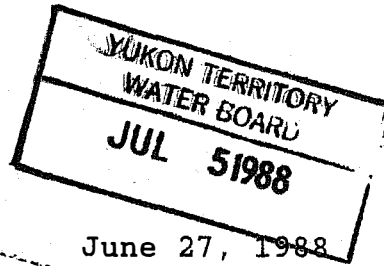


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Ms Dianne Granger  
Chairman, Yukon Water Board  
302 - 4114 Fourth Avenue  
Whitehorse, Yukon  
Y1A 4N7

Re: Geotechnical and Hydrological Inspection  
Curragh Resources

Dear Ms Granger:

I inspected the Curragh Resources mine project near Faro, Yukon on June 2, 1988 with Ken Nordin of the Water Board.

The mine which is primarily extracting lead and zinc is operating somewhat in excess of design capacity. Geotechnical and hydrological considerations involve tailings dams, a fresh water dam, waste piles, creek diversion channels and seepage interception channels. All of these were inspected. Comments and recommendations are as follows. Typical site photographs are appended.

North West Interception Trench

This trench (photo 1) extends from beyond the mill along the N.W. side of the project to intercept seepage and surface water. Portions of this trench have scour protection where the slope is steeper. Scour has occurred along some portions of this channel.

It is important that a maintenance program be carried out each year to ensure the required channel section and scour protection is adequate to carry the design flood flow.

Intermediate Dam

The intermediate dam was constructed to standard engineering specifications. A spillway allowing flow into the sedimentation pond above the Cross Valley dam, lined with rip rap is operating efficiently (photo 3).

Cracks were observed on the crest of the dam. These are generally parallel to the centerline and more common in the south half of the dam. Golder Associates have postulated that frost heave in the dam is the cause of these and that there is no danger to stability of dam.

I agree that these pose no serious stability problems at this time. However, if the cracks remain open at depth and the dam elevation is raised they could influence stability later.

I consider it necessary to determine the cause of the failure so it can be remedied before any further construction is performed. The cracks could also, for example, be caused by permafrost thawing in the foundation and the dam spreading as a result. Thermistors and lateral and vertical movement monitors should be installed.

#### Cross Valley Dam

This dam was constructed to standard engineering specifications. A siphon is used to carry overflow from the pond (photo 4). An emergency spillway with coarse rock in the channel has been developed. Heavy seepage was observed issuing from several locations near the toe of the dam (photo 5 and 6). The volumes are greater than desirable. Steffin Robertson and Kirsten have referred to some evidence of piping (water carrying fines with the seepage indicating cavities are developing). I saw no evidence of this. However, I consider the seepage is excessive and recommend Curragh be instructed to develop a toe drain pipe within a sandy gravel toe berm designed to filter requirements.

With the exception of the excess seepage the dam is functioning satisfactorily. All instrumentation data should be included in the annual report.

#### Rose Creek Diversion

The lower portion of Rose Creek is scouring and has developed a meander pattern (photo 8). It is recommended that scour protection along the north creek bank be extended for about 400 feet.

The steep portion of the channel has been developed with side channel rip rap and velocity checks (photo 7). This channel is working well under normal flow conditions. Some of the rip rap in the velocity checks has moved. During low water the rip rap should be replaced.

Slope erosion on the south channel slope has occurred at several locations (photo 9 and 14). These should be filled with erosion resistant material to stop the scour. In photo 14 the channel section has been reduced. Heavier rip rap will be required here.

Two slides are occurring which involve the stability of the diversion dyke (photo 10 and 12). At several locations heavy seepage and piping is occurring from the dyke toward the pond (photo 11 and 13). These conditions are serious and must be rectified. A failure of the dyke could allow Rose Creek to flow into the tailings pond. It is recommended that the slides be stabilized and the piping be controlled this summer. This is considered urgent.

In the event of very high flood flow there will be some scour develop. In order to be prepared for adverse scour it is recommended that about 2000 cu. yds. of rip rap be stockpiled along the dyke for emergency use.

#### Fresh Water Dam

The Fresh water dam is about 50 feet high (photo 16). A toe berm was constructed some years ago to improve stability.

Very high pore water pressures existed recently below the toe berm. I was advised that the water level in a piezometer rose about 6 feet above the toe berm. I also observed seepage from the toe of the dam (photo 18). Severe cracks were observed along the dam (photo 17).

The ground below the toe of the berm was very spongy to walk over, suggesting high pore water pressures and a near 'quick' condition (water pressure equals weight of the soil).

This region of the Yukon is in an earthquake area and dams and dykes must be designed for seismic events.

The condition of the dam and pore water pressures suggest to me the dam may not meet adequate stability standards. Accordingly I recommend a stability evaluation by a specialist geotechnical engineer, including installation of piezometers, thermistors, slope indicators, lateral movement gages etc. be made this summer. If the stability is low I recommend the necessary stabilization this fall. In addition the condition of the pipe under the dam should be inspected to determine if it is intact.

#### Acid Generation Test Program

The Acid Generation Test Program is underway as part of the 4 year program. Photo 19 shows the test site.

An interim report on the progress of the test program is required.

#### North Fork Diversion

A temporary diversion of the North Fork Creek around the pit is necessary until the pit and possible underground mine is depleted. At that time it is proposed to divert the creek into the open pit.

Considerable seepage from the creek into the pit has resulted in slope stability problems. Attempts to reduce this seepage using a plastic liner has been partially successful (photo 20). It is noted that this is a temporary procedure.

#### Runoff and Seepage Control

Some runoff and seepage is presently being drained into Pit 2 (photo 21). The water quality should be monitored to determine if any special precautions are required.

