Greenland Minerals & Energy A/S

Kvanefjeld Project

Environmental Impact Assessment

September 2018

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List of Abbreviations and Acronyms

Acronym / Abbreviation	Description
A/S	Aktieselskab, Danish name for a stock-based corporation
AIDS	Acquired Immune Deficiency Syndrome
BAT	Best Available Technology
BFS	Bankable Feasibility Study
BWM	International Convention for the Control and Management of Ships' Ballast Water and Sediments
Bn	Billion
Bq	Becquerel, Unit of radioactivity
BWS	Blue Water Shipping, Denmark
C	Centigrade
Capex	Capital expenditure
CE	Common Era (also referred to as Anno Domini (AD))
COPC	Contaminants of potential concern
Power station	Combined Heat and Power Station
CRSF	Chemical Residue Storage Facility
dB	Decibels
DCE	Danish Centre of Environment and Energy
DHI	DHI Water and Environment
DILT	Department of Industry, Labour and Trade
DKK	Danish Kroner
DMP	Dust Management Plan
DWT	Dead Weight Tonnage
EAMRA	Environmental Agency for Mineral Resources Activities
EBRD	European Bank for Reconstruction and Development
EC	European Community

EIA	Environmental Impact Assessment
EL	Exploration License
EMP	Environmental Management Plan
ERM	ERM Ltd
et al.	Et alii (and others)
EU	European Union
FIFO	Fly-In Fly-Out
FS	Feasibility Study
FTSF	Flotation Tailings Storage Facility
GA	Employers’ Association of Greenland
GE	Greenland Business Association
GHD	GHD Pty Ltd
GHG	Greenhouse Gas
GME A/S	Greenland Minerals and Energy A/S
GINR	Greenland Institute of Natural Resources
GML	Greenland Minerals Limited
GoG	Naalakkersuisut
GoG	Government of Greenland
ha	Hectare
HDPE	High Density Poly-ethylene
HFO	Heavy Fuel Oil
IAEA	International Atomic Energy Agency
ICRP	International Commission for Radiological Protection
IMO	International Maritime Organisation
IUCN	International Union for Conservation of Nature
JORC	Joint Ore Reserves Committee
km	Kilometre

Km^2	Square Kilometre
LCD	Liquid Crystal Display
LTIFR	Lost Time Injury Frequency Rate
m^2	Metres Squared
m^3	Cubic Metres
MARPOL	International Convention for the Prevention of Pollution From Ships
MFA	Danish Ministry of Foreign Affairs
MIE	Ministry of Industry and Energy
MLSA	Mineral License and Safety Authority
mm	Millimetre
MMR	Ministry of Mineral Resources
mRL	Metres Relative Level
mSv	milliSievert, Unit of radiation dose
Mt	Million Tonnes
Mtpa	Million Tonnes Per Annum
MW	MegaWatt
NCA	Nuclear Co-operation Agreement
NEA	Nuclear Energy Agency
NPV	Net Present Value
OCE	Operating Cost Estimate
OECD	Organisation for Economic Co-operation and Development
OPRC	International Convention on Oil Pollution Preparedness, Response and Co-operation
PEL	Pacific Environment Limited
PM	Particulate Matter
ppm	Parts Per Million
REE(s), RE(s)	Rare Earth Element(s)
REO	Rare Earth Oxide

REMC	Rare Earth Mineral Concentrate
RoM	Run Of Mine
SIA	Social Impact Assessment
SIK	Greenland Labour Union
Sv	Sievert
t	Tonne
TDS	Total Dissolved Solids
ToR	Terms of Reference
tpd	Tonnes Per Day
TSF	Tailings Storage Facility
TSP	Total Suspended Particulates
TWP	Treated Water Placement
UK	United Kingdom
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
$ or USD	United States Dollars
WHO	World Health Organisation
WNA	World Nuclear Association
WRS	Waste Rock Stockpile
w/w	Weight for weight

1. Introduction

1.1 Purpose and scope of document

Greenland Minerals Limited (GML) is proposing to develop the Kvanefjeld rare earth (RE, REE) project (the Project) in Greenland. The Project includes integrated mine, processing plant and port facilities.

This document provides an assessment of the potential environmental impacts of the Project and describes the environmental management practices that will be in place during the Project's operations and following mine closure.

1.2 Project overview

GML is an Australian mining company based in Perth and listed on the Australian Securities Exchange. Greenland Minerals and Energy A/S (GME) is the Greenlandic subsidiary of GML and is headquartered in Narsaq. GML acquired a majority stake in GME, the holder of the license to explore the Project (Project), in 2007. In 2011 GML acquired the outstanding shares in GME and thereby assumed 100% ownership and control of the Project.

The Project is located within the Kommune Kujalleq, the Municipality of southern Greenland, approximately 7.5 km to the north of the town of Narsaq and 40km to the southwest of the international airport and settlement of Narsarsuaq (Figure 1).

The Project is in the Arctic region, with the primary mineralisation located at an elevation of approximately 600 m above sea level.

The Kvanefjeld site has unique geological and environmental features:

- The resource is comprised of highly alkaline rocks that are strongly enriched in REEs, lithium, beryllium, uranium and high-field-strength elements such as niobium and tantalum (see Section 7)
- Natural occurring radionuclides, such as uranium and thorium, are present in all soils and rocks. The Kvanefjeld ore carries significant concentrations of uranium and thorium, approximately 300 ppm and 800 ppm, respectively. Over time natural processes, such as glaciation and wind and water erosion, have dispersed uranium and thorium into the surrounding environment, inclduing the Narsaq valley (see Section 9)
- The resource contains high levels of the water-soluble mineral villiaumite (NaF). This has given rise to naturally-elevated fluoride levels in surrounding waterbodies including the the Narsaq and Taseq rivers and the Taseq basin (see Section 10)
- It is characterised by low fauna and flora diversity (see Section 12).

Mining operations will involve conventional open pit mining with blasting followed by truck/shovel haulage. Broken ore is transported to a concentrator to produce a RE mineral concentrate (REMC), a zinc concentrate and fluorspar. The REMC is further processed in the refinery to produce RE products and uranium oxide. All saleable products will be transported to a purpose built port and exported.

While the ore in Kvanefjeld deposit comprises multiple elements with commercial value, REs are the primary value products and the zinc, fluorspar and uranium are by-products that provide additional revenues to strengthen project economics.

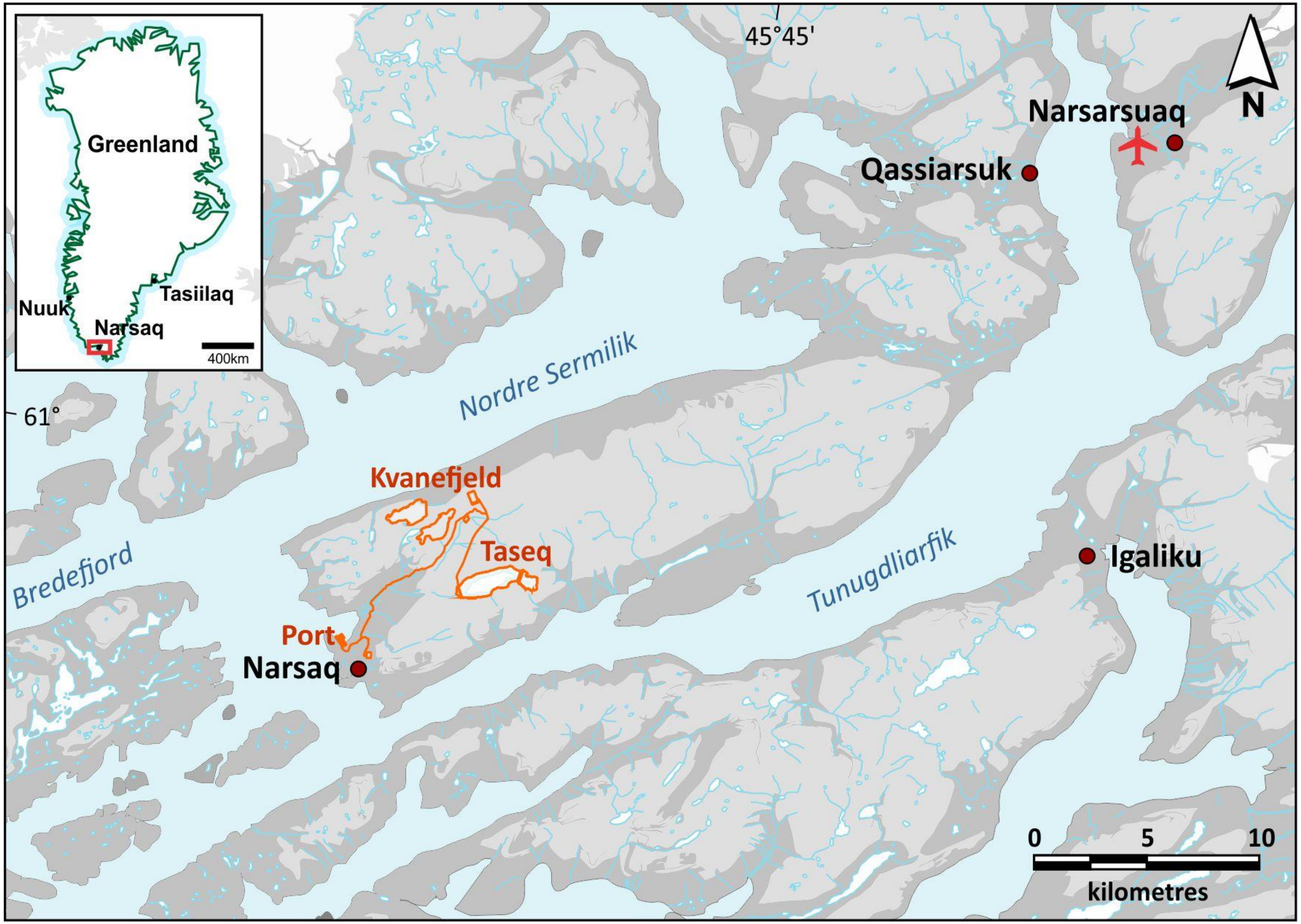


Figure 1 Project locality

1.3 Environmental Impact Assessment process

Inatsisartut Act no. 7 of 7 December 2009 (the Mineral Resources Act) requires that mining companies prepare an environmental impact assessment in connection with the development of any proposed mineral project. The Act also stipulates that an exploitation license for a proposed project will only be granted once the project's environmental impact assessment has been accepted by the Government of Greenland (GoG).

The aim of a project's environmental impact assessment is to identify, predict and communicate the potential environmental impacts of the planned mining project in all of its phases - construction, operations, closure and post-closure. The assessment should also identify mitigation measures designed to eliminate or minimize negative environmental effects, such measures, as far as possible, being incorporated into project design.

This environmental impact assessment (the EIA) has been prepared in accordance with the *Guidelines for preparing an Environmental Impact Assessment (EIA) report for mineral exploitations in Greenland* (Mineral Resources Authority, 2015), (the Guidelines). The Guidelines identify the requirements for impact assessments relating to:

- Environmental baseline studies, including background concentrations and variations, vegetation and fauna, and local use and knowledge
- Project related environmental studies, including quantifying potential sources of contamination such as ore, waste rock and tailings
- Discharges and emissions to the environment, including air and water emissions.

The Guidelines also specify the requirements for environmental management and monitoring plans.

1.3.1 Study Area

The EIA defines the EIA's "Study Area" which is the area potentially influenced by the Project including the close vicinity of the project components and infrastructure. The Study Area is shown in Figure 2.

The EIA also defines a "Project Area" which is the area within the Study Area where direct impacts occur, such as ground disturbance and loss of habitat for flora and fauna.

1.4 Limitations of this report

GHD has prepared this report on the basis of information provided by GML , Orbicon and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information.

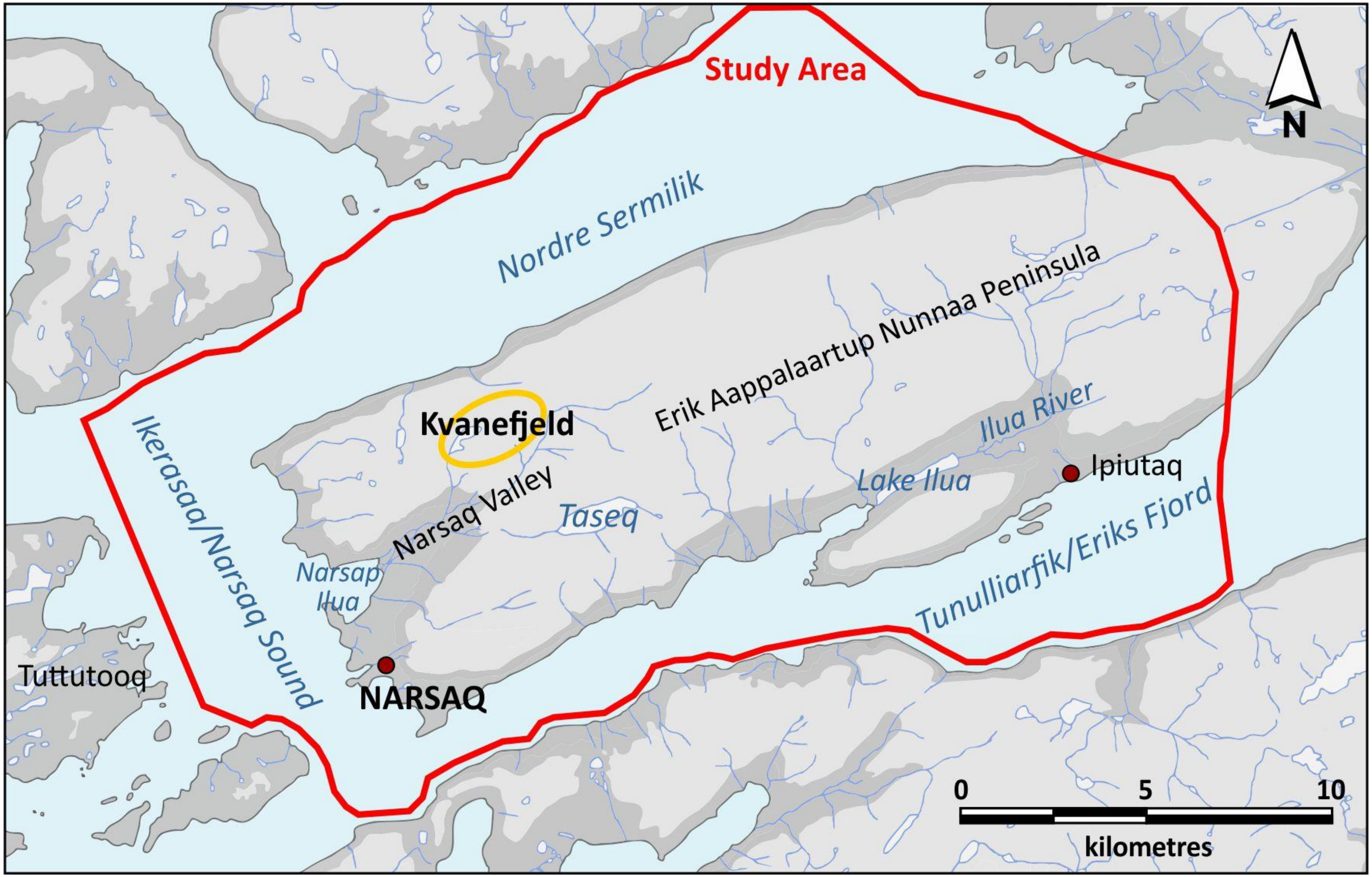


Figure 2 Study Area

2. Non-Technical Summary

2.1 Project description

GML is an Australian mining company based in Perth and listed on the Australian Securities Exchange. Greenland Minerals and Energy A/S (GME) is the Greenlandic subsidiary of GML and is headquartered in Narsaq. GML acquired a majority stake in GME, the holder of the license to explore the Kvanefjeld RE project (Project), in 2007. In 2011 GML acquired the outstanding shares of GME and thereby assumed 100% ownership of the Project.

GML proposes to develop a mine and integrated minerals processing facilities at Kvanefjeld. In addition to producing significant quantities of RE products, the Project will also produce small but commercially valuable quantities of uranium concentrates, zinc concentrates and fluorspar.

The Project is located within the Kommune Kujalleq, the Municipality of southern Greenland (Figure 3). The mine and processing facilities will be located approximately 7.5 km from the town of Narsaq with a port to be developed for the Project (the Port) to be located approximately 1 km from Narsaq.

