



REPORT

Nalunaq Gold Mine

Water Management Plan

Submitted to:

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c/o Nuna Advokater ApS

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1.0 INTRODUCTION

Nalunaq A/S (“the Company”) has engaged Golder Associates (UK) Ltd (“Golder”) to provide technical support at its Nalunaq Gold Mine (“the Project”) in southern Greenland. Following discovery of the Nalunaq mine in the early 1990s and development and operation by Crew Gold Corporation (“Crew Gold”), development was continued by Angus & Ross plc and Angel Mining (Gold) A/S, between 2004 and 2013. Subsequently additional exploration work has been undertaken in the Nalunaq area. It is understood that Nalunaq A/S are aiming to restart mining operations in 2021.

Golder has been contracted by the Company to provide support for the water and tailings management of its Project. As part of the Hydrology and Hydrogeology Assessment mandate, Golder has prepared a water management plan for the Nalunaq Gold Mine (“the Site”). This report outlines the steps taken to assess the mine water management requirements for the Site.

2.0 SITE DESCRIPTION

The Project is located in southern Greenland, approximately 35 kilometres (km) northeast of the town of Nanortalik, in the Municipality of Kujalleq. The mine lies on the northern slopes of Kirkespirdalen around 9 km from the eastern side of the Sarqå Fjord. The Project location is shown on Figure 1.

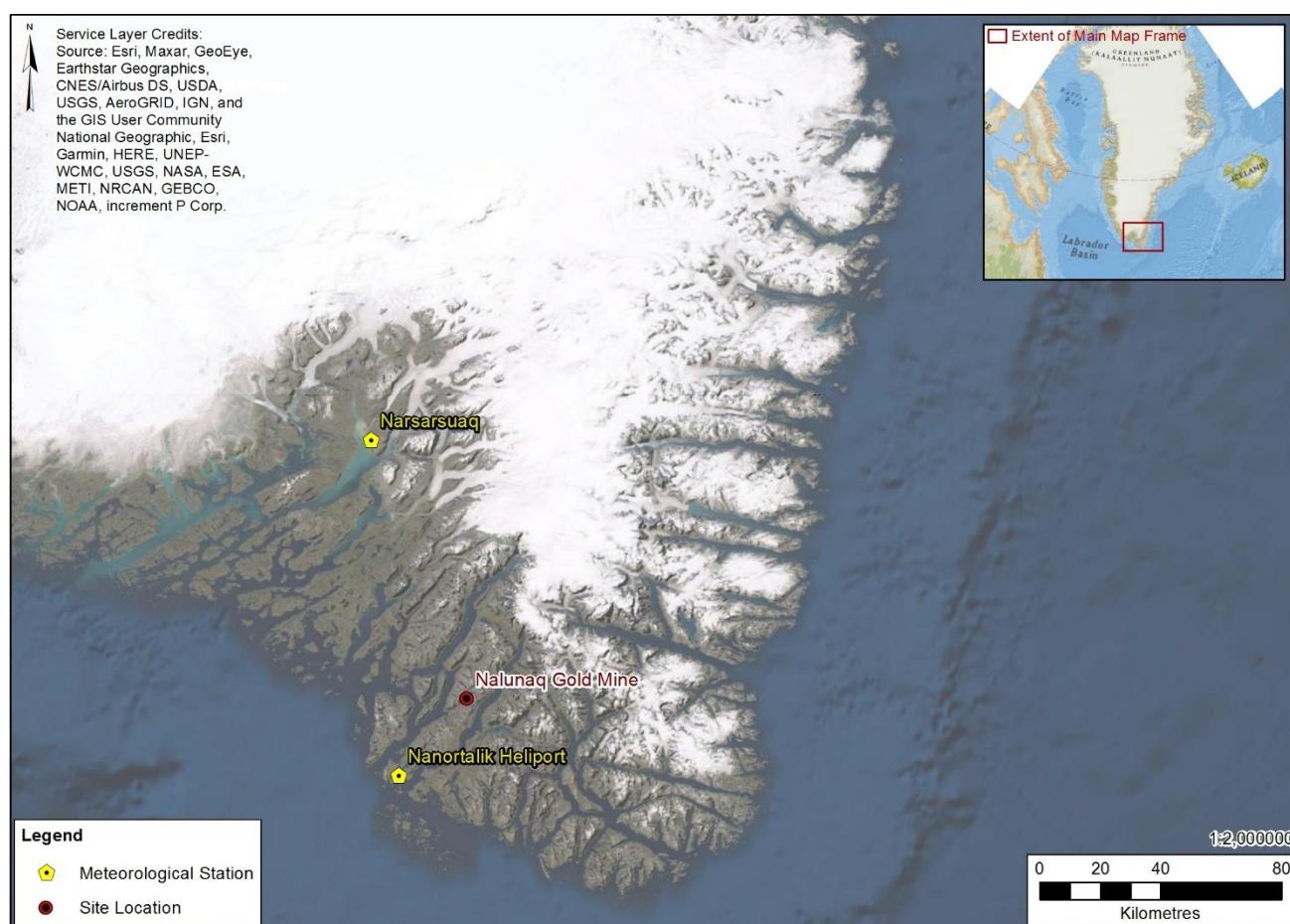


Figure 1: Project Location Plan

2.1 Proposed Site Layout

The mine facilities will consist of underground workings along the northern slopes of Kirkespirdalen, as well as several facilities along the valley bottom, namely a Dry Stack Tailings Storage Facility (DTSF), Process Plant and Ore Pad (Figure 2). The Kirkespir River flows as a braided network of streams across the valley floor, with the centreline of the main river channel currently aligned approximately 20 to 50 metres (m) away from the proposed facility layouts.

