



Talga Resources Ltd

Nunasvaara South Mine - Integrated Waste Facility IWF Feasibility Study

December 2019

Executive summary

The Nunasvaara South Mine (part of the Vittangi Project) is situated in the County of Norrbotten, in Vittangi, 50 km east of the town of Kiruna, northern Sweden. The proposed mine was estimated to produce approximately 100,000 tonnes per annum of run-of-mine (ROM) graphite ore over an estimated life of mine (LoM) of at least 22 years.

Talga intends to mine the graphite ore using a conventional open pit mining methods. The ore will be treated onsite through a beneficiation plant. The ore beneficiation will generate tailings, which are planned to be filtered and then reported to the Integrated Waste Facility (IWF) for a permanent storage. The tailings and mine waste are expected to generate acid forming seepage if left exposed to the environment. The design solution presented in this report therefore focuses on minimisation of the acid forming potential of the tailings and mine waste.

An in-house tailings option study has previously been completed, which concluded that the preferred tailings management for the project involves tailings filtration and co-disposal with the mine waste.

Following completion of the in-house tailings option study, Talga engaged GHD to complete a concept design for the IWF, to support the mine feasibility study and the application of environmental and mining approvals for the project.

The concept design presented in this report was built upon and further developed this preferred tailings management method and included the following key activities:

- Selection of the IWF storage capacity, location and shape
- Definition of the IWF staging and internal zoning the IWF
- Design of the IWF surface and underdrainage systems
- Preliminary stability assessment , water balance and closure concept
- Identification of future studies, opportunities and risks to support the detailed design

The preferred location of the IWF is directly to the north of the Lake Hosiojärvi on gently sloping terrain covered with a secondary forest. The IWF was designed to contain tailings together with the mine waste produced in the first ten years of the mine operation. The IWF concept takes advantage of the positive mine waste to tailings ratio and utilizes the mine waste to form the structural shell of the IWF. The short term and long term performance of the IWF is therefore independent to the tailings properties, which therefore limits the overall risk of the project. The design allows for a progressive rehabilitation of the outer shells from the fourth year of mine operation.

An underdrainage system was included in the design to allow contaminated seepage to be collected and safely discharged to the water treatment plant on site, while lowering the likelihood of acid seepage contaminating the surrounding environment. The underdrainage system is expected to be operated after the IWF closure until the end of Life of Mine to collect water released from the stored tailings and mine waste during the settlement of the stored material.

A separate surface water management system was designed to divert the surface flow around the IWF and thus limit the volume of potentially contaminated water that would otherwise need to be treated. In addition, surface water structures were designed to collect and store contaminated surface runoff from the IWF, which can be sent to water treatment plants on site.

To prevent oxidation of the mine waste and tailings and generation of acid leachate, the entire IWF is designed to be encapsulated by a low permeability clayey barrier. The encapsulation system includes a footprint liner and surface capping, which will wrap around the final IWF landform. The closure concept assumes a dome type structure with natural surface drainage and vegetative cover.

This report defines further studies required to support the detailed design of the IWF. Of highest importance, is the detailed characterisation of tailings and mine waste that is expected to be produced throughout the LoM.

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1. Introduction

1.1 General

The Feasibility Study (FS) for the Integrated Waste Facility (IWF), refers to the concept design and documentation for the IWF at Talga Resources' (Talga's) Nunasvaara South Mine, which is part of the Vittangi Project. The project located in the County of Norrbotten, Vittangi, Sweden.

1.2 Purpose of this document

The purpose of the report is to document the work, including inputs, methods, analyses and results, completed for the FS of the IWF. To support the application of environmental and mining approvals for the project.

In addition, gaps in required information and knowledge to support next stage of design was detailed throughout this report and summarised in Section 16.

1.3 Project background

The Vittangi Project is situated in the County of Norrbotten, in Vittangi, 50 km east of the town of Kiruna, northern Sweden (Figure 1-1).

The mine was estimated to produce approximately 100,000 tonnes per annum of run-of-mine (ROM) graphite ore over an estimated life of mine (LoM) of at least 22 years.

Talga intends to mine the graphite ore using a conventional open pit mining methods. The ore will be treated onsite through a beneficiation plant.

An option study to determine the preferred tailings process and storage method was completed by Talga in early 2019. The selected option included filtration of tailings, to be disposed in a dry-stack or co-disposal facility with mine waste.

This FS provides a concept-level design for the preferred tailings disposal method.

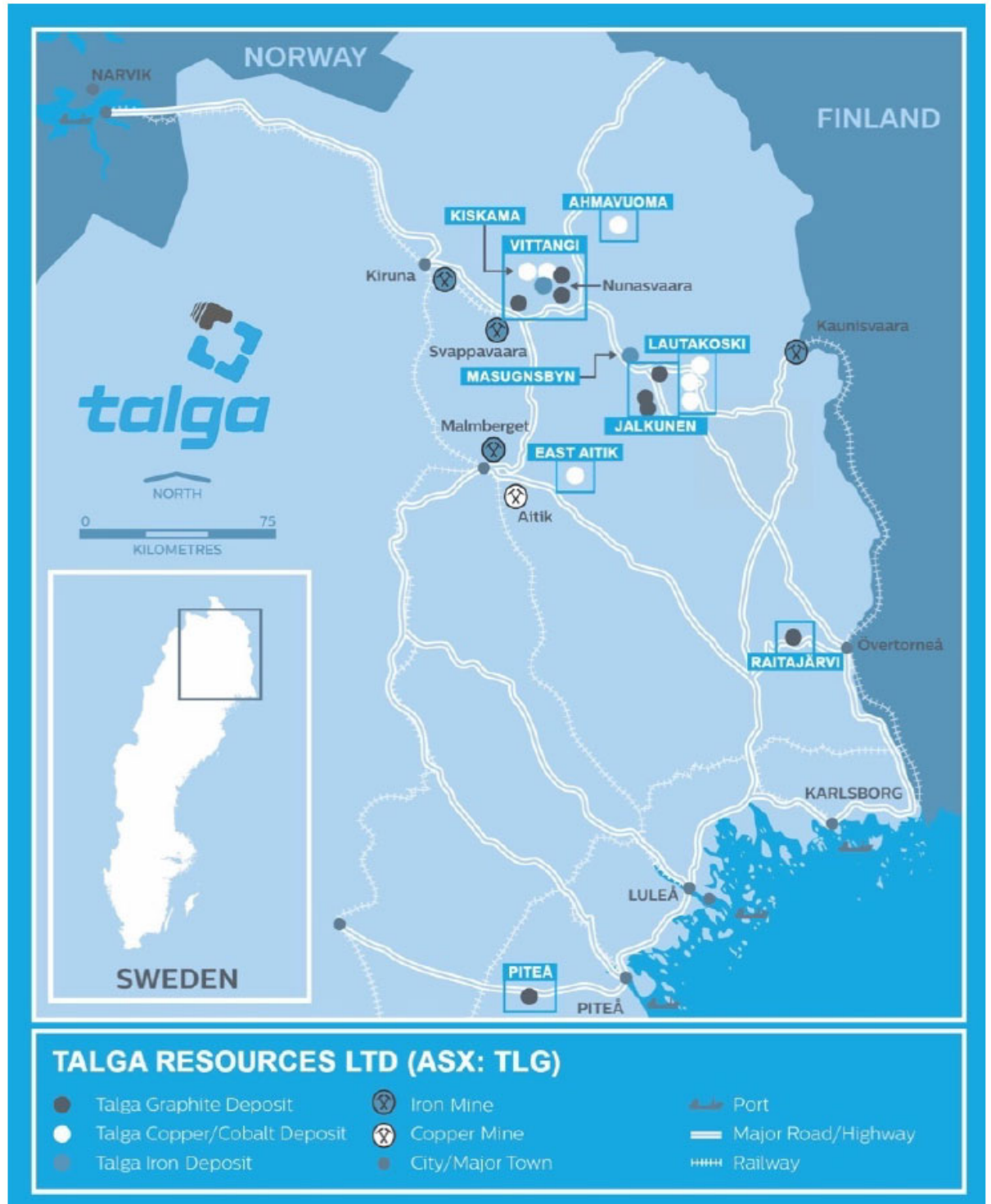


Figure 1-1 Project location map

1.4 Limitations

This report was prepared by GHD for Talga Resources Ltd and may only be used and relied on by Talga Resources Ltd for the purpose agreed between GHD and the Talga Resources Ltd as set out in Section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Talga Resources Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

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The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described throughout this report. GHD disclaims liability arising from any of the assumptions being incorrect.

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2. Site characteristics

2.1 Topography

The project area is dominated by two hills Hosiorinta and Nunasvaara that rise 50 m to 100 m above Lake Hosiojärvi at RL 290 m. The future open pits follow the eastern slopes of Hosiorinta (RL 350 m) in an arch shape as shown in Figure 2-1.

The area is undeveloped and mostly consisting of coniferous forest with elements of deciduous trees.

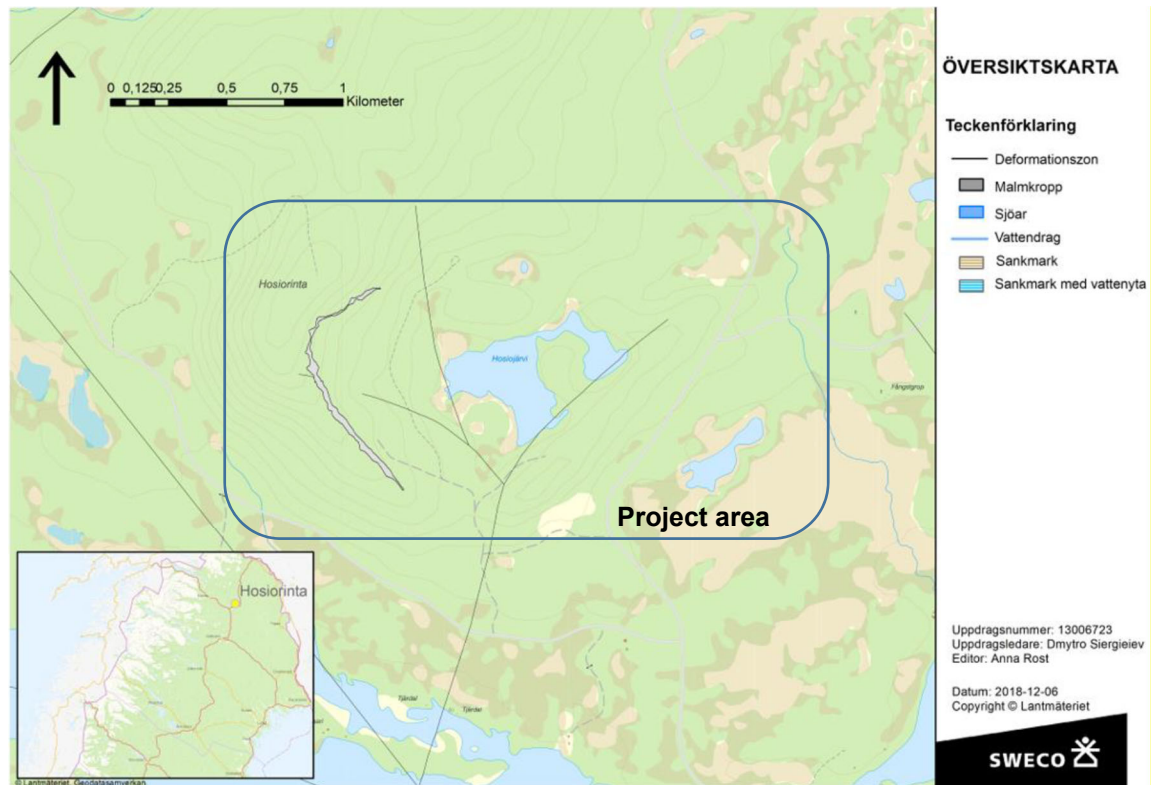


Figure 2-1 Project area orientation map (Sweco, 2019)

2.2 Climate

The annual precipitation at the project area is about 500 mm with about 45% in the form of snow that normally covers the area from October to April.

Average annual temperature is about -1°C, the maximum monthly average temperature is about 12°C in July and the coldest month is January with a monthly average temperature of about -14°C.

The mean annual evaporation varies between 200 mm and 300 mm, which account for approximately 50% of the mean annual precipitation.

2.3 Extreme hydrology

The Swedish Meteorological and Hydrological Institute (SMHI) was commissioned to provide Intensity-Frequency-Duration (IFD) curves for various extreme precipitation events. The return periods that were analysed from 2 to 100 AEP and the durations ranged from 15 minutes to 72 hours.

The estimates were produced using precipitation data for a 23 year period (1996-2018) from the Parkalompolo (located in Norrbotten).

The values and curves for the IFD estimates are shown in Table 2-1, Figure 2-2 and Figure 2-3.

Table 2-1 IFD values (mm/hr) for extreme precipitation events

Precipitation Intensity (mm/h)	Return period					
Duration (h)	2 years	5 years	10 years	20 years	50 years	100 years
0.25 (15 min)	26.9	34.6	39.7	44.6	50.9	55.7
0.5 (30 min)	18.5	24.7	28.8	32.8	37.9	41.8
0.75 (45 min)	14.2	18.6	21.6	24.4	28.0	30.7
1	11.7	15.4	17.8	20.1	23.1	25.4
2	6.9	9.0	10.4	11.8	13.5	14.8
3	5.3	6.8	7.9	8.9	10.1	11.1
4	4.3	5.5	6.2	7.0	7.9	8.7
5	3.7	4.7	5.3	6.0	6.8	7.4
6	3.3	4.2	4.8	5.3	6.1	6.6
12	2.0	2.6	3.0	3.3	3.8	4.1
24	1.2	1.6	1.9	2.2	2.5	2.7
36	0.9	1.2	1.4	1.6	1.9	2.1
48	0.8	1.1	1.2	1.4	1.7	1.8
60	0.7	0.9	1.1	1.2	1.4	1.6
72	0.6	0.8	0.9	1.1	1.2	1.4

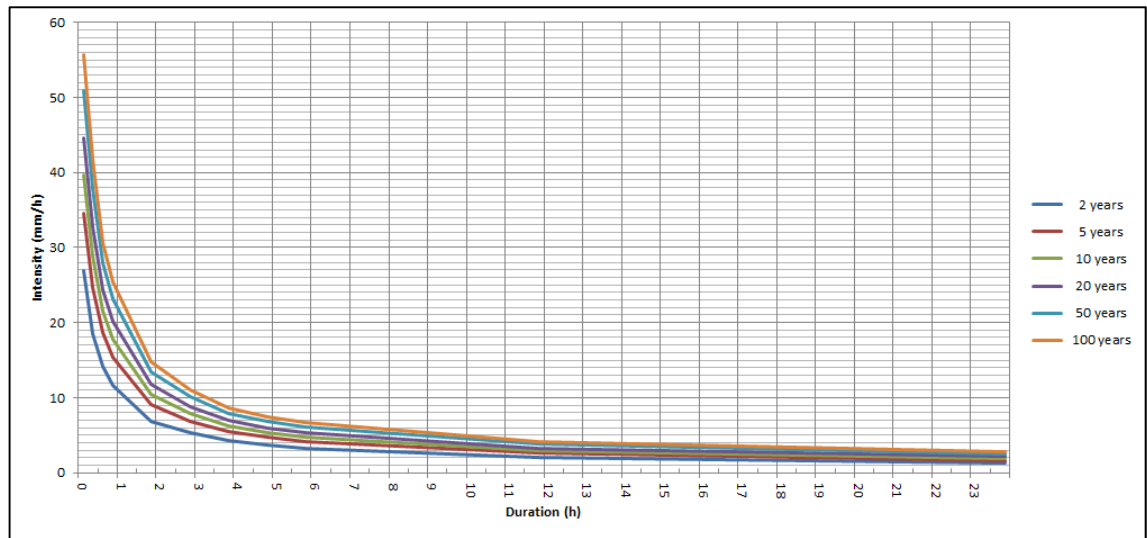


Figure 2-2 IFD curves for duration up to 24 hours

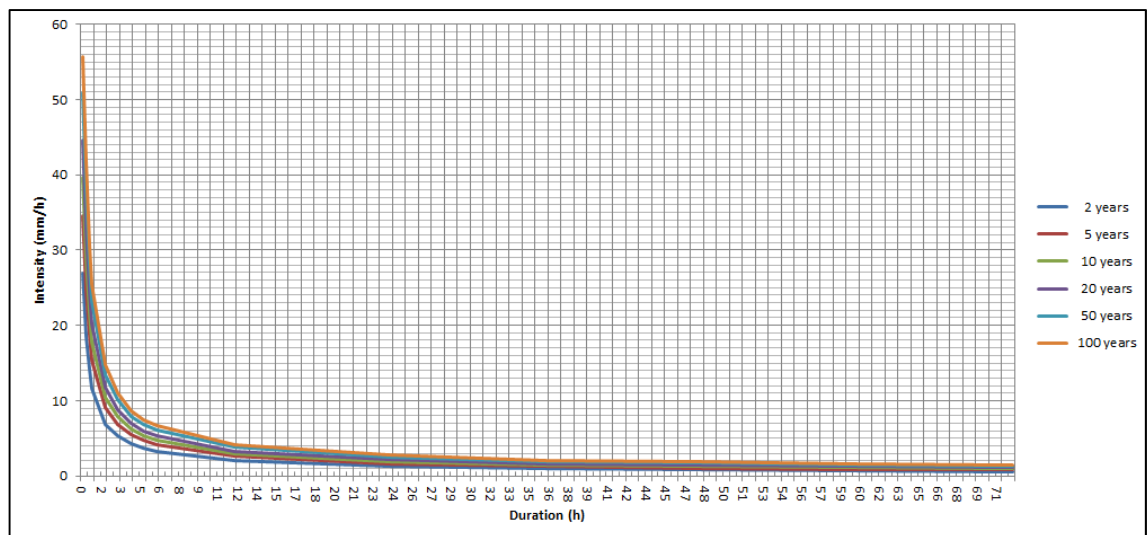


Figure 2-3 IFD curves for duration up to 72 hours

2.4 Geology

The geology of the project area comprises greenstones (basalt to andesite), metasediments (quartzite, slate, marble) and metadolerites that form part of Vittangi greenstone group and belongs to Paleoproterozoiska vulkanosedimentära domain in northern Sweden located on archaic subgrade (Lynch and Jörn Berger, 2013). The geological map, reproduced in Figure 2-4, shows numerous deformation zones and discontinuities intersecting the project site.

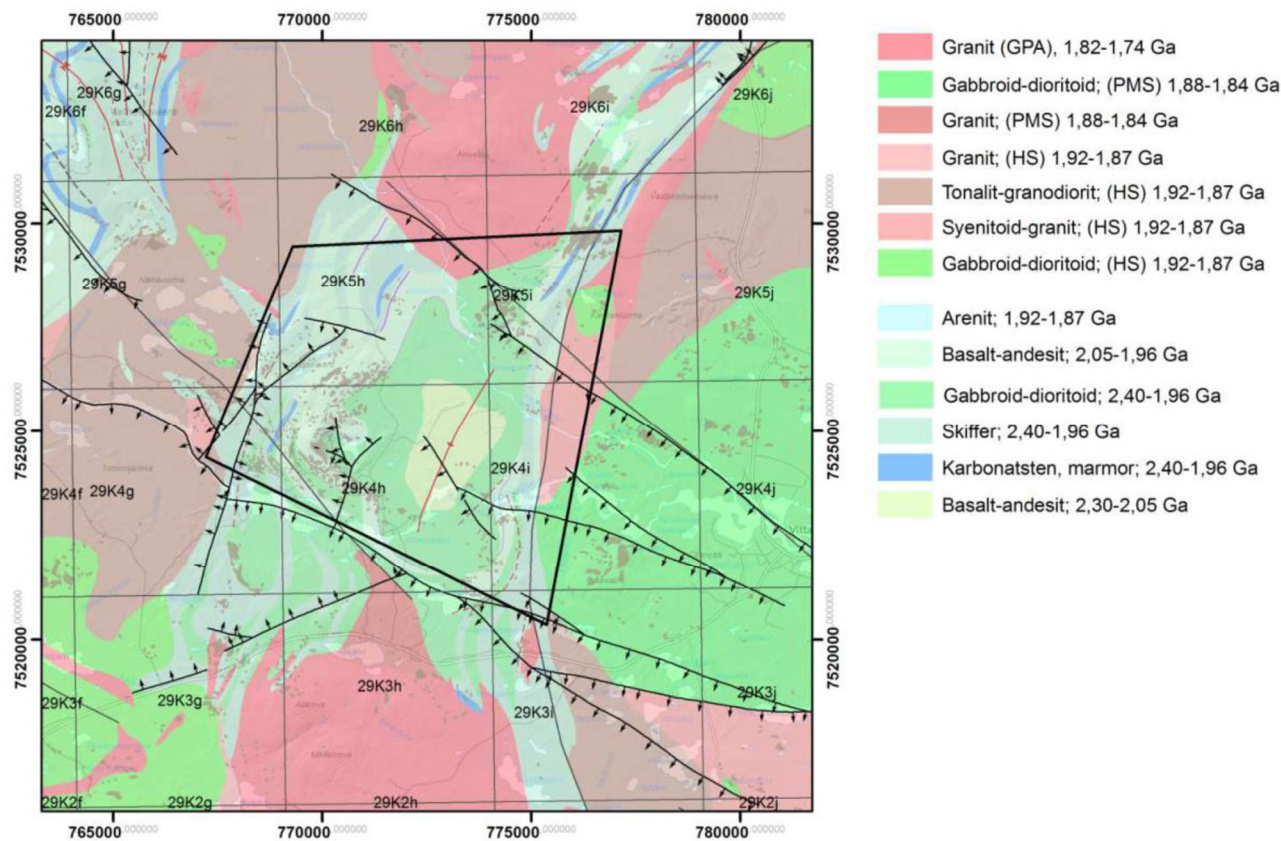


Figure 2-4 Geological map (Lynch and Joern Berger, 2013)

The soils type and thickness varies significantly across the project area and the surface soil map is provide in Figure 2-5.

At Hosiorinta hill, the bedrock daylights or it is covered with a thin layer of moraine. In low-lying areas, the soils are deeper and comprise peat and moraine (as observed by GHD onsite).

Southeast of Lake Hosiojärvi are glacial and fluvial deposits consisting of clayey sand and gravel. Further south of Hosiorinta are sandy and gravelly materials with strands of glacial structure from higher to lower terrain. Occasional glacial relicts also occur in a northerly direction while most are directed to the south. Further south and along the River Torne are glacial sediments.

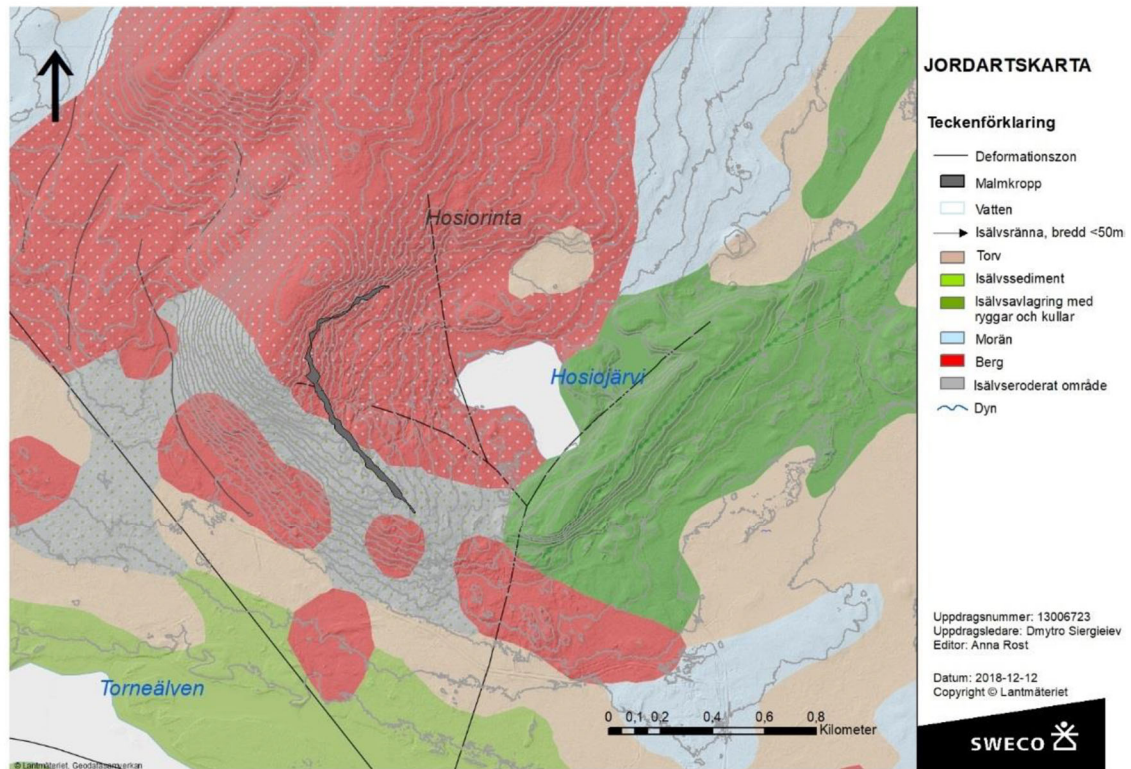


Figure 2-5 Soil Map (Sweco, 2019)

In early 2019, Golder was commissioned by Talga to conduct an introductory soil survey in a defined area surrounding Nunasvaara and the outcomes of the soil survey were provided in Golder (2019b). The purpose of the survey was to identify, at a high level, areas and quantity of suitable soil (till) to be potentially used for the IWF construction and the mine site closure activities. The survey included a desktop study, a site visit, test pitting, soil sampling, ground penetration radar survey and laboratory testing. The suitability of in situ soil for construction was investigated in four areas shown in Figure 2-6 and the IWF is proposed to be located within area B (Section 7.2).

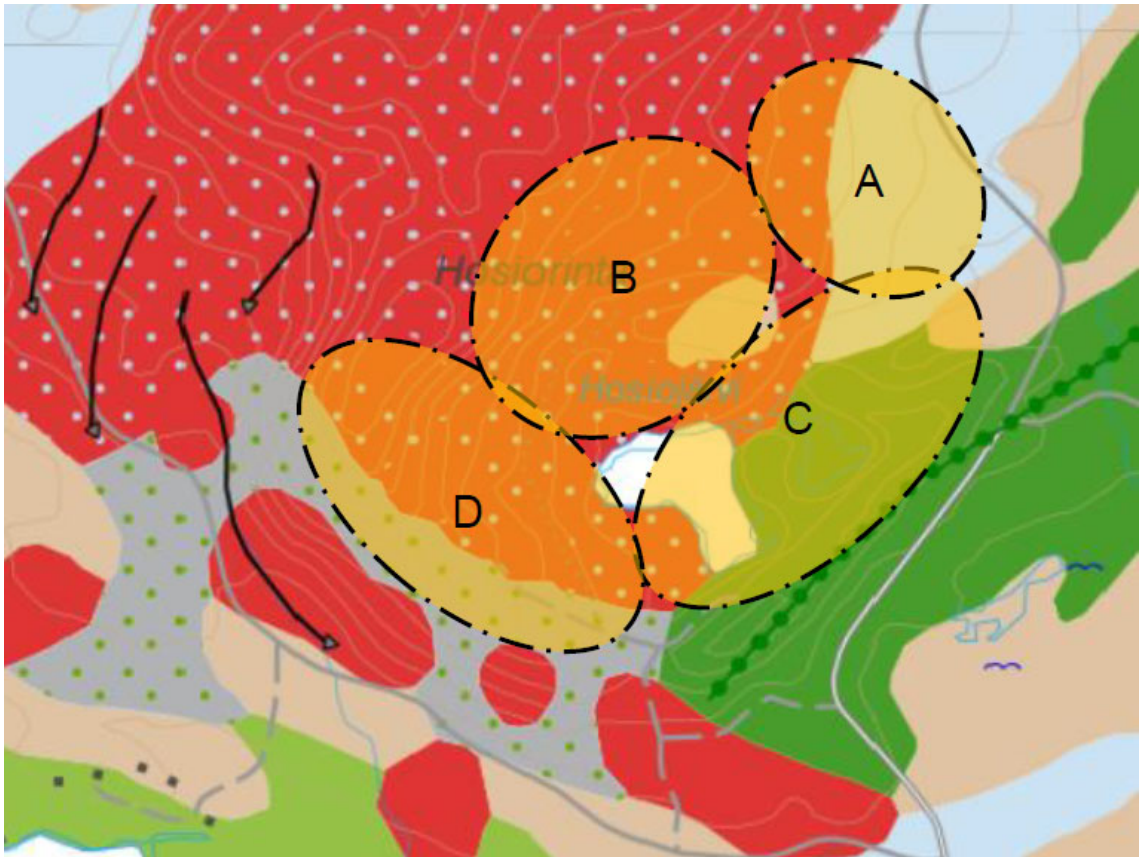


Figure 2-6 Areas selected for the soil survey evaluation (Golder 2019b)

Golder (2019b) concluded that the estimated soil depth across area B was less than 1 m based on the high gamma radiation level and the soil map that described the area as bedrock with a thin or partly not present soil layer of till.

Golder later advised (via email dated 29 November 2019) that based on field observations and test pits carried out onsite, the local soil depth at the IWF area is likely to be in the range of 3 m to 4 m. In addition locally elevated areas throughout the site may consist of rock outcrops or boulders, but generally the soil was overlying fresh rock

Areas A and C were identified as containing sources of low permeable clayey soils and the analysed soils from within these areas indicated to be dense and with a low permeability. If the naturally occurring soils were to be used as a low permeability liner, Golder (2019b) recommended the soils to be mixed with bentonite or other agent.

Based on the information provided in Golder (2019b), GHD assumed that suitable materials for construction of the clayey liner and closure capping would be found within 5 km from the IWF. GHD also assumed that the borrowed soils would be mixed with bentonite to reduce the permeability of the liners.

In addition, as there was some uncertainty over the soil coverage at the IWF site and the likely foundation conditions, GHD has provided a design that is relatively independent on the foundation conditions, whether it is determined to be residual soils or fresh rock.

2.5 Surface water

The main water feature of the project area is Lake Hosiojärvi, which collects streamflow from numerous watercourses from the surrounding hills. Water from the lake drains through a small stream that runs in the north-east direction to enter a larger system of streams, which forms a tributary of the Torne River as shown in Figure 2-7.

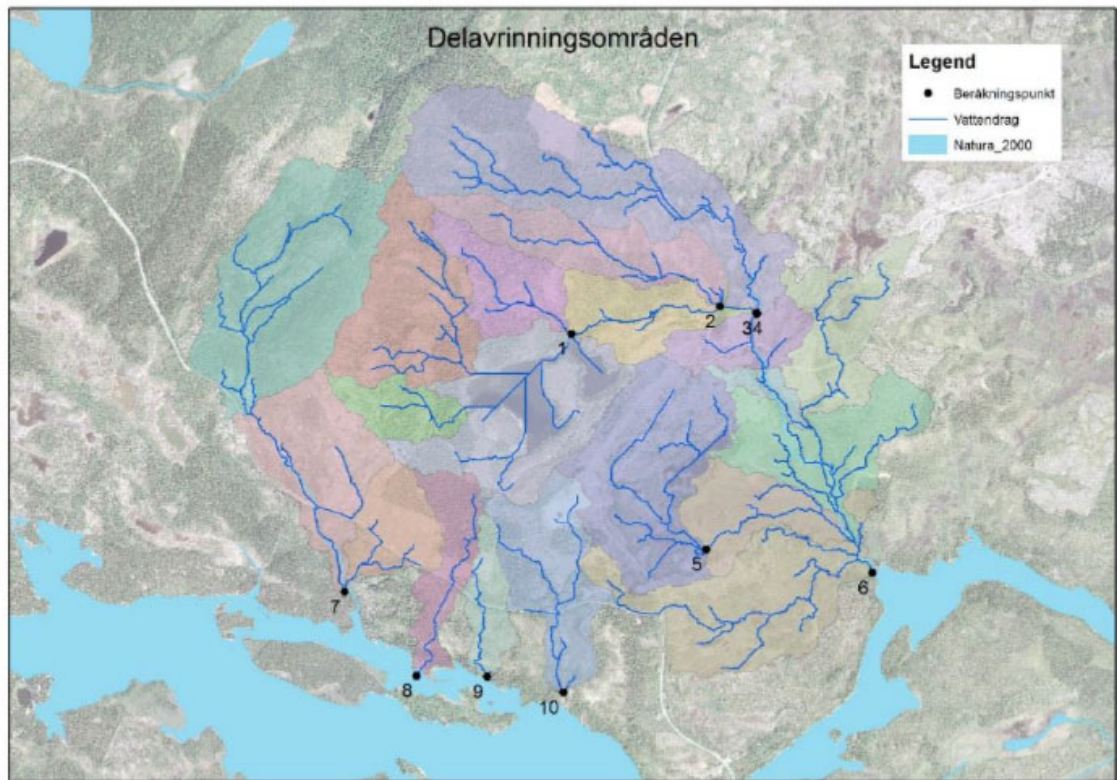


Figure 2-7 Water courses map (Sweco, 2019)

There are no recognized groundwater bodies in the immediate vicinity of the project area and the nearest groundwater aquifer is located on the south side of the Torne River about 2 km southwest of Hosiorinta. Local groundwater is present in bedrock fractures and other discontinuities.

A groundwater study completed by Sweco (2019) concluded that there is limited interaction of local groundwater in the bedrock and surface water collected in Lake Hosiojärvi. Lake Hosiojärvi is considered fully dependent on the surface water inflow from the surrounding hills.

2.6 Previous studies

The key previous studies relating to the Vittangi Project were as follows:

- *Vittangi Graphite Project, Pre-Feasibility Study Summary*, May 2019 (Talga, 2019)"
- *Mining Technical Description, Vittangi Graphite Project*, February 2019 (Golder, 2019)
- *Soil Survey, Nunasvaara, July 2019* (Golder, 2019b)
- *Hydrological and hydrogeological investigation Nunasvaara, October 2018* (Sweco, 2018)

3. Feasibility Study

3.1 Feasibility Study objectives

The objectives of the FS was to provide a concept-level design for a IWF that were:

- Designed as a dry stacking facility, which will combine the filtered tailings with mine waste to form a stable landform
- Designed to account for disposal of potentially acid forming (PAF) materials and the facility will therefore include seepage barriers and seepage recovery systems.
- Designed to be progressively closed to limit the acid forming potential of the deposited mine waste and tailings
- Sized to contain the tailings production from the Vittangi project over the agreed timeframe.

3.2 Feasibility Study Scope of Works

The agreed Scope of Works (SoW) for the FS was:

- Review of the tailings management strategy
- Carry out the trade-of study
- Develop basis of design for the dry-stack facility
- Conduct a site visit
- Option assessment
- Completed a preliminary consequence assessment of the facility
- Develop a feasibility design for the facility
- Prepare a preliminary MTO for the dry-stack facility to define the requirements for borrow materials for external shells and closure of the facility
- Prepare a risk assessment for the dry-stack facility
- Prepare a tailings governance principles document
- Prepare a feasibility study report for the dry-stack facility
- Prepare up to 10 preliminary design drawings for the dry-stack facility

3.3 Scope of work exclusions

The following was excluded from GHD's SoW:

- Tailings Filtration test
- Design of the tailings thickener and filter plant
- Design of the tailings delivery system between the filter plant and the IWF
- Design of electrical or power systems
- Mechanical design for water return works
- Selection of unit rates for cost estimate

3.4 Battery limits

3.4.1 General

Battery limits were agreed where there were interfaces between the IWF and other components of the mining operations. The sections below detail the interfaces and the respective battery limits.

3.4.2 Tailings filtration and filter cake transport

An interface was identified to exist between the production and materials handling of filtered tailings.

The agreed battery limits for the dry-stack facility design for the filtered tailings delivery is at the perimeter of the dry-stack area. Note that selection and management of the mine fleet used to place the filtered tailings at the IWF was also agreed to be outside of the scope of this study.

3.4.3 Mine waste transport

An interface was identified to exist between the production and materials handling of the mine waste to be used in the construction of the IWF and as co-disposal material.

The battery limits for the dry-stack facility design for the mine waste delivery is at the perimeter of the dry-stack area

The distribution and placement of the mine waste at the dry-stack facility will be included in design, however, the design of the haul road between the co-disposal facility and the mine pits as well as the selection of mine fleet to be used was outside GHD's scope.

3.4.4 Surface water management

An interface was identified to exist between the surface water management associated with contaminated water and the water treatment plants downstream of the IWF.

In addition, an interface was identified to exist between the surface water management associated with uncontaminated water and infrastructure downstream of the IWF (i.e. roads).

The agreed downstream battery limit is the points of discharge/collection of clean and potentially contaminated water at the boundary of the IWF.

The agreed upstream battery limit for the surface water management was the boundary of the dry stack area which was later defined by the haul road north of the IWF.

3.4.5 Underdrainage system

An interface was identified to exist between the underdrainage system and the water treatment plants downstream of the IWF.

The battery limit for the underdrainage system will be the discharge point at the boundary of the IWF.

3.4.6 Foundation design

The proposed design for the IWF has it being founded on in-situ materials. The foundation design was based on the foundation conditions and material characteristics provided by Talga.

Planning, undertaking, supervising and preparing the results of any geological and geotechnical investigations was agreed to be beyond GHD's scope.

3.4.7 Closure

Closure concept of the dry-stack area was developed as part of this project. GHD understood that the details for closure, such as likely capping material and capping requirements, were being developed by others. As such, the closure concept presented in this report has considered the need to cap the facility upon closure.

3.4.8 Cost estimate

GHD has not provided cost estimating services for the IWF CAPEX or OPEX. Instead, it was agreed that GHD would provide a material take-off (MTO) to allow Talga to produce a CAPEX estimate.

3.5 Referenced information and data

The key previous studies relating to the Vittangi Project were as follows:

- *Vittangi Graphite Project, Pre-Feasibility Study Summary*, May 2019 (Talga, 2019)”
- *Mining Technical Description, Vittangi Graphite Project*, February 2019 (Golder, 2019)
- *Soil Survey, Nunasvaara, July 2019* (Golder, 2019b)

In addition to the above reports, the following data was provided in digital format:

- Ore bodies
- Planned mine pits
- Environmental exclusion zones –
- Areas of natural value
- Prospective graphite beds
- Heritage exclusion zones

A mine plan produced by Golder was also provided, which detailed expected mine waste and tailings production on an annual basis.

4. Project Team

4.1 Project stakeholders

The project stakeholders and their positions are shown in Table 4-1.

Table 4-1 Project stakeholders

Stakeholder	Position	Company
Peter French	Sustainability and Permitting Consultant	Talga
Duncan Turner	Engineering Manager	Talga
Catherine Hanson	Manager - Projects	Talga
Martin Phillips	Project Manager	Talga
Magnus Sundling	Design Consultant	AF Consultant

4.2 Design team

The GHD design team consisted of:

- Jiri Herza – Technical Director
- Ryan Singh – Senior Tailings Engineer
- Louise Thomas – Senior Tailings Engineer

5. Basis of Design

5.1 Basis of Design report

A Basis of Design document was produced and updated throughout the project to document the assumptions, inputs and requirements for the design.

The BoD as at the completion of the Feasibility Study was included in Appendix.

5.2 Key parameters

5.2.1 General

The following sections detail the key parameters considered in the design. All parameters can be found in the BoD (Appendix A).

In addition, the design criteria used for various components of the IWF (i.e. drainage) were stated in the relevant section in this report.

5.2.2 Purpose of facility

The purpose of the IWF is to provide a safe and economical storage of tailings and mine waste in a co-disposal facility. Section 7.2 provides further detail on the evolution of the tailings and mine waste management philosophy throughout the development of the FS.

5.2.3 Facility life

It was agreed with Talga that the base-plan for the IWF would be to receive tailings and mine waste in a co-disposal facility from the mine operation years 0 to 11.

From Year 11 to end of LoM, tailings and mine waste will be co-disposed of in mined-out pits.

5.2.4 Tailings and mine waste volumes

Tailings and mine waste volumes to be stored in the IWF were derived from the mine plan produced by Golder (2019). As agreed with Talga, an assumption was made regarding the breakdown of tailings and waste that was likely to be produced each quarter as a percentage of the predicted annual throughputs (Table 5-1).

Table 5-1 Tailings and mine waste production proportions

Quarter	Tailings production proportion	Mine waste production proportion
Q1	25% (0% in Year 0)	0%
Q2	25% (33% in Year 0)	25%
Q3	25% (33% in Year 0)	50%
Q4	25% (33% in Year 0)	25%

The tonnages and volumes to be stored in the IWF is shown in Table 5-2.

In determining the annual volumes, the following placed unit densities were adopted:

- Tailings – 1.5 t/m³ (based on consolidation test results – Refer to Section 6.4)
- Mine waste – 2.09 t/m³ (provided by Golder)

Table 5-2 Tailings and mine waste tonnages and volumes for ex-pit storage

Year	Quarter	Ex-pit mine waste annual tonnage (kt)	Tailings annual tonnage (kt)	Mine waste ex-pit tonnage (kt)	Tailings tonnage (kt)	Mine waste ex-pit volume (m³)	Tailings volume (m³)	Year	Quarter	Mine waste annual tonnage (kt)	Tailings annual tonnage (kt)	Mine waste ex-pit tonnage (kt)	Tailings tonnage (kt)	Mine waste ex-pit volume (m³)	Tailings volume (m³)
0	1	607	82	0	0	0	0	6	1	370	82	0	20	0	0
	2			152	27	72,608	18,189		2			93	20	72,608	18,189
	3			304	27	145,215	18,189		3			185	20	145,215	18,189
	4			152	27	72,600	18,189		4			93	20	72,608	18,189
1	1	204	81	0	20	0	13,637	7	1	325	81	0	20	0	13,637
	2			51	20	24,402	13,637		2			81	20	24,402	13,637
	3			102	20	48,804	13,637		3			162	20	48,804	13,637
	4			51	20	24,402	13,637		4			81	20	24,402	13,637
2	1	188	81	0	20	0	13,557	8	1	289	81	0	20	0	13,557
	2			47	20	22,499	13,557		2			72	20	22,499	13,557
	3			94	20	44,998	13,557		3			145	20	44,998	13,557
	4			47	20	22,499	13,557		4			72	20	22,499	13,557
3	1	610	81	0	20	0	13,527	9	1	235	80	0	20	0	13,527
	2			153	20	72,967	13,527		2			59	20	72,967	13,527
	3			305	20	145,933	13,527		3			118	20	145,933	13,527
	4			153	20	72,967	13,527		4			59	20	72,967	13,527
4	1	610	82	0	20	0	16,5367	10	1	182	82	0	20	0	13,567
	2			153	20	72,967	16,5367		2			45	20	72,967	13,567
	3			305	20	145,933	16,5367		3			91	20	145,933	13,567
	4			153	20	72,967	16,5367		4			45	20	72,967	13,567
5	1	599	82	0	20	0	13,592	TOTAL		4,179	895	4,179	895	1,999,453	596,800
	2			140	20	66,863	13,592								
	3			279	20	133,726	13,592								
	4			140	20	66,863	13,592								

6. Tailings properties

6.1 General

Two separate testing suites were carried out on tailings samples as part of the FS stage:

- Filtration testing by two filter plant suppliers
- Geotechnical testing on filtered tailings samples

Filtration testing was carried out to determine the most suitable form of filtration for the tailings that is expected to be produced at Vittangi. The filtration testing was organised by Talga, with filtered tailings being sent from the filter plant suppliers to the geotechnical testing laboratory.

GHD was responsible for organising and providing the testing program for the geotechnical testing.

This section details the results and interpretation of the testing, as well as collates the results and interpretation of previous testing completed on the tailings samples.

6.2 Previous investigations

6.2.1 Ore and waste rock

Elemental characterisation of the was undertaken at typically 2 metre intervals from 19 drill holes resulting in 473 samples analysed before 2019.

The preliminary test results indicated highly variable content of sulphur and trace metals across the ore body as summarised in Table 6-1.

Table 6-1 Abundance and range of selected elements in Nunasvaara South ore.

Element	As	Cd	Cr	Cu	Ni	Zn	S
Unit	ppm	Ppm	Ppm	Ppm	ppm	ppm	%
Min	0	0	8	41	3	0	0,2
Median	3	0	178	310	191	5	2,6
Max	1,575	50	381	3,050	645	7,740	9,0

An initial acid rock generation testwork was undertaken on eight historical ore samples. All ore samples tested were found to be potentially acid forming (PAF) and all, but one, samples were potentially acid forming – short lag (PAF-SL). Importantly, most samples had CO₃-C values less than 0.01% and the two that had CO₃-C values at around 0,5% were inferred to contain siderites meaning the CO₃-C present is ineffective for circum-neutral buffering under unsaturated conditions. The initial testwork also found circum-neutral ore samples had water-extract-Se values up to approximately 150 µg/L, and water-extract-Ni concentrations within the multi-mg/L range.

The initial acid generation tests were completed on samples, which could were exposed to the environment for extensive period time. Therefore, the short PAF-SL potential indicated by the initial testing was not considered to be representative and more detailed acid generation tests were completed during mid 2018 to early 2019 (kinetic testing).

The more detailed assessment of the acid generation potential of the ore has focused on a waste rock deposit several hundred meters east of the trial mining area. It was assumed that the waste deposit was a result of trial mining performed by LKAB during the 1970's. Waste materials in the deposit should then were exposed to air and water for approximately 40 years.

This material was assumed to represent a scenario, in which the waste rock had been left exposed and naturally weathered.

Three test pits were dug by hand in the waste deposit down to around 700 mm. Two composite samples were collected from each test pit; one representing relatively fresh material and one consisting of mainly fine, residual soil. Simple shake tests were also performed in the field using the solid material (around 2 kg material and 4 litres of water) to obtain an indication about the already generated acidity. pH and electrical conductivity were measured using a hand-held field instrument after 24 hours.

In addition to the samples from the waste deposit at the trial mining area some composite samples (as chip samples) were also sampled from waste piles in the northern part of the concession area Nunasvaara South.

Four composite samples, for large kinetic testing were selected from already available drilled cores. The sampling represented the four rock types proposed to be mined: ore, hanging wall, footwall and dyke. The composite samples were sized in a jaw crusher before being placed into plastic containers. The weathering process was promoted by exposing the samples to dry and moist air for ½ week each. Distilled water was added to the samples on weekly basis to maintain moist conditions before sampling. Sampling was performed by adding distilled water corresponding to L/S 0.1 each week. After one hour added water was drained and collected for chemical analysis.

Samples from the field work was analysed for elemental content by ALS. Composite samples from the large kinetic tests were sent for analysis with respect to acid-base accounting (ABA), total element concentrations and mineralogy. Leachates from the large kinetic tests were analysed for pH, electrical conductivity, alkalinity, sulfate and element concentrations.

From the shake tests performed on the material from the old waste deposit it is clear that acid production was either ongoing or had ceased with an average pH around 4. pH was also generally lower in the fine material indicating the presence of secondary weathering products from the original waste rock and not only overburden. Electrical conductivity was rather low, indicating that the current acid generation has peaked or is rather low or even has stopped.

The acid-base-accounting test results demonstrated that three of the composite samples (HGW, Sgr and FW) were potentially acid generating while one sample (Dyke) was not. The test results confirmed the acid generating potential of the ore determined in earlier work by Campbell (2018).

Ongoing large kinetic tests do show acid generation after around 17 weeks from the Sgr sample. Sulfate analysis indicate a sulfide oxidation rate (SOR) of between 18 and 32 mg SO₄ 2-/kg/week. Preliminary elemental analysis of the leachates indicate that cobalt, nickel and copper are possible problematic elements, also at circum neutral pH. Element concentrations will be determined in all leachates from the initial 20 weeks.

There is still no acid generation from the FW and HGW samples after 20 weeks of testing. It must, however, be noted that 20 weeks are to be considered a very short time period in order to determine when acid will be formed. The ongoing kinetic study indicate that the evolution of acid drainage might not be as fast as was indicated by earlier laboratory studies.

Altogether it is clear that waste rock from Nunasvaara South will eventually generate acid rock drainage. Acid-base-accounting indicate a significant acid generating potential and the samples from the old waste deposit was acid. It is, however, hard to predict exactly when the acid will form.

There is a risk that, at least the ore samples (Sgr), can react spontaneously with added explosives prior to ignition. This means that there is a risk for premature detonation during

blasting. It also means that there is a risk for spontaneous combustion of waste rock containing high concentrations of graphite. Waste piles allowing for convective flow of air should therefore be avoided.

The tailings will be generated as part of the processing, whereby the acid forming minerals present in the ore are retained in the tailings. Therefore, the acid forming characteristics of the ore samples (Sgr) are considered conservatively indicative of the tailings.

6.2.2 Previous tailings testing

Tailings properties were tested by Talga as part of the tailings option study. However, it was found that the tailings samples were significantly contaminated with the mill grinding media (Ceria-zirconia minerals). Therefore, the tailings sample and the associated test results were not considered to be representative of the actual tailings produced at the mine..

6.3 Feasibility study filtration testing

6.3.1 General

Tailings slurry samples were sent to two separate filter plant suppliers:

- Diemme filtration (Diemme)
- Outotec

6.3.2 Diemme filtration results

Diemme carried out filtering of the tailings slurry utilising a plate filter press.

No formal reports from the Diemme filtration tests were provided to GHD for review so the filtering process is not understood. However, an achieved average moisture content of 26% was reported by Diemme.

It was noted that this average moisture content was calculated using the formula:

$$\text{Moisture content (\%)} = \text{mass of water} / \text{mass of the total tailing cake (including water)}$$

Traditionally, moisture content of soils is calculated as:

$$\text{Moisture content (\%)} = \text{mass of water} / \text{mass of **dry solids**}$$

As a result the reported moisture content was estimated to have greatly under-reported the achieved moisture content. It was later estimated that the actual achieved moisture content was closer to 39%, using the traditional moisture content equation.

