October 18, 2018

Use of Non-Traditional Materials to Cap Northern Mine Shafts

Michael Webster
Senior Reclamation Specialist

cameco.com

Cameco

Introduction

Uranium City

- 830 km North of Saskatoon
- ~60 permanent residents
- Winter road access (<2 months/year)
- Accessible by scheduled plane service

Beaverlodge Mine/Mill

- Main facility located ~8 km east of Uranium City with road access

Introduction

- **Mining and milling**
  - 1952 to 1981 by Eldorado Resources
- **Decommissioning and reclamation**
  - 1982 to 1985
  - Approved by regulators of the day
  - Infrastructure removed or buried
  - Concrete caps installed on exposed vertical mine openings
- **Cameco management**
  - 1988 to present
- **Goal is to return lands to Crown**
  - Institutional Control (IC) program

Introduction

Government of Saskatchewan
Ministry of the Economy

The Reclaimed Industrial Sites Act

being

Chapter R-4.21 of *The Statutes of Saskatchewan, 2006* (effective March 1, 2007), as amended by the *Statutes of Saskatchewan*, 2014, c.E-13.1.

- **Institutional Control (IC) Program**
  - Introduced by the province in 2007
  - Transfer site responsibility to the Province of Saskatchewan, but sites must be **safe, secure and stable**
  - **Purpose:** Long-term management of decommissioned mine and mill sites
  - Funding provided up front to cover the cost of future monitoring and maintenance
- **Historic vertical mine openings**
  - Needed to ensure **safe, secure and stable**
  - Approved long-term sealing method

Historic Mine Openings

1985 Proposed Sealing Method

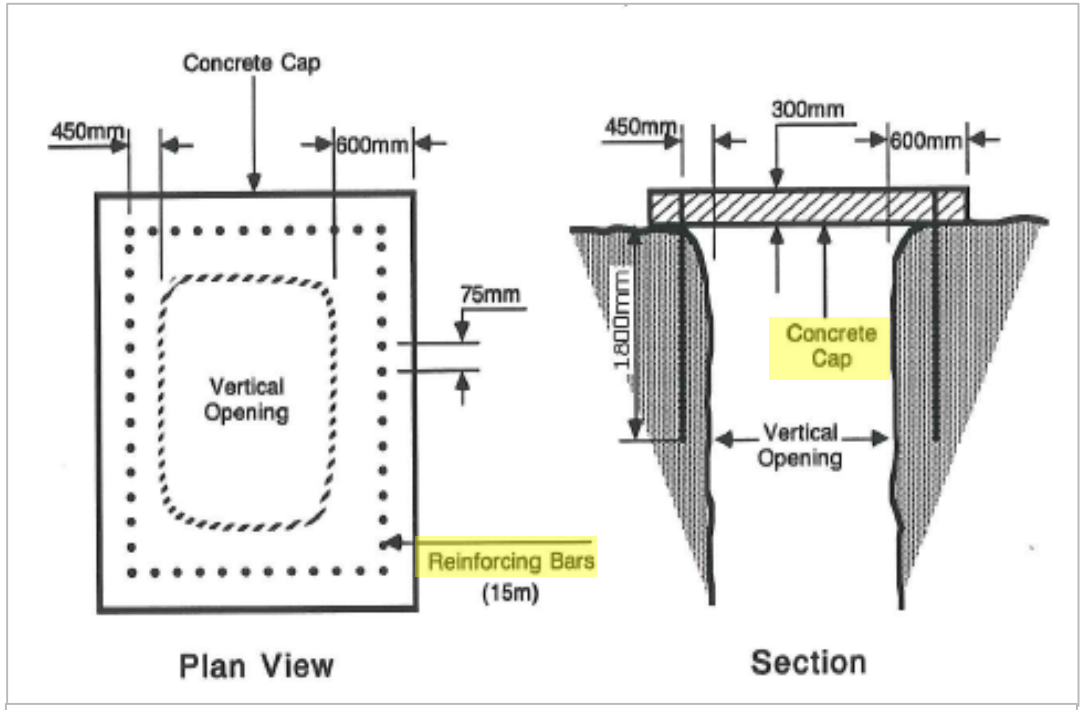


Figure 5.2

BEAVERLODGE CLOSE – OUT

Typical Detail Sealing Vertical Opening

(Dimensions in Millimetres)

Actual Sealing Method

- No reinforcement bars
- No QC for concrete
- No consistent overlap to bedrock
- Resulting in **no engineer sign-off** regarding quality of cap

Mines Regulations

Openings to underground mines

407(1) If a shaft, raise, adit or other opening to the surface is abandoned or if the workings are discontinued, the employer, contractor or owner shall ensure that the shaft, raise, adit or other opening is secured against unauthorized entry in accordance with this section.

