A Climate Adaptation Case Study
in Canada's Mining Sector

Addressing Weather-Related Challenges at the Galore Creek Project, Northwestern British Columbia

Fraser Basin Council

Galore Creek Mining Corporation

1 • Introduction

From long-range planning to day-to-day operations, mining companies face various risks at all stages of the mining life cycle. The dynamics of global mineral markets, commodity price swings, skills shortages, regulatory considerations, as well as geotechnical, environmental and social licence issues all represent sources of risk that companies regularly assess and address.

Weather events such as episodes of intense rainfall or prolonged drought have always posed risks to mining operations. Recent climate change research,[1] along with a marked increase in attention given to weather-related catastrophic losses observed in recent years,[2] have provided the impetus for leading resource companies to continue to prepare for severe weather events in the future.

This case study has been prepared to assist Canadian mining companies as they respond to challenges and opportunities posed by weather and climate extremes. By sharing the experiences and efforts of Galore Creek Mining Corporation (GCMC) at its development project in northwestern British Columbia, it is hoped that Canada's mining industry as a whole will benefit.

This case study provides suggestions for further investments in knowledge, tools and practices that would help the industry as well as other natural resources sectors.

This case study is made possible through funding from Natural Resources Canada's Enhancing Competitiveness in a Changing Climate Program. The Program facilitates the sharing and development of knowledge, tools and practices to assist decision-makers in managing climate- and weather-related risks. This case study has been prepared by the Fraser Basin Council (FBC), a not-for-profit organization that facilitates collaborative efforts to advance sustainability throughout British Columbia and beyond, and is in partnership with the Mining Innovation, Rehabilitation and Applied Research Corporation (MIRARCO) of Sudbury and its parent organization, the Ontario Centre for Climate Impacts and Adaptation Resources (OCCIAR).

This case study would not have been possible without the contributions of Andrew Thrift of GCMC and his colleagues. FBC and MIRARCO are most grateful for GCMC's interest in sharing its knowledge and experiences with others.

2 • Galore Creek Mining Corporation Overview

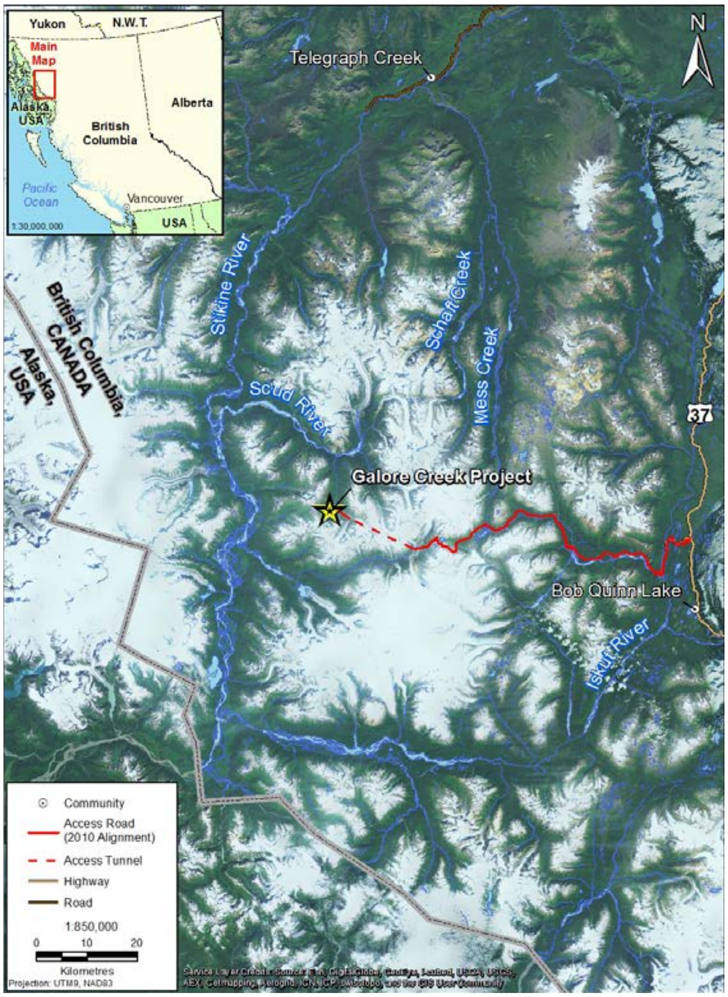


Figure 1 | Galore Creek Project Location

Galore Creek Mining Corporation (GCMC) is a private company equally owned by NOVAGOLD RESOURCES INC. and Teck Resources Limited. Both share a strong commitment to sustainability. The company's sole asset is the Galore Creek Project, a large copper-gold-silver open pit deposit situated approximately 200 km northwest of Stewart, BC (Figure 1) and 1000 km northwest of Vancouver, BC. GCMC completed a pre-feasibility study in 2011 and is conducting additional internal studies to further optimize mine planning and design. As envisioned in the pre-feasibility study, the proposed mine would provide ore to a process plant at a nominal rate of 95,000 tonnes per day over an approximate 18-year mine life.

