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RECLAMATION ACTIVITIES AT THE NICKEL PLATE MINE TAILINGS FACILITY

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ABSTRACT

The Nickel Plate Mine is a former gold producing operation owned and operated by Homestake Canada Inc. Since the cessation of tailings deposition in October 1996, the tailings facility has become a focus of the reclamation activities at the Mine. The reclamation of the Facility was initiated in May 1998 with the start of the tailings cover system construction.

Reclamation activities at the tailings facility since closure include the following: a tailings cover system designed to ensure long-term management of surface water runoff using materials that would support vegetation; a lined containment facility constructed to store high density sludge produced by the water treatment process; and a design for post closure surface water management comprising a sediment control pond and emergency spillway.

This paper presents an overview of these reclamation activities and the progress of construction to date. In addition, instrumentation and monitoring data has been used to evaluate the post closure stability of the tailings facility and to demonstrate that its overall stability has improved with the removal of the supernatant pond and construction of the tailings cover.

INTRODUCTION

The Nickel Plate Mine is a former gold producing operation owned by Homestake Canada Inc. The Mine is located 3 kilometres north-east of Hedley, B.C. at the southern end of the Thompson Plateau, in south-central British Columbia. During its 9 year operating life, from April 1987 to October 1996, the average daily tailings production rate was approximately 3500 tons/day, generating a total of almost 12 million short tons of solids that were deposited into the tailings facility. The Mine is currently engaged in full time reclamation activities, including tailings cover construction and treatment of tailings solution and seepage water.

TAILINGS COVER SYSTEM

A cover on the tailings surface was required for reclamation to provide both short term and long term solutions to water management issues. An efficient tailings cover surface was designed to provide positive drainage of surface runoff from the facility, using materials that would support vegetation growth. A staged construction plan was implemented for the cover construction to enable a flexible construction strategy.

The effectiveness of using locally borrowed till materials for the top layer of the cover was confirmed by Homestake Canada Inc. from their results of test plots carried out on alternative cover arrangements. The cover design described in the approved reclamation plan is a 2 feet thick rock layer over the tailings, covered by a 2 feet thick till layer. The rock layer is intended to behave as a capillary break between the vegetation layer and the tailings materials.

Development of Tailings Cover

The tailings cover has been constructed in stages, with the initial portion constructed adjacent to the tailings embankment. Subsequent stages have extended the cover further towards the natural slope on the west side of the facility. The progression of cover construction generally started above the coarser more consolidated beach tailings and has moved towards the finer tailings material, which are deposited further upstream. This has provided additional time for the finer tailings to consolidate and dewater and to develop a more trafficable working surface. The development of tailings surface strength from consolidation and evaporative drying was expedited by the removal of the supernatant pond. The development of the tailings cover, along with ancillary works, is shown on Figure 1.

A series of diversion ditches and ponds have been used in conjunction with pumping to control surface drainage during the interim stages of cover development. The primary objective of the diversion schemes is to minimize the amount of surface water requiring treatment.

The final tailings cover arrangement is shown by Figure 1c. It has been designed with a gentle slope of approximately 0.5% at the south end and 0.25% near the spillway. The final surface will direct surface runoff both in a westerly and northerly direction so that all flows are guided away from the embankment wall and towards the final spillway.

Tailings Cover Settlement

A finite difference computer model was used to predict the magnitude of tailings cover settlement, using tailings consolidation parameters determined from laboratory testing. The computer model was calibrated to existing conditions within the tailings mass by comparing with measured in-situ tailings pore water pressure profiles developed from Cone Penetration Test data collected in 1996, prior to closure of the facility.

The computer modelling estimated that the average degree of consolidation of the tailings was approximately 80% at closure. This indicated that the majority of tailings settlement has already occurred during operations and that post-closure settlements would be relatively minor. Tailings settlements from the loading provided by the cover were predicted to be approximately 0.3 metres after placement of the Stage 1 cover. For development of the final tailings cover, settlements were predicted to be about 0.3 to 0.6 metres with the largest settlement occurring in partially consolidated fine tailings. The majority of the tailings settlements were predicted to occur during and shortly after placement of the tailings cover. Thereafter, the rate of settlement reduces rapidly, with on-going settlements predicted to be negligible after about one year for the beach tailings and two years for the finer tailings. Details of the post closure consolidation assessment of the tailings are presented by Brown et al (1998).