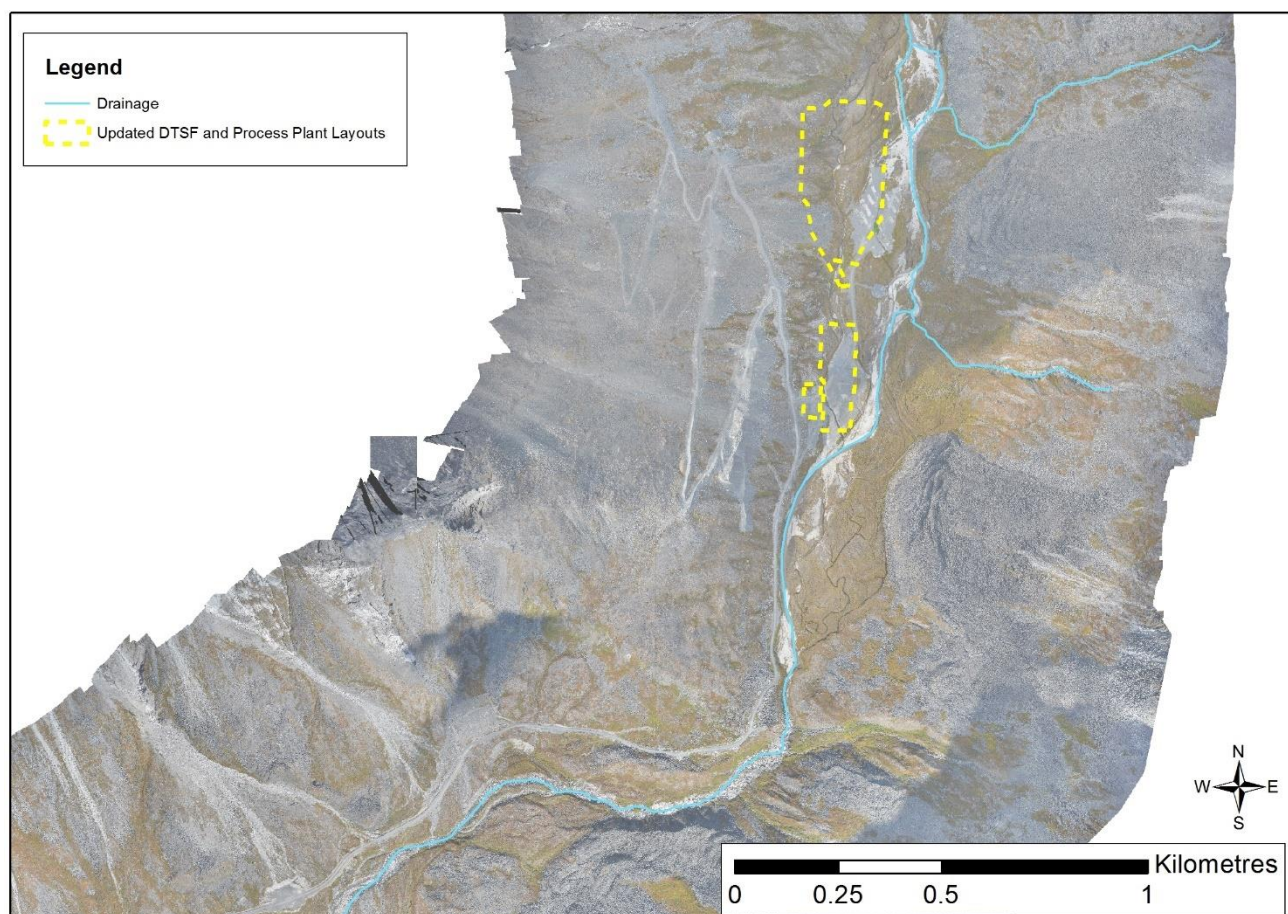


Figure 2: DTSF and Process Pad Layouts

3.0 CLIMATE ASSESSMENT

3.1 Climatic Setting

The Site location has a tundra climate with strong oceanic and polar influences (SRK Consulting, 2002). Precipitation (including both rainfall and snowfall) is moderate with an annual average of 602 mm and snow cover is relatively limited with an annual average cumulative snowfall depth 194 mm. Temperatures show little variation between seasons. July is the hottest month with a mean temperature of 10.7 degrees Celsius (°C) and February is the coldest month with a mean temperature of -7.9 °C.