(2) A shaft, raise, adit or other opening must be secured by covering the top of it with a bulkhead designed by a professional engineer of reinforced concrete at bedrock or at the top of the concrete collar of the shaft, raise, adit or opening.

(3) An employer, contractor or owner shall ensure that the cover required pursuant to subsection (2) is clearly marked with a substantial 1-metre high marker or sign that identifies the party responsible for the opening and the cover.

16 May 2003 cO-1.1 Reg 2 s407.

Mines Regulations

Openings to underground mines

20-3(1) If a shaft, raise, adit or other opening to the surface is abandoned or if the workings are discontinued, the employer, contractor or owner shall ensure that the shaft, raise, adit or other opening is secured against unauthorized entry in accordance with this section.

(2) A shaft, raise, adit or other opening must be secured by:

a) covering the top of it with a bulkhead designed by a professional engineer of reinforced concrete at bedrock or at the top of the concrete collar of the shaft, raise, adit or opening; or

b) a suitable closure method designed and approved by a professional engineer and approved by the chief mines inspector consisting of a long-lasting and suitable material anchored at bedrock or at the top of the concrete collar of the shaft, raise, adit or other opening.

(3) An employer, contractor or owner shall ensure that the cover required pursuant to subsection (2) is clearly marked with a substantial 1-metre high marker or sign that identifies the party responsible for the opening and the cover.

***The Mines Regulations, 2018* have been approved and will come into force on April 6, 2019**

http://publications.gov.sk.ca/freelaw/documents/gazette/part2/2018/G2201814.pdf

Challenges with concrete caps in remote areas

- **Shipping concrete and aggregate to remote location**
- **Water availability**
- **Strict concrete engineering QA/QC requirements**
  - Difficult to meet in remote field locations
- **Safety concerns with working near open holes**
- **Requirement to replace concrete cap every 75 – 200 years**

Potential solutions available?

- **local contractor suggested stainless steel**

Stainless Steel Cap

Why Stainless Steel?

Buy In	Practicality	Longevity	Economics
• Well understood engineering principles • Existing success stories • Previous exemptions	• Ease of installation, future inspections and replacement	• Engineered drawings stamped for 1200 year life (minimum)	• Lower cost for remote area installation • Lower calculated net present value for future replacement

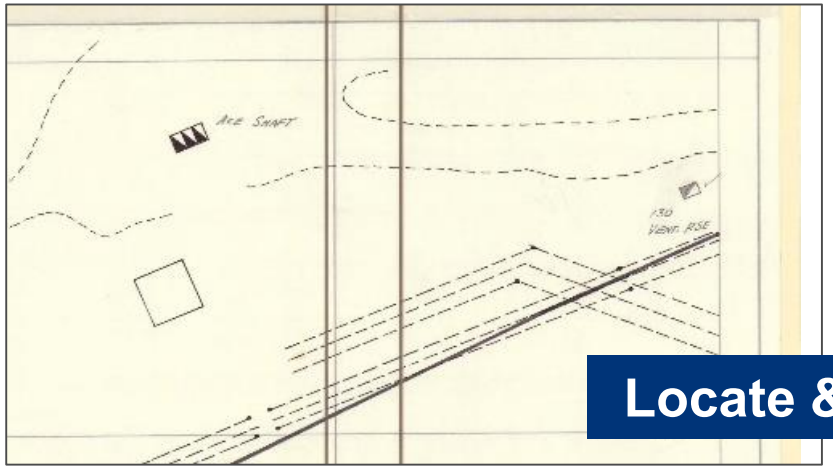
Comparison of Steel to Concrete

	Material Options	
	Stainless Steel	**Concrete**
Cost	Similar to concrete	Similar to steel
Degradation	Very Low (1mm/1200 years)	Low if engineered for specific site environmental conditions
Durability	High	High to Very High
Longevity	Likely > 1200 years	75 – 200 years
Ease of Installation	Moderate • field construction • requires small/medium size equipment • easy to adapt in field	Difficult • remote location construction challenges • requires small/medium size equipment • Adaptable until poured
Safety	Limited worker exposure to open holes	Workers exposed to open holes
Approvals	Requires exemption from Mines Regs	Accepted methodology
NPV replacement cost	Very Low	High

Stainless Steel Cap - Design Criteria

Loading Criteria	– Able to withstand a loader/skidder.
Drainage Criteria	– Promote drainage away from the opening and prevent water from pooling on the cap.
Transportation Criteria	– Cap or cap sections limited to a maximum width of 4 metres. Incorporate anchor points to facilitate loading, unloading and placement.
Security Criteria	– Securely anchored to competent bedrock where possible.
Field Fitting Criteria	– Although it is desirable to limit the amount of field fitting required, field fitting will be unavoidable and allowances in design need to be incorporated.
Inspection Access	– Consideration of future inspections for conditions while insuring the security of the cap and the limitation of intrusion by the public and or wildlife.