Figure 3 Map of Kommune Kualleq showing towns and settlements (Source: www.kujalleq.gl)

The mining operations will involve conventional open pit mining via blasting followed by truck/shovel haulage. Broken ore will be transported to a concentrator to produce a REMC, zinc concentrate and fluorspar. The REMC will be further processed in the refinery to produce RE products and a uranium product. The saleable products will then be transported to the port and exported.

While the ore in Kvanefjeld deposit contains a number of elements with commercial value, the REEs are the primary value products, and the zinc, and uranium extracted as by-products.

Key elements of the Project are summarised in Table 1.

Table 1 Project summary

Project Element	Description	Details
Tenement	EL 2010/02	80 km^2
Mine reserve		108 Mt
Mining rate		3.0 Mtpa
Mine method	Open pit	Extraction of ore and waste rock using drilling, blasting and power shovels
Processing method	Mechanical (concentrator) and Chemical processing (refinery)	
Life of Mine		37 years
Construction phase		3 years
Operating phase		37 years
Closure and decommissioning		6 years
Products	REEs	30,000 tonnes per annum (tpa)
	Zinc concentrate	15,000 tpa
	Fluorspar	16,000 tpa
	Uranium Product	517 tpa
Supporting infrastructure	Power station	59 MW
	Power lines	2 x 11 km, 11 Kv transmission lines
	Roads	10 km dual lane (8 m wide) unsealed road from port to mine
Size of Project elements	Total footprint (at 37 yrs)	5.946 km^2
	Mine pits	1.1371 km^2
	Waste rock dumps	1.255 km^2
	Flotation Tailings	2.516 km^2
	Chemical residue	0.4656 km^2
	Port	0.1346 km^2
	Accommodation	0.0421 km^2
Water use	Fresh water requirements	191 m^3/h from Narsaq river
Excess water	Discharge of treated excess water to Nordre Sermilik	816 m^3/h
Waste volume	Waste rock	2.6 Mtpa
Tailings volume	Flotation tailings	122 m^3/h of solids
	Chemical residue tailings	11.4 m^3/h of solids
Product Transport	22 ships per year	Handy-Max vessel 40,000 DWT
Employee Transport	Airport	Narsarsuaq
Employees	Construction	200 Greenlandic, 921 foreign
	Operations	323 Greenlandic, 392 foreign
	Closure	41 Greenlandic, 7 foreign

2.2 Environmental Impact Assessment process

In 2009, Naalakkersuisut (the Government of Greenland) assumed responsibility for the administration of Greenland's mineral resources from Denmark. Responsibilities assumed included the administration of environmental issues in relation to mining projects. The Greenlandic *Mineral Resources Act* came into force on 1 January 2010 and is the backbone of the legislative regulation of the sector, regulating all matters concerning mineral resource activities, including environmental issues (such as pollution).

In order to conduct mining activities in Greenland, a licensee must first apply for and obtain an exploitation licence for the area that it proposes to mine. An exploitation licence is granted pursuant to the *Mineral Resources Act* (as amended 2014). To apply for an exploitation licence for the Project, GML must submit the following documents to the relevant authorities:

An application with key information on the proposed mining project

- A bankable feasibility study
- An environmental impact assessment
- A social impact assessment.

GML submitted a draft of its EIA to the GoG in November 2015. An extensive period of consultation with GoG agencies and advisers has ensued. Feedback from this process has been incorporated in this document which comprises the Company's EIA for the Project.

The EIA has been prepared in parallel with the Project's social impact assessment (SIA) to ensure that the interplay between the environmental and social impacts of the Project are properly captured.

The EIA has been prepared in accordance with the the Guidelines which state that the aims of the EIA are:

- To estimate and describe the surrounding nature and the environment, as well as the possible environmental impacts of the proposed project
- To provide a basis for the consideration of the proposed project for Naalakkersuisut (the GoG)
- To provide a basis for public participation in the decision-making process
- To give the authorities all information necessary to determine the conditions of permission and approval of a proposed project.

In order to best present the environmental baseline data and the assessment of potential environmental impacts, this report has been structured to consider Project impacts associated with each of the environmental factors set out below:

- Chemical and toxicological factors (pollution) which have been broken down into:
  - Physical elements
  - Atmospheric setting
  - Radiological emissions
  - Water environment
  - Waste management
- Disturbance factors (impacts on flora and fauna)
- Local use and local knowledge.

For each of the factors listed above the assessment discusses:

- The existing environment
- Potential impacts on the environment
- The assessment of impacts
- Mitigation of impacts
- Predicted outcomes.

The assessment of the predicted outcomes considers, for each, the spatial scale of the impact, the duration of the impact and the significance of the impact.

2.3 Consultation completed to date

In 2010 GML prepared an initial feasibility study for the Project.

At the same time, to initiate activity to satisfy the requirements for obtaining an exploitation license for the Project, work on the "scoping phase" of an environmental impact assessment was also commenced.

During the scoping phase, several stakeholder engagement workshops were conducted to present the Project to stakeholders and to receive feedback on topics to be covered in its environmental impact assessment. In July 2011, after extensive consultation, GML drafted the first version of the Terms of Reference (ToR) for the Project's EIA.

Subsequent changes to the Project design and an amendment to the *Mineral Resources Act* in 2014 prompted the development of an updated ToR. Public consultation in respect of the updated ToR occurred in the period August – October 2014, with comments from the consultation process consolidated in a subsequent White Paper.

In the first half of 2015 GML prepared a further revision of the ToR based on comments collated in the White Paper. The 2015 version of the ToR was approved by the GoG in late 2015. This EIA has been developed in accordance with this ToR.

The EIA has been developed with the involvement of stakeholders as much and as effectively as possible at all stages of its development. Table 2 summarises the key stakeholders the Company has engaged with in relation to the development of the Project.

Table 2 Summary of consultation undertaken

Regulators	Community	Other
Ministry for Nature and Environment	Narsaq residents	Air Greenland, Nuuk
Danish Parliament Commission	Info Group Narsaq	Arctic Business Network
Danish Centre for Environment and Energy (DCE)	Qaqortoq residents	Businesses in Qaqortoq
The Environmental Agency for Mineral Resource (EAMRA)	Residents of Aasiaat	Employers Association (GA)
Employers Association of Greenland (GA)	Residents of Ilulissat	Greenland Business Association
Greenland Institute of Natural Resources (GINR)	Residents of Kangaamiut	Hunting Fishing Narsaq Info group
GoG	Residents of Maniitsoq	Mineral Resources Committee
Kujalleq Municipality	Residents of Nuuk	Transparency Greenland
Mayor of Qaqortoq	Residents of Qasigiannguit	WWF Office Copenhagen
Ministry of Labour and Trade (MILT)	Residents of Qeqertarsuaq	
Mineral Licence and Safety Authority, Administration (MLSA)	Residents of Sisimiut	
Ministry for Industry and Minerals - Legal	Municipality of Sermersooq	
Ministry of Industry and Mineral Resources		
Municipality Mineral Manager		
Municipality Nuuk		
Office of Danish Ministry		
Greenland Labour Union (SIK)		

2.4 Alternatives considered

A number of alternatives for all or part of the Project have been considered during the course of Project design.

Alternative 1 Not proceeding with the Project

Not proceeding is an alternative in a commercial environment subject to volatile commodity prices and increasing processing costs. However, the Project has the potential to provide significant short and long term social and economic benefits to Greenland, in particular the Narsaq region.

If the Project were not developed, USD of capital investment would not occur in Greenland and the annual operating expenditure of USD would also be foregone. The Project anticipates paying approximately USD per annum in taxes and duties and anticipates generating approximately Greenlandic jobs during the operations phase.

Alternative 2 Utilising different processing methods

Three alternative processing scenarios were examined:

i. mechanical concentrator only
ii. mechanical concentrator and chemical processing or
iii. mechanical concentrator, chemical processing and REE separation.

The mechanical (concentrator) and chemical processing (refinery) option was selected as the processing method for the Project. This method involves some downstream processing of REEs in Greenland and the production of several saleable by-products.

This option is aligned with the priority of the GoG to ensure that, as much as practically possible, processing of mineral products takes place within Greenland.

Alternative 3 Varying the location of Project components

Two potential locations for each of the concentrator and refinery, and port and accommodation facilities were considered: Location East and Location West.

Following public consultations, Project development was focused on the alternative where facilities and activities would be located in the Ilua valley (Location West).

Alternative locations for employee accommodation and port facilities within the Ilua valley were also considered with the final locations selected to minimise social and environmental impacts associated with these facilities.

Alternative 4 Utilising alternative sources of energy for the Project

The development of hydropower for the Project was evaluated because a potentially suitable water source is located 55 km north at Johan Dahl Land.

Based on construction requirements this option was not considered feasible for the first stage of development of the Project.

Power generation using heavy fuel oil (HFO) was abandoned because of the level of sulphur emissions which would be produced.

Alternative 5 Managing the Project's tailings in different ways

A number of options for the location of the tailings storage facilities were considered, including various locations on the Kvanefjeld plateau and in the Taseq basin.

In addition to the location of the facilities, alternative methods for the management of tailings have also been considered - wet and dry disposal of tailings during the Project's operations phase and wet and dry covering of tailings facilities after the completion of operations.

After evaluation of the environmental risks, wet deposition in the Taseq basin and wet closure were selected for tailings management.

2.5 Assessment of impacts

The assessment has been structured into seven environmental categories. The impacts in each of these categories are described below.

2.5.1 Physical impacts

Construction and operation of the Project has the potential to have the following impacts on the physical environment:

- Physical alteration of the landscape and reduced visual amenity
- Increased erosion
- Increased noise
- Increase light emissions.

Visual Impact

Visual impact on the landscape is an unavoidable part of a mining project and cannot be completely eliminated by mitigation measures.

The development and operation of the Project will result in landscape alterations which will be localized within the Study Area but will be visible to varying degrees from various vantage points. Some of the alterations will be permanent while others will be removed or ameliorated during the Project's closure phase.

The most significant alterations will be development and construction of:

- An open pit mine and haul roads (the Mine)
- Stockpiles for material that is mined but not processed, waste rock stockpile (WRS)
- A processing plant in the vicinity of the open pit (the Plant)
- A facility to store processed waste material in the Taseq basin (the TSF)
- A new port facility on the shore of Narsap Ilua (the Port)
- A road from the Port to the Mine and Plant (the Port-Mine Road)
- Permanent employee accommodation adjacent to the town of Narsaq (the Village).

During the operating life of the Project a number of these physical features will be visible, some only partly, from Narsaq or from the Narsaq valley.

- Structures at the Port will be visible from Narsaq
- The Port-Mine Road will be visible from Narsaq
- The Plant will be visible in the Narsaq valley, but not from the town of Narsaq
- The Mine will be visible from the highest part of the Narsaq valley but not from the lowlands or the town of Narsaq
- Embankments for the TSF will be visible from the highest part of the Narsaq valley but not from the lowlands or the town of Narsaq.

During the Project's closure phase the structures that are no longer required will be removed and other physical features of the Project will be remediated.

Erosion

Generally, erosion is not expected to be an issue for the Project as most construction works will take place in areas with consolidated rock. There are very limited clay or soils in the Project area as a result of the local geology and recent glaciation.

Noise

The Project will create additional noise in the Project Area. The level of noise will vary according to the phase of the Project.

Construction Phase

During the construction phase:

- Limited blasting will take place in the Mine
- Grading will take place in all key Project areas to prepare level surfaces for various purposes

- Construction of the Port-Mine Road will be sequential, the road will be constructed in stages gradually progressing from the Port to the Mine and Plant areas
- Excavating or blasting of the seabed bedrock will be required for the construction of an anchored sheet pile wall at the Port
- Ship traffic associated with the construction will increase noise levels in the town of Narsaq. However, due to low vessel speed and the distance from the Port to Narsaq, the average noise from vessel movements will be below the 35 dB(A) Danish guideline for night time noise in residential areas.

Overall the noise impact during construction is expected to be at or below noise levels that have been calculated and modelled for the Project's operations phase (see below).

Operations Phase

Activities during the Project's operation phase will result in an increase in the ambient noise level near several Project facilities. The noise assessment for the Project used 30 dB(A) as the ambient noise level that characterizes the existing baseline acoustical environment.

Noise arising from Project activities that exceeds the existing baseline acoustical environment is defined as the Project's Noise Footprint.

The most significant sources of noise during Project operations will be:

- The Mine, Plant and the Power station
- The Port-Mine Road
- The Port area.

Modelled noise load distribution indicates that noise loads above the 30 dB(A) background level are limited to the Mine/Plant areas and the upper parts of the Narsaq valley. Noise levels above the 30 dB(A) background level extend, depending on the terrain, for between 800 and 1200 m on both sides of the Port-Mine Road.

Traffic on the Port-Mine Road will not increase the noise level in town of Narsaq.

The noise-sensitive locations closest to the Port-Mine Road are summer houses located in the Narsaq valley just north of the town of Narsaq. The Project-related traffic noise loads calculated for the houses closest to the road are approximately 38 dB(A). This is above the natural background level of 30 dB(A). Compared to Danish noise limits for summer housing, the calculated noise loads are below the daytime limit (40 dB(A)) but above the evening and night limit (35 dB (A)).

The calculated noise load for the Port will exceed 70 dB(A) in a small area where containers are unloaded. The area where the average noise load exceeds the 30 dB(A) background level extends approximately 1800 m from the center of the Port.

The noise level in the residential areas of Narsaq, and at the Village will be less than 40 dB(A) and will therefore meet the Danish noise guidelines for noise levels in towns.

Mitigations

The following mitigation measures will be applied to reduce the Project's impacts on the physical environment:

- Pre-stripping and tailings embankments will be planned to blend, as far as practical, with the surrounding landscape

- Roads will be planned to minimize impacts on the surrounding landscape
- Embankments and diversion channels will covered with local materials (rock and gravel). Over time the embankments will also be covered by natural vegetation which will reduce the visual impact
- Blasting to be undertaken between 6am and 6pm
- Rock and gravel materials will be used where possible for construction.

2.5.2 Atmospheric impacts

The Project has the potential to generate dust and emissions during all of its phases. Emissions of fugitive dust arising from Project activities include blasting and excavation in the Mine, materials handling and transport on unpaved roads. Air emissions will be produced from diesel powered machinery and trucks, equipment used for power generation and heating, and vessels at the Port.

Particulates and gaseous emissions have the potential to affect both the environment and human health.

Emissions for each phase of the Project were estimated to show the potential impact on air quality of the activities taking place during the phase. Based on the types and sources of emissions, the spatial distribution of the sources and the duration of each phase of the Project, analysis shows that the highest level of atmospheric emissions will occur during the Project's operations phase. The operation of mine haul trucks will be the main source of dust.

Emissions during the Project's operations phase were subjected to further detailed analysis using CALPUFF for dispersion modelling. The analysis included both the potential impact attributable to the Project in isolation as well as the combined impact of the Project and existing emission sources in the Study Area.

Ambient levels of air pollutants (NO_X, SO_x) and dust (Total Suspended Particulates - TSP) during the Project's operations phase were predicted.

Dispersion modelling shows that high concentrations of TSP, both less than 2.5 and less than 10 microns in diameter ($PM_{2.5}$ & PM_{10}), are only recorded close to the haul roads in the Mine. It is predicted that most dust will be deposited in the Mine itself or to the south west of the Mine and associated facilities.

Outside this area, the levels of dust deposition are well below international ambient air quality limit criteria. At the Ilua valley farm, in the in Narsaq valley, in the town of Narsaq and at Ipiutaq and the farms further to the northeast at Qassiarsuk, dust concentrations will at all times be well below guideline criteria.

All particulate concentrations are less than 20% (Project emissions in isolation) and 43% (cumulative, including background emissions) of the assessment criteria. Therefore, the impact of particulate emissions from the Project is assessed to be very low.

Emissions from the combustion of diesel will include solid particles, NO_X (nitrous oxides), SO_X (oxides of sulphur), black carbon and PAHs.

The cumulative modelling results indicate that the predicted ground level concentrations for nitrogen deposition, NO_2, H_2S, SO_2 and SO_4 do not exceed the relevant limit criterion at the receptor locations. The impact of gaseous emissions from the Project is assessed to be very low

The potential impact of black carbon and PAHs from the Project has also been assessed as very low.

Mitigations

The following mitigation measures will be applied to reduce the Project's impacts on air quality.

GML has developed a Dust Control Plan (GML 2015b) which describes dust suppressing activities that will be implemented during operations.

Mitigation measures in the Dust Control Plan include:

- Dust containment and wetting of materials and areas prone to dust
- Vehicle speed limits, regular road grading and maintenance
- Vehicle washing systems at the exit point of the mining area (to minimize dispersal of dust along roads outside mine area).

Additional mitigations will include:

- Using vehicles and equipment with energy efficiency technologies to minimize emissions rates
- Maintaining power plant, vehicles and other fuel powered equipment in accordance with manufacture's specifications to minimize emissions.