In 2006, GCMC signed a Participation Agreement with Tahltan First Nation, whose traditional territory includes the Galore Creek Project site. The Tahltan have actively participated in the Project through employment and contracting, as well as environmental performance review and project planning.

Figure 2 | View of Galore Creek West Fork & Utlahn camp in foreground, East Fork in background

3 • Examples of Weather- and Climate-Related Challenges

Galore Creek is located in heavily glaciated, rugged terrain that imposes challenging geotechnical and geohazard constraints (Figure 2).

The Project area is in a transition zone between wet coastal and dry/cold interior climate zones. The orographic influence of the mountain ranges on the Pacific and the continental air masses result in precipitation and air temperatures that are extremely variable over the Project area. Annual runoff is relatively high (over 2000 mm in the upper Galore Valley, where the open pits are planned). Glacial melt provides a substantial contribution to runoff throughout the summer. Peak flows can occur during freshet, in late summer and/or in the fall.

An extreme precipitation event occurred over the course of five days in September 2011, when a total of 333 mm of rain fell in the region. In one 24-hour period, 111 mm of rain was observed at the site. Such rainfall over an extended period produced very high runoff conditions. At Galore Creek, the event caused flooding in areas of the access road and creek channel migration, causing damage to two temporary bridges (Figure 3), a hydrological station (Figure 4) and a meteorological station.

Figure 3 (top) | Flooding of access road

Figure 4 (bottom) | Hydrological station washout due to high runoff and channel migration

The storm system also caused washouts on Highway 37A near Stewart, a major transportation route in the region. During this emergency, GCMC played a critical role in keeping Highway 37 open by deploying its trucks to haul rip-rap from its access road to protect bridges from being washed out, which would have led to highway closures.

Weather-related challenges at Galore Creek include:

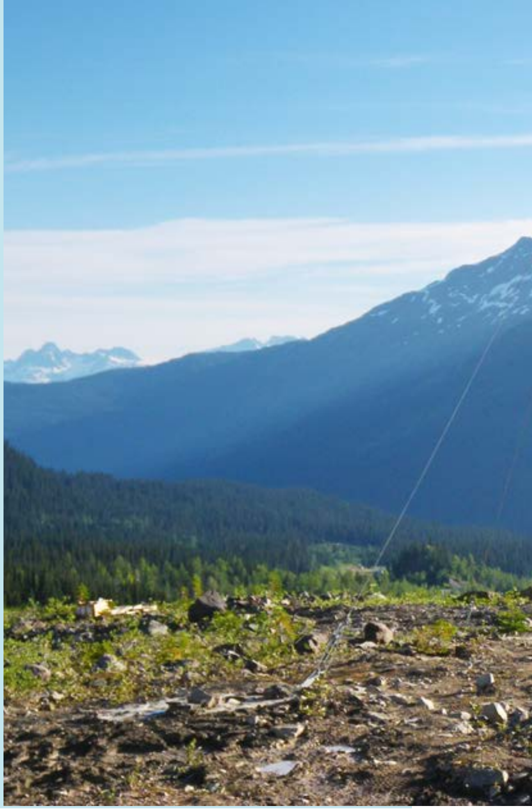
- Significant variations in precipitation over relatively small distances in rugged terrain, introducing complexity in terms of designing robust water management infrastructure. For example, the west and east forks of the Galore Valley have notably different annual rainfall amounts, even though they are only a few kilometres apart. Comparing the upper and lower portions of the watershed, the 24-hour precipitation totals may differ by almost 100%.
- Getting people, equipment and supplies to and from the site, which relies heavily on helicopter transport due to its remote location in northwestern BC (approximately 70 km from the nearest public highway).
- Under-reporting of precipitation (known as "under-catch") due to strong winds in exposed locations (Figure 5), which can cause precipitation to blow past the orifices of gauges, thus affecting the accuracy of precipitation data.
- Lack of long-term historical climate and hydrological data in proximity to the Project, resulting in greater reliance on data from stations that are a considerable distance from the site to supplement data from Project stations, which have a shorter period of record. Long-term regional data and shorter-term Project data are correlated to create "synthetic" long-term site datasets, which are used for Project design and "what-if" future scenario analyses.
- Receding of glaciers located near the site. Glacial activities can either add or subtract from the hydrological water balance. For example, although a recent trend of glacial retreat is evident from a time series of aerial photographs, site glacier studies have shown that in some years the glacier can accumulate ice, effectively withdrawing runoff from the water balance in that year.
- Although more of an institutional resources challenge than a physical one, the reduction in government resources for primary scientific research and long-term meteorological data collection has led to an increasing burden on industry to undertake or otherwise fund this research, which may not be economically feasible or practically achievable. Resulting data gaps, particularly in long-term climate and hydrological datasets, can constrain informed planning and decision-making.

Figure 5 | Galore Creek weather monitoring station in West Fork of Galore Valley

4 • Company Responses

GCMC takes a risk assessment approach in all aspects of its business. The existing challenging weather conditions in the area of the Galore Creek Project underline the value of a risk-based approach to future weather variability and climate change.