Some additional construction fill will be required to compensate for on-going settlements due to tailings consolidation. Areas of the final tailings cover that undergo settlement will be rebuilt, as required, over the next few years, as the majority of the expected settlement is realized.

Construction Materials

Construction materials for earthwork activity are borrowed locally. The rock is borrowed primarily from the existing quarry at the north end of the facility and from excavated material from the spillway construction. Till material is sourced from the previously developed borrow area, west of the facility above the Hedley Road.

The tailings cover was constructed by advancing a rockfill causeway from the northeast corner of the facility, along a line approximately 300 feet from the facility perimeter to the south west, as shown in Photo No. 1. The area between the access road created by the causeway and the tailings facility perimeter was progressively covered with rockfill to an average design depth of 2 feet. Once the rockfill cover was established in an area, a 2 feet thick layer of soil comprising till and loamy topsoil was placed on the rockfill. The condition of the tailings surface and pond area prior to any fill placement for cover construction can be seen in Photo No. 1.

The fill materials in the cover were minimally compacted by truck trafficking. The tailings surface was generally quite stable; however, on several occasions local instabilities occurred resulting in localised slumps of the advancing face of the rockfill. Also, when two advancing faces of rockfill met, in some cases, minor tailings flows and sand boils were observed due to the generation of excess pore pressures. In every case, the area was left for a brief period of time and the excess pore pressures rapidly dissipated allowing construction to continue. Where soft tailings contaminated the rockfill cover, this material was removed to waste and replaced with clean rockfill. By the end of the 1998 construction season, approximately 80% of the cover had been placed, as shown by Photo No. 2. Since this time, observed settlements of the tailings cover have been minor and within predicted values.

TAILINGS SOLUTION MANAGEMENT

After closure of the tailings facility there was a need to provide a water treatment plant for removal of cyanide and other contaminants from tailings water stored in the facility and seepage collected by seepage collection ditches, drains and sumps. Consequently, a water treatment plant utilizing a combined aerobic and anaerobic biological treatment system was commissioned to remove residual cyanide, thiocyanate, ammonia and nitrates. This is coupled with a High Density Sludge (HDS) process for removal of residual metals. The full-scale treatment system commenced in October 1996, with discharge of treated water achieved in February 1997. A detailed discussion of the development and operation of the combined biological treatment process is presented by Given and Meyer (1998).

Collected seepage water is conveyed to a seepage storage pond before reporting to the water treatment plant for treatment and release. The seepage storage pond has been constructed on the tailings surface at the northeast corner of the facility and is lined with 60 mil HDPE membrane. The pond is designed to temporarily store untreated seepage water prior to pumping to the treatment plant and is sized to store approximately 1.5 million US gallons of water. The seepage pumpback at present varies between 80 and 200 USgpm and seepage rates are estimated to reduce to less than 5 USgpm within five years of closure. The pond has been conservatively designed to provide approximately 5 days of storage based on a seepage return rate of 200 USgpm. The seepage storage pond at completion is shown by Photo No. 3.

SLUDGE DISPOSAL FACILITY

A by-product from the water treatment plant is a sludge produced by the HDS process. This sludge material is a reddish-brown, ferric hydroxide with a solids content of approximately 20 percent and specific gravity of 2.5. It is expected that a higher solids content, approximately 40 percent, will be achieved after settling.

The Mine had anticipated that sludge production would remain at the initial rate of 4000 tons per year until 1999, and then at 2500 tons per year for an additional 2 years. For the purposes of sizing a containment facility, a total of 9000 tons was assumed. At a calculated average settled dry density of 0.5 tons/cu.yd., storage for about 18 000 cu.yd. of sludge was estimated to be required over the predicted operating life of the containment facility.