Emissions of oxides of nitrogen and sulphur compounds from the Project will not result in significant impact.

- The Project's activities will produce greenhouse gas primarily in the form of carbon dioxide (CO_2) together with small quantities of nitrous oxide (N_2O) and methane (CH_4). It is estimated that the Project will emit 0.24 million tons of CO_2 per year thereby increasing Greenland's CO_2 total emissions by 43%.

2.5.3 Radiological impacts

Radionuclides occur naturally in the environment and are present in all soils and rocks. Kvanefjeld ore contains elevated concentrations of uranium and thorium and, over time, natural processes such as glaciation and wind and water erosion have dispersed radionuclides into the Narsaq valley and Narsaq. As a result radionuclide concentrations around the Project are higher compared to global average soil levels.

Project activities, predominantly Mine operations, will release radioactivity to the air and water. This radioactivity, if absorbed in significant quantities, has the potential to cause harm to humans, flora and fauna. However for residents of Narsaq, radiation emissions will represent a very small increase of background radiation, approximately 1%.

The potential sources of radioactive material from the Project, and their potential receptors, were identified as:

- Dispersal of dust containing radionuclides, which settles on the soil, in water and on flora and fauna and is transferred through the food chain
- Release to the atmosphere of radon gas and radon progeny which is inhaled by fauna
- Discharge of contaminated water into Nordre Sermilik fjord, which may impact marine flora and fauna.

A radiological assessment was conducted for the Project. Potential radiological releases from the Mine and Plant were estimated and the radiological contaminants of concern were identified. Estimates of releases were combined with data on air and water dispersion to estimate radionuclide concentrations occurring as a result of Project activities. These estimates were calculated for different locations within the Study Area. These concentrations were used, together with "behaviour characteristics" (e.g. what and how much is eaten by animals and people) and existing dose coefficients, to estimate radiological doses for selected flora, fauna and humans.

The potential for effects on the health of humans and fauna is determined by comparing the total calculated radiological dose for the various receptors (the sum of the natural background dose and the dose arising from Project activities) to the International Commission on Radiological Protection (ICRP) benchmark dose limit. Where the dose is below the protective dose limit the health of the species is not at risk.

For all modelled organisms, the incremental increase in dose resulting from Project activities will be extremely low. The calculated dose values have been compared to known reference values, where no harmful effects of chronic radiation have been observed in natural populations. For all studied organisms the calculated dose values are far below the reference values implying that there will be no adverse effects to animals or plants.

For residents of Narsaq, the natural baseline exposure through food ingestion and radon / thoron inhalation was calculated to be between 8-10 mSv/year. Exposure to radon makes up approximately 70% of this dose. For residents of Narsaq the estimated incremental dose due to Project activities was modelled to be between 0.09-0.14 mSv/year, representing an increase of approximately 1% over background radiation levels.

The transport and handling of uranium product will be as per International Atomic Energy Agency (IAEA) Safety Standards and the relevant national and international transport codes applicable to Class 7 products. A specific uranium transport assessment has been carried out for the Project. The assessment identified the potential for a:

- Spill of yellow cake into rivers or the harbour
- Spill of yellow cake on land.

For a spill into water there may be a short term impact on aquatic life. In the long term, released material should be contained, removed and the area remediated. The long-term quality of sediment in the area of the spill may be adversely affected with the result that biota may be exposed to contaminated water and sediments.

Based on experience from Arctic Canada the risk of a spill into water is calculated to be extremely low.

In case of an accident involving the release of uranium products on land, both flora and fauna and members of the public (and workers) could be exposed to external gamma radiation as well as inhalation of airborne yellow cake particles.

A review of road transportation accident statistics for Canada and the U.S. showed that the probability of an accident and release of yellow cake into the environment is extremely unlikely.

The other major source of potential radiological release from the Project is a TSF embankment failure. Failure of the TSF embankment would potentially release tailings water and solids to downstream land and water bodies.

Where only tailings water is released downstream into the Taseq and Narsaq rivers, the potential radiological impact is assessed to be very low with no effect on human health expected.

There are possible effects to wildlife during the release period but once the release has ceased the radionuclide levels are expected to decline and doses to decrease.

The release of tailings has the potential to have a greater impact but the overall population of terrestrial receptors is not expected to be affected long term by residual radionuclides. The maximum estimated radiological impact is to birdlife.

In time, dried tailings could desiccate, releasing dust and potentially allow the slow release of radon gas.

The potential radiological impact to the natural environment if the TSF embankment were to fail has been assessed as medium. However, given that there is an extremely low risk of a TSF embankment failure the overall impact has been assessed as low.

Aerosols originating from the TSF are a potential source of uranium for the Taseq and Narsaq rivers. However, given prevailing wind directions (easterly and north easterly), local topography and the marked mountain ridge separating Taseq valley from the area used for abstraction of raw water to Narsaq water supply (the ridge south of the valley is more than 200 m above Lake Taseq), deposition of aerosols from the TSF is considered to be limited. Modelling demonstrates that the quantity of uranium potentially deposited in the Narsaq drinking water catchment is well below WHO guidelines.

Mitigations

The following mitigation measures will be applied to reduce the Project's radiological impacts

- Management of dust through the DCP
- The Plant will be engineered to minimise radiation emissions
- The transportation and packaging of the uranium will be in accordance with IAEA safety standards
- During and after operations tailings solids will be stored underwater to prevent dust and radon emissions.

2.5.4 Water environment

Hydrology

The hydrology of the Project area is characterized by a catchment area of 30 km^2, most of which is without vegetation and as a result, has a rapid runoff rate. The two major tributaries to the Narsaq river are influenced by the lake in the Taseq basin and by Lake Kvane, respectively

Due to the significant quantity of the water-soluble mineral villiaumite (NaF) in the geological environment, the Narsaq and Taseq rivers and water in the Taseq basin have elevated natural concentrations of fluoride. Fluoride levels in the Narsaq river exceed international guidelines for freshwater environments including the World Health Organization (WHO) drinking water guidelines. The level of uranium is below international guidelines.

Narsaq is supplied with water from the Napasup Kuua, Kuukasik and Langnam rivers. The Project will not affect the supply of drinking water to the town of Narsaq.

The Project will cause changes to the hydrology of the Study area primarily by interrupting the flow of the Taseq and Kvane rivers in the catchment and by drawing water from the Narsaq river. Over the course of a year, about a quarter of the water flowing in upper reaches of the Narsaq river will be used in the Plant.

These changes will have only a limited impact on the overall hydrology of the area.

Tailings

Appropriate management of tailings, during the Project's operations and post-closure phases, is a key environmental requirement for the Project.

Taseq basin will be drained and used as the TSF for the Project. The natural outflow from the Taseq basin will be blocked by a dam during the Project's operations and closure phases.

The Project will source recycled water from the TSF and fresh water directly from the Narsaq river. No waste water from the Project will be released into streams or rivers in the Narsaq valley during Project operations.

During the six year closure phase, water in the TSF will be pumped to the water treatment plant and then discharged to Nordre Sermilik fjord. TSF water will be gradually replenished by precipitation and run off from the catchment area resulting in steady improvement to the quality of the water in the TSF. When the water in the TSF meets the Greenlandic and International water quality criteria, water treatment will cease. The water level in the Taseq basin will be allowed to rise naturally and eventually overflow via a spillway into the Taseq river.

Modelling shows that, during the Project's operations phase, the concentrations of certain elements and reagents in TSF water will exceed ambient water quality criteria for Greenland. However in the post closure phase, once treatment of TSF water has been completed, the concentrations of all elements (with the exception of fluoride) will be within Greenland ambient water quality guidelines. Natural levels of fluoride in the Narsaq river will be above Canadian standards (there is no relevant Greenland standard). All reagent concentrations will be below Predicted No Effect Concentration (PNEC) values. Quality will be measured downstream of the merge point of the Taseq and Narsaq rivers.

Modelling of WRS run-off water quality shows that run-off water requires little dilution to mirror the composition of sea water. Post closure it is expected that WRS run-off will be released into the surrounding environment.

Culverts will be constructed as required, including one across the Narsaq river. These will be designed to minimise flow restrictions in the river. During culvert construction, water flow will be maintained by pumping water around the culvert construction area. This will have the added benefit of ensuring a dry construction zone.

Failure to contain tailings and tailings cover in the TSF

Embankments for both the flotation tailings storage facility (FTSF) and the chemical residue storage facilities (CRSF) will be constructed to withstand extreme inflows of water and large diversion channels will be constructed to take water away from the TSF. Were supernatant to overflow, it would overflow via a spillway in the FTSF embankment and into the Taseq and Narsaq rivers.

The impact of an overflow on the freshwater biota and marine life will depend on the amount and quality of water that overflows the FTSF embankment. Following extreme rainfall or snow melt, the supernatant will be diluted prior to overflowing and the impact on the rivers would likely be short term. There would be limited impact on marine life.

Given that there is a low risk of an overflow event and that the overflow water would be highly diluted, the impact from an overflow is assessed as low.

Three scenarios for a potential partial or total failure of the TSF embankment were assessed:

- The release of the water cover on the TSF

- The release of the water cover and a proportion of the tailings in the TSF
- The release of the water cover and a significant proportion of the tailings in the TSF.

The main impact of the release of the TSF water cover would be large and extended water flow that would overwhelm the natural river flow and biota, such as fish, could be swept away with the flow. The Narsaq river's fan zone would be expected to flood for a period of time and it is likely that terrestrial species of flora and fauna would be overwhelmed in the affected area.

The release of the water cover and some tailings will produce similar effects but with greater impacts as a result of the presence of solids in the release. The flow would overwhelm the natural river flow and biota would be swept away. It is estimated that approximately 65% of the tailings material, particularly coarser particles, would settle in the lower reaches of the Narsaq river. The majority of the balance of the tailings would settle in Narsap Ilua with only a small proportion reaching the fjord.

Were the TSF embankment to completely fail, it is estimated that 21 Mm^3 of combined water and tailings would be released. Tailings solids and dam material would be deposited over a wide area downstream of the breach, progressively shallower stream gradients and side slopes resulting in tailings deposition expanding to cover large portions of the valley surface.

There will be short and long term impacts to the environment associated with any failure of the TSF embankment. There will be physical impacts from the surge of water and/or tailings into the water courses and surrounding landscape and there may be local contamination of receiving surface waters and the landscape.

However, given that there is an extremely low risk of a TSF embankment failure of any magnitude the overall impact has been assessed as low.

Aerosol spray from the TSF

Aerosols originating from the TSF are a potential source of pollutants for the Taseq and Narsaq rivers.

However, given prevailing wind directions (easterly and north easterly), local topography and the marked mountain ridge separating Taseq valley from the area used for abstraction of raw water to Narsaq water supply (the ridge south of the valley is more than 200 m above Lake Taseq), deposition of aerosols from the TSF is considered to be limited.

The potential impact from the deposition from aerosol spray is assessed as low.

Marine water quality

During the Project's operations and closure phases, surplus water from the Project will be stored in the TSF. Water that is not required for the Project will be treated (to meet water quality criteria) prior to discharge to Nordre Sermilik fjord from a single discharge point at a depth of more than 40 m.

The composition of the water to be released into the fjord was evaluated in order to determine the dilution required to reach PNEC concentrations.

A hydrodynamic model for the fjord system was developed and the quality and quantity of all major contaminants in the water stream were modelled in terms of temperature, concentration and flow. All chemical species in the discharged water meet the Greenland water criteria except for arsenic, cadmium and mercury. A dilution factor of ~1300 will be required to obtain "no effects" levels for the most critical parameters including safety margins. The required dilution can be obtained in the marine area on a local scale of 1-2 km^2 and in a vertical confined lens of water when the outlet is constructed sub-surface. This dilution will take place locally near the discharge diffusor.

Toxicological testing was carried out to determine if the discharged water would be acute and chronically toxic to algae, copepods or fish. Testing indicated that algae and fish appeared to be unaffected by the effluent, even at high concentrations however, under certain high concentrations, the effluent may impact copepods.

Spills

During the Project's operations, chemicals and hydrocarbons will be shipped to Greenland and then moved to the Project location where they will be stored and used. During transportation and use there is the potential for spills.

The environmental impacts of chemical or fuel spills on land are confined to the Study Area or to a narrow corridor of a few km around the Project activities. Spills affecting Narsaq river (or other watercourses) in summer periods with high flows might spread downstream of the spill location and reach the fjord, if no mitigating measures are in place.

There is the potential for the discharge of untreated process water into the fjord. With appropriate mitigations in place any release would be minor.

Mitigations

The following mitigation measures will be applied to minimise the Project's impacts on the water environment:

- Tailings embankments will be constructed in accordance with best international practice
- Diversion channels will be well maintained during the operations and closure phases
- Discharge water will be treated to meet water quality criteria prior to discharge
- Discharge water will be discharged at a miminla distance of 1km from the discharge point for required dilution
- No discharge to the Taseq river will take place in the operations or closure phases
- Low speed limits will be mandated to avoid transport accidents
- To reduce the risk of spills of fuel and chemicals in the fjords during operations:
  - Navigational speed restrictions
  - Compulsory pilotage and separation of shipping lanes
  - Procedures for loading and unloading of ships
  - The Port will be equipped with appropriate equipment for combating operations spills
  - All fuel storage tanks will have geotextile containment berms that can contain 110% of total tank volume in case of complete tank rupture.

2.5.5 Waste management

Waste produced during the Project's construction and operations phases will include domestic waste, construction waste, iron and scrap metal, tyres from mobile equipment and various types of hazardous waste (oily waste, chemical waste, batteries).

All combustible solid waste will be shipped to Qaqortoq for incineration. Sewage from all buildings, except the Village and the Port, will be treated using a package sewage treatment plant, with treated effluent disposed of within the Plant. Hazardous waste will be registered, handled and shipped to

Denmark for treatment and disposal in compliance with Danish and EU requirements. Where possible waste products will be recycled.

As waste handling will be managed in accordance with best environmental practice, with recycling where applicable, the impact of waste production on the environment is assessed to be of low significance.

Mitigations

The following mitigation measures will be applied to reduce the impact of the Project's waste on the local environment:

- Development of waste handling procedures and waste management plan
- Installation of a sewage treatment package plant
- Remediation of any contamination as a result of the Project.

2.5.6 Biodiversity

Disturbance created by Project activities during construction and operation will potentially impact flora and fauna on land and in rivers, lakes and fjords in the Study Area. Disturbance includes permanent habitat loss and temporary habitat loss during periods of disturbance.

Flora

The vegetation in the Study Area is dominated by terrestrial habitats and plant species which are common and widespread in south Greenland. Native vegetation in south Greenland is largely determined by temperature and precipitation, both of which follow oceanic-inland/continental and altitude gradients.

Three vegetation communities were identified in field assessment:

- Narsap Ilua Bay and the lower Narsaq valley (0 – c. 200 m altitude)
- The higher reaches of the Narsaq valley and the Kvanefjeld plateau (c. 200 – 680 m altitude), and
- The upper northern slopes of the Narsaq valley and surrounding the Taseq basin (c. 350 – 650 m altitude).

A botanic study was conducted which identified several rare species and unusual vegetation communities in the Study Area:

- One rare plant species, *Gentiana Amarella*, was recorded on the northern side of the mouth of the Narsaq river. *Gentiana Amarella* is rare in Greenland and 50 individual plants were counted at this location
- The round-leaved orchid (*Amerorchis rotundifolia*), Greenland's rarest orchid, has previously been recorded between the gravel road and a location just to south of the "test piles" at c. 300 m altitude. No observatons of the rare orchid were made during the 2014 survey
- The lowland stretch of the road had a small fen that is dominated by mountain bog-sedge (*Carex rariflora*), single-spike sedge (*Carex scirpoidea*) and carnation sedge (*Carex panacea*). The latter is a rare species in Greenland
- The protected northern green orchid (*Platanthera hyperborean*) growing along the streams in the lowland areas and around Lake Taseq.

No Project activities will take place in areas with rare or threatened plants or habitats. The overall footprint of Project is relatively small when compared to the distribution of similar habitat in South Greenland. Typically, low densities of flora and fauna occur in these habitats and the significance of lost terrestrial habitats due to the Project is assessed to be very low.

Terrestrial fauna

Noise and visual disturbances from Project activities can potentially have an impact on birdlife and mammals. Reprofiling and landscaping to accommodate the Project will lead to some loss of natural habitat and displacement of most terrestrial animals from the affected areas.

The white-tailed eagle is the only bird which is sensitive to disturbance and which is known to occur in the area. The white-tailed eagle is particularly sensitive to disturbance close to its nest during the breeding season. As there are no known nesting sites in the Project area or in the Kvanefjeld or Narsaq valleys, the disturbance impact is assessed to be low.