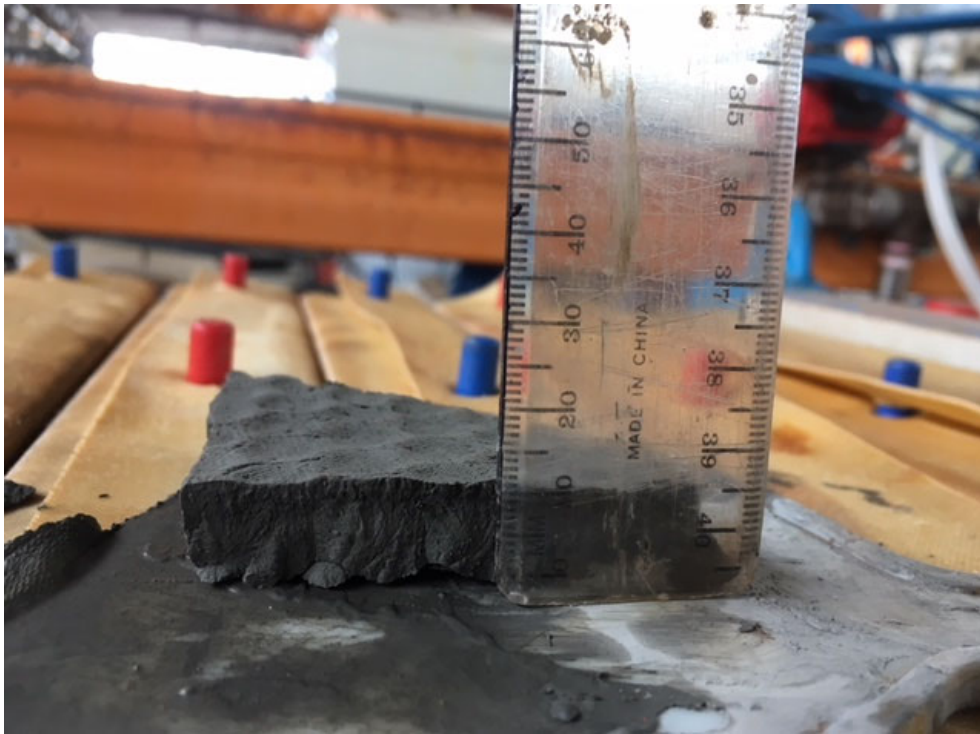
Photograph 6-1 to Photograph 6-3 (supplied by Diemme) shows the final filter cakes.



Photograph 6-1 Diemme filter cake (1)



Photograph 6-2 Diemme filter cake (2)



Photograph 6-3 Diemme filter cake (3)

6.3.3 Outotec

Outotec carried out filtering of the tailings samples using their Membrane Filter Press (MFP) process. The Outotec filter test report is provided in Appendix B.

The tailings slurry was adjusted to 45% solids, as specified by Talga to match the thickening testwork.

Filtering was then carried out for full cycle test runs in two chamber sizes:

- 25 mm
- 40 mm

An initial run was completed for both chambers, which consisted of slurry being pumped into the chamber until it was filled to capacity. The chambers were then pressed to dewater the slurry. The process was completed until no further filtrate was extracted. Air-drying of the filter cake was then completed to force residual water from the cake.

For the subsequent runs were then completed to increase the filtration performance. Increased drying pressure for the 40 mm chamber was completed to improve the dewatering during the air-drying phase.

Figure 6-1 presents the results for the initial run and final subsequent run. For the 25 mm chamber, the majority of filtrate was collected in the first two minutes, with minor filtrate being collected thereafter. For both the initial and optimum runs, approximately 0.3 kg of filtrate was collected.

For the 40 mm chamber, the majority of filtration for the initial run and final subsequent run was collected in the first 3.5 minutes, with a large majority of the filtrate being extracted between 3 and 3.5 minutes. Approximately 0.5 kg of filtrate was collected for the 40 mm chamber.

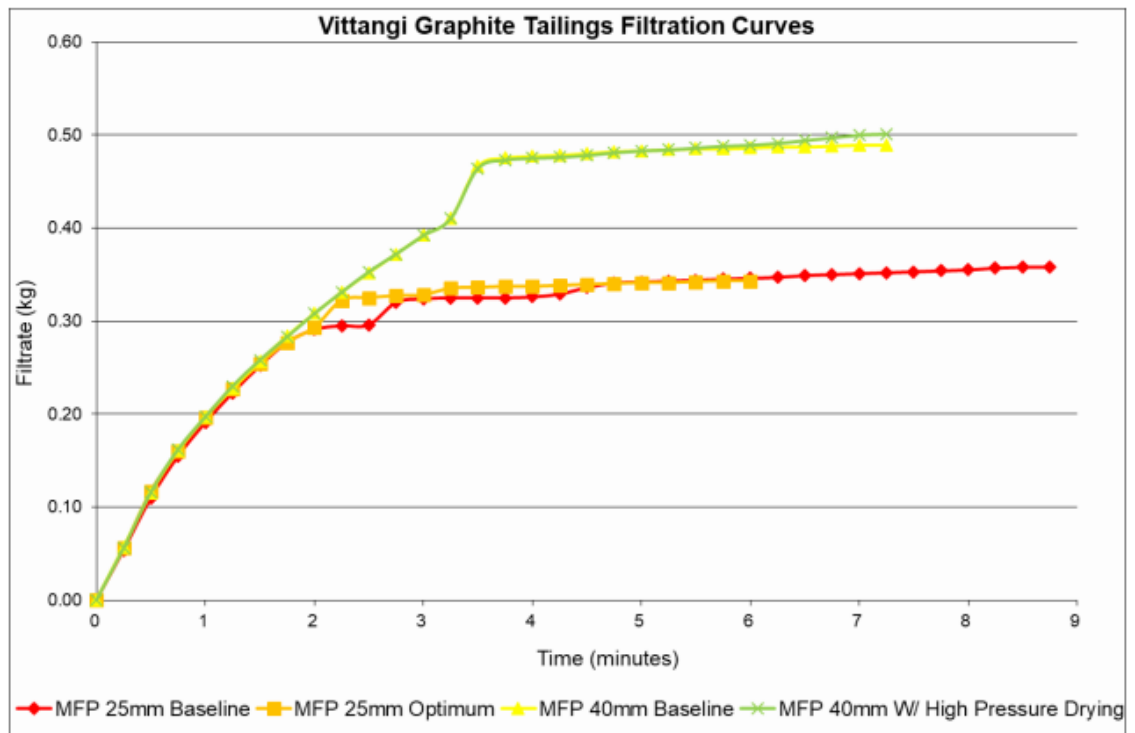


Figure 6-1 Filtration curve for the tailings sample

Figure 6-2 presents the moisture content over time for air-drying. For the 25 mm chamber, the majority of drying occurred in the first three minutes and for the 40 mm chamber, within the first five minutes. The use of high-pressure drying increased the reduction in moisture content, as expected.

For the 25 mm chamber, the achieved filter cake moisture contents were 21.9% and 24.8%. For the 40 mm chamber, the filter cake moisture contents were 25.3% and 26.4%.

Photograph 6-4 presents a filter cake with a moisture content of 25.3%.

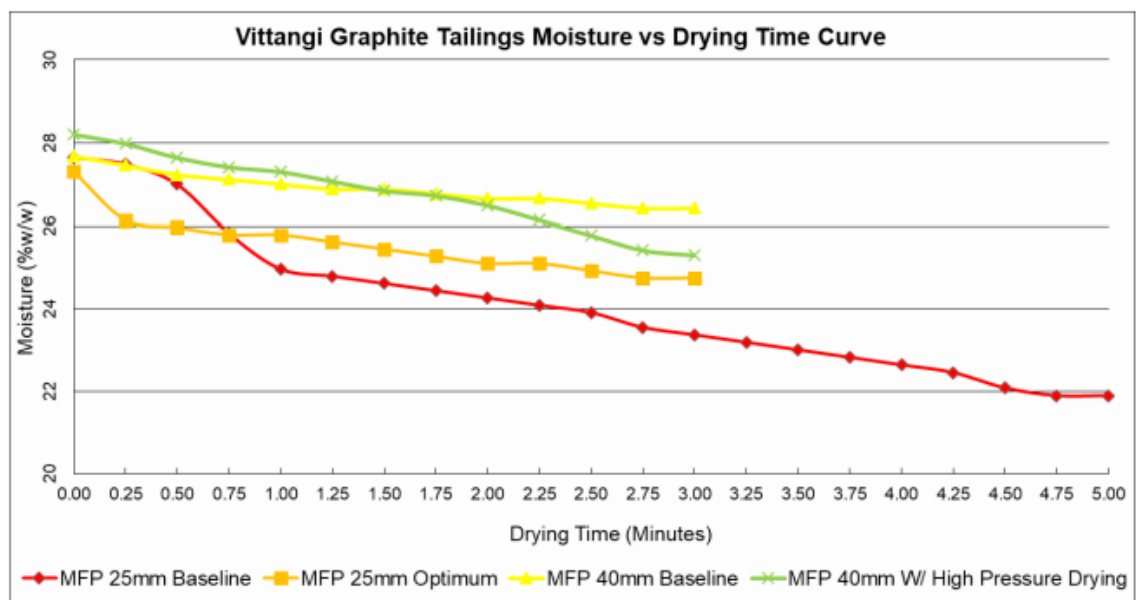


Figure 6-2 Air-drying time vs moisture content



Photograph 6-4 Filter cake with a moisture content of 25.3%

The results for the 40 mm chamber was presented by Outotec, as follows:

- Test filtration rate – 62 kgD.S/m²h
- Average cake thickness – 33 mm
- Moisture content – 25.3%

It should be noted that filter tests for graphite concentrate was also undertaken, as well as rheology testing for both tailings and graphite concentrate, however, review of these results is outside the scope of this study.

6.3.4 Interpretation of results

The results, specifically from Outotec, indicate that the tailings can be successfully filtered using plate and membrane filters. The moisture content of the filter cake was just above or below the plastic limit of the tailings (Section 6.4.2) depending on the chamber cell and the drying time.

The tailings slurry that are expected to be produced can be filtered via filter press methods. In addition, the resultant filter cakes should be able to be handled and transported, as required.

6.4 Feasibility study geotechnical testing

6.4.1 General

Geotechnical testing was carried out on samples of filtered tailings cake which was sent from Diemme. Three bulk samples were provided:

- VITT-0001-DO1S
- VITT-0001-DO2S
- VITT-0001-DO3S

The following testing was carried out:

- 3 no. classification testing:

- Moisture content
- Particle size distribution (PSD)
- Soil particle density (Specific density, G_s)
- Atterberg limits
- 1 no. Emerson class
- 1 no. shrink-swell index
- 1 no. Oedometer consolidation test
- 1 no. Rowe cell consolidation test
- 1 no. Multi-stage triaxial test
- 1 no. Single stage triaxial test
- 3 no. pH measurement

Based on the results of the testing, the tailings can be classified as low plasticity and poorly graded silts, which are relatively incompressible and impermeable. Further detail on the results of the test are provided below.

6.4.2 Classification test results

A summary of the classification test results is shown in Table 6-2.

Generally, the classification tests indicate that the three samples were homogenous.

In addition, the estimated moisture content of each sample indicates that the filter cakes supplied by Diemme had actual average moisture content of 38%. This should be compared to the average liquid limit of 42%. Based on the achieved average being relatively close in percentage to the liquid limit, the proposed filtration method presented by Diemme would be unlikely to achieve filter cakes that would be suitable for the transportation and placement methods proposed by Talga and in this study.

The PSDs indicate that that tailings has a large fines fraction (93% average) and a significant clay sized fraction (30%) (Figure 6-3). The coefficient of uniformity was calculated for each sample

The estimated Atterberg Limits indicate that the fines in the tailings were on the border of the A-Line, with the fines likely to behave like intermediate clays or low plasticity silt (Figure 6-4).

The Emerson Class of 6 (estimated for Sample 1) indicates that the tailings would be unlikely to dispersive, even with remoulding and disturbed in water.

The estimated pH of the three samples indicate that the filtered tailings was neutral, or very slightly acid of neutral (<6).

Table 6-2 Summary of filter cake classification tests

Sample	Moisture Content (%)	Solid Content (%)	SG	Fines content (% <75 microns)	Clay sized content (% <2 microns)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	Linear Shrinkage (%)	Emerson Class	Shrink-Swell Index (I _{ss})	pH
VITT-0001-DO1S	36.4	73.3	2.86	92	27	39	26	13	4.0	6	1.9	5.8
VITT-0001-DO2S	35.2	74.0	2.87	93	27	42	25	17	4.0			5.8
VITT-0001-DO3S	42.8	70.0	2.79	93	35	46	30	16	4.5			6.0

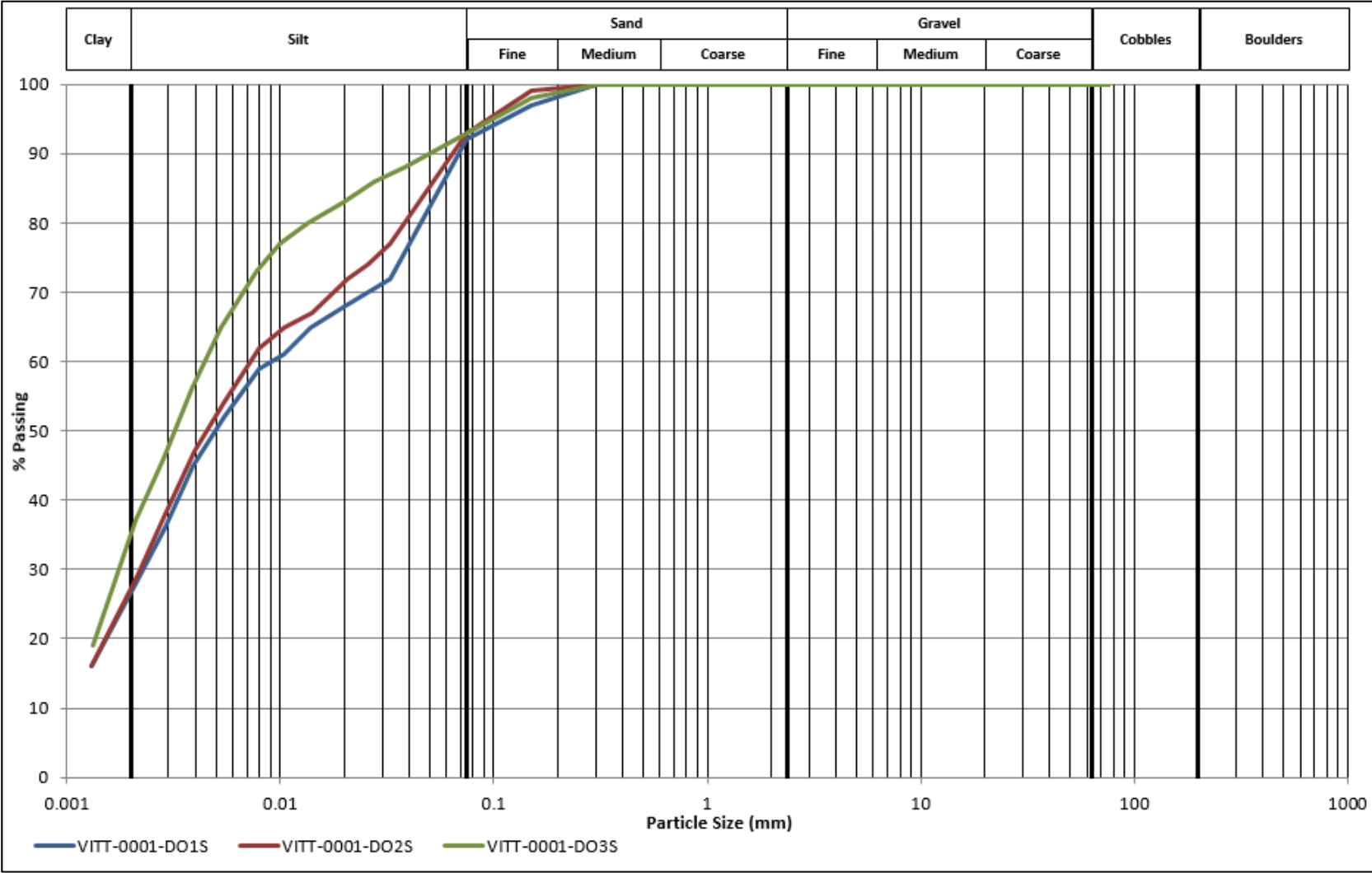


Figure 6-3 PSD results – filtered tailings

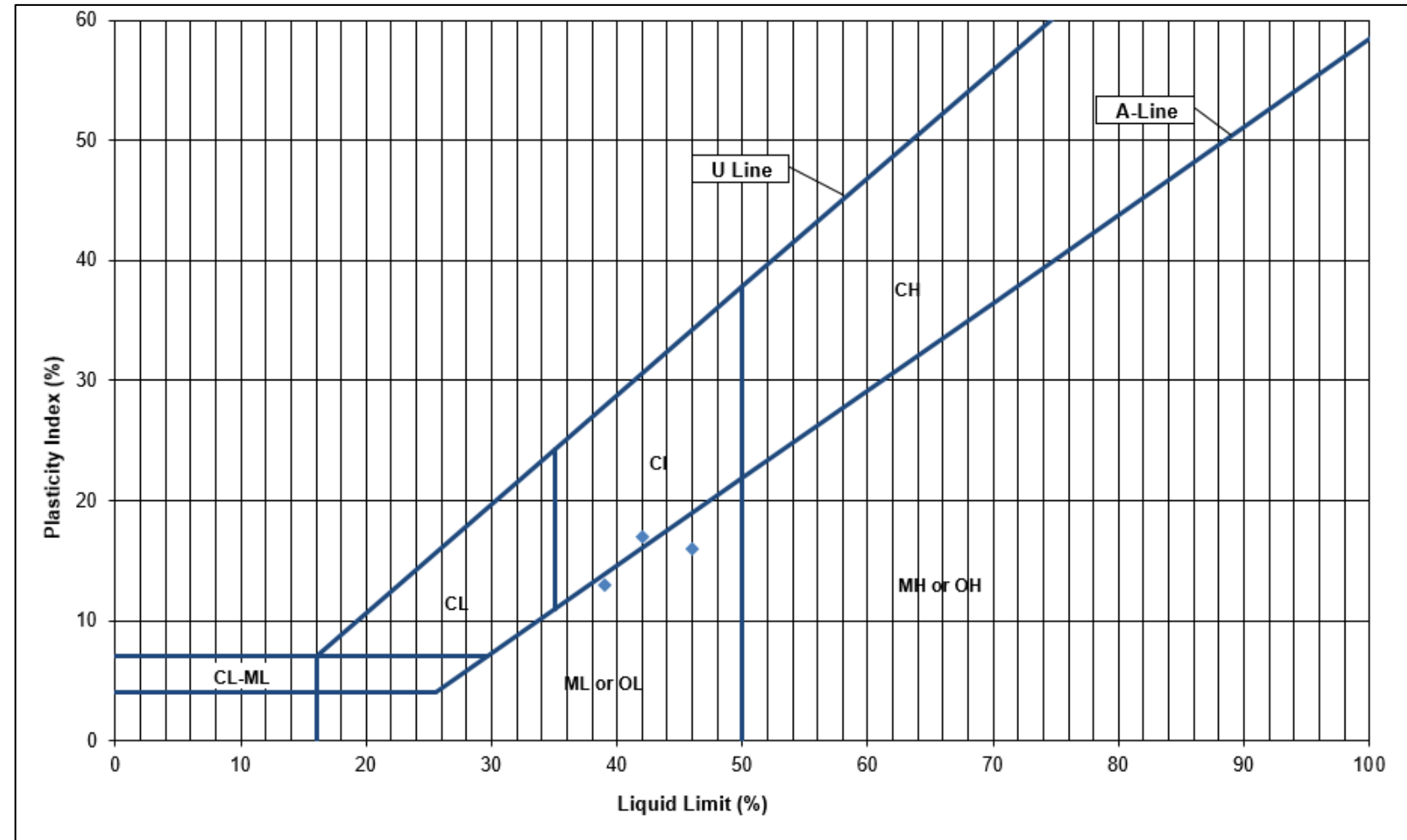


Figure 6-4 Atterberg limit results – filtered tailings

6.4.3 Consolidation test results

Consolidation is the reduction of volume of saturated soil as a result of dissipation of pore pressures under vertical loading.

Understanding how the tailings will act during consolidation is important. Over the life of the facility, the amount of tailings and mine waste within the facility will increase, resulting in increasing vertical loads on the tailings already stored within the facility. As such, having an understanding of the amount of consolidation settlement that will be expected will allow appropriate measures to be implemented to counteract ongoing settlement during operation and closure.

Two tests were carried out to determine the behaviour of the filtered tailings during consolidation:

- Oedometer consolidation test
- Rowe Cell test

The Oedometer consolidation test was carried out on a mixed bulk sample of tailings. The sample was prepared to an initial moisture content of 32.33% and dry density of 1.46 t/m³.

The sample was loaded over nine stages, with increasing vertical pressures, from 6 kPa to a maximum vertical load of 1,600 kPa. The sample was then unloaded from this maximum vertical stress back to 6 kPa over four stages. The sample height was monitored after each incremental load stage to determine the change of height after primary consolidation was believed to have finished. For reference, the specified maximum vertical stress of 1600 kPa is approximately equal to loading due to 78 m of mine waste at the assumed unit mass of 2.09 t/m³ (Section 5.2.4).

This change in height was then used to determine the tailings void ratio at the end of each consolidation stage.

The results of the Oedometer consolidation test with respect to applied vertical stress and void ratios is shown in Figure 6-5. The final moisture content was 27.13% and had a dry density of 1.59 t/m³.

The calculated compression index, which indicates the decrease in void ratio (and therefore decrease in volume) for a unit increase in log vertical stress, was 0.108. This compression index indicates that the filtered tailings is relatively incompressible under loading. As a result, the settlement of the tailings due to consolidation from ongoing loading of tailings and mine waste within the facility was expected to be negligible over the life of the facility. Further detail is provided in Section 10.7.

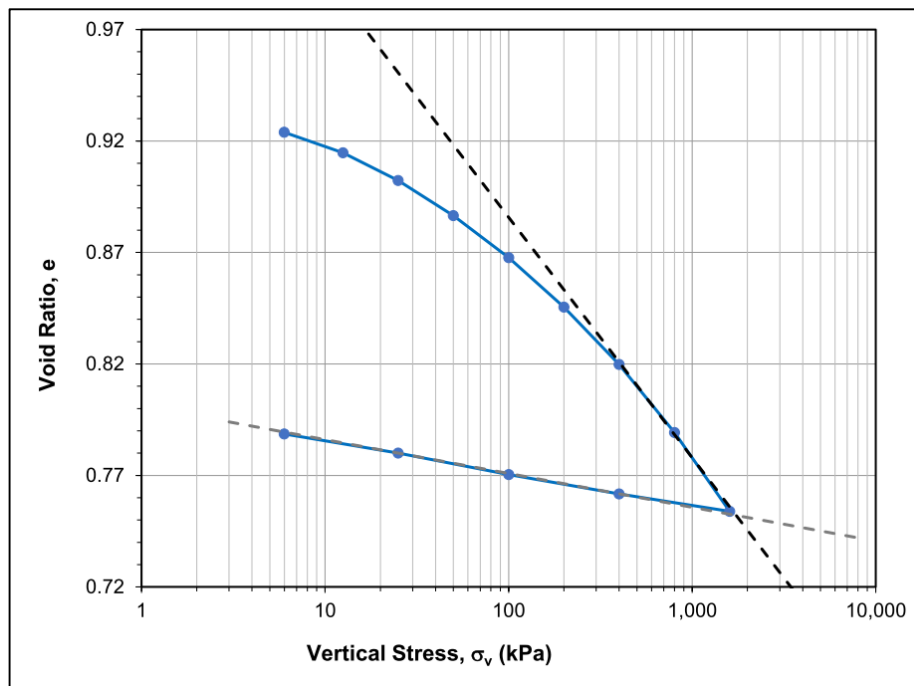


Figure 6-5 Oedometer consolidation test result - filtered tailings

The Rowe Cell test was carried out on a sample of tailings from VITT-0001-DO1s.. The sample was prepared to an initial moisture content of 55.02% and dry density of 1.12 t/m^3 . The sample was loaded over nine stages from an initial pressure of 10 kPa to 650 kPa. The sample was then unloaded over five stages back to the initial vertical stress.

In addition to measuring the void ratio over each loading stage, the permeability of the material was estimated using two pressure head differences: 5 kPa and 10 kPa. The following was measured during the Rowe Cell test:

- Coefficient of consolidation, c_v (m^2/year) – The rate of consolidation over time when a soil is subjected to vertical loading
- Coefficient of compressibility, m_v (m^2/kn)– defined as the volume change per unit increase in effective stress
- Coefficient of permeability, k (m/s) – The measured permeability of the material at each loading stage.

The void ratio against each loading stage, as well as the measured values for the above parameters are shown in Figure 6-6 and Table 6-3.

The results shown in Figure 6-6 and Table 6-3 agree with the Oedometer test results indicating that the tailings are relatively incompressible, especially for void ratios lower than 1.0.

In addition, the calculated and measured permeability indicate that the tailings is relatively impermeable, even at high void ratios.

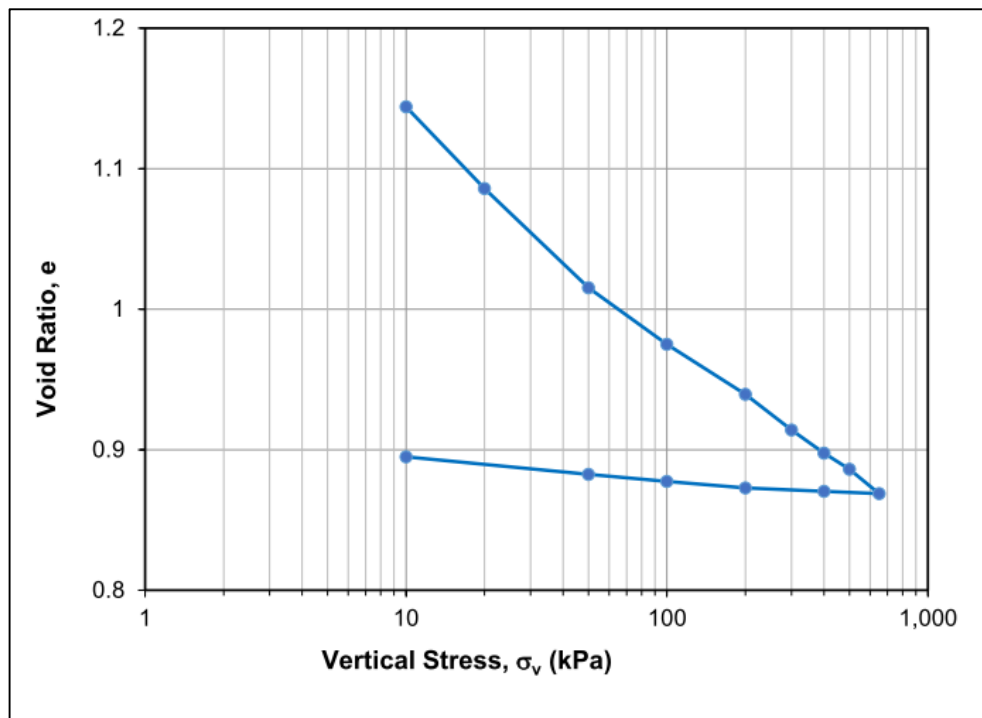


Figure 6-6 Rowe Cell test results - filtered tailings

Table 6-3 Rowe Cell test parameters - filtered tailings

Stage		Vertical Stress	Void ratio	Coefficient of			
				Consolidation, c_v	Compressibility, m_v	Permeability, k	
Type	No.	σ_v kPa	e	m^2/year	m^2/kN	Calculated m/sec	Measured m/sec
Loading	1	10	1.144	-	-	-	-
	2	20	1.086	89.0	2.7E-03	7.5E-08	2.5E-08
	3	50	1.015	135.2	1.1E-03	4.7E-08	2.0E-08
	4	100	0.975	137.0	4.0E-04	1.7E-08	1.8E-08
	5	200	0.939	220.9	1.8E-04	1.2E-08	1.6E-08
	6	300	0.914	235.0	1.3E-04	9.5E-09	1.4E-08
	7	400	0.898	237.8	8.6E-05	6.4E-09	1.4E-08
	8	500	0.886	107.4	6.0E-05	2.0E-09	1.3E-08
	9	650	0.869	246.8	6.2E-05	4.7E-09	1.2E-08
Unloading	10	400	0.870	-	3.5E-06	-	-
	11	200	0.873	-	6.6E-06	-	-
	12	100	0.877	-	2.5E-05	-	-
	13	50	0.882	-	5.4E-05	-	-
	14	10	0.895	-	1.7E-04	-	-

6.4.4 Triaxial tests

Two separate triaxial tests were carried out on bulk mixed tailings samples:

- 1 no. multi-stage isotropic-consolidation undrained (CIU) triaxial test
- 1 no. single stage CIU triaxial test

The samples for testing were prepared to a dry density of 1.43 t/m³ and an initial moisture content of 28%. These initial conditions were elected to replicate the tailings filter cakes that could be expected (Section 6.3).

Subsequent stages of the multi-stage triaxial test was carried out at increasing isotropic consolidation pressures:

- 50 kPa
- 100 kPa
- 400 kPa

The single stage triaxial test was carried out at a higher initial isotropic consolidation pressure of 800 kPa.

The summary of triaxial test results are presented in Table 6-4. In addition, the stress path for each test is shown in Figure 6-7.

The stress paths for all triaxial tests indicate that the tailings are dilative when sheared. This is further shown by the plots of deviator stress against axial strain, where no decrease in stress was noted for strains up to 20% (Figure 6-8).

An estimate of peak shear strength has also been indicated by the dashed line in Figure 6-7. This line represents the following shear strength parameters:

- $\Phi' = 33.4^\circ$
- $c' = 0 \text{ kPa}$

To allow a linear line to be drawn, it can be seen that the estimated peak strength underestimates the shear resistance for higher confining pressures.

Table 6-4 Summary of triaxial test results - filtered tailings

Sample ID	Stage	Consolidation		Loading Rate	Results			
		σ'_v	σ'_h		q_{\max}	$q_{\text{stage end}}$	$\varepsilon_{a-q_{\max}}$	$\varepsilon_{a-\max}$
	No.	(kPa)	(kPa)	(mm/min)	(kPa)	(kPa)	(%)	(%)
Combined – VITT-0001-DO1S, VITT-0001-DO2S VITT-0001-DO3S	1	52	50	0.1	44.2	44.2	1.09	1.09
	2	102	100		109.3	109.2	5.03	5.04
	3	402	400		822.0	822.0	17.7	17.7
	1	802	800	0.1	1380.3	1379.3	21.5	22.0

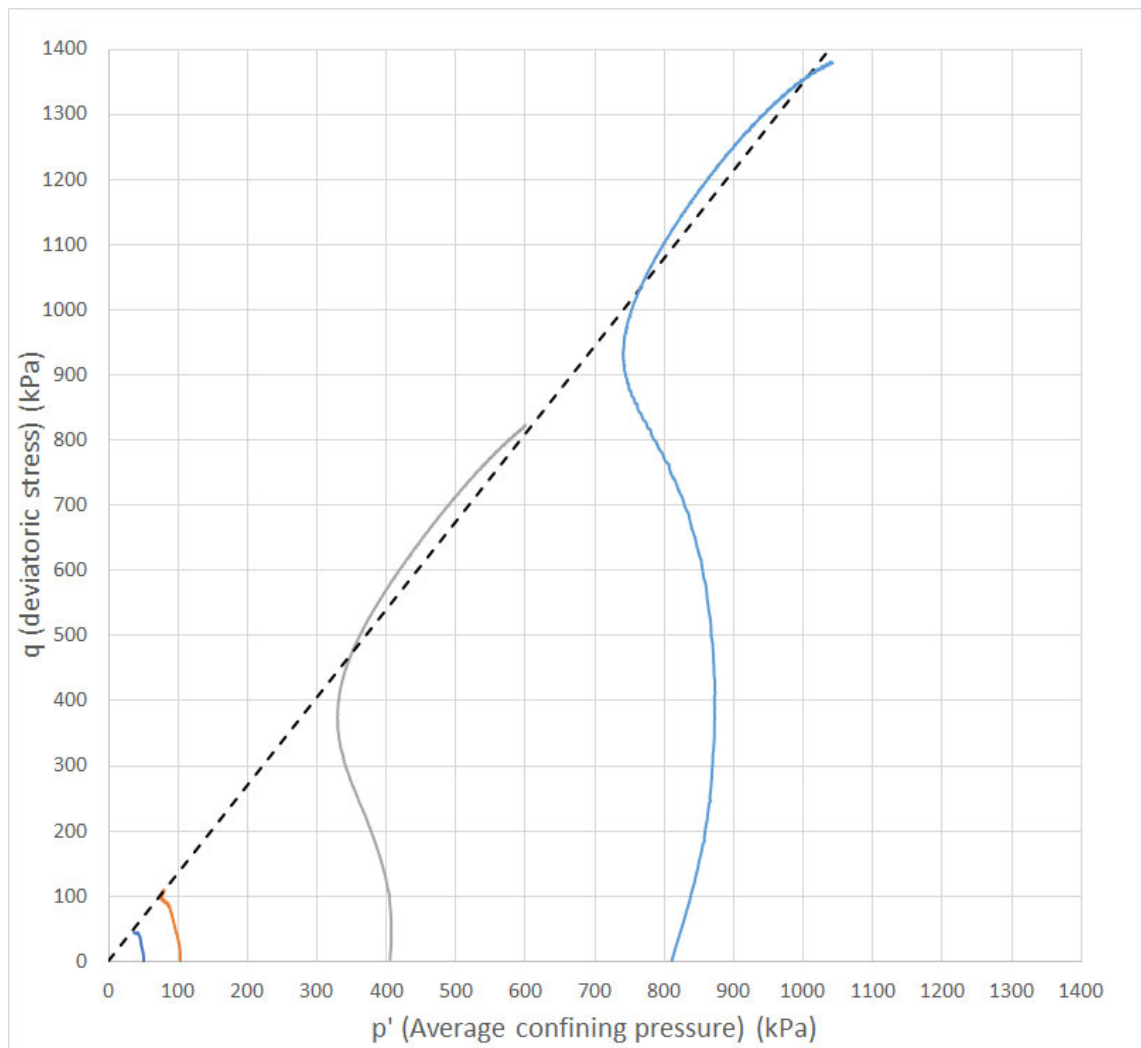
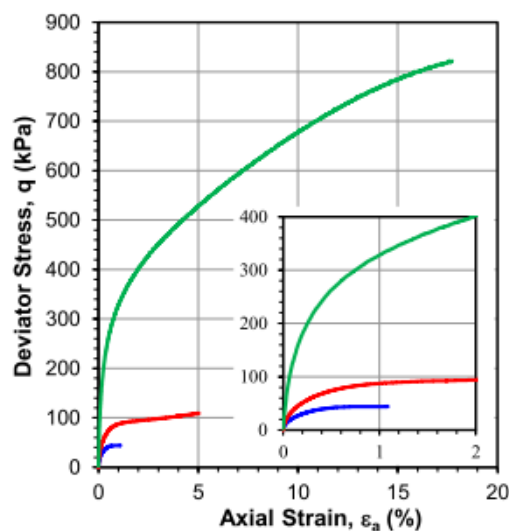
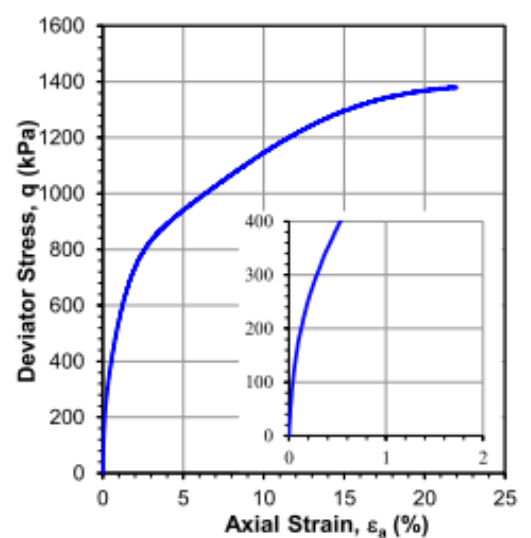


Figure 6-7 Stress paths for triaxial tests- filtered tailings



a) Multi-stage triaxial



b) Single stage triaxial

Figure 6-8 Axial strain vs Deviator stress - filtered tailings

7. IWF location and arrangement

7.1 Key criteria

The IWF design and staging was formulated with consideration to the following key criteria:

- Properties of the filtered tailings to be stored within the IWF
- Volume of tailings and mine waste to be stored over time
- Ability of the proposed design to allow co-disposal of tailings mine waste
- Managing the potentially acid-forming nature of the mine waste and tailings
- Available location of the facility
- Proximity to the mine pits and filter plants
- Use of haul trucks to deposit tailings and mine waste, with a dozer to be used to maintain the placed material
- Closure of the facility, including the desire to progressively close the facility
- Consequence of the facility failure

The following section details the development of the IWF design and staging throughout the design process.

7.2 Location of IWF

Several locations were considered for the IWF. The locations and order of consideration are shown in Figure 7-1.

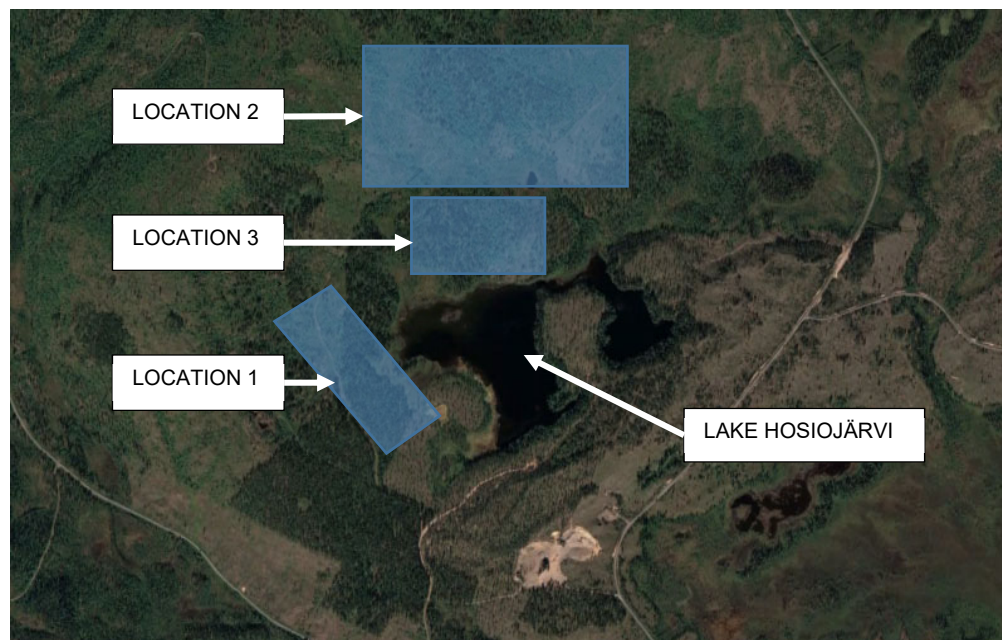


Figure 7-1 Locations considered for IWF

Location 1 was originally designated in the 2019 Golder study as the location for the mine waste and tailings facility. Location 1 was bounded by Lake Hosiojärvi to the east and the hillside to the west, which contains the ore bodies.

A nominal IWF shape, which could store the LoM tailings and mine waste, is shown in Figure 7-2. However, this location and the resulting IWF shape was determined to be unsuitable for the following reasons:

- Proximity to the proposed mine pits, which was likely to cause issues with haul road access, especially when considering the increasing footprint of the IWF over time. This is illustrated in Figure 7-3, with the ore bodies illustrated in red.
- Proximity to Lake Hosiojärvi, where the foundations of the IWF would be marshland, resulting in excessive differential settlements across the IWF over time

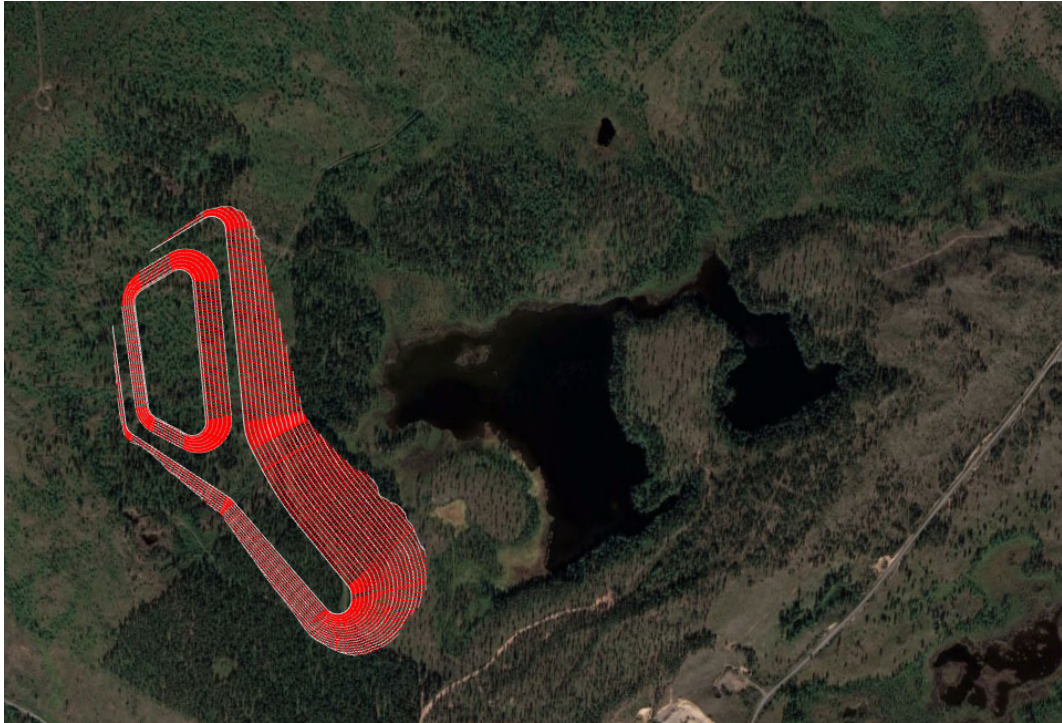


Figure 7-2 Location 1 IWF

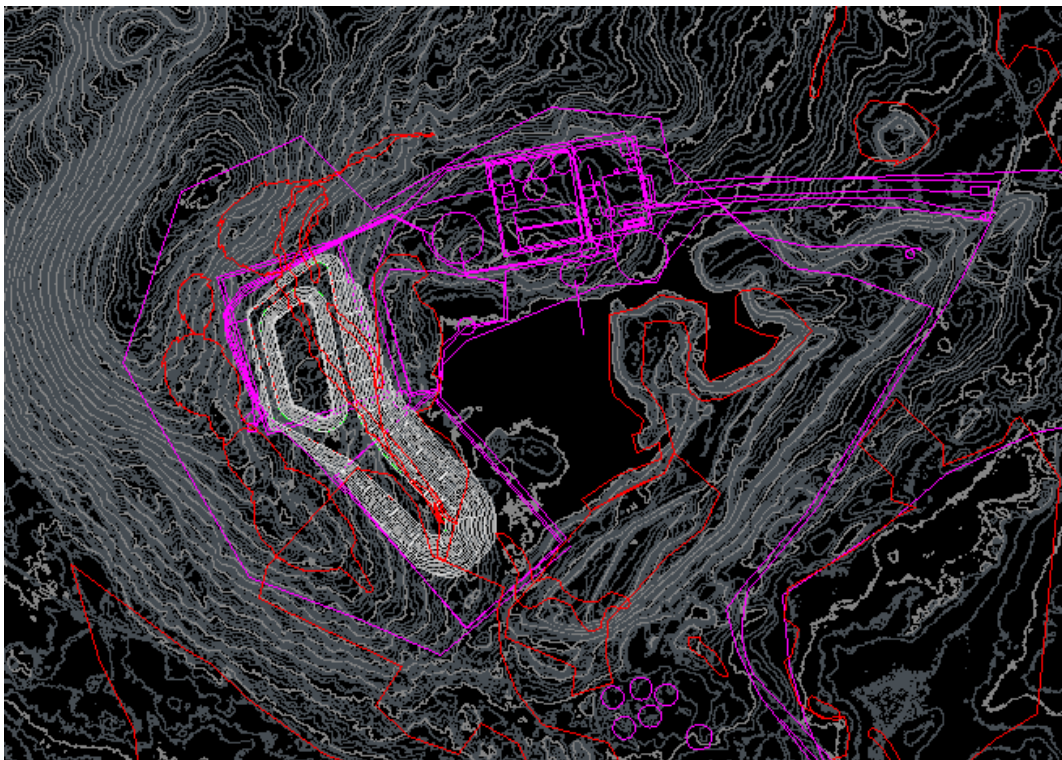


Figure 7-3 Proximity of Location 1 IWF to proposed mine pits

As a result of Location 1 being deemed unsuitable it was proposed that Location 2 (Figure 7-1) be considered. Location 2 was located north of Lake Hosiojärvi. It was bounded to the east by the watercourse connecting Lake Hosiojärvi to Torne River and bounded to the west by hillside.

Several options were developed for location two, as shown in Figure 7-4 to Figure 7-6.

Ultimately, Location 2 and all options for Location 2 were deemed unsuitable for the following reasons:

- Proximity or overlap of the IWF footprints with ore bodies to the east, which Talga indicated may be developed past the current LoM
- Potential difficulties with staging the IWF options presented for Location 2, specifically Option 1 (Figure 7-4)
- Increased consequences and risk presented by the IWF, due to the process plant being located directly downhill and south of all Location 2 options

Due to these concerns, Talga decided that the location of the IWF should be a primary consideration, with other infrastructure being relocated, as required.

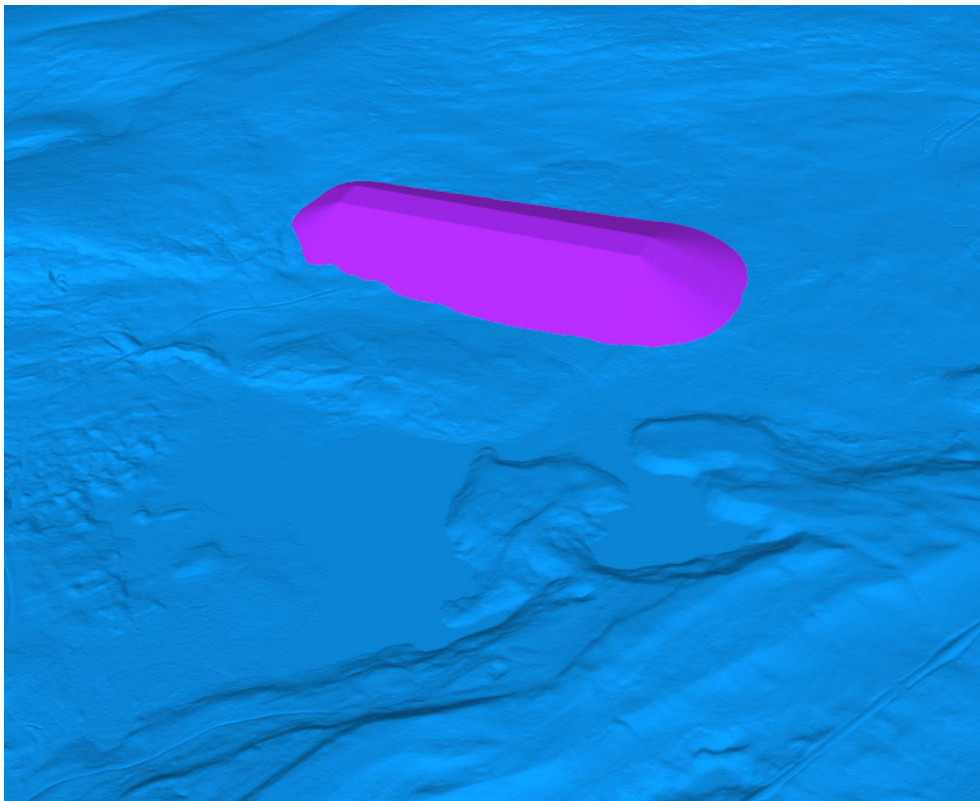


Figure 7-4 Location 2 - Option 1 IWF

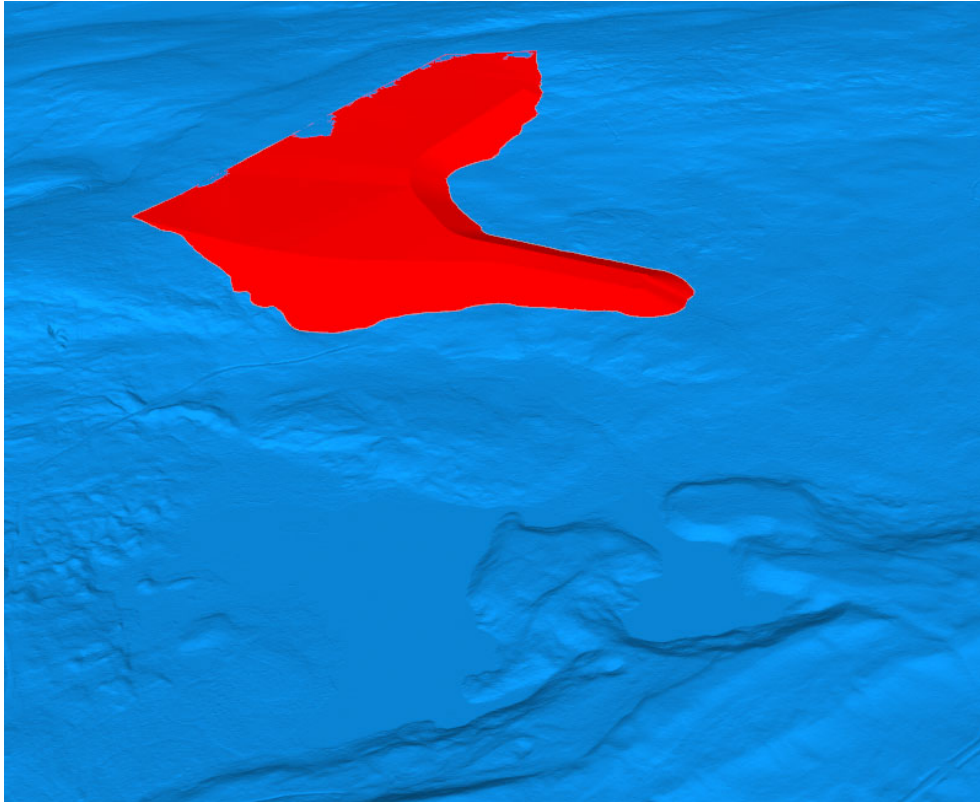


Figure 7-5 Location 2 - Option 2 IWF

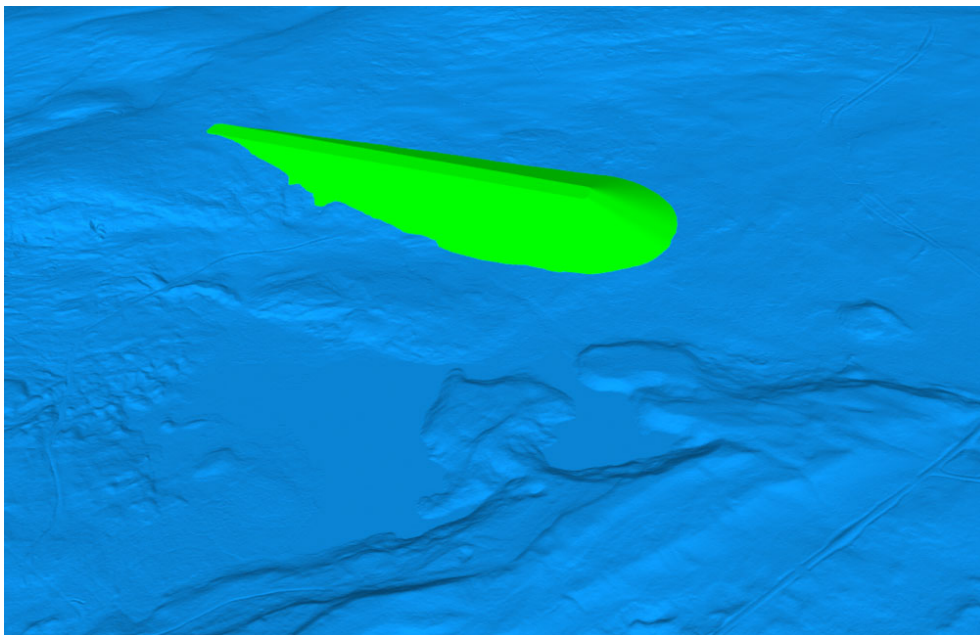


Figure 7-6 Location 2 - Option 3 IWF

Following the change of the IWF location priorities, Location 3 which was the original location of the process plant, was chosen as the preferred site for the IWF.