3.2 Regional Climate Stations

There is no onsite meteorological station at the Site, with only short climate datasets available during which local data capture (e.g., rainfall) has been carried out as part of a specific site-based study. These are too short to be sufficient for hydrological analysis. As such, daily precipitation, and temperature data from two (2) stations

(Nanortalik Heliport and Narsarsuaq) were sourced from NOAA (2020) and Tutiempo (2020), respectively. The location of these stations relative to the Site are shown in Figure 1 and station details are listed in Table 1.

Table 1: Climate station details

Station Name	Latitude Longitude	Distance from Mine (km)	Elevation (m)	Record	Data Type	Portion of Record Complete
Nanortalik Heliport	60.13°N -45.23°E	35 (SE)	5	01/01/1980 02/11/1985	Daily Precipitation	92.5%
				01/01/2014 10/07/2020	Hourly Average Air Temperature	89.7%
Narsarsuaq	61.13°N -45.41°E	91 (NNE)	34	01/01/1973 31/12/2003	Daily Precipitation	98.8%
					Daily Average Temperature	99.5%

As less than five (5) years of daily precipitation data was available for the Nanortalik Station, this record was dismissed in favour of Narsarsuaq, which has a longer and more complete dataset (1973 to 2003). For consistency, the same record was used for temperature.

3.2.1 Reconciliation with Site-based Climate Data

A site-based hydrological analysis was carried out entitled *Water Resource in Nalunaq Valley* by ASIAQ (Greenland Survey) in November 2019 for the purposes of evaluating the potential availability of water within the Kirkespir River to satisfy mine and/or camp demands. As an outcome of the study, a short period of site-based climate data was interrogated to provide the basis for a regional appraisal of hydrological baseflow (i.e. low flow) characteristics. In order to reconcile the long term Narsarsuaq Station data with the local available data, the following steps were carried out:

- Golder collated a number of precipitation datasets and supporting regional (and site-based) studies, including regional climate models, precipitation datasets for sites across southern Greenland, published EIA reports for surrounding sites, and historical reports.
- The most complete long term precipitation dataset that could be located was at Narsarsuaq. Golder also collated a shorter term (incomplete) dataset for Nanortalik.
- Before adopting this as the basis for the hydrological analyses, Golder “sense-checked” the data against regional & local studies, to ensure that it is representative, as follows:
 - The ASIAQ report has been prepared specifically to review water availability in the local river valley. The report concluded that they had a number of local short-term precipitation datasets, however as these did not coincide, it was necessary for them to revert to a predictive model to establish a monthly precipitation record for low flow modelling purposes. For flood flow analysis, it is required to consider rainfall intensity & resulting cumulative snowmelt, and therefore monthly information is not something that could be used. Nevertheless, a seasonal comparison was carried out to ensure that the general climate and runoff trends that were being reported were consistent, and indeed they were.

- Golder carried out a similar seasonal analysis against river baseflows reported by SRK, once again to ensure a consistency in the climatic trends observed (e.g. reported seasonal variability in rainfall & snowmelt) and hydrology (i.e. timing & relative quantum of site-based recorded low flows in comparison to rainfall). Once again, Golder could see a strong correlation with the Narsarsuaq climate data, indicating a strong correlation between Golder's dataset & the short-term local records.
- Finally, Golder carried out a direct comparison between the cumulative rainfall recorded at Nanortalik, and that at Narsarsuaq. Here Golder did identify a problem with the Nanortalik dataset, in that it was providing monthly and cumulative annual rainfall depths that were an order of magnitude greater than not only Narsarsuaq, but also all published information relating to Greenland climate averages. This immediately cast significant doubt on the Nanortalik record, and it was dismissed. It is assumed that this may have been an issue associated with nomenclature or units. Nevertheless, by this stage the review of the Narsarsuaq precipitation record (i.e. against the local studies provided by the Company) gave Golder confidence that this was fully representative of site conditions (for flood risk analysis purposes) and Golder proceeded on this basis.

3.3 Precipitation

Total precipitation depths (i.e. including both rainfall and snowmelt) were available for the Narsarsuaq station. In order to estimate rainfall and snowfall values, potential snowfall depths were derived using the degree-day method (Maidment, 1993). A base daily average air temperature of 0 °C was assumed between April and October, while a base daily average air temperature of 2.5 °C was assumed between November and March. Any daily recorded precipitation which occurred on days with recorded daily air temperatures that exceeded the base temperature was assumed to report to the Site as rainfall. The assignment of these base temperatures reflect lower air temperatures required to trigger snowmelt between April and October, as opposed to other times of the year. This is due in part to energy available from the sun, as well as other factors (such as warmer rainfall and higher ground temperatures). A melt factor of 0.9 mm/°C • day per day was also applied, which accounts for the accelerating effect of rainfall on the melting of the snowpack (and hence rate of snowmelt).

Annual total precipitation averaged 601.8 mm, of which approximately 68% was estimated to occur as rainfall and the remainder as snowfall. The wettest month was September with an average monthly total precipitation depth of 73.8 mm, and the driest month was March, with an average monthly total precipitation depth of 35.6 mm. Measurable snowfall occurred from October to April, with rainfall occurring predominantly in the summer months.