The Arctic fox and the Arctic hare are the only terrestrial mammals in the area. Both usually habituate well to human activities but are likely to avoid the Project facilities. The disturbance impact on these animals is also assessed to low.

Marine fauna

The fjords around the Project area are important to a range of marine birds and mammals that potentially could be disturbed by Project activities. Of particular significance are:

- Ringed seals
- Harp seals during summer
- Sea bird colonies at Akullit Nunaat
- Flocks of wintering eider duck
- Arctic char during summer.

The construction of the Port will:

- temporarily create underwater noise from blasting and ramming
- increase the turbidity of the seawater close to construction areas
- cause a loss of inter-tidal habitat.

During the Project's construction and operations phases, vessels using the Port will generate noise above and below water and visual disturbance above water.

Little specific knowledge exists about the marine flora and fauna of Narsap Ilua but no marine mammals or sea birds are specifically associated with this part of the fjord. The loss of foraging ground for Arctic char, which will result from Port construction, is believed to be insignificant given that large areas of similar habitat exist along the shore of fjords in the region.

Disturbance from the construction works will be local and temporary and will take place in an area with low marine fauna diversity. The impact of construction disturbance has been as assessed as low.

Freshwater fauna

Construction of culverts across the Narsaq river and the construction of an embankment at the outlet of the Taseq basin may cause short-term increases in the turbidity in the Narsaq and Taseq rivers. This could disturb freshwater organisms, including Arctic char, in the Narsaq river.

Water will be sourced from the Narsaq river for the production process during times of high river flow. The reduced flow which will result could potentially impact the Arctic char population in the river. During winter, which the entire char population spend in the lower part of the river, no water will be extracted from the Narsaq river.

Project related changes to flow patterns in Narsaq river will lead to an average reduction of water flow in the main spawning area in Narsaq river by about 15%. This is a minor flow reduction which is will not have a significant impact on the breeding success of Arctic char in Narsaq river.

Project related changes in the hydrology of the Narsaq river and its tributaries are assessed to have low impact on the population of Arctic char in the Narsaq river.

Since any rise in turbidity due to construction works will be temporary, the disturbance to the Arctic char population and the freshwater ecosystem is considered insignificant.

The Taseq river, Taseq basin and the pond east of Taseq do not support fish but are inhabited by invertebrate fauna which are common and widespread in south Greenland. Almost no vegetation is found along the shore or in the lakes.

No significant impact on the freshwater fauna and fauna of local rivers is expected during the Project's operations phase.

Mitigations

The following mitigation measures will be applied to reduce the Project's impacts on biodiversity in the local environment.

- Minimize the disturbance footprint of the Project Area
- Restrict the movement of staff members outside the Project Area to minimize the general disturbance of wildlife
- Maintain a minimum Narsaq river flow during winter
- Mandate low vessels speeds while in fjords.

2.5.7 Local use and heritage

With the exceptions listed hereunder, access to the Study Area for Narsaq residents and visitors will not be interrupted during the operation of the Project.

- Access to the Project Area will not be permitted for security and safety reasons
- A 'no hunting' security zone (1 - 2 km) from the Project Area will be implemented
- A no-fishing zone will be implemented around the treated water discharge point in Nordre Sermilik
- The public will have limited access to the Port-Mine Road.

The Project will disturb two heritage sites, a rock shelter along the shore of Taseq and a tent foundation and shooting blind situated on the tip of the Tunu peninsula close to the location of the Port. The rock shelter at Taseq will be flooded, while the shooting blind close to the port will be demolished.

Prior to any construction activities commence, sites will be recorded and registered by Greenland National Museum and Archives.

In 2017, five areas representing sub-Arctic farming landscapes in Greenland, collectively referred to as Kujaata, were admitted to the UNESCO World Heritage List. The areas are located in the fjord system around the Tunulliarfik and Igaliku fjords and comprise:

Area 1 – Qassiarsuk

Area 2 – Igaliku

Area 3 – Sissarluttoq

Area 4 – Tasikuluulik

Area 5 – Qaqortukulooq.

The five parts of Kujataa together represent the demographic and administrative core of two farming cultures, a Norse Greenlandic culture from the late-10th to the mid-15th century AD and an Inuit culture from the 1780s to the present. Area 5 is the closest to the Project, at a distance of approximately 18km to the area boundary from the Project. The Project will have no impact on this site.

Mitigations

The following mitigation measures will be applied to reduce the impact of the Project on local land use and heritage.

- Greenland National Museum & Archives will record and register archaeological structures
- During the construction and operation phases implementing a 'no hunting' security zone on land and in Narsap Ilua
- During the construction and operation phases implementing 'no-fishing' zone around the water discharge point in Nordre Sermilik.

2.6 Closure and decommissioning objectives

The overall closure goal is to return the Project Area to viable and, wherever practicable, self-sustained ecosystems that are compatible with a healthy environment and human activities.

In order to achieve this, the following core closure principles will be adopted:

Physical Stability

All Project components remaining after closure will be physically stable for humans and wildlife;

Chemical Stability

Any Project components (including associated wastes) remaining after closure will be chemically stable and non-polluting or contaminating. Any deposits remaining on the surface or in lakes will not release substances at a concentration that would significantly harm the environment;

Minimized radiological impact

Long-term radiation exposure of the public due to any radiological contamination of Mine area will be kept "as low as reasonably achievable" (ALARA);

No Significant Change to Baseline Landforms

Baseline landforms and land use prior to the mining operations will returned to similar visual amenity and geography.

Table 3 Summary of environmental impacts assessed

Impact	Project Phase	Mitigation	Spatial extent	Duration	Significance	Assessment
Physical environmental						
Visual Amenity	Construction Operations Closure	Pre-stripping will be planned to blend as far as practical with the existing landscape. Tailings embankments will be planned to blend as far as practical with the existing landscape. Roads will be planned to minimize impacts on the existing landscape. Decant barges will be removed at Mine closure. Embankments and diversion channels will be covered with local materials (rock and gravel). Over time the embankments will also revegetate which will also reduce visual impact. Following Mine closure disturbed areas will revegetate reducing visual impact.	Project footprint	Permanent	Medium	Several of the facilities will be visible in the Narsaq valley although the footprint of the Project is relatively small compared to the surrounding area. There is no current or future expected competing land use.
Erosion	Construction Operations	Rock and gravel materials will be used where possible for construction.	Project footprint	Permanent	Low	Construction methods and routing of infrastructure alignments will limit erosion.
Noise and Vibration	Construction Operations	Blasting to be undertaken between 6am and 6pm.	Project footprint	Life of mine	Low	Noise from the Project will be well below Danish noise guideline limits in Narsaq. Traffic noise will exceed the Danish evening and night limit of 35 dB(A) by up to 3.7 dB(A) for summer houses in Narsaq valley. No known sensitive wildlife areas will be impacted by operations noise of the mining activities.

Impact	Project Phase	Mitigation	Spatial extent	Duration	Significance	Assessment
Light Emissions	Construction Operations	No mitigation required.	Project footprint	Permanent	Very Low	Artificial light will mostly be needed during the winter months, during which time almost no bird migration takes place. Therefore no impacts to birds are expected.
Atmospheric Setting						
Dust and Air Quality	Construction Operations	Wetting of rock stockpiles, concentrates and waste materials with water sprinkler systems (summer). Wetting of haul roads with water spray trucks (summer). Salting of haul roads to melt ice and snow. Low vehicle speed limits. Regular grading and maintenance of unsealed roads. Drilling dust containment procedures. Wetting down blast areas and activating "fog cannon" which generates fine water mist towards the blasting region (summer). Vehicle wash system at the exit point of the mining area to minimize dispersal of dust along roads outside Mine area.	Study Area	Life of Mine	Low	The modelling shows that high concentrations of dust in the air are only recorded close to the haul roads. Most dust is predicted to deposit on the Project and on the mountainous plateau to the south-west of Kvanefjeld. Outside the Mine area the deposition and concentration amounts are well below the Greenland guidelines.
Greenhouse gas	Construction Operation	Using vehicles and equipment with energy efficiency technologies to minimize emissions rates. Maintaining power plant, vehicles and other fuel powered equipment in accordance with manufacture's specifications to minimize on emissions.	Study Area	Life of mine	Low	Greenland is estimated to contribute approximately 1.3% of GHG attributed to Denmark. The Project will increase Greenland's total contribution of GHG from Denmark to 2.1%.

Impact	Project Phase	Mitigation	Spatial extent	Duration	Significance	Assessment
Radiological emissions						
Radioactivity	Operations	Implement the dust control measures in GMLs DCP.	Study Area	Life of mine	Very Low	The radiological impacts of the Project to plants and animals associated with marine, freshwater and terrestrial habitats in the studies area as well as to people in Narsaq and Ipiutaq (and visitors) are very low. The estimated dose to all these receptors is far below benchmark values.
Spills	Operations	Transport uranium product in accordance with international best practice requirements.	Study Area	Life of mine	Very Low	Based on experience from Arctic Canada the risk of a spill into water is calculated to be extremely low (less than 5x10-7 event per year).
Water environment						
Modification of hydrological processes	Construction	Water flow will be maintained utilising pumps during culvert construction, with water taken from one side and returned to the other side to ensure a dry construction zone.	Study Area	Long term	Low	Changes to the hydrology of rivers and lakes during construction are expected to be minor. While reduced flows will be experienced in the upper sections of the Kvane and Taseq rivers, flows in the lower sections of these watercourses is expected to be maintained.

Impact	Project Phase	Mitigation	Spatial extent	Duration	Significance	Assessment
Operation of tailings dam	Construction Operations Closure	The tailings embankments for the Project will be constructed in accordance with best international practice. Rock fill and a conservative wall design will be used and the embankments will be equipped with a double liner to protect against seepage. Both embankments will be constructed to withstand extreme inflow of water, for example due to exceptional snow melting under a føhn wind event.	Study Area	Life of mine	Low	No water will be released from the TSF during the operation phase. After closure the water will be treated for a period of six years to ensure that water meets appropriate water quality criteria prior to discharge.
Discharge of water	Operations	Excess water will be treated for fluoride reduction prior to discharge to the fjord. If the treatment plant fails during the operations or closure phase, production will be stopped immediately. Optimization of diffusor outlet. Waste rock runoff water will be used in the concentrator as process water.	Study Area	Life of mine	Low	A dilution factor of ~2500 will be required to obtain “no effects” levels for the most critical parameters including safety margins. The required dilution can be obtained in the marine area on local scale of 1 – 2 km^2 and in a vertical confined lens of water when the outlet is constructed sub-surface.

Impact	Project Phase	Mitigation	Spatial extent	Duration	Significance	Assessment
Spills	Construction Operations	Impose strict speed limits and avoid road transport when weather conditions are difficult (slippery roads). Conduct a navigational safety survey Navigational speed restrictions in fjord. Compulsory pilotage. Separating shipping lanes. Procedures for loading and unloading of ships. Appropriate size and quantity of equipment for combating operations spills, including containment booms available for berthed ships, extra booms and skimmers. Incident and season related contingency plans and training. All fuel storage tanks will have geotextile containment berms that can contain a full spill in case of total tank rupture.	Study Area	Life of mine	Low	The impact of spills is expected to be limited based on the application of international best practice standards and standard operating procedures.
Waste management						
Contamination resulting from waste	Construction Operation Closure	Waste handling procedures. Remediation of contamination.	Study Area	Life of mine	Very Low	With proper waste handling procedures in place, the impact of waste production to the environment is assessed to be very low.

Impact	Project Phase	Mitigation	Spatial extent	Duration	Significance	Assessment
Biodiversity						
Disturbance of terrestrial fauna and flora habitat	Construction Operation Closure	Restrict the movement of staff members outside the Mine area during spring and summer to minimize the general disturbance of wildlife. Minimize the area to be disturbed by planning infrastructure to have as small a footprint as possible.	Study Area	Life of mine	Low	Noise and visual disturbance during operations will only cause localised disturbance of terrestrial birds and mammals.
Disturbance of freshwater species habitat	Construction	Minimise disturbance of the water in Narsaq river and Taseq river when building culverts and embankments by keeping the construction period as short as practically possible.	Study Area	2 years	Very low	Flow in the Narsaq and Taseq rivers will only be impacted whilst culverts are constructed. Once constructed, flow will return as before.
Disturbance of habitat for marine fauna	Construction Operation Closure	Low speed while in fjords. Distance restrictions to flocks of wintering sea birds (when possible).	Study Area	Life of mine	Low	The impact to marine fauna and habitat is expected to be limited based on the application of international best practice standards.
Contamination of terrestrial fauna habitat	Construction Operation Closure	Emergency Response Plans.	Study Area	Life of mine	Low	The impact to terrestrial fauna and habitat is expected to be limited based on the application of international best practice standards.
Contamination of freshwater and marine habitats	Construction Operation Closure	Enforcement of waste handling procedures. Emergency Response Plans.	Study Area	Life of mine	Medium	The impact to freshwater marine fauna and habitat is expected to be limited based on the application of international best practice standards.

Impact	Project Phase	Mitigation	Spatial extent	Duration	Significance	Assessment
Increased vehicle strikes of terrestrial fauna	Construction Operation	Speed limits and restrictions on site.	Study Area	Life of mine	Very Low	The impact to terrestrial fauna and habitat is expected to be limited based on the application of international best practice standards.
Invasive non-indigenous marine species	Construction Operation	Ballast Water and Sediments Management Plan.	Study Area	Life of mine	Very Low	The impact to marine fauna and habitat is expected to be limited based on the application of international best practice standards.
Local use and cultural heritage						
Disturbance of heritage sites	Construction	Register the recorded archaeological structures and heritage sites. Where required, fence off 50 m buffer around heritage sites.	Study Area	Long term/ permanent	Low	A rock shelter at Taseq will be flooded and a tent foundation and shooting blind on the tip of the Tunu Peninsula will be removed.
Disturbance of UNESCO World Heritage sites.	Construction Operation	No mitigation required. Emission monitoring.	Study Area	Life of Mine	Very Low	No disturbance or impact is expected due to distance from the Project.
Local use	Construction Operation	No hunting' security zones.	Study Area	Long term	Very Low	Local access for hunting, fishing and traditional uses will only be subject to minor restrictions, such as close to the new port site and in the no-fishing zone around the discharge port in Nordre Sermilik.

3. Project Description

3.1 Project setting

The Project has unique geological and environmental features, including volatile-rich alkaline magmas containing REEs, lithium, beryllium, uranium, and high-field-strength elements such as niobium and tantalum. Natural occurring radionuclides such as uranium and thorium are present in all soils and rocks. Kvanefjeld ore carries significant concentrations of uranium and thorium, approximately 300 and 800 ppm respectively. Over time natural processes such as glaciation, wind and water erosion have dispersed uranium and thorium into the Narsaq valley and the town of Narsaq.

The Project area is also notable for its low biodiversity, with common fauna species recorded and only three vegetation communities identified. Some rare flora were located in the area but will be avoided by Project activities. High levels of water-soluble mineral villiaumite (NaF) is present in the Narsaq river, Taseq basin and the Taseq river which has given rise to high fluoride levels in these waterbodies.

3.1.1 History of mineral exploration

The Kvanefjeld deposit is geologically located inside the northwest margin of the Ilimaussaq Complex. The area represents a lujavrite-rich area that has been exposed by erosion. The Kvanefjeld deposit is characterised by thick, mostly sub-horizontal slabs of lujavrite. Other rock types that outcrop include basalt, gabbro and sandstone of the Eriksfjord Formation, and augite syenite and naujaite.

The Danish Atomic Energy Commission identified the Kvanefjeld deposit in 1955. Over the next 30 years Narsaq was regularly the base for technical studies of the Kvanefjeld deposit. Renewed interest in the deposit developed following the assumption, by the GoG, of responsibility for the administration of mineral resources in 2009 (previously this had been the responsibility of the Government of Denmark). Since this time GML has undertaken extensive geological exploration of the area and has collected extensive environmental data to support the development of the deposit.

Drilling results identified that the highest metal grades occur near the surface, with grades of REEs, uranium and zinc decreasing with depth. Steenstrupine is the dominant host mineral for REEs and uranium. It is a rare phosphrous and silicate alkaline mineral with contains both REs and uranium. Other minerals that are important hosts of REEs include the phosphate mineral vitusite, and to a lesser extent, cerite and monazite. Aside from steenstrupine, uranium is also hosted in unusual sodic silicate minerals that are rich in yttrium, heavy REEs, zirconium and tin. Sphalerite is the dominant host mineral for zinc.