The initially proposed IWF shape for Location 3 as shown in Figure 7-7. This IWF was sized to store LoM tailings production and all ex-pit mine waste. As further discussed in Section 5.2.4, this was later revised to only store tailings and mine waste production up to Year 11 of the mining operations (volumes shown in Table 5-1).

As a result of the revised storage requirements, the IWF shape for LoM was optimised and it is shown in Figure 7-8. Note that the shape shown is for the confining embankments only, with the volume of the internal void being sufficient to contain the tailings and mine waste up to Year 11.

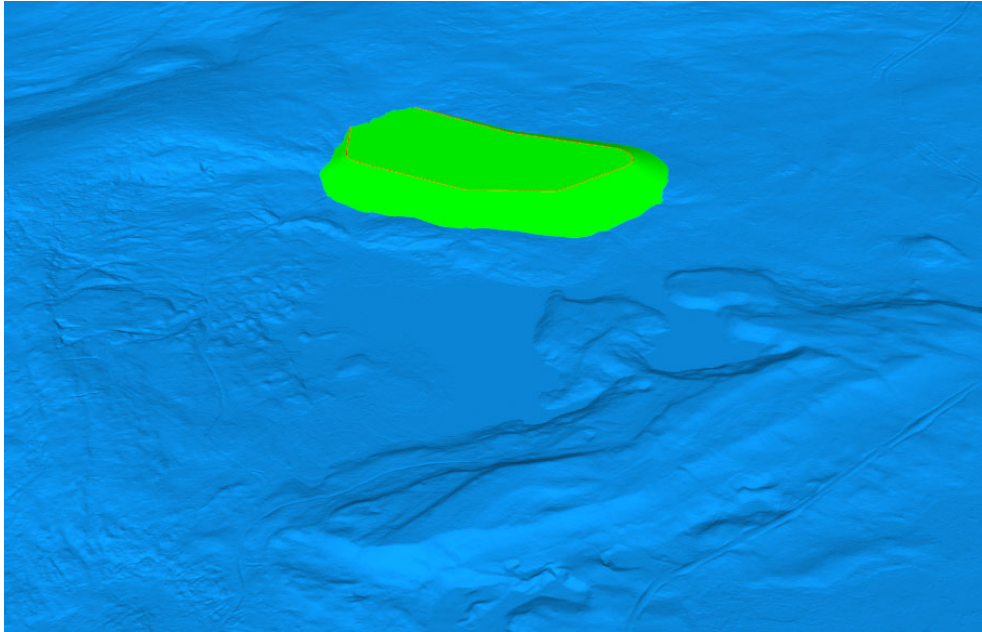


Figure 7-7 Location 3 – IWF for LoM tailings production

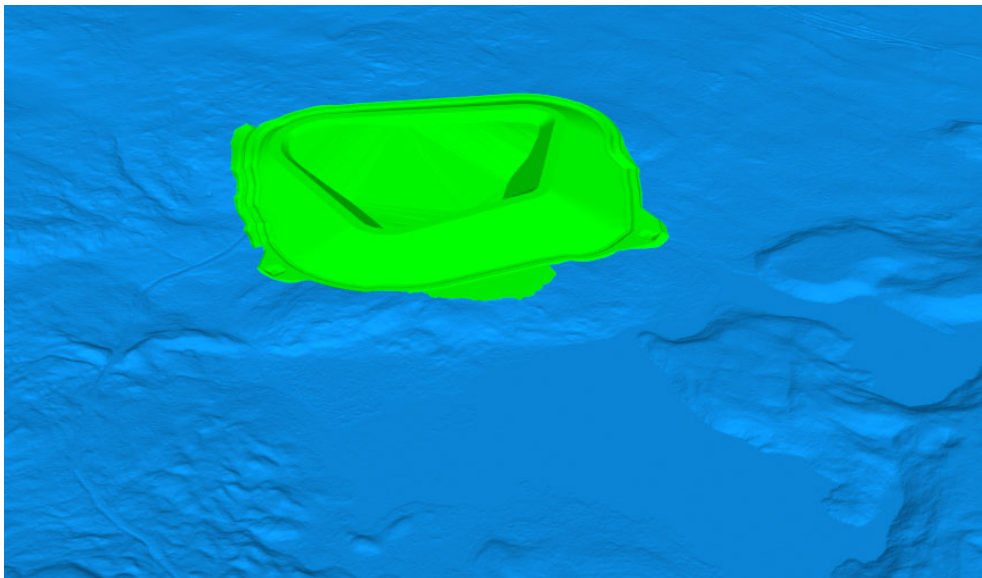


Figure 7-8 Location 3 – IWF for storage up to Year 11

7.3 IWF arrangement

7.3.1 General

With the final footprint and shape of the IWF defined, the staging of the IWF was developed to account for the increasing storage demands of tailings and mine waste. The key considerations in developing the staging of the IWF included:

- Proportion of mine waste and tailings over time
- Constructability of the stages
- Ability to concurrently dispose of the filter cakes and mine waste
- Zoning of the filtered tailings and mine waste within the IWF and the effect on the stability and settlements of the IWF

- Complexity and ongoing management requirements of filtered tailings and mine waste, considering plant and equipment to be utilised
- Closure requirements

Two methods were seriously considered, which were designated:

- Internal storage cells
- Co-disposal IWF

The sections below describe each method and provides a qualitative assessment of each.

7.3.2 Internal storage cells

The “internal storage cells” option consisted of the IWF consisting of cells constructed from mine waste, which would then be filled with co-disposed tailings and surplus mine waste. The shape of the cells would be based on constructability considerations (i.e. not circular cells). In addition, the mine waste cell dimensions and cell wall thicknesses would be defined by the stability requirements of the IWF.

The mine waste cells, being relatively permeable, would allow the filtered tailings to drain over time, therefore decreasing the likelihood of high pore pressures developing with IWF structure.

The initial stages of the IWF would involve constructing mine waste cells to provide sufficient storage for produced tailings. The number of cells that would have to be initially constructed would be dependent on supplying storage for the filtered tailings before more mine waste is produced to construct further cells. So that the global stability of the IWF is not dependent on the internal zones of stored filtered tailings, the outer embankments would have to be relatively wide.

Tailings would be dumped within the cells using haul trucks coming from the plant. A dozer would then push out and compact the filtered tailings to ensure even raising of the tailings surface and to achieve nominal compaction.

Through time, the IWF would be developed both laterally and vertically, with further mine waste cells. Careful planning and construction management would be required to ensure sufficient mine waste is provided to construct the cells for storage and that an appropriate mix of tailings and mine waste to allow trafficability for the dozer and light vehicles.

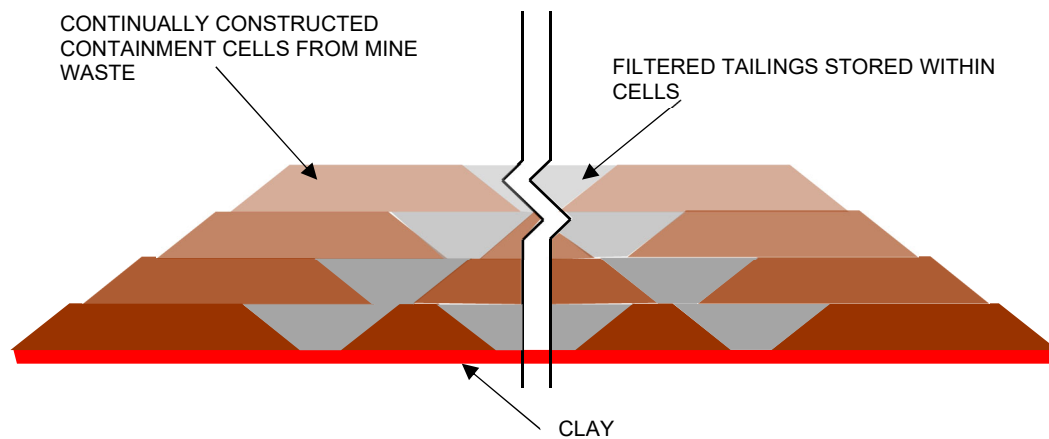


Figure 7-9 Typical section for co-disposal IWF option

7.3.3 Co-disposal IWF

The “co-disposal IWF” option consisted of constructing confining embankment(s) from mine waste material. Note that due to the storage requirements and topography of the area selected for the IWF, only one confining embankment would be required.

Co-disposed tailings and mine waste would be deposited behind the confining embankments using haul trucks from the process plant and mine pit, respectively. Over time, the confining embankment would be raised to provide additional storage for further tailings and mine waste.

So that the stability of the embankment raises is not dependent on the strength of the previously deposited co-disposed waste, the embankment will be raised in a downstream fashion.

Similar to the internal storage cell, an appropriate mix of tailings and mine waste would be required for the co-disposed storage, to allow the surface to be trafficable by a dozer and light vehicles.

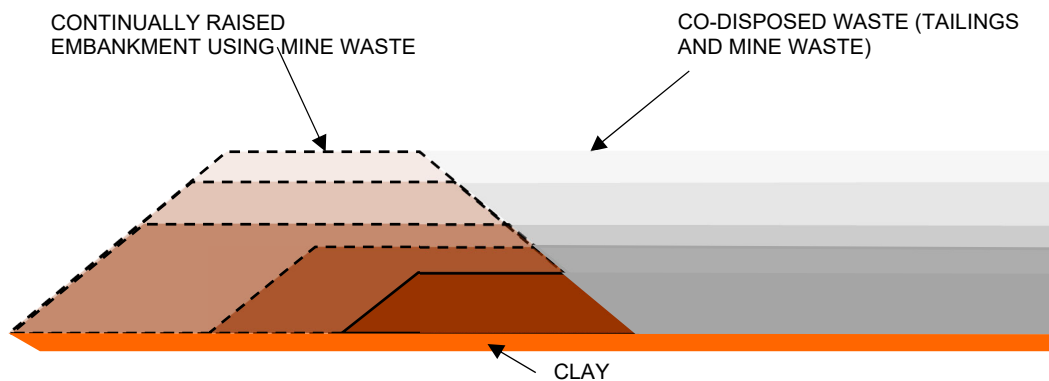


Figure 7-10 Typical section for co-disposal IWF option

7.3.4 Comparison of methods

Comparison of the two options described above, was completed by qualitatively comparing the options against the criteria listed in Section 7.3.1. Table 7-1 presents this comparison. In addition, for each consideration, the option which provides the more preferable solution (e.g. less complex) for each consideration was highlighted. Where both options address the consideration in the same way, both were highlighted.

Table 7-1 Qualitative assessment of IWF options

Criteria/consideration	Internal storage cells	Co-disposal IWF
Proportion of mine waste and tailings over time	<p>Mine waste would be almost exclusively used to construct external walls and internal cell walls.</p> <p>All filtered tailings placed into internal cells.</p>	<p>Mine waste would be used to continually raise the confining embankment. Remainder of mine waste to be disposed of in within the facility.</p> <p>All filtered tailings stored within the facility.</p> <p>Ratio of mine waste to filtered tailings must be managed to ensure trafficability.</p>
Constructability of the stages	<p>Careful management of the construction of the cells would be required to ensure cell locations, size and placement meets requirements for stability.</p> <p>The planned cell sizes and locations would have to be reviewed over time, with consideration to deposited tailings properties and mine waste over time required.</p>	<p>Management to ensure sufficient mine waste is being used to raise the confining over time required.</p> <p>Design and construction review will be independent of tailings properties, though consideration with respect to mine waste properties over time is required.</p>
Ability to deposit filter cake and mine waste	<p>As long as sufficient cells are available, deposition of filtered cakes is possible.</p> <p>Trafficability for haul trucks over cell embankment crest not impacted by seasonal effects due to properties of mine waste.</p> <p>Trafficability for dozer or LVs over stored tailings surface may be impacted by seasonal effects on filtered tailings.</p>	<p>As long as embankment has sufficient height, deposition of filtered tailings and mine waste is possible.</p> <p>Trafficability for haul trucks over embankment crest not impacted by seasonal effects due to properties of mine waste.</p> <p>Trafficability for dozer or LVs over stored tailings surface managed by ratio or mine waste to tailings stored within facility as waste. .</p>
Zoning of the filtered tailings and mine waste, considering stability and settlements	<p>Careful management of the construction of the cells would be required to ensure cell location, size and</p>	<p>No consideration to zoning required, with embankment being</p>

Criteria/consideration	Internal storage cells	Co-disposal IWF
	placement meets requirements for stability.	constructed from mine waste.
Complexity and ongoing management requirements of filtered tailings and mine waste	Based on considerations stated above, management and construction is relatively more complex.	Based on considerations stated above, management and construction is relatively simpler.

Based on Table 7-1, the preferred option was identified to be the “co-disposal IWF” option due to the simpler operation and construction requirements over time. In addition, it provides more construction and operational flexibility, due to the independence from the properties of the filtered tailings over time and simpler design.

The selected IWF arrangement comprised the following elements:

- Footprint lining to prevent seepage of contaminants from the PAF mine waste and tailings (Section 11.2).
- Soil and rock cover to protect the liner from mechanical and frost damage (Section 11.2)
- Underdrainage system to safely collect and convey water released from the consolidating tailings and mine waste (Section 11.2).
- A mine waste embankment to provide sufficient structural support for the IWF landform without relying on the properties of filtered tailings (Section 10)
- A capping and cover system to progressively close and rehabilitate the IWF (Section 15).

The remainder of this reports presents the feasibility study level design for the co-disposal IWF option.

7.4 IWF for LoM

As part of this study, the IWF shape and size that would be required to store the LoM tailings and waste rock should in-pit deposition not occur for any reason was investigated. The location of the facility was assumed to be same as the preferred option, Location 3.

Assuming the provided production rates for the waste streams and assumed unit weights, the total storage volume required was estimated to be 4.7 Mm³. As a contingency, the facility was sized for 5 Mm³.

The IWF required to supply this storage is shown in Figure 7-11.

It should be noted that it was assumed that all waste streams would be stored in the ex-pit IWF as the placement methodology requires co-mingled waste to be stored within the facility for trafficability of the stored material.

Should this facility be required it would feature the following considerations:

- Larger liner area
- More complex underdrainage system, due to topography of the natural ground
- Large complexities to implement ex-pit storage for LoM waste once the initial IWF for storage up to Year 10 has been implemented, due to the liner and underdrainage interactions and implementation

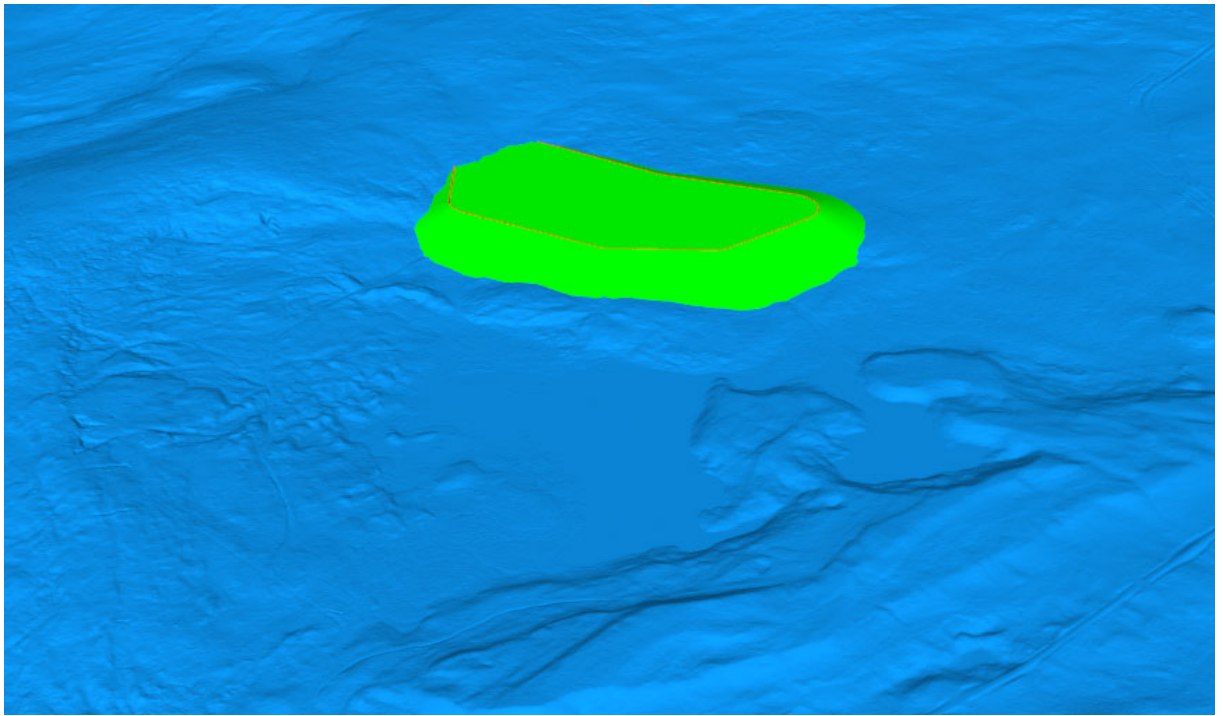


Figure 7-11 Location 3 - Co-disposal to Year 10 and LoM tailings

7.5 Existing co-disposal facilities

A list of existing co-disposal filtered or thickened tailings with waste rock in cold climates is presented in Table 7-2.

Table 7-2 Existing or planned co-disposal facilities

Mine	Owner	Location	Resource	Disposal Method
Greens Creek	Kennecott	Juneau, Alaska	Gold	Filtered tailings co-disposed with waste rock
Nunavik	Canadian Royalties	Deception Bay, Quebec	Nickel, Copper	Thickened tailings co-disposed with waste rock
Nico (Feasibility)	Fortune Minerals	Yellowknife (Northwest Canada)	Gold, Cobalt, Bismuth, Copper	Thickened tailings co-disposed with waste rock
Ajax (Feasibility)	Abacus Mining	Kamloops, British Columbia	Copper, Gold	Thickened tailings co-disposed with waste rock

8. IWF Staging and material delivery

8.1 General

The following section details the required staging and material delivery over time for the proposed co-disposal facility.

8.2 Considerations for staging

The staging of a co-disposal embankment was dependent on the following inputs and assumptions:

- Tailings and mine waste volumes to be disposed of over time
- Ratio of tailings to mine waste required for trafficability of waste surface, which defines the amount of material available for the embankment raise
- Availability of storage at commissioning of plant
- Consideration of stability for all staged embankments
- Ability for progressive closure of staged embankments

8.3 Tailings and mine waste volumes

The tailings and mine waste volumes over time were derived from the mine plan produced by Golder (2019) as detailed in Section 5.2.4.

An annual summary of the volumes of tailings to mine waste is shown in Table 8-1. As stated in Section 5.2.4, these volumes were estimated, assuming placed densities of:

- Tailings – 1.5 t/m³
- Mine waste – 2.09 t/m³

Table 8-1 Annual tailings and mine waste volumes (cumulative)

Year	Volume of tailings (m ³)	Volume of mine waste (m ³)	Total volume (m ³)
0	54,567	290,431	344,997
1	109,113	388,038	497,152
2	163,340	478,034	641,374
3	217,447	769,900	987,346
4	271,713	1,061,766	1,333,479
5	326,080	1,329,217	1,655,297
6	380,427	1,506,347	1,886,774
7	434,627	1,661,617	2,096,244
8	488,667	1,800,040	2,288,707

Year	Volume of tailings (m ³)	Volume of mine waste (m ³)	Total volume (m ³)
9	542,280	1,912,480	2,454,760
10	596,800	1,999,453	2,596,253

8.4 Ratio of waste

To allow the waste surface to be trafficable for all seasons, the ratio of the co-disposed waste must be such that the bearing pressure of the waste surface will be predominately defined by the properties of the mine waste and not that of the filter cakes. This is due to the bearing strengths of the filtering cakes being susceptible to the increased moisture contents as a result of rainfall percolating through the filtered tailings.

For the purpose of this study, it was assumed that a ratio of 1:1, tailings to mine waste, would be sufficient to provide a competent surface for trafficability for a tracked vehicle or LV.

Further testing would be required as part of the detailed design to confirm this ratio.

The calculated volumes of stored waste and mine waste available for construction of the embankment are shown in Table 8-2.

Table 8-2 Annual waste and available rock volumes (cumulative)

Year	Volume of tailings (m ³)	Volume of mine waste for waste (m ³)	Volume of total waste (m ³)	Volume of mine waste for embankment (m ³)
0	54,567	54,567	109,133	235,864
1	109,113	109,113	218,227	278,925
2	163,340	163,340	326,680	314,694
3	217,447	217,447	434,893	552,453
4	271,713	271,713	543,427	790,052
5	326,080	326,080	652,160	1,003,137
6	380,427	380,427	760,853	1,125,921
7	434,627	434,627	869,253	1,226,990
8	488,667	488,667	977,333	1,311,373
9	542,280	542,280	1,084,560	1,370,200
10	596,800	596,800	1,193,600	1,402,653

The proposed co-disposal landform was sized for the volume of total waste (Column 3 in Table 8-2) with the staged embankment sized to match the volume of mine waste for embankment (Column 5 in Table 8-2).

8.5 Staging of IWF

Based on the volumes shown in Table 8-2 and the identified preferred location and IWF shape (Figure 7-7), the proposed stages at 2-yearly intervals were developed, as shown in Figure 8-1 and Figure 8-2). It should be noted that the surface of the stored material is not shown in these figures. Assuming proper management (see Section 0), the average final surface elevation will be the same as the crest elevation at the start of the year.

The embankment crest level required at the start of each year is shown in Table 8-3.

The final landform elevation refers to the landform surface at the end of Year 10, where surplus ex-pit mine waste will be used to form the final closure landform, prior to total encapsulation of the landform for closure (Section 0).

Table 8-3 IWF crest elevations over time

Year	Embankment crest level at start of year (RL)
0	305.9
1	310.0
2	312.9
3	315.2
4	317.1
5	318.7
6	320.2
7	321.7
8	323.0
9	324.4
10	325.7
Final landform (not accounting for closure cover)	327.0

Details of the internal zoning and appurtenant structures for each stage are described in the relevant sections below.

Figure 8-3 shows a typical section of the IWF embankment over time at two-year intervals.

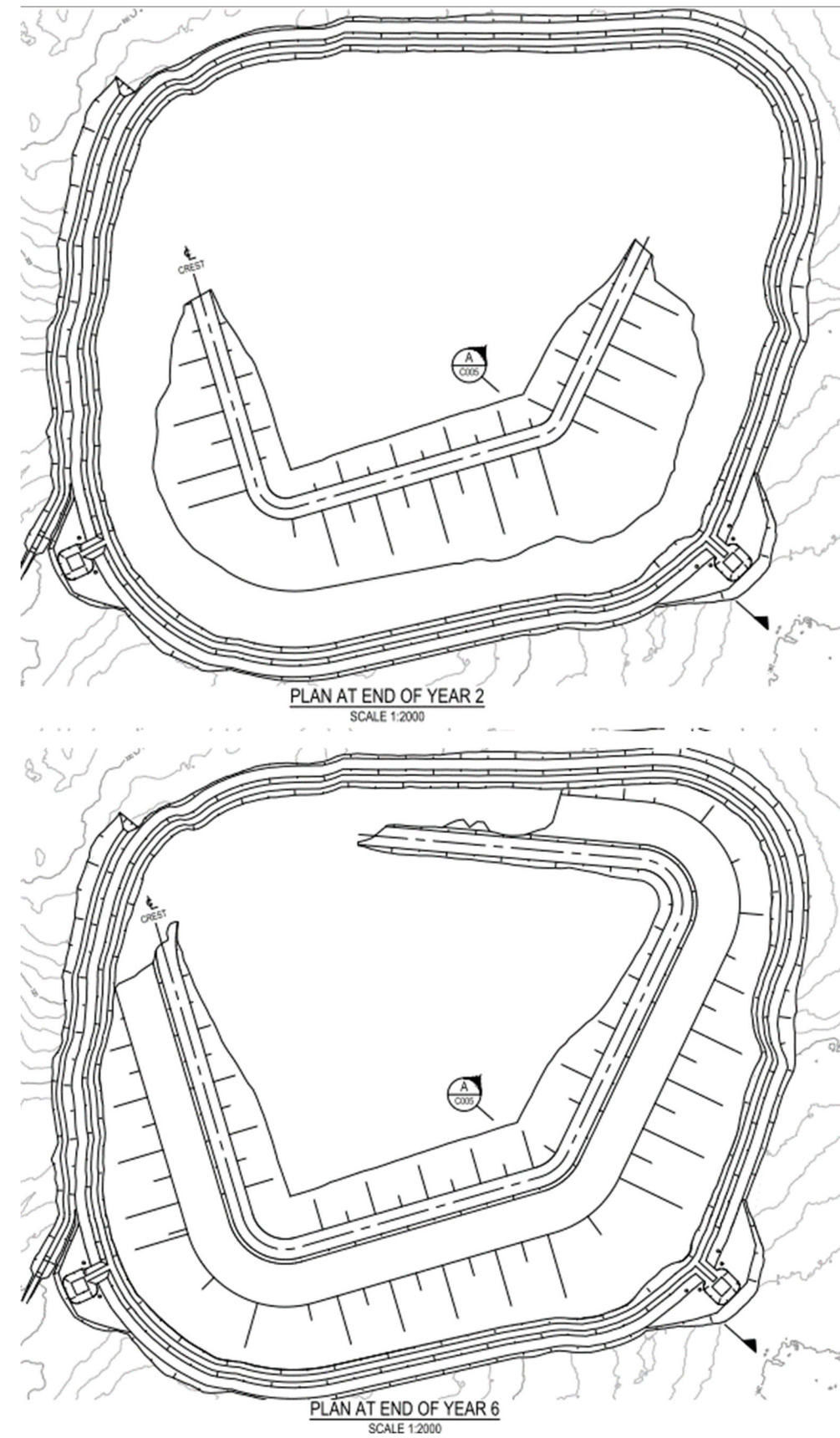
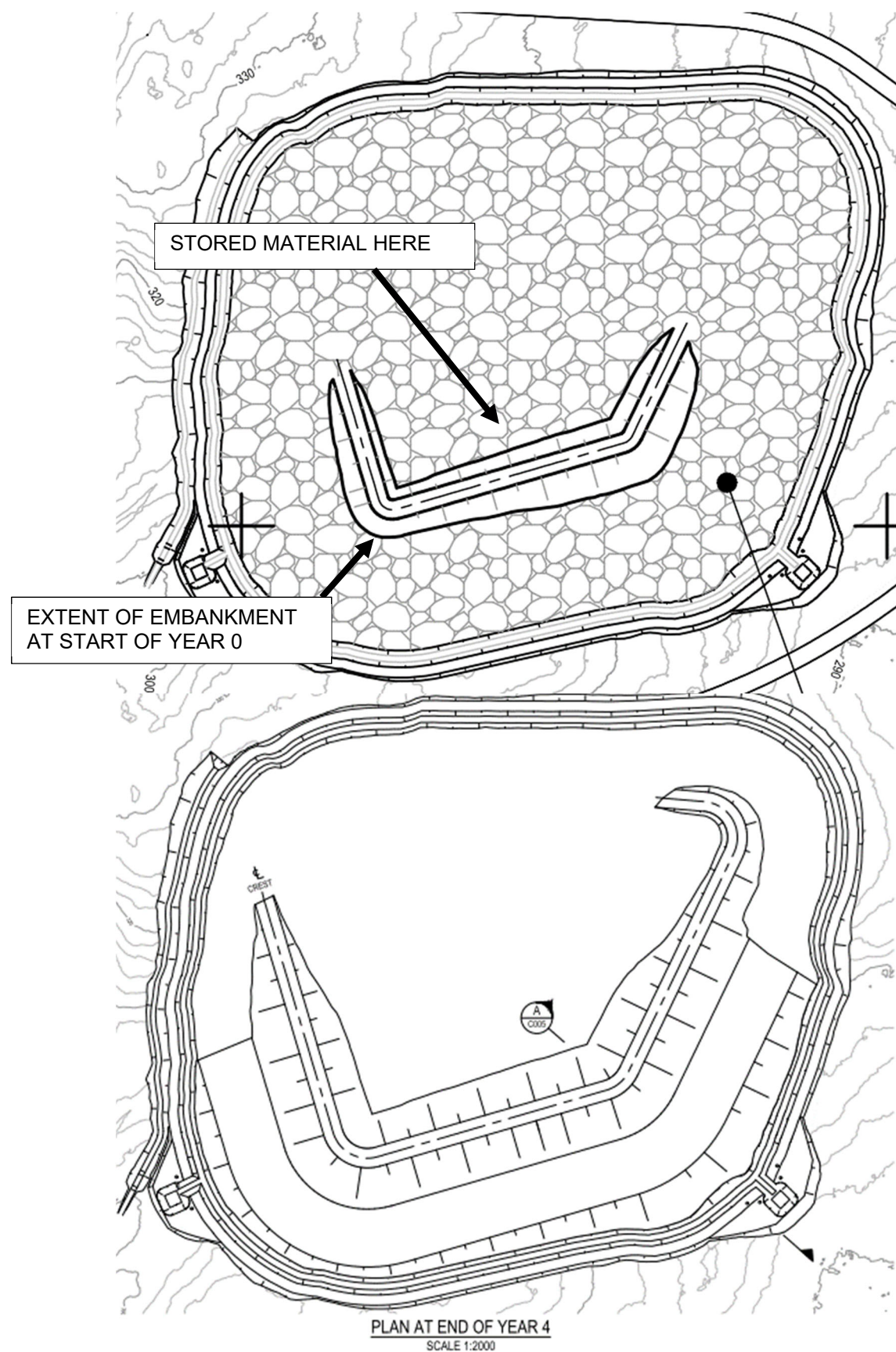


Figure 8-1 – Stages of IWF embankment Year 0 to Year 6

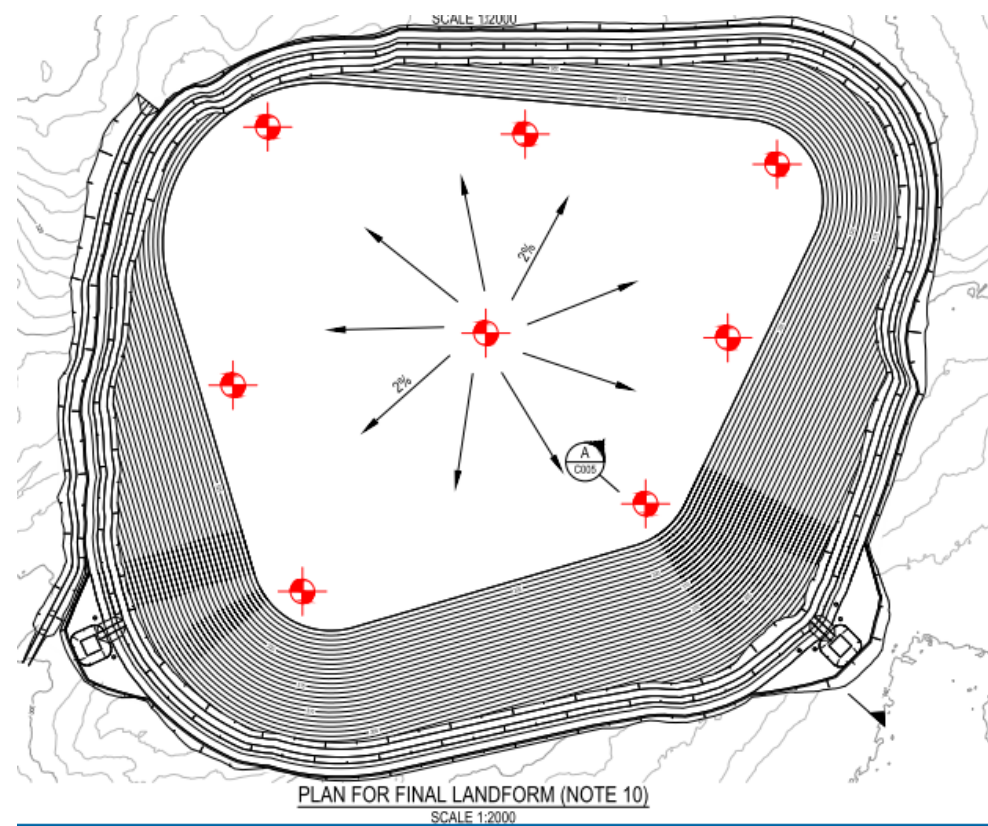
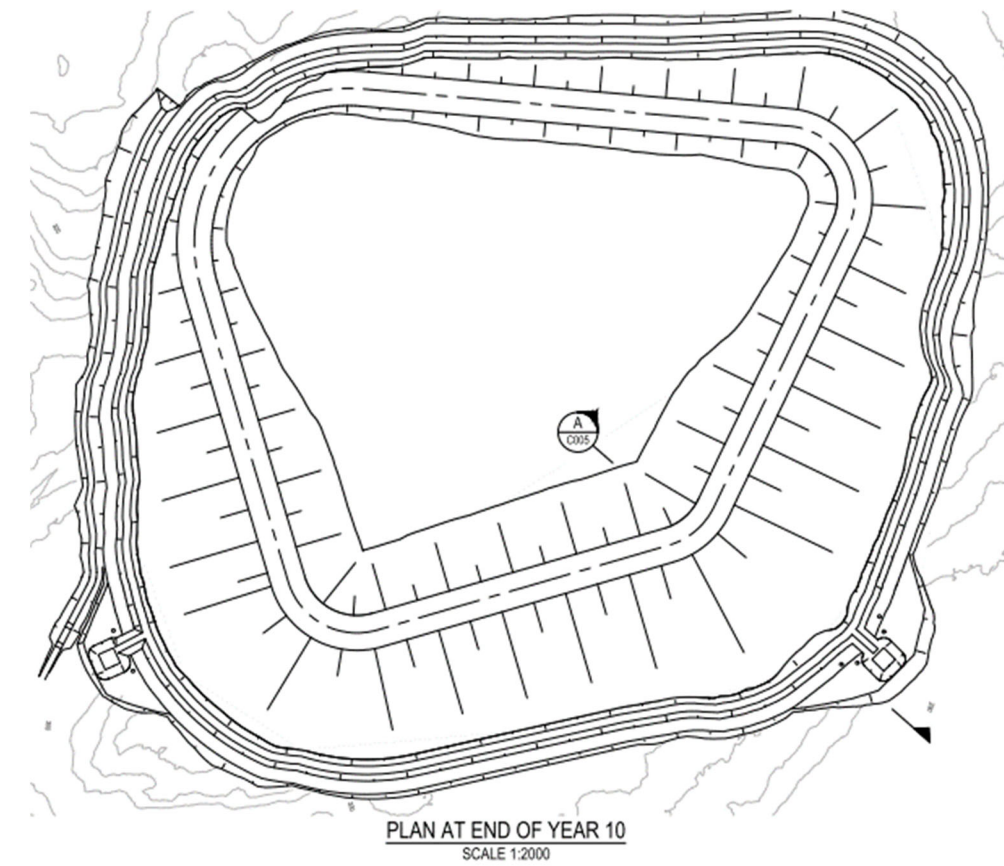
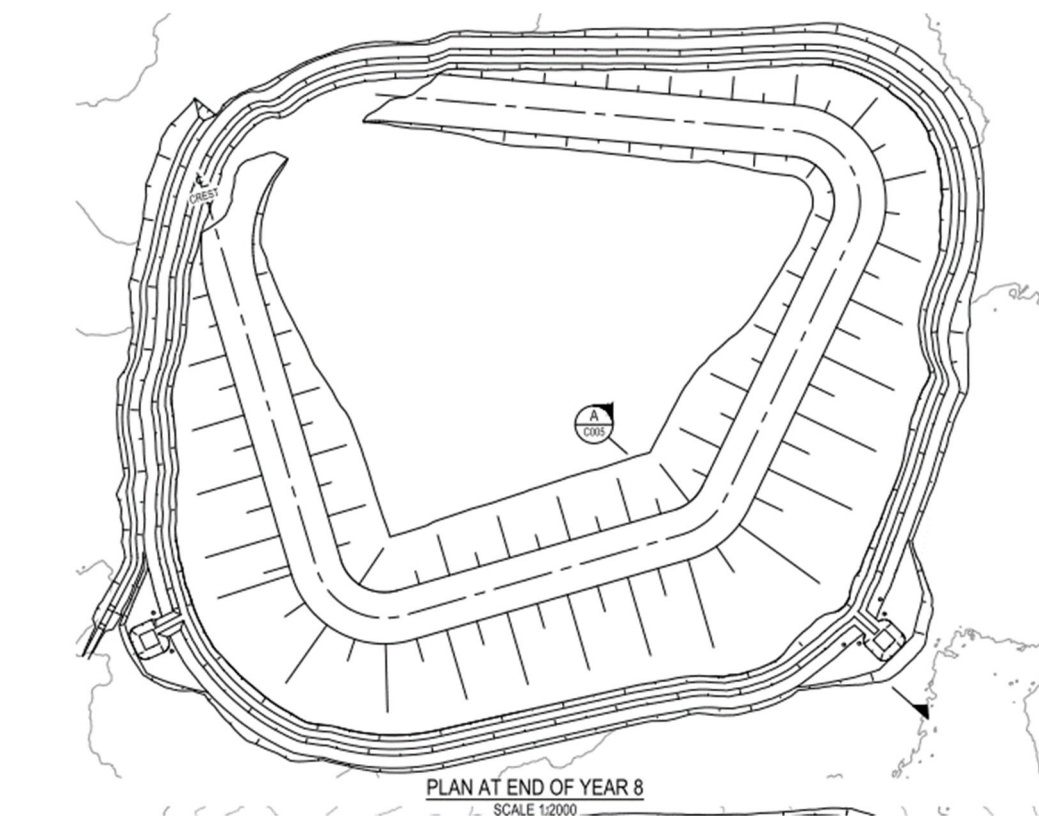


Figure 8-2 Stages of IWF embankment Year 6 to Year 10 and Final Landform

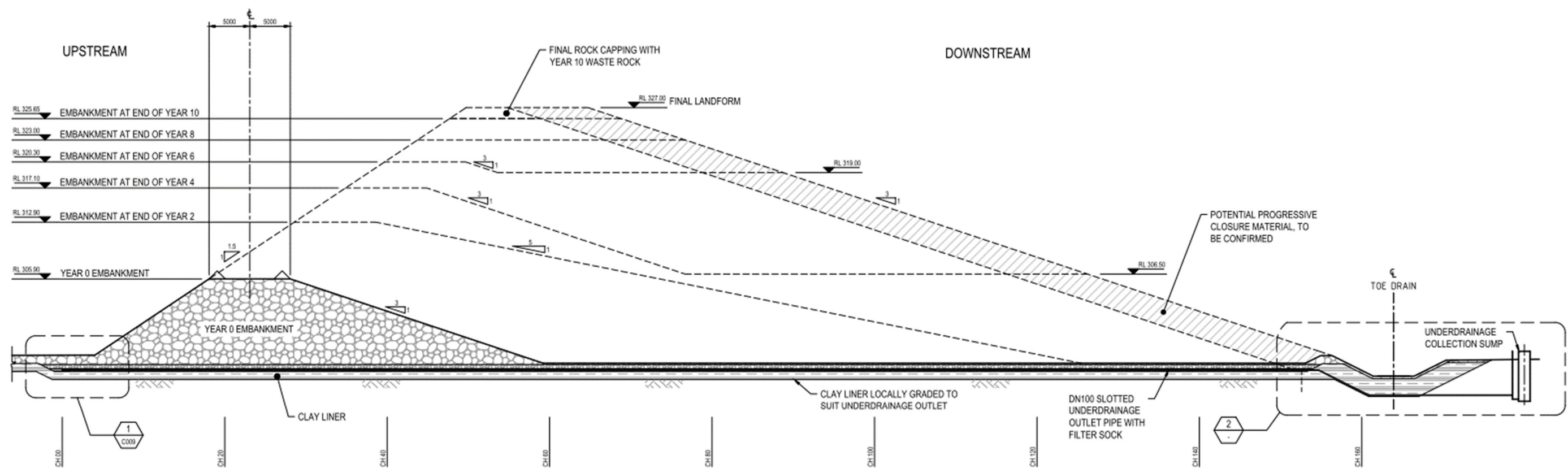


Figure 8-3 Co-disposal IWF - Typical Section

8.6 Storage curves

The storage curve of the IWF assuming the IWF location, staging and typical section shown above is shown in Table 8-4 and Figure 8-4.

Table 8-4 IWF Storage curve

RL within storage (RL)	Incremental Cumulative available volume between elevations (m ³)	Cumulative available volume (m ³)
296	0	0
297	47	47
298	1,600	1,647
299	5,371	7,018
300	8,330	15,348
301	10,681	26,028
302	13,683	39,711
303	15,407	55,118
304	16,897	72,015
305	18,634	90,649
306	20,796	111,445
307	23,225	134,670
308	25,649	160,320
309	27,982	188,301
310	30,449	218,750
311	33,387	252,136
312	36,730	288,866
313	40,517	329,383
314	44,574	373,957
315	48,853	422,809
316	54,062	476,871
317	60,094	536,965
318	65,785	602,749

RL within storage (RL)	Incremental Cumulative available volume between elevations (m ³)	Cumulative available volume (m ³)
319	69,242	671,992
320	71,703	743,694
321	74,244	817,938
322	76,876	894,814
323	79,223	974,037
324	81,231	1,055,268
325	82,997	1,138,266
326	84,670	1,222,936
327	86,356	1,309,291

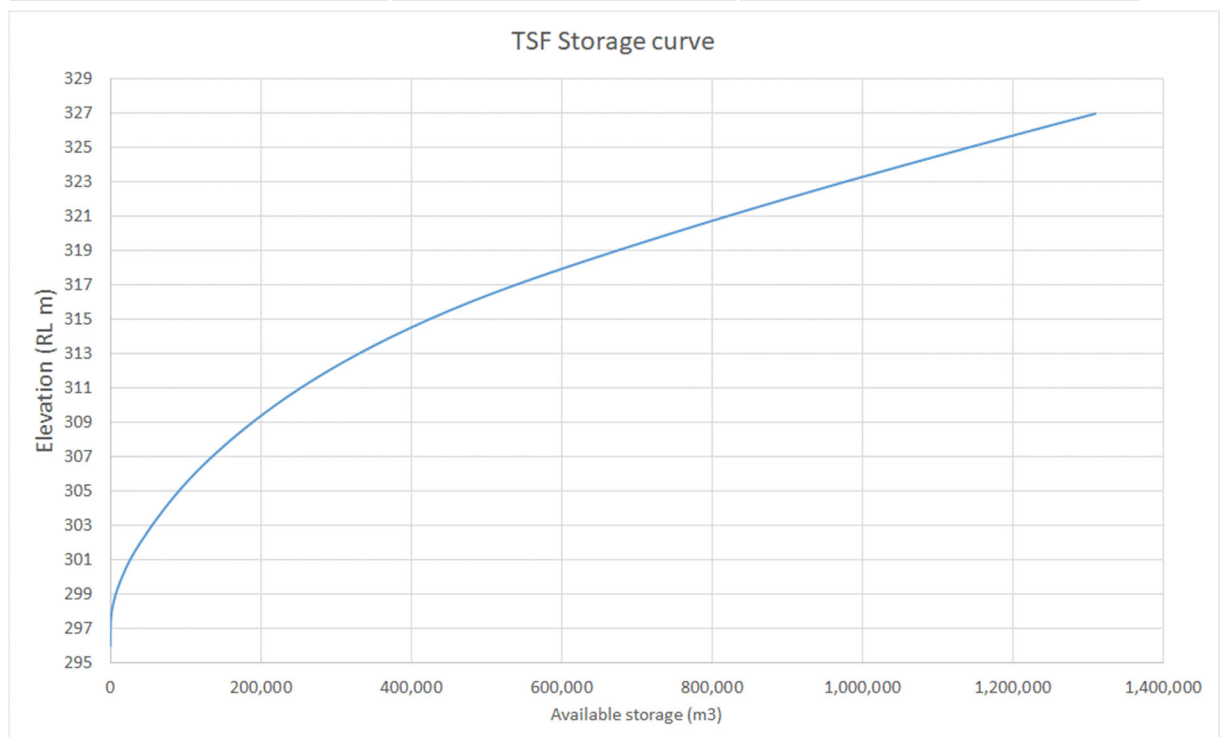


Figure 8-4 IWF storage curve

In addition to the IWF storage curve, the volume of material required for each stage of the embankment is shown in Table 8-5 and Figure 8-5. It should be noted that the italicised numbers in Table 8-5 were interpolated from modelled embankment volumes.

Table 8-5 IWF embankment volumes

Year	Embankment crest level at start of year (RL)	Required cumulative embankment volume (m ³)	Required cumulative embankment volume (m ³)
0	305.9	80,326	80,326
1	310.0	137,489	217,815
2	312.9	137,490	355,305
3	315.2	135,734	491,039
4	317.1	135,734	626,773
5	318.7	224,752	851,525
6	320.2	224,752	1,076,277
7	321.7	74,677	1,150,954
8	323.0	74,677	1,225,631
9	324.4	39,342	1,264,973
10	325.7	39,343	1,304,316
Final landform (not accounting for closure cover)	327.0	38,859	1,343,175

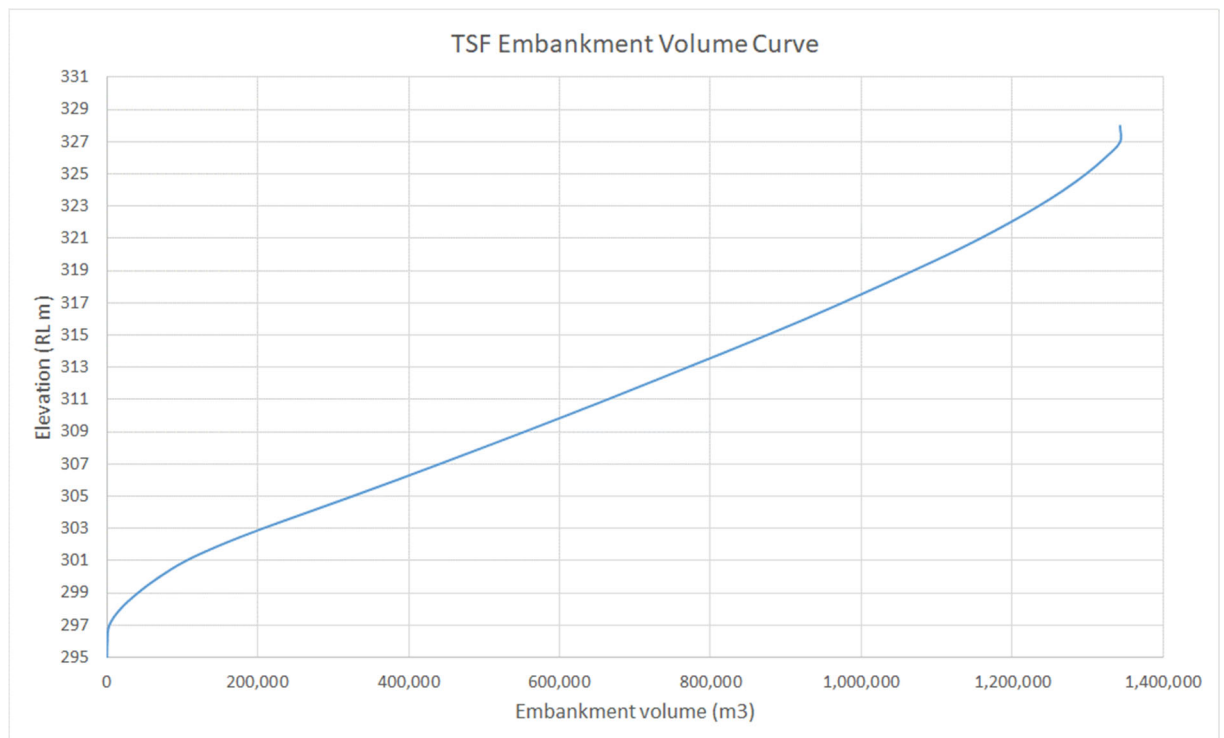


Figure 8-5 Embankment volume curve

8.7 Material delivery and placement

Delivery of waste material can be thought of in two streams:

1. Filtered tailings from the filter plant
2. Mine waste from mine pits

Mine waste and tailings will be delivered via haul trucks, with the haul roads to the IWF designed by others. GHD has proposed a haul road entry point as shown on Figure 8-6 with red arrows. This entry route results in a haul road which always be at a higher or equal elevation than the IWF embankment crest for all stages. The entry haul road would only have to be constructed once minimal modifications as the embankment crest centreline changes over time, due to raising.

