Red Dog Mine
Closure and Reclamation Plan

SD B3: Plan of Operations for Tailings and Water Management

Plan of Operations for Tailings and Water Management

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1 Introduction

The Closure and Reclamation Plan for the Red Dog Mine (SRK 2007a) makes several commitments related to tailings and water management during operations. This document collects these commitments and provides further details. The topics are grouped into two main categories, as follows:

- Tailings management:
  - Required dam raises for the Main and Back Dams;
  - Segregation of construction and cover materials;
  - Tailings beach requirements;
  - Water cover; and
  - Tailings deposition.
- Water management:
  - Pond volume reduction;
  - Pre-treatment of largest sources of loadings;
  - Construction of improved Main Waste Stockpile Seepage Collection System; and
  - Re-alignment and final construction of Red Dog Creek Diversion.

The operational procedures associated with each of these areas are discussed in the following sections. Specific plans pertaining to normal and routine management of tailings and water at Red Dog Mine are maintained separately by Teck Cominco Alaska (TCAK).

2 Tailings Management

The Red Dog Mine tailings impoundment is located in the upper valley of the South Fork of Red Dog Creek. The impoundment is contained by the Main Dam at the north end, the Back Dam at the south end, and the surrounding topography.

As of May 2006, the tailings impoundment contained an estimated 27,400,000 tons (24,870,000 tonnes) of tailings. If the tailings were uniformly distributed within the tailings impoundment, this would be equivalent to a “struck-level” elevation of approximately 912 feet. The surveyed water level as of May 2006 was 949.4 feet, at which time it was estimated that the impoundment contained approximately 4 billion gallons of water (SRK 2007b).

The current mine plan estimates a total tailings production of 88,000,000 tons (79,800,000 tonnes) by the end of ore processing in 2031. Estimates of the final tailings density range from 94.3 to 98.6 pcf. Using the lowest density estimate, the projected 88,000,000 tons, and the 2004 pond bathymetry, the final struck-level tailings surface is estimated to be at an elevation of 975 feet (SRK 2007b).

The estimate of the final struck-level elevation will need to be revised as mining proceeds. Other estimates of total tonnage, density and bathymetry lead to final struck-level elevations ranging from approximately 965 to 980 feet. The estimate of 975 feet is used consistently throughout this document.

2.1 Main Dam

The Main Dam crest is currently at an elevation of 960 feet (Stage VII-B), and the maximum dam height is 182 feet. Information on the past construction of the dam is contained in "Stability Analysis for Future Raises to Closure, Tailings Main Dam, Red Dog Mine, Alaska" (URS 2007b). The routine operations and maintenance required for the Main Dam are described in the Operations and Maintenance Manual, Red Dog Tailings Dam (URS 2005).

As tailings continue to be deposited in the impoundment and the tailings and water levels increase over time, the Main Dam will need to be raised. Conceptual design of the future Main Dam raises has been completed (URS 2007a). The conceptual design assumes a final dam crest elevation of 986 feet, which will be reached in three raises: Stage VIII to 970 feet, Stage IX to 980 feet, and Stage X to 986 feet. Final designs of the dam raises will need to be completed at the appropriate time.

URS 2007a also includes a conceptual design for a spillway sized to pass the probable maximum flood, or PMF. The PMF flow through the spillway would reach a depth of 1.1 feet. The invert of the spillway is set at elevation 984.5 feet to keep the maximum flow below the dam crest.

The distance between the assumed tailings surface elevation of 975 feet and the spillway invert at elevation 984.5 feet determines how much water can be stored in emergencies. Table 1 shows that even the combination of the minimum end of year water cover of 2 feet, plus the 95th percentile autumn to spring inflow, plus the probable maximum flood, plus wind setup and wave runup will still keep water 3.6 feet below the spillway invert. That 3.6 feet provides a significant additional level of safety. For example, in the unlikely event that treatment and discharge of the pond water ceased completely, the 3.6 feet would be sufficient to store more than two years of normal annual inflows, or a single year of inflows under 1:100 wet conditions.