The sludge disposal facility (SDF) has been located at the northeast corner of the tailings facility, adjacent to the seepage storage pond. This location is convenient for the existing sludge delivery pipelines. The SDF comprises three ponds, each with a storage capacity of approximately 6,000 cubic yards. The SDF was designed to permit sludge deposition into each pond in turn, allowing time for the material to settle and dry prior to further deposition. Each pond is sized approximately 220 ft wide, 255 ft long and 4 ft deep and constructed from locally borrowed fill material.

The ponds are designed as lined facilities, each incorporating the upstream face of the tailings embankment wall as an enclosure along one length. As the sludge settles, some entrapped water will come to the surface. The supernatant water will be removed regularly to allow the surface to dry. The construction of base drains to promote bottom drainage was considered as a possible benefit to the dewatering and consolidation of the sludge. However, more detailed information on the sludge characteristics was not available to appraise base drainage as a feasible and cost effective option.

It was anticipated that a layer of sludge, 4" thick, will be placed in each pond in turn. At a production rate of 4000 tpy, the resulting cycle time for deposition is approximately 1 month per pond. The two months between deposition in each pond will allow the sludge to drain and desiccate, significantly increasing its density.

Surface runoff from the tailings cover will be diverted around the SDF by a small diversion ditch constructed along the southern edge. This diversion ditch will be directed into the main diversion ditch constructed along the upstream edge of the constructed tailings cover. An overview of the Sludge Disposal Facility is shown by Photo No. 2

SEDIMENT CONTROL AND EMERGENCY SPILLWAY

The rock quarry to the northeast of the tailings facility was shaped to provide adequate volume for sediment control of surface water draining from the reclaimed tailings surface. A spillway was designed to pass water from the tailings facility to the sediment control pond and another spillway was designed to discharge water from the sediment control pond to Cahill Creek. The first section of the spillway channel is designed for excavation into till, with flat side and base slopes lined with erosion protection. The second section is a steep chute with near vertical side walls, exposing the natural rock found in this area. At the end of the 1998 construction season, the sediment control pond was completed and the spillway from the pond to Cahill Creek was excavated. The spillway from the tailings facility to the sediment control pond will be excavated once the tailings cover is completed and the surface runoff is of an acceptable quality to permit discharge into downstream receiving waters.

INSTRUMENTATION AND MONITORING

The goals of the tailings cover system (TCS) are to achieve long term stability, and long term protection for the downstream environment. In order to evaluate the success in achieving these goals, the operational monitoring program was supplemented, as required, to provide the needed information during post-closure monitoring.

Survey monuments were installed on the completed tailings cover and will be used to monitor any settlement or movement. The groundwater monitoring program will continue to determine the rate of decline in seepage volumes as the tailings mass consolidates. Seepage volume measurements at both the

East and West Zone seepage locations will be required to monitor this progress. In addition, the water quality of surface runoff and downstream waters will be monitored. Samples of ground water will be collected and tested from all existing wells.

The post-closure monitoring program has replaced the operational monitoring program and will continue for at least 4 years following closure. Instrumentation equipment may be decommissioned and removed as each aspect of the monitoring program is discontinued.

EMBANKMENT STABILITY

Instrumentation and monitoring data has been used to evaluate the post closure stability of the tailings facility. The stability of the tailings embankment has been reviewed annually since closure using the most recent pore pressure conditions and changes to the tailings facility as a result of removal of the supernatant pond and tailings cover construction.

At closure of the facility in 1996, embankment stability analyses indicated that the minimum factor of safety was approximately 1.3 for a potential slip surface passing through the embankment and underlying foundation soils. For long term performance of the tailings embankment after closure a minimum factor of safety of 1.5 is required. By the end of 1997, the size of the supernatant pond had been reduced as water was conveyed to the water treatment plant. This resulted in the development of larger exposed tailings beaches and a corresponding decrease in piezometric levels within the tailings embankment. Approximately one year after closure of the TSF (end of 1997), the minimum factor of safety had increased to 1.41. The factor of safety was shown to have increased to 1.46 after construction of the tailings cover in 1998.

These analyses indicate that the stability of the embankment has improved since closure and has essentially achieved the minimum required factor of safety of 1.5 for long term stability within two years since closure. The overall embankment stability will continue to improve with time, as piezometric levels decrease in the tailings mass, embankment fill and foundation materials.

