



# Analysis of Surface Water Quality at Seven Legacy Uranium Mines in Saskatchewan

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# SRC

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- › Energy
- › Environment
- › Mining and Minerals
- › Agriculture and Biotechnology



# Background

# Project CLEANS (CLEanup of Abandoned Northern Sites)

- › 37 cold-war era legacy uranium mine and mill sites
  - Gunnar Mine and Mill
  - Lorado Mill
  - 35 “Satellite Sites”
- › Managed by SRC on behalf of SK Ministry of Energy & Resources
- › Goal: Ensure the sites are safe, secure, and stable for transfer into the province’s Institutional Control Program



# Outline

- › Background  
(Introduce the Sites)
- › Problem/Challenges
- › Approach/Methodology
- › Outcome
- › Questions/Discussion



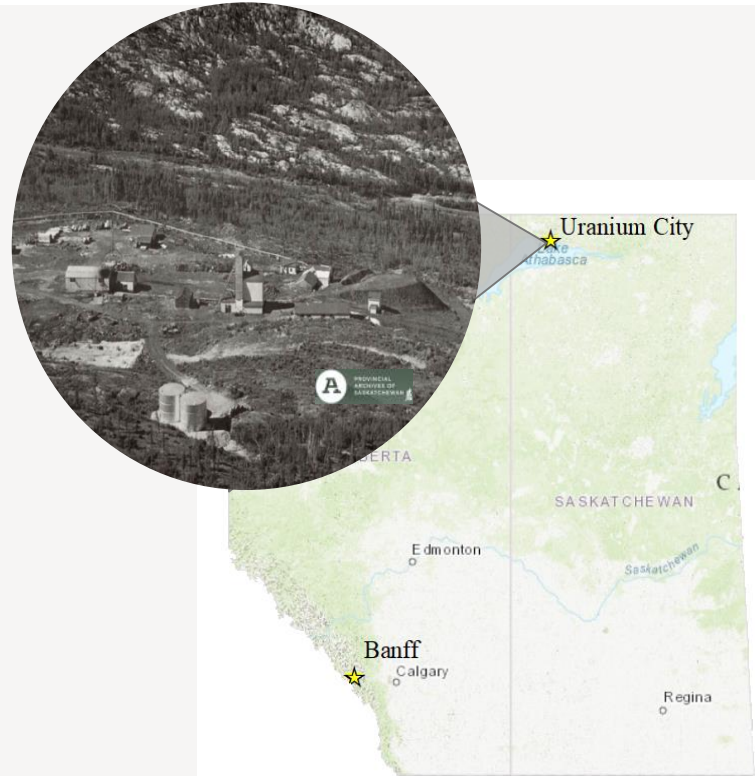
N.LABC Mine





# The Seven Sites

- › Abandoned uranium mines that were operational between the 1950s to 1970s located near Uranium City
- › Ore was processed off site
- › SK Ministry of Environment is the main regulator
- › Remediation near completion at all seven sites



# Previous Remediation Activities

- › Closure of mine openings
- › Gamma shield soil cover
- › Perimeter fence around unstable underground mine working
- › Collection and burial of legacy debris
- › Slope regrading





## Additional Context



- › Region historically impacted by mining activities
- › Remote and seldom accessed by the public
- › Traditional land use (hunting, fishing, etc.) should be considered
- › Protection of human health and safety has been the main driver, but environmental considerations cannot be ignored



# Problem/Challenges

# Problem/Challenges

- › SRC has completed 5 years of surface water monitoring program at these sites
- › A preliminary review of this data identified the need for further critical analyses in the following areas:
  - Water quality exceeded tier 1 and 2 endpoints in some instances (metals, radium)
  - Insufficient understanding of contaminant sources: waste rock? underground workings? background?
  - Potential risk to human health receptors
  - Requirements for transfer into ICP vague
    - i.e., what level of residual human health and ecological risk is acceptable?
  - Balancing available financial resources vs. scale/complexity of the site
  - Development of site specific objective costly
  - Accessing the underground water quality