All other potential haul roads entering the facility would have to be reconstructed over time and as such, is not recommended.

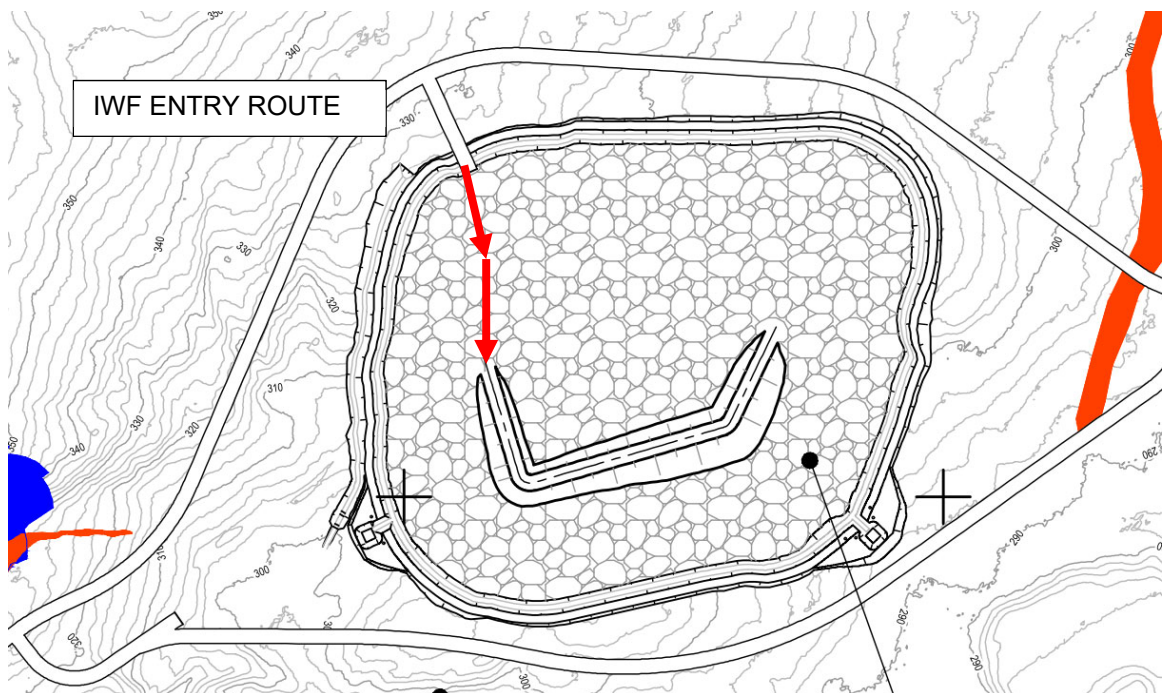


Figure 8-6 Recommended IWF entry route

For deposition of the filtered tailings, the haul trucks will enter the IWF area, dump the filtered tailings. The material will either be dumped directly into the facility from the crest, or at a location where a dozer can push it into the facility (potentially near the abutments). The deposited tailings will then be pushed out by a dozer and track compacted to create a level and compacted surface.

For the mine waste which will be deposited into the facility as waste, the above method for tailings is applicable.

For the haul trucks carrying mine waste which will be used to construct the embankment raises, a second haul route, which will have the same access point into the IWF area, will be established. This second haul route will allow the haul trucks to access the downstream areas of the existing embankment to dump mine waste material. This material will then be pushed out and compacted, as required.

9. Consequence Category

9.1 General

The consequence category or class for the proposed IWF was determined in accordance with two classification systems:

- ANCOLD's *Guidelines on the Consequence Categories for Dams* (ANCOLD, 2012) and *Guidelines on Tailings Dam* (ANCOLD, 2019).
- Energi Företagen's *RIDAS – Energiföretagens riktlinjer för dammsäkerhet* (Energi Företagen, 2019)

9.2 ANCOLD guidelines

ANCOLD recommends that the consequence category of a storage facility is defined as a function of:

- The population at risk (PAR) as a result of failure – defined as a number
- The severity of losses and damages for various categories – defined using qualitative descriptors

Consequence categories should be defined for various failure scenarios and should be considered separate to the likelihood of said scenario occurring. ANCOLD recommends that the following scenarios be considered:

- Sunny Day Failure (SDF) – Failure of the facility as a result of non-flooding triggers
- Current flood capacity with failure (FF) – Failure of the facility as a result of extreme rainfall event resulting in an exceedance of the facilities flood handling capability

In addition to the above failure scenarios, ANCOLD recommends that an Environmental Spill Consequence Category be assessed. This category assessed the effect of spilling water from the facility during an extreme rainfall event without “failure” of the facility occurring (i.e. breach of a confining embankment).

9.3 Energi Företagen RIDAS

The RIDAS document provides a method to assign a storage facility a consequence assessment based on qualitative descriptors as a result of failure of the facility.

The system ranges from a classification of A, indicating the highest consequence, to E, indicating negligible consequences of failure.

9.4 Feasibility study assessment

Given the current phase of the design (feasibility) for the facility, it was determined that an initial qualitative assessment of the likely inundation area and resulting consequences would be the most appropriate method at this stage.

As a result, only the worst case scenario was assessed in this assessment. Additionally, only the total impacts in the event of a IWF failure was assessed and not the incremental impacts of the IWF failure. Assessing the incremental impacts would take into account and address any concurrent flooding or effects that may be occurring in the downstream areas regardless of failure of the IWF.

A semi-quantitative or quantitative based consequence category assessment should be considered for the next stage

9.5 Inundation area

The potential inundation area for the IWF is dependent on several variables and assumptions including the amount of stored material within the facility at the time of failure, the assumed failure mechanism and the presence of concurrent flooding in the downstream area.

For the purpose of this assessment, the following was assumed:

- The amount of stored material within the facility at the time of failure was representative of the final landform (total of 2.65 Mm³ embankment and stored waste volumes)
- The failure mechanism would be akin to a landslide failure of the IWF, with the released material not acting in a flowable manner due to:
 - The stored mine waste and tailings not being fully saturated and therefore not being able to be mobilised in a flowable manner
 - The embankment material not being saturated due to it being free draining material and the presence of underdrainage at the upstream toe and underneath all stages of the confining embankment
 - Given the likely unsaturated nature of the materials, the mine waste material being dilative due to material being compacted
- It was conservatively assumed that there is sufficient precipitation on the areas downstream of the IWF such that Lake Hosiojarvi has outflows into the Torne River system

Given these assumptions, it is likely that in the event of failure, embankment and stored material would flow out into the Lake Hosiojarvi (assuming sufficient flows in the downstream areas). Material would then be transported into the Torne River via natural outflows. This is shown in Figure 9-1. It should be noted that this figure does not indicate the amount of material that would be transported into the river system, but that there is a potential for it.

Due to the failure type, it is likely that the majority of material that is mobilised would be located either immediately downstream of the IWF, or within the lake. In addition, due to the relatively low grade of the water course connecting Lake Hosiojarvi to Torne River (approx. 2%) any material that does flow out of Lake Hosiojarvi would likely settle out of the flows prior to reaching Lake Hosiojarvi.



Figure 9-1 Transportation of stored material in the event of failure

9.6 Population at Risk

An assessment on the population at risk (PAR) was completed, based on the likely inundation area of the tailings described in Section 9.5.

The definition of PAR is *all people who would be directly exposed to flood water (tailings) assuming they took no action to evacuate* (ANCOLD, 2012).

Reviewing the likely extent of inundation in the event of the IWF failing, it is evident that no locations, structure, roads or other areas where people may be would be inundated. It was identified that outflows from Lake Hosiojarvi to Torne River flow under several road embankments, however, due to the releases not acting in a flowable matter, these roads are unlikely to be inundated by released material.

As such, no civilian PAR was identified.

It is feasible, however, that a mine operator could be downstream of the dam at the time of failure, as a result of carrying out daily IWF inspections or operating underdrainage seepage return works. While the time that these operators would be exposed to the risk of the IWF failing is small, the PAR estimate does not take this into account.

As a result, the PAR associated with the IWF failing was estimated as 1.

9.7 Severity of damage and losses

The severity of damage and losses was qualitatively assessed against various categories, as recommended by ANCOLD (2012). A summary of this assessment, with commentary as required, is shown in Figure 9-1.

It should be noted that these severities were selected based on the estimated inundation area and likely transportation of stored materials as described above.

Table 9-1 Severity of damage and losses

Damage and Loss		Minor	Medium	Major	Catastrophic
Total infrastructure costs	Comments				
Includes residential, commercial, Community Infrastructure & IWF replacement costs	Medium severity is described as total infrastructure costs being in the range of \$10M to \$100M. The total direct costs to Talga are unlikely to exceed this.		X		
Impact on dam owner's business					
Importance to the business	IWF is essential to maintain operations			X	
Effect on services provided by the owner	Operations would be impacted for at least one year			X	
Effect on continuing credibility	Severe widespread reaction		X		
Community reaction and political implications	Likely to have extreme discontent from local communities			X	
Impact on financial viability	Significant impact with considerable impact in the long term		X		
Value of water in storage	N/A				
Health and social impacts					

Damage and Loss		Minor	Medium	Major	Catastrophic
Public Health	<100 people affected	X			
Loss of Service to the community	<100 people affected	X			
Cost of emergency management	1000 to 10,000 person days required		X		
Dislocation of people	<100 people affected	X			
Dislocation of businesses	<20 business months	X			
Employment affected	<100 jobs lost	X			
Loss of heritage	Local facilities affected only	X			
Loss of recreational facility	Local facilities affected only	X			
Environmental impacts					
Stock and fauna	Discharge would be unlikely to contaminate water supplies used for stock and fauna. Health impacts minimal		X		
Ecosystems			X		
Rare and endangered species	Short term impacts on ecosystems, with natural recovery expected after one wet season.		X		
Highest level of severity of damage and loss for SDF scenario				X	

9.8 ANCOLD consequence category

The consequence category of the facility was selected based on the recommended by ANCOLD, which considers the PAR and severity of damage and losses.

It was determined that the consequence category for the IWF was **High C**.

A dam spill consequence category can also be determined, which only considers release of stored material from the IWF, without failure (i.e. material transported due to heavy rainfalls). In this event, PAR would be 0. In addition, the severity of damage and losses would likely be **Medium**, as the operations would not be severely affected and could likely continue operation.

As a result, the dam spill consequence category would be Low.

Table 9-2 Consequence category based on PAR

PAR	Severity of Damage and Loss			
	Minor	Medium	Major	Catastrophic
<1	Very Low	Low	Significant	High C
1 to 10	Significant (Note 2)	Significant (Note 2)	High C	High B
10 to 100	High C	High C	High B	High A
100 to 1,000	(Note 1)	High A	High A	Extreme
> 1,000		(Note 1)	Extreme	Extreme

Note 1: With a PAR in excess of 100 it is unlikely that damage will be minor. Similarly PAR excess of 1,000 it is unlikely damage will be classified as medium.

Note 2: Change to High C where there is the potential of one or more lives being lost

9.9 RIDAS classification

Based on the RIDAS classification system, the IWF was estimated to be a **dam safety class of C**, due to the “Significant local consequences and disturbances” and “the risk of loss of life being negligible”.

While it was identified that a PAR of 1 is possible, as stated in Section 9.6, when taking exposure time into account (which the use of the word risk and negligible indicates) this becomes negligible.

As has been advised to GHD, for dam safety classes between A and C, these are verified and confirmed by the regulator of the area that the storage facility is located in (the county administration board), based on conditions/reports by the owner) As a result, this class may be updated by the local regulator.

9.10 Design loading

As a result of the above consequence categories, ANCOLD recommends the following design criteria be adopted:

- Minimum extreme storm allowance – Determined by risk assessment
- Recommended design earthquake:
- Operating Basis Earthquake 1:475 AEP up to 1: 1,000 AEP
 - Safety Evaluation Earthquake 1:2,000

The current design criteria for extreme storm allowance of 1:20 AEP aligns with the design criteria for the rest of the project.

A site specific seismic study should be carried out to allow seismic design criteria to be defined and assessed in the detailed design of the IWF, as well as other plant infrastructure.

When the RIDAS classification has been confirmed, the resulting impact on design criteria should be confirmed for the detailed design.

10. Stability analyses

10.1 General

A stability assessment of the IWF was carried out based on the material properties derived from the laboratory testing and typical cross-section for the IWF at the highest embankment. The stability assessment was carried out using the software SLOPE/W, which uses limit equilibrium techniques to assess the Factor of Safety against slope failure. The Morgenstern-Price analysis method was utilised for this assessment.

In addition, an assessment of the likely settlement that can be expected for the stored waste was completed, to determine if large settlements should be considered for closure and post-closure design and management.

10.2 Material properties

The material properties that were used in the stability assessment were derived from laboratory test results and from engineering judgement based on experience from encountering similar materials. A summary of the material properties and the source of the properties are shown in Table 10-1.

Table 10-1 Material properties for slope stability

Material	Unit weight (kN/m ³)	Friction Angle (degrees)	Source of data
Clay liner	18	28	Previous experience – Conservatively assigned
Co-disposed waste	18	32	Triaxial test results (Section 6.4.4)
Foundation rock	22	38	Previous experience – Conservatively assigned
Mine waste (embankment material)	21	35	Triaxial test results for tailings and conservatively assigned(Section 6.4.4)
Soil cover – closure	18	28	Previous experience – Conservatively assigned

10.3 Scenarios analysed

The only scenario directly analysed was steady-state conditions. In addition, a sensitivity analysis was carried out. Dynamic loading scenarios were not analysed for several reasons, including:

- A site specific seismic study not being available to understanding the loading conditions
- Uncertainty on the pore pressure conditions within the facility (see Section 10.4), which greatly effects the understanding on generation of excess pore pressures
- All materials being dilative, due to the properties, preparation and compaction of all materials, which lowers the likelihood of excess pore pressures being generated in dynamic loading scenarios

10.4 Phreatic surface

A very conservative phreatic surface was assigned for the stability assessment. The presence of an underdrainage system will aid to drain the stored waste and embankment and lower pore pressures within the facility. In addition, the use of mine waste will allow the confining embankment to be relatively permeable and free draining, which also aids in having lower or non-existent pore pressures.

Further testing will allow the permeability of representative mine waste to be determined for consideration in the detailed design.

10.5 Geometry

The final landform geometry was adopted for the assessment. This was done as this stage features the greatest destabilising loads on the embankment. In addition, the interim stages feature shallow downstream slopes.

10.6 Slope stability results

The result of the stability assessment is shown in Figure 10-1. The FoS achieved for the critical failure plane (1.7) exceeds the minimum FoS of 1.5.

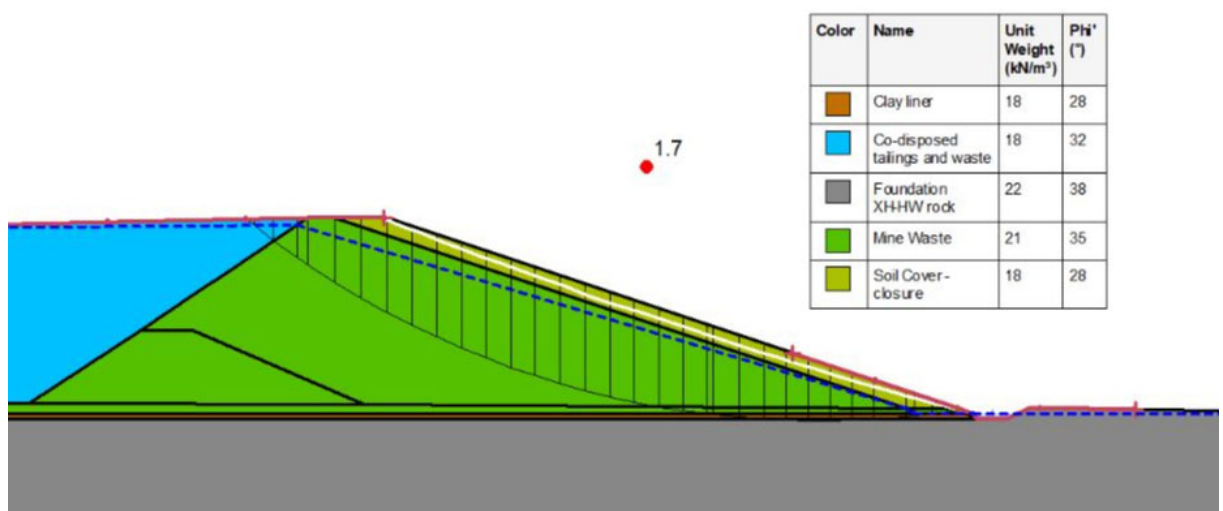


Figure 10-1 Slope stability result

Due to several assumptions made in assigning the material properties, a sensitivity analysis was carried out, by altering the friction angle of the mine waste embankment material. This material was selected for sensitivity analysis due to how critical this zone was in the stability of the embankment.

The mine waste friction angle was altered for values between 22° and 42°. It should be noted that for the expected mine waste material, a friction angles of 28° can be expected to be the lower bound for the material.

The change in FoS for changes in mine waste friction angle is shown in Figure 10-2. As can be seen, for expected friction angle values, the FoS against slope failure exceed the minimum required FoS.

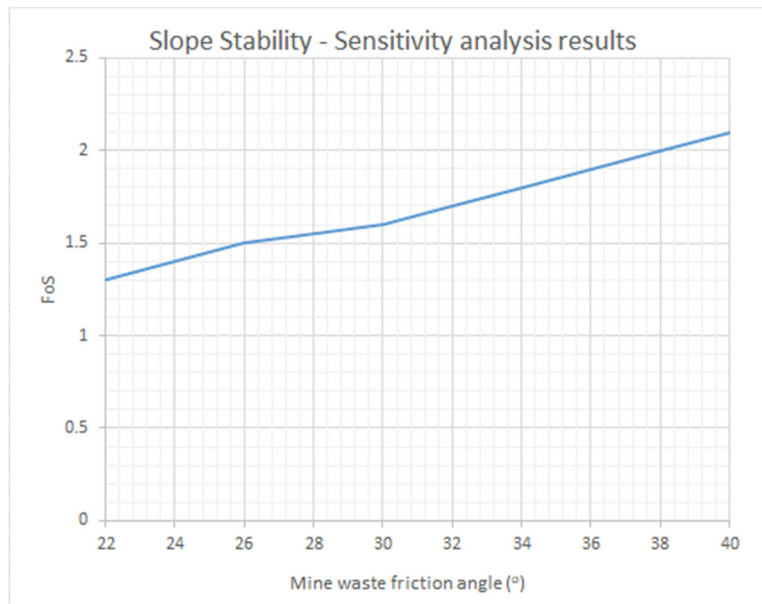


Figure 10-2 Slope stability - sensitivity analysis results

The results of the sensitivity assessment confirmed that the IWF will maintain satisfactory slopes stability even if the mine waste in the perimeter embankment undergoes significant shear softening. Shear softening can occur as a result of cyclic shear during an earthquake event. As the satisfactory FoS (1.3) is maintained at a material shear strength, which is considered to be below the conceivable limits, the IWF landform is very unlikely to be compromised by even a very severe earthquake.

Because the mine waste in the embankment will be compacted, liquefaction of the embankment is very unlikely.

Liquefaction of the IWF foundation is also unlikely given that the IWF will be founded on weathered rock and all loose soils will be removed as part of the foundation treatment.

10.7 Settlements

The expected settlement of the tailings was estimated using the oedometer test results, which allow the consolidation of materials to be understood. Understanding the expected settlements is imperative to achieving successful closure of the facility, as excessive settlements may result in cracking of the capping layer which will ultimately compromise the liner.

The settlement was estimated by considering the coefficient of compressibility of the tailings material and loads that layers of tailings will experience as a result of additional stored waste. The estimated total settlement that can be expected for the tailings was 3.3 m.

It should be noted however, that this settlement will occur over the course of the IWF being active, with only a small portion of this settlement expected once loading ceases, that is, deposition is completed. As such, it is not expected that settlements will compromise the closure capping (Section 15).

10.8 Piping considerations

Piping is a process of internal erosion in which seepage through a continuous defect carries out particles of soils. Under a sufficient hydraulic head and in material susceptible to internal erosion, piping can lead to an embankment failure.

As the IWF is designed not to hold water, the tailings are being filtered and an underdrainage system is provided, piping through the embankment and/or foundation is extremely unlikely.

11. Underdrainage design

11.1 General

An underdrainage system was included in the design to allow contaminated seepage to be collected and safely discharged to the water treatment plant on site, while lowering the likelihood of acid seepage contaminating the surrounding environment.

The underdrainage system was detailed to deal specifically with seepage percolating through the IWF and not surface runoff from the facility. Surface drainage to handle surface runoff is detailed in Section 12.

The underdrainage system consists of:

- Clay liner
- Underdrainage collection system
- Seepage interception trench

11.2 Clay liner

A clay liner was allowed for over the whole footprint where contaminated seepage is expected to come into contact with the ground. The extent of the clay liner is shown in Figure 11-1.

The liner will be placed and graded to create a low permeability basin which will collect percolating seepage. Local grading of the liner will be completed to encourage drainage into the underdrainage system.

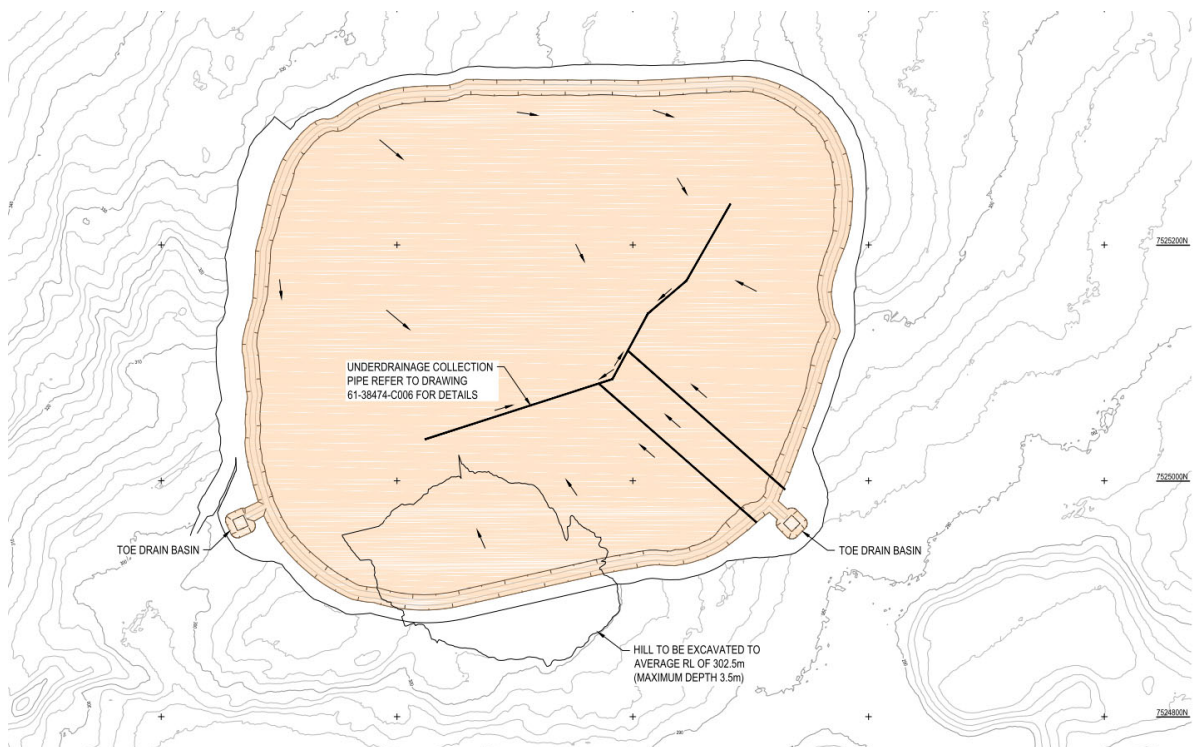


Figure 11-1 Extent of clay liner

The proposed clay liner will consist of borrowed material with appropriate proportions of medium to high plasticity fines (>30%). Materials of this nature will allow the clays to be worked and placed to create a relatively impermeable basin. In addition, to improve the liner material, it is proposed that bentonite be mixed with the borrow materials in proportions of approximately 1:10 to 1:12, bentonite to soils.

The clay liner will require protection from:

- Vehicles trafficking over the IWF area
- Freezing

For the purpose of this study, a protection layer consisting of 1 m of general fill and 1 m of mine waste (rock) will be placed over the clay liner has been allowed for. The 2 m of fill should ensure that moisture in the liner does not freeze/swell due to seasonal variations. In addition the rock will provide a robust surface for vehicles to traffic without affecting the clay liner.

It has been recognised that due to the subzero yearly average temperature at the site, freeze-induced damage for this arrangement may be possible, based on the likely PSD of the natural till material to be used,

However, the potential damage to the material is also function of the consistency of the material and the confining stresses. The harder the material (more compacted) and the greater the confining stress, the lower the likelihood of damage due to freezing. In the case of the IWF case, the critical period will be the period when the clay liner is only covered with the initial protection layer.

While studies and literature have explored the effect of cold temperatures on soils, the subzero average yearly temperature presents conditions that have not been well explored.

It is recommended that prior to the detailed design of the IWF, a site specific liner study be carried out to determine the most suitable liner system. The study should assess:

- Current practice for other mines in Sweden
- Effect of various ratio of bentonite to till on freeze damage resistance
- Synthetic liner systems, mainly LDPE due to the brittleness of HDPE in cold temperatures
- Combined liner system (natural and synthetic)

It should be recognised that the provided seepage interception trench will provide a redundancy system to capture seepage should the provided liner fail (Section 11.4).

11.3 Underdrainage arrangement

The underdrainage system consists of a slotted “draincoil” pipe placed at the upstream toe of the starter embankment and under the footprint of the IWF embankment (shown as the red lines in Figure 11-2).

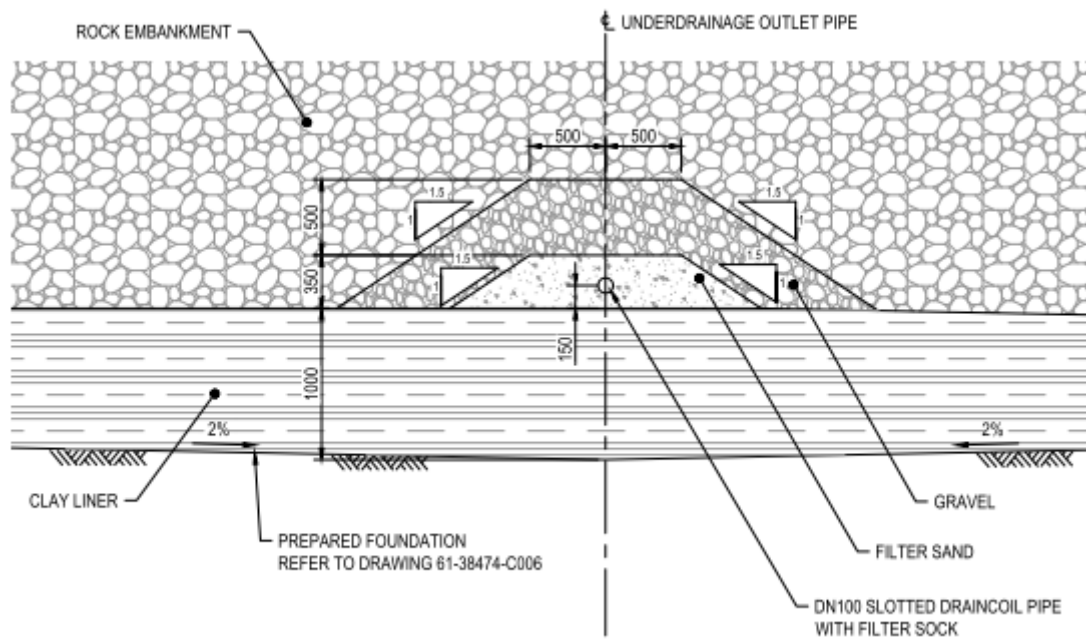


Figure 11-4 Upstream underdrainage outlet detail

Where required, the underdrainage was detailed to include filtering principles, that is inclusion of graded materials and filter socks, to limit the likelihood clogging of the underdrainage pipe and to provide robustness to the system over the life of the facility.

The underdrainage system will report to two seepage wells via unslotted pipes which will run through the clay liner. Assuming proper construction of the clay liner, the likelihood of seepage at these locations is minimal.

The seepage wells will collect seepage to be pumped to two water treatment plants located on site. In addition, the wells will be sufficiently deep to limit the likelihood of freezing. A breather pipe has also been included, to allow the system to be grouted for closure of the system.

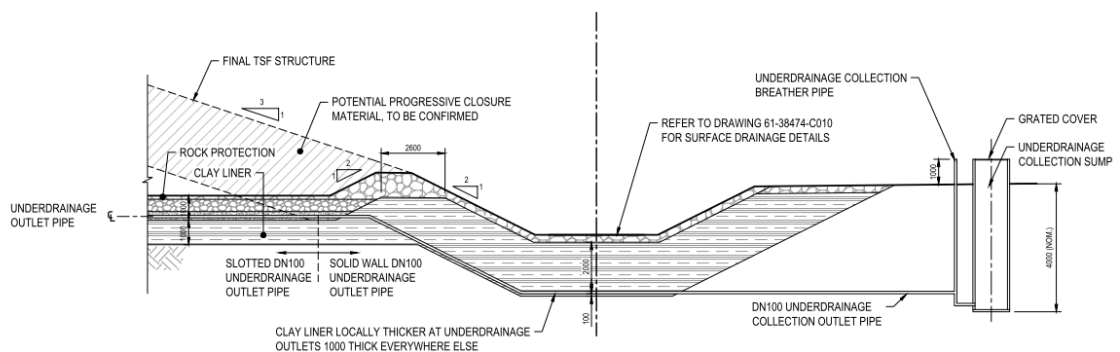


Figure 11-5 Underdrainage outlet

All underdrainage pipework was nominated as DN100, which has a drainage capacity of 15 m³/hr at a grade of 2%. This capacity is expected to be more than sufficient for normal operating conditions.

11.4 Seepage interception trench

A secondary underdrainage system was allowed for in the form of a seepage interception trench. The location of this trench is shown in Figure 11-2 as a blue line. This trench will be located downstream of the clay liner and to intercept any seepage outside the IWF should the IWF liner be compromised.

The trench consists of a slotted draincoil pipe located at the bottom of the trench, with graded zones to limit the likelihood of the drainage pipe becoming blocked. The depth of the trench will be dictated by the topography of the area, however, the trench must be taken deep enough to intercept any zones in the ground which may be able to transmit seepage from the IWF.

The interception trench will report to separate seepage wells, which will allow the monitoring of seepage quantity. In addition, any seepage that is observed can be tested for water quality to allow an understanding the likelihood of contaminated seepage leaking into the environment.

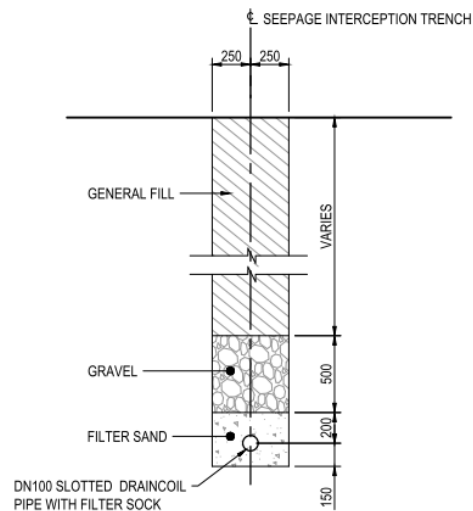


Figure 11-6 Seepage interception trench - section

12. Surface water drainage design

12.1 General

Surface water drainage was included in the design to manage surface flows from the IWF and from external catchments. Due to the potential for contamination of water from surface runoff from the IWF, the design of surface water had to consider the separation of surface flows, based on the source of the runoff. The surface water drainage system therefore consists of:

- Toe drain and toe drain basin
- Diversion drain and outlets

12.2 Design inflows

To align with the design basis for the Pre-Feasibility Stage of the Vittangi Project (AF, 2019), the design inflow events for the surface drainage was 1:20 AEP. The critical duration for the return period was selected based on the total volume of precipitation that would be expected for this return period.

Using the total precipitation volume to define the critical period was due to the reasoning that the worst-case scenario would be the extreme event occurring in winter and the precipitation taking the form of snow over the various catchment areas. In the worst event, sudden snowmelt may occur, with all precipitation reporting to the surface drains.

As stated by SMHI, the IFD curves (Section 2.3) present precipitation in the “melted form” regardless of whether the precipitation occurred as snow or rain. As a result, no volume adjustment for the precipitation was required.

Using the reasoning above, the critical duration was determined to be a 72 hour event. This is shown in Table 12-1, with the 72 hour event resulting in the largest unit volume. For any longer events, it is assumed that the drainage system will be operational and therefore the total volume of water retained in the surface drains will be less.

Table 12-1 IFD and extreme precipitation event volumes (1:20 yr AEP)

Duration (hr)	Intensity (mm/hr)	Unit volume (mm ³ /m ²)	Unit Volume (m ³ /m ²)
0.25	44.61	11.153	0.011
0.5	32.79	16.394	0.016
0.75	24.37	18.274	0.018
1	20.12	20.123	0.020
2	11.76	23.515	0.024
3	8.85	26.556	0.027
4	6.98	27.903	0.028
5	5.97	29.857	0.030
6	5.34	32.036	0.032
12	3.31	39.698	0.040

Duration (hr)	Intensity (mm/hr)	Unit volume (mm ³ /m ²)	Unit Volume (m ³ /m ²)
24	2.16	51.958	0.052
36	1.64	59.013	0.059
48	1.43	68.597	0.069
60	1.21	72.818	0.073
72	1.07	76.744	0.077

12.3 Surface flow catchments

Three separate catchments and the type of surface flows were identified with respect to the surface water management structures are as follows:

1. IWF surface east (includes some external catchments) – Contaminated flows
2. IWF surface west – Contaminated flows
3. Western external catchment – Uncontaminated flows

These approximate areas were shown in Figure 12-1. Note that these areas are applicable for all stages of the IWF.

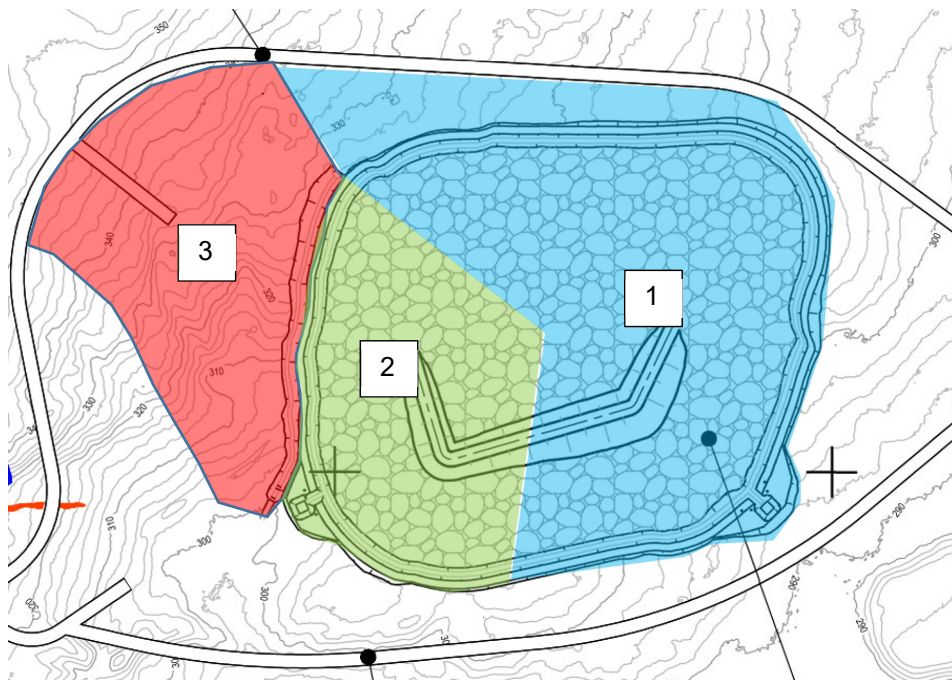


Figure 12-1 Catchment areas

The area and volume of runoff expected for each catchment is shown in Table 12-2. These volumes were determined for the IWF stage that presented the highest catchment area.

Table 12-2 Surface runoff volumes

Catchment	Area (m ²)	Volume of runoff (m ³) (Area multiplied by unit volume of precipitation)
1	156,805	12,034
2	57,626	4,422
3	32,864	2,522

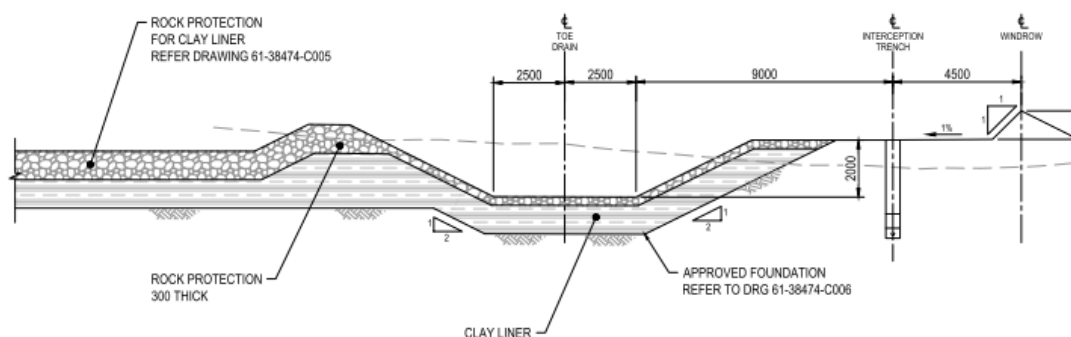
It should be noted that the IFD curves for the site was received late in the FS stage. As a result, all drains were nominally and conservatively sized. As agreed with Talga, the drains will be resized when the FS design is finalised to reflect the actual precipitation requirements for each catchment.

12.4 Toe drain and basin

The toe drain and basin system collects and manages potentially contaminated surface flows from the IWF (Catchments 1 and 2). The toe drains and basin are located directly downstream of the IWF and surround the total perimeter of the IWF footprint so that runoff during all stages of the IWF life.

To lower the likelihood of contaminated runoff escaping to the environment, the drains will be clay lined. In addition, windrows downstream of the drains were allowed for to further delineate contaminated and uncontaminated surface runoff.

The typical toe drain cross-section, including confining windrow is shown in Figure 12-2.

**Figure 12-2 Toe drain - typical section**

The perimeter toe drains will be graded such that catchments 1 and 2 report to two separate sections of toe drain, designated toe drain east and toe drain west. These toe drain sections were designed to report to two toe drains basin, located at the south-east and south-west extents of the facility.

These basin will be underlain by an extension of the clay liner to minimise the risk of uncontrolled release of contaminated seepage. From these basins, all contaminated surface flows can be pumped back to water treatment plants located on site. .

The basins are sized to relatively shallow, to allow them to be dredged of silt and other build-up. It was recognised that any contained flows may freeze in the winter, but this was not identified to be a risk to the function of the basin.

All drains and basin will be rock lined to protect the underlying clay liner from damage.

The typical plan and section through the toe drain and basin is shown in Figure 12-3 and Figure 12-4, respectively.

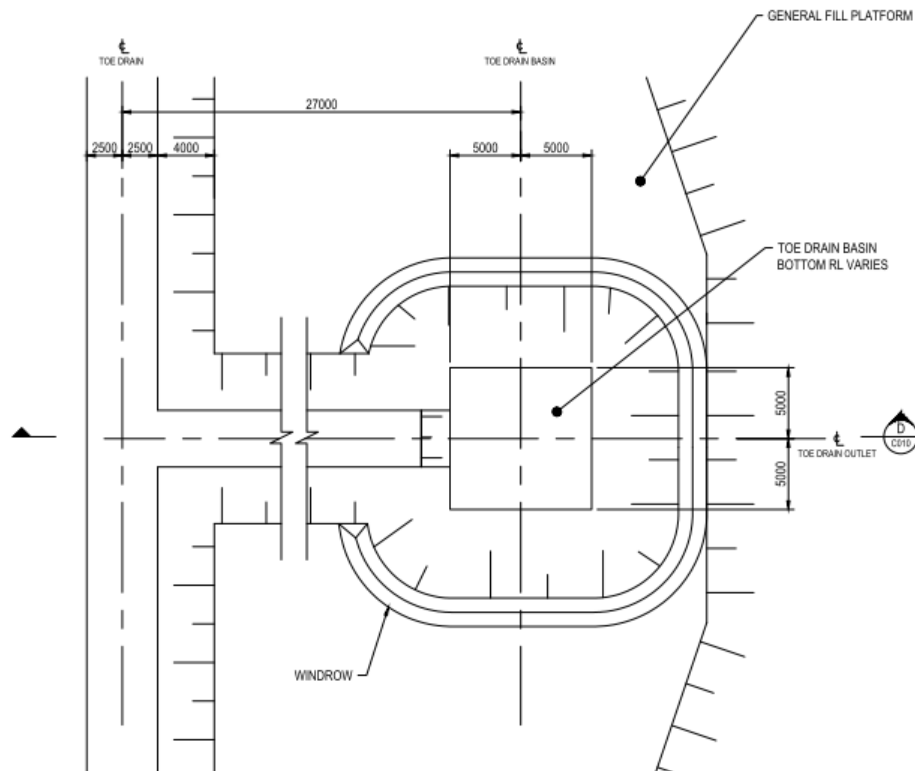


Figure 12-3 Toe drain basin - typical plan

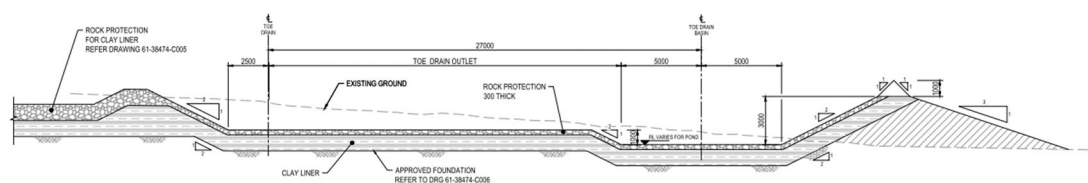


Figure 12-4 Toe drain basin - typical section through outlet

As stated above, the drains shown were conservatively sized. Review of the volume of the drains showed that the currently sized drains can contain:

- East drain – 19,080 m³
- West drain – 8,640 m³

As these volumes exceed the expected runoff volumes, they will be resized as part of the finalisation of the FS study.

12.5 Diversion drain

A diversion drain was allowed for in the design to:

- Direct uncontaminated flows back into the environment, via Lake Hosiojärvi
- Minimise the volume of water reporting to the water treatment plants on site

The diversion drain was located at the western extent of the IWF, which features the largest external catchment. All surface flows from this catchment will report to the drain, which will direct flows south towards the lake.

Outflows will be conveyed from the drain via a “settling pond” outlet arrangement which will lower the outflows velocity. This will result in sediments settling out the flows prior to returning them to the environment. The outlet was sized to be relatively shallow to allow it to be easily dredged of sediments.

The typical drain cross-section and outlet long-section is shown in Figure 12-5 and Figure 12-6.

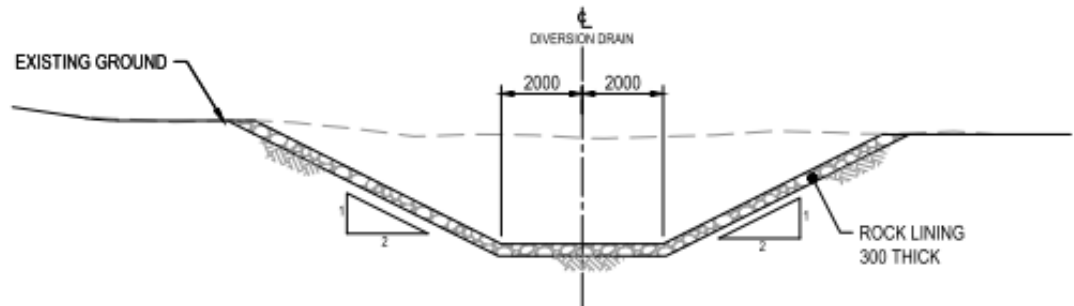


Figure 12-5 Diversion drain - typical section

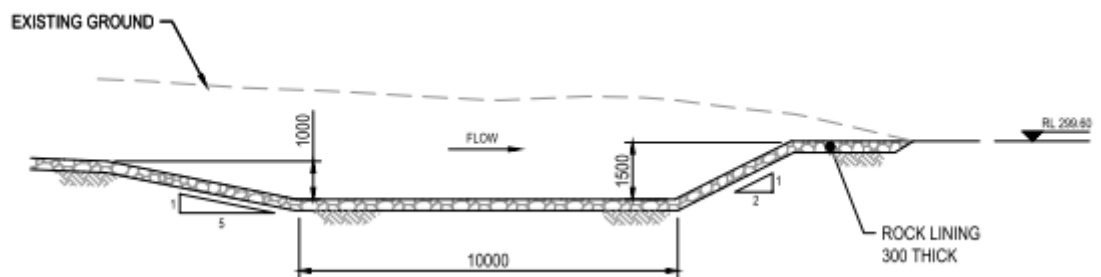


Figure 12-6 Diversion drain outlet - long section

Similar to the toe drain system, the diversion drain shown was conservatively sized. Review of the volume of the drain showed that the currently sized drain can contain 5,936 m³. As this exceeds the expected inflows, the diversion drain will be resized as part of the finalisation of the FS study.

13. Water Balance

13.1 General

A high-level water balance was carried out for the IWF system to provide insight into the volumes that will be required to be processed at the two water treatment plants on site.

It was identified that the volume of contaminated water to be sent to the plant will largely be dominated by the surface runoff reporting to the toe drains and basins. The seepage rates, while constant, are expected to be marginal compared to the surface flows, due to the de-watered and relatively impermeable nature of the tailings. However, it was recognised that the sizing of the water treatment plant was dependent on an estimate of seepage flows expected.

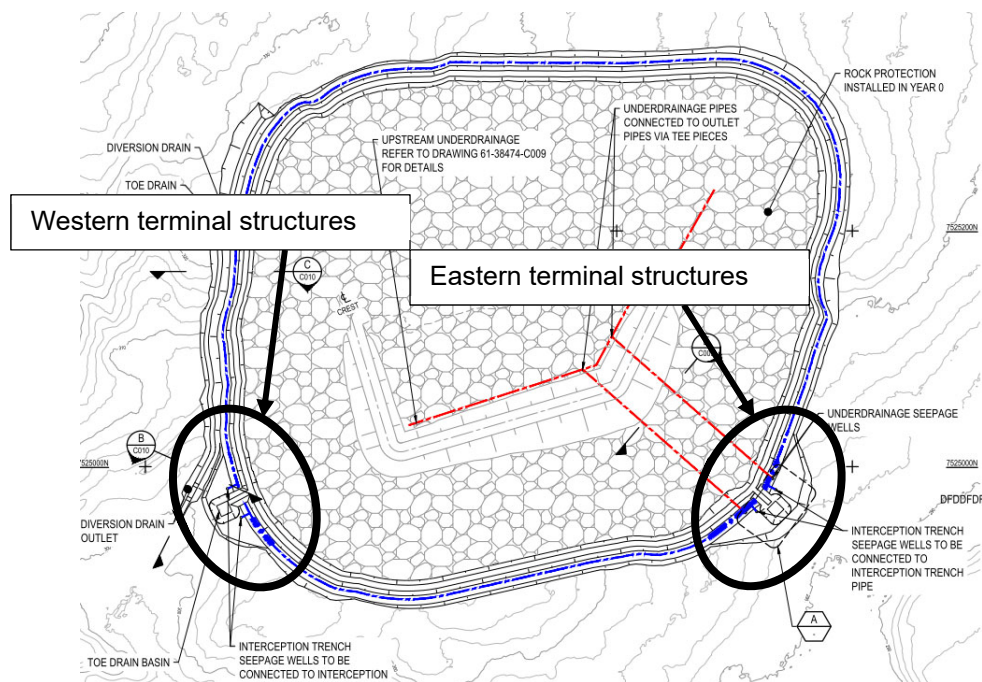
It is understood that there will be two water treatment plants on site, located to the east and west of the IWF. The underdrainage and surface drainage systems will report to both plants, due to the location of the water management infrastructure. For ease of reference, the underdrainage and surface water management terminal structures have also been designated east and west.

The eastern terminal structures consist of:

- Underdrainage outlet wells
- Eastern interception trench outlet wells
- Eastern toe drain basin

The western terminal structures consist of:

- Western interception trench outlet wells
- Western toe drain basin



13.2 Average precipitation values

The water return values were based on reported average monthly precipitation values for the Vittangi, as reported by SMHI. These values have stated to include precipitation as a result of snowfall.