SUMMARY

The reclamation of the tailings facility is successfully nearing completion almost 3 years after closure of the Mine and cessation of tailings deposition into the facility. A tailings cover system was designed to ensure long-term management of surface water runoff using a rockfill base and till top cover that will provide an environment which is conducive to the establishment of a sustainable vegetative cover.

Several lined ponds were constructed on the tailings surface to contain residual products from the HDS process used to treat the tailings solution water and for temporary seepage storage. The construction of a sediment control basin and emergency spillway system has been initiated and will be completed once the tailings cover is fully in place.

Instrumentation and monitoring data have been used to evaluate the post closure stability of the tailings embankment and demonstrate that its overall stability has improved with the removal of the supernatant pond and construction of the tailings cover. Embankment stability will continue to improve with time, as piezometric levels decrease in the tailings mass, embankment fill and foundation soils.

ACKNOWLEDGEMENTS

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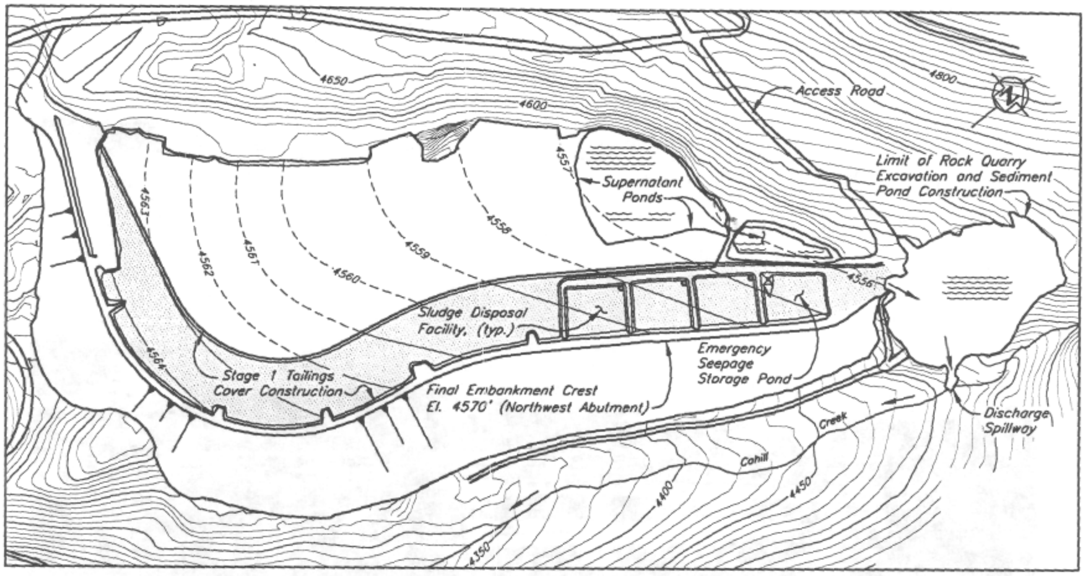

FIGURE 1A DEVELOPMENT OF TAILINGS COVER (STAGE 1)