Precipitation, rainfall and snowfall depths for Narsarsuaq are provided in Table 2 and Figure 3.

Table 2: Average monthly precipitation at Narsarsuaq (1973 – 2003)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Precipitation (mm)	44.0	37.7	35.6	45.6	35.8	57.4	58.2	64.6	73.8	57.6	47.6	43.9	601.8
Rainfall (mm)	3.2	7.5	2.4	33.5	35.0	57.4	58.2	64.6	73.1	50.4	16.2	6.4	407.8
Snowfall (mm) ⁽¹⁾	40.7	30.3	33.3	12.2	0.8	0.0	0.0	0.0	0.6	7.2	31.4	37.5	194.0

NOTE: ⁽¹⁾ As water equivalent

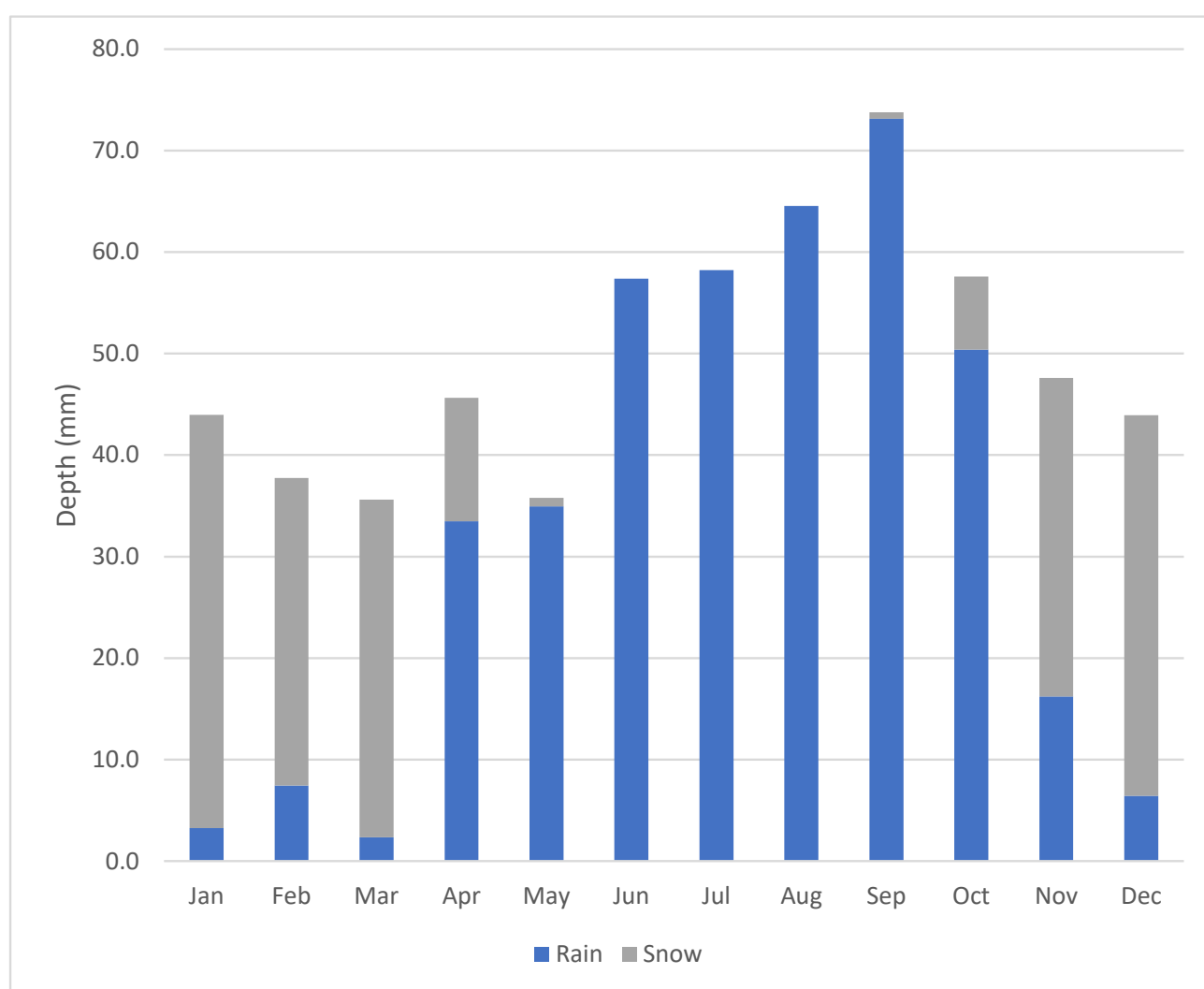


Figure 3: Average monthly rainfall and snowfall at Narsarsuaq (1973 – 2003)

3.4 Temperature

Average temperature data recorded at the Narsarsuaq Station between 1973 and 2003 are presented in Table 3. The values presented are the mean (average) minimum, mean maximum and mean daily temperatures for the 30-year period of record. The mean annual temperature was 0.9 °C. Temperatures were highest from April to October, and lowest from November to March (mean temperatures did not exceed 0 °C). July was the hottest month with a mean maximum temperature of 20.3 °C. February was the coldest month, with a mean minimum temperature of -24.0 °C. The highest temperature recorded in the 30-year record was 25 °C (02/04/1998) and the lowest was -39.8 °C (23/01/1984).