Securing the Mine Openings - Overview



Locate & Expose Cap

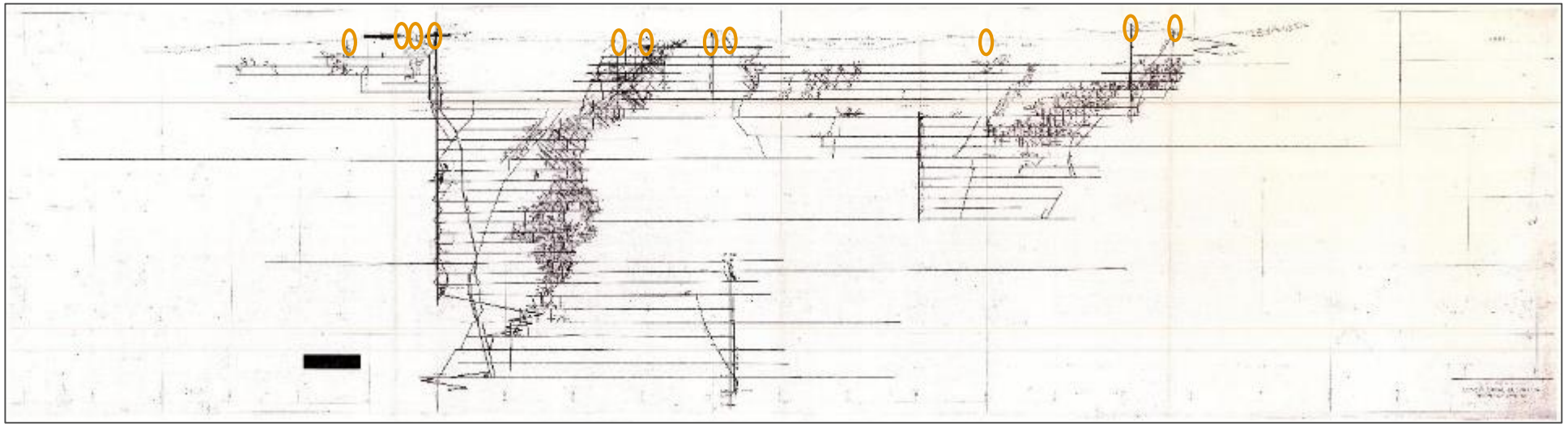
Clean cap and surrounding bedrock

Completed cap at Ace 130 Raise

Mine Openings – Locate

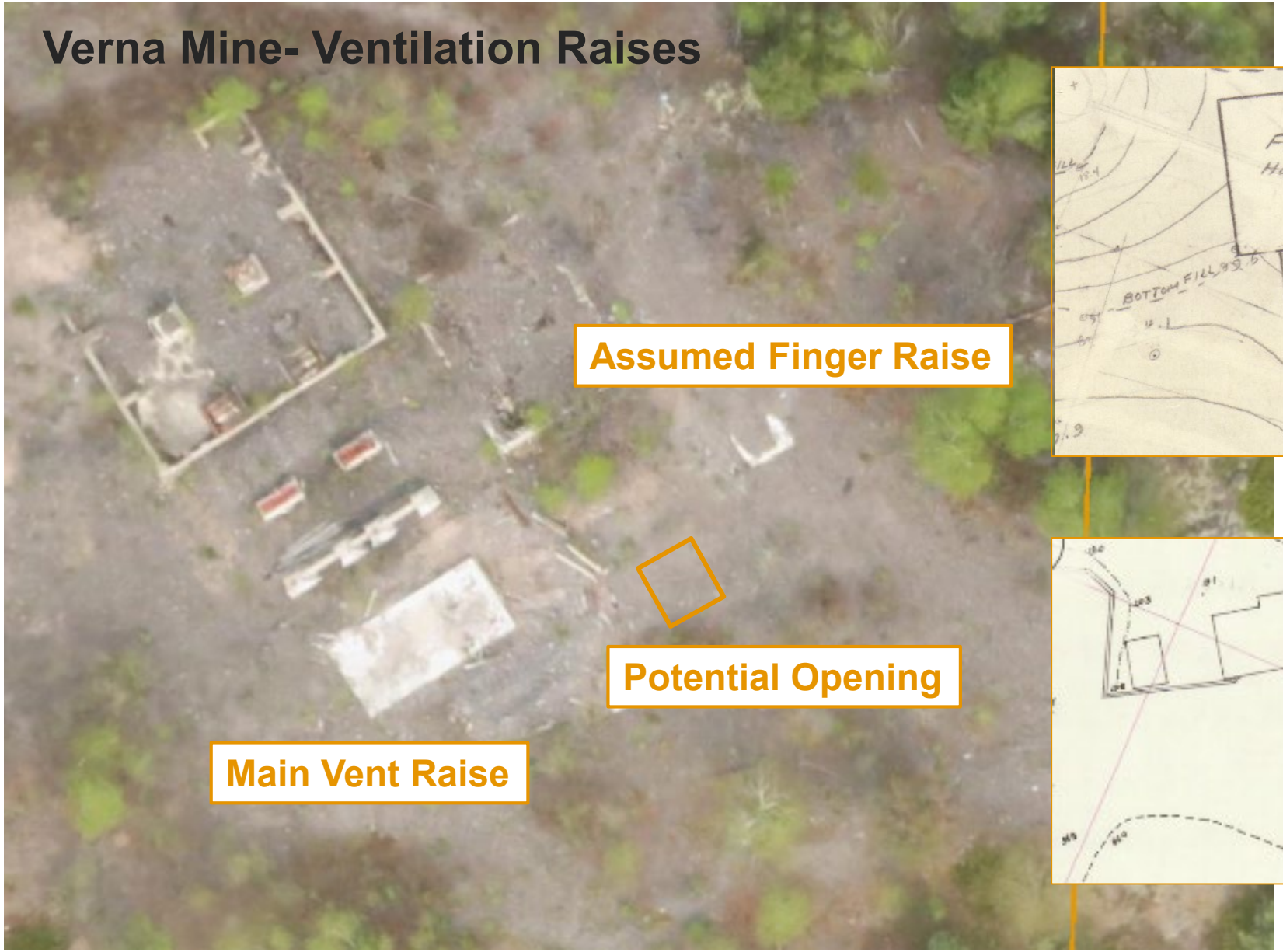
1. Locate

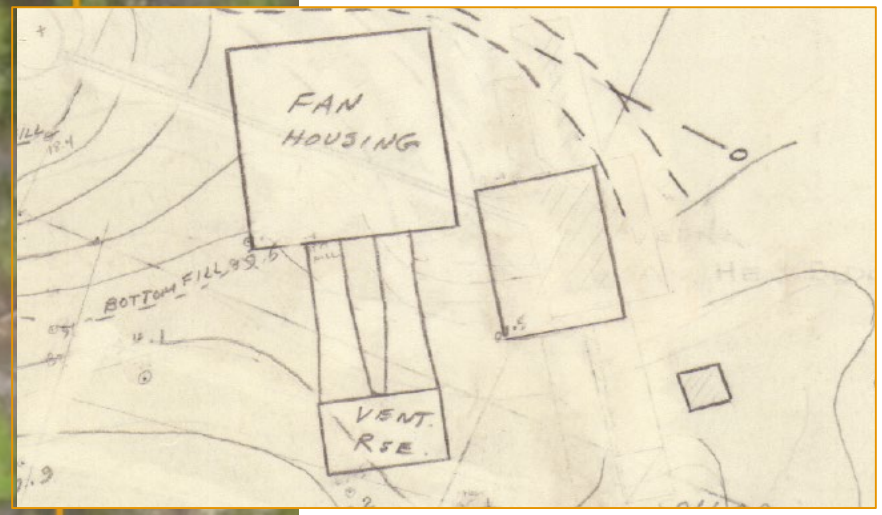
- **List of openings from the final decommissioning report**
- **Some concrete caps left uncovered, most buried with waste rock**
  - Previous attempts to locate openings partially successful in 2010, 2013/2014
  - Located remaining openings from 2016 – 2018 using historical drawings and aerial photos

