nhc
memorandum

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To:	**John Brodie, FMCPO**	Date:	November 17, 2006
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Re: DRAFT MEMO: FARO Mine
RCDC Breach Over Intermediate Impoundment

October 26, 2006, northwest hydraulic consultants (**nhc**) was requested to incorporate analysis of flow across the Intermediate Impoundment in its ongoing study of Rose Creek conveyance strategies. Flow may be directed across the Intermediate Impoundment through a designed discharge structure or through an unexpected breach of the Rose Creek Diversion Channel (RCDC). This memo has been prepared to summarize preliminary analysis of flow distribution and tailings erosion during such an event.

Background

The Faro Mine Closure Planning Office (FMCPO) is currently working to develop a closure plan for the Faro Mine site. **nhc** was retained to provide hydrotechnical expertise and preliminary engineering in the development of conveyance strategies capable of safely passing the Probable Maximum Flood (PMF) past the tailings impoundments within the historic Rose Creek Valley. A number of conveyance scenarios are being developed to coincide with potential tailings removal scenarios. Initial conveyance strategies incorporated a portion of Rose Creek flood flow over the existing tailings (**nhc**, 2004)[1]. The present hydrotechnical analysis was initially directed to avoid scenarios that incorporated flow over the tailings in order to avoid risk of tailing suspension and subsequent downstream conveyance of tailings materials. However, recent technical review initiated further investigation into the potential consequences and mitigation of flow over the tailings impounded by the Intermediate Dam.

Flow across the Intermediate Impoundment is more likely than flow over the upstream impoundments as it is has a relatively low elevation in comparison to the RCDC. Whereas, the upstream impoundments are higher than the RCDC, and the RCDC is adequately sized to pass the PMF upstream of the Intermediate Impoundment.

[1] **nhc**, June 2004. *Hydrotechnical study for closure planning, Faro Mine Site area, Yukon.* Final report. Prepared for SRK Consulting Inc. File 1-6399.

Hydrology and Routing

The Intermediate Impoundment has the potential to be supplied flow from the north wall of the valley and the North Fork and South Fork of Rose Creek. A previous PMF study[2] suggests that the watershed area of the North Fork Rose Creek is 122.5 km^2, the watershed area of the South Fork Rose Creek is 83.5 km^2, and the combined PMF instantaneous peak flow is 674 m^3/s. The watershed area of the north wall upstream of the Intermediate Dam is roughly 4.9 km^2, 2.3% of Rose Creek. To simplify the preliminary hydrologic analysis, peak flow from the north wall was assumed to arrive at the same time as peak flow from the Rose Creek (i.e. equal lag times) and the PMF flow follows the same hydrograph as Rose Creek with an amplitude 2.3% that of Rose Creek.

It was proposed that the Intermediate Dam crest be raised by 5 m to a maximum level of 1054.0 m El. in order to provide attenuation of flood flows and allow re-entry of flow from the impoundment to the RCDC. Current crest elevation of the dam is 1049.0 m, and the RCDC at the Intermediate Dam has an invert elevation of 1048.9 m and a right bank (north) crest elevation of 1053.9 m. The existing configuration of the RCDC provides conveyance of the 500-yr instantaneous flood event. Additional flow or channel blockages within the RCDC would result in overtopping flow into the Intermediate Impoundment.

Using existing 1-D hydraulic models of the RCDC and the Intermediate Dam spillway, rating curves were generated for each conveyance structure. The Intermediate Dam north spillway was raised by 1 m and its rating curve appropriately adjusted. Raising the spillway crest was done through an iterative trial and error process to provide increased flood attenuation while maintaining approximately 1 m of freeboard below the proposed Intermediate Dam crest. Using the rating curves and assuming Intermediate Impoundment areas of 547,000 m^2 at 1048 m El. and 1,122,800 m^2 at 1054 m El., a routing model was developed. The PMF hydrograph provided from the previous PMF study[2] was used as the model input.

Preliminary model results are presented in the following figure. The Intermediate Impoundment attenuated the combined PMF inflow (north wall and Rose Creek) by reducing the combined peak outflow (RCDC and Intermediate Dam spillway) from 705 m^3/s to 640 m^3/s. Combined inflows into the impoundment are as high as 575 m^3/s and flow through the Intermediate Dam spillway as high as 470 m^3/s.