# Approaches/Methodology

# Approaches – Data Screening and Statistic Summary

- › Type of Water Course (permanent or ephemeral)
- › Identify areas of high gamma radiation -will be covered
- › Identify sample locations that are considered to be background – derive background concentrations
- › Remove outliers
- › Identify maximum and 95 percentile
- › Statistic Summary

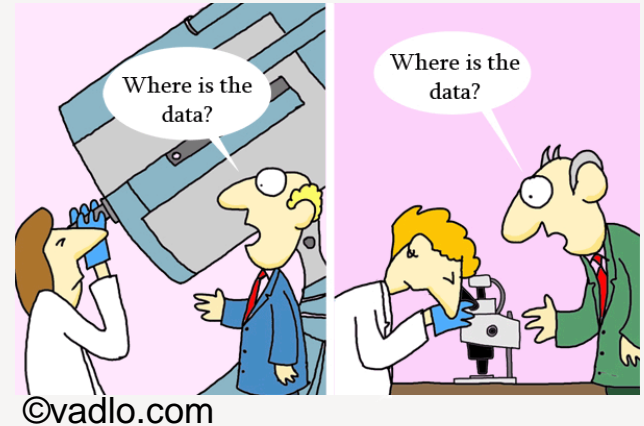


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# Approaches – Data Review

- › Compare with applicable regulatory criteria
- › Review historical site activity and waste rock information to determine whether retained list of chemicals are related to historical mining activities at the Site
- › Retain chemicals as Constituents of Potential Concerns in refined data set that contains:
  - the maximum concentration exceeds Tier 2 SEQS
  - the maximum concentration exceeds background concentrations
  - the chemical is related to site activities





# Approaches – Data Interpretation

- › Further Statistic Summary of the exceedances
  - Number, frequency, and magnitude of exceedances
- › Compare data from upstream with downstream to determine whether historical mining activities has contributed to the impact
  - A statistical test will be used to determine if the deference between in/out flow is at a significance level of 0.05 (i.e.,  $p < 0.05$  statistically different)
- › Determine whether downstream concentration exceeds applicable regulatory standards
- › If flowrate data is available, calculation potential loading to receiving environment
- › Complete Mann-Kendall analysis to determine surface water concentration trend
- › Calculate CCME water quality index for various areas of the Site
- › Determine if any additional assessment is required to evaluate the risks associated with the exceedance and develop a remedial plan



# CCME Water Quality Index (WQI)

- › The WQI incorporates the following three elements of water quality data:
  1. *Scope* – the number of parameters whose guidelines are not met
  2. *Frequency* – the number of time these guidelines are not met
  3. *Amplitude* – the amount by which these guidelines are not met
- › These elements are combined as the summation of the three vectors to produce a single value between 0 and 100 that describes the water quality for a given location (CCME, 2017).

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# CCME Water Quality Index (WQI) – Sample output

Sampling Stations	WQI for Potable Water <sup>a</sup>	WQI for Aquatic Life <sup>a</sup>	WQI for Livestock Watering <sup>b</sup>
<b>Upstream</b>			
Jean Lake, upstream from the mine site (Cayzor 2)	97 – Excellent	85 – Good	100 – Excellent
Pond/creek sampling stations upstream from the mine site (Cayzor 6, 8)	95 – Excellent	92 – Good	100 – Excellent
<b>Main Site Area</b>			
Runoff or pooled water at or adjacent to the main site area (Cayzor 4, 5, 7)	60 – Marginal	49 – Marginal	89 – Good
Jean Lake, adjacent to the main site area (Cayzor 1)	85 – Good	78 – Fair	95 – Excellent
<b>Downstream</b>			
Jean Lake, downstream from the mine site (Cayzor 3)	100 – Excellent	96 – Excellent	100 – Excellent





# Outcome

- › A multiple line of evidence approach with a number of statistical analyses were used to refine historical data set.
- › Able to identify that there is limited to no risk to human health
- › Determined that no significant remedial actions needed at six of the seven sites. Further assessment needed at one
- › Collaborative approach between client and consultant was helpful
  - SRC able to provide the context, while SNC-Lavalin able to provide technical expertise
  - Regulators and client able to understand the significance of findings