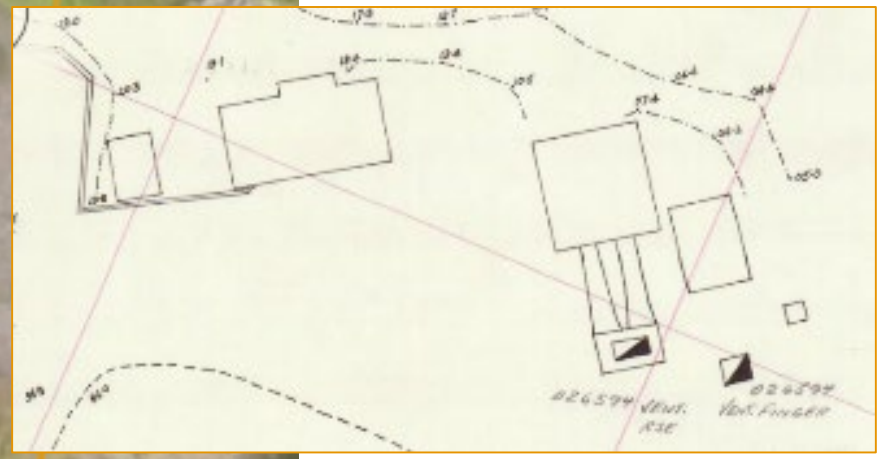


Beaverlodge Mine Longitudinal Section - 1982

Mine Openings – Locate

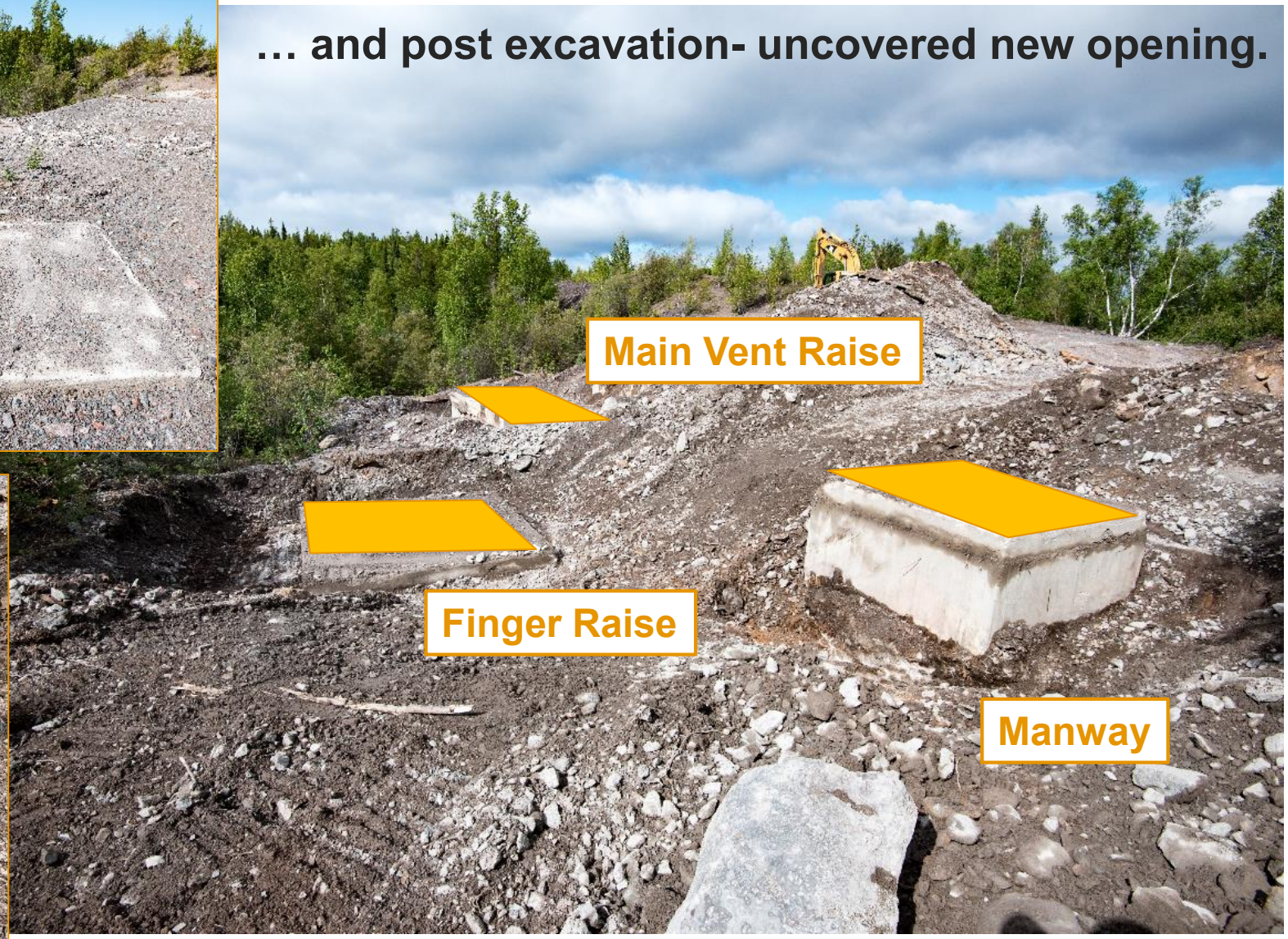






Mine Openings – Locate

Activities – Locate



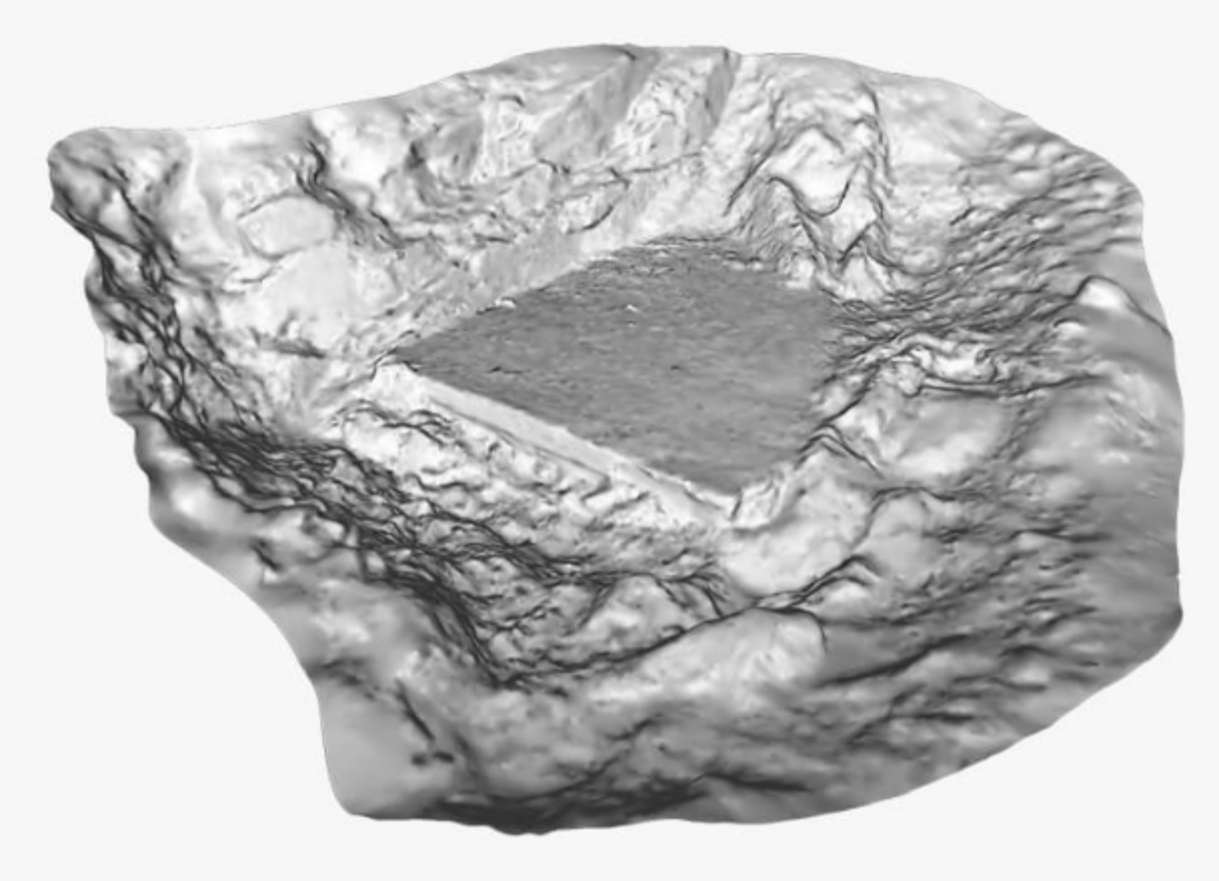
Mine Openings – Design

- **Once located, the cap and surrounding bedrock are cleaned**
- **Design engineer (Kova) on site to determine anchor placement and scan bedrock to develop 3D model**
  - *Staying on the same page*: field review of proposed design with installation contractor
  - *Considerations*: bedrock competency, size of opening, drainage, final landscaping
- **Kova then generates drawings for approval and fabrication**