Table 13-1 Average recorded monthly precipitation (SMHI, Vittangi weather station No. 18190)

Month	Average monthly precipitation (mm/month)
January	23.6
February	20.8
March	20.2
April	20.7
may	31.5
June	50
July	76.4
August	68.3
September	44.7
October	40.1
November	35.0
December	26.7

13.3 Water return volumes – surface flows

To estimate the return water volumes as a result of surface flows, average monthly volumes based on the average monthly rainfalls described above for each toe drain has been produced. The volumes have taken into account the catchment sizes reporting to each drain. With regards to the underdrainage seepage, as stated above, it is expected that these volumes will be relatively minimal. As such, a 10% uplift on the volumes of the surface runoff has been allowed for to account for the seepage volumes.

The monthly flows of potentially contaminated surface water flows from the IWF are provided in Table 13-2.

Table 13-2 IWF monthly surface water return volumes

Month	Water return volumes for eastern terminal structures (m ³ /month)	Water return volumes for western terminal structures (m ³ /month)
January	648	4,071
February	571	3,588
March	555	3,484

Month	Water return volumes for eastern terminal structures (m ³ /month)	Water return volumes for western terminal structures (m ³ /month)
April	569	3,570
May	865	5,433
June	1,374	8,624
July	2,099	13,178
August	1,876	11,781
September	1,228	7,710
October	1,102	6,917
November	962	6,037
December	734	4,605

13.4 Water return volumes – seepage flows

An estimate of the return water flows due to seepage from the IWF was carried out, based on the expected consolidation of the tailings. The assumptions that were made in this estimate were:

- The stored material would be purely tailings – Consolidation test results did not exist for the mixed waste material
- The tailings was fully saturated – This would not be the case for the filtered tailings which would feature moisture contents closer to 30%. This was done as an estimation of seepage for partially saturated soils is a complex procedure requiring further laboratory testing. This assumption would result in a conservative seepage estimate
- The plan area of the TSF was taken as a constant 197,000 m² – This is the footprint area at Year 0 and would result in a conservative seepage estimate
- Seepage would occur at a constant rate throughout the year – In reality, seepage is likely to occur during Spring and potentially stop during Winter if the underdrainage pipe freeze, or partially freeze
- The change in permeability of the filtered tailings was not taken into account as the tailings consolidate over time

Assuming the assumptions stated above, an average seepage rate was estimated for each year that the IWF is active as shown in Table 13-3.

Due to the above assumptions and complexity in calculating a more accurate seepage estimate, it is recommended that these seepage rates be used as an order-of-magnitude to size any water treatment plant requirements.

Table 13-3 Estimated seepage rates

Year	Seepage (m3/yr)	Seepage (m3/sec)	Seepage (L/sec)
0	26,573	0.0008	0.84

1	39,408	0.0012	1.25
2	45,868	0.0015	1.45
3	50,434	0.0016	1.60
4	55,318	0.0018	1.75
5	60,503	0.0019	1.92
6	66,109	0.0021	2.10
7	69,232	0.0022	2.20
8	76,253	0.0024	2.42
9	80,170	0.0025	2.54
10	85,297	0.0027	2.70

14. Instrumentation and monitoring

The performance of the IWF during its operation and post closure will be monitored using the following:

- Surface movement surveys
- Internal pore water pressure boreholes
- Underdrainage flows measurement
- Groundwater monitoring bores

Surface movement survey points will be installed at the crests of the perimeter embankment to monitor the surface movement to assure safety during construction. After the final IWF landform is achieved additional surface movement measuring points will be installed across the IWF surface to monitor the long-term performance of the IWF.

The internal pore water pressure will be measured by monitoring bores, which will be installed through the perimeter embankment and inside the IWF once the IWF is closed. The monitoring bores will also be used to sample and test the water quality from within the IWF to determine the level of contamination, if any, over time. The size of the boreholes will be sufficient to allow for deployment of dewatering pumps if the pore water pressure within the IWF raises, though this is considered unlikely.

The underdrainage flows will be measured to provide an indication of the seepage (rain water and snowmelt) through the deposited mine waste and tailings. After the IWF closure, the underdrainage flows will be used to detect when the consolidation of the deposited mine waste and tailings has finished. When the underdrainage flows stop indicating that primary consolidation has finished, the underdrainage system will be grouted closed.

Groundwater monitoring bores external to and downstream of the IWF will also be installed. These bores will allow the monitoring of groundwater for elevation and water quality to determine the effectiveness of the IWF underdrainage system and clay liner.

The plan of the IWF at Year 0 showing the location of the monitoring instrumentation is shown in Figure 14-1. In addition, the location of the pore pressure monitoring bores for the closed IWF is shown in Figure 14-2.

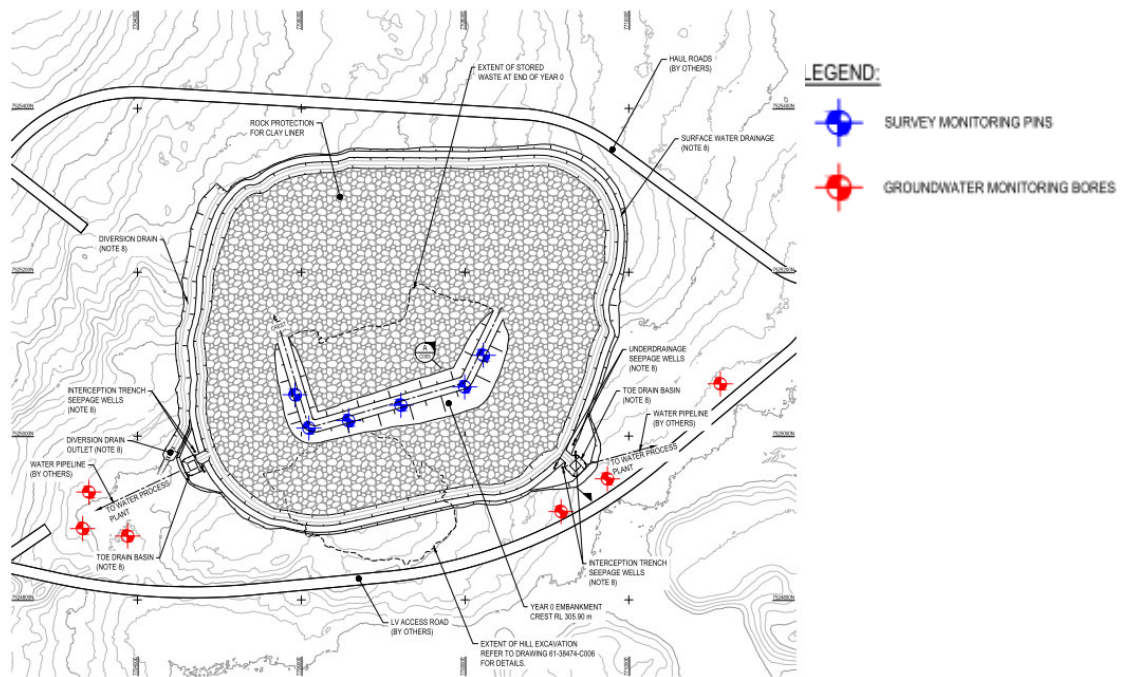


Figure 14-1 Year 0 monitoring instrumentation plan

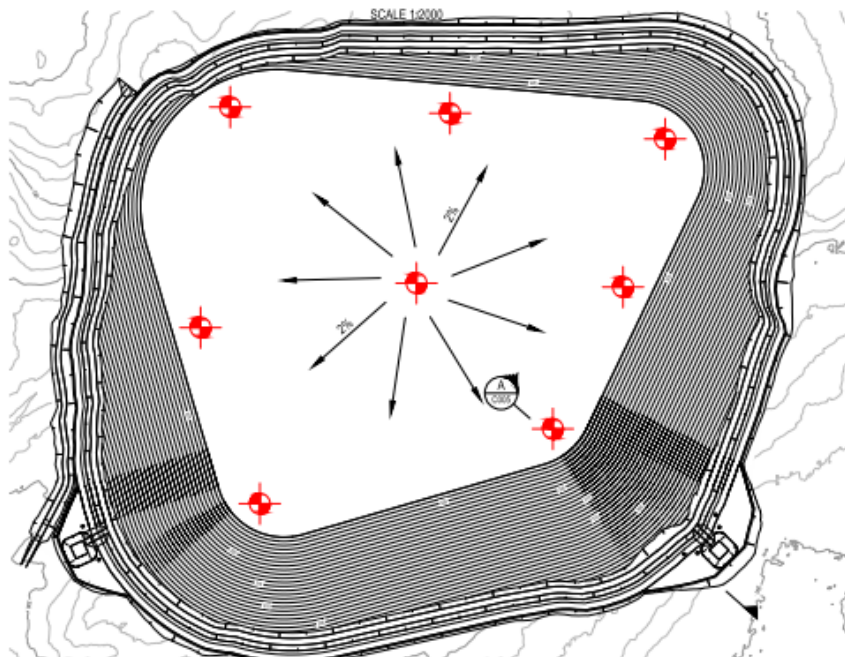


Figure 14-2 Closed IWF monitoring instrumentation plan

15. Closure concept

The closure concept developed as part of this FS assumes a fill encapsulation of the mine waste and tailings within a low permeability mineral liner as shown in Figure 15-1. This is to prevent oxidation of the mine waste and tailings and generation of heavy metals.

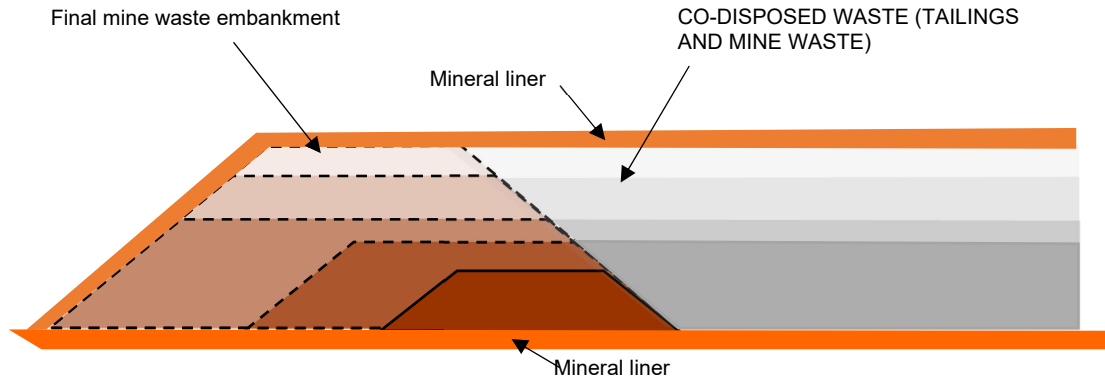


Figure 15-1 Encapsulation of IWF

During the operation of the IWF, the IWF surface will receive rainwater and snow. The rainwater and snowmelt will percolate through the deposited mine waste and tailings to the base of the facility. The underdrainage system, described in Section 11, will collect the surface water entering the IWF and report it to the water treatment plant. The underdrainage system will also collect water released from the IWF as a result of the mine waste and tailings consolidation. As the consolidation process will continue even after the facility is encapsulated, the underdrainage system will be operated until the LoM. The closure of the underdrainage system by grouting the outlet will be completed only after the underdrainage flow ceases.

To limit the volume of rainfall and snowmelt reporting to the underdrainage system, the external slopes of the IWF are planned to be progressively encapsulated and rehabilitated. The progressive closure is planned to start after Year 4 when the final external slopes of the facility will start to be formed. To allow for the progressive closure the external slopes of the IWF will be constructed to the slope of 1V in 3H.

The encapsulation of the external face of the IWF will utilise the footprint liner which extends past the downstream toe of the embankment.

The internal top surface of the IWF will be reshaped, as part of the closure operation, to provide a camber and thus allow for the ongoing settlement of the mine waste and tailings.

The final surface of the encapsulated IWF will be hydro-mulched with seeds of native plants.

The performance of the IWF after its closure will be monitored using surface movement and internal pore water pressure measurements. Details of the monitoring system are provided in Section 14.

16. Future studies

16.1 General

The following sections detail the work that is recommended or that will be required to complete the detailed feasibility study and the detailed design of IWF.

16.2 Surveys

Detailed ground survey of the area nominated for the IWF will be required for completion of the IWF design and MTOs.

16.3 Hydrogeology

A IWF specific hydrogeology study should be carried out as part of the detailed design to define the groundwater flow underneath the IWF and to quantify the potential impact of the IWF operation and inform the design of the seepage barriers.

The current IWF design does not include a ground water management system because the groundwater flows are not expected to resurface within the IWF footprint. If ground water resurfacing is confirmed to potentially cause significantly elevated pore water pressures underneath the facility, the ground water drainage system may be needed.

16.4 Geotechnical investigation

A detailed geotechnical investigation of the IWF and borrow area will be required to confirm the foundation conditions as well as the borrow materials quality and quantity. It is recommended the geotechnical investigation include the following:

- Seismic Cone Penetration Tests with pore water pressure measurement for the foundations of the IWF and the borrow areas
- Boreholes within the IWF area with permeability testing and samples taken
- Test pits in the foundation of the IWF and the borrow area with samples taken

In addition to site investigations, the following laboratory tests should be carried out:

- Particle size distribution tests
- Atterberg Limit tests
- Dispersion tests (with water of both neutral pH and with the pH expected in the IWF seepage)
- Permeability tests
- Maximum compaction tests
- Triaxial tests

16.5 Liner study

A detailed liner study will be required to define the construction technique and the mass of the required additives based on the geotechnical tests. The liner study will also confirm the performance (permeability) of the clayey liner under various conditions (low pH, freezing etc.).

16.6 Closure study

The IWF closure will be integrated in the mine closure and the closure technique for the tailings facility must conform to the overall closure technique and the desirable land forms and post mining land use. A detailed IWF closure study will be developed as part of the detailed design based on the geotechnical investigations, the liner study and the mine closure principles.

16.7 LoM tailings characterisation and detailed filtration testing

The filter plant performance (throughput and filter cake moisture content) is controlled by the tailings characteristics and a modest change of the tailings materials may have a severe impact on the plant performance.

Additional filtration testing must therefore be undertaken on samples representing the operational envelope of the plant. This additional testing will define the operational envelope for the filter plant and the filter plant size.

16.8 Mine waste characterisation

The geotechnical characteristics of the mine waste are needed due to the co-diposal nature of the facility, as well as the proposed plan to use mine waste as the structural fill of the IWF. The mine characterisation should include conventional geotechnical testing (classification and performance) to inform the detailed design of the IWF.

17. Risks and opportunities

As part of the FS, GHD identified a number of risks and opportunities to be addressed in the future stages of the project and identified risks and opportunities registers are provided in Table 17-1 and Table 17-2.

For the identified risks, GHD has provided a qualitative risk rating, based on perceived likelihoods of the risks occurring based on existing information (i.e. conditions on site) and assuming no action was undertaken to address it.

GHD also estimated the consequences that Talga may be exposed to should the risks eventuate. GHD recommends that Talga review and update the risk register as more information regarding the risks are known.

With respect to the IWF, the highest risk was identified to be the adverse likely affecting the clay liner. As discussed in Section 11.2, a site specific study should be undertaken to determine the most appropriate liner system to reduce the risk of contaminated seepage being released into the environment. In addition, GHD recommends that visits to existing mine operations in the region are carried out to determine how these sites deal with the adverse climate conditions.

Further details of the likelihood and consequence descriptors can be found in the risk identification document (6138474-PMD-_Talga Vittangi IWF Risk and Opportunities).

Table 17-1 IWF risk register

No.	Risk Nature	Hazard description	Consequence description	Probability of occurrence	Consequence	Risk	Mitigation action	Impacted Items
1	Poor performance of filter plant	Filter plant performance (throughput, MC, etc.) is worse than expected because of plant under sizing and/or change of the tailings properties and/or mine plan changes resulting in different waste characteristics	High MC filter cake - change of the tailings deposition - higher OPEX Lower throughput - reduction of production - loss of revenue Lower throughput - need for a temporary bypass - higher CAPEX Higher TSF seepage rates - increase demand for water filtration	Possible	Medium (Production)	Moderate	Further filtration tests as part of the DFS Better definition of the LoM tailings Better definition of mine plan	CAPEX OPEX
2	Unplanned filter plant shutdown	Malfunctioning of the filter plant	Lower throughput - reduction of production - loss of revenue Lower throughput - need for a temporary bypass - higher CAPEX	Likely	Minor (Opex)	Moderate	Further filtration tests as part of the DFS Good manufacturing	CAPEX Revenue
3	Insufficient construction material	Insufficient volume of clayey soils required for the clayey liner	Higher CAPEX	Possible	Serious (Capex)	High	Geotechnical investigation as part of the DFS	CAPEX
4	Low mine waste/tailings ratio	Ratio of mine waste to tailings is lower than expected	Change of the tailings deposition - higher OPEX	Possible	Medium (Opex)	Moderate	Detailed mining schedule as part of the DFS	OPEX
5	Uncontrolled seepage from TSF	Poor construction of the clayey liner Clay dispersion of clayey liner Frost or mechanical damage of clayey liner	Seepage from the TSF into the environment	Likely	Serious (Compliance)	High	Liner study in DFS QA/QC during construction On-going monitoring of the underdrainage flow Tertiary seepage collection system	Non-compliance CAPEX
6	Poor post-closure performance	Failure of the encapsulation system post closure	Seepage from the TSF into the environment	Unlikely	Serious (Compliance)	Moderate	Encapsulation study in DFS QA/QC during construction On-going monitoring of pore water pressures Tertiary seepage collection system	Non-compliance CAPEX
7	Adverse climate	Very low temperatures impeding infrastructure and operations (blocked drains, frozen pipes and pumps, trafficability issues, etc.)	Lower production - loss of revenue Higher CAPEX	Almost Certain	Serious (Compliance)	Critical	Design for extreme weather conditions Designer to learn from local mine operation during winter Diligent Operation and Maintenance	CAPEX Revenue Compliance
8	Unsuitable foundation conditions	Foundation materials at TSF differ from the FS assumptions	Change of the foundation treatment	Possible	Minor (capex)	Low	Geotechnical investigation as part of the DFS	CAPEX
9	Softer than expected mine waste	Mine waste material containing excessive proportion of fines	Trafficability issues at TSF	Likely	Minor (opex)	Moderate	Mine waste study as part of the DFS	OPEX
10	Increase tailings production	More than expected tailings produced (lower ore quality, increase production rate)	Increase filter throughput - CAPEX	Possible	Medium (capex)	Moderate	Detailed mining schedule and definition of the ore and mine waste	CAPEX
11	Uplift pressures under TSF	Rainwater infiltrates the ground above the TSF footprint and then resurfaces underneath the TSF causing uplift pressures.	Uplift pressure impeding stability and eroding clayey liner	Unlikely	Serious (Capex)	Moderate	Dedicated groundwater drainage system Site specific hydrogeology study	CAPEX

Table 17-2 IWF opportunity register

No.	Opportunity type	Opportunity description	Planned action	Impacted Item
1	Alternative filter plant	Lower CAPEX filter plant options (screw filter)	Investigate suitability of a screw filter	CAPEX
2	Reduction of the TSF	Optimise the mine plan to reduce the size of the TSF	Consider alternative mine plans	CAPEX and OPEX
3	Pozzolan addition	Addition of material to induce pozzolanic reactions in the tailings to create cementitious waste	Study being carried out	CAPEX and OPEX

Appendices

Appendix A Basis of Design



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Talga Resources

Vittangi Project – Feasibility Study Basis of Design – Tailings Storage Facility

GHD: 61-38474-00000-CI-BOD-002

Revision B

November 2019

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1. Introduction

1.1 Purpose of this document

This document presents the Basis of Design that will be adopted for the feasibility study (FS) for the Tailings Storage Facility at the Talga Resources (Talga) Vittangi project in Sweden.

The Basis of Design presents the design criteria and assumptions used in the FS, in order to prepare a design in compliant with the statutory requirements.

The Basis of Design presented in this document may be modified in the future depending on the new input information made available during the feasibility study.

The Basis of Design will be reviewed by and agreed upon by Talga and the third party reviewer in the early stage of the feasibility study to allow for the study to progress.

The Basis of Design will be progressively updated as required as the design proceeds.

1.2 Project information

Talga requires a feasibility study, including the preparation of budget bill of quantities to provide tailings storage for the Vittangi project as recommended in the Pre-Feasibility Study (PFS) completed by Talga in May 2019.

The preferred tailings solution presented in the PFS involved the following steps:

- Tailings thickening
- Tailings Dewatering
- Co-disposal of the filtered tailings with mine waste in dry-stacking in an on-site dry TSF

The Vittangi Project is situated in the County of Norrbotten, in Vittangi, 50 km east of the town of Kiruna, northern Sweden ().

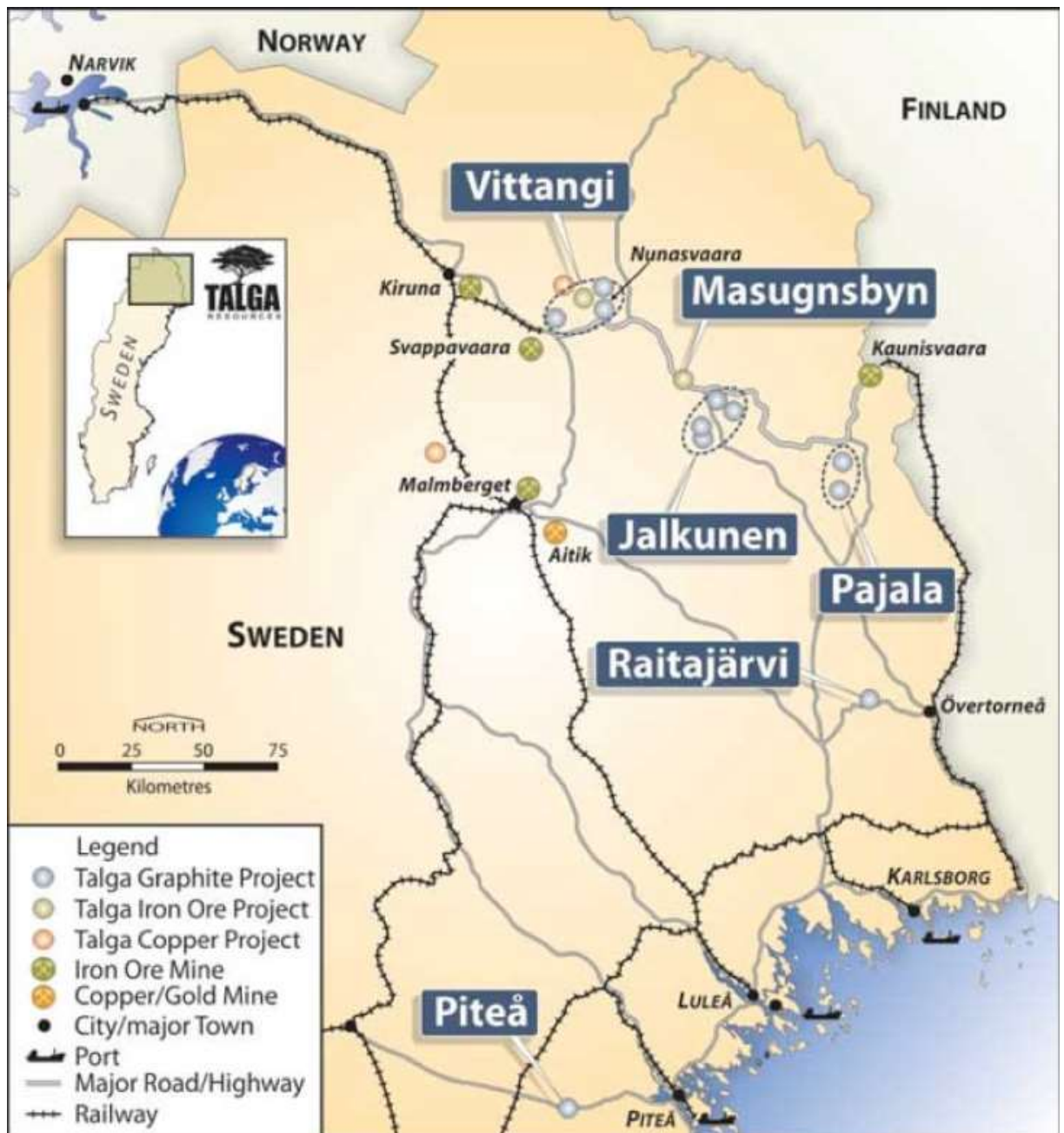


Figure 1 Vittangi project location

1.3 Scope of Basis of Design

This Basis of Design is related to tailings deposition and it addresses the design of the TSF.

1.4 Previous studies

The key previous studies relating to the Vittangi Project were as follows:

- Talga, 2019, "Vittangi Graphite Project, Pre-Feasibility Study Summary" May 2019.
- Golder, 2019, "Mining Technical Description, Vittangi Graphite Project, February 2019.

1.5 Feasibility Study objectives

The primary objective of the feasibility study for the Vittangi TSF is to produce:

- Review the option selection process and prepare a trade-off study to confirm the preferred tailings management strategy for the Project
- Investigate potential opportunities presented in the Tailings Option Report

- Compare the standalone tailings dry-stacking against the co-disposal with mine waste and select the preferred options
- Develop feasibility level design for the selected tailings disposal system
- Prepare an FS report and drawings to support the environmental and mining applications for the project

1.6 Feasibility Study scope of work

The feasibility study scope of work for the TSF comprises the following tasks:

- Review of the tailings management strategy
- Carry out the trade-of study
- Develop basis of design for the dry-stack facility
- Conduct a site visit
- Option assessment - Develop up to three conceptual options for the facility layout and the arrangement to allow for selection of the most economical option
- Completed a preliminary consequence assessment of the facility
- Develop a feasibility design for the facility
- Prepare a preliminary MTO for the dry-stack facility to define the requirements for borrow materials for external shells and closure of the facility
- Prepare a risk assessment for the dry-stack facility
- Prepare a tailings governance principles document
- Prepare a feasibility study report for the dry-stack facility
- Prepare up to 10 preliminary design drawings for the dry-stack facility

1.7 Scope of work exclusions

The following exclusions apply to the scope of work:

- Tailings Filtration test
- Design of the tailings thickener and filter plant
- Design of the tailings delivery system between the filter plant and the TSF
- Selection of unit rates for cost estimate.

1.8 Key design principles

- The TSF will be designed as a dry stacking facility, which will combine the filtered tailings with mine waste to form a stable landform.
- The facility will be designed to account for disposal of acid forming materials and the facility will therefore include seepage barriers and seepage recovery systems.
- The facility will be designed to be progressively closed to limit the acid forming potential of the deposited mine waste and tailings
- The facility will be sized to contain the Life of Mine tailings production from the Vittangi project.

1.9 Battery limits

Battery limits for the Feasibility Study are summarised in

Table 1-1 TSF battery limits

Design area	Battery Limit type	Battery limit	Reference / note
Roads	Physical extent	Area boundary of TSF	Section 5.3.1
Underdrainage	Connection point	Underdrainage collection sump	Section 5.9
Power supply	Excluded from TSF scope		GHD to prepare a list of equipment requiring power
Surface water drainage	Connection point	Open drains outlet at the perimeter of TSF or collection point	Section 5.10
Surface water diversion	Discharge point	Open drains outlet at the perimeter of TSF	Section 5.12

1.10 Exclusion zones

The following data sets have been included by Talga in digital format

- Ore bodies
- Planned mine pits
- Environmental exclusion zones –
- Areas of natural value
- Prospective graphite beds
- Heritage exclusion zones

Other Exclusion zones to be considered and which may not be initially available include:

- Roads
- Building and infrastructure
- Process plant
- Electrical infrastructure

In the absence of these exclusion zones being available, clearance zones will be assumed and approved by Talga.

2. General basis of design

2.1 Purpose of facility

The purpose of the TSF is to provide a safe and economical storage capacity for tailings produced by the Vittangi process plant for the LoM of the project.

2.2 Design life and target dates

The design life of the TSF is 22 years.

2.3 Design standards

The design standards and technical references adopted for this project will be as follows:

- Swedish dam safety guidelines, GruvRIDAS, 2012.
- Directive 2006/21/EC – Management of waste from extractive industries and amending Directive 2004/35/EC.
- EC07 Parts 1 and 2
- Australian National Committee on Large Dams (ANCOLD) Guidelines on Tailings Dams (2012).
- ANCOLD Guidelines on Consequence Categories for Dams (2012).
- ANCOLD Guidelines on Selection of Acceptable Flood Capacity for Dams (2000).
- Other relevant ANCOLD Guidelines.
- Relevant ICOLD Guidelines.
- Internationally recognised guidelines of other national dam authorities (e.g. USACE, USBR, FERC).

2.4 Existing Permits / Licences

Not applicable.

2.5 Required Permits / Licences

The Vittangi TSF will be subject to the conditions in the following permits:

- Exploitation Concession (as required under the Swedish Minerals Act)
- Environmental Permit, including a Natura 2000 permit if deemed necessary (as required under the Swedish Environmental Code)

Note that these permits and licences are not in place. The outcomes of the FS will be used by Talga in the application process of these permits. As such, GHD will not allow for any conditions which may be required in these permits that are not otherwise covered in the design standards stated in Section 2.3.

3. Tailings properties

3.1 Tailings discharge rates

The design tailings discharge is **75,000** dry tonnes per annum (tpa)

3.2 Geochemistry

Tailings are considered likely to be potentially acid forming. The tailings are comprising mainly silicates with variable proportion of Fe-Sulphides.

3.3 Geotechnical parameters

The key geotechnical and engineering properties of the tailings are provided in Table 3-1.

Table 3-1 Key properties of the tailings

Property	Value	Source
Solids specific gravity	2.87	Geotechnical testing
Average slurry density ex filter plant	1357 g/L	Filtrations testing
Average moisture content of filtered tailings	28%	Filtration testing
Compression index of filter cake	TBC	Geotechnical testing
Particle size distribution	PSD as per Figure 2 will be considered	Geotechnical testing
Hydraulic conductivity of filtered tailings	TBC	Geotechnical testing
Undrained Shear Strength parameters	TBC	Geotechnical testing
Effective Shear Strength parameters	TBC	Geotechnical testing

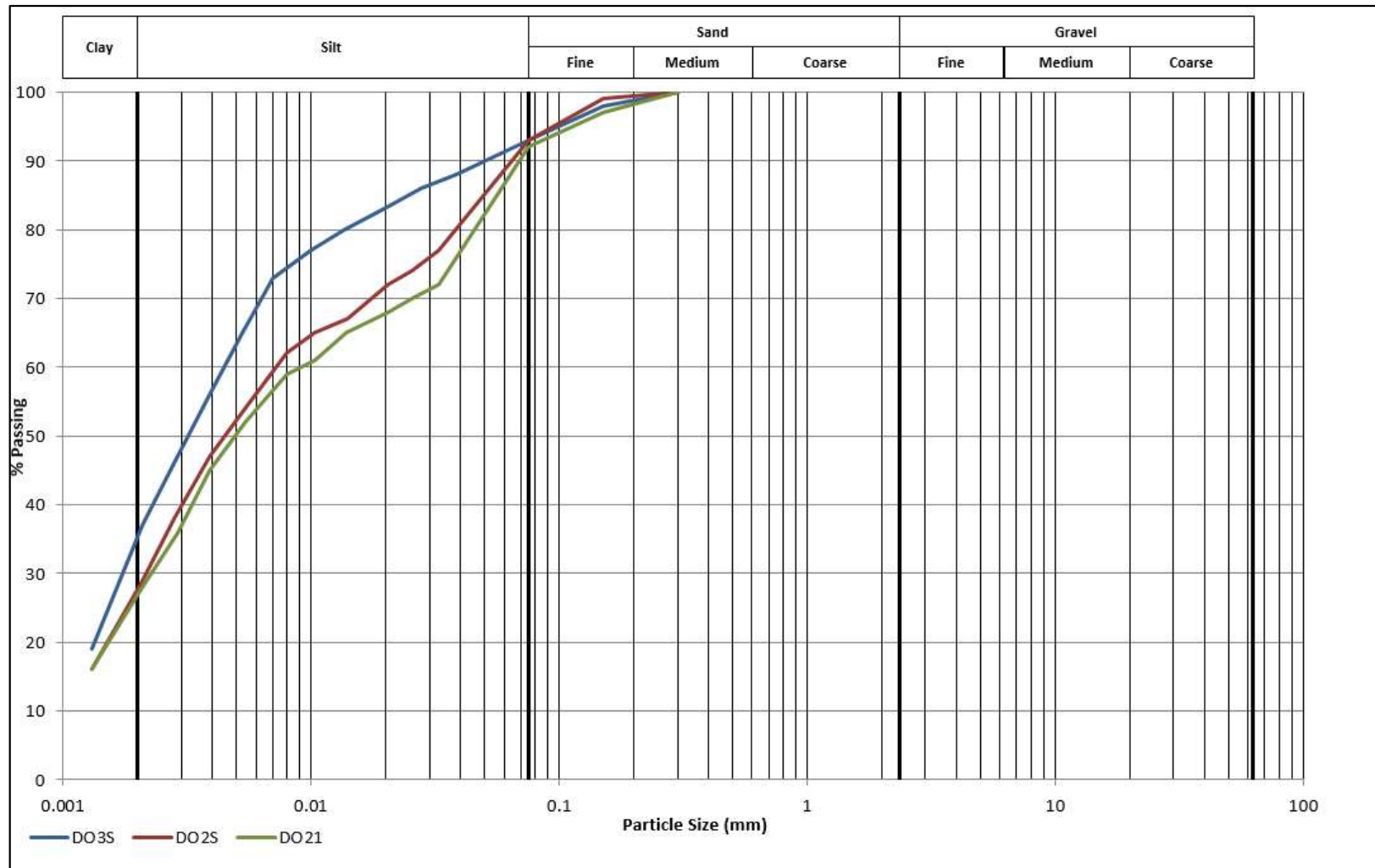


Figure 2 PSD of filtered tailings samples

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Consequence category

A consequence category assessment for the facility will be completed as part of the FS in accordance with GruvRIDAS (2012) and ANCOLD (2012).

In accordance with ANCOLD Guidelines (2012), the consequence category will determine the following:

- Minimum extreme storm allowance, contingency freeboard and drainage capacity.
- Minimum design earthquake loads.
- Inspection and maintenance requirements.

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5. TSF design

5.1 Location

The TSF will be located within the mining area, within the white polygon shown in Figure 3.

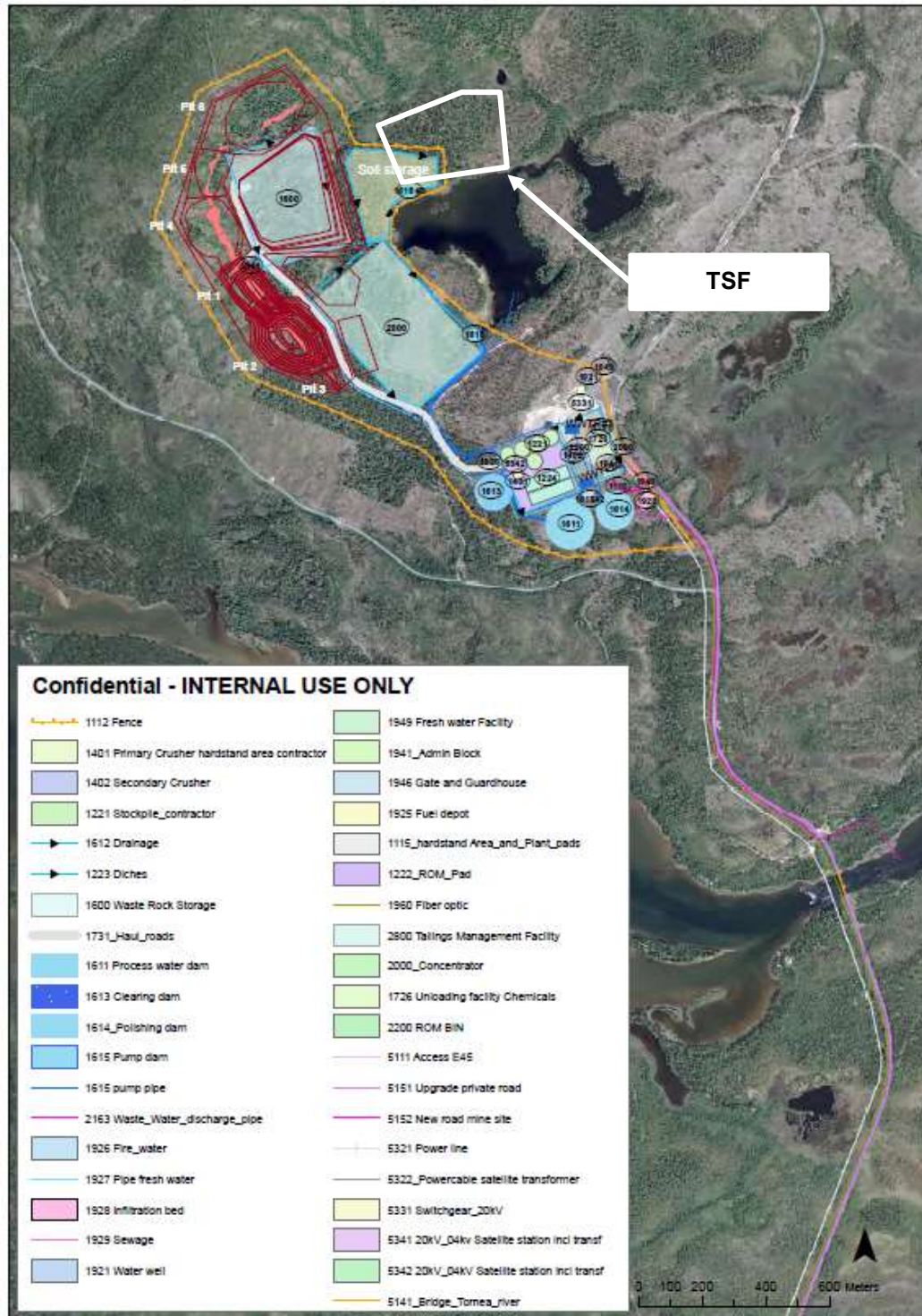


Figure 3 Infrastructure layout

5.2 General arrangement

The shape of the TSF will be approximately rectangular as shown in and it will be optimised as part of the FS, with consideration to the natural topography..

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5.3 TSF components

5.3.1 Access

Dedicated access to the facility will be required for both the light vehicles (LV) and heavy vehicles (HV).

The HV access will be required from the main haul road to supply waste rock for the TSF structure. Based on the previously indicated location of the main haul road, this has been assumed to be from the western extents of the TSF.

LV access will required to access the TSF from the Concentrator.

The key characteristics of the roads design are listed in Table 5-1.

Table 5-1 Roads design basis

Parameter	HV	LV
Nominated vehicle type	????	n/a
Road width single-lane (m)	????	????
Road width double-lane (m)	????	????
Maximum speed (km/h)	????	????
Maximum gradient (%)	????	????
Cross fall of crest (%)	????	????
Windrows height (m)	????	????

5.3.2 Embankments

Based on the PFS recommendations, the outer shell of the TSF dry stack (embankment) will be constructed from mine waste. The mine waste will be free draining and water which percolates through the embankment will be collected and treated (Section ??) . The key characteristics of the embankment are listed in Table 5-2.

Table 5-2 Embankment design basis

Parameter	Value	Note
Minimum crest width (m)	TBC	To allow for trucks movement
Upstream slope (1 V in X H)	1 in 2	To be confirmed based on the construction material
Downstream slope (1 V in X H)	1 in 3	To be suitable for progressive closure, final slope to be confirmed as part of this FS
Crest Cross fall (%)	2%	inwards
Material	Mine waste	Free draining
	Filtered tailings	
Outer shell material	Treated till	For progressive closure

5.4 Foundation treatment

The foundation treatment for the facility will include:

- Seepage barrier (blanket seal) from compacted till mixed with bentonite
- Underdrainage system (Section 5.9)
- Seepage detection and recovery system (Section 5.10)

5.5 Design loads

The design loads to be used for the TSF design are listed in Table 5-3.

Table 5-3 TSF design loads

Design load type	Value	Reference
Maximum Design Earthquake	??? based on consequence	
Operational Basis Earthquake	??? based on consequence	
Design Rainfall	??? based on consequence	
Design Wind	??? based on consequence	

These will be based and updated on the consequences determined due to failure of the emplacement, in accordance with the relevant standards and design guidelines.

5.6 Slope stability requirements

The stability analysis of the embankments will be undertaken for static and dynamic loading, including construction cases, using the limit equilibrium theorem. The outcomes from the stability analysis will determine the embankment geometry required to achieve the minimum factors of safety in accordance with Table 5-4.

Table 5-4 Minimum factors of safety

Loading condition	Recommended minimum for tailings dams
Static loading	1.5
Post-seismic	1.2

5.7 Progressive closure

All outer slopes of the TSF will be designed to be progressively capped and rehabilitated using bentonite treated till layer and topsoil.

Golder Luleå are responsible for the design and requirements of the integrated waste landform capping layer and the statement currently in this section is accurate. Outputs from Golder's work will be supplied to GHD for input into the FS report.

5.8 Instrumentation

TSF instrumentation will be included to satisfy the requirements of ANCOLD will include:

- Piezometers placed within the co-disposal emplacement to monitor pore water pressures

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- Surface movement pins on the crest to monitor movement of the embankment
- Stationary radar or InSar to monitor movement of the embankment

5.9 Underdrainage

The underdrainage system will comprise drain pipes surrounded by NAF filter/drainage aggregates. The drainage network will be covered with a blanket drain constructed from the mine waste. The underdrainage system will span the footprint of the TSF storage area; underneath the perimeter shells and above the foundation blanket seal. It will collect water expelled from the deposited tailings together with the rain and snow melting water which percolates through the waste rock materials used in the TSF.

Water collected in the underdrainage pipes will be discharge through the foundations of the TSF perimeter shells into collection sumps from where it will be pumped back to the concentrator (pumping and piping by others).

5.10 Seepage detection and recovery system

A seepage detection and recovery system will be implemented to allow detection of failure of the underdrainage and to act as a redundancy should the underdrainage fail.

The system will consist of a seepage recovery trench which will surround the perimeter of the TSF. The system will collect any bypass seepage and direct them to monitoring wells for detection and recovery back to the concentrator (pumping and piping by others).

5.11 Surface water drainage

Rainwater and water from melting snow will be discharged through the waste rock into the underdrainage and will be collected in the underdrainage sumps. To limit the likelihood of contamination of rainfall and snow melt runoff from natural ground, a dedicated drainage channel will also be provided to capture any surface runoff from the TSF.

5.12 Surface water diversion

Surface water perimeter drains will be designed along the perimeter of the TSF to divert surface water from the TSF area. The surface water diversion drains will be discharged through a sediment control pond to the Lake Hosiojärvi and downstream channel.

6. Mechanical design

GHD will provide a list of mechanical equipment to be required for the TSF. The mechanical design is excluded from GHD scope

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7. Closure

A preliminary closure design will be developed as part of this PFS and it will include the following elements:

- Dome capping
- Surface water drainage
- Closure of underdrains
- Monitoring system for closure performance

Golder Luleå is responsible for undertaking geochemical modelling to determine the requirement dome capping performance criteria. Outputs from GHD and Golder's respective studies will be considered in the closure design.

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GHD

GHD, 999 Hay Street, Perth, WA 6000

P.O. Box 3106, Perth WA 6832

T: 61 8 6222 8222 F: 61 8 6222 8555 E: permail@ghd.com.au

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[https://projects.ghd.com/oc/WesternAustralia2/talgaresourcesgraphi/Delivery/Documents/Talga Vittangi TSF BOD.docx](https://projects.ghd.com/oc/WesternAustralia2/talgaresourcesgraphi/Delivery/Documents/TalgaVittangiTSFBOD.docx)

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
A	J Herza					
B	R Singh (updates)	J Herza		J Herza		
C	R Singh	J Herza		J Herza		

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Appendix B Outotec filter test report

Outotec	Test Report 319968 T1 Vittangi Graphite	TESTING
Sales		1 / 37

Customer:	Talga Resources Ltd.
Contact Person(s):	Duncan Turner & Alisha Jones
Country:	Sweden
Place:	20 kms East of Svappavaara, Sweden
Application:	Vittangi Graphite
Product of Test:	Vittangi Graphite Tailings and Concentrate Samples
Case. No.:	319968
Case Manager:	Shane Freeman
Test Case No.:	319968T1
Test Performed by:	Jonathan Nguyen
Date of Test:	09 – 10 September 2019
Location of Test:	Outotec Lab, West Perth
Test equipment:	Buchner Funnel & Labox 100
Date of Test report:	September 2019
Test reported by:	Jonathan Nguyen

CONTENT

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Outotec	Test Report	TESTING
Sales	TEST CASE NO.: 319968 T1	2 / 37

1. GENERAL INFORMATION

Located approximately 20km east of LKAB's iron ore mine and railhead at Svappavaara, the Vittangi graphite project (containing the Nunasvaara deposit) has a total JORC resource of 12.3Mt at 25.5% graphite ("Cg"), the highest resource grade of any JORC/NI 43-101 graphite deposit in the world. Nunasvaara has been declared a mineral deposit of national interest by the Swedish Geological Survey, providing benefits against competing land uses.

Nunasvaara forms part of the Vittangi project which comprises multiple exploration permits covering more than 400km². Historical work across the Vittangi project identified extensive graphite as well as numerous skarn iron deposits and copper sulphide occurrences.

The Vittangi graphite deposits were first discovered in 1898, with trenching across the Nunasvaara deposit during 1916-18. Early work during the 1920s reviewed the possibility of using the graphite as a reducing agent in the production of pig iron, and Nunasvaara was declared a state mining field in 1929. Extensive work, including geophysics, trenching, core drilling (20 holes for 949m) and bulk sampling, was conducted by the SGU and LKAB during the period 1970-1982.

2. OBJECTIVE OF TESTS AND SELECTED TEST EQUIPMENT


Talga Resources Ltd. Vittangi Graphite Project is looking to dewater the graphite concentrate and tailings via filtration to proceed with the plant processes or transport and dry stack. One sample of concentrate and tailings were tested to determine their filtration performances. Outotec's Pressure Filtration technologies such as Pressure Filtration (PF) for the concentrate sample and Membrane Filter Press (MFP) for the tailings sample. Horizontal Vacuum Belt Filtration was also analysed for the concentrate sample to determine if this technology is suitable.

Filtration testwork was conducted to determine:

- cake thickness
- maximum filtration capacity
- moisture content of the cake
- cake handling

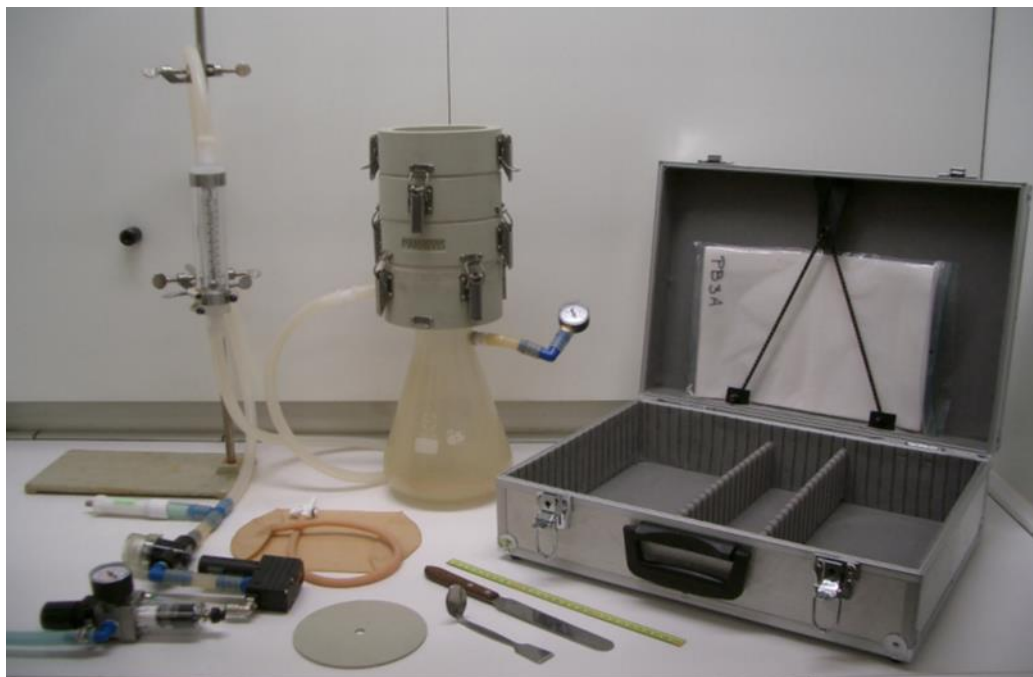
Labox 100 was used to evaluate the Pressure Filtration and Membrane Filter Press technologies whilst the Buchner Funnel was tested on the concentrate in addition to PF to determine the filtration performance.



	<h1>Test Report</h1>	TESTING
Sales	TEST CASE NO.: 319968 T1	3 / 37



Picture 1 - Labox 100 Test Kit



Picture 2 - Buchner Funnel Test Kit



Outotec	Test Report	TESTING
Sales	TEST CASE NO.: 319968 T1	4 / 37

3. CUSTOMER PROCESS DATA AND SIMPLIFIED FLOWSHEET

Not available at the time of testwork.

4. PRODUCTION DATA REQUIREMENTS

Filter cake:

- Cake moisture: Suitable for handling and dry stacking

Filtrate

- Contains max.: <250 ppm

5. DESCRIPTION OF FILTRATION PROCESS AND SIMPLIFIED FLOW SHEET

Outotec PF – Automatic Pressure Filter



Outotec automatic pressure filters have been developed to meet the needs of industry. Outotec automatic pressure filters are recessed plate membrane filters in which the chambers lie horizontally.

OUTOTEC Horizontal Vacuum Belt Filter:

The Outotec RB-SV (Rubber Belt – Side Vacuum) is the latest re-innovation of the mature Rubber Carrier belt filter. Focussing to eliminate the main aggravations of operation and maintenance in former Rubber belt filter designs and incorporating modern first world safety standards, the Outotec designers have produced a new industry benchmark for carrier belt filters.



In the Outotec RB-SV design the vacuum box is once again placed under the rubber belt, but it is still located on the outer edge of the belt. It therefore requires the sealing of the vacuum box on only one surface as with conventional vacuum box designs. For the widest filters in the range, a vacuum box can be located on each side of the filter to maximize hydraulic flow and ensure optimal performance.



