EVALUATING AND PLANNING REHABILITATION IN AN HISTORIC MINING CAMP USING A RISK ASSESSMENT APPROACH IN COBALT, ONTARIO

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Introduction

The Cobalt silver mining camp, in northeastern Ontario, was active starting in the early 1900's and has been the host to over 100 mines and 15 mills over the course of the last century. Cobalt is considered the "Cradle of hard rock mining in Canada"; it has greatly contributed to the development of Canada's mining expertise now exported all over the world. The rich mining history of Cobalt is evident and recognized.

Along with the heritage associated with these old mine sites also comes the potential for physical mine hazards (e.g. openings to surface), residual mine rocks, tailings areas and former industrial buildings/foundations to be present. These features can present a certain level of risks to public health and safety, as well as to the aquatic and terrestrial environments.

Agnico Eagle holds to this day the rights of a portion of the historic mining sites in the Cobalt-Coleman Area (about 230 properties). Some of these sites were operated and closed well before Agnico Eagle acquired the properties. From 1957 to 1989, Agnico Eagle Silver Division operated 23 mines, 4 mills and 1 refinery in the Cobalt-Coleman Area. Closure plans (7) were developed and filed with the Ministry of Northern Development and Mines (MNDM) between 1993 and 1998. Closure and rehabilitation work was done during the same period, and extended up to 2004.

In 2012, the MNDM asked for amendments to 1990's closure plans. Agnico Eagle thus engaged in a thorough inventory and investigation of their properties. The amount of information gathered during this exercise called for a system to be developed to support data analysis. We also needed to process the information in order to prioritize additional/required rehabilitation actions based on criteria that would take into account technical and economic factors, but also environmental and socio-cultural factors. A risk assessment approach was selected to reach that goal.

Risk Assessment Approach

The risk assessment approach consisted of 6 steps (Fig. 1). Steps are detailed in the following subsections.

