3.28 Doris Primary Vent Raise Pad

General Description
The Doris North Primary Vent Raise is located along the Secondary Road. The west end of the facility was cut into bedrock so that the raise could be collared on sound bedrock. A thermal pad extends east from the rock cut. A higher level or tier adjacent to the raise, houses the vent raise collar building, and the lower tier further east contains a fuel storage tank inside a bunded secondary containment structure. (Photos 3.28-1 to 3.28-3)

Observations
Surface runoff from the top of the bedrock wall surrounding the west and east sides of the vent raise has presented problems with seepage into the raise opening. A sump has been excavated into the bedrock at the base of the wall. It will be connected to a bedrock ditch that will run along the toe of the wall and will intercept run off from of the top of the wall.

There were no signs of standing water on the surface of the pad and no areas of significant settlement. There was no standing water noted along the toe of the pad, and no tension cracks were observed along the crest of the pad.

Recommendations
The rock wall is in close proximity to the vent raise. Previous recommendations with respect to the installation of appropriate barricades and signage should be implemented to keep people and equipment at a safe distance from the wall.

The sump and cut-off trench should be completed to divert surface runoff from the bedrock into the vent raise.

Photo: 3.28-1
Doris Primary Vent Raise Pad

Direction:
North

Photo: 3.28-2
Doris Primary Vent Raise Pad; cut off trench at base of rock cut

Direction:
n/a

Photo: 3.28-3
Doris Primary Vent Raise Pad; fuel containment bund

Direction:
East

3.29 Frozen Core Plant Pad

The Frozen Core Plant Pad could not be inspected because of construction activities for the new explosive containment structures just east of the North Dam. No buildings remain on the pad.

3.30 Doris North Dam

General Description
The TIA presently consists of a frozen core dam at the north end of Tail Lake, called the North Dam. It was constructed across a narrow portion of the valley that contains Tail Lake. It will form the downstream limit of the TIA and retain the reclaim pond once mining operations begin. (Photos 3.30-1 to 3.30-6)

The North Dam was constructed in the winter of 2011 and 2012. It consists of a frozen core keyed into the underlying foundation. The core consists of fine crushed basalt rock that was placed in a near saturated state. Sloped single pipe passive thermosyphons were installed at the base of the key trench to enhance foundation cooling. On the upstream side of the core, a geosynthetic clay liner (GLC) was installed to provide a secondary water retaining capability should cracks develop in the core due to thermal degradation, creep deformation, or differential settlement. The core and GCL extend 1.8 m above the design full storage level to provide freeboard.

The core is surrounded by a transition layer consisting of 0.15 m minus crushed basalt that acts as a filter, if the dam thaws. A minimum 1.5 m thick outer shell of ROQ rock acts as a thermal protection layer for the frozen core and provides a buttress against creep deformation.

The top of crest elevation is 37.6 metres above sea level (masl), and the valley bottom lies at approximately elevation 26 m. The dam length is approximately 200 m, and it has a crest height of about 11 m at the deepest part of the valley. The upstream slope lies 6H:1V and the downstream slope at 4H:1V. An overflow spillway wraps around the east abutment.

No tailings have been deposited although water from the Pollution Control Pond is pumped to the North Dam, and then into Doris Creek providing water quality requirements are met. Water is presently being pumped to keep the water level at approximately 28.3 m, which is the normal lake level. Once the water level begins to rise above that elevation, the vegetation along the shoreline will die off and the permafrost will begin to deteriorate. The overburden soils will thaw and release a sediment load into the lake (reclaim pond). Although this was anticipated to happen during operation, for it to happen would incur water treatment costs.

Instrumentation
Permanent instrumentation installed inside and across the North Dam are reported to be vertical ground temperature cables (thermistors), horizontal ground temperature cables and surficial survey monitoring points located throughout the downstream face, crest survey monitoring points located along the upstream and downstream crests of the dam, deep settlement points,

inclinometers within the downstream face, and thermistors measuring thermosyphon contact temperatures.