Outotec	Test Report	TESTING
Sales	TEST CASE NO.: 319968 T1	5 / 37

Outotec Larox FP and FFP



The Outotec Larox Fast Acting Filter Press incorporates the following;

- Adaptability to unsteady process conditions and variable products
- Fast opening system and hydraulic closing system
- Membrane squeezing reduces cycle time
- Cake discharge and cloth cleaning system
- Short technical times ensure the highest specific filtration capacity



Outotec	Test Report	TESTING
Sales	TEST CASE NO.: 319968 T1	6 / 37

6. TEST – PRODUCT AND WASH LIQUID DATA

Kind of process/product

- Product : Vittangi Graphite
- Operation : Concentrate

Slurry

- Temperature : 20 °C
- Density : 1074 g/l
- Solids content : 12 wt%
- pH : 5
- p80 : 10 µm (Provided via CSIRO)
- Solids phase
Composition : Graphite, trace amounts of clay minerals and Albite
- Liquid phase
Composition : Perth Tap water
Corrosive Elements : No

Kind of process/product

- Product : Vittangi Graphite
- Operation : Tailings

Slurry

- Temperature : 18 °C
- Density : 1357 g/l
- Solids content : 45 wt%
- pH : 6
- p80 : 39 µm (Provided via CSIRO)
- Solids phase
Composition : Biotite, tremolite, pyrophyllite, pyrite, calcite, albite, residual graphite
- Liquid phase
Composition : Perth Tap water
Corrosive Elements : No



Outotec	Test Report	TESTING
Sales	TEST CASE NO.: 319968 T1	7 / 37

7. FILTRATION TEST DATA

7.1. Filtration Data – Vittangi Graphite Concentrate Sample

T1 – Outotec Larox Pressure Filtration (PF):

The following results are achieved with a chamber height of 33mm by using AINO T50 filter cloth.

- Specific filtration rate	84	kgDS/m ² h
- Residual filter cake moisture	36.8	% w/w
- Average drying air consumption	0	l/min
- Solids in filtrate	196	ppm
- Cake thickness	25	mm
- Cake density	1.5	kg/l
- Total cycle time	16.5	min

T2 – Outotec Horizontal Vacuum Belt Filtration (HVBF):

The following results are achieved using S60 filter cloth.

- Specific filtration rate	87	kgDS/m ² h
- Residual filter cake moisture	53.4	% w/w
- Cake thickness	7.5	mm
- Flocculant Dosage (M155)	173	g/t

7.2. Filtration Data – Vittangi Graphite Tailings Sample

T3 – Outotec Larox Membrane Filter Press (MFP):

The following results are achieved with a chamber height of 40mm by using FPC 601 filter cloth.

- Specific filtration rate	62	kgDS/m ² h
- Residual filter cake moisture	25.3	% w/w
- Average drying air consumption	19	l/min
- Cake thickness	33	mm
- Cake density	1.9	kg/l
- Total cycle time	22.25	min



Outotec	Test Report	TESTING
Sales	TEST CASE NO.: 319968 T1	8 / 37

8. ANALYSIS OF SAMPLES

Cake moisture is analysed using a Mettler Toledo moisture analyser and is also oven dried at 105°C over-night. Particle size distribution was provided by CSIRO.

9. EXPLANATION OF TESTS

Filtration testwork for the Vittangi Graphite project was to be conducted on the Graphite Concentrate and Tailing samples. Prior thickening on the concentrate sample showed to have very minor effect on underflow density. The filtration testwork was then completed at the feed density of the thickening testwork (12% solids). Pressure filtration (PF) was conducted on the concentrate sample along with Horizontal Vacuum Belt Filtration (HVBF) to determine the filtration performances. Graphite Tailing sample was tested using Membrane Filter press technology.

The concentrate sample produced high moisture contents in PF however, the filter cake was stable and suitable for handling or transportation. The main issue was the cake to filter chamber ratio during testing. As the feed pumping in at 12 % solids, the pump stops once the chamber can no longer physically allow more slurry. Once the dewatering from pressing and drying occurs, the solid filter cake only occupies 55% of the chamber. This issue was resolved using extended pumping time and higher pumping pressure. HVBF proved to not be suitable for this application as it produced significantly higher cake moistures and requires a large amount of flocculant as a filter aid to produce reasonable results.

The graphite tailings samples showed better filtration results. 25mm MFP chambers were easily filled and the filter cakes were very stable and can be transported or dry stacked. Increasing the chamber size to 40mm however showed signs of deformation when lightly vibrated. The issue however was resolved once drying pressure was increased to promote further dewatering.

Individual results are outlined below.

Rheology Testing

Outotec were requested as part of the scope to arrange for Rheology testing for both the concentrate and tailings samples.

Following the thickener testing, samples of each were collected at the appropriate solids content (12% for the con and 45% for the tails) and sent to Newpark Drilling Fluids who conducted the rheology testing at those densities. The results of the rheology testing can be seen in appendix 4.



Outotec	Test Report	TESTING
Sales	TEST CASE NO.: 319968 T1	9 / 37

9.1. Vittangi Graphite - Concentrate Sample

Outotec Pressure Filtration (PF)

Vittangi Graphite Concentrate sample was adjusted to 12% solids to match the thickener feed. This was due to minor underflow density changes during thickening testwork.

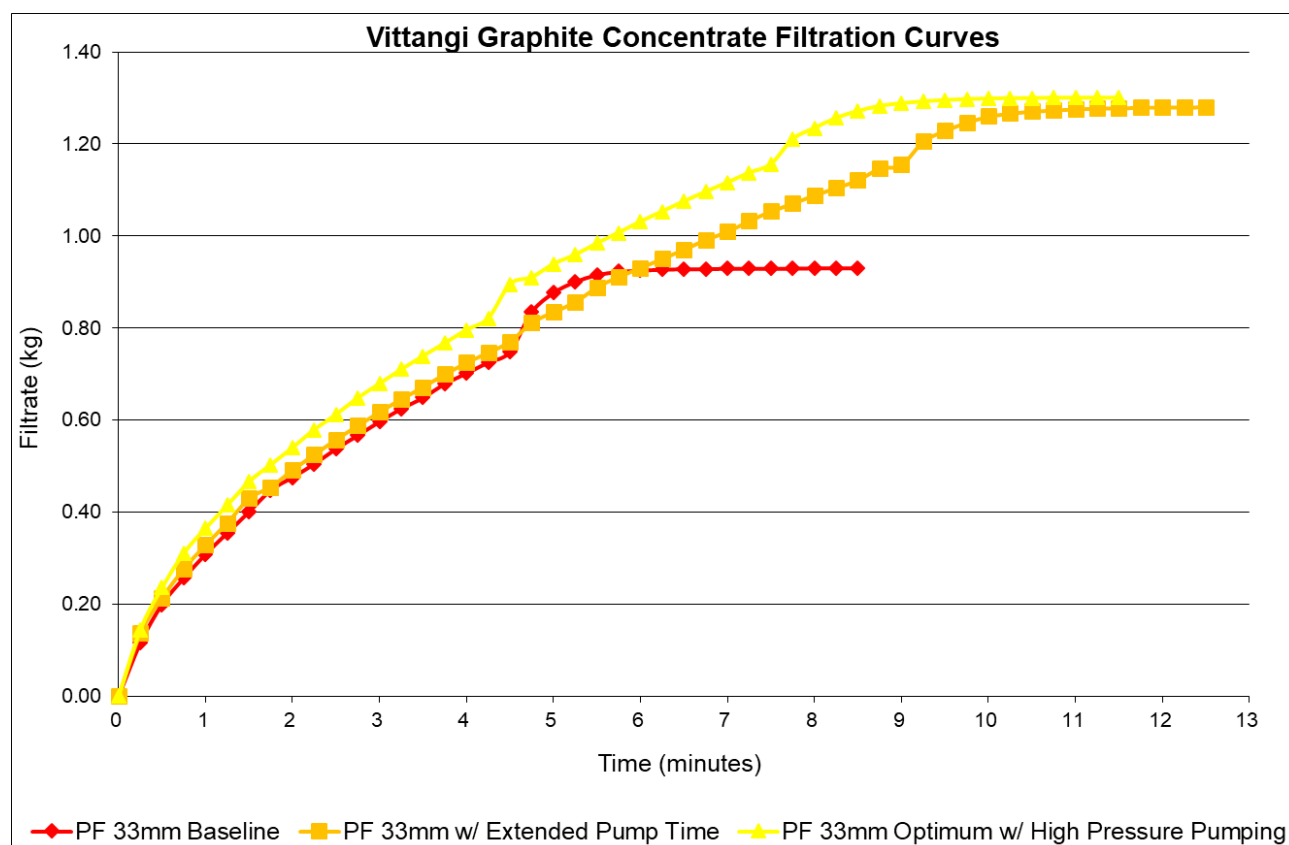


Chart 1 - PF Filtration Curve for the Vittangi Graphite Concentrate Sample

Chart 1 shows the filtrate accumulation during full cycle test runs. Filtration accumulation is rapid during the pumping and pressing stages of filtration. The cake is then consolidated before air-drying is introduced to promote further filtration. The first run is a baseline test which utilising the standard PF testing conditions. The slurry is pumped into the chamber until it reaches the chamber capacity. It is then pressed to dewater the slurry with the pressing diaphragm. This process occurs until no further filtrate is removed. The final stage is air-drying the filter cake to force residual water from the cake.

Following a baseline test, the subsequent runs incurred slight changes to the standard operating conditions to increase the filtration performance. Extended pump time was attempted to force more filtrate and increasing the pumping pressure will also improve the cake to chamber ratio.



Outotec	Test Report	TESTING
Sales	TEST CASE NO.: 319968 T1	10 / 37

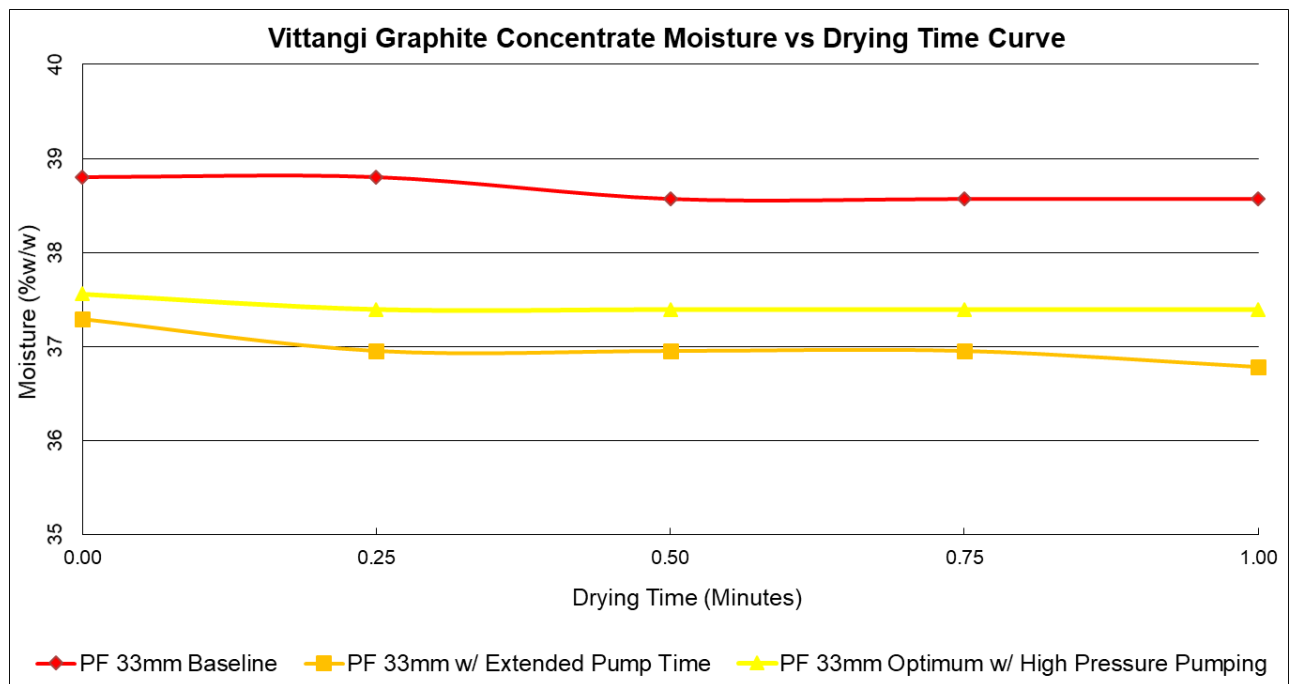


Chart 2 - PF Drying Time vs. Cake Moisture Content for the Vittangi Graphite Concentrate Sample

Chart 2 shows the cake moisture reduction during the air-drying stage. Most of the dewatering occurs within 0.5 minutes. Extending pumping time and increasing the pumping pressure were able to further reduce the moisture content from 38.6% to 36.8%.



Outotec	Test Report	TESTING
Sales	TEST CASE NO.: 319968 T1	11 / 37

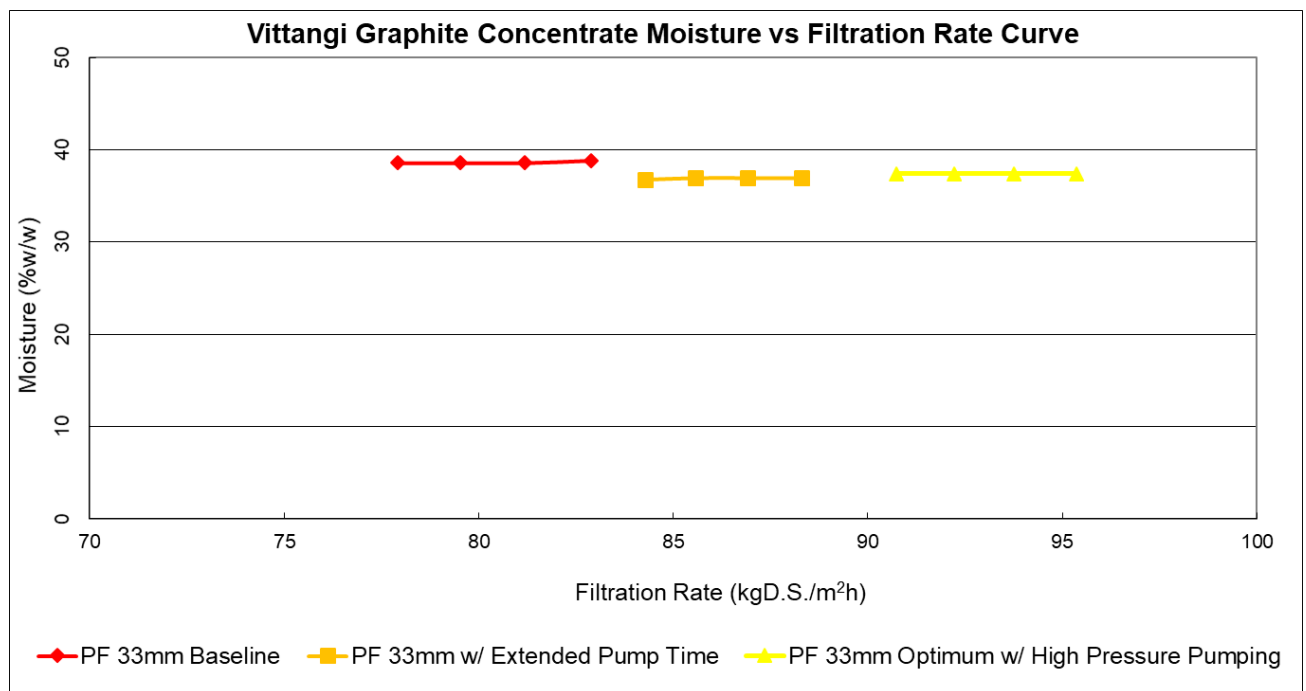



Chart 3 - PF Moisture Content vs. Filtration Rate for the Vittangi Graphite Concentrate Sample

Chart 3 shows the relationship between the filtration rate and cake moisture content that occurs within the air-drying stage. As shown in the chart above, increasing the pumping pressure from 6 bar to 8 bar also increases the filtration rate. The extended pump time was also able to increase the filtration rate when compared to the baseline.



	<h1>Test Report</h1>	TESTING
Sales	TEST CASE NO.: 319968 T1	12 / 37



Picture 3 - 25mm PF Vittangi Graphite Concentrate Filter Cake

Picture 3 shows a 25mm Vittangi Graphite Concentrate filter cake with a moisture content of 36.8%.



Outotec	Test Report	TESTING
Sales	TEST CASE NO.: 319968 T1	13 / 37

Outotec Horizontal Vacuum Belt Filtration

Vittangi Graphite Concentrate sample was adjusted to 12% solids. This was due to minor underflow density changes during thickening testwork.

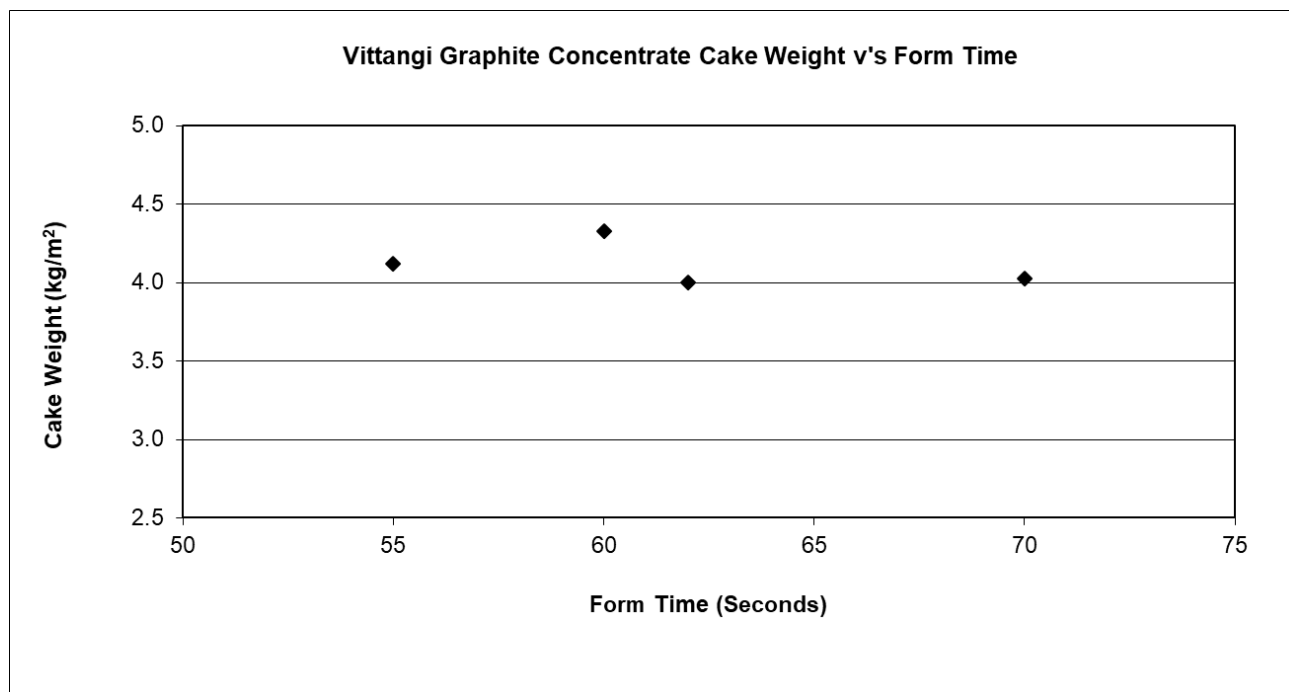


Chart 4 - HVBF Cake Weight vs Form Time for the Vittangi Graphite Concentrate Sample

Chart 4 shows the relationship between the cake weight and the cake form time. Form time is defined as the time point at which the slurry separates to form a solid cake. As shown in the chart above, the form times can vary from 55 to 70 seconds. Flocculant was introduced as a filter aid in order to reduce the form time and improve dewatering performance. There was insignificant improvement in cake form time with the presence of flocculant.



Outotec	Test Report	TESTING
Sales	TEST CASE NO.: 319968 T1	14 / 37

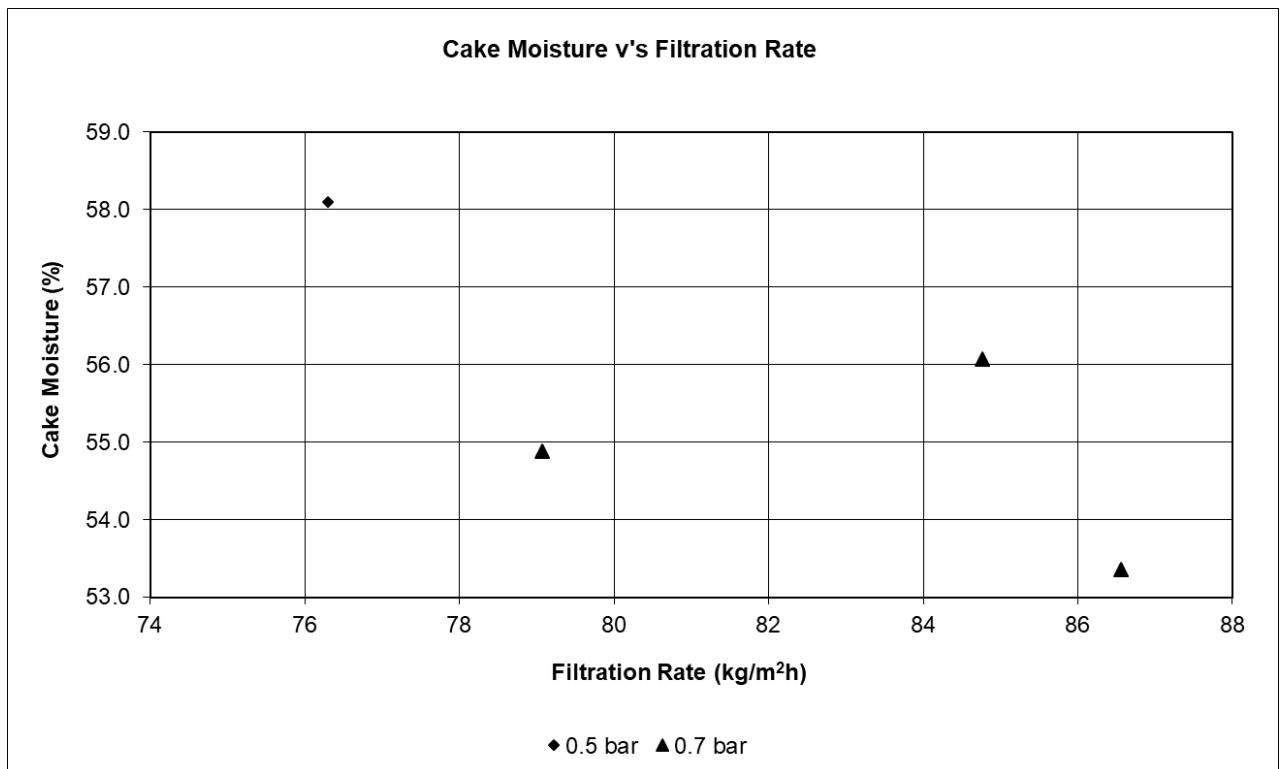


Chart 5 - HVBF Filtration Rate vs. Cake Moisture for the Vittangi Graphite Concentrate Sample

Chart 5 shows the relationship between filtration rate and cake moisture when the vacuum pressure is increased from 0.5 to 0.7 bar. As shown in the chart above, the filtration rate is increased with 0.7 bar as the pressure was able to improve dewatering performance. The filter cakes remained very unstable and is not suitable for handling and transportation.



Outotec	Test Report	TESTING
Sales	TEST CASE NO.: 319968 T1	15 / 37

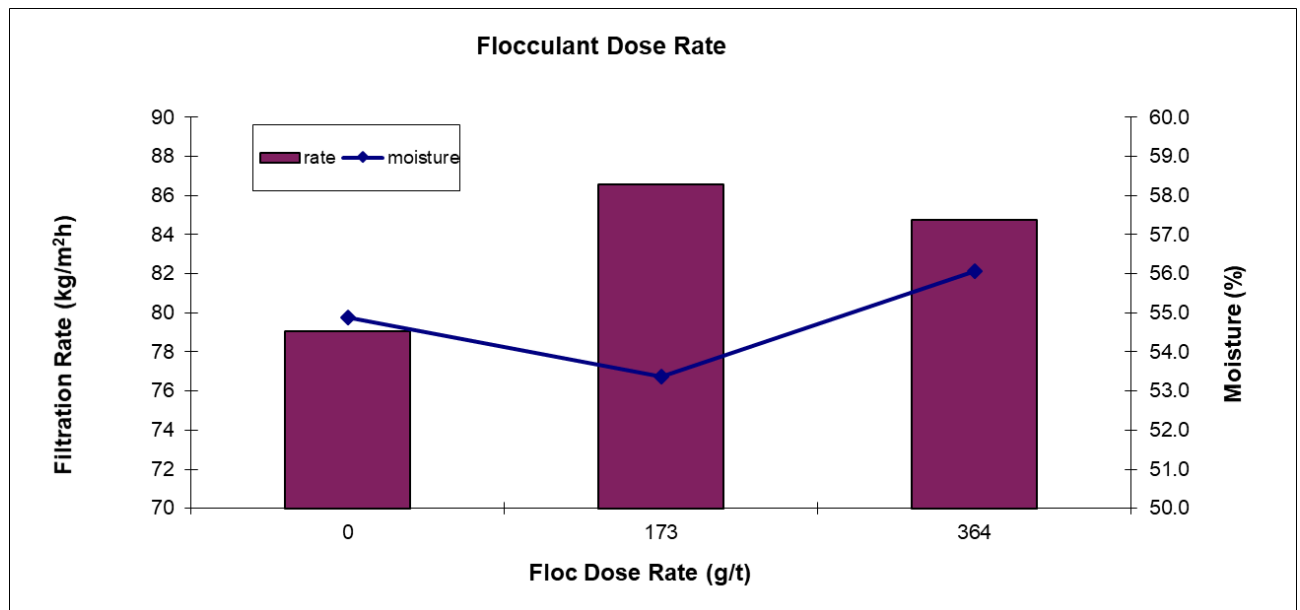

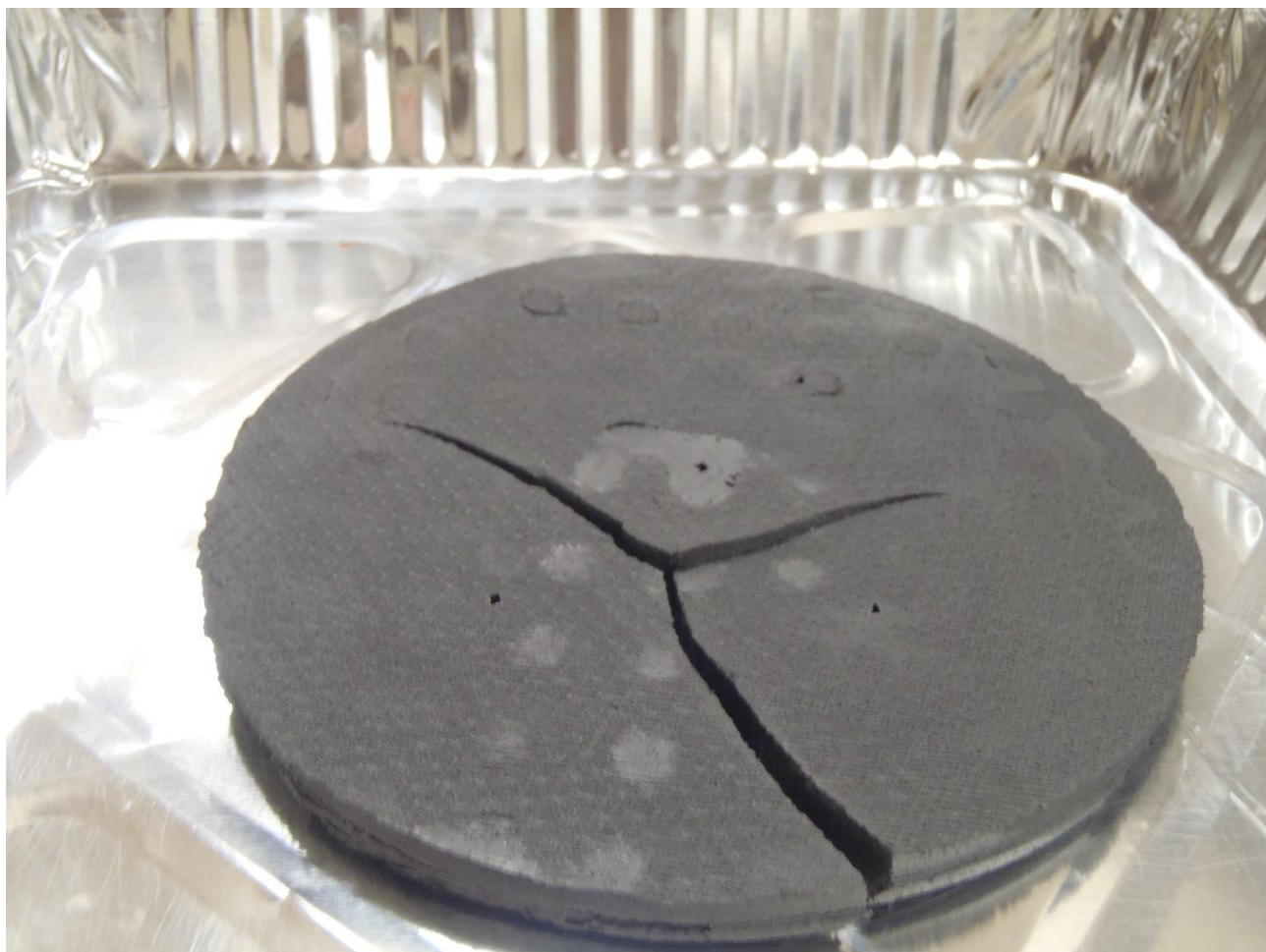


Chart 6 - HVBF Flocculant Dosage vs. Filtration Rate and Cake Moisture for the Vittangi Graphite Concentrate Sample

Chart 6 shows the effect of flocculant on the filtration rate and cake moisture. As shown in the chart above, increasing the flocculant dosage from 0 g/t to 173 g/t was able to increase the filtration rate and slightly reduce the moisture content. The dosage amount required is not viable for the application of this sample.



	<h1>Test Report</h1>	TESTING
Sales	TEST CASE NO.: 319968 T1	16 / 37



Picture 4 - 7.5mm HVBF Vittangi Graphite Concentrate Filter Cake

Picture 4 shows a 7.5mm HVBF filter cake with a moisture content of 53.4%.



Outotec	Test Report	TESTING
Sales	TEST CASE NO.: 319968 T1	17 / 37

9.2. Vittangi Graphite - Tailings Sample

Vittangi Graphite Concentrate sample was adjusted to 45% solids as indicated from thickening testwork.

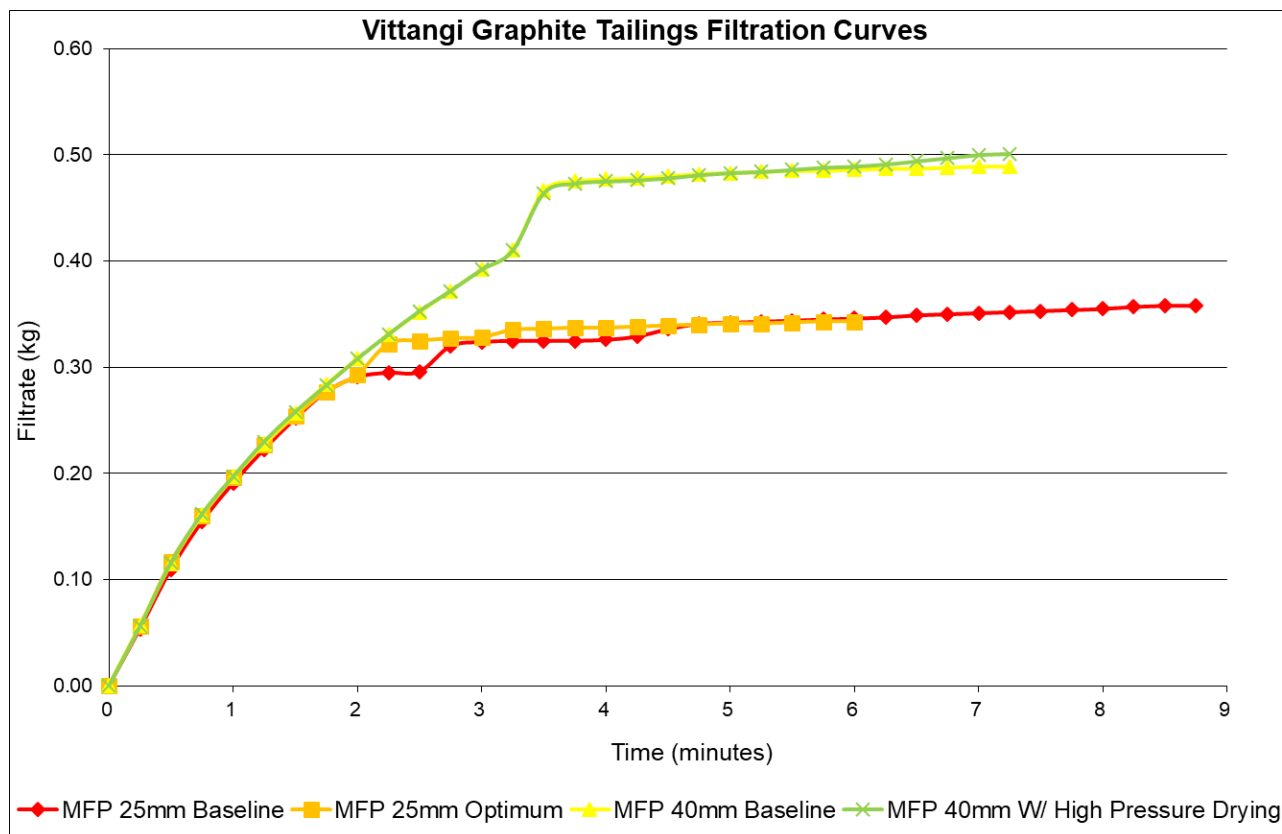


Chart 7 - MFP Filtration Curve for the Vittangi Graphite Tailings Sample

Chart 7 shows the filtrate accumulation during full cycle test runs. Filtration accumulation is rapid during the pumping and pressing stages of filtration. The cake is then consolidated before air-drying is introduced to promote further filtration. The first run is a baseline test which utilising the standard MFP testing conditions. The slurry is pumped into the chamber until it reaches the chamber capacity. It is then pressed to dewater the slurry with the pressing diaphragm. This process occurs until no further filtrate is removed. The final stage is air-drying the filter cake to force residual water from the cake.

Following a baseline test, the subsequent runs incurred slight changes to the baseline conditions to increase the filtration performance and utilising a larger chamber size to increase the filtration rate. Increasing drying pressure in the 40mm chamber was ran to improve the dewatering during air-drying.



Outotec	Test Report	TESTING
Sales	TEST CASE NO.: 319968 T1	18 / 37

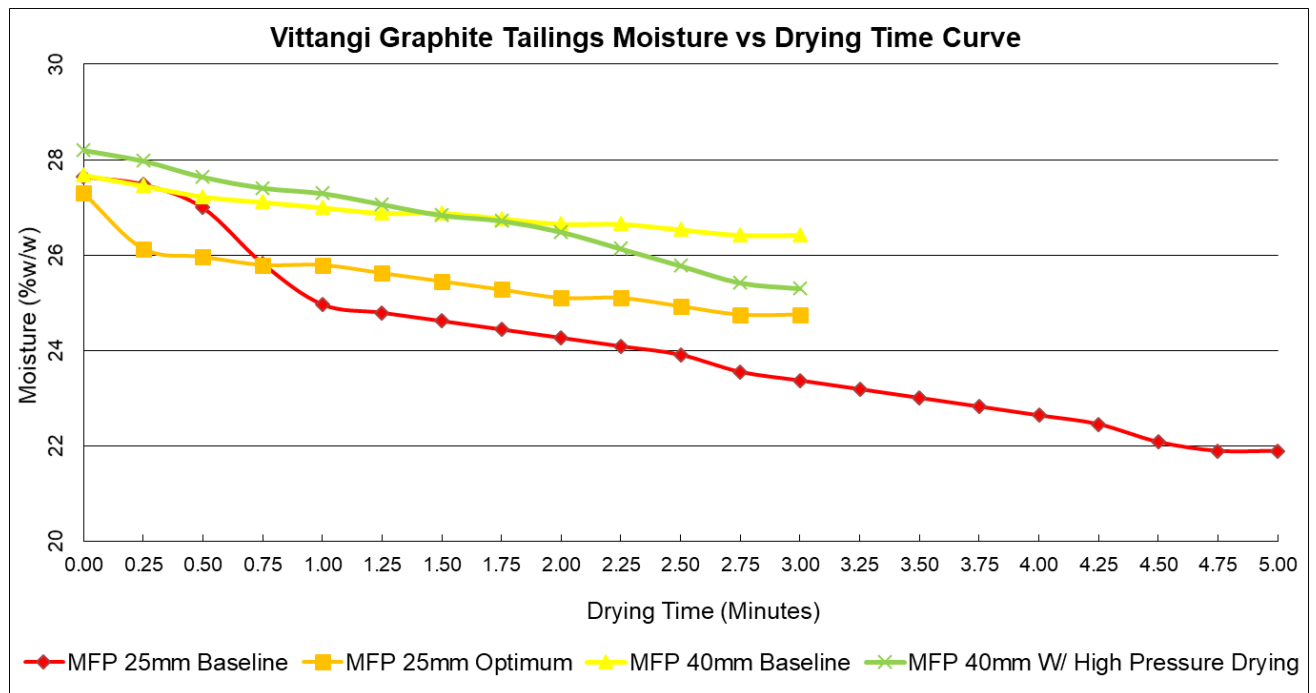


Chart 8 - MFP Air-drying Time vs. Cake Moisture Content for the Vittangi Graphite Tailings Sample

Chart 8 shows the cake moisture reduction during the air-drying stage. Most of the dewatering occurs within three minutes in a 25mm chamber and five minutes in a 40mm chamber. Subsequent runs after the 40mm baseline introduced high pressure drying to further promote dewatering. MFP runs at 25mm was able to generate filter cake moistures of 21.9 to 24.8%. MFP runs at 40mm was able to generate filter cake moistures of 25.3 to 26.4%.



Outotec	Test Report	TESTING
Sales	TEST CASE NO.: 319968 T1	19 / 37

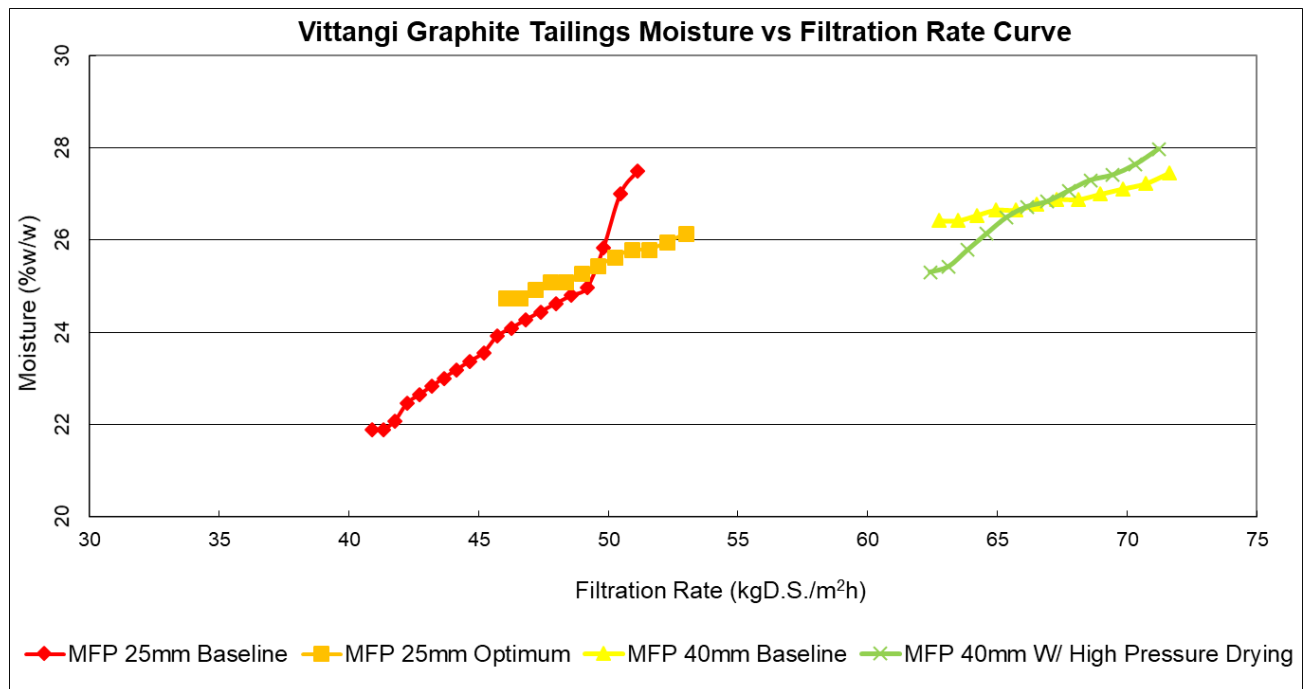



Chart 9 - MFP Moisture Content vs. Filtration Rate for the Vittangi Graphite Tailings Sample

Chart 9 shows the relationship between the filtration rate and cake moisture content that occurs within the air-drying stage. As shown in the chart above, increasing the chamber size from 25mm to 40mm increases the filtration rate due to allowing more slurry in the chamber. The increase in chamber size however also increases the filter cake moisture.



	<h1>Test Report</h1>	TESTING
Sales	TEST CASE NO.: 319968 T1	20 / 37



Picture 5 - 33mm FFP Vittangi Graphite Tailings Filter Cake

Picture 5 shows a 33mm FFP Vittangi Graphite Tailings filter cake with a moisture content of 25.3%.



Outotec	Test Report	TESTING
Sales	TEST CASE NO.: 319968 T1	21 / 37

10. CONCLUSIONS AND RECOMMENDATIONS

The Vittangi Graphite Concentrate and Tailings samples were able to be readily dewatered using the desired Outotec filtration technologies outlined in the client questionnaire. The Vittangi Graphite Concentrate was tested using Outotec's Pressure Filtration technology along with Horizontal Vacuum Belt Filtration. Pressure Filtration was successful in producing viable filter cakes with reasonable moisture contents utilising extended pump time or higher pumping pressures. Horizontal Vacuum Belt Filtration did not produce viable cakes as the moistures were high and the cakes were thin and unstable.

Vittangi Graphite Tailings sample was tested using Outotec's Membrane Filter Press technology and was able to generate viable filter cakes and moisture contents that is suitable for handling and transportation.

Vittangi Graphite Concentrate Sample

Outotec Pressure Filtration

Test Filtration Rate:	84	kgD.S./m ² h*
Average Cake Thickness:	25	mm
Moisture Content:	36.8	%

Outotec Horizontal Vacuum Belt Filtration

Test Filtration Rate:	87	kgD.S./m ² h*
Average Cake Thickness:	7.5	mm
Moisture Content:	53.4	%

Vittangi Graphite Tailings Sample

Outotec Membrane Filter Press

Test Filtration Rate:	62	kgD.S./m ² h*
Average Cake Thickness:	33	mm
Moisture Content:	25.3	%

**The "Filtration Rate" (kgD.S./m²h) in the rest report are instantaneous results and may vary from rates in production filters. The rates differ as a standard technical time is used in testing which does not take into account the specific technical associated with the different filter technologies, sizes and/or the filter availability. Data collected from testing is used in combination with additional processing requirements to provide a detailed and tailored filtering solution, please contact one of the technology experts below to discuss options available for your full scale processing plant needs.*



Outotec	Test Report	TESTING
Sales	TEST CASE NO.: 319968 T1	22 / 37

11. CONTACT INFORMATION

For further questions, please contact...

Shane Freeman
 Technology Manager – Filtration
 Outotec Pty Ltd
 Tel. 08 9211 2413
 Fax: 08 9211 2201
 Email: shane.freeman@outotec.com

12. APPENDIX

1. Filtration Testwork – Client Questionnaire
2. Vittangi Graphite Concentrate Particle Size Distribution (Supplied via the CSIRO)
3. Vittangi Graphite Tailings Particle Size Distribution (Supplied via the CSIRO)
4. Rheology Testwork Report
5. Testwork Data

END OF REPORT

Jonathan Nguyen
 Testwork Engineer
 Outotec South East Asia Pacific

Email: jonathan.nguyen@outotec.com
 Tel: 08 9211 8589
 Web: www.outotec.com



Outotec	Test Report	TESTING
Sales	TEST CASE NO.: 319968 T1	23 / 37

APPENDIX 1 – FILTRATION TESTWOK CLIENT QUESTIONNAIRE

Outotec Project Number: 319968

CUSTOMER INFORMATION

Project name:	Vittangi Graphite Project
Customer:	Talga Resources Limited
Invoicing address:	TALGA GRAPHENE AB, C/- Intertrust Sweden AB, PO Box 162 85, SE-103 25 Stockholm, Sweden
Contact person(submitter):	Alisha Jones
Title/company:	Office Manager, Talga Resources Limited
Telephone:	+61 8 9481 6667
Email:	admin@talgaresources.com
Contact person (end client, if different to above):	Duncan Turner – Engineering Manager
Title/company:	Talga Resources Limited
Telephone:	+61 419 66 44 13
Email:	engineering@talgaresources.com
Report recipient(s):	Duncan Turner and Alisha Jones by email

GENERAL INFORMATION ABOUT MATERIAL TO BE FILTERED

Please complete a separate questionnaire for each sample type or application

Application:	Slurry filtration
Sample name:	1080Y-AB; Cleaner Concentrate
Composition of solids:	>92%w/w Cg – graphite, trace amounts of clay minerals and Albite
Chemical formula:	
Composition of liquid:	TBA – solution being assayed
Chemical formula:	
Corrosive compounds:	None to our knowledge
Preferred MOC for wetted parts:	benign
Hazards (also attach SDS):	6.5 kg
Estimated solids available (kg)	240 L
Estimated liquor available (l)	none
Estimated wash liquor available (l)	No washing required
Other information:	Solid and process water samples sent for testing. Please use process water to make pulp density adjustment to simulate recycle of salts in the process (sodium silicate).
	Upon completion of testwork program and final report issued, solids to be returned to Core Metallurgy, solutions can be disposed of

SAMPLE RETURN INFORMATION (sample to be returned to client at client's expense or waste treatment charges will apply)

Company name:	Solid samples only return to Core Metallurgy
Address:	36 Corunna St, Albion QLD 4010, Australia
Contact person:	David Cavanagh
Title:	General Manager – Process Engineering
Telephone:	(M) 0407 751 404
Email:	DCavanagh@coreresources.com.au
Courier/transport details:	Contact David Cavanagh for courier details if required
Courier account number:	



Outotec	Test Report	TESTING
Sales	TEST CASE NO.: 319968 T1	24 / 37

PRESENT FILTRATION EQUIPMENT ☐ Does not exist

Process Information	Client Information	Example/units
Type of filter		Outotec PF, Belt Filter, FFP etc...
Filtration area		m ²
Filtration rate (capacity)		Kgd.s./m ² .hr or l/m ² .hr
Cake moisture		%
Filtrate clarity		mg/l or ppm
Wash liquid consumption		m ³ /td.s.
Wash result / efficiency		mg/l or %
Construction material		List any special materials

PURPOSE OF TESTWORK

Undertake filtration testwork to define optimum floc type and dosage and filtration condition and technology selection for sizing commercial plant and providing process warranties considering thickener and filtration options and configurations. Final cake moisture levels need to be minimised as this impacts dryer capital and operating costs. Refer to scope define in proposal and email communiques. Process water provided to be used for dilution to ensure sodium silicate is present that may potentially impact filtration performance and filtrate clarity.

PLANT DATA

Process Information	Client Information	Example/units
Production rate	Project has 2 stages and information already provided in emails and initial enquiry	t/h or m ³ /h
Operation time		Days/year or hours/day
Steps before and after filtration		Thickening, transport, leach etc...
Process flow sheet	Ball mill-rougher-UFG-cleaner circuit	

FILTRATION CONDITIONS

Process Information	Client Information	Example/units
Dry solids in feed	To be advised by Outotec, depends on settling results (35-50% solids possible)	%
Feed slurry density		g/l
Liquor density	Close to water, but please determine the SG of the solution provided	g/l
Slurry pH	neutral	pH
Solids SG	2.6 to 2.8 – please check actual sample received for trial work	t/m ³ = g/mL
Feed temperature	10-30°C	°C
Is feed temperature sensitive?	No	Yes or No
Particle size distribution (If available please send)	Data already provided – p80 = 8 microns; note binomial distribution	P80 in µm
Contains corrosive compounds	No	Yes or No
Is cake washing required?	No	Yes or No
Type of wash liquid	Use supplied process water	Tap water, site water etc.



Outotec	Test Report	TESTING
Sales	TEST CASE NO.: 319968 T1	25 / 37

Temperature of wash liquid	Not applicable	°C or ambient
Important wash elements	Not applicable	Cu, Cyanide, Ni, Cl etc...
Is filter aid allowed	No	Yes or No
Type of filter aid allowed?	Yes provided won't impact float performance when in recycled process water	Coag, flocc, surfactant etc....



Outotec	Test Report	TESTING
Sales	TEST CASE NO.: 319968 T1	26 / 37

FILTRATION OBJECTIVES

Process Information	Client Information	Example/units
Filtration rate (capacity)		Kgd.s./m ² .hr or l/m ² .hr
Cake moisture		%
Wash result / efficiency	Not applicable	mg/l or %
Wash liquid consumption		m ³ /t d.s.
Filtrate clarity	<250 ppm solids or clarity 30-40 on clarity wedge, water recycled to milling and rougher and cleaner circuit	mg/l or ppm
Other		Please specify

ADDITIONAL INFORMATION

Please send safety datasheets with sample.

