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GEOLOGICAL SURVEY OF CANADA
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Datasets to Support Infrastructure Cost Modelling

Introduction

The economic viability of a mining project is highly dependent on its access to infrastructure (Suárez Nieto et al., 2024). Road and power transmission line construction represent two important examples of capital expenditures (CAPEX) related to infrastructure (eg. Haynes et al., 2020; Walsh et al., 2020). Mining projects closer to the existing road network and with good access to the energy grid are generally associated with lower CAPEX (Walsh et al., 2020) whereas remote parts of northern Canada with limited access to infrastructure are generally associated with higher CAPEX (PDAC, 2016). Based on simple input-output economic modelling, mining projects located in remote areas with high CAPEX would likely require higher grade or large tonnages to be economically viable relative to mining projects located closer to existing infrastructure (PDAC, 2016; Walsh et al. 2020). As a result, infrastructure CAPEX is an important component of both pre-feasibility and feasibility studies that evaluate a mining project's potential return on investment (PDAC, 2015, 2016). Moreover, proximity to infrastructure can be combined with mineral potential modelling during the exploration stage to identify potential economically viable mineral deposits with low CAPEX and high geological favorability if road and transmission line costs can be estimated a priori (Walsh et al. 2020). Herein, we provide estimates for the cost per km of building road and transmission lines based on public infrastructure project data. We then transform cost estimates to maps showing the expected infrastructure CAPEX across Canada based on proximity to existing infrastructure following (1).

$$project\ cost\ (CAD) = euclidean\ distance\ (km)\ x\ cost\ estimate\ (CAD)/km \quad (1)$$

Although the cost estimates are subject to large uncertainties due to the scale and scope of individual infrastructure projects, the CAPEX maps can help guide mineral exploration to low-cost areas or can be used by governments to plan infrastructure that reduces barriers to new mineral development.

Roads

The ability to transport a subset of commodities like diamond and gold by air from mine sites is an important factor in the economic viability of mining in northern Canada despite the region's remoteness and limited infrastructure. However, most other commodities require road, rail, and/or port access for transporting materials. Building roads require CAPEX and the cost of construction roughly scales to the distance between the mining project and the existing road network (Walsh et al. 2020). Other factors that impact the cost of road construction include the type of road (e.g., one lane, two lane), material (e.g., gravel, pavement), terrain, rock excavation, property acquisition, water management, forest management, engineering, design, safety features, and signage, which underlay the cost variations observed across geographic regions (Appendix 1). To provide rough estimates for road construction costs, we compiled data from 86 infrastructure projects included within the Canada Infrastructure Bank. At the time of writing, these data are available through the Housing and Infrastructure Project map (https://housing-infrastructure.canada.ca/gmap-gcarte/index-eng.html). Additional road construction cost estimates were acquired from public data available through the British Columbia Ministry of Transportation and Infrastructure, and the Ontario Ministry of Transportation, along with personal communications with other transportation ministries (Appendix 1). All cost estimates included within the source datasets were then inflation-adjusted to 2024 using inflation rates provided by the International Monetary Fund (IMF, 2025) and divided into five regions: (1) Atlantic (i.e., Newfoundland and Labrador, Nova Scotia, Prince Edward Island, and New Brunswick), (2) East (i.e., Quebec, Ontario); (3) Central (i.e., Manitoba, Saskatchewan, and Alberta); (4) West (i.e., British Columbia); and (5) North

(i.e., Nunavut, Northwest Territories, and Yukon). Dividing the data into regions was required because the terrain has a strong impact on road construction costs (e.g., permafrost, mountains), although with more data it may be possible to better account for these systematic differences in costs across Canada. Road construction cost estimates based on the first and third quartile for each region are presented in Table 1. Although these high- and low-cost estimates include a range of road infrastructure projects, they generally do not include bridge construction, winter road construction, or the potential for environmental issues. Furthermore, mine roads that can support trucks with large payloads have different requirements compared to most other types of road construction included in the Canada Infrastructure Bank data. As a result, the high- and low-cost estimates for road construction are subject to large uncertainties. The high-cost estimate for each region was then combined with the CanVec roads data (NRCan, 2024) to generate a CAPEX map across Canada with a 2 km resolution (Fig. 1). This simple CAPEX map provides an indication of expected road building costs based on the Euclidean distance from each pixel to existing infrastructure but does not consider that the true length of roads to a mining project will likely vary to avoid natural obstacles (e.g., fresh water) or other considerations (e.g., protected areas; ECCC, 2024). Calculations for road costs in the Canadian Arctic Archipelago, which included distance to roads connected to ports, are associated with high uncertainties due to a lack of data for most of Nunavut, Northwest Territories, and the Yukon.