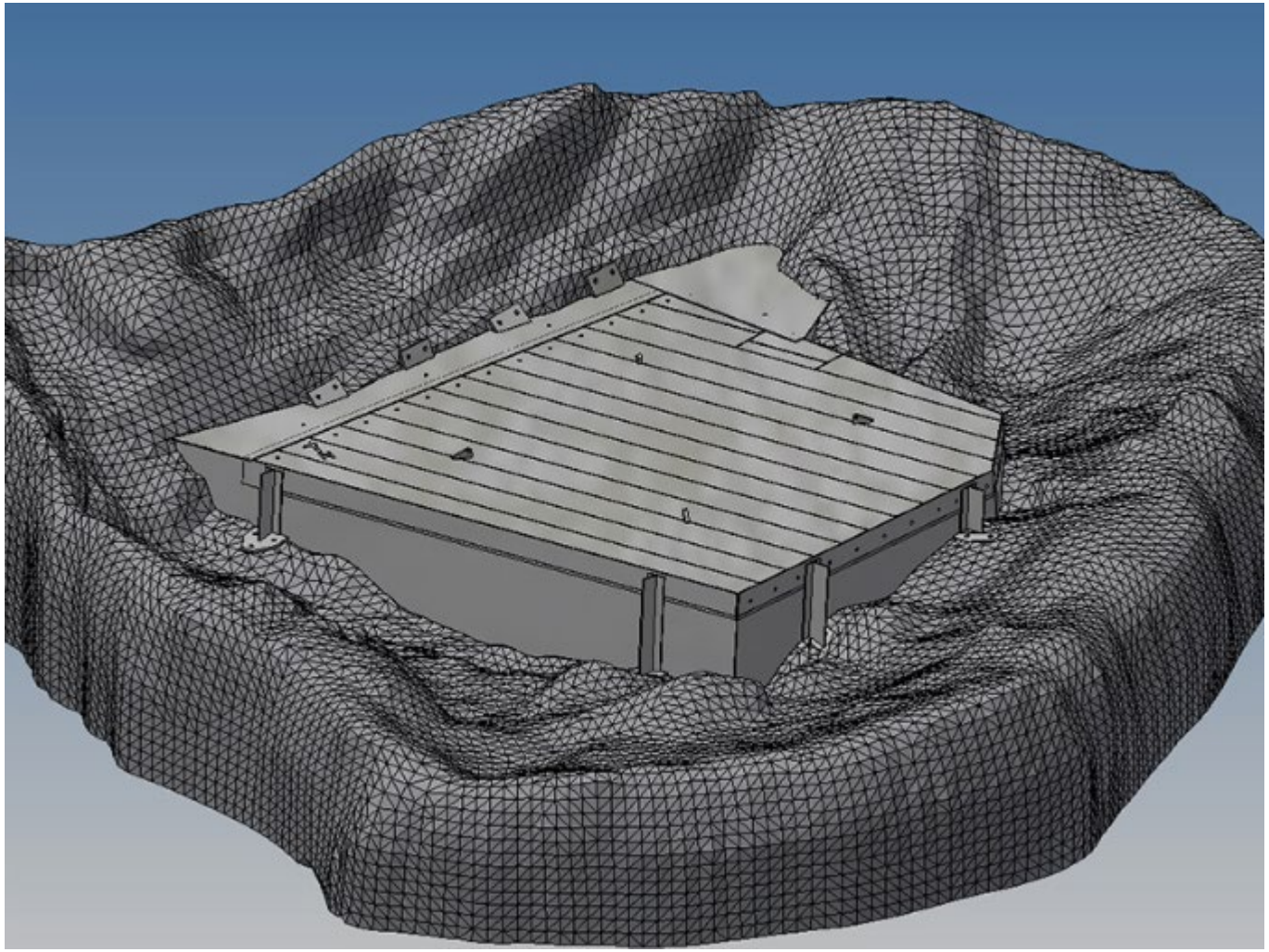
Mine Openings – Design

Cap cleaned off with bedrock expose

Meshed surface of the cap and surrounding bedrock



Mine Openings – Design



Inventor model – showing designed cap

Completed Cap

Mine Openings – Fabricate and Install

- Fabrication in Saskatoon and pre-shipment QA checks
- Shipped up to Uranium City via the winter ice road
- Uranium City Contracting is the installation contractor
- Design Engineer inspection during fabrication, install, and following final “pickle”