3.1.2 What is being mined and why

The Project involves the mining and processing of ore from the Kvanefjeld deposit to produce four REE products together with a number of by-products. While the ore in Kvanefjeld deposit contains a number of elements with commercial value, the REEs are the primary products, and zinc, fluorspar and uranium are by-products.

The mining rate will be approximately of 3.0 million tonnes of ore per annum (Mtpa), at which rate the Project would be expected to produce (approximately:

- Rare earth oxide (REO) products ( )
- Zinc metal ( )
- Fluorspar ( )

- Uranium oxide (500 tpa).

The Total Proven and Probable Mine Reserve (JORC 2012) for the Kvanefjeld deposit is tonnes (Mt) @ U_3O_8, REO and zinc. The Mine Reserve represents approximately 10% of established Mineral Resource Estimate (JORC 2012), and, therefore, can be readily expanded.

REs are a group of specialty metals with unique physical, chemical and light-emitting properties. Many electrical products are dependent on these unique properties - for example wind turbines, hybrid vehicles, rechargeable batteries, mobile (cell) phones, plasma and LCD screens, laptop computers and catalytic converters. As a result of the widespread use of REEs global consumption is increasing substantially and is outstripping global supply.

The majority of the global production of REEs is in China. With only a relatively small proportion available for export there is a global demand for a stable source of REEs outside China to meet demand for REEs, particularly in the production of emerging technologies. China is a leader in RE processing technology, which potentially stands to benefit RE mines outside of China.

The Kvanefjeld deposit is one of the largest deposits of REEs in the world. Kvanefjeld has the potential to meet the world's rapidly growing demand for REs and in doing so, can become a major contributor to the Greenland economy for decades to come.

The Project will be a minor uranium producer globally, producing less than 1% of the total global uranium production.

3.1.3 Local community

The Project is situated approximately 7.5 km from the town of Narsaq in South Greenland (Kommune Kujalleq) and approximately 40km from Narsarsuaq where the nearest airport is located.

The town of Narsaq was originally settled in the 1830s. The establishment of a landing site in the bay adjacent to the settlement in the 1880s stimulated scientific activity in the vicinity and by the 1900s geological mapping of the area had indicated the presence of radioactive minerals.

Agriculture in the form of sheep farming was introduced in the early 1900s.

The first major expansion of economic/industrial activity took place shortly after the end of the World War II when people came from all over Greenland to work at the slaughterhouse and cod processing plant. Today the primary occupations in Narsaq include public administration, fishing and wholesale activities, with farming activities continuing across the Kommune.

Narsaq was granted civic status granted in 1959. In 2017, the district of Narsaq had an estimated population of approximately 1,600, of whom approximately 1,400 live in the town of Narsaq with the remainder in the surrounding settlements of Narsarsuaq, Qassiarsuk and Igaliku, or on one of the farms in the area.

3.2 Overview of operations

Mining operations involve conventional open pit mining via blasting followed by truck/shovel haulage. Ore will be transported to a concentrator to produce REMC, zinc concentrate and fluorspar. The zinc concentrate and fluorspar will be sold and the REMC further processed in a refinery to produce REE products and uranium oxide. All saleable products will be transported to the Port and exported. Overburden from the Mine will be stored in a WRS. Tailings from the concentrator and refinery will be stored within a tailings storage facility (TSF).

The overall design of the operation is shown in Figure 4 and described in further detail below. In addition to the design of the Project, details pertaining to the operation of the Project, for example water and reagent use, are described.

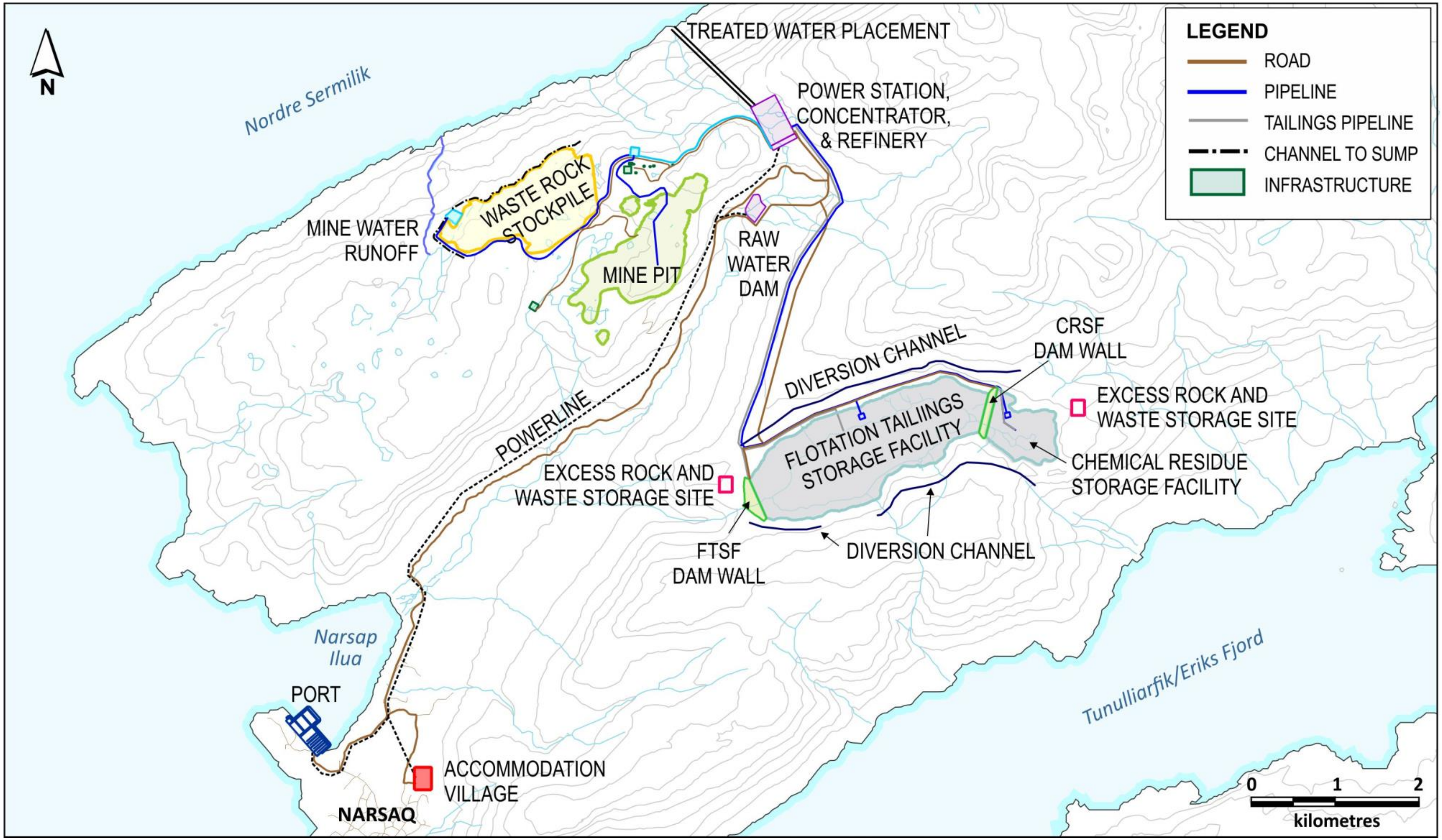


Figure 4 Project layout

3.3 Project phases

The phases of Project commencement are described in Table 4. Closure and decommissioning timing is described in Section 3.15.

Table 4 Project phases

Phase	Timing	Description
Construction	3 years	Construction primarily involves FIFO personnel plus local employees and local subcontractors. Prior to the construction of the Port, a temporary landing pad will be used for beaching barges. Packaged equipment will arrive on site and be installed by specialist construction workers. Large buildings will be erected to provide protection against weather events. There will continuous deliveries of plant and equipment from the Port to the Mine and Plant. The Port will also be constructed at this time. Once the temporary facilities and basic infrastructure are established construction activities increase as the Plant is constructed.
Operations	37 years	Once operations commence the Mine and Plant will gradually ramp up operations until steady state operation is achieved.
Closure	6 years	Plant and utilities will be removed while treating water in the TSF. Mine pits will be fenced off to prevent access from people, livestock and animals.

3.4 The Mine

The Mine has been designed taking into consideration its environmental setting. The Kvanefjeld deposit is located on the plateau at an elevation of 600 m, with the orebody outcropping at the surface, and the highest grade material occurring in the upper zones.

The Mine will have an open pit design with 10 m wide benches. Mining will be a standard drill-blast-truck-shovel operation. This configuration has been identified as the lowest operating risk mining method, both in terms of cost and productivity. Ore will initially be hauled to the run of mine (RoM) pad located adjacent to the pit where it will be arranged in stockpiles. Ore selected from individual piles will be blended by a front end loader and the blended ore will be hauled in mine trucks to the plant site, an average haul distance of 1.5 km. The trucks will dump directly into the primary crusher.

The active mining fleet will initially include three 150 t mining trucks and one excavator. As the pit deepens and haul distances increase, truck numbers will increase to a maximum of 6 trucks.

The Mine will operate 24 hours per day and 365 days per year.

Water diversions will be used to minimise the water ingress into the open pit mine.

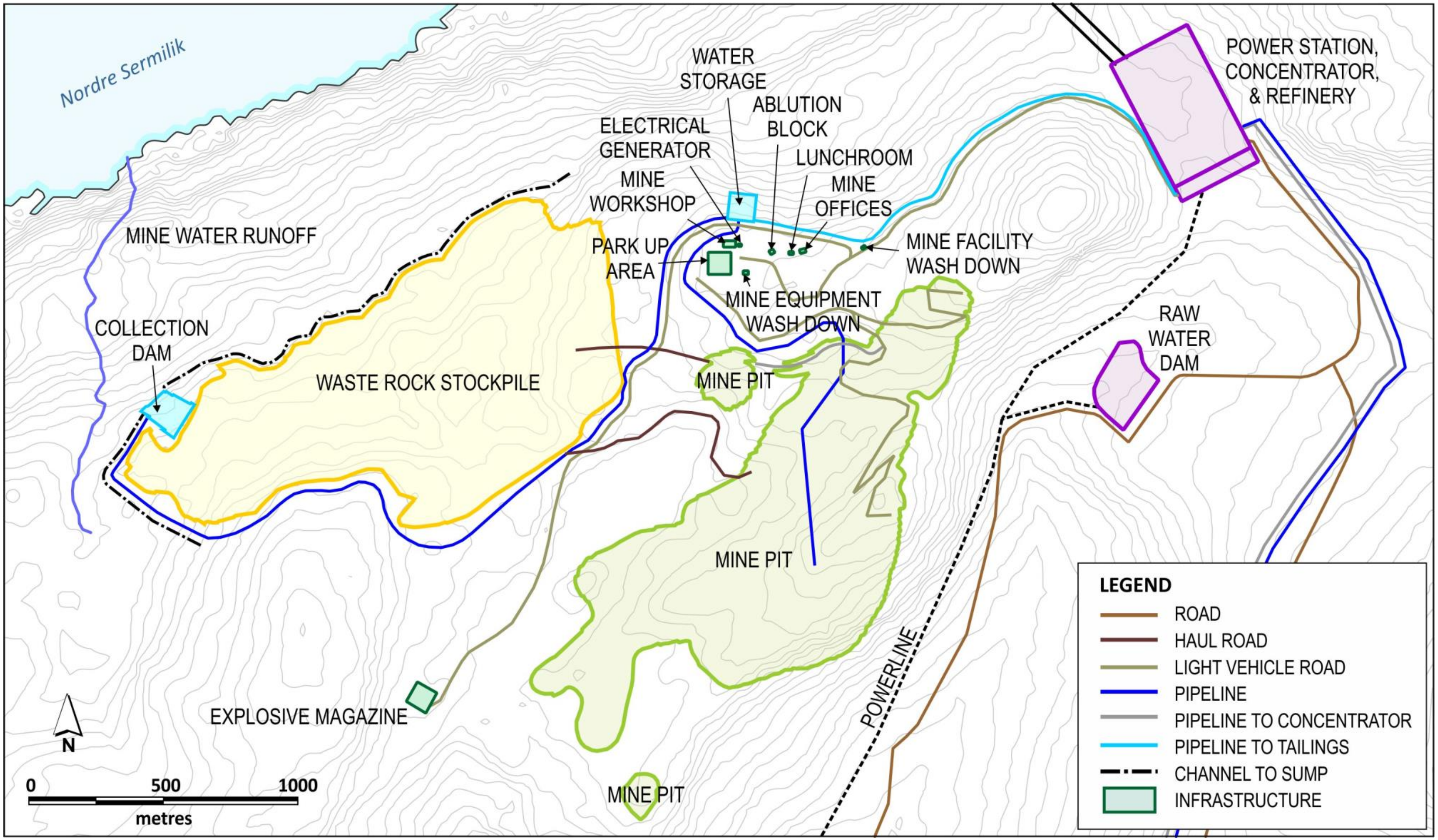


Figure 5 Mine layout

3.5 Waste rock stockpile

The Mine will have a low strip ratio (waste material moved per tonne of ore) with expected ratio of only 1 tonne of waste per tonne ore. Waste rock is barren natural rock overlying the ore in a mine. On average approximately 3.0 Mtpa of waste rock will be mined and transported to the WRS. The WRS has been located to the north west of the Mine as this location offers a relatively short, down grade haul and good access to the maximum height of the east side of the dump.

This location also allows reasonable storage volumes on steep topography near the mine.

The WRS will be developed by tipping and pushing from the 590 mRL level using haul trucks and standard dozing practices to contour to stabilise the stockpile. The final design will reach a height of 590 mRL, or 120 m in total.

Static and kinetic acid rock drainage and metal leaching prediction tests have shown little metal leaching potential in the waste rock. Field tests and monitoring during Project operations will further characterize Mine waste water, including the concentration of fluoride. WRS run-off will be used to supplement fresh water requirements for processing. A channel will be excavated around to toe of the waste dump to collect the runoff from the flanks. The channel will discharge into a sump located at the north of the waste dump, and water from the sump will be pumped via a pipeline to the concentrator.

The overall capacity of the WRS will be will 34.8 Mm^3 or 95.6 Mt.

3.6 Concentrator and refinery

The Project will include two separate processing facilities, a concentrator (which uses a physical process) and a refinery (which uses chemical processes). The processing facilities will operate for 365 days per year and 24 hours per day.

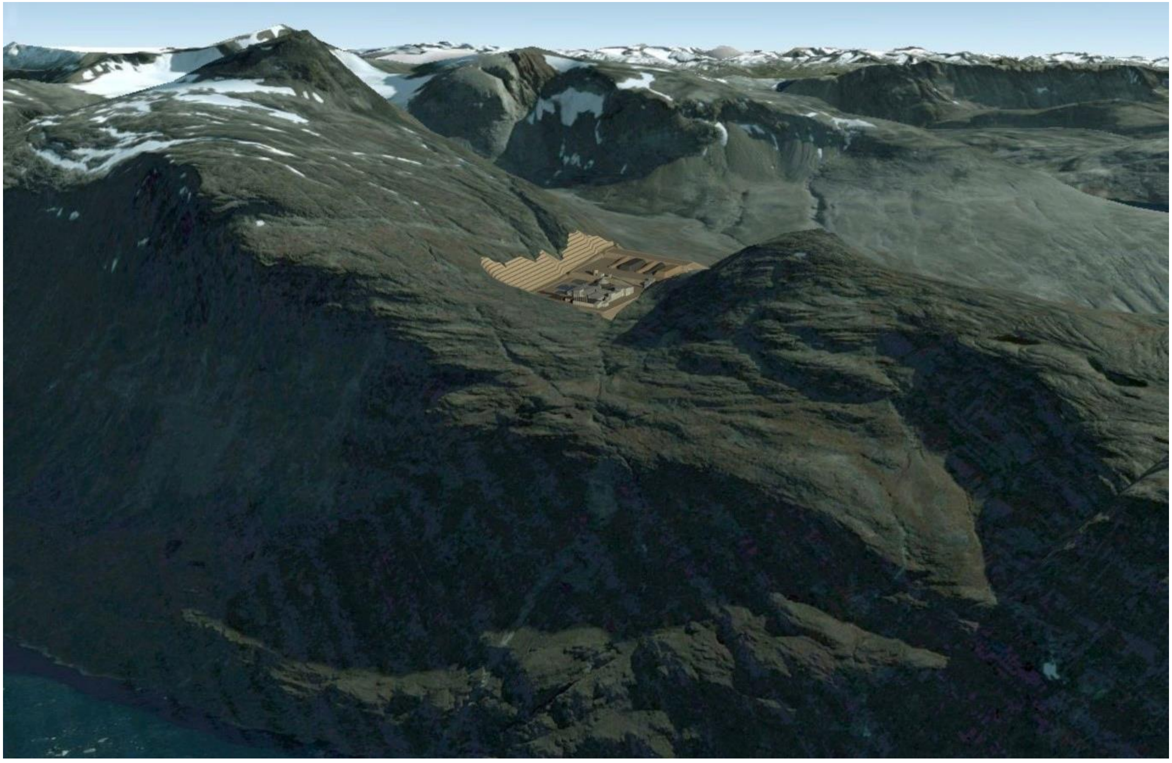


Figure 6 3D Drawing of the Processing Plant site location

The concentrator will use froth flotation (flotation) to concentrate the value bearing minerals delivered from the mine. Flotation involves the use of minor quantities of benign reagents to separate minerals and is a standard processing technique.

