Appendix 11-D

Calcification Assessment

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Technical Memo

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To	Mike Allen, NWP Coal
From	Stephen Day
Cc	
Subject	Calcification Assessment – Crown Mountain Project
Client	NWP Coal
Project	1CN028.003

1 Introduction

The Crown Mountain Project will involve construction of a valley-fill waste rock dump in West Alexander Creek. Experience at the nearby Teck Coal mining operations shows that creeks downstream of conventional waste rock dumps constructed from the same waste rock material as Crown Mountain have calcite ($CaCO_3$) concretions. These deposits are the result of contact waters emerging from the waste rock which are over-pressurized with carbon dioxide and contain dissolved calcium and bicarbonate (MacGregor et al 2012). This water chemistry results from the neutralization of acid produced by oxidation of iron sulphide by reaction with dolomite ($CaMg(CO_3)_2$). Calcite is precipitated when dissolved CO_2 ($H_2CO_3^0$) off-gases which causes the pH to rise:

$$Ca^{2+} + HCO_3^- \rightarrow H^+ + CaCO_3$$

The Crown Mountain waste rock dump has been designed to mitigate selenium and nitrate leaching by the incorporation of layers of compacted plant reject. This mitigation will reduce oxygen access to the waste rock which will turn limit the processes which cause calcite deposits to form.

This memorandum describes an assessment of the potential for calcite precipitates to form in the Alexander Creek drainage area.

2 Assessment Method

The potential for calcite to precipitate considers the mixing of natural waters with contact waters from the waste rock dump. The combined chemistry determines whether calcite will form based on the calcite saturation index ($SI_{calcite}$):

$$SI_{calcite}=\log_{10}\left(\frac{IAP}{k_{sp}}\right)$$

IAP is the ion activity product which is determined by the chemistry of the mixed water, and k_{sp} is the solubility product for the formation of calcite which is determined by thermodynamics. Theoretically, if $SI_{calcite}>0$, calcite can be precipitated (i.e. is over-saturated); however, in practice, calcite will not precipitate until $SI_{calcite}$ is well above 0 because there are kinetic barriers to the formation of calcite. For this reason, unimpacted waters in the Elk Valley often have $SI_{calcite}>0$ but calcite deposits are not observed. It is only when $SI_{calcite}$ is well above 0 that calcite will precipitate. A commonly observed threshold is 0.5.

For the mixing calculation, $SI_{calcite}$ for the current conditions in Alexander Creek were calculated using PHREEQCi (Parkhurst and Appelo 2013). Water chemistry was then selected for mixing with an estimate of contact water chemistry for waste rock indicate for similar full-scale spoils by MacGregor et al. (2012). This input does not consider the effect of the layered waste rock system and possibly reducing dissolved carbon dioxide concentrations. As there are no existing analogs for the layered system, this was assessed qualitatively.

3 Results

3.1 Baseline Conditions

Figure 1 shows $SI_{calcite}$ for West Alexander Creek at monitoring location WA-1 for four years (2012-2015). $SI_{calcite}$ is normally above 0 indicating theoretical over-saturation with calcite, but peak $SI_{calcite}$s are only slightly above 0.5 typically later in the year. Based on this observation, natural calcite deposits are not likely to be present. Seasonally, $SI_{calcite}$ drops below 0 briefly during freshet when snowmelt dilutes baseflow. If calcite deposits were present they would theoretically dissolve during the high flow conditions.

3.2 Effect of Addition of Contact Water

The modelled effect of mixing of contact and non-contact water is shown in Figure 2. $SI_{calcite}$ is shown as a function the proportion of contact water for two flow conditions representing the seasonality shown in Figure 1. The proportion of non-contact water will increase downstream so that Figure 2 indicates the decrease in potential for calcite to precipitate with distance downstream. Also, as the size of the facility increases, the proportion of non-contact water will decrease and the potential for calcite precipitation increases.

The modelling indicates that under low flow conditions calcite precipitation is predicted at WA-1 because $SI_{calcite}$ will normally exceed 0.5. Under high flow conditions, $SI_{calcite}>0.5$ when the proportion of contact water is less than 80%.