Table 1: Basis for Estimated Final Main Dam Crest Elevation

Component of Storage	Depth (feet)	Resulting Elevation (feet)
Tailings	N/A	975.0
Minimum Water Cover	2.0	977.0
95th Percentile Autumn to Spring Inflow	1.6	978.6
Probable Maximum Flood	1.1	979.7
Wind Setup	0.3	980.0
Wave Run-Up	0.9	980.9
Available Additional Storage	3.6	984.5
Spillway Invert	1.5	986

Table 2 shows the estimated construction dates and amount of construction material required for each raise. The dates were estimated using the annual water and load balance model (SRK 2007b) to simulate a range of precipitation conditions:

- Average precipitation of 20.7 inches/year from 2007 to the end of the model (long-term average for the site;
- 1:10 year storms applied three consecutive years starting in 2007, with the long-term average of 20.7 inches/year elsewhere;
- 1:100 year storm applied for one year in 2008, with the long-term average of 20.7 inches/year elsewhere; and
- A slightly higher long-term average of 22.0 inches/year from 2007 to the end of the model.

Table 2: Main Dam Raises

Raise	Elevation (feet)	As Early As	As Late As	Material (tonnes)
Stage VIII	970	2009	2013	540,000
Stage IX	980	2018	2023	740,000
Stage X	986	2025	2029	500,000

For all the scenarios, the same water discharge rate was assumed during the years 2007 to 2025. In the simulations of higher long-term average precipitation, the discharge rate was increased from 2025 to closure to ensure the water level did not rise above the required freeboard elevation.

Varying weather conditions or water discharge rates could affect the dam raise dates. Further factors affecting the timing of the raises include economics and availability of construction materials.

2.2 Back Dam

The Back Dam at the south end of the tailings impoundment will straddle the divide between the pond and Bons Creek. As with the Main Dam, the crest elevation of the Back Dam at closure will need to be 986 feet. Design of the Back Dam has been completed to a crest elevation of 960 feet, and conceptual design to elevation 986 feet (Golder 2006). The raise or raises of the Back Dam from 960 feet to 986 feet will need to be timed in the same manner as the Main Dam raises.

2.3 Segregation of Construction Materials

Rock or overburden with a low potential for ARD and metal leaching will be required for ongoing construction of the tailings dams. Waste rock from the Main Pit and Aqqaluk Deposit has been assessed for this purpose. The assessment concluded that Okpikruak Shale and portions of the Siksikpuk Shale from the mining operations continue to be suitable for tailings dam construction, and that both of these materials as well as portions of the Kivalina Shale could be suitable for cover construction. To minimize borrow requirements, TCAK will segregate and stockpile these materials during the operations period.

Detailed information on the segregation of materials is included in “Plan of Operations for Waste Rock Disposal” (SRK 2007c). Segregation criteria for dam construction materials and cover material are shown in Table 3. Material meeting the criteria will be placed in temporary stockpiles.

Table 3: Material Segregation Criteria

Intended Use	Rock Types	Analytical Criteria
Dam Construction	Siksikpuk Shale	Single blast hole assays not to exceed: 1% Zn 1% Pb 3.5% Fe Average blast hole assays not to exceed: 0.5% Zn 0.5% Pb 2.5% Fe

2.4 Tailings Beach

The deposition of tailings to seal the upstream face of the Main Dam began in 1997, and a complete tailings beach was formed by 2000. Seepage records maintained by TCAK indicate that the tailings beach contributes to seepage control. Additionally, a seepage analysis conducted by URS clearly demonstrates that a wide tailings beach reduces seepage from the dam (URS 2007c). TCAK therefore plans to maintain the tailings beach against the Main Dam during operations. Measures to control dust from the beach are currently in place and will be maintained in compliance with air quality regulations.

2.5 Water Cover

The tailings produced at the Red Dog Mine are potentially acid generating. A minimum water cover of two feet will be maintained over the tailings surface throughout the operating period to minimize the generation of acid. More details on management of the water cover are provided in Section 3.

2.6 Tailings Deposition

In order to minimize oxidation of the tailings, they are deposited sub-aqueously. Tailings have been deposited sub-aerially intermittently, during periods of plant maintenance and during placement along the face of the dam to create beaches, but sub-aqueous deposition is the principal method used.

The sub-aqueous deposition often results in cones of tailings. A steep cone has been observed to form immediately below the deposition point, and a much shallower cone spreads outwards over a wider area. To ensure that the tailings cones are uniformly distributed, it will be necessary to move the deposition point. Current estimates, based on cone geometries observed to date, suggest that the deposition point will need to be moved on roughly a 200-foot grid to obtain an approximately uniform deposition. However, that estimate will need to be tested. The current concept is to build up the tailings deposit in three layers, so that experience gained in the lower layers will be available by the time the final layers are placed.