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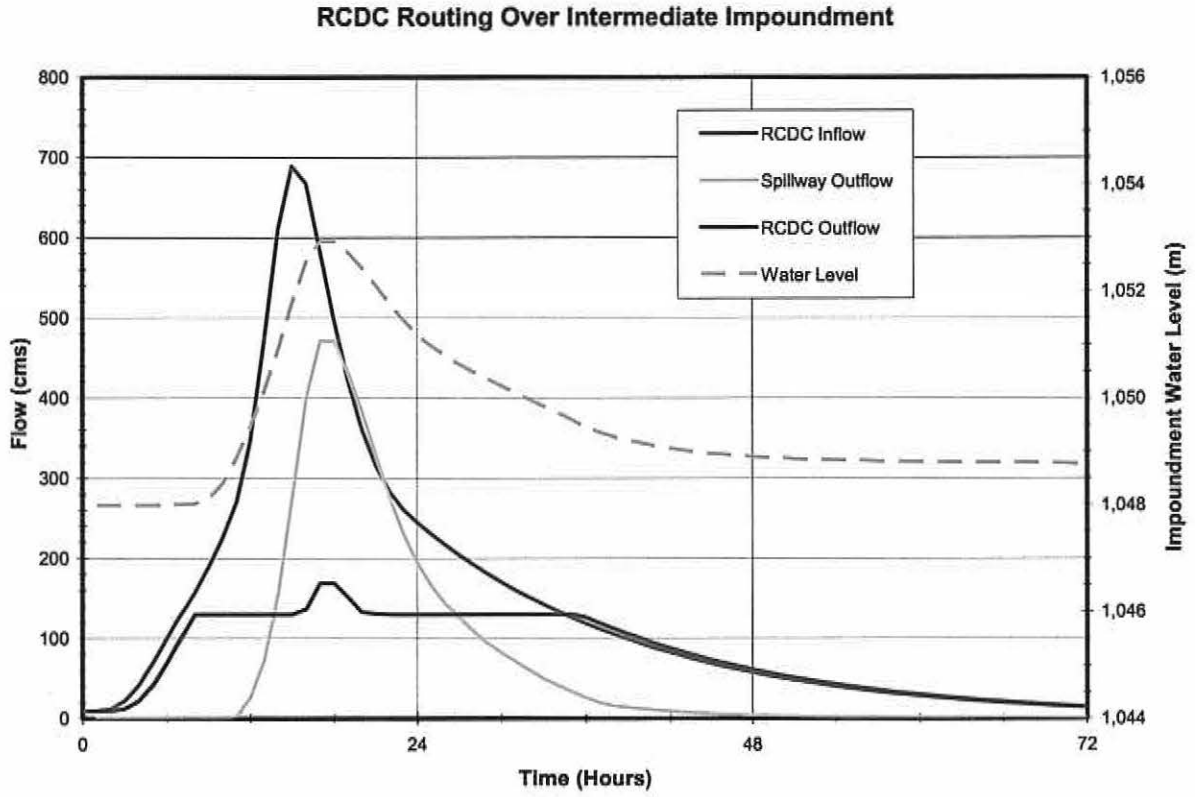
[2] Watershed Management Consultants. 2006. *Faro Mine, Rose Creek Probable Maximum Flood.* Draft Report. Prepared for the Faro Mine Closure Project Office.



Erosion

Depending on the inflow route from the RCDC to the Intermediate Impoundment (i.e. through designed RCDC overtopping, designed fuse-plug, or unplanned dike breach) a wide range of flow velocities could be experienced. This being said, as flow progresses across the tailings it is likely a preferential channel will evolve and maintain velocities in the order of 1 m/s. Relationships between flow patterns, velocities, and sediment entrainment are complex and are roughly estimated at this level of analysis. As well as inflow conditions, potential surfacing and existing surface gradation strongly influence erosion potential.

Under current conditions it is not unlikely to experience outgoing suspended sediment load as high as 5 g/L. Assuming the majority of this load is derived from the tailings pond; an average Intermediate Impoundment outflow of 70 m^3/s over the 72 hour period during and following a PMF event, could result in approximately 90,000 tonnes of tailings being washed downstream. This equates to roughly 40,000 m^3 or less than 10 cm average depth of erosion across the entire tailings impoundment.

Any suspended tailings are likely to remain in suspension until the flood recedes and flow is ponded. Surfacing the tailings with a filter and erosion resistant material such as 100 mm minus rock spalls, could limit erosion of the tailings. An inlet apron would require increased armouring to prevent erosion at the spillover or breach location.

Summary

A brief analysis was conducted into the hydrotechnical consequences of flow being directed over the tailings impounded upstream of the Intermediate Dam. Extreme flood flows maybe directed into the impoundment though a breach in the RCDC or through pre-designed fuse-plug or overtopping dyke structures. The size of the Intermediate Impoundment is capable of providing in the order of 10% attenuation of peak PMF flows.

Flow over the existing tailings layout could result in suspension and transport of magnitude of 90,000 tonnes of tailings. Suspended tailings would be carried downstream and gradually deposited after the flood receded.

Hydrotechnically it is feasible to develop a PMF conveyance strategy incorporating flow over the Intermediate Impoundment tailings. However, further study is required to proceed with such a design scenario. Recommended additional study and design would include:

- development of design concepts for a fuse-plug or overtopping sections of the RCDC,
- assessment of need and subsequent design of a potential re-entry structure allowing flow from the impoundment back into the RCDC,
- assessment of improvements required along the existing RCDC,
- numerical flow modelling across the impoundment,
- assess armouring requirements for the tailings,
- dam height optimization, and
- design improvements to increase the conveyance and stability of the Intermediate Dam spillway.

The numbers presented in this report are preliminary estimates.

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