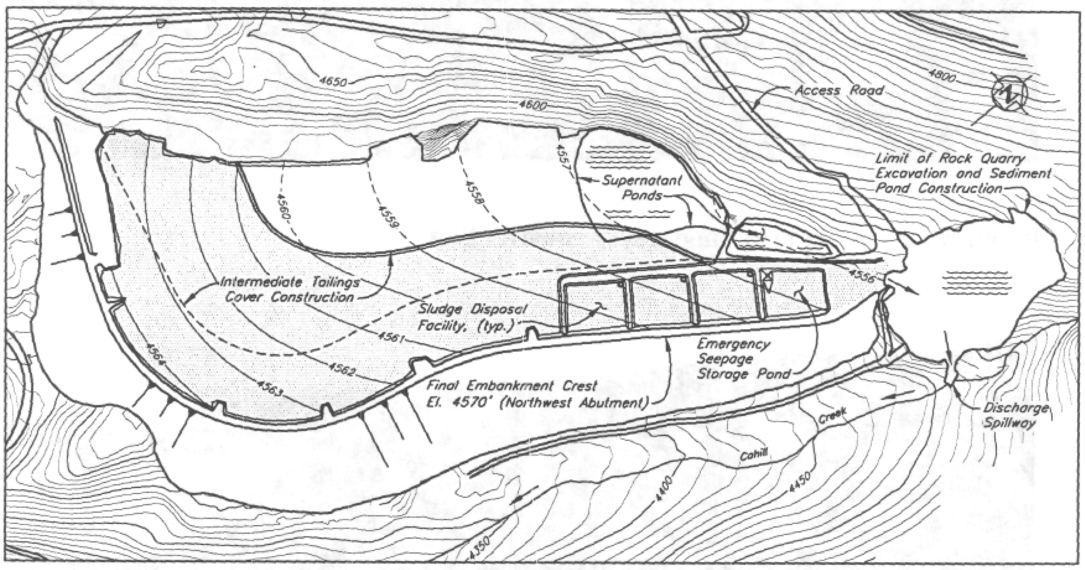

FIGURE 1B DEVELOPMENT OF TAILINGS COVER (INTERMEDIATE STAGE)

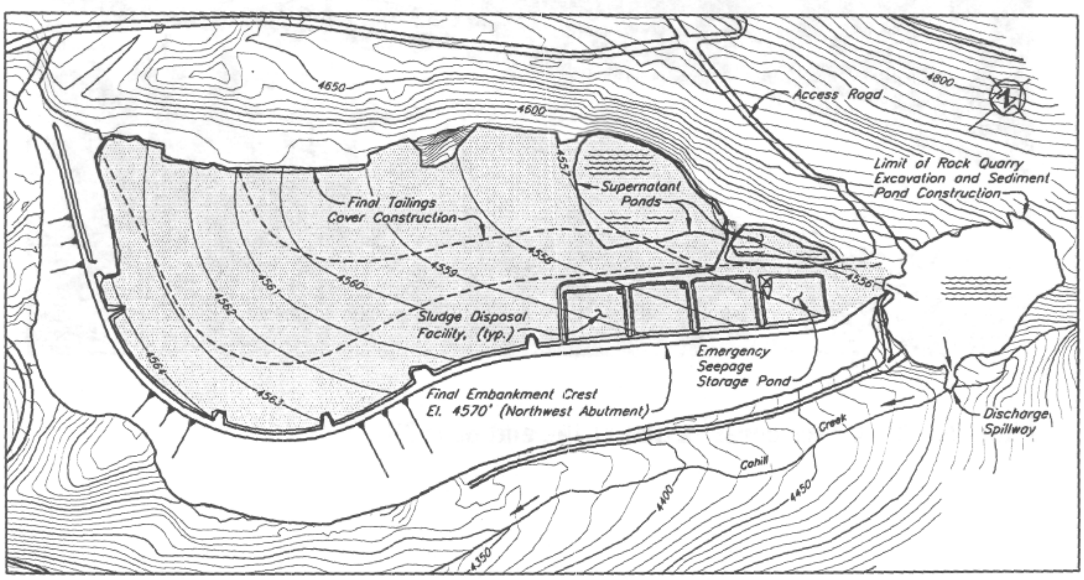

FIGURE 1C DEVELOPMENT OF TAILINGS COVER (FINAL STAGE)