Table 3: Average temperature at Narsarsuaq (1973 – 2003)

Parameter	Temperature (°C)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Mean (Average) Maximum Daily Temperature	8.4	7.0	8.6	12.3	16.2	19.2	20.3	19.2	16.6	12.8	11.4	9.1	13.4
Mean (Average) Daily Temperature	-7.5	-7.8	-6.0	0.3	5.4	8.9	10.7	9.4	5.8	0.8	-3.5	-6.0	0.9
Mean (Average) Minimum Daily Temperature	-23.3	-24.0	-21.1	-13.1	-4.3	1.3	3.4	2.3	-3.1	-9.8	-17.9	-20.7	-10.9

3.5 Evaporation

Potential evapotranspiration (PET) at the Narsarsuaq Station was calculated between 1973 and 2003 from the temperature dataset using the Thornthwaite method (Thornthwaite, 1948). Average monthly and annual PET depths are presented in Table 4.

Table 4: Average potential evaporation at Narsarsuaq (1973 – 2003)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Potential Evapo-transpiration (mm)	0.1	0.5	0.0	14.9	64.4	100.6	118.0	96.3	56.3	12.2	1.5	0.4	465.2

Average annual potential evapotranspiration over the considered time period was calculated to be 465.2 mm. Potential evaporation rates were highest from June to August (over 95 mm of potential evaporation in each of these months). Potential evaporation rates were lowest from November to March, with little to no evaporation in these months.

4.0 HYDROLOGICAL ASSESSMENT

4.1 Hydrological Setting

The Nalunaq Mine is located in the fjords of southern Greenland. The area is mountainous and is characterised by steep topography with slopes reaching from sea level to elevations of approximately 1500 m above sea level (masl). The mine sits on the northern slopes of the Kirkespirdalen, U-shaped glacial valley. The valley surface is predominantly covered in grass and scree, however, vegetation becomes more limited at higher elevations.

The Kirkespir River flows approximately 15 km along the length of the valley, originating at a small glacial lake at the head of the valley and discharging into the Sarqå Fjord at its base. The river has no major tributaries and has an estimated catchment area of 95 km² (Kvaerner E&C, 2002). Flow measurements from the river are limited, though measurements taken between 25/05/1998 and 31/08/1998 give an indication of typical base flow

in the river, with an average¹ flow rate of 3.95 m³/s being recorded immediately downstream of the Site over the 3-month monitoring period (SRK Consulting, 2002).