Figure 1: Calcite Saturation Indices for West Alexander Creek at WA-1

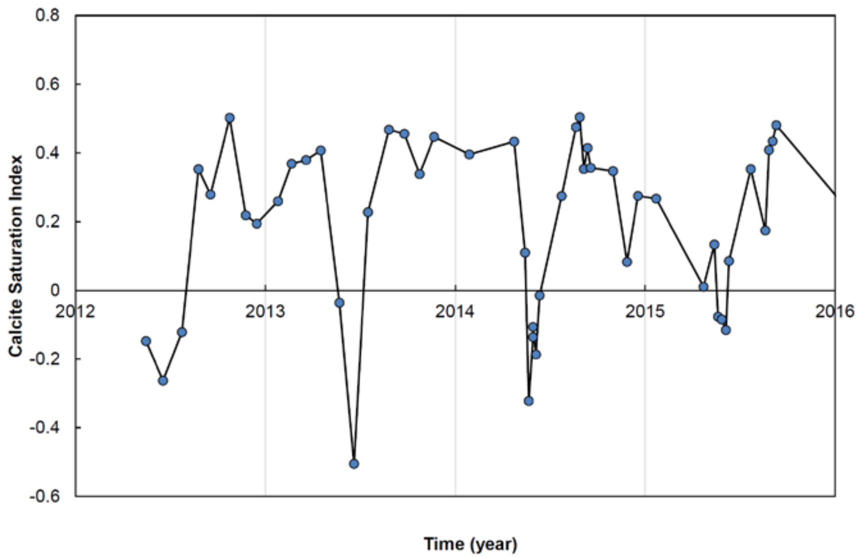
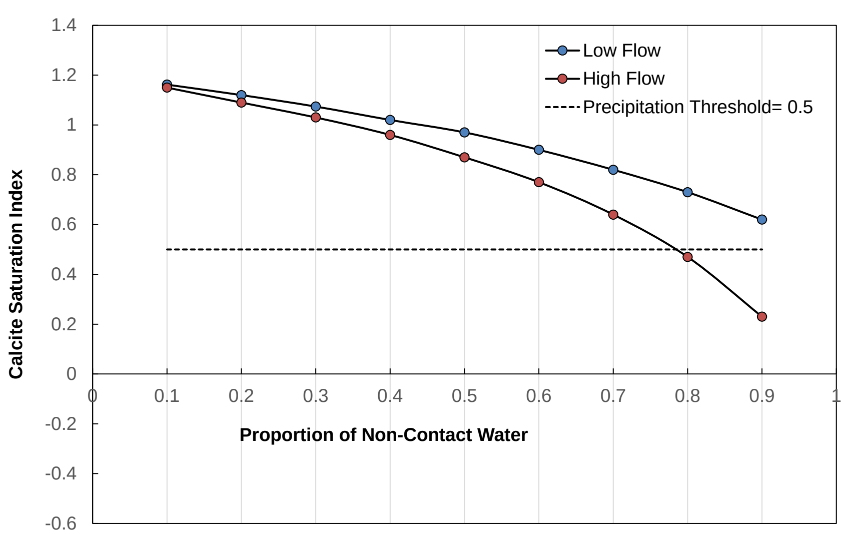


Figure 2: Modelled Calcite Saturation Index for Mixing of Contact and Non-Contact Waters



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The proportion of the West Alexander Creek catchment covered by waste rock will be less than 10% in the first four years of mining. Localized calcite precipitation might be expected near the waste rock dump. As the waste rock dump grows to be 31% of the catchment, the modelling predicts that calcite deposits will progress downstream and eventually reach WA-1. The method does not specifically predict where calcite will precipitate but experience indicates precipitation can be expected to decrease with distance from the source as calcite is removed from the water column nearer the source.

It is unclear if calcite precipitation would continue into Alexander Creek. Dilution immediately downstream of the confluence is not sufficient to decrease $SI_{calcite}$ below 0.5 but the proportion of contact flows at the mouth of Alexander Creek at the full footprint at 3% indicates calcite precipitates would not likely extend to the mouth.

3.3 Effect of the Layered Waste Rock System

The layered waste rock system should result in lower overall acid neutralization reaction products due to reduced oxygen entry. This is shown by a predicted reduction in sulphate concentrations of about 75%. However, the layered system relies on the oxidation of organic carbon in the reject layers to sustain the removal of oxygen which will contribute carbon dioxide and increase dissolution of dolomite. Qualitatively, the overall effect is expected to be a decrease in calcite precipitation potential which could delay the appearance of precipitates and possibly reduce the extent of precipitation in West Alexander Creek.

4 Conclusions

This modelling assessment of the potential for calcite precipitation indicates that:

- If the layering system does not reduce oxygen entry, calcite deposits can be expected to form in West Alexander Creek to its confluence with Alexander Creek. The deposits might extend into Alexander Creek but not to the mouth.
- Calcite deposits are expected to increase in extent in West Alexander Creek as the mine footprint increases.
- The waste rock layering system is expected to reduce but not eliminate the potential for calcite precipitation.

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References

MacGregor, D., Day, S and Lopez, G. 2012. Investigations of Calcite Deposits in Streams Downstream of Coal Waste Rock Dumps, British Columbia and Alberta, Canada. Proceedings of the 9th International Conference on Acid Rock Drainage. Ottawa, ON, May 2012.

Parkhurst, D.L. and Appelo, C.A.J., 2013. Description of input and examples for PHREEQC version 3: a computer program for speciation, batch-reaction, one-dimensional transport, and inverse geochemical calculations (No. 6-A43). US Geological Survey.