Dose exposure exceeds regulatory emergency dose limit.</p>
Environmental Risk	<p>Minor:</p> <p>Incident, spill or occurrence reportable to regulators, measurable impacts to the environment is localized, exceeds administration level</p>	<p>Moderate:</p> <p>Incident, spill or occurrence reportable to regulators, measurable impact to the environment causes harm but limited to site, exceeds regulatory action level requiring an official investigation</p>	<p>Major:</p> <p>Incident, spill or occurrence causes extensive harm beyond property, impacts have short term or reversible effects, exceeds regulatory limits</p>	<p>Catastrophic:</p> <p>Life shortening incident, spill or occurrence causes ecosystem to be impaired, either long term or irreversible effect to the environment, public inquiry</p>



6. Consequence Of Release into Water

- Short term
 - Water quality
- Long term
 - post remediation exposure to water, sediment and other biota
 - Exposure to humans through drinking water and eating fish (large lake only)
- Ecological receptors and humans
- Radioactive and non-radioactive (uranium) exposure to aquatic, semi-aquatic and terrestrial receptors
- Small Lake
 - accidental release of UOC to a small lake will result in compromised water and sediment quality
- Larger Lakes and Rivers

Summary Results for Water Crossings

Receptor	North Saskatchewan River	Lac La Ronge	Wollaston Lake	Assiniboine River	Lake of the Woods	Mississippi River	Lake Saint-Louis
Water-short	✗	✗	✗	✗	✓	✗	✗
Water-long		✓	✓		✓		✓
Aquatic							
Benthic Invertebrate	✗	✗	✗	✗	✗	✗	✗
Semi-aquatic							
Muskrat		✗	✗		✗		✗
Merganser		✗	✗		✓		✓
Mallard		✓	✓		✓		✓
Scaup		✗	✗		✓		✗
Sandpiper		✗	✗		✗		✗
Swallow		✓	✓		✓		✓
Terrestrial							
Grouse	✓	✓	□	✓	✓	✓	✓
Vole	✓	✓	✓	✓	✓	✓	✓
Deer	✓	✓	✓	✓	✓	✓	✓
Squirrel			✓				
Caribou-B			✓				
Caribou-W			✓				
Public							
Short-term Drinking Water		✗			✓		✗
Long-term Drinking water and fish		✓			✓		✓

6. Consequences

To humans from release into water

Large lake scenario

- **Drinking water and eating fish from the large lake was determined to be safe for adults, children and toddlers**
 - Water quality was predicted to exceed the drinking water quality standard in the short term
 - Water quality will not exceed the drinking water quality standard in the long term

6. Consequences

To humans from release onto land

It was concluded that overall no adverse health effects are expected for the driver exposed to the dust following an accident

- **Gamma radiation to workers (truck drivers, handlers, emergency responders)**
 - maximum time a worker could spend beside the spill without exceeding the dose limit is 380 hours
- **Radon inhalation** – not applicable
- **Dust inhalation**
 - Chemical toxicity – exposure to uranium concentration in the air was calculated to 39 mg/m³
 - Significantly less than the benchmark of 1990 mg/m³
 - No statistically or biologically significant increases in frequency or severity of an effect is expected
 - Calculated total inhalation dose of 0.10 mSv is much less than the regulatory dose limit (which is 1 mSv/year for the general public and 50 mSv/year for a nuclear worker)

6. Consequences

To public from release into air

- **Air quality impact for public (fire and no fire)**

- Air dispersion modelling conducted
- Max uranium concentration in air for both scenarios is below the benchmark

No impact to members of the public is expected



Risk Rating Matrix

Likelihood / Probability		Consequence			
		1	2	3	4
		Minor	Moderate	Major	Catastrophic
4	Almost certain: > 1 in 10 yrs	2	3	4	4
3	Likely: 1 in 10 to 1 in 100 yrs	2	3	3	4
2	Unlikely: 1 in 100 to 1 in 1000 yrs	1	2	2	3
1	Highly unlikely: < 1 in 1000 yrs	1	1	2	2
Where:					
4– High Risk					
3– Moderate Risk					
2 – Low Risk					
1 – Negligible Risk					

7. Rate the Risk

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Conclusions

- **It was concluded that the impact of transportation accidents that would result in the release of UOC to land, on the workers is minor. Given the low probability of such accidents, the risk from such accidents is deemed to be low**
- **Overall, the consequence assessment for release to surface water indicates that the effects for release to large lakes and rivers are minor. The effects to small lake systems could be major to catastrophic.**
- **The probability of an accident that would result in a release is extremely small, resulting in low to moderate risk.**

ERAP Training and Outreach

- **Given the low probability of an incident occurring with a release of yellowcake, the risk is determined to be low**
- **Enter spill area for life saving measures**
- **Limit entry to shortest possible time**
- **Implement protection measures for short term may be required, however the product will not travel a great distance and will be easily recovered and remediated**
- **Evacuation of nearby communities likely not necessary**



Questions?

● **Thank You!**

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