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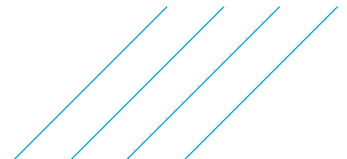
# Site 1

Evidence	Yes/No <sup>1</sup>	Comments
Exceedances of human receptor criteria (potable water)	Yes	Number, frequency, and magnitude of exceedances reflected in CCME WQI classifications
Exceedances of ecological receptor criteria (protection of aquatic life)	Yes	Number, frequency, and magnitude of exceedances reflected in CCME WQI classifications
CCME WQI upstream water quality “fair” or better <sup>2</sup>	Yes	“Good” with respect to aquatic life, and “excellent” with respect to potable water
CCME WQI downstream water quality “fair” or better <sup>2</sup>	Yes	“Excellent” with respect to all criteria examined
CCME WQI receiving environment adjacent to site water quality “fair” or better <sup>2</sup>	Yes	“Fair” with respect to aquatic life, and “good” with respect to potable water
CCME WQI onsite runoff and/or pooled water quality “fair” or better <sup>2</sup>	No	“Marginal” with respect to aquatic life and potable water – skewed by water quality in pooled water (Cayzor 4). Not considered source of drinking water or significant aquatic habitat.
Downstream water quality significantly poorer than upstream water quality	No	No statistical difference in priority SOPC concentrations (uranium and radium 226)
SOPC source is likely related to the site	Yes	Significant upstream sources are not suspected, however trenching and exploration activities are known to have occurred along the stream that feeds Jean Lake (GSC, 1971).
Priority SOPC concentrations in the receiving environment, stable, decreasing or indeterminate	Yes	Uranium – stable Radium 226 – stable in the receiving environment near the site, indeterminate downstream



# Site 2

Evidence	Yes/No <sup>1</sup>	Comment
Exceedances of human receptor criteria (potable water)	Yes	Number, frequency, and magnitude of exceedances reflected in CCME WQI classifications
Exceedances of ecological receptor criteria (protection of aquatic life)	Yes	Number, frequency, and magnitude of exceedances reflected in CCME WQI classifications
CCME WQI upstream water quality “fair” or better <sup>2</sup>	Yes	“Excellent” with respect to all criteria examined
CCME WQI downstream water quality “fair” or better <sup>2</sup>	Yes	“Good” with respect to the protection of aquatic life and “excellent” with respect to potable water.
CCME WQI receiving environment adjacent to site water quality “fair” or better <sup>2</sup>	N/A	Although there are sample stations located in the former beaver pond downstream of the Zone-62 Adit, only the station in Emu Lake (at the outlet) was considered to be representative of the receiving environment downstream of the site.
CCME WQI onsite runoff or pooled water quality “fair” or better <sup>2</sup>	No	Drainage from Zone-62 Adit is “poor” with respect to the protection of aquatic life and “marginal” with respect to potable water. Other runoff/pooled water onsite is “fair” with respect to the protection of aquatic life and “good” with respect to potable water.
Downstream water quality significantly poorer than upstream water quality	Yes	There was a statistically significant difference in concentration of priority SOPCs (uranium and radium-226) upstream (Boom Lake) and downstream (Emu Lake) of the site.
SOPC source is likely related to the site	Yes	Significant upstream SOPC sources are not suspected, and the comparison of upstream and downstream concentration suggests that the site is contributing to an increase in chemical concentrations.
Priority SOPC concentrations in the receiving environment, stable, decreasing or indeterminate	Yes	Uranium – Stable downstream of the site in Emu Lake Radium-226 – no trend downstream of the site in Emu Lake





# Acknowledgement

# Questions?



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and how we engage with our clients and stakeholders.*

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*We put safety at the heart of everything we do, to safeguard people, assets and the environment.*

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*We do the right thing, no matter what, and are accountable for our actions.*

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