Dam Classification

The dam presently does not retain tailings. The water quality behind the dam meets regulatory requirements that allow the water to be pumped into Doris Creek, maintaining a minimum water level behind the dam. A 2014 assessment of the hazard classification was carried out in accordance with current Canadian Dam Association (CDA) Guidelines (CDA 2013), based on the current use of the dam and the downstream environment. The dam is considered to have a low hazard classification.

Observations

General observations made at site are summarized in Table 3.1.

The shallow depressions observed across the upstream and downstream faces are being attributed at this time to either the loss of finer stone into the coarser rock within the shell layer, or as areas of poor surface grading, rather than indications of foundation settlement. The depressions are being monitored during the annual geotechnical inspection by TMAC's consultant, and by TMAC personnel.

Seepage was not observed along the toe during the geotechnical inspection; nevertheless it has been observed during previous inspections. It is believed that the seepage may originate from the north abutment. It has previously been recommended that the origin of the seepage water be determined by sampling.

No significant areas of shoreline erosion were noted, although observations were limited to the area immediately adjacent to the North Dam.

Review of Instrumentation Results

A general review of the instrumentation data was carried out for the period covering September 2014 to August 2015, except where noted.

- The readings from 12 horizontal thermistors generally fall within previous years' minimum and maximum temperature ranges and the temperatures are below the core design temperature of -2ºC.

Table 3.1 Summary of Site Observations for North Dam

	Upstream Slope	Crest	Downstream Slope	Toe Area		Abutments	Spillway / Adjacent to Spillway
Sloughing (slopes)	N	-	N	-		-	N
Bulging (slopes, toe and adjacent to toe)	N	-	N	N		-	N
Beaching (upstream slope)	N	-	-	-		-	-
Sinkholes	N	N	N	N		N	N
Excess vegetation	N	N	N	Y		N	
Depressions/ Settlement	Y	N	Y	N		N	N
Surface runoff erosion (gullies)	N	N	N	N		N	N
Poor surface drainage (crest)	-	N	-	-		-	-
Rutting of travel surface / potholes (crest)	-	N	-	-		-	-
Misalignment of crest	-	N	-	-		-	-
Longitudinal cracking (crest)	-	N	-	-		-	-
Transverse cracking (crest)	-	N	--	-		-	-
Insufficient width (crest)	-	N	-	-		-	-
Soft, saturated areas	N	N	N	N		N	N
Wet spots; seepage (slopes, toe, abutments, adjacent to spillways)	N	N	N*	N		N	N
Blocked drains (toe)	-	-	-	N		-	-
Accumulation of fine soil material (toe; spillway; adjacent to spillway)	-	-	-	-		-	-
Vortices in Reservoir (offshore from upstream slope)	-	-	-	-		-	-
Boils (toe, abutments)	-	-	-	N		N	N
Suspended silt / soil in seepage water (toe, spillway, adjacent to spillway)	-	-	-	-		-	N
Debris	N	N	N	N		N	N
Animal burrows (spillways, downstream slope)	N	N	N	N		N	N

Note: Seepage at toe has been noted during previous inspections

- The readings from 10 vertical thermistors from September 2014 to August 2015, generally fall within previous minimum and maximum temperature ranges.

  The foundation temperatures met the design temperature of 8ºC except as measured by ND-VTS-175-KT in October 2014.

- The readings from 6 inclinometers located within the downstream face show maximum movement of about 22 mm perpendicular to the core and 25 mm parallel to the core, over the period from Aug-Sept 2012 to Aug-Sept 2015; the readings from 18 surficial survey monitoring points on the downstream face show vertical displacement of about 0.2 m, horizontal displacement of less than 0.2 m, total displacement of less than 0.4 m, a change in Easting equal to less than 0.2 m and a change in Northing of less than 0.2 m from original coordinates.

- The readings from 3 deep settlement survey monitoring points on the downstream face show vertical displacement of less than 0.1 m, horizontal displacement of less than 0.1 m, total displacement of less than 0.2 m, a change in Easting equal to less than 0.1 m and a change in Northing of less than 0.1 m from original coordinates.

