nhc
memorandum

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To:	**John Brodie, FMCPO**	Date:	March 20th, 2006
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Re: RCDC Detail Design Issues

This memo has been prepared to summarize and present the additional study we suspect to be required through progression from conceptual to final design of the Rose Creek Diversion Channel (RCDC) at Faro Dam. The following list of items is likely to be revised as the design progresses. The intent is to develop a tracking and solution list to ensure all relevant design issues encountered in the process are addressed and / or resolved.

Hydraulic Design

Depending on tailings removal scenarios the hydraulic investigations of the RCDC upgrade can be broken into four components: the inlet, the PMF channel, the channel side spillway, and the downstream portion of the RCDC and fishway – if required. Following is a summary of further investigations required for each of these components:

Inlet

The inlet zone extends from the entrance of the RCDC upstream in both the South and North forks of Rose Creeks as required to address hydraulic, geotechnical, fisheries and channel process issues. Issues are:

1. *Inlet Hydraulics:*
   Potential design issues result from the concentration of flow and through the constriction and head increases upstream of the RCDC entrance. Current 1D HEC RAS modelling does not provide sufficient resolution of potential hydraulic effects. We propose to conduct unsteady 2D numerical modelling to determine local depths, velocities and hydraulics at the inlet area resulting from flows combining from North and South forks of Rose Creek.

2. *Stability Analysis*:
   Using local velocities and depths extensive erosion and scour analysis will be conducted to design a stable rock size in order to fulfill armour requirements along the primary tailings impoundments as well as local improvements to provide freeboard.

3. *Channel Erosion and Sediment Deposition:*
   Erosion and channel process in the stream reaches upstream of the RCDC inlet could result in yet un-assessed quantities of coarse and fine sediments transported into the inlet are and RCDC itself. Using both the 2D and 1D models and review of the tributary conditions, we would determine potential quantities of sediment, their potential effects and subsequent mitigation to ensure hydraulic conveyance during the PMF.

RCDC PMF Channel

1. *1D Numerical Modelling:*
   The 1D numerical model will be updated to reflect design modifications throughout the design progression. This would include hydraulic structures and channel section modifications required to ensure conveyance with correct freeboard requirements. Model scenarios will be run to account for a variety of "worst case" conditions that would influence hydraulic performance. These include: sediment aggradation, side slope failures and slumps, ice blockages, and dynamic conditions associated with sudden slope failures and wave run-up. Results from these scenarios will provide additional insight into maximum possible water depth and local velocities within the channel. They will also determine freeboard and overtopping risks along the channel.

2. *Channel Sediment Transport Analysis:*
   Sediment transport rates will be calculated for various flood flows at and below the PMF in order to estimate the potential sediment deposition from upstream sources and rate of re-erosion of deposited or slumped material during flood conditions. Stability analysis will also be conducted to determine if the existing armour layer of riprap is appropriate or if larger material is required.

3. *Stability Analysis:*
   Using a physical model, the stability of the RCDC design section and proposed countermeasures can be modeled. Potential scour, erosion, and breach scenarios can be modeled and effectiveness of the reinforced concrete channel invert control sections can be examined under PMF conditions.

Channel Side Spillway

The side channel spillway is currently proposed for the partial tailings removal scenario. It is intended that the side spillway will be designed to convey roughly 90% of the PMF with the remaining flow or volumes from higher frequency floods conveyed by the existing downstream portion of the RCDC. These more frequent floods could be potentially less than estimated 100-year flood or as required to ensure stability of the remaining RCDC.

1. *Hydraulic Design and Numerical Analysis:*
   Hydraulic detailed design is required to determine flow depths and expected hydraulic conditions. Numerical methods will be used to further develop the spillway design, with key parameters including width, slope, inlet sill elevation and section properties as well as flow transition areas.

2. *Stability Analysis:*
   Iteratively with finalizing the spillway design, stability analysis will be conducted to estimate required size of armouring rock. Experience from similar projects including detailed physical modelling conducted by **nhc** will be used in conjunction with standard numerical methods.