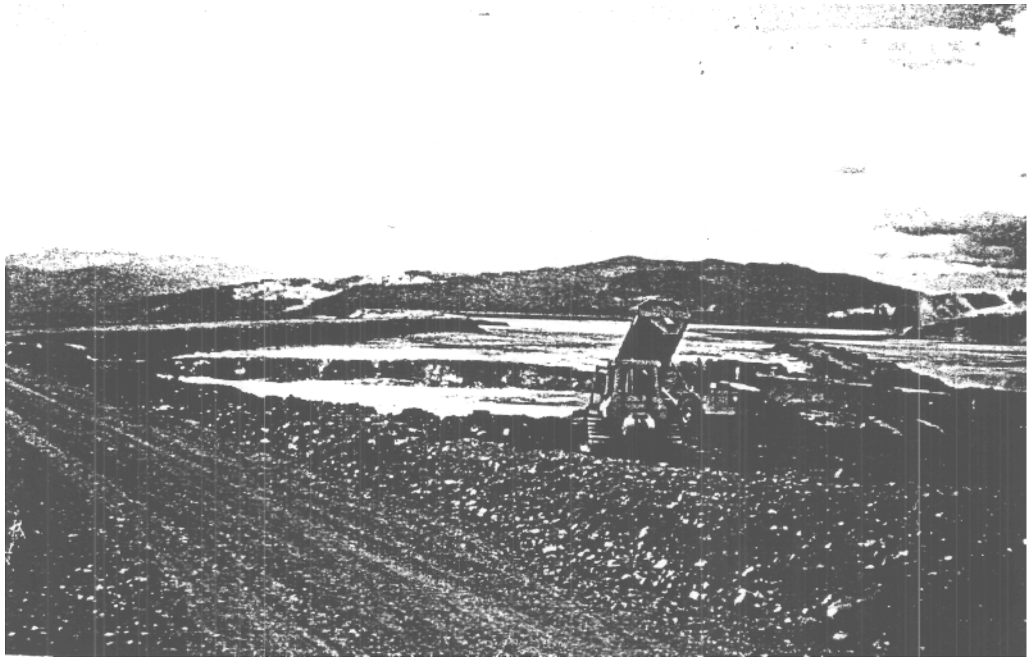

Photo No.l - Start of tailings cover construction.

Photo No.2 - Cover construction at the end of 1998.

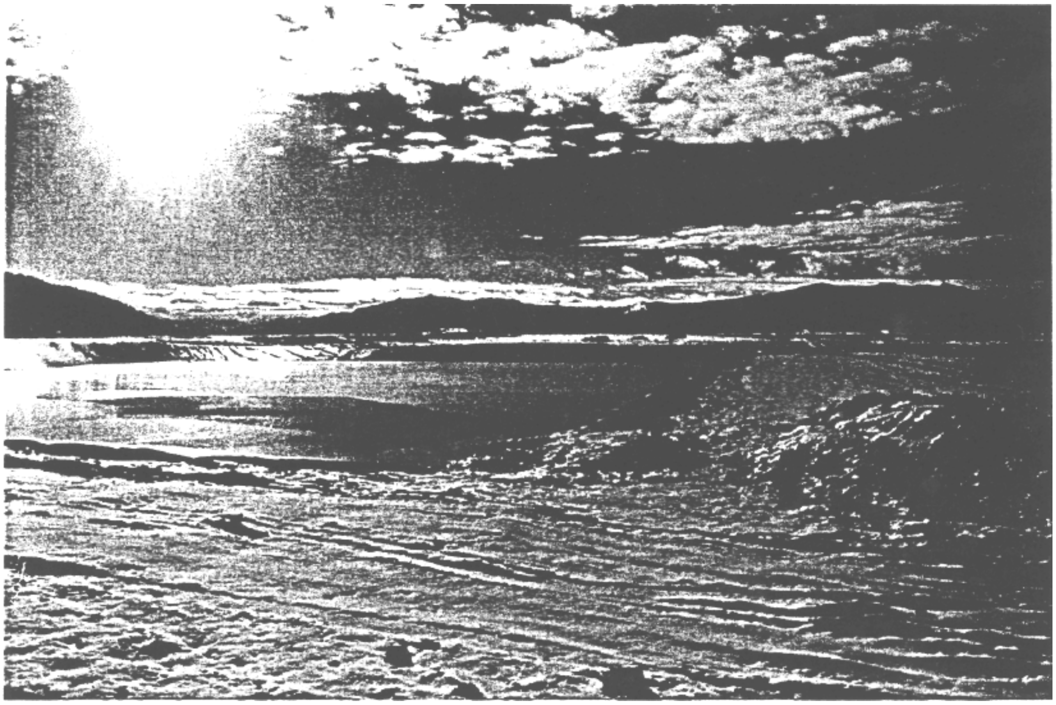

Photo No.3 - Seepage Storage Pond.