Prior to flotation, the ore will pass through a crushing and milling circuit in which the ore particles will be reduced in size to the consistency of fine sand [80% passing 75 microns]. This size optimises the efficiency at which particles of value minerals in the ore are liberated from the relatively barren host rock.

The concentrator will produce two saleable products, zinc concentrate and fluorspar, and will produce REMC, which moves to the refinery for further processing. Approximately 80% of the REs will be recovered into the REMC. From the initial 3.0 Mtpa that is delivered to the crusher, the concentrator will produce:

- [redacted] tpa of REMC (containing REEs and uranium)
- [redacted] tpa of zinc concentrate
- [redacted] tpa of fluorspar
- 2.8 Mtpa of flotation tailings.

REMC from the concentrator will be pumped via a pipeline to the adjacent refinery. The refinery is comprised of three sections:

- acid leaching
- uranium recovery
- REE recovery.

Acid leaching will dissolve the REE and uranium bearing minerals making REE and uranium available for recovery in subsequent processing steps. The refinery will produce four RE products via solvent extraction (SX). These are:

- lanthanum oxide
- cerium hydroxide
- a mixed lanthanum cerium oxide, and
- a mixed REO.

All REE products will be exported.

A uranium by-product will be produced from the leach solutions via SX. The final product will be uranium peroxide UO_4, which is directly saleable to power utilities.

[redacted] tpa that is fed into the refinery will produce approximately:

- [redacted] tpa of RE products
- [redacted] tpa uranium oxide
- [redacted] tpa waste chemical residue tailings.

The processing facilities will also include water treatment facilities (described in Section 3.7.3) and two acid plants (for hydrochloric acid and sulphuric acid).

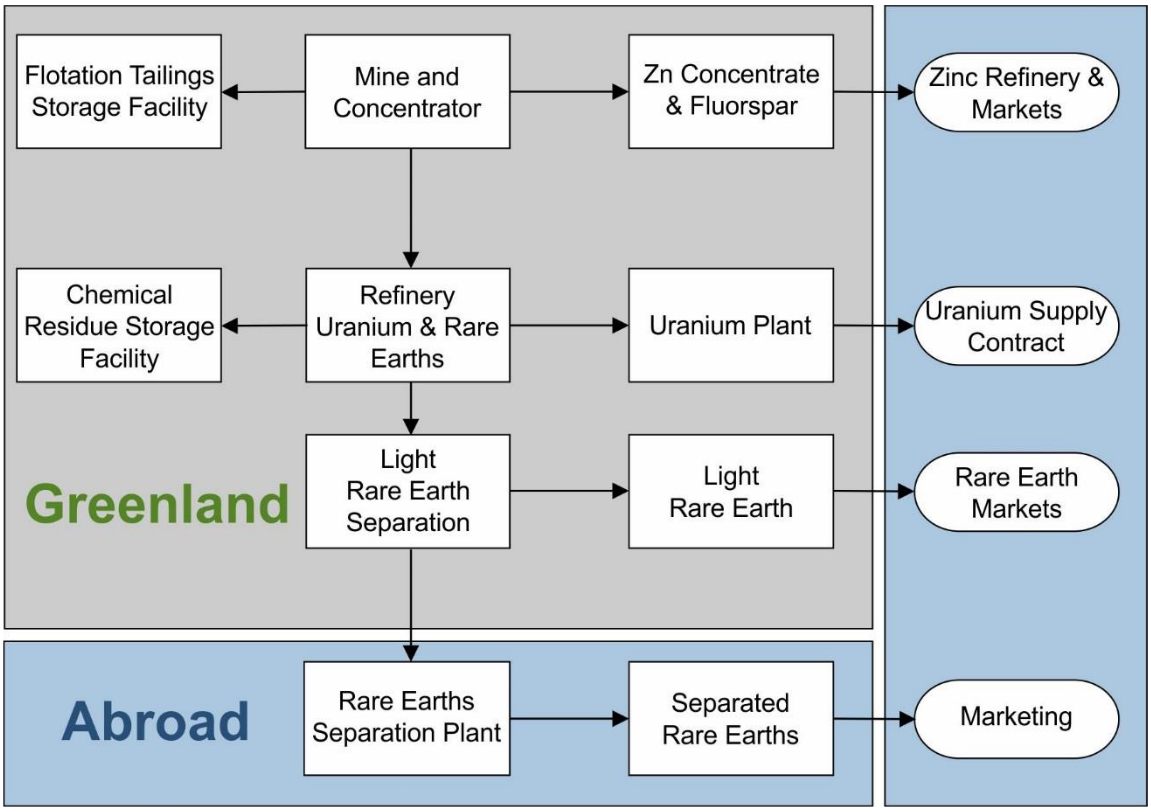


Figure 7 Main process plant steps

3.6.1 Sulphuric Acid Plant

Sulphuric acid will be produced in the sulphuric acid plant which will be located at the refinery. Acid will be produced by the oxidation of elemental sulphur. The capacity of the plant will be 370 tpd of concentrated sulphuric acid. The process will generate heat which can be converted into power by a turbo generator set (2.3MW) electrical generator.

The sulphuric acid plant will be skid mounted and compact. Emissions control systems will be installed on all environmental contact points to meet EU emission standards. All releases from the sulphuric acid plant have been included in the air quality modelling (ERM 2018).

3.6.2 Chlor-Alkali Plant

Hydrochloric acid will be produced from an acid plant using chloralkali cell technology. The chloralkali cell will also produce caustic soda (a concentrated solution of sodium hydroxide) as a by-product which will be used as a reagent in the refinery.

The main feedstock for the chloralkali cell is standard salt (sodium chloride). The chloralkali cell process works by performing electrolysis on a brine solution which splits the salts in solution. A high amount of energy is required to provide the power for electrolysis.

The chlor-alkali plant will have the capacity to produce tpd of caustic soda and tpd of hydrochloric acid. In addition, tpd of sodium hypochlorite will be produced as a by-product.

The chlor-alkali plant will be housed within a building and will incorporate environmental controls for all emissions in accordance with European standards for air quality. All releases from the chlor-alkali plant have been included in the air quality modelling (ERM 2018).

3.7 Tailings Facilities

3.7.1 Overview of Tailings Storage Facility

As identified in Section 3.6, the majority material mined as ore will eventually be stored as tailings. The concentrator and the refinery will produce two distinct tailings streams that will be handled and stored separately.

Tailings will be in the form of very fine solids (silt) suspended in water and will be pumped through a pipeline and discharged to the TSF.

The TSF will be located within the Taseq basin to allow sub-aqueous discharge of tailings (wet disposal). Embankments will be constructed to form two discrete tailings storage areas within the Taseq basin - a FTSF to receive tailings from the concentrator and a CRSF to receive tailings from the refinery (Figure 8).

The embankments will be lined with a geosynthetic membrane to prevent any seepage to Taseq river. The embankments will be constructed from local scree material and pre-strip waste rock. The waste rock is inert, hard, competent, crystalline rock.

Over time the embankments will be sequentially raised to increase the volume of the respective storage facilities. The embankments will be raised five times over the life of the Project to eventually reach heights of 45 and 46 m above the original ground level for the FTSF and CRSF (Figure 9). The maximum thickness of deposited tailings will be 68 m in the middle of the FTSF and 40 m in the CRSF.

The maximum rise rate occurs during the early years of TSF operation. The rise rate then gradually decreases with embankment rises staying well ahead (>6 m) of the top of the tailings level.

On closure, the TSF will remain covered by a permanent water layer. This water layer will mitigate against release of radon and dust.

The concentrator will produce 2.8 Mtpa of solid tailings and is the major source of this material, with the refinery producing a further 0.3 Mtpa. The combined total of the tailings over the life of the Mine will be 111.7 Mtpa, consisting of 101.0 Mtpa from the concentrator and 10.7 Mtpa from the refinery (Table 5).

Table 5 Tailings production

Year	Flotations Tailings (Mtpa)	Chemical Residue (Mtpa)
1- 36	2.8	0.3
37	1.4	1.5
Total	101.0	10.7

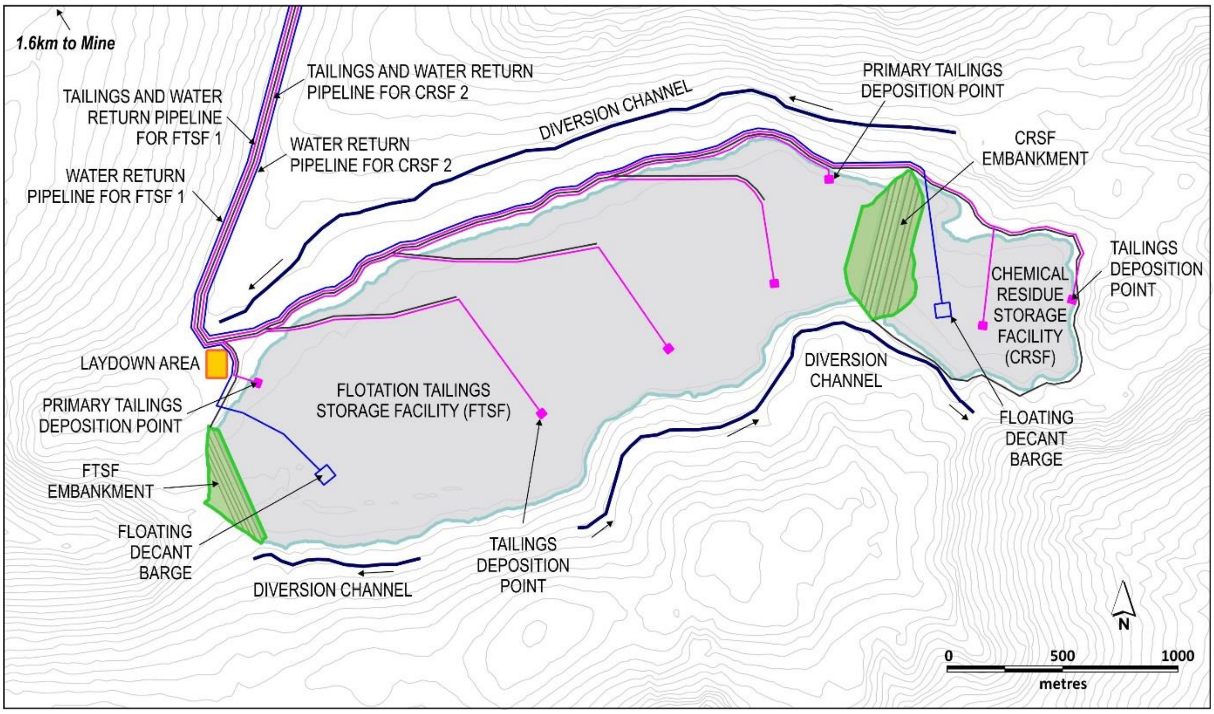
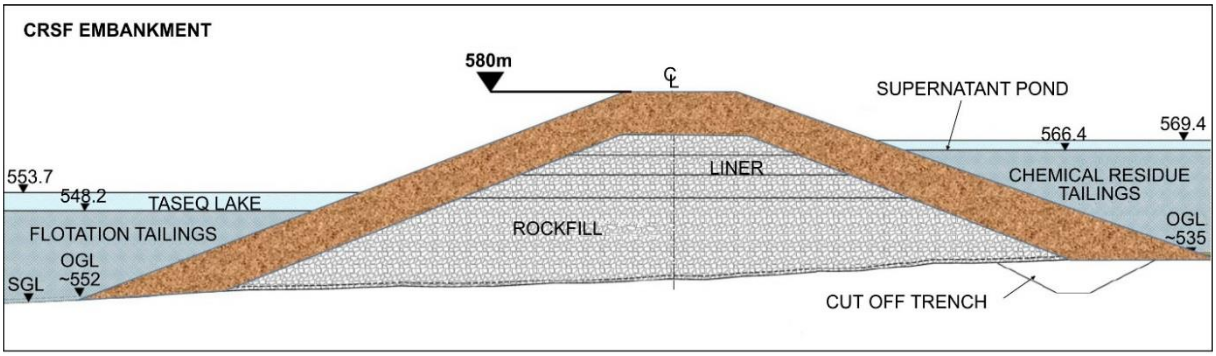


Figure 8 The Tailings Storage Facility



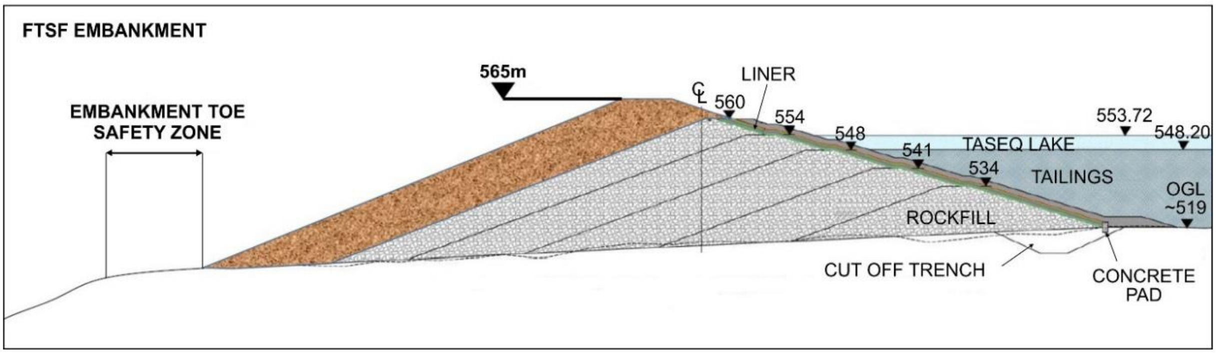


Figure 9 Cross-section of embankment at the CRSF (above) and FTSF (below) at year 37

3.7.2 Operation of the Tailing Storage Facility

The tailings will be covered by 6 m of water at all times. The key advantages of subaqueous tailings storage are the prevention of radon gas release and elimination of dust. In the Project's operations phase tailings slurries will be discharged below the water surface into the respective storage facilities.

The main source of elements and reagents in the supernatant will be displaced pore water following compaction of the slurries over time (from 60% w/w to 70% w/w for the FTSF and 40% w/w and 50% w/w for the CRSF). The water (supernatant) in the tailings ponds is decanted and re-circulated to the Plant (Figure 10).

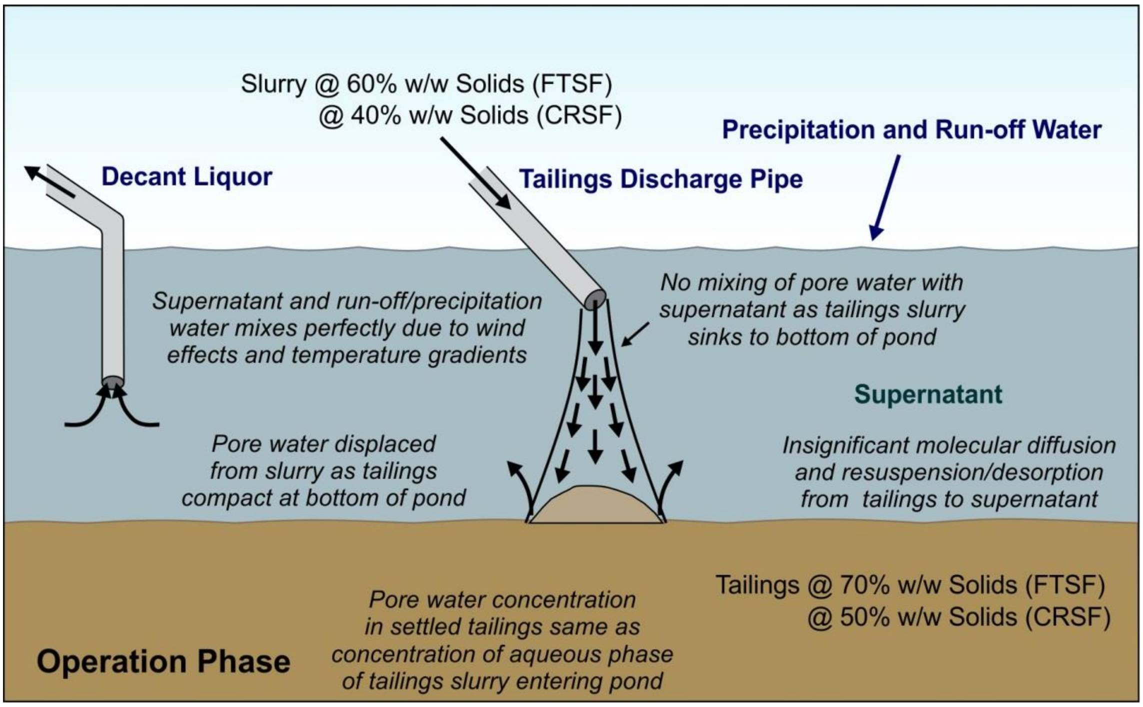


Figure 10 Operations phase schematic

However, an emergency spillway will be maintained to allow for safe and passive discharge of excess water in the rare event that unforeseen circumstances produce a high water level.