Table 1: Road cost estimates

Group	Low-cost per km (CAD; 2024)	High cost per km (CAD; 2024)
Atlantic	$ 551,700.40	$ 1,445,282.00
East	$ 500,295.40	$ 5,033,767.82
Central	$ 424,285.55	$ 1,391,306.12
West	$ 1,985,848.92	$ 6,756,602.05
North	$ 955,067.99	$ 3,875,000.00

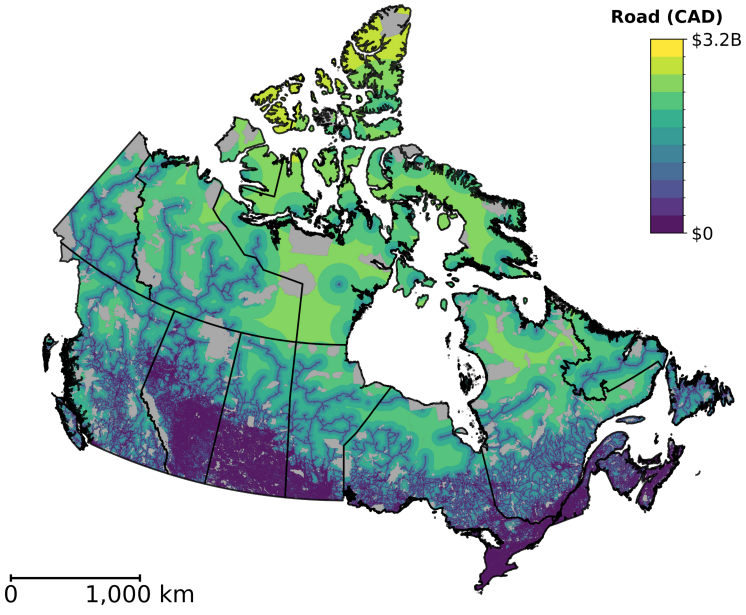

Figure 1: Road CAPEX map based on high-cost estimate and proximity to CanVec data (NRCan, 2024). Protected areas are shown in grey (ECCC, 2024).

Transmission Lines

All stages of mineral development require access to energy. Diesel generators are a key source of energy for remote mineral exploration field camps, however, access to the energy grid is preferred given its potential for lower cost (Igogo et al., 2021). The construction of transmission lines is a major component of mining CAPEX, and the cost of construction roughly scales to the distance between the mining project and the closest access point to the energy grid (Walsh et al. 2020). The cost of building transmission lines also depends on the material (e.g., wood, steel), voltage (e.g., 25 Kv, 120 Kv), construction season (e.g., summer, winter) and the nature of the terrain (e.g., flat, rugged, wet). For example, data for three projects in the Yukon and Alberta indicate a wood-framed 25 Kv transmission line built on flat ground in the summer would cost approximately $0.66M CAD per kilometer as of 2024; whereas a steel-framed 120 Kv transmission line constructed in rugged terrain would cost approximately $3.2M CAD per kilometer as of 2024. Other factors that could impact cost estimates include environmental mitigation, the number of water crossings, and connection to the energy source and termination point; however these were excluded from the model. As a result, the high- and low-cost ranges for transmission line construction are subject to large uncertainties. The high-cost estimate was then combined with the CanVec transmission line data (NRCan, 2024) to generate a simple CAPEX map across Canada with a 2 km resolution (Fig. 2). This simple CAPEX map provides an indication of expected transmission line construction costs based on the Euclidean distance from each pixel to existing infrastructure but does not consider that the true length of transmission lines for a mining project will likely vary to avoid natural obstacles or other considerations (e.g., protected area; ECCC, 2024).

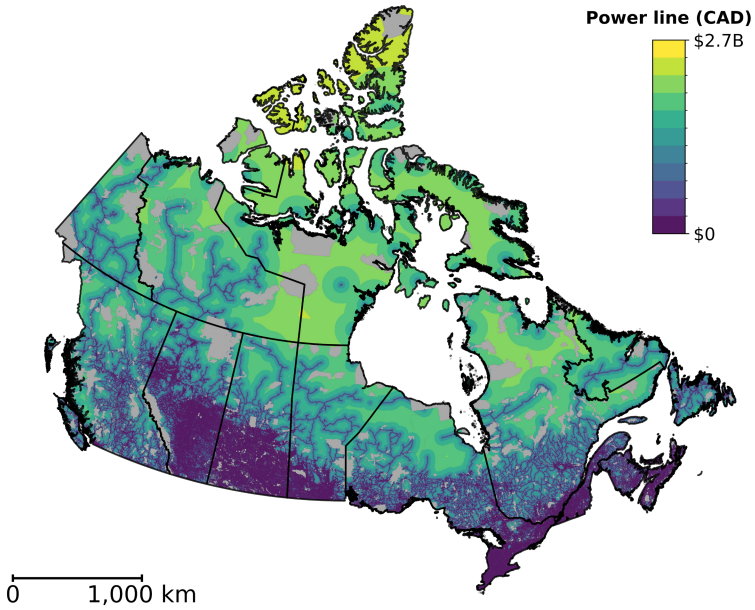

Figure 2: Transmission line CAPEX map based on high-cost estimate and proximity to CanVec data (NRCan, 2024). Protected areas are shown in grey (CPAD, 2024).

Conclusions

Transport ministries and national initiatives such as the Canada Infrastructure Bank provide public data to estimate the cost of building new roads and transmission lines. Here, we combine data for individual projects to estimate infrastructure costs across Canada and generate CAPEX maps based on the proximity to existing infrastructure. The data and maps can be combined with mineral potential models to identify geologically favorable areas with low CAPEX in the search for economically viable mineral deposits, or to help unlock mineral potential through infrastructure development.

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