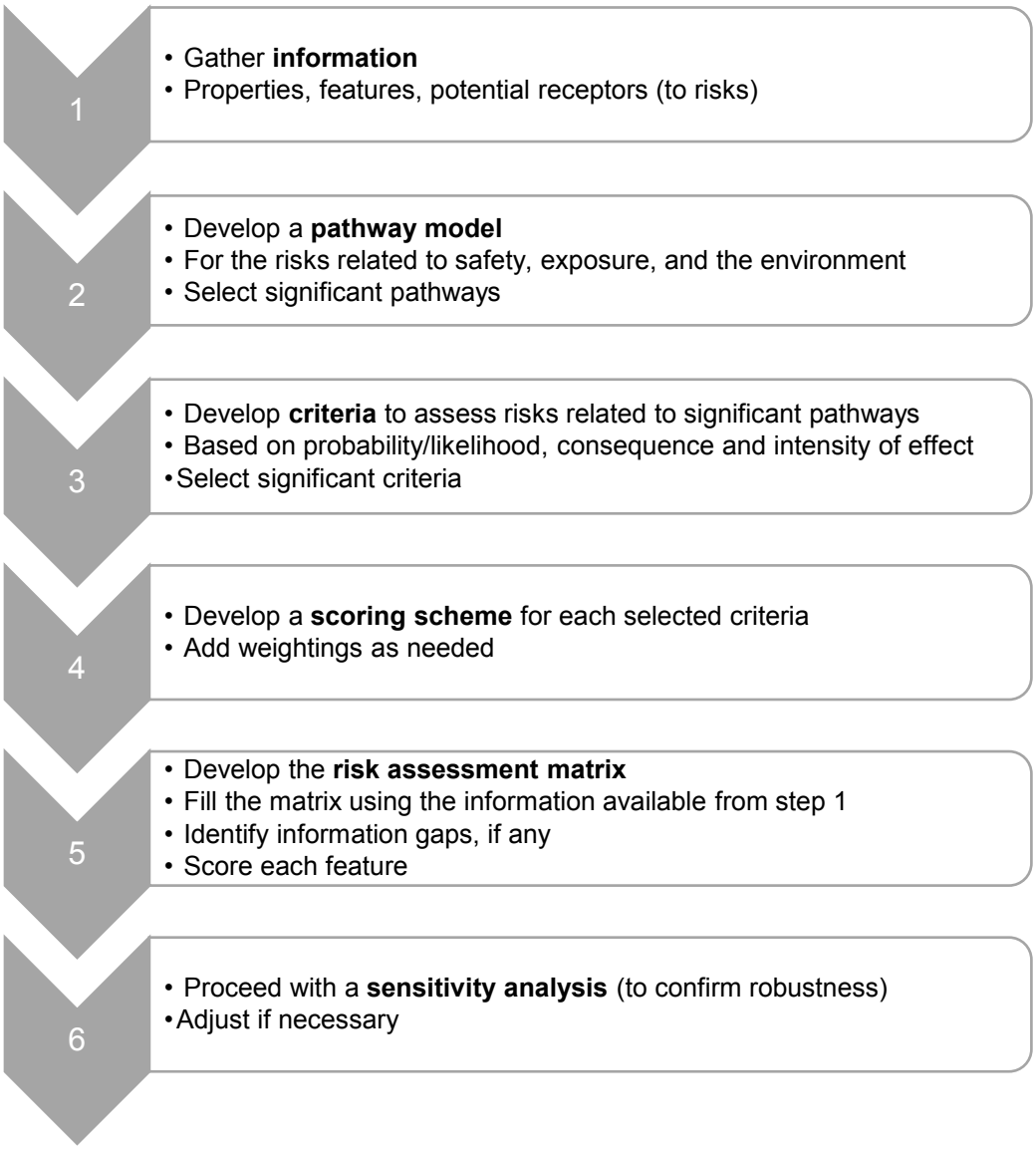

Figure 1: Legacy Mine Hazards Risk Assessment Tool Development Steps

Step 1: Information Compilation

From 2012 to 2015, Agnico Eagle conducted a review of the features on their Cobalt-Coleman properties in order to update the information on the status of potential mine hazards. The following types of features (Table 1) were identified. To ensure clarity and consistency when using the terminology, these were defined (Golder Associates, 2014).

Table 1: Types of Features encountered in the Cobalt-Coleman Historical Mining Area

Adits	Head Frames	Shafts
Buildings	Open Cuts	Stopes to Surface
Crown Pillars	Open Holes	Subsidence
Exploration Pits	Pits	Tailings Areas
Exploration Shafts	Portals	Trenches
Exploration Trenches	Raises	Waste Rock Piles
Foundations	Settling Ponds	Water Quality

Historical information[1] (map, reports) was used to find attributes (depth, dimensions, previous status, rehabilitation method, etc.) and general information on the features. Results of the studies done over the years in the area in terms of tailings and waste rock characterization, as well as surface and groundwater quality, were also compiled and analyzed. This was followed by field inspections and sampling programs to confirm/infirm data and to complete data coverage. All this information was inputted on Field Sheets, in a data management system, and then into a Georeferenced Information System (GIS).

This review identified 517 openings to surface, 300 crown pillars, 10 tailings areas, and 20 waste rock piles. Mitigation measures and rehabilitation already in place were inventoried as part the status of the features. Results indicated that 88% of openings to surface are considered rehabilitated, and 62% of crown pillars do not require further assessment. Some features would thus require additional work to ensure safety and/or to manage potential risks.

In addition to the information pertaining to the historical mining features, a field work program and mapping exercise was performed to complete the database related to the natural and social environment (receptors). Field and desktop work allowed for the mapping of the types of surrounding habitats, location of population, sensitive habitats, and species (notably, species at risk). All this information was also inputted into the GIS.

Step 2: Pathways

Two main categories of risk source were identified with reference to the legacy mine features in the Cobalt-Coleman Area. These are (1) the **physical hazards** (safety risk, e.g. falling in a hole), and (2) the **risks of exposure to contaminant** (for both the population and the environment). Three main receptors were identified: (1) **humans**, (2) **animals**, and (3) **ecosystems**. Table 2 summarizes the pathway analysis that was done to link the potential risks with potential receptors.

[1] It should be noted that the quality of the historical information may vary depending on the source. Notes were added to the database to take that into consideration.