The free board allowances in the TSF will allow for the containment of a 1 in 10,000 year rainfall event and still leave > 4 m of freeboard until overtopping.

To minimize the inflow of water from rain and snow that falls on the slopes surrounding Taseq, diversion channels and embankments will be constructed on both sides of the basin to divert some rain and snow melt. Most of this water will be directed towards the Taseq river that currently drains the lake in order to ensure that it avoids contact with the TSF (See Figure 8).

Narsaq Town is supplied with drinking water from the Napasup Kuua, Kuukasik and Langnam rivers. In the event that water from the TSF was directed toward the Taseq river this will not affect the supply of drinking water for Narsaq Town.

Closure and decommissioning phase

After Mine closure the water in the TSF will be treated at the processing plant site for a period of six years (the closure period). This will remove fluoride and solids from the water thereby producing water suitable for discharge to Nordre Sermilik fjord.

The water depth above the tailings will typically be up to 10 m in the FTSF and 8 m in the CRSF throughout the closure period.

The water in the tailing dams is replenished with precipitation and run-off from the catchment area. This combined with water treatment will gradually improve the water quality until it is compatible with the natural environment.

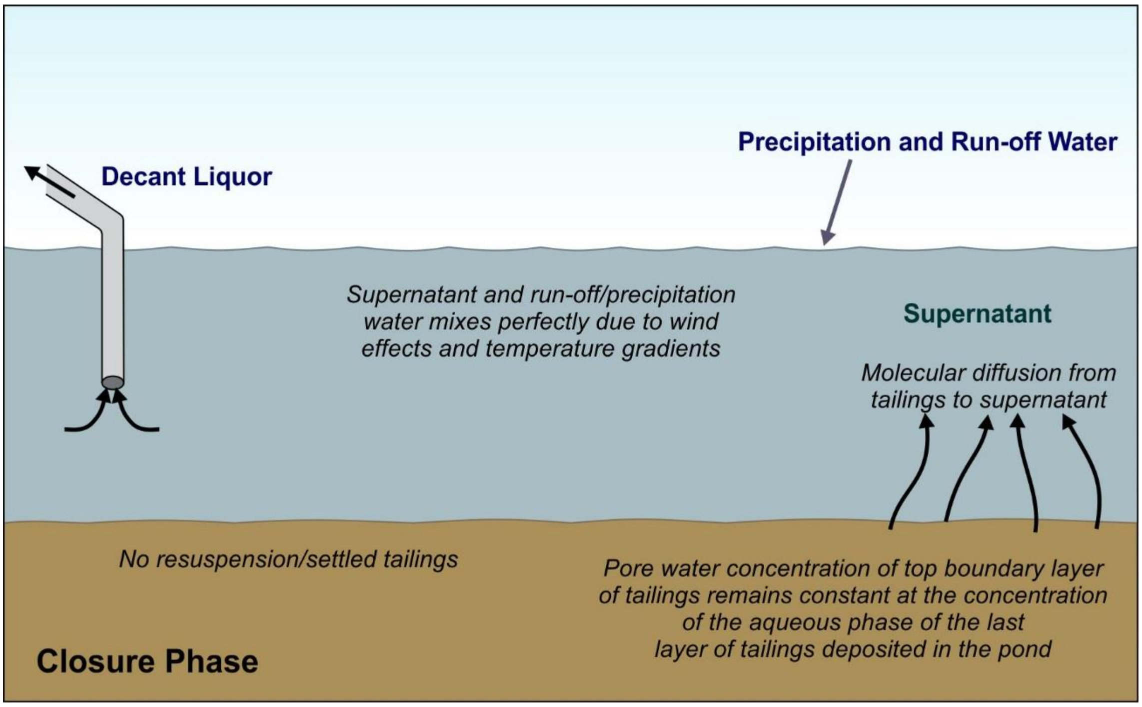


Figure 11 Closure phase schematic

At the end of the closure phase the supernatant depth will be lowered to around 0.25 m above the top of the tailings and the water quality will reach levels that present no harm to the environment. From this point the water treatment will cease, and the tailings dam allowed to gradually re-fill with natural water ingress.

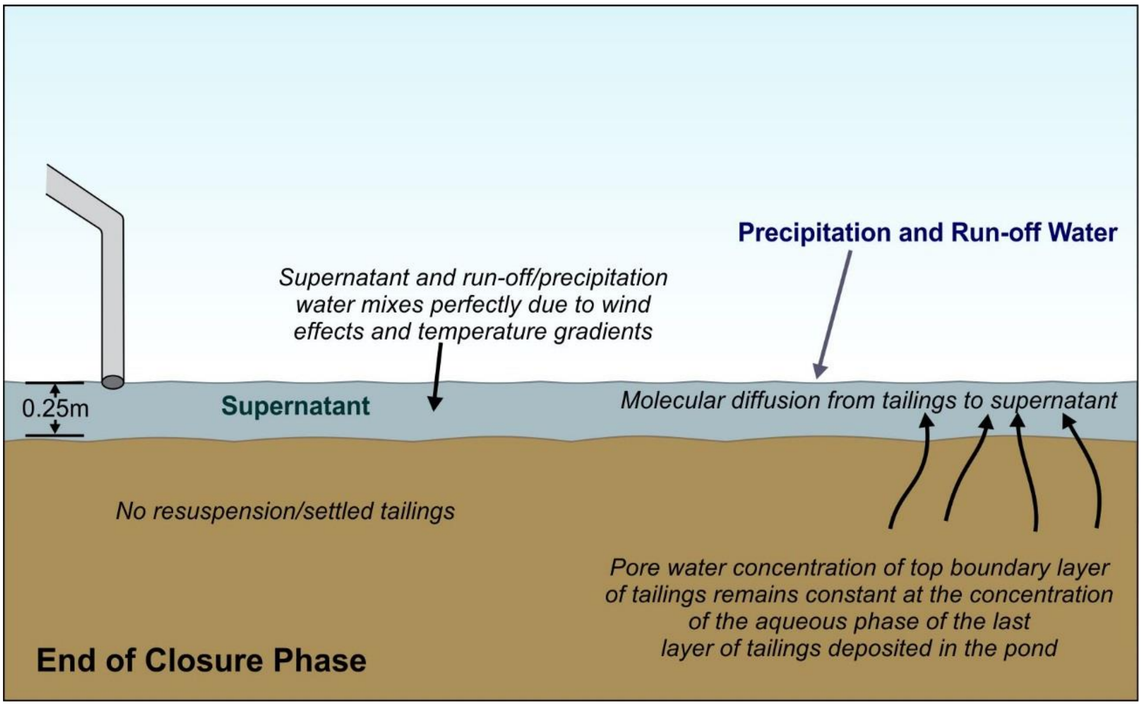


Figure 12 End of Closure

Post-closure

The water level will increase gradually post closure and eventually reach the crest level of the embankment at which point it will start to overflow downstream into the Taseq river/Narsaq river system via a specifically designed and dedicated spillway, downstream into the Taseq river/Narsaq river system. The function of the diversion channels will gradually deteriorate with natural erosion and in-fill of soil and gravel.

The hydrology in the Taseq valley will, in broad terms, return to the existing conditions before the mining operation commenced.

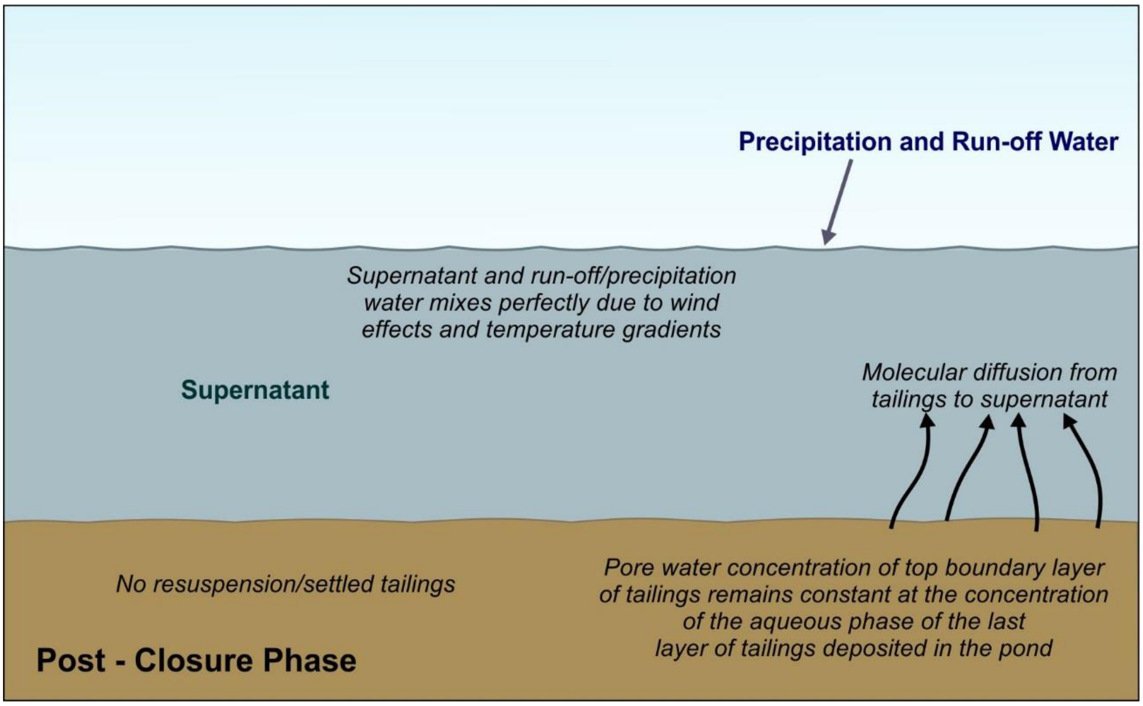


Figure 13 Post- closure phase schematic

3.7.3 Flotation tailings

The flotation tailings produced by the concentrator will be stored in the western end of the Taseq basin in the FTSF. This facility is located approximately 3 km to the south of the refinery. To ensure isolation of the contents of the FTSF, the embankment will be sealed with a double composite geosynthetic liner.

The flotation tailings represent approximately 90% of the overall tailings. These tailings consist of finely ground rock following the physical removal of zinc, uranium and REEs through a flotation process at the concentrator. There will be no chemical change to the rock during the concentration process. Concentrator tailings will be stored in the FTSF without treatment as they are already in a stable condition.

The flotation tailings will be transported to the FTSF as a slurry (mixture of fines and water) with a solids percentage of 60%. The water used to form the slurry contains soluble natural fluoride ions and will be isolated from the environment and returned back to the concentrator for re-use.

Water returned to the concentrator passes through the water treatment plant to remove the fluoride (process summarised in Figure 14). Fluoride is precipitated from solution with the addition of calcium chloride salt. The removed fluoride forms a calcium fluoride, which is a commercial grade fluorspar that can be offered as a saleable product. This method is best available technology internationally for fluoride removal and marine release. A thickener, filter and clarifier will be installed to ensure the fluoride solids are captured and the treated water is clear.

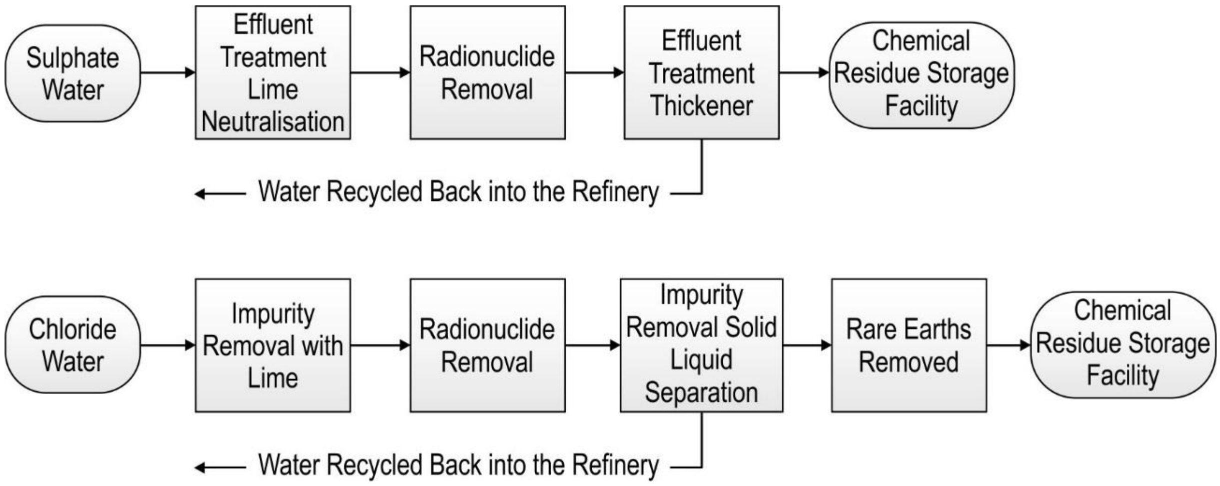


Figure 14 Flowchart of concentrator water treatment plant

3.7.4 Refinery tailings

The tailings produced by the refinery will be a mixture of finely crushed inert rock and neutralised chemical precipitates. This tailing stream represents approximately 10% of the overall tailings. The uranium and REEs will have been removed from this tailings stream. The associated water contains chloride and sulphate salts in solution and is, therefore, isolated from the environment and stored in a double lined tailings dam. The refinery tailings slurry (mixture of rock and water) will have a solids percentage of 43% or greater at the bottom of the tailings pond.

In the refinery a number of contaminants will be precipitated from solution as stable solid particles prior to reporting to the refinery tailings stream. Such contaminants include low concentration radionuclides such as polonium, lead, bismuth and radium.

Water treatment circuits have also been included to remove organic contaminants from released water as well. Water treatment solids are mixed with the bulk of the refinery tailings thus removing the requirement for a separate solids or ‘sludge’ solid liquid separation systems.

Refinery tailings will undergo treatment prior to dispatch to the CRSF in order to ensure they are stored in a neutralized condition thereby preventing migration of deleterious elements. This treatment will involve neutralizing with hydrated lime to produce a neutral pH level. At this neutral pH level many potentially deleterious elements, including actinium, precipitate from solution.

The tailings are thickened in commercially proven high rate thickener systems. These systems run continuously producing a thickened slurry (suspension of fine solids in liquid) and clear solution. The clear solution produced can then be recycled within the processing plant reducing overall water consumption.

3.7.5 Chemical and radiological properties of the tailings

For both tailings streams the main component is silica (SiO_2), which makes up approximately 50% (or greater) of each by mass.

The radioactivity of the concentrator tailings will be low and similar to surrounding country rock in the Kvanefjeld area (Table 6). The refinery tailings will be elevated in thorium, which produces a higher specific activity even though the vast majority of uranium has been removed.

Table 6 Chemical and radiological properties of the tailings

Tailings Source	Fe %	Al %	Na %	F %	Pb %	U %	Th %	Radioactivity Becquerels/gram
Baseline Rock Cover	4.78	10	10.55	0.30	0.059	0.005	0.01	1.03
Concentrator	10	7.11	8.48	0.25	0.01	0.02	0.02	3.34
Refinery	6.8	1.55	2.66	0.1	0.03	0.01	0.32	14.52

3.8 Port facility

Dedicated new port facilities (the Port) will be installed on the Tunu Peninsula at Narsap Ilua (Bay) for the Project. During the Project's operation phase the Port will handle the import of fuel, reagents, consumables and the export of products. The new facilities will be designed to handle 40,000 DWT Handy-max vessels, which are 200 m long. Port utilisation is expected to be 20% of the year with vessels docked for up to 5 days at a time.