- The readings from 14 surficial survey monitoring points on the crest (upstream and downstream edges) show vertical displacement of less than 0.1 m, horizontal displacement of less than 0.1 m, total displacement of about 0.2 m, a change in Easting equal to less than 0.1 m and change in Northing of less than 0.1 m from original coordinates.

Recommendations

If not already implemented, a regular program should be carried out for the depressions across the upstream and downstream faces.

As previously recommended, sampling and testing of the seepage water along the toe should be carried out to characterize the seepage water to eliminate seepage from under the dam as a source.

Regular maintenance of the thermosyphons should be implemented.

Photo: 3.30-1
Doris North Dam

Direction:
North / East from west abutment

Photo: 3.30-2
Doris North Dam; downstream slope, instrumentation and radiators

Direction:
North / East

Photo: 3.30-3
Doris North Dam; depression along downstream slope face

Direction:
n/a

Photo: 3.30-4
Doris North Dam; downstream slope face

Direction:
n/a

Photo: 3.30-5
Doris North Dam; depression along up stream slope face and pumping equipment at toe

Direction:
East

Photo: 3.30-6
Doris North Dam; depression along downstream slope face

Direction:
n/a

3.31 All-Weather Roads (Doris Site)

General Description

The following all-weather roads have been constructed on site:

Table 3.2 Summary of All Weather Roads (Doris Site)

Road Name	Approximate Dimensions	Description
Roberts Bay Access Road	120 m long, 8 m wide	Connects 5ML tank farm / Roberts Bay Waste Management Area to shoreline on east side of Roberts Bay
Jetty Road	250 m long, 10 m wide	Connects the Jetty to the Roberts Bay Waste Management Area
North Primary Road	600m long, 8 m wide	Connects Roberts Bay area to the north end of the airstrip
South Primary Road	2600 m, 8 m wide	Connects the south end of the airstrip to the Doris North Camp
ANFO Mixing Plant Road	75 m long, 8 m wide	Driveway from South Primary Road to the former wash bay
Quarry #2 Access Road	300 m long, 8 m wide	Connects the South Primary Road to Quarry #2
Doris Lake Pump Station access Road	870 m long, 8 m	Connects the South Primary Access Road to Doris Lake
Secondary Road	1570 m long, 8 m wide	Connects Doris North camp to the Tailings Impoundment Area
Tail Lake Access Road	260 m long, 8 m wide	Connects the frozen core plant pad to Tail Lake

The roads were constructed as raised thermal rock fill pads constructed directly on the tundra, between 1 to 3 m thick. The fill material consists of ROQ material with a surfacing layer of 1 ½" minus crush rock. All roads are single lane roads with turnouts; many of the original turnouts have been removed and the rock fill removed from the tundra. There are no culverts or rock drains under the roads to allow drainage of overland surface runoff flow.

A surficial slope failure occurred in August 2010 during construction of the Secondary Road (west side of the road), just south of the Doris North Portal. A temporary bypass was constructed and the ground was allowed to refreeze over the following winter months.

Observations

Generally, the roads were observed to be in good condition. Standing water against the toe of the road structures was observed at a few isolated locations, suggesting that runoff is able to make its way through the road structures. Minor loss of stone (into the underlying ROQ material) was noted along the edges of the roads, and a few cracks were noted along the shoulders. No standing water or obvious settlement was noted across the road surfaces.

No obvious, recent movement was noted across the surficial slope failure area.

Recommendations

Former roadside turnout areas should be monitored for signs of thermal settlement. Areas where water regularly ponds against the road toe should be documented and checked during freshet and after periods of significant precipitation. Standing water should be pumped from these areas.

It has been recommended that a buttress be constructed along the toe of the Secondary Road where there was a previous instability, although this has not been implemented. With construction activities, and as the mine goes into production, this road is expected to see increased traffic. It is recommended that a toe berm should be constructed. Until it is in place, the slope should be monitored for signs of movement.