Outotec Project Number: **319968**

CUSTOMER INFORMATION

Project name:	Vittangi Graphite Project
Customer:	Talga Resources Limited
Invoicing address:	TALGA GRAPHENE AB , C/- Intertrust Sweden AB, PO Box 162 85, SE-103 25 Stockholm, Sweden
Contact person(submitter):	Alisha Jones
Title/company:	Office Manager, Talga Resources Limited
Telephone:	+61 8 9481 6667
Email:	admin@talgaresources.com
Contact person (end client, if different to above):	Duncan Turner – Engineering Manager
Title/company:	Talga Resources Limited
Telephone:	+61 419 66 44 13
Email:	engineering@talgaresources.com
Report recipient(s):	Duncan Turner and Alisha Jones by email

GENERAL INFORMATION ABOUT MATERIAL TO BE FILTERED

Please complete a separate questionnaire for each sample type or application

Application:	Slurry filtration
Sample name:	1080Y-Q; Flotation Tails (combined rougher tails and cleaner tails)
Composition of solids:	Biotite, tremolite, pyrophyllite, pyrrhotite, pyrite, calcite, albite, residual graphite
Chemical formula:	
Composition of liquid:	TBA – solution being assayed
Chemical formula:	
Corrosive compounds:	none
Preferred MOC for wetted parts:	



Outotec	Test Report	TESTING
Sales	TEST CASE NO.: 319968 T1	27 / 37

Hazards (also attach SDS):	benign
Estimated solids available (kg)	17.8 kg
Estimated liquor available (l)	240 L - Use supplied process water for dilution and slurry preparation as required
Estimated wash liquor available (l)	No washing required
Other information:	Solid and process water samples sent for testing. Please use process water to make pulp density adjustment to simulate recycle of salts in the process (sodium silicate).
Upon completion of testwork program and final report issued, solids to be returned to Core Metallurgy, solutions can be disposed of	

SAMPLE RETURN INFORMATION (sample to be returned to client at client's expense or waste treatment charges will apply)

Company name:	Solid samples only return to Core Metallurgy
Address:	36 Corunna St, Albion QLD 4010, Australia
Contact person:	David Cavanagh
Title:	General Manager – Process Engineering
Telephone:	(M) 0407 751 404
Email:	DCavanagh@coreresources.com.au
Courier/transport details:	Contact David Cavanagh for courier details if required
Courier account number:	

PRESENT FILTRATION EQUIPMENT ☐ Does not exist

Process Information	Client Information	Example/units
Type of filter		Outotec PF, Belt Filter, FFP etc...
Filtration area		m ²
Filtration rate (capacity)		Kgd.s./m ² .hr or l/m ² .hr
Cake moisture		%
Filtrate clarity		mg/l or ppm
Wash liquid consumption		m ³ /td.s.
Wash result / efficiency		mg/l or %
Construction material		List any special materials

PURPOSE OF TESTWORK

Undertake filtration testwork to define optimum floc type and dosage and filtration condition and technology selection for sizing commercial plant and providing process warranties considering thickener and filtration options and configurations. Final cake moisture levels need to be minimised as this impacts dry stacking and TMF design options. Refer to scope define in proposal and email communiques. Process water provided to be used for dilution to ensure sodium silicate is present that may potentially impact filtration performance and filtrate clarity.

PLANT DATA

Process Information	Client Information	Example/units
Production rate	Project has 2 stages and information already provided in emails and initial enquiry	t/h or m ³ /h
Operation time		Days/year or hours/day
Steps before and after filtration		Thickening, transport, leach etc...
Process flow sheet	Ball mill-rougher-UFG-cleaner circuit	



Outotec	Test Report	TESTING
Sales	TEST CASE NO.: 319968 T1	28 / 37

FILTRATION CONDITIONS

Process Information	Client Information	Example/units
Dry solids in feed	To be advised by Outotec, depends on settling results (35-50% solids possible)	%
Feed slurry density		g/l
Liquor density	Close to water, but please determine the SG of the solution provided	g/l
Slurry pH	neutral	pH
Solids SG	2.6 to 2.8 – please check actual sample received for trial work	t/m ³ = g/mL
Feed temperature	10-30°C	°C
Is feed temperature sensitive?	No	Yes or No
Particle size distribution (If available please send)	Data already provided – p80 = 26.3 microns; note binomial distribution	P80 in µm
Contains corrosive compounds	No	Yes or No
Is cake washing required?	No	Yes or No
Type of wash liquid	Use supplied process water	Tap water, site water etc.
Temperature of wash liquid	Not applicable	°C or ambient
Important wash elements	Not applicable	Cu, Cyanide, Ni, Cl etc...
Is filter aid allowed	No	Yes or No
Type of filter aid allowed?	Yes provided won't impact float performance when in recycled process water	Coag, floc, surfactant etc....



Outotec	Test Report	TESTING
Sales	TEST CASE NO.: 319968 T1	29 / 37

FILTRATION OBJECTIVES

Process Information	Client Information	Example/units
Filtration rate (capacity)		Kgd.s./m ² .hr or l/m ² .hr
Cake moisture		%
Wash result / efficiency	Not applicable	mg/l or %
Wash liquid consumption		m ³ /t d.s.
Filtrate clarity	<250 ppm solids or clarity 30-40 on clarity wedge, water recycled to milling and rougher and cleaner circuit	mg/l or ppm
Other		Please specify

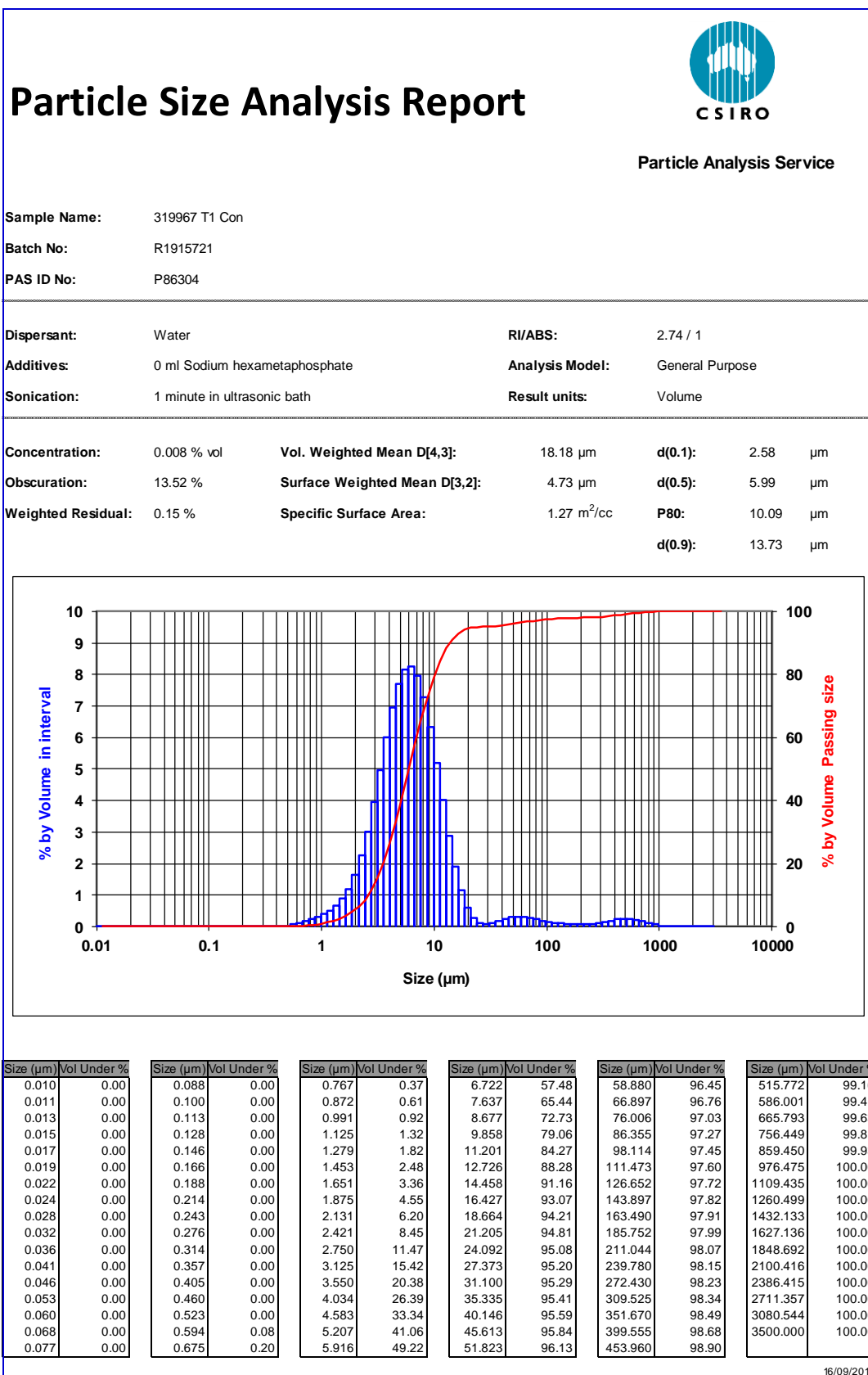
ADDITIONAL INFORMATION

Please send safety datasheets with sample.



Outotec	Test Report	TESTING
Sales	TEST CASE NO.: 319968 T1	30 / 37

APPENDIX 2 – CONCENTRATE PARTICLE SIZE DISTRIBUTION



Outotec	Test Report	TESTING
Sales	TEST CASE NO.: 319968 T1	31 / 37

APPENDIX 3 – TAILINGS PARTICLE SIZE DISTRIBUTION

Particle Size Analysis Report

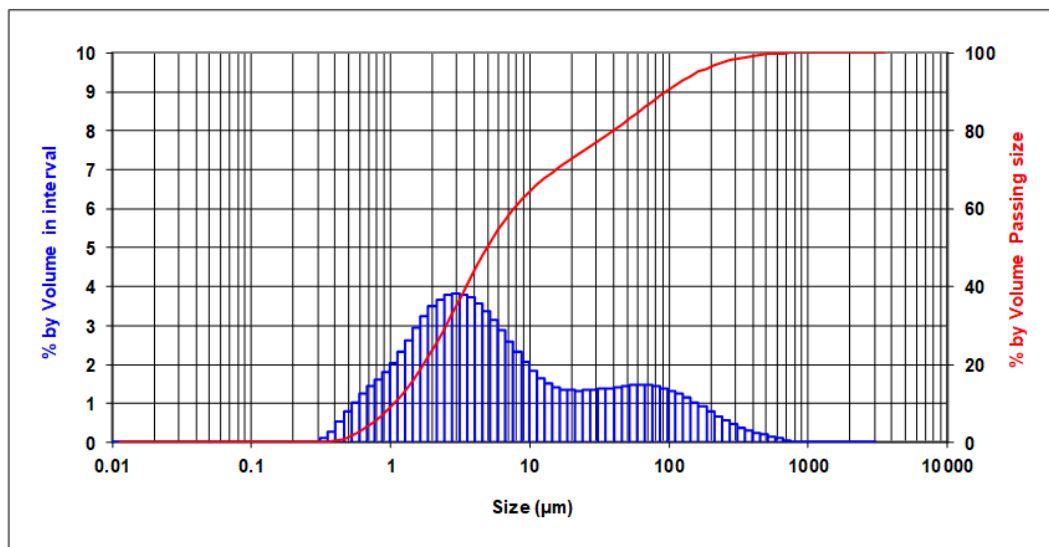


Particle Analysis Service

Sample Name: 319967 T1 Tails
Batch No: R1915721
PAS ID No: P86303

Dispersant:	Water	RI/ABS:	2.74 / 1
Additives:	0 ml Sodium hexametaphosphate	Analysis Model:	General Purpose
Sonication:	1 minute in ultrasonic bath	Result units:	Volume

Concentration:	0.008 % vol	Vol. Weighted Mean D[4,3]:	31.99 μm	d(0.1):	1.07 μm
Obscuration:	22.27 %	Surface Weighted Mean D[3,2]:	2.78 μm	d(0.5):	4.97 μm
Weighted Residual:	0.32 %	Specific Surface Area:	2.16 m^2/cc	P80:	39.46 μm
				d(0.9):	95.29 μm



Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %	Size (μm)	Vol Under %
0.010	0.00	0.088	0.00	0.767	5.40	6.722	57.28	58.880	84.53	515.772	99.68
0.011	0.00	0.100	0.00	0.872	7.02	7.637	59.88	66.897	86.01	586.001	99.83
0.013	0.00	0.113	0.00	0.991	8.83	8.677	62.20	76.006	87.48	665.793	99.94
0.015	0.00	0.128	0.00	1.125	10.87	9.858	64.27	86.355	88.92	756.449	100.00
0.017	0.00	0.146	0.00	1.279	13.19	11.201	66.11	98.114	90.32	859.450	100.00
0.019	0.00	0.166	0.00	1.453	15.81	12.726	67.76	111.473	91.65	976.475	100.00
0.022	0.00	0.188	0.00	1.651	18.76	14.458	69.28	126.652	92.91	1109.435	100.00
0.024	0.00	0.214	0.00	1.875	22.00	16.427	70.70	143.897	94.06	1260.499	100.00
0.028	0.00	0.243	0.00	2.131	25.49	18.664	72.07	163.490	95.10	1432.133	100.00
0.032	0.00	0.276	0.00	2.421	29.17	21.205	73.40	185.752	96.02	1627.136	100.00
0.036	0.00	0.314	0.00	2.750	32.96	24.092	74.73	211.044	96.81	1848.692	100.00
0.041	0.00	0.357	0.10	3.125	36.79	27.373	76.07	239.780	97.49	2100.416	100.00
0.046	0.00	0.405	0.38	3.550	40.59	31.100	77.42	272.430	98.06	2386.415	100.00
0.053	0.00	0.460	0.91	4.034	44.31	35.335	78.79	309.525	98.54	2711.357	100.00
0.060	0.00	0.523	1.69	4.583	47.88	40.146	80.19	351.670	98.92	3080.544	100.00
0.068	0.00	0.594	2.72	5.207	51.25	45.613	81.61	399.555	99.23	3500.000	100.00
0.077	0.00	0.675	3.97	5.916	54.40	51.823	83.06	453.960	99.48		

10/09/2019



Outotec	Test Report	TESTING
Sales	TEST CASE NO.: 319968 T1	32 / 37

APPENDIX 4 – RHOLOGY TESTWORK DATA



Rheology Testwork
Report No: 20190917

Rheology Testwork for Outotec South East Asia Pacific

Job No: 1630
Report No: 20190917
Revision: 1.0
Client Name: Outotec South East Asia Pacific
Contact: Ken Taylor
Client PO No: 4500446739
Test Date: 16-17/9/2019
Tested By: Tracy Lim and Lucas Dival
Written By: Tracy Lim
Approved By: Tanghua Zhao
Date: 17/9/2019



Outotec	Test Report	TESTING
Sales	TEST CASE NO.: 319968 T1	33 / 37



Rheology Testwork
Report No: 20190917

1. Background

Newpark Drilling Fluids (Australia) received two samples from Outotec South East Asia Pacific. Rheogram of each sample was requested to test with Hakke VT 550 at ambient temperature.

2. Sample Preparation

Two samples received are listed as below.

- 319968T1 Vittangi Graphite Cons
- 319968T1 Vittangi Graphite Tails

3. Test Procedure and Result of Rheograms of the two samples

Rheograms of each sample have been produced using a VT 550 rheometer with SV 2 Sensor System at Room Temperature. The shear rate ranged from 600 s^{-1} to 0.05 s^{-1} and the shear stress was recorded.

- Test result of 319968T1 Vittangi Graphite Cons is shown in Table 1 below and illustrated in Fig. 1 ~ Fig.3;
- Test result of 319968T1 Vittangi Graphite Tails is shown in Table 2 below and illustrated in Fig.4 ~ Fig.6;



Outotec	Test Report	TESTING
Sales	TEST CASE NO.: 319968 T1	34 / 37



Rheology Testwork
Report No: 20190917

Client Outotec South East Asia Pacific
Contact Ken Taylor
Job Number 1630
Date 17/09/2019
Sample ID 319968T1 Vittangi Graphite Cons
Sample received 13/09/2019
Test temperature Ambient Temperature

Results Summary

Rheograms and Viscosity Curves of Sample 319968T1 Vittangi Graphite Cons

Shear Sweep Rheogram was conducted on Slurry 319968T1 Vittangi Graphite Cons
Test results were summarized in Table 1 and illustrated in Fig. 1 ~ Fig.3.

Table 1 Shear Sweep Rheograms of 319968T1 Vittangi Graphite Cons Sample

319968T1 Vittangi Graphite Cons		
$\dot{\gamma}$ [1/s]	[Pa]	[Pa.s]
599.9	11.67	0.019
499.9	10.29	0.021
400.1	9.83	0.025
300	8.61	0.029
200.1	7.37	0.037
99.99	6.61	0.066
74.96	5.84	0.078
49.92	5.38	0.108
25.04	4.61	0.184
19.97	3.88	0.194
14.98	3.22	0.215
9.98	2.84	0.285
4.99	3.84	0.770
2.964	2.30	0.777
2.026	3.53	1.744
1.005	2.30	2.291
0.499	1.54	3.078
0.09682	1.54	15.860
0.05214	1.54	29.460



Outotec	Test Report	TESTING
Sales	TEST CASE NO.: 319968 T1	35 / 37



Rheology Testwork
Report No: 20190917

Fig. 1

Rheograms of 319968T1 Vittangi Graphite Cons Shear Rate: 600 - 0.05 1/s

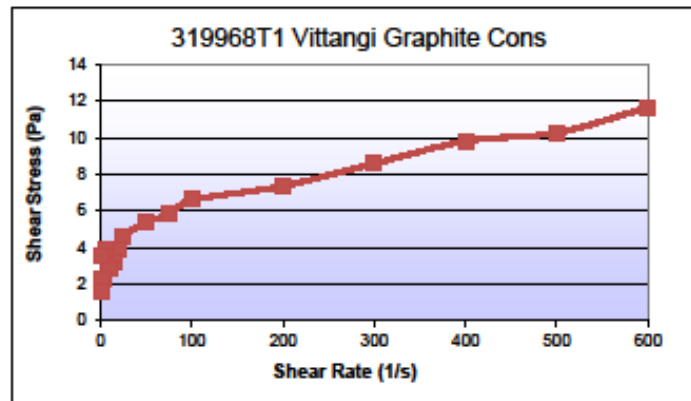


Fig. 2

Rheograms of 319968T1 Vittangi Graphite Cons Shear Rate: 100 - 0.05 1/s

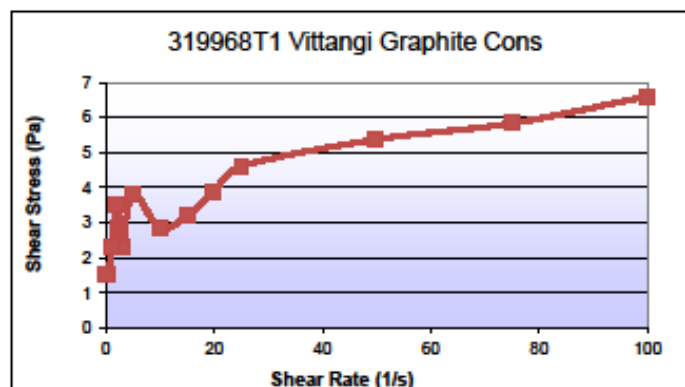
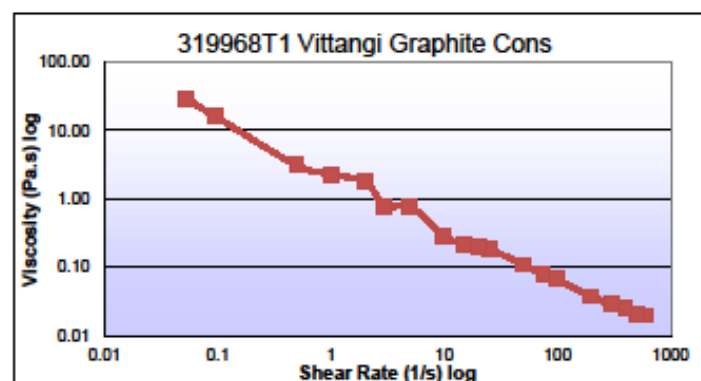


Fig. 3

Viscosity Curve of 319968T1 Vittangi Graphite Cons Shear Rate: 600-0.05 1/s



Outotec	Test Report	TESTING
Sales	TEST CASE NO.: 319968 T1	36 / 37



Rheology Testwork
Report No: 20190917

Client Outotec South East Asia Pacific
Contact Ken Taylor
Job Number 1630
Date 17/09/2019
Sample ID 319968T1 Vittangi Graphite Tails
Sample received 13/09/2019
Test temperature Ambient Temperature

Results Summary

Rheograms and Viscosity Curves of Sample 319968T1 Vittangi Graphite Tails

Shear Sweep Rheogram was conducted on Slurry 319968T1 Vittangi Graphite Tails
Test results were summarized in Table 2 and illustrated in Fig. 4 ~ Fig.6.

Table 2 Shear Sweep Rheograms of 319968T1 Vittangi Graphite Tails Sample

319968T1 Vittangi Graphite Tails		
$\dot{\gamma}$ [1/s]	[Pa]	[Pa.s]
599.9	15.82	0.026
499.9	11.37	0.023
400.1	8.45	0.021
300	7.53	0.025
200.1	5.69	0.028
99.99	1.54	0.015
74.96	0.77	0.010
49.92	0.77	0.015
25.04	0.00	0.000
19.97	0.00	0.000
14.98	0.00	0.000
9.98	0.00	0.000
4.99	0.00	0.000
2.964	0.00	0.000
2.026	0.00	0.000
1.005	0.00	0.000
0.499	0.00	0.000
0.09682	0.00	0.000
0.05214	0.00	0.000



Outotec	Test Report	TESTING
Sales	TEST CASE NO.: 319968 T1	37 / 37



Rheology Testwork
Report No: 20190917

Fig. 4

Rheograms of 319968T1 Vittangi Graphite Tails Shear Rate: 600 - 0.05 1/s

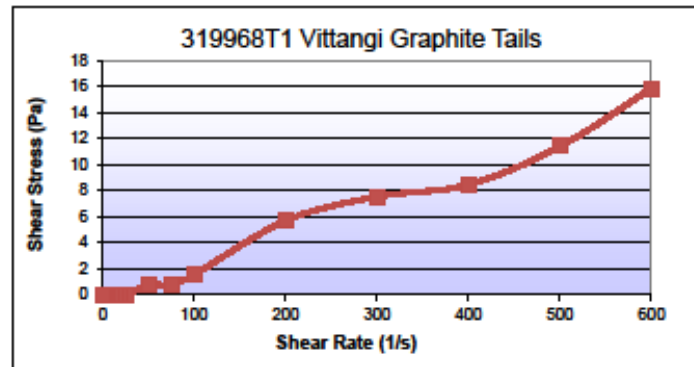


Fig. 5

Rheograms of 319968T1 Vittangi Graphite Tails Shear Rate: 100 - 0.05 1/s

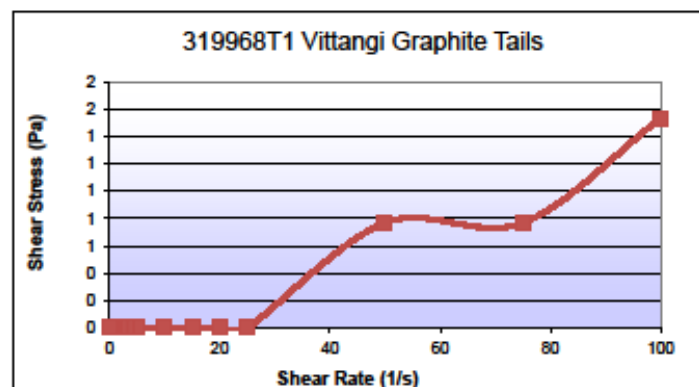
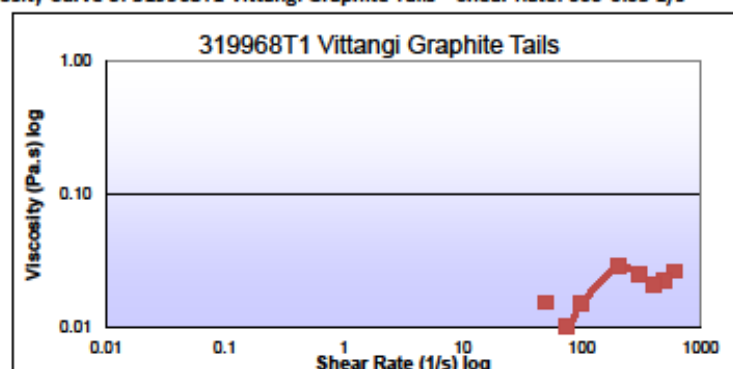


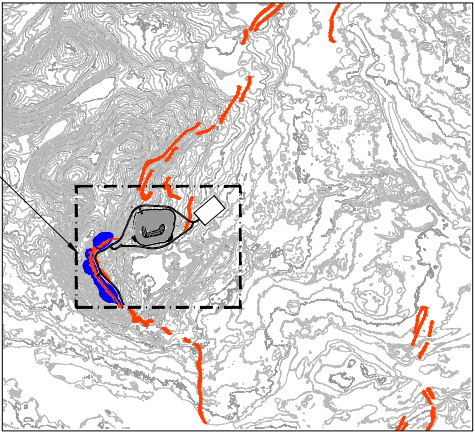
Fig. 6

Viscosity Curve of 319968T1 Vittangi Graphite Tails Shear Rate: 600-0.05 1/s



Appendix C Feasibility Study Design Drawings

- NOTES:
1. THESE DRAWINGS SHALL BE READ IN CONJUNCTION WITH THE LATEST REVISION OF THE NUNASVARRA SOUTH MINE IWF FEASIBILITY DESIGN REPORT.
 2. THESE DRAWINGS SHALL NOT BE USED FOR CONSTRUCTION.
 3. ALL DIMENSIONS ARE IN MILLIMETRES (mm) UNLESS OTHERWISE NOTED.
 4. ALL RL's ARE IN m RH 2000.
 5. THESE DRAWINGS SHALL NOT BE SCALED.
 6. HAUL ROAD, ACCESS ROAD, MINE PITS AND ROM PAD DESIGN HAVE BEEN COMPLETED BY OTHERS.
 7. ORE BODY AND PLANNED MINE PIT LOCATIONS SUPPLIED BY TALGA.

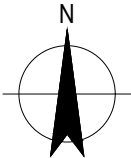
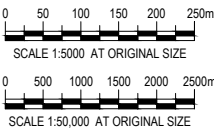


LOCATION PLAN
SCALE 1:50000

DRAWING INDEX	
DRAWING NUMBER	DRAWING TITLE
61-38474-C001	SITE PLAN AND DRAWING LIST
61-38474-C002	GENERAL ARRANGEMENT - YEAR 0
61-38474-C003	GENERAL ARRANGEMENT - YEARS 2 TO 6
61-38474-C004	GENERAL ARRANGEMENT - YEARS 8 TO 10 & FINAL
61-38474-C005	TYPICAL EMBANKMENT SECTION AND DETAILS
61-38474-C006	FOUNDATION PREPARATION PLAN
61-38474-C007	FOUNDATION PREPARATION DETAILS
61-38474-C008	UNDERDRAINAGE AND SURFACE WATER MANAGEMENT ARRANGEMENT
61-38474-C009	UNDERDRAINAGE DETAILS
61-38474-C010	SURFACE WATER MANAGEMENT DETAILS

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No	Revision	Note: * indicates signatures on original issue of drawing or last revision of drawing	Date
Drawn	Job Manager	Project Director	



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Drafting Check		Design Check	
Approved (Project Director)		Date	
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Client	TALGA RESOURCES
Project	NUNASVARRA SOUTH MINE IWF
Title	INTEGRATED WASTE FACILITY SITE PLAN AND DRAWING LIST
Original Size	A1
Drawing No:	61-38474-C001
Rev:	0

NOTES:

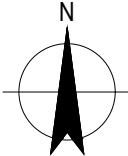
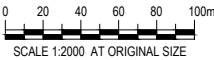
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7. REFER TO IWF FEASIBILITY REPORT FOR TIMING OF IWF STAGES.
8. REFER TO DRAWING 61-38474-C008 FOR DETAILS OF UNDERDRAINAGE AND SURFACE DRAINAGE.
9. ALL STRUCTURES SHOWN ON THIS DRAWING SHALL BE CONSTRUCTED IN YEAR 0.
10. FINAL LOCATIONS AND DEPTHS OF MONITORING BORES TO BE CONFIRMED BASED ON DETAILED SITE HYDROGEOLOGY STUDY.
11. DETAILS OF MONITORING BORES TO BE PROVIDED BY SITE HYDROGEOLOGIST.
12. SURVEY MONITORING PINS TO BE INSTALLED AT THE DOWNSTREAM EDGE OF CRESTS IN BREAKS IN WINDROW.
13. LOCATION AND DETAILS OF SURVEY CONTROL POINTS (NOT SHOWN) TO BE DETERMINED BY SITE SURVEY TEAM.
14. LOCATIONS OF SURVEY MONITORING POINTS FOR FUTURE STAGES TO BE DETERMINED BASED ON OBSERVED MOVEMENTS OF STARTER EMABANKMENT.

LEGEND:

-  SURVEY MONITORING PINS
-  GROUNDWATER MONITORING BORES

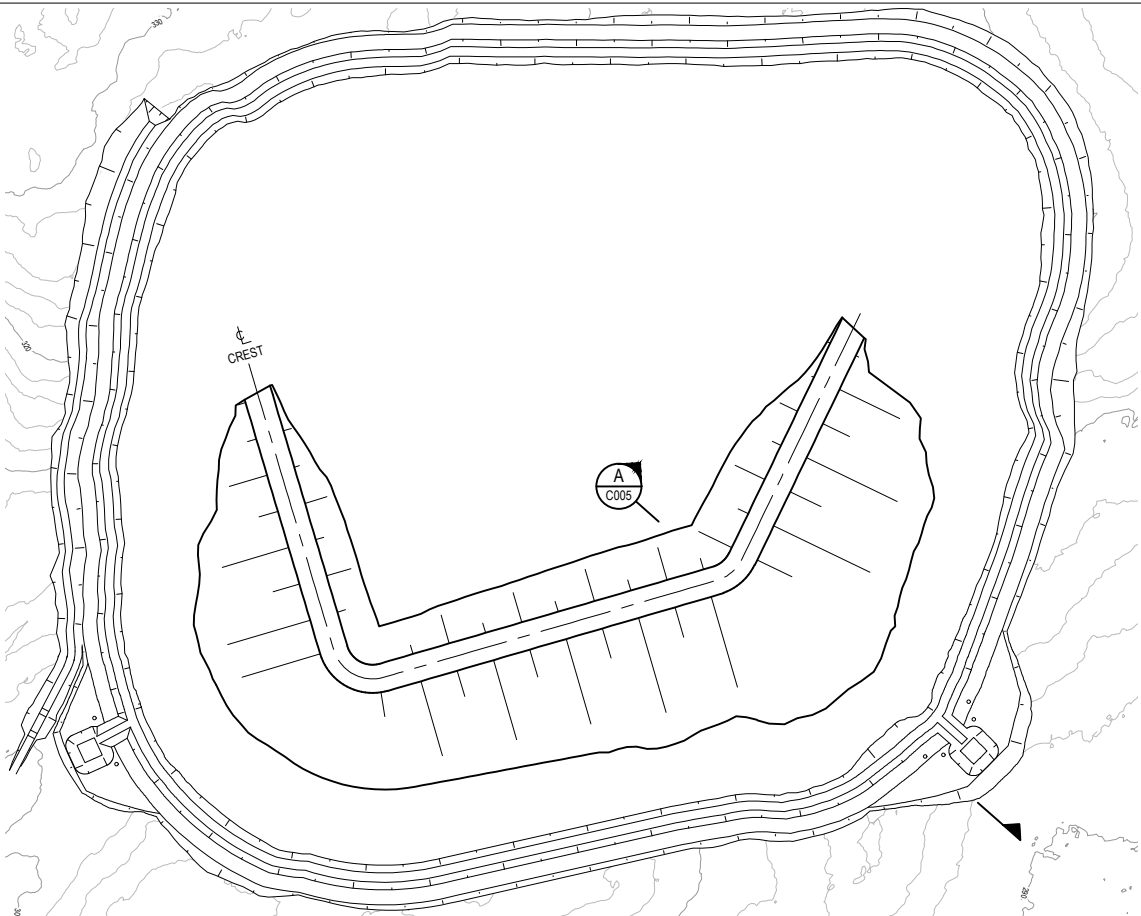
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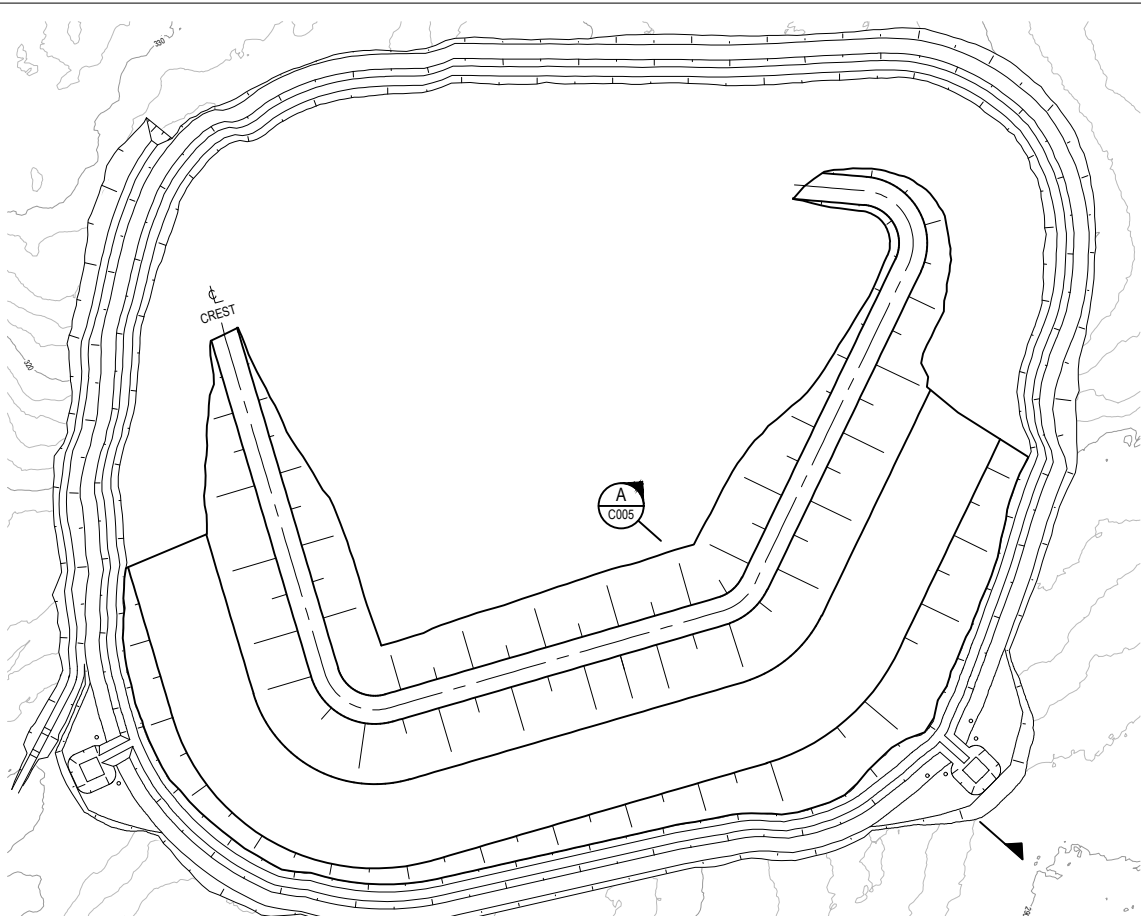


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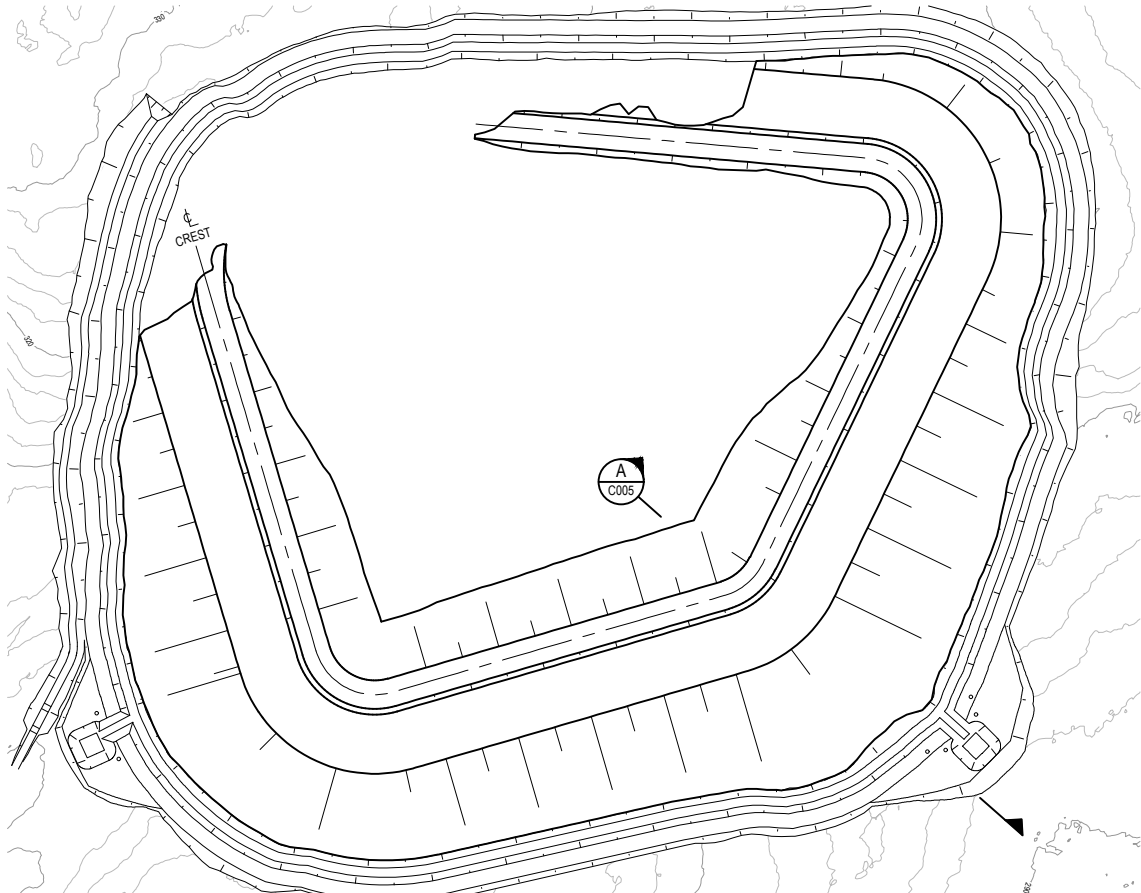
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	Approved (Project Director) Date		Title INTEGRATED WASTE FACILITY GENERAL ARRANGEMENT - YEAR 0	
	Scale AS SHOWN	This Drawing must not be used for Construction unless signed as Approved	Original Size A1 Drawing No: 61-38474-C002	Rev: 0



PLAN AT END OF YEAR 2
SCALE 1:2000



PLAN AT END OF YEAR 4
SCALE 1:2000



PLAN AT END OF YEAR 6
SCALE 1:2000

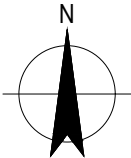
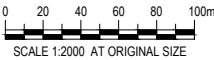
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7. REFER TO IWF FEASIBILITY REPORT FOR TIMING OF IWF STAGES.
8. ROCK PROTECTION AND PROGRESSIVE STORED WASTE SURFACE NOT SHOWN FOR CLARITY.
9. REFER TO DRAWING 61-38474-C004 FOR YEAR 8 TO 10 AND FINAL LANDFORM.

IWF CREST RL's OVER TIME	
END OF YEAR	CREST RL
0	305.90
1	310.00
2	312.90
3	315.20
4	317.10
5	318.70
6	320.30
7	321.70
8	323.00
9	324.30
10	325.65
FINAL	327.00

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					Date



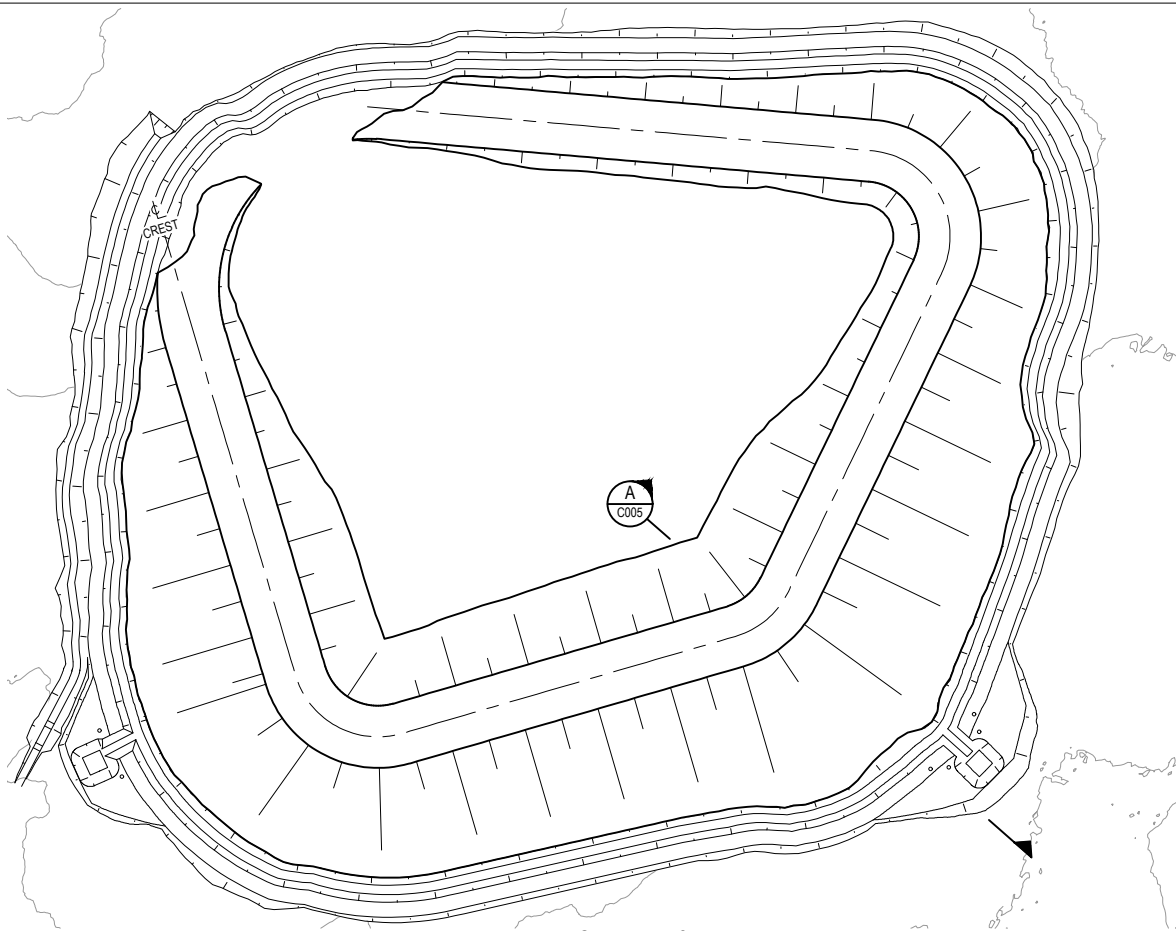
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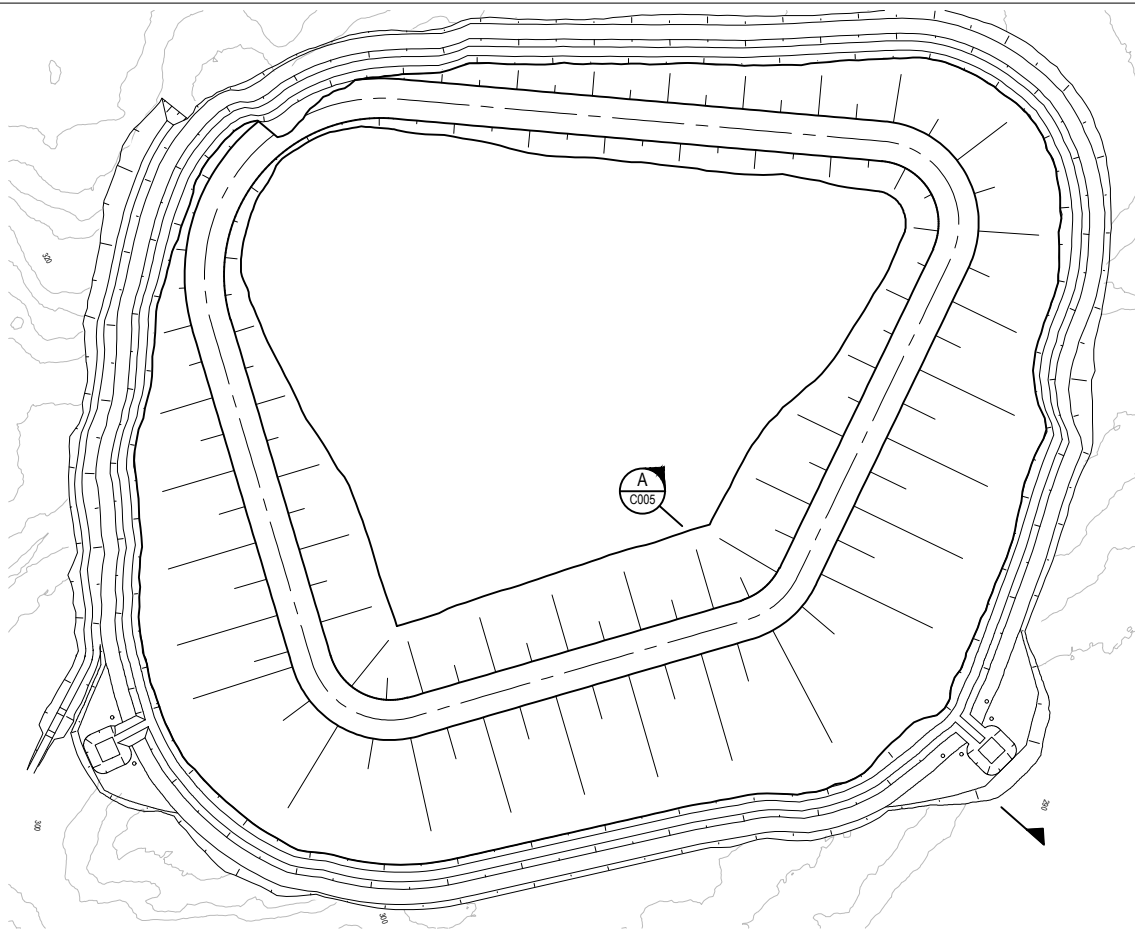
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Drafting Check		Design Check	
Approved (Project Director)		Date	
Scale	AS SHOWN	This Drawing must not be used for Construction unless signed as Approved	

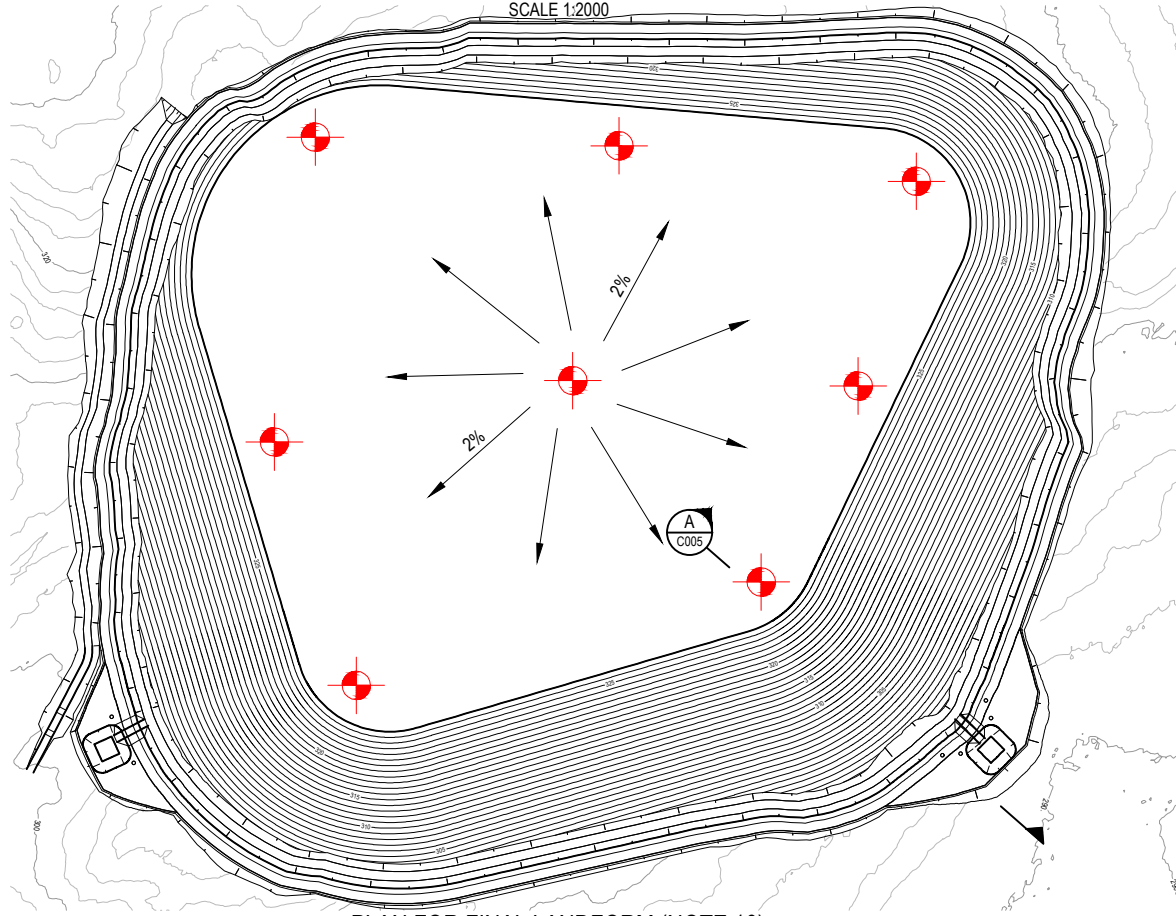
Client	TALGA RESOURCES
Project	NUNASVARRA SOUTH MINE IWF
Title	INTEGRATED WASTE FACILITY GENERAL ARRANGEMENT - YEARS 2 TO 6
Original Size	A1
Drawing No:	61-38474-C003
Rev:	0



PLAN AT END OF YEAR 8
SCALE 1:2000



PLAN AT END OF YEAR 10
SCALE 1:2000

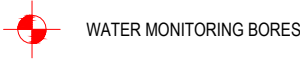


PLAN FOR FINAL LANDFORM (NOTE 10)
SCALE 1:2000

NOTES:

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4. ALL RL's ARE IN m RH 2000.
5. THESE DRAWINGS SHALL NOT BE SCALED.
6. HAUL ROAD, ACCESS ROAD, MINE PITS AND ROM PAD DESIGN HAVE BEEN COMPLETED BY OTHERS.
7. REFER TO IWF FEASIBILITY REPORT FOR TIMING OF IWF STAGES.
8. ROCK PROTECTION AND PROGRESSIVE STORED WASTE SURFACE NOT SHOWN FOR CLARITY.
9. REFER TO DRAWING 61-38474-C003 FOR YEARS 2 TO 6.
10. FINAL LANDFORM INCLUDES FINAL SHAPING FOR WASTE ROCK PRODUCTION.
11. FINAL LOCATIONS AND DEPTHS OF MONITORING BORES FOR CLOSURE WILL BE CONFIRMED AS PART OF CLOSURE DETAIL DESIGN.