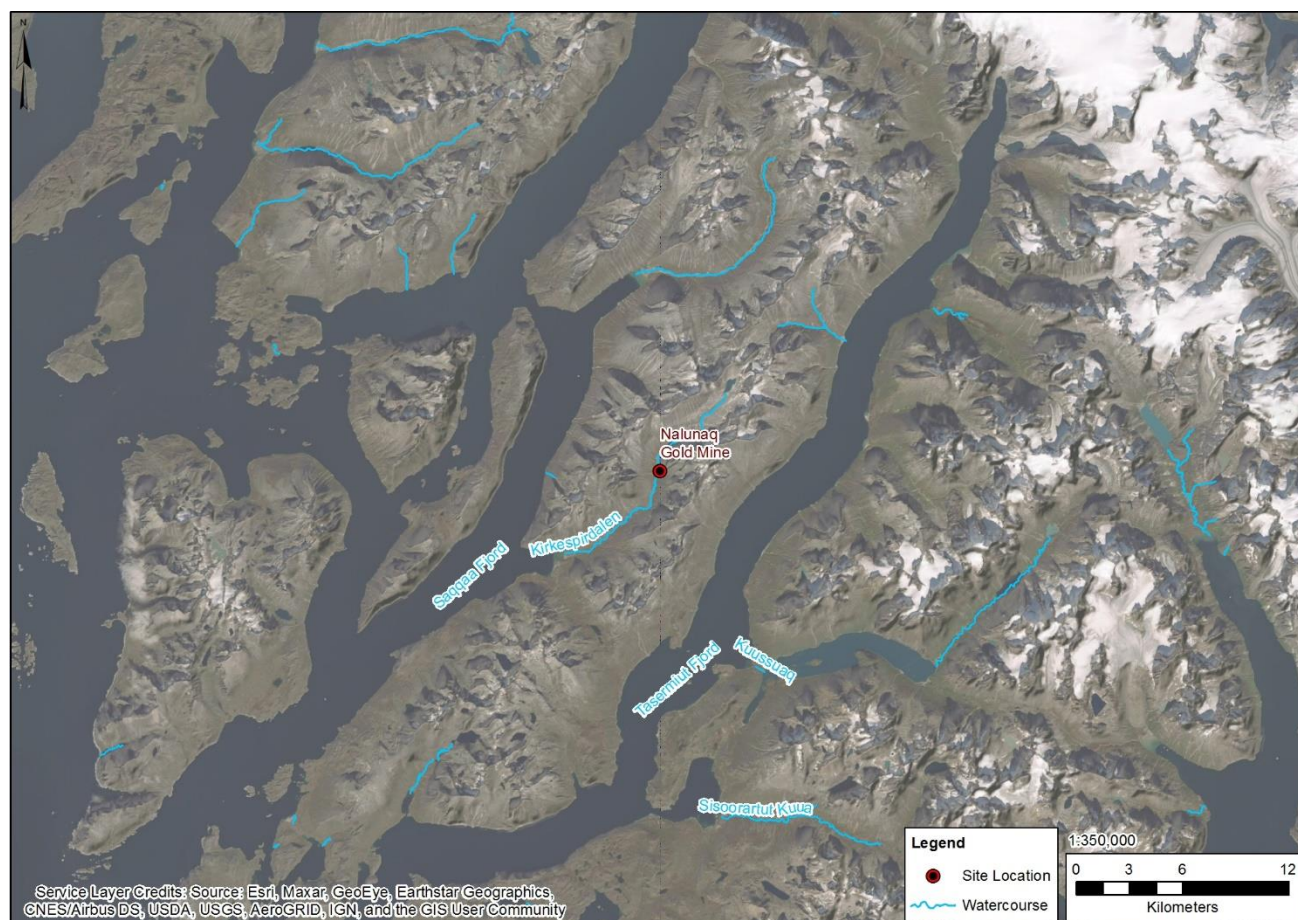


Figure 4: Location of Mine and surrounding fjords

4.2 Precipitation Analysis

4.2.1 Snowmelt

The annual spring melt plays a key part in the local hydrology and the 30-year total precipitation and temperature records for the Narsarsuaq Station (1973 - 2003) were used to derive snowmelt data. As described in Section 3.3, snowmelt data was derived using the degree-day method (Maidment, 1993) with a melt factor, which accounts for the accelerating effect of rainfall on the snowmelt rate. This approach allows for accumulation of a synthetic snowpack according to the daily snowfall and subsequent depletion of the snowpack, based on a potential snowmelt. A snow density of 0.1 was assumed in the calculations to convert snow depth into its water equivalent.

The calculated average monthly and annual snowmelt water equivalents from 1973 to 2003 are presented in Table 5, along with average rainfall plus snowmelt depths. Snow melt is predicted in all months barring August, however, it peaks in spring (i.e. April) with a maximum average of 83.1 mm.

¹ The maximum recorded stream flow rate was in late May 1998 (i.e. 4.4 m³/s) and the minimum recorded stream flow rate was in late August 1998 (3.6 m³/s). There was no rainfall recorded during the 3 month monitoring window, with the last recorded rainfall observed on 25th April 1998

Table 5: Average snowmelt and rainfall plus snowmelt at Narsarsuaq (1973 – 2003)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Snowmelt (mm)	6.2	7.9	6.0	83.1	50.3	26.9	3.0	0.0	0.1	3.2	6.5	8.3	201.4
Rainfall plus Snowmelt (mm)	9.4	15.4	8.3	116.6	85.2	84.3	61.2	64.6	73.3	53.6	22.7	14.7	609.3

The total rainfall and snowmelt of 609.3 mm indicated in Table 5 (above) is the *calculated* value based on the degree-day method described in Section 3.3, and therefore the annual total is marginally higher than the recorded annual average precipitation of 601.8 mm (Table 2).

5.0 MINE WATER MANAGEMENT PLAN

The water management requirements for storage, control and discharge are presented in the following sections.

5.1 Conceptual Model

A flow diagram representing the suggested water management plan for the Mine is presented in Figure 5. Key processes for operational water management are as follows:

- Make-up water for the Process Plant (3.14 m³/hr) is pumped from Supply Wells;
- Bleed water from the Process Plant will be recirculated within the Plant at a rate of 1.34 m³/hr. Water will be consumed at a rate of 0.49 m³/hr (i.e. production of the concentrate);
- Water required for other operational uses will also be pumped from the Supply Wells (10 m³/hr);
- Tailings (low water content) from the Process Plant will be trucked to the DTSF with a water equivalent rate of 2.63 m³/hr;
- Runoff from the DTSF is collected in a constructed drain, before being diverted to a settling basin ("Sediment Pond"); and
- Treated water from the Sediment Pond is discharged to the environment.

Additionally, some key processes involving water from the underground mine are as follows:

- Groundwater inflow to the underground mine is pumped from the 235 Level portal to a holding pond ("Holding Pond") at a rate of 15 m³/hr, to be temporarily stored for drilling in the underground mine;
- Water from the Holding Pond will be pumped to the underground operations for drilling use. Note that, for planning purposes, it has been assumed that the Holding Pond will be constructed within the proximity of the Process Plant (i.e. within the open environment) rather than underground; and
- Excess groundwater inflows into the underground mine will bypass the Holding Pond, and will be discharged to the environment via a weir (i.e. to facilitate monitoring).