To ensure that the tailings remain submerged as the depth of water cover in the impoundment is reduced to two feet, the final tailings surface will have to be as flat as possible. A flat final surface will also maximize the volume of tailings that can be stored. To achieve an adequately level surface, tailings re-distribution may be required. Several methods have been used at other facilities. At Teck Cominco's Louvicourt Mine located near Val d'Or, Quebec, a shallow-water boat equipped with a harrow is used to grade tailings in areas of shallow water where a standard craft with an outboard motor is not adequate. Barge-mounted dredges are also employed to spread large accumulations of shallow tailings. Further investigation of these methods will be completed and a preferred method selected prior to 2025.

3 Water Management

TCAK plans to reduce the water volume in the pond to achieve the minimum two-foot water cover by 2025. Over the same time, measures will be implemented to begin "cleaning up" the pond by pre-treating the largest sources of contaminant loading, and by capturing as much of the Main Waste Stockpile seepage as possible.

The water management plans are linked to the closure objective for the pond. Significantly reducing the pond volume will allow the benefits of capturing and treating inflows to be attained in a much shorter time. Keeping the pond less contaminated during the last few years of operations will ensure that the porewater in the uppermost few feet of tailings will be as clean as possible. That porewater will then be less likely to be a source of contaminants to the closed pond.

3.1 Pond Volume Reduction

Reducing the water storage in the impoundment to two feet by 2025 will require an average annual discharge of 1.5 billion gallons. As is the case currently, all discharged water will be treated in WTP2 and discharged to Outfall 001. Once the two foot target is reached, subsequent discharges would need to average 1.35 billion gallons per year to maintain the two foot water level. The discharge requirements will of course vary around these averages, depending on precipitation, evaporation and diversion effectiveness.

3.1.1 Pretreatment of Largest Sources of Loading

Water Treatment Plant #3 began operating in 2006. The plant was designed to treat some of the Main Waste Stockpile seepage and Mine Sump water before it enters the tailings impoundment. Under its current capacity limitations, it treats Main Waste seepage as a priority, and Mine Sump water with any remaining treatment capacity. It is estimated that between 200 and 250 million gallons of water could be treated annually under the current WTP3 configuration.

Expanding the capacity of WTP3 would allow pre-treatment of more of the contaminated inflows to the pond, including:

- The portion of the Main Waste Stockpile seepage that currently escapes capture;
- The entire flow from the Mine Sump; and/or
- Seepage pumped back from the toe of the Main Dam.

A number of options for increasing the treatment capacity of WTP3 are under consideration. Examples include increasing the lime slaking capacity, improving the lime handling system, and adding a roof or heated enclosure. Further analysis and engineering is needed before options are selected and implemented.

An additional measure to reduce the contaminant inputs to the pond is the pre-treatment of tailings discharge water. This could be accomplished through lime addition to the tailings pump box.

3.1.2 Main Waste Stockpile Seepage Collection System

A portion of the seepage from the Main Waste Stockpile is currently collected through a seepage collection system and pumped to WTP3 for treatment, while the remaining portion flows to the tailings impoundment. It is estimated that the current seepage collection system can capture roughly 50% of water reporting to the toe of the Main Waste Stockpile.

Improvements to the collection system will be required to collect the maximum amount of seepage for pre-treatment, thereby improving the pond water quality. The timing will coordinate with the reclamation of the Main Waste Stockpile:

- Construct South End – as early as 2010, but no later than 2025;
- Construct North End – as early as 2014, but no later than 2025;
- Implement monitoring of new system – as early as 2011, but no later than 2026;
- Improvements to monitoring system – as early as 2012, but no later than 2026.

3.2 Red Dog Creek Diversion

The main drainage through the mine area is the Middle Fork of Red Dog Creek. Tributaries that enter the Middle Fork through the mine area are Rachel Creek, Connie Creek, Shelly Creek and Sulfur Creek. This water is diverted through the mine area by the Red Dog Creek Diversion. A portion of the existing channel that is currently lined will be converted to a 96-inch diameter, heat-traced culvert by the end of 2007 due to glaciation problems. Additionally, the current alignment will need to be revised in 2020 due to mine planning considerations. Finally, the existing design will need to be modified to ensure it is suitable for long-term, post-closure conditions. The realignment will be completed by 2020, with the final, closure design completed by 2032.

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