Table 2: Pathway Analysis – Risks related to Legacy Mine Features in the Cobalt-Coleman Area

Receptor	Risk Source					
	Physical hazards	Exposure to contaminants				
		Soils[1]	Sediments	Air	Surface water	Groundwater
Humans Ingestion		○			√	○
Inhalation				√		
Safety	√					
Animals Aquatic wildlife			○		√	
Terrestrial wildlife	○	○			○	
Livestock						
Ecosystems Land-based		√		○		
Freshwater		√	○		○	

[1] Raw tailings/waste rock material is considered in this risk category

○ Potential Pathways √ Selected Pathways

Step 3: Criteria

The overall approach to develop criteria was to determine, for each risk source and their selected pathway(s), the **factors** that could influence the risks, could they be related to the:

- Probability/Likelihood;
- Consequence;
- Intensity; or
- Current mitigation.

A first exhaustive list of potential criteria was developed. Of these, only the ones that actually would discriminate the features were retained/selected (Table 3).

Step 4: Scoring Schemes and Matrix

All selected criteria were developed into scoring schemes using a scale from very low to very high. The criteria were developed using measurable units as often as possible in order for the tool to be objectively filled by any user. For more subjective criteria (e.g. potential for injury, consequence of failure), detailed scales were developed to describe as much as possible each option and try to eliminate most of the potential subjectivity.

Current mitigation was introduced in the scoring scheme using a multiplicator (from 0 to 1) lowering the feature's score when mitigation is in place.

Table 3: Criteria Selected for the Cobalt Legacy Features Risk Assessment

	Risk to public safety		Risk of exposure		Risk to the environment	
	Accessibility and risk of injury	**Stability**	**Particulate matters**	**Surface water**	**Surface water**	**Habitat**
Probability	Distance to nearest residence	Distance to nearest residence	Distance to nearest residence	Accessibility of impacted water	Downstream distance to Lake Timiskaming	Risk of material to migrate into surrounding environment
	Ease of public access	Ease of public access			Probability of contact	Mine waste storage area
Intensity	Height/depth of feature	Potential of failure (POF)	Arsenic concentration	Arsenic concentration		
Consequence/ Likelihood	Potential injury	Consequence of failure	Mine waste storage area	Use of surface water	Contribution to arsenic concentration in Farr Creek	Type of downstream habitat
Mitigation	Current mitigation	Current mitigation	Current mitigation	Current mitigation	Current mitigation	Current mitigation

The risk assessment matrix was then developed with these criteria and scoring schemes. To better reflect the importance of the risks in the overall analysis, the tool allows for the possibility to weight both the risks and/or the pathways.

Step 5: Fill the Matrix and Score Features

Once the risk assessment matrix was fully developed, it was tested, adjusted, and then the assessment took place. Each feature was inputted into the matrix, described, and then evaluated using the applicable set of criteria. Total score for a given feature was the sum of all applicable risk mitigated scores. So the more residual risks there was for a given feature, the higher the total score was. Features scores can be summed to give an overall score for a given property.

Step 6: Sensitivity Analysis

A sensitivity analysis was finally done to ensure robustness of the tool and the results. Since different features (e.g. open holes vs tailings areas) were compared all together, attention was given to evaluate representativeness of the results. The basis for comparison needed to be clear and solid for the tool and results to be used with confidence.

Results: Ranking to Inform Action Plan

Once all the features were scored, it allowed for the ranking of all of them. Priority for additional rehabilitation work will be given to the features with the highest scores. Scores could also be used to determine if additional rehabilitation work is required, taking inherent risks into account. Property's score will also be looked at to identify areas that could benefit the most from additional rehabilitation efforts, taking into account proximity for enhanced effectiveness.

This approach allowed for effective use of the information available on the features in order to assess their potential/residual risks. The tool was used to score and compare legacy mine features from a health and safety, social and environmental risk perspective. It provided with a detailed and documented tool to help communicating priorities to stakeholders.

References

Golder Associates. 2014. Physical Mine Hazards, Far Field Areas (Closure Plan Amendment #1). Agnico Eagle Mines Ltd. Cobalt – Coleman Area Properties. Report Number 1405040, December 2014. 29 pages + figures and appendices.

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