3. *Physical Modelling:*
   After the spillway design has been "finalized", a scaled physical model testing is recommended. The physical model will accurately represent the hydraulic performance of the spillway control section, the ramp section and the downstream flow control section. Scaled riprap used to construct the spillway will be used to ensure the stability of the structure. Physical modelling provides an opportunity to examine anomalous and temporary local hydraulics and potential concentrations of flows which otherwise can not be accurately predicted by any other means. Previous physically modeling on other projects has identified these features which could have initiated the loss of armouring riprap.

RCDC Steep Section/Fishway

The downstream portion of the RCDC will be upgraded to safely convey the PMF in the design scenario that stabilizes tailings in place, whereas the downstream portion of the RCDC has to be examined and reconstructed as necessary to convey flows less than some predefined event 5% to 20% of the PMF, currently set at the 100-year event - approximately 12% of the PMF.

1. *1D Numerical Model:*
   The 1D numerical model will be updated to reflect design modifications throughout the design progression. Model scenarios will be run to account for channel aggradation, mass wasting and slumps, and ice blockage. Results from these scenarios will provide additional insight into maximum possible water depth and local velocities within the channel, as well as freeboard and channel section requirements.

2. *Stability Analysis:*
   Sediment transport rates will be calculated for various flood flows at and below the PMF in order to estimate the rate of erosion of deposited or slumped material. Stability analysis will be conducted to determine if the existing armour layer of riprap is appropriate or if larger material is required. Special consideration will be given to the stream complexity elements incorporated within the channel providing improved fish passage. During higher flows these elements are likely to be altered or lost all together. Loss of the channel complex fish passage structures may be advantages as it will reduce stress on adjacent channel armouring.

3. *Fish Passage:*
   If substantial changes are required in either the existing section or in a new proposed channel to provide fish passage, both numerical and physical modelling can be undertaken to provide hydraulic designs that provide similar hydraulic properties to the existing channel – that is know to pass fish, or to ecohydraulic criteria derived fro the

channel or other references. Physical modelling at a sufficient scale would provide an opportunity to define a channel section design and roughness element placements to maximize passage opportunities over a wide range of flow conditions.

Structural

There are several large structural elements proposed in the two concept scenarios. Large reinforced concrete control structures provide primary hydraulic and stability at key areas in the RCDC upgrade design. Constructed of reinforced concrete and protected with a layer of rock, these are massive features designed as failsafe control in the unlikely event of any downstream failure. The channel and spillway are to be designed to be geotechnical and hydraulically stable without these structures, and the structures are to be designed to be stable without the surrounding rock.

Notional sizing has been provided in the conceptual design, but final sizing will be determined by detailed structural analyses and physical model testing. Complete stress, shear and bearing analysis will be conducted on these structures to account for hydraulic forces, earth pressures, dynamic forces, rock bearing capacity and potential rock scour and erosion. Shape and size of these structures will be modified to meet all structural geotechnical, hydraulic and seismic requirements.

Geotechnical

Geotechnical investigations and design are required throughout the channel upgrade both prior to construction and during construction. Geotechnical input will be required for hydrotechnical and structural elements of the final design.

Preconstruction

Bedrock will be further located at the location of the proposed concrete structures and side channel spillway. This information will be required to optimize the design of these structures and reduce the field engineering requirements during the construction phase.

Bearing strength, material composition, potential for liquefaction and settlement, will be investigated for all fill-supporting ground.

During Construction

Bedrock soundness must be inspected during construction with cutoff trenches installed where bedrock has fissures and cracks allowing extensive seepage.

Bedrock slopes should be inspected to determine where slope stabilization techniques need to be applied; such as, slope flattening, scaling, rock bolts, and/or shotcrete.

Pockets of ice rich soil or overlying ice rich colluvial exposed during construction will have to cut back and covered or removed to control sloughing. Thermal liners will be added as deemed necessary during construction.

Summary

The presented list of detail design issues are presented to ensure concerns of all parties are identified and a pathway to address the issues is incorporated in the plan of work. This list is likely to be supplemented as the design progresses and further issues are discovered. We welcome any comments and suggestions at any time in the design process.

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Please contact us if you have any questions or comments regarding the outlined design criteria.

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