Inflows to the water management system include:

- Rainfall and snowmelt falling directly into the Sediment Pond, DTSF and Holding Pond;
- Pumped groundwater inflow to the Holding Pond;

- Freshwater pumped from the Supply Wells to the Process Plant; and
- Freshwater pumped from the Supply Wells to satisfy demands related to other mine operational uses (such as dust suppression), as well as equipment uses.

Outflows from the water management system include:

- Evaporation from the exposed water surfaces in the Sediment Pond, DTSF and Holding Pond; and,
- Releases to the environment from the Sediment Pond and Underground Mine.

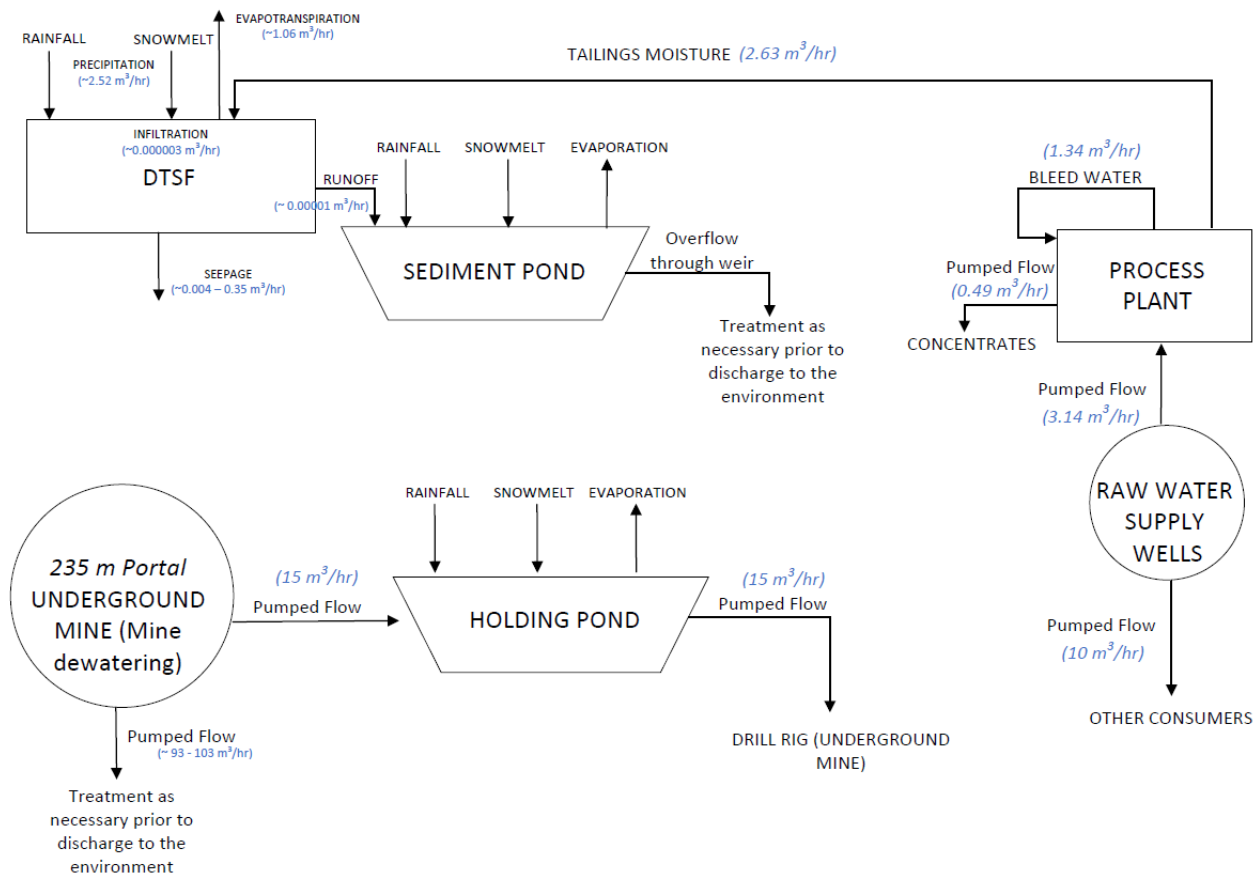


Figure 5: Block flow diagram of water management plan (steady-state pumped flows shown in blue)

5.2 Mine Water Storage

As mentioned previously, the operation of a settling basin ("Sediment Pond") and a holding pond ("Holding Pond") has been considered as part of the water management approach.

The purpose of the **Sediment Pond** will be to remove fines from the DTSF runoff during the 99.9th percentile daily rainfall conditions (i.e. a net inflow due to rainfall of 36 m³/hr). The pond will also be sized to temporarily store runoff reporting from the DTSF resulting from a 1-in-2 year storm event (combined rainfall and snowmelt).

Only runoff reporting from the top of the DTSF (as opposed to the slopes and DTSF platform) will report to the Sediment Pond. Settling of runoff generated from the slopes of the DTSF will not be required, as it is not anticipated that fine particles would be mobilised from the slopes. However, due to the constant movement of haul trucks on the top surface of the DTSF, some mobilisation of particles is anticipated on the DTSF top surface.

The runoff from the slopes of the DTSF will therefore be collected in a toe drain (without treatment) and be discharged to the Kirkespir River.