Mine Openings – Secure

Securing the Mine Openings - Overview

2016

Trial Install

Fabricated and installed steel cap at the Ace Shaft

Started process for additional 11 based on success of the initial install

2017

Easily Accessible

Fabricated and installed 11 steel caps at several properties

Measured and designing 6 steel caps for install in 2018

2018

Large Caps

Fabricate and install 6 steel caps

Measure and design 2 steel caps for install in 2019

2019

Unique Caps

Fabricate and install 2 steel caps identified as the Hab Heater Raise and the Verna Main Vent Raise

Measure and design final 2 caps for installation in 2020 Fish Hook Bay Shaft, and the Fay Shaft

Steel caps complete

Stainless Steel – not always the best option

- **Stainless steel caps can be utilized in most circumstances, however there are occasions where it may not be practicable. These include but are not limited to:**
  - Areas where the bedrock is unstable
  - Areas with significant overburden
  - Shallow but known shaft depth
  - Likely more suited to remote areas
    - Concrete caps likely cheaper when materials are readily available
    - Potential vandalism if easily accessible

Example on next slide

Other Alternative Methodologies

1. Strategic Boulder Placement

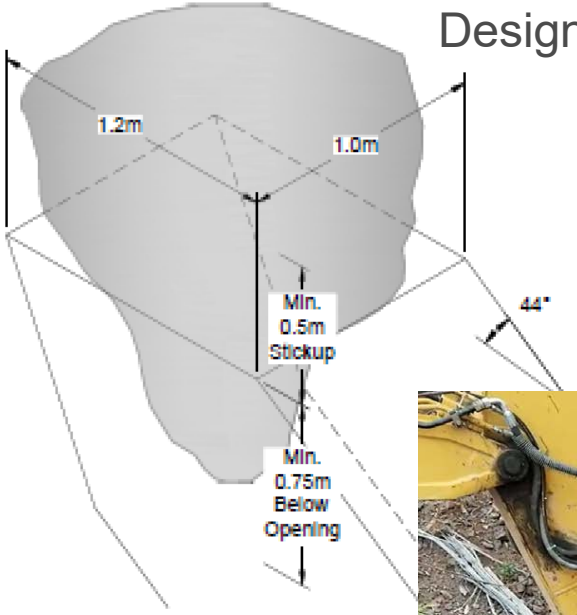
Beaverlodge Example - Small Ventilation Raise

- Located near area of unstable crown pillar
- Remediation of crown pillar required additional fill placement near opening
- Future inspection of a Stainless Steel cap would be difficult due to waste rock cover

Ventilation raise located ~4 m below surrounding grade

Other Alternative Methodologies

Design specifications of key boulder



Placement of key boulder in opening

- Plan required approval from Mines Branch as it was not a concrete cap
- Not recommended for high traffic areas
- Potentially limited by boulder sizes and equipment capacity

Other Alternative Methodologies

Boulders placed around key boulder

Location of Ventilation Raise graded to surrounding area

Other Alternative Methodologies

Steel Grates

- Recent design accepted in Ontario

Expandable Foam

- Limited use, considered temporary measure to address immediate safety concerns
- Not currently accepted in Saskatchewan for long-term use

Waste Rock Backfill

- Requires known volume of shaft
- Requires approval from Mines Branch

Expandable foam in northern Saskatchewan (Non-Beaverlodge) used as a temporary closure method to address immediate safety risk
photo by Michael Webster

Conclusion

Where applicable Stainless Steel caps have proven to be a safe, cost effective, long-term alternative to traditional concrete caps in remote areas of Northern Saskatchewan

- ***Buy in***: Well understood engineering principles for design and construction
  - Exemptions received from Saskatchewan Mine Regulations
- ***Practicality***: Ease of installation, future inspections and replacement
- ***Longevity***: Engineered drawings stamped for 1200 year life (minimum)
- ***Economics***:
  - Similar cost compared to concrete for remote area installation
  - Significantly lower calculated NPV for future replacement

Not applicable in all situations

Now being explored in other jurisdictions in Canada

Acknowledgements

Kova Engineering 311 Wheeler Place, Saskatoon 306-652-9229	Paul Caughlin Engineering design of Stainless Steel Caps
SRK Consulting Suite 205 2100 Airport Drive, Saskatoon 306-955-4778	Trevor Podaima Engineering design of Strategic Boulder Placement
	Warren Medernach UAV photo collection and processing; mine overlays
Uranium City Contracting Uranium City 306-498-2761	Kevin Lewandoski Transport and Installation of Stainless Steel Caps

Questions

Thank You !

Cameco