The northern most spoil pile (photo 22) is confining water which is high in zinc content. The option of placing a low permeability clay till on the upstream slope to reduce seepage flow and fill the valley with waste rock is recommended for consideration.

#### Vangorda Road Rock Drain

The new road being constructed to the Vangorda deposit crosses the North Fork Creek. Instead of placing a culvert, very coarse durable rock was placed in the channel which allows the water to flow through.

I am not aware of approval from Water Resources or the Water Board for this type of construction.

This rock drain must be inspected periodically to ensure it is operating efficiently.

I also recommend a water chemistry sampling station be established directly below the fill to monitor water quality.

#### Sulphide Waste Rock

There are zones of sulphide waste rock in the waste piles. These are acid generating.

Curragh should be requested to supply the Water Board with a plan showing the location of the sulphide waste rock and describe the program to control adverse acid generation contamination.

#### Summary of Recommendations

1. The North West interceptor trench requires some upgrading to contain the design flood flow.
2. Determine by monitoring the cause of the cracks in the intermediate dam.
3. Design and install a toe drain and filter berm to control seepage and piping below the Cross Valley dam.

4. Rose Creek channel requires the following upgrading -
  - Install rip rap protection along the north edge of the lower Rose Creek.
  - Replace moved rip rap in the velocity checks in the Steep Channel section.
  - Control slope erosion along the south side of the Creek.
5. Stabilize the slides in the Rose Creek dyke and control seepage and piping along the outside of the dyke.  
Place a stockpile of rip rap long the dyke for emergency use.
6. Evaluate the stability of the Fresh Water Dam with a suitable geotechnical investigation this year and stabilize if necessary.  
Inspect the culvert under the dam to determine if it has stretched apart and is leaking.
7. An interim report on the progress of the Acid Generation Tailings Test program is required.
8. The North Fork diversion should be maintained as water tight as reasonably possible to improve pit slope stability.
9. A water chemistry sampling station should be installed below the Vangorda road rock drain.
10. A plan showing the location of sulphide waste rock and the plan to control adverse acid generation should be requested.

If you have any questions please contact me.

Yours truly,

  
C.O. Brawner, P. Eng.

COB/pm

CURRAGH



Photo 1 - N.W. interception trench. Limited scour has taken place. Some maintenance desirable to upgrade ditch to carry flood flow.



Photo 2 - Longitudinal crack on top of intermediate dam. Golder Associates consider these are due to frost heave. Note the water table is likely well below the surface. It is possible the dam foundation is spreading over thawed permafrost. The installation of movement monitors and thermistors is recommended.



Photo 3 - Overflow rip rap spillway at the south end of the intermediate dam. This spillway is operating efficiently.



Photo 4 - Pipe siphon carrying water from lower pond over spillway location. North end Cross Valley dam.



Photo 5 - Seepage exiting below the north end of the Cross Valley dam. A V notch gauge installed to measure seepage. W2 is a water sampling station for metals and chemical analysis. The volume of seepage is considerable. The water must be monitored closely to evaluate if any piping (loss of soil) is occurring. If it is a collection pipe and granular toe term are recommended.



Photo 6 - Downslope area of Cross Valley dam. Note seepage at left.



Photo 7 - Rose Creek diversion. Rip rapped section with heavier rap rapped velocity checks. This channel is in reasonable condition. Some of the large rip rap has moved. They should be moved back to original position.



Photo 8 - The run out area of the Rose Creek diversion is developing scour and building a delta. This area should be stabilized.



Photo 9 - Cut slope erosion above Rose Creek diversion. If the erosion becomes excessive these channels should be filled with small waste rock.



Photo 10 - Crack across the Rose Creek diversion dyke. This slope has moved toward the tailings pond. The slope should be stabilized. Horizontal drains are a low cost stabilization procedure.



Photo 11 - Seepage through the Rose Creek diversion dyke. Some piping is also occurring. A sandy gravel filter cover and horizontal drains are recommended.



Photo 12 - A second crack with vertical displacement on the Rose Creek diversion dyke. This slide must be stabilized. If a major failure occurred Rose Creek could flow into the tailings pond.



Photo.13 - Seepage and piping through Rose Creek dyke slope. This must be stabilized and controlled. This is occurring at several locations along the slope below the Rose Creek diversion.



Photo 14 - Slope erosion partially filling in Rose Creek diversion. This material should be removed.



Photo 15 - Rose Creek diversion. The road elevation is lower than the dyke. It is recommended the several rip rap piles be positioned along the dyke in case emergency repairs are required quickly.



Photo 16 - Fresh water dam about 50 feet high.



Photo 17 - Crack on top of fresh water dam. The cause must be definitely determined and corrected.



Photo 18 - Seepage at the toe of the berm below the fresh water dam. Several weeks prior to this inspection artesian pressures were monitored in a piezometer on the berm. The soil is spongy. The stability of this dam must be evaluated. It appears to have low stability.



Photo 19 - Test plots in the old tailings pond to evaluate acid generation under various conditions.



Photo 20 - Diversion of N. Fork around the open pit. Plastic lining has been placed to reduce seepage and pumping from the pit. This is a temporary program until the pit is mined out and the water will likely be diverted into and through the pit.



Photo 21 - Seepage ponded in the remainder of pit 2 that has not been completely filled.



Photo 22 - North Fork seepage with excess zinc concentration ponded. I consider the upper waste pile slope can be covered with low permeability clay till and the valley be filled with waste rock.



Photo 23 - North Fork flowing through a rock drain under the road being constructed to the Vangorda property. Properly constructed rock drains will operate effectively for short to moderate term. On abandonment the fill must be excavated and the creek channel redeveloped.