LEGEND:

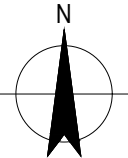
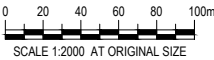


WATER MONITORING BORES

IWF CREST RL's OVER TIME	
END OF YEAR	CREST RL
0	305.90
1	310.00
2	312.90
3	315.20
4	317.10
5	318.70
6	320.30
7	321.70
8	323.00
9	324.30
10	325.65
FINAL	327.00

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					Date



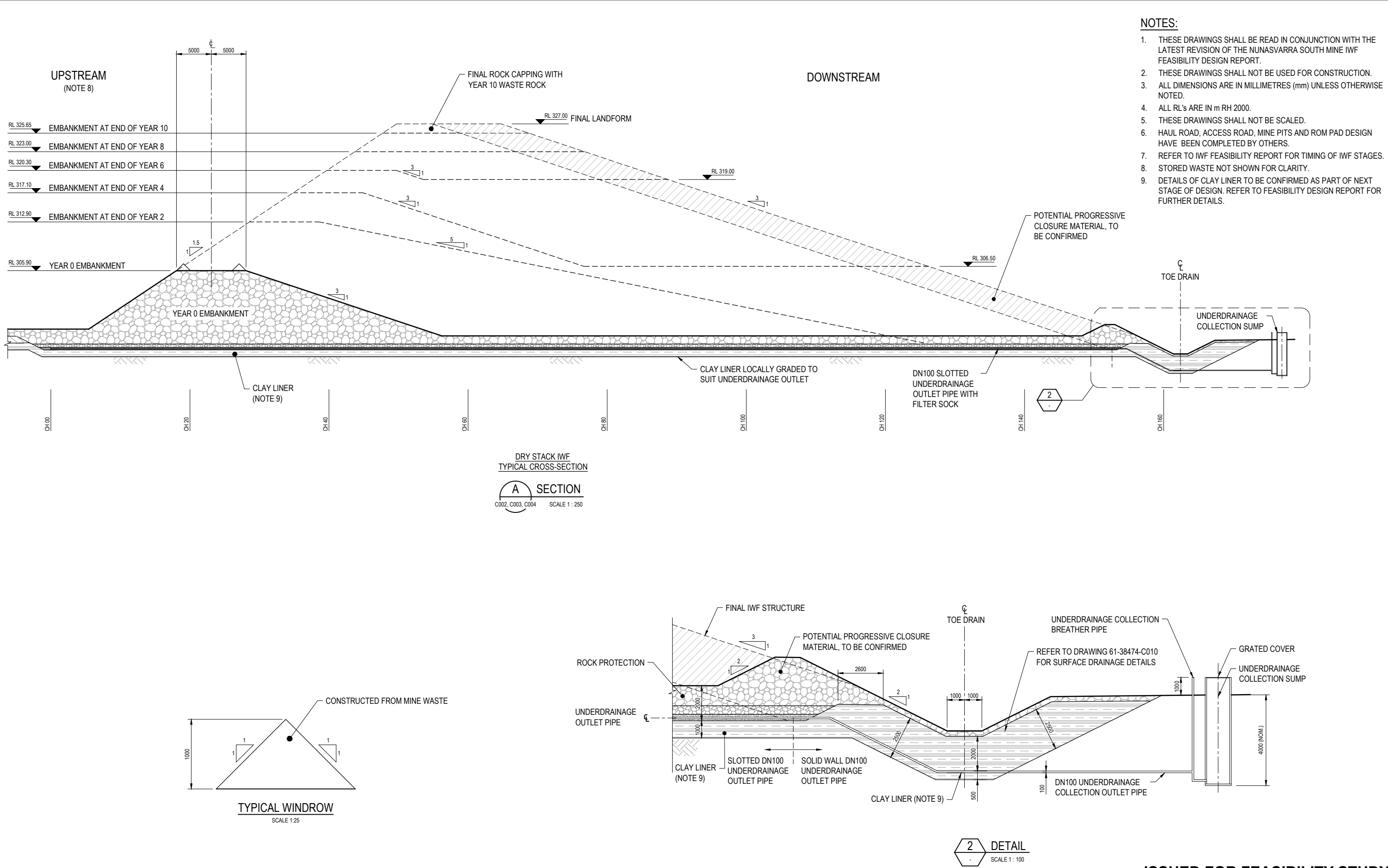
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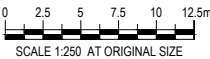
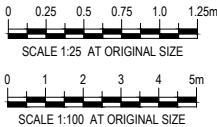
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Drafting Check		Design Check	
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Client	TALGA RESOURCES
Project	NUNASVARRA SOUTH MINE IWF
Title	INTEGRATED WASTE FACILITY GENERAL ARRANGEMENT - YEARS 8 TO 10 & FINAL
Original Size	A1
Drawing No:	61-38474-C004
Rev:	0



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 3. ALL DIMENSIONS ARE IN MILLIMETRES (mm) UNLESS OTHERWISE NOTED.
 4. ALL RL's ARE IN m RH 2000.
 5. THESE DRAWINGS SHALL NOT BE SCALED.
 6. HAUL ROAD, ACCESS ROAD, MINE PITS AND ROM PAD DESIGN HAVE BEEN COMPLETED BY OTHERS.
 7. REFER TO IWF FEASIBILITY REPORT FOR TIMING OF IWF STAGES.
 8. STORED WASTE NOT SHOWN FOR CLARITY.
 9. DETAILS OF CLAY LINER TO BE CONFIRMED AS PART OF NEXT STAGE OF DESIGN. REFER TO FEASIBILITY DESIGN REPORT FOR FURTHER DETAILS.

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Drawn C. PISAWIS

Designer R. SINGH

Drafting Check

Design Check

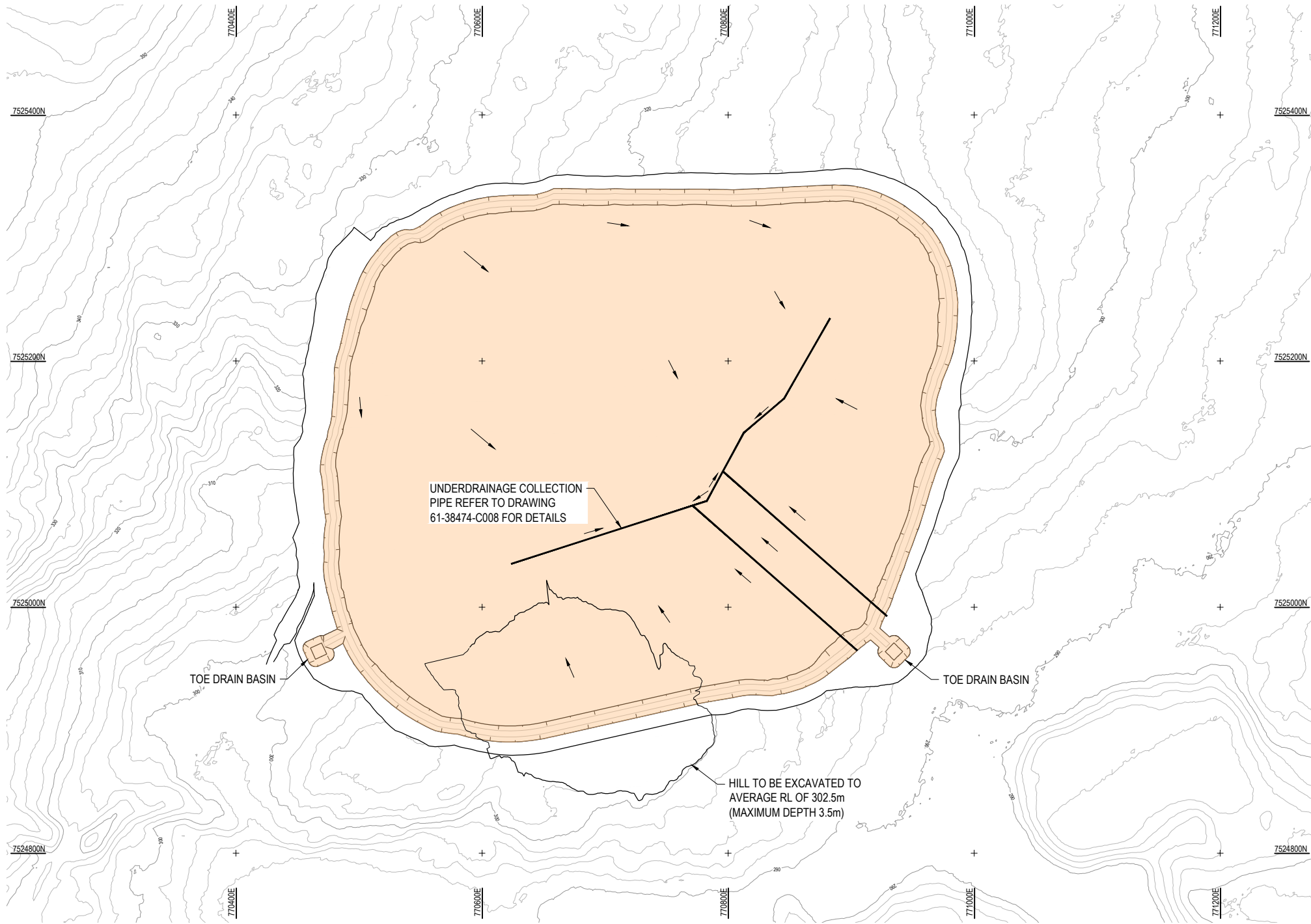
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Client	TALGA RESOURCES
Project	NUNASVARRA SOUTH MINE IWF
Title	INTEGRATED WASTE FACILITY TYPICAL EMBANKMENT SECTION AND DETAILS
Original Size	A1
Drawing No:	61-38474-C005
Rev:	0

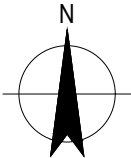
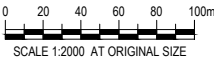


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 - THESE DRAWINGS SHALL NOT BE USED FOR CONSTRUCTION.
 - ALL DIMENSIONS ARE IN MILLIMETRES (mm) UNLESS OTHERWISE NOTED.
 - ALL RL'S ARE IN m RH 2000.
 - THESE DRAWINGS SHALL NOT BE SCALED.
 - REFER TO IWF FEASIBILITY REPORT FOR TIMING OF IWF STAGES.
 - REFER TO DRAWING 61-38474-C007 FOR FOUNDATION PREPARATION DETAILS ON ROCK.

- LEGEND:**
- FOUNDATION PREPARATION FOR CLAY LINER (NOTE 7)
 - GENERAL FOUNDATION PREPARATION
 - DIRECTION OF LOCAL GRADING TO AID WITH DRAINAGE

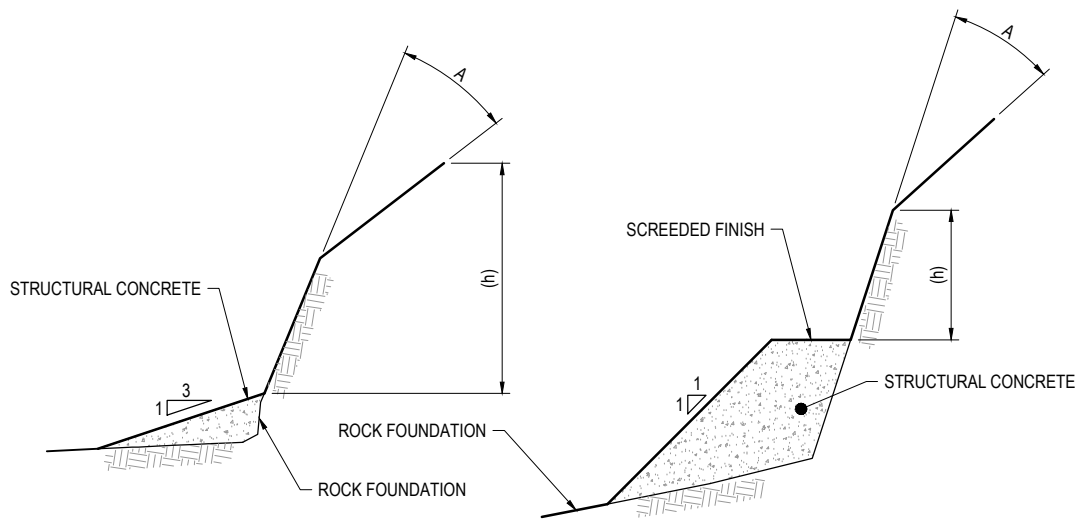
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		Approved (Project Director) Date		Title INTEGRATED WASTE FACILITY FOUNDATION PREPERATION PLAN
Scale 1 : 2000		This Drawing must not be used for Construction unless signed as Approved		Original Size A1 Drawing No: 61-38474-C006 Rev: 0



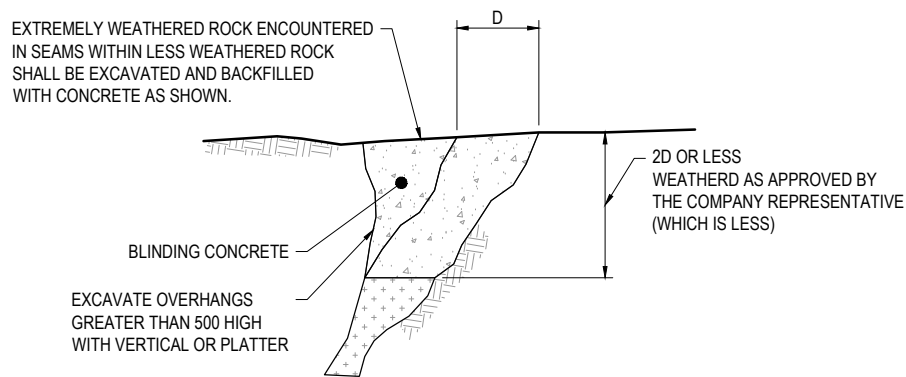
SCREEDED
N.T.S

FORMED
N.T.S

(h) HEIGHT OF SLOPE ABOVE CONCRETE SHALL NOT EXCEED THE RELEVANT LIMITS GIVEN FOR VARIABLES X, Y, AND Z.

CONCRETE TREATMENT FOR SLOPES AND OVERHANGS
N.T.S

NOTE: CONCRETE TO BE EITHER SCREEDED OR FORMED AS DIRECTED BY THE COMPANY REPRESENTATIVE

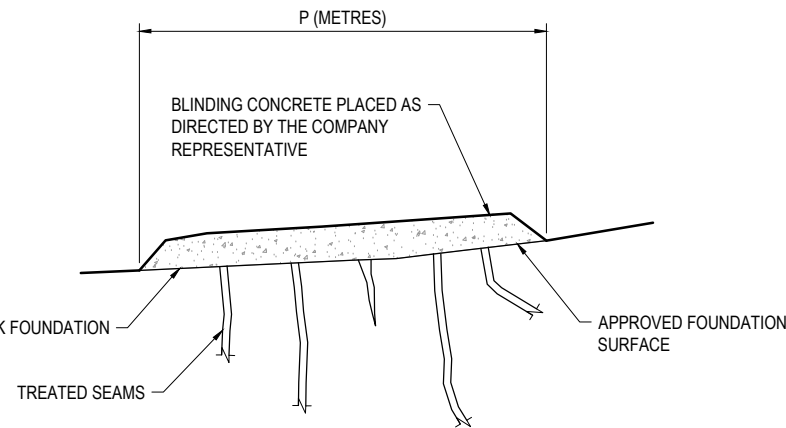


INDIVIDUAL SEAM TREATMENT

INDIVIDUAL SEAM TREATMENT SHALL BE CARRIED OUT AS DIRECTED BY THE COMPANY REPRESENTATIVE OR AS FOLLOWS:

- ON ALL SEAMS FOR WHICH D IS GREATER THAN 150 TREATMENT SHALL BE AS SHOWN ABOVE.
- ON ALL SEAMS FOR WHICH D IS BETWEEN 75 AND 150 EXCAVATION SHALL BE AS ABOVE BUT SEAMS SHALL BE BACKFILLED WITH BLINDING CONCRETE.
- ON SEAMS FOR WHICH D IS LESS THAN 75 EXCAVATION SHALL BE DIRECTED BY THE COMPANY REPRESENTATIVE AND ALL SEAMS SHALL BE COVERED WITH BLINDING CONCRETE AS PER TREATMENT OVER BANDS OF SMALL SEAMS.

SEAM TREATMENTS
N.T.S

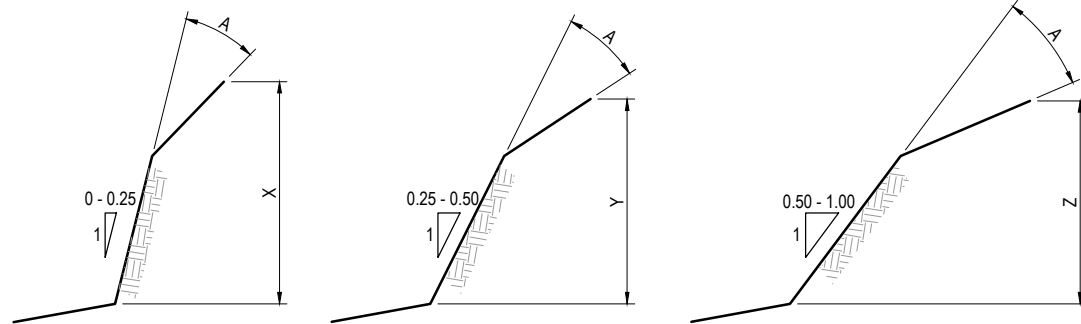


TREATMENT OVER BANDS OF SMALL SEAMS
N.T.S

WHERE WIDTH OF INDIVIDUAL SEAMS IS LESS THAN 75

P	<5	5-10	>10
Q	50 MIN.	100 MIN.	150 MIN.

NOTE: PERSISTENT EXCAVATION FACES SHALL BE FLATTENED UNTIL ANGLE (A) IS LESS THAN 30°, SLOPES HIGHER THAN 5m SHALL BE EXCAVATED AT 2H:1V.



FINISH PROFILES AFTER TREATMENT
N.T.S

SLOPES AND OVERHANGS REQUIRING TREATMENT

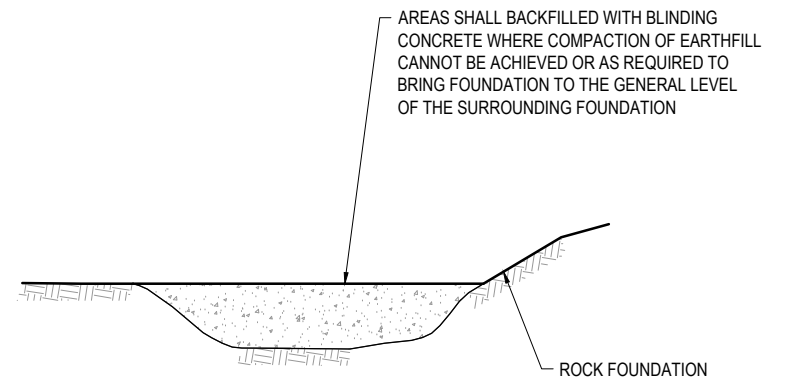
- FOUNDATION TREATMENT EITHER BY FURTHER EXCAVATION OR CONCRETE TREATMENT, AS DIRECTED BY THE COMPANY REPRESENTATIVE SHALL BE CARRIED OUT WHEN VARIABLES X, Y AND Z EXCEED THE FOLLOWING VALUES:
X=500 Y=1000 Z=2000
- THE COMPANY REPRESENTATIVE MAY REQUIRE SHAPE TREATMENT TO BE CARRIED OUT BY ADDITIONAL EXCAVATION. ALL REQUIRED EXCAVATION SHALL BE CARRIED OUT IN SUCH A WAY THAT THE FOUNDATIONS ARE NOT DAMAGED.

NOTES:

- ALL DIMENSIONS ARE IN MILLIMETRES (mm) UNO.
- ALL RL'S ARE IN METRES.
- DRAWINGS SHALL NOT BE SCALED.
- FOR MATERIAL REQUIREMENTS REFER TO FEASIBILITY STUDY REPORT.
- UNLESS OTHERWISE SHOWN OR DIRECTED THE FOUNDATION TREATMENT DETAILED ON THIS DRAWING APPLIES TO ALL ROCK UNDER CLAY LINER.

LEGEND:

	BLINDING CONCRETE
	STRUCTURAL CONCRETE



CONCRETE TREATMENT OF HOLLOW
N.T.S

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Designer R. SINGH

Drafting Check

Design Check

Approved (Project Director)

Date

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Client

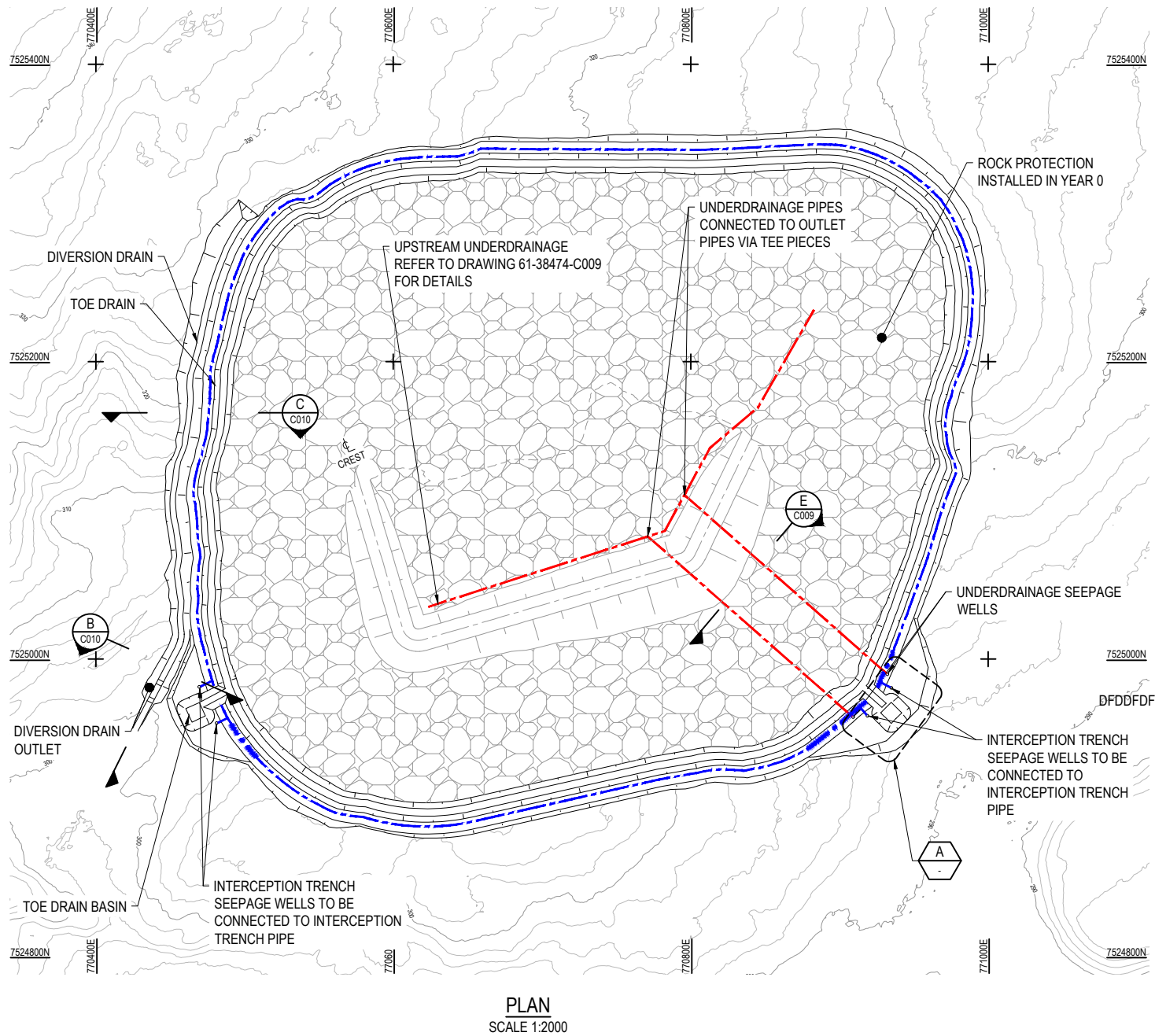
**TALGA RESOURCES
NUNASVARRA SOUTH MINE IWF
INTEGRATED WASTE FACILITY
FOUNDATION PREPARATION DETAILS**

Original Size

A1

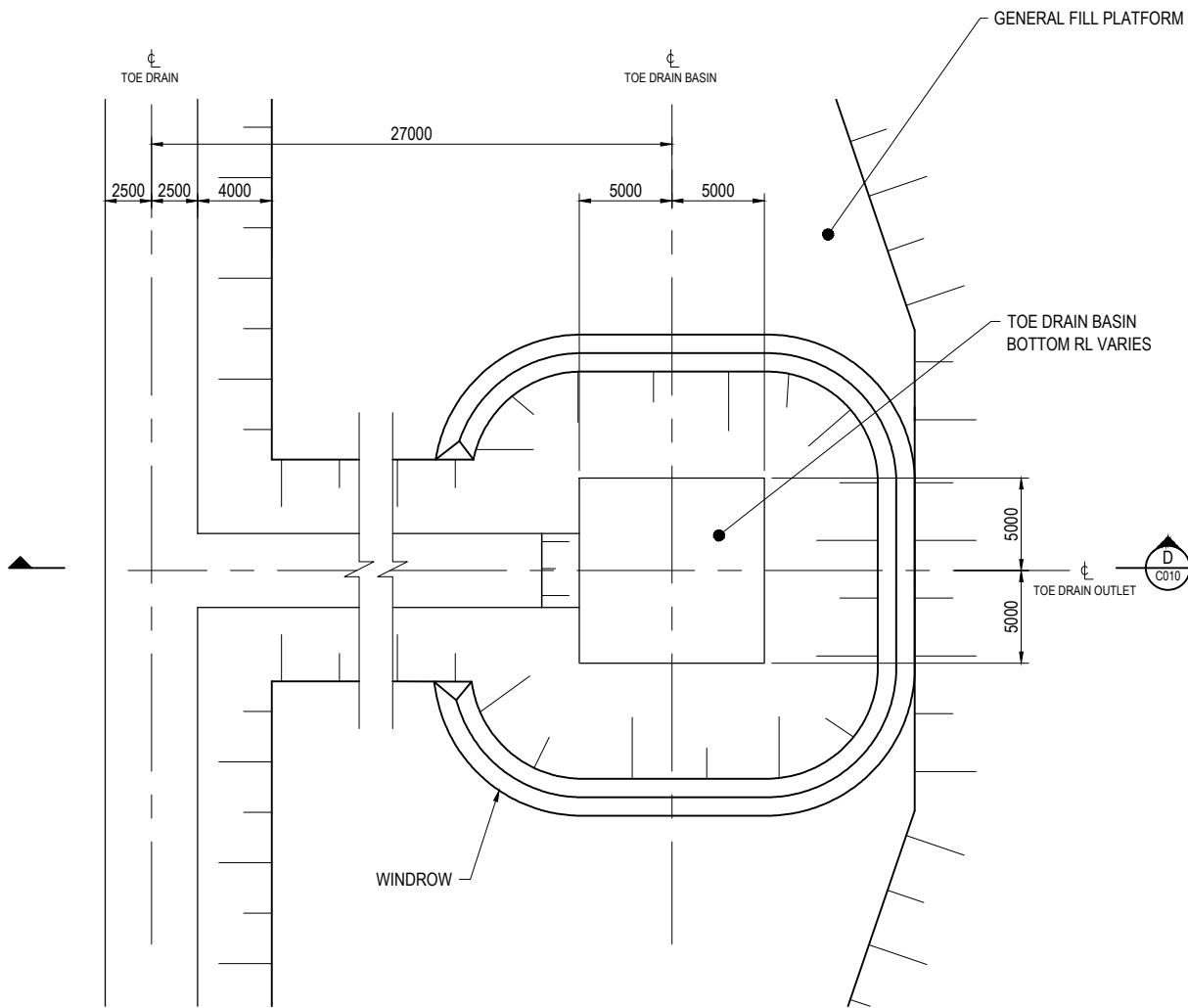
Drawing No: **61-38474-C007**

Rev: **0**



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 5. THESE DRAWINGS SHALL NOT BE SCALED.
 6. HAUL ROAD, ACCESS ROAD, MINE PITS AND ROM PAD DESIGN HAVE BEEN COMPLETED BY OTHERS.
 7. ROCK PROTECTION HATCH NOT SHOWN FOR CLARITY.
 8. ALL STRUCTURES SHOWN ON THIS DRAWING SHALL BE CONSTRUCTED IN YEAR 0.

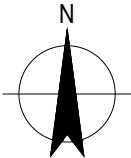
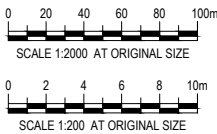
- LEGEND:**
- INTERCEPTION TRENCH
 - UNDERDRAINAGE SYSTEM



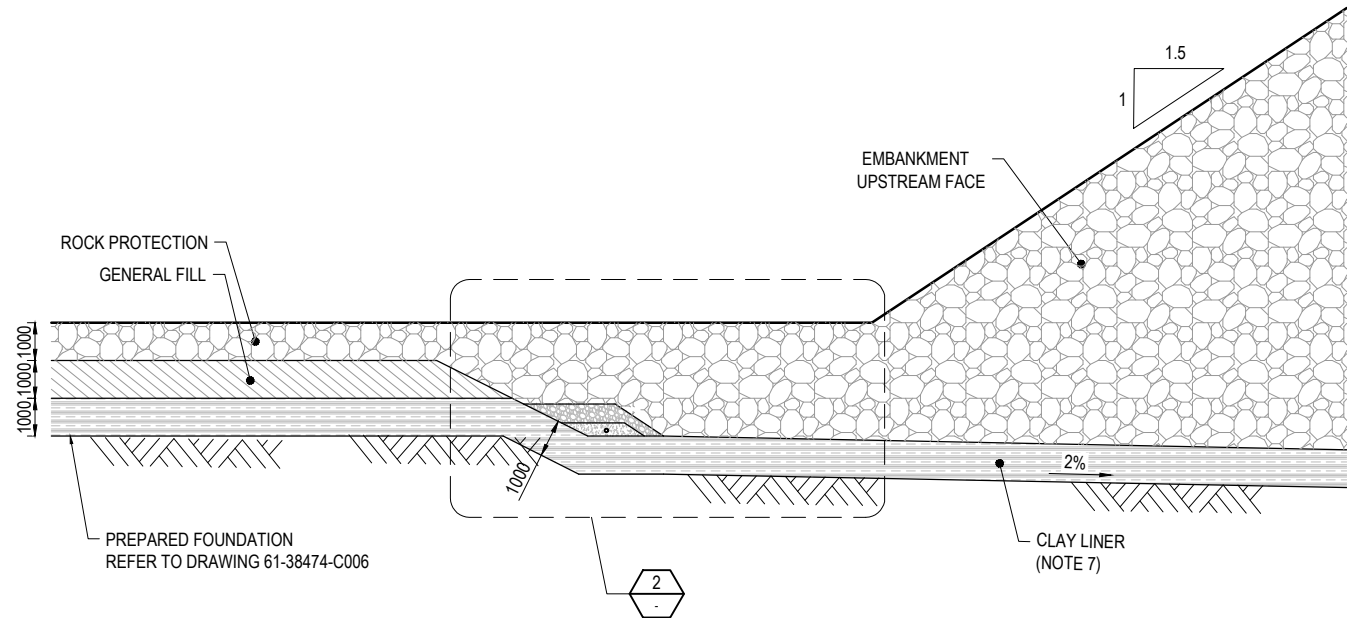
A TOE DRAIN OUTLET AND BASIN
SCALE 1: 200

ISSUED FOR FEASIBILITY STUDY

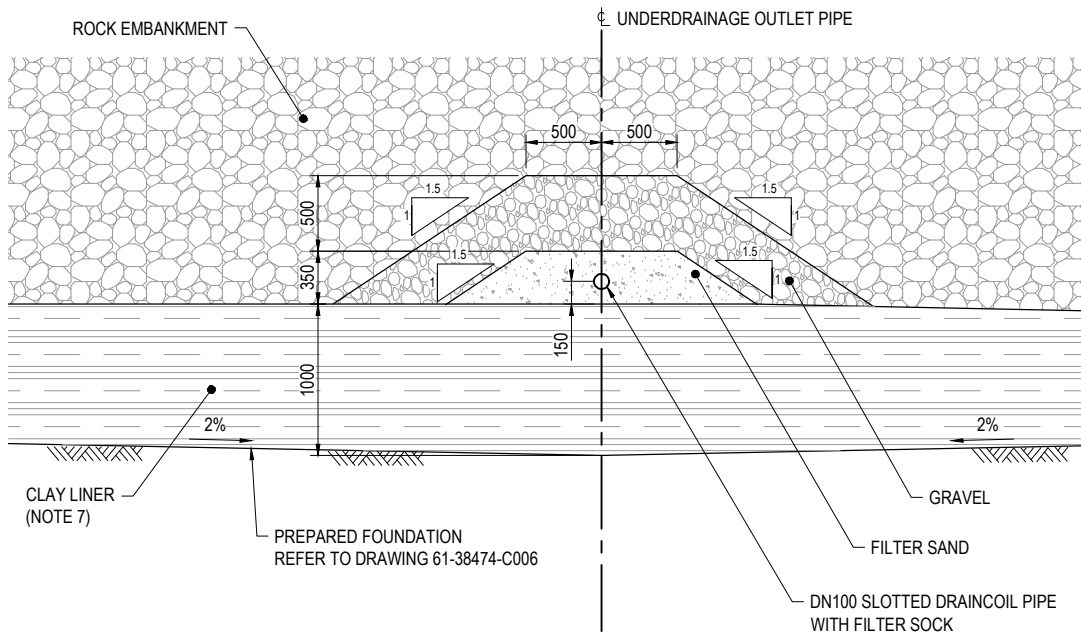
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No	Revision	Note: * indicates signatures on original issue of drawing or last revision of drawing	Drawn	Job Manager	Project Director
					Date



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	Approved (Project Director) Date		Title INTEGRATED WASTE FACILITY UNDERDRAINAGE AND SURFACE WATER MANAGEMENT ARRANGEMENT
	Scale AS SHOWN	This Drawing must not be used for Construction unless signed as Approved	Original Size A1 Drawing No: 61-38474-C008 Rev: 0

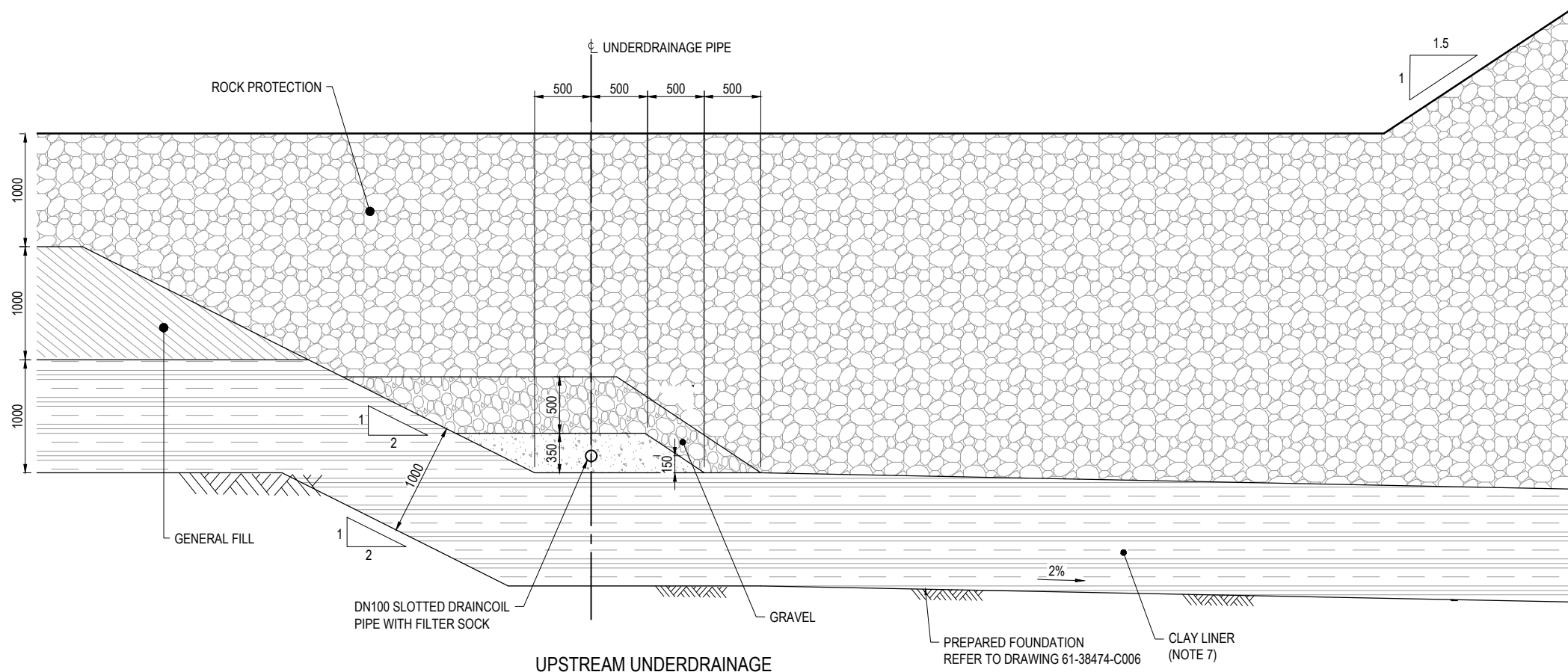


UPSTREAM UNDERDRAINAGE AND LINER DETAIL



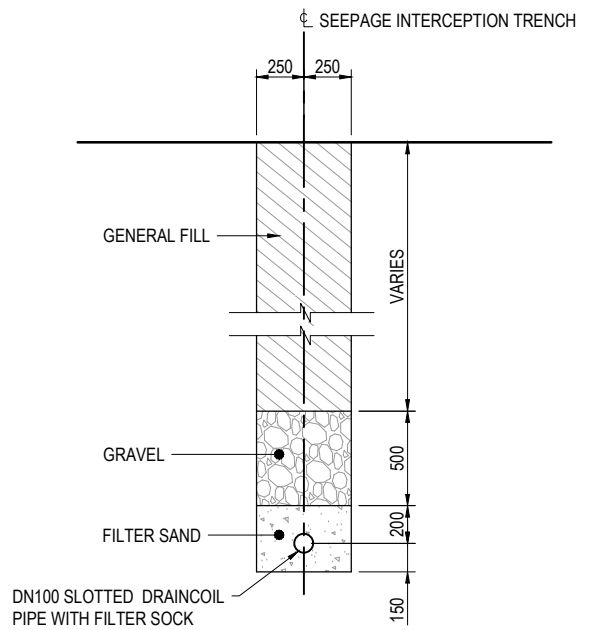
UNDERDRAINAGE OUTLET PIPE

E
C008
SCALE 1 : 100



UPSTREAM UNDERDRAINAGE

2
SCALE 1 : 25



SEEPAGE INTERCEPTION TRENCH
TYPICAL SECTION

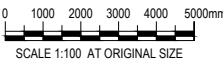
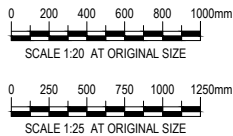
SCALE 1 : 20

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4. ALL RL's ARE IN m RH 2000.
5. THESE DRAWINGS SHALL NOT BE SCALED.
6. REFER TO IWF FEASIBILITY DESIGN REPORT FOR MATERIAL PROPERTIES.
7. DETAILS OF CLAY LINER TO BE CONFIRMED AS PART OF NEXT STAGE OF DESIGN. REFER TO FEASIBILITY DESIGN REPORT FOR FURTHER DETAILS.

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No	Revision	Note: * Indicates signatures on original issue of drawing or last revision of drawing	Date
Drawn	Job Manager	Project Director	Date



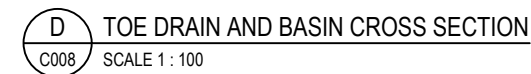
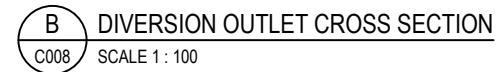
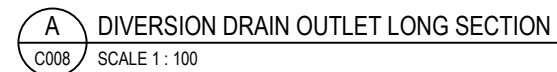
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Approved (Project Director)		Date	
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Client	TALGA RESOURCES
Project	NUNASVARRA SOUTH MINE IWF
Title	INTEGRATED WASTE FACILITY UNDERDRAINAGE DETAILS
Original Size	A1
Drawing No:	61-38474-C009
Rev:	0



- | TOE DRAIN BASIN
BOTTOM ELEVATION | |
|-------------------------------------|--------|
| BASIN | RL |
| WESTERN | 298.22 |
| EASTERN | 291.87 |

Cad File No: G:\61\38474\CADD\Drawings\61-38474-C010.dwg

Appendix D Report Review and Comments Register

Project	Vittangi Project: Nunasvaara South mine	GHD Project Number	6138474					
Client	Talga Resources / Talga AB	GHD Project Director	Jiri Herza					
Deliverables Reviewed	All deliverables	GHD Project Manager	Ryan Singh					
Comment No.	Comment	Deliverables Affected	Section/Drawing	Commenter	GHD response	Action required to address comment	Owner	Open/Closed
1	This design is for the Nunasvaara South mine, which is one component of the Vittangi Project. Please update title and Introduction to reflect this.	All	N/A	Peter French	All deliverables will be updated to reflect this	Update all deliverables	Ryan Singh	Closed
2	We would like this report to explicitly refer to international and Swedish standards that would normally be referenced in traditional tailings storage dams, i.e. ICOLD and RIDAS (Riktlinjer för Dammsäkerhet = Guidelines for dam safety))and GruvRIDAS. We have copies of RIDAS and GruvRIDAS that we can share with you, but I understand these standards are in Swedish language. Reference to ICOLD and GruvRIDAS would probably be more appropriate than ANCOLD (as referenced in Section 10)	Design Report	Section 10	Peter French	Noted. It should be noted that existing ICOLD bulletins do not have a consequence/hazard category. Reference will be made to the GruvRIDAS TSF classification standards	See updated Section 9	Ryan Singh	Closed
3	It would also be good to give reference to other sites in the world that have successfully built and operated similar facilities, preferably in the cold climate zone such as, for instance Canada.	Design Report		Peter French	Case studies can be provided.	See Section 7.5	Ryan Singh	Closed
4	As we have discussed previously, we need some understanding of what happens with monitoring etc. after year 11, when the material will be deposited in the mined out pits.	Design Report	Section 16, page 75	Peter French	Section 15 provides commentary on monitoring for closed IWF emplacement	None	Ryan Singh	Closed
5	External Review – we are currently investigating options for a Peer Review of the report. We will do one. Just not sure who and when at this point. Does this need to be referred to in your report?	Design Report	Section 5	Peter French	We will remove Section 5	Remove Section 5	Ryan Singh	Closed
6	Rather than the TSF, tailings storage facility, can we call this an Integrated Waste Facility or similar? As there will be more waste rock there than tailings.	All		Peter French	Noted. All references to Tailings Waste Facility (TSF) shall be changed to Integrated Waste Facility (IWF)	Change all references to TSF	Ryan Singh	Closed
7	Please include a succinct presentation (a figure and a short description) of the base case design (11 years ex-pit followed by in pit deposition of tailings and waste rock) and the ‘worst case’ design (all waste rock and tailings ex-pit).	Design Report		Peter French	We can add this in Section 9	Add in a new Section, Section 7.4	Ryan Singh	Closed
8	Figure 2-6 is an outcome of Golder’s desktop study in the soil survey. Just as the 1m depth of till is not a conclusion, but a summation of desktop data prior to the site investigations, which includes ground penetrating radar in 2 areas which intersect the SW and NE corners of the proposed ex-pit waste facility.	Design Report	Figure 2-6	Peter French	GHD understands that there are quite a few unknowns surrounding the insitu ground conditions. The proposed design works relatively independently of the ground conditions (e.g. fresh rock or residual soils), however, it is recognised that better understanding is required for the detailed design.	Section 2.4 has been updated to state the uncertainty of the soil coverage at the IWF site, with extra information from Golder provided.	Ryan Singh	Closed
9	Section 2.6 – extra bullet point	Design Report	Section 2.6	Peter French	Noted	Remove bullet point	Ryan Singh	Closed
10	4th paragraph, second line mentions four ore types proposed to be mined. Should read four rock types, ore, HW, FW and dyke.	Design Report	Section 7.2, page 19	Peter French	noted	Section will be amended to reflect this	Ryan Singh	Closed
11	last sentence “mine waste at the assumed unit mass of 2.09 t.” What is “unit mass”?	Design Report	Section 7.4.3, page 28	Peter French	Unit mass is the mass of a material, per cubic meter.	2.09 t will be amended to 2.09 t/m3 GHD believes no further amendment is required,	Ryan Singh	Closed
12	the shape shown here is a waste rock storage facility, not tailings. Tailings footprint was not defined in this design. Same for Figure 8-3	Design Report	Section 8.2, page 34	Peter French	This is not correct. This landform was produced as a co-disposal landform and was sized 5Mm3 (ex-pit waste rock and LoM tailings). GHD note that the location was at the site of the previously located waste rock dump, however, it was identified to be available for the IWF when co-disposal was agreed.	None	Ryan Singh	Closed
13	insert ‘2’ or change wording as suggested here - “Ultimately, Location 2 and all options for Location 2 was were deemed...”	Design Report	Section 8.2, page 35	Peter French	Noted	Wording will be amended	Ryan Singh	Closed
14	error in the title.	Design Report	Section 8.2, page 37, Figure 8-8	Peter French	Noted	Title will be amended	Ryan Singh	Closed
15	AF have generated an updated road design, let me know if you don’t have it and I can sent it through.	Design Report	Figure 9-6 and Figure 13-1	Peter French	Noted	Drawings will be amended to reflect	Ryan Singh	Closed
16	“The embankment material not being saturated due to it being free draining material and the presence”. Of what?	Design Report	Section 10.3, page 53	Peter French	Noted. Should read "and the presence of underdrainage"	Sentence will be amended	Ryan Singh	Closed
17	Refers to a tow drain instead of a toe drain.	Design Report	Section 13.4, page 68	Peter French	Noted	Spelling will be fixed	Ryan Singh	Closed
18	This is to prevent oxidation of the mine waste and tailings and generation and generation of heavy metals.” There’s something wrong here, maybe the second instance of generation should be deleted	Design Report	Section 16, page 75	Peter French	Noted	Sentence will be reworded	Ryan Singh	Closed
19	TSF Opportunity Register – as Duncan described in the call we are actively investigating adding materials to induce pozzalonic reactions and create a cementitious solid tailings ‘product/material’	Design Report	Table 18-2	Peter French	Noted	Table 17-2 Updated	Ryan Singh	Closed
20	Quantify seepage rate expected from tailings	Design Report	Section 14	Peter French	GHD will provide an estimate of seepage over time	Calculations and results detailed in Section 14	Ryan Singh	Closed
21	Update discussion on clay liner and freezing	Design Report	Section 12.2	Peter French	GHD will provide further discussion on the clay liner and potential freezing issues. We will provide further discussion and recommendations for future studies	Updated Section 11.2	Ryan Singh	Closed
23	Risk register - Link Risk 1 to mine plan and variability	Design Report	Section 18	Peter French	Noted	Risk 1 hazard and mitigation action has been updated	Ryan Singh	Closed
24	Risk register - Rank risks	Design Report	Section 18	Peter French	Noted	GHD has provided risk ratings based on perceived likelihoods and consequences of the risks	Ryan Singh	Closed

GHD

Level 10

999 Hay Street

T: 61 8 6222 8222 F: 61 8 9463 6012 E: permail@ghd.com

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28147/<https://projects.ghd.com/oc/WesternAustralia2/talgaresourcesgraphi/Delivery/Documents/6138474-REP-Talga Resources - Vittangi Project TSF Feasibility Design Report.docx>

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
A	R Singh	J Herza	<i>Jiri Herza</i>	J Herza	<i>Jiri Herza</i>	17/11/2019
0	R Singh	J Herza	<i>Jhera</i>	J Herza	<i>Jhera</i>	12/12/2019

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