In response to the September 2011 extreme precipitation event, the company undertook a damage assessment and carried out necessary remedial works. GCMC contacted regional staff at Environment Canada, who provided intensity-duration-frequency (IDF) curves for the closest long-term regional meteorological station in Stewart. Although this station is approximately 200 km from the Project site, its data provided a reasonable basis for estimating the return period of rainfall events experienced at the site.



To assist with planning for future weather and climate-related conditions, the company is:

- Studying available regional long-term climate and weather data and comparing it with Project data collected locally over a shorter timeframe (approximately eight years) to ascertain whether local variability in precipitation intensity and seasonality is consistent with regional data and trends.
- Upgrading Project weather monitoring stations to improve the company's understanding of baseline conditions. This included installing additional windscreens around precipitation gauges to minimize under-catch in windy conditions and adding satellite telemetry capability to transmit data in near real-time, to avoid data gaps caused by sensor malfunction and more efficiently plan station maintenance trips.
- Installing a network of 24 tipping bucket rain gauges throughout the Galore Valley to characterize the spatial variability of rainfall at the site.
- Adjusting historical data to account for under-catch, using a methodology from research literature that relates under-catch to concurrent wind speed, to increase the accuracy of the Project precipitation dataset.
- Improving the company's understanding of the nature and extent of weather- and climate-related risk to inform design criteria and associated costs for water management infrastructure, to be used in the future feasibility study.
- Tapping into the expertise and tools of Teck Resources to plan site water balance modelling in a manner consistent with other Teck projects.
- Conducting a site visit at high-snowfall mine operations in Chile to learn about what operational and design measures were used to manage snowfall. Company professionals also keep abreast of the work of institutions such as the Canadian Institute of Mining and the Centre for Excellence in Mining Innovation.
- Sharing regional weather forecasts at daily on-site morning meetings to inform short-term planning (e.g., understand likely constraints on helicopter travel).
- Exploring options for an incremental approach to mine development – the is, making capital investments incrementally to incorporate knowledge gained (both operational and scientific) during the early phases of development.
- Harnessing traditional knowledge that has been accumulated by First Nations over a much longer time-frame than any other available data source. As GCMC has a positive working relationship with the Tahltan First Nation, GCMC has benefited from such knowledge. For example, early on a Tahltan elder advised GCMC that periods of high rainfall in autumn occur in some years. This was confirmed by data subsequently collected at GCMC's meteorological stations.
- When the cost of studying or flow-related design criteria is high relative to construction costs for certain infrastructure alternatives, the company may decide in some cases to simply implement the more conservative alternative. For example, it may cost $2,000 to install a bigger culvert versus $5,000 to analyze the case for it.

5 • Suggestions for Further Investment in Tools, Knowledge & Collaboration

As GCMC continues to manage the Galore Creek Project, infrastructure design criteria are a central consideration.

The company wishes to ensure that the design and operational plans are resilient under foreseeable severe weather conditions, including precipitation events that are particularly intense over a short time period.

For example, a long-duration, high intensity rain event at an operational mine allows time for mobilizing additional pumps to remove water from an open pit and move loading activities to a higher-elevation production face that has a lower risk of flooding. In contrast, an unpredicted very high-intensity rainfall event over a short duration may cause flooding of the pit, resulting in operational interruptions, or in a worst case, flood damage to loading equipment and potentially large economic losses.

Within this context, the company is working to continually improve its understanding of hydrological conditions, particularly extreme weather events, which are dominantly influenced by climatic conditions. The shorter-duration, extreme events are the most critical for informing engineering design and risk assessment.

With this need in mind, specific investments in tools, knowledge and collaboration were identified, as follows:

1. A more extensive network of regional weather and hydrology stations that operate long-term are key to a more complete understanding of regional spatial and temporal variability and to detecting shifting climate and weather patterns. Such stations would be of great value to multiple users undertaking adaptation planning, including multiple levels of government, First Nations communities and various industry sectors operating or planning to operate in the region. Governments must take a leadership role in managing these stations in order to obtain critical long-term datasets.
2. More region-specific climate and weather data are needed to provide a robust baseline upon which to undertake project-specific analyses. For example, a "climate atlas" for northern BC would be a useful resource, particularly if the information provided is reasonably current and also reflects variability and trends.
3. To take full advantage of a robust set of climate and weather data, more practical and accessible predictive tools are needed to generate future climate scenarios. These tools need to be designed and configured for practical application at a site-specific scale.
4. Enhanced collaboration among industry, consultants and researchers is important to sharing knowledge, conducting research that leads to practical tools, and harmonizing research and development led by industry with that led by academic institutions. Fostering further industry-academia communication would be constructive in identifying such opportunities (e.g., involving more graduate research in priority areas identified by industry). Researchers in the field of climate science have a key role to play in assisting the sector move from reliance on synthetic datasets and "what-if" scenarios at a broad scale to more accurate downscaled tools to better assess climate- and weather-related risk.
5. More accurate and locally relevant short-term weather forecasts would help with operational adjustments and other activities such as transportation planning.

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