The **Holding Pond** will receive water pumped from the underground mine at a rate of 15 m³/hr (i.e. equivalent to the anticipated demand for underground drilling), which will be temporarily stored for 24 hours. Water from this pond will then be supplied to the Drill Rig (located in the underground mine). The pumped quantity of 15 m³/hr is for operational uses and is a proportion of the total groundwater inflows predicted to report to the underground mine, the balance of which will discharge to the environment. Predicted groundwater inflows to the underground mine are presented in “20136784.618.A0 Nalunaq Gold Project: Mine Inflow Assessment – Groundwater and Surface Water” Technical Memorandum (Golder, 2021a).

Details of the Sediment Pond and Holding Pond designs are provided in the “20136781.612.A0 Nalunaq Surface Water Infrastructure Design” report (Golder, 2021b). However, key design criteria are presented in Table 6 and key dimensions presented in Table 7.

Table 6: Key design criteria - Sediment Pond and Holding Pond

Design Criteria	Description	
	Sediment Pond	Holding Pond
Inflow Source	Runoff from DTSF tailings surface	Pumped flow from underground mine
Design Inflow	36 m ³ /hr (0.010 m ³ /s)	15 m ³ /hr (0.0042 m ³ /s)
Outflow Conditions	Gravity Controlled (Weir outlet)	Pumped

Table 7: Key dimensions - Sediment Pond and Holding Pond

Dimension	Sediment Pond	Holding Pond
Depth (m)	1	1
Base Length (m)	30	30
Base Width (m)	8	15
Side Slopes (H:1V)	2	2
Top Area (m ²)	400	630
Total Capacity (m ³)	320	540

5.3 Mine Water Control and Discharge

5.3.1 Pumping Requirements

During the operational phase, pumps will be required to transfer water between facilities. The maximum pumping requirements for each facility are presented below:

- An average groundwater inflow rate of 15 m³/hr will be required to report to the Holding Pond from the underground mine (i.e. to satisfy drilling requirements), therefore a pump with 15 m³/hr capacity is required;

- Similarly, a 15 m³/hr pump will be required to pump water from the Holding Pond to the underground mine Drill Rig;
- The Process Plant will require water to be pumped from the Supply Wells at a rate of 3.14 m³/hr; and
- A pump with 10 m³/hr capacity is required to transfer water from the Supply Wells to the operational mine for ancillary operational uses.

5.3.2 Discharges to the Environment

Water will be discharged to the environment from the underground mine and the Sediment Pond.

- Water from the underground mine will be discharged to the environment via a gravity-controlled weir outlet. However, water will only be discharged for testing purposes; and
- Water from the Sediment Pond will be released to the environment via gravity flow, through a weir system. However, it will only be discharged once the water level in the pond reaches the height of the weir invert. This will allow the water within the sediment pond to achieve the intended retention time before passively being discharged to the environment.
- The discharge from the DTSF to the sediment pond will comprise surface water runoff only it is anticipated that any contaminants can be controlled through sedimentation.
- There will be no discharge from the process plant to the environment and process fluid will be reused within the processing circuit. Any residual concentrations of chemicals arising from process plant in the tailings will be *de minimis*.
- Any water discharged from the mine that is not recirculated back for use in the mine will be tested prior to discharge and treated if necessary to settle any suspended solids, and if necessary, passed via an interceptor to remove any residual hydrocarbons.

5.4 Flow and Water Quality Monitoring

A comprehensive flow and water quality monitoring system is recommended to improve certainty in hydrological and hydrogeological predictions, and to more fully understand the water environment within which the mine will be operating. Flow monitoring should be undertaken:

- As part of the underground dewatering system; and
- As part of the Process Plant circuit.

As noted previously, climate data from the Narsarsuaq Station was used in lieu of site-specific precipitation data. In addition, evaporation was calculated using the Thornthwaite (1984) method, which resulted in very high rates of evaporation during the summer. For this reason, a hydrometric station should be set up to monitor (i) rainfall (ii) snowfall and (iii) pan evaporation.

5.5 Considerations for Maintenance

A comprehensive water management and maintenance regime will be required to ensure the long-term integrity of the system throughout the life of mine (and beyond). As a minimum however:

- Water distribution systems will need to be monitored and maintained to prevent freezing or ice-build up in the systems;
- The Sediment Pond and Holding Pond need to be inspected and cleaned regularly to prevent build-up of sediment within the ponds, and to retain the required operating capacity throughout the life of mine; and

- During operations, as well as closure, any channels that collect runoff from the DTSF would need to be inspected and cleaned regularly to prevent build-up of sediment in the channels.

5.6 Extreme Event Planning

Considerations for extreme event planning include the following:

- High inflows to the Sediment Pond due to rainfall and/or snowmelt events that exceed the design capacity of the system;
- Sediment-laden outflows from the Sediment Pond due to rainfall and/or snowmelt events that exceed the design capacity of the system; and
- Flooding of the mine site facilities due to significant rainfall and/or snowmelt events that may result in the inundation of the Sediment and/or Holding Pond.

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