3.32 Doris Creek Bridge

General Description

A single span prefabricated bridge carries Secondary Road traffic over Doris Creek, between the Doris North site and the Tailings Impoundment Area (TIA). The bridge is supported on thermal abutment pads. Two thermistor strings were installed in 2011 (one in each abutment) to monitor permafrost conditions. (Photos 3.32-1 to 3.32-4)

Observations

The bridge abutments appear to be in good condition. There is some deformation of the gabions around the top of the bridge abutment.

Recommendations

The thermistors should continue to be used to monitor permafrost conditions at the bridge abutments. The gabions should be monitored to see if there is ongoing deformation.

Photo: 3.32-1
Doris Creek Bridge

Direction:
East

Photo: 3.32-2
Doris Creek Bridge; north east abutment

Direction:
East

Photo: 3.32-3
Doris Creek Bridge; south east abutment

Direction:
East

Photo: 3.32-4
Doris Creek Bridge; south east abutment

Direction:
East

3.33 Doris-Windy All-Weather Road

General Description

The Doris-Windy All Weather Road is approximately 10 km in length, running north south between the Doris Camp and the Windy Camp. The road is an 8 m wide single lane with the design of the turnouts based on lines of sight; many of the original turnouts have since been removed and the rock fill removed from the tundra. It is a raised thermal rock fill pad constructed directly on the tundra, having a road fill thickness between 1 and 2+m. The road has been constructed with ROQ material with a surfacing layer of 2-inch crush material (Photos 3.33-1 and 3.33-2).

There are no rock drains under the road to allow drainage of overland surface runoff flow, although there are four stream crossings. Two caribou-crossing ramps were also incorporated into the road construction.

Observations

Generally, the road was observed to be in good condition. Standing water against the toe of the road was observed at a few isolated locations, suggesting that runoff is able to make its way through the road structures. Minor loss of stone (into the underlying ROQ material) was noted along the edges of the roads, and a few cracks were noted along the shoulders. No standing water or obvious settlement was noted across the road surfaces.

Recommendations

Former roadside turnout areas should be visually monitored for signs of thermal settlement.

Photo: 3.33-1
Doris Windy All-Weather Road

Direction:
South

Photo: 3.33-2
Doris Windy All-Weather Road; Caribou ramp

Direction:
South

3.34 Doris-Windy All-Weather Road Stream Crossings

General Description

There are four stream crossings along the Doris-Windy All-Weather Road. The northernmost stream crossing (#1) consists of an arch culvert founded on add-freeze piles (Photos 3.34-1 and 3.34-2). The remaining three stream crossings consist of prefabricated bridge sections resting on thermal abutment pads. The bridges at stream crossing #2 (Photos 3.34-5 and 3.34-6) and #3 (Photos 3.34-3 and 3.34-4) are separated by a central abutment, while stream crossing #4 is a standalone bridge. Thermistors have been installed at the thermal abutment pads to monitor the permafrost conditions.

Observations

Generally, the bridge approaches and abutments appear to be in good condition. A few potholes were noted at the top of the approaches to the bridge structures. Standing water was observed against the toe of the west end of the middle abutment between stream crossings #2 and #3, and the west side of the north abutment at stream crossing #4.

Recommendations

Rock fill should be placed at locations where standing water is noted against the thermal bridge abutment pads to provide insulation and stabilize potential deterioration of the permafrost.

In earlier geotechnical inspections, it was noted that the web of the I-beam, on top of the fourth pile from the northwest corner of the arch culvert at stream crossing #1, was buckled, but that there had been no change since first noticed in 2012. Some damage to the bridge section was also noted at stream crossing #3. If notable changes are observed in subsequent inspections, structural assessments should be undertaken.

Photo: 3.34-1
Doris-Windy All-Weather Road; Stream Crossing #1 arch culvert

Direction:
East

Photo: 3.34-2
Doris-Windy All-Weather Road; Stream Crossing #1 arch culvert

Direction:
West

Photo: 3.34-3
Doris-Windy All-Weather Road; Stream Crossing #2 and #3; east abutments

Direction:
South

Photo: 3.34-4
Doris-Windy All-Weather Road; Stream Crossing #2 and #3; south west abutment

Direction:
South