The Port will be designed with a 200 m quay frontage with conveyors for bulk cargo, and mobile stackers for containers (Figure 15). Adjacent to the quay, an area will be prepared for container stacking and covered bulk storage for both imports and exports.

It is anticipated that there will be approximately 174 heavy vehicle movements per day to take material to the Port and an additional approximate 150 trips by light vehicles.

A dedicated vessel will sail between the Port and a major mainland European port. From the mainland Europe port all cargos will be unloaded and forwarded to other destinations using commercial transport lines.

Dredging and possible rock blasting will be required for the port construction. Land reclamation is the main method for port construction.

Shipping containers loaded at the processing plant will be loaded onto trucks and transported to the Port for temporary storage prior to loading onto ships.

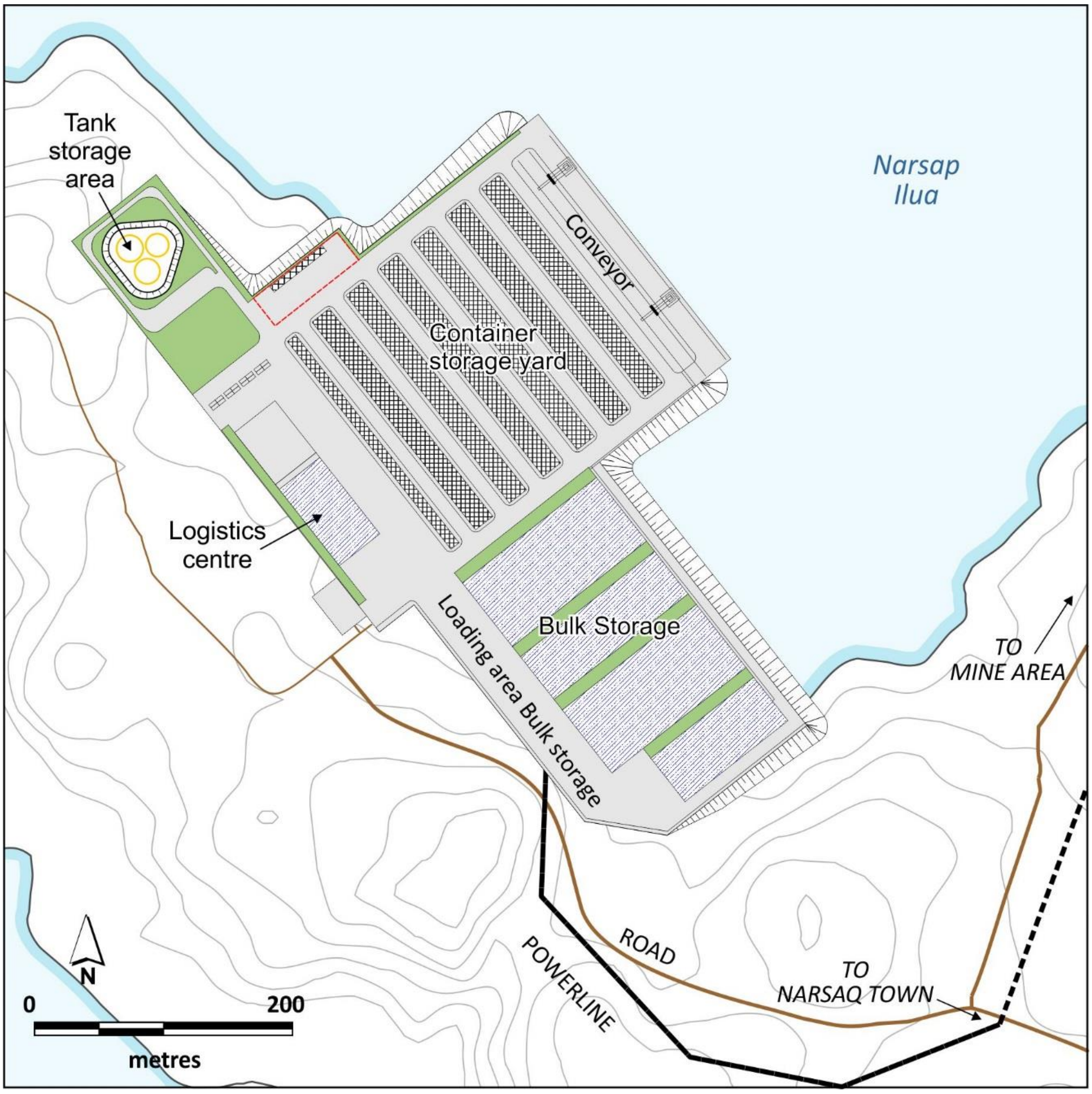


Figure 15 The Port layout

3.9 Handling of radioactive material

3.9.1 Overall management

World's best practice principles will be applied from successful mining operations in developed countries. This will include radiation protection practices used in REE and uranium mines operating in Australia and Canada. Precautions will be taken throughout the mining steps to minimize worker exposure to dust and other hazards. All worker radiation exposure will be constantly measured and monitored. Further details on occupational health, safety and radiation protection will be provided in the forthcoming Occupational Health and Safety Management Plan.

Overall radiation exposure management will involve:

1. Inductions and extensive training
2. Consistent monitoring of all employees
3. Best available technology dust control
4. Engineering out areas of potential radiation exposure in the design.

In order to remove any dust from vehicles, a wash-down facility will be built to be used by all vehicles leaving the Mine area. The facility will operate automatically and operators will not be required to leave the cabins of their vehicles during wash down. Radiation clearance control will be used to ensure that contaminated vehicles do not leave the Mine area.

3.9.2 Security of nuclear products

The uranium product (“yellow cake”), will be packed in sealed 200 L steel drums at the refinery which will then be loaded into standard shipping containers, also sealed, before being transported to the Port on trucks. The containers will remain sealed to the final point of delivery.

Containers will be unloaded from the flatbed truck at the Port and moved to a dedicated storage area. The storage area will have a gate and security that meets/exceeds the requirements of International Ship and Port Security Codes.

The uranium product will be packaged and transported in compliance with IAEA Safety Standards SSR-6: Regulations for the Safe Transport of Radioactive Material (2018) and relevant international and national codes and regulations for the transport of radioactive material.

3.10 Water Management

3.10.1 Water balance

Water for Plant operations will be supplied from the following sources:

- The Narsaq river
- Recycled water from the TSF
- Recycled water from the Plant in times of low flow in the Narsaq river
- Mine water and run off from the waste rock stock pile.

The TSF will perform the dual function of tailings and water reservoir.

A minimum water layer of 6 m will be maintained in the TSF to ensure effective subaqueous disposal of tailings is always possible. Maintaining this water level will be managed through the control of the amount of decant water which is recycled back to the Plant.

The decant water is pumped from the tailings facilities to the concentrator and refinery in pipelines adjacent to the pipes that transport the tailings slurries to the tailings facilities.

Recycled decant water will be filtered to remove grit and other debris.

The conceptual water balance is shown in Figure 16.

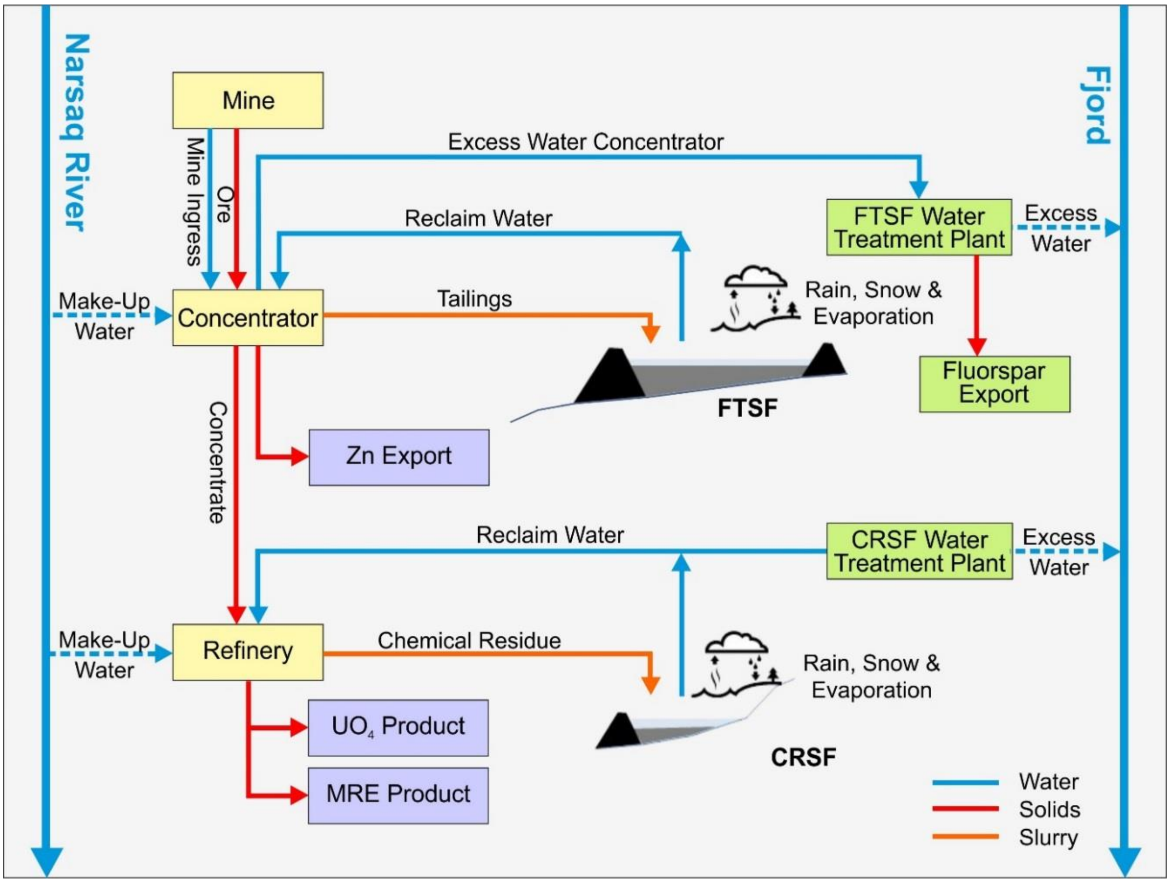


Figure 16 Water balance

3.10.2 Surface water management

Surface water management is an important design feature across the site. Surface water diversion structures will be constructed to minimise the flow of water into operations areas as well as maintain natural stream flows.

The rainwater and snow that ends up in the pit (pit water) will be pumped through a pipe to the concentrator. Water that drains from the WRS will also be pumped to the concentrator. The Kvane river (a Narsaq River tributary), which normally contains water naturally elevated in fluoride and uranium, will have significantly reduced flows as a result of a planned diversion. During Mine production the water level of Kvane basin next to the pit will also be lowered to prevent water from seeping into the pit.

In order to prevent excess water entering the TSF, diversion channels will be constructed. These large channels, which will be approximately 4 m wide at the bottom and at least 2 m deep, have been planned to partially divert melt water and precipitation run off. The water diversion will be directed to natural watercourses, including the Taseq river.

3.10.3 Water discharge

Excess water produced from the Plant will be treated. For the concentrator this treatment process removes dissolved fluoride and solids from the water. Excess water from the refinery including the barren chloride liquor will be neutralised and treated to remove organic material and radionuclides.

After treatment and monitoring water will then be discharged into Nordre Sermilik.

The excess water will be discharged at a depth of approximately 40 m in order to achieve optimal dilution.

3.11 Support Infrastructure

3.11.1 Administration and accommodation

During the construction phase, a peak workforce of 1,171 employees is anticipated. Of these, approximately 200 are expected to be Greenlandic citizens who will commute on a rotational basis to the Project. The remaining foreign workforce will be accommodated in a temporary construction worker's camp which will be constructed in proximity to the concentrator. Temporary accommodation for construction workers will be also be provided locally in Narsaq and Narsarsuaq. Potential overflow accommodation utilizing a marine vessel (cruise ship style) may also be provided in the Narsaq harbour for peak periods

During Project operations, with an average workforce of 715 of which 328 are expected to be Greenlandic, non-local employees will be accommodated in the Village to be constructed on the outskirts of the town of Narsaq. The location of both the temporary construction workers' camp and the permanent Village are illustrated in Figure 17.

There will be a road providing access from the Village to the Port-Mine Road. The Village will be supplied with power (from the Project's Power station), water and sewerage treatment will be connected to the town services. A large centre is envisaged with recreation facilities, meeting rooms, canteen, laundry and internet connection.

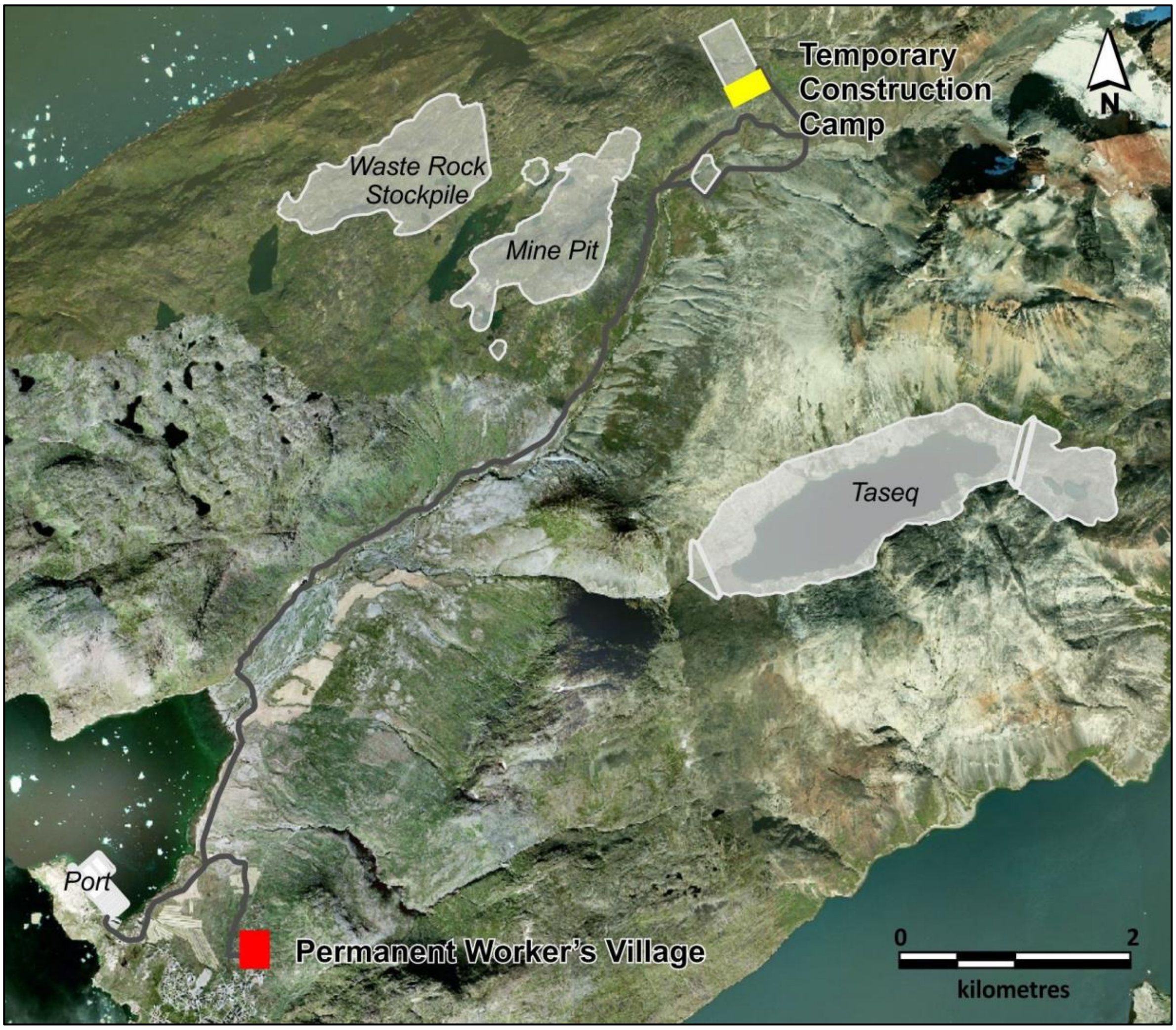


Figure 17 Accommodation village and temporary construction worker's camp location

3.11.2 Airports

The Project will not involve the construction of an airport and GML will largely utilise the airport at Narsarsuaq, approximately 42 km north east of Narsaq.

3.11.3 Transport Facilities

The FIFO workforce is expected to utilise the Narsarsuaq airport as the Greenland entry point. This is likely to be the case for the imported construction workforce in addition to the operations FIFO workforce. A ferry will be used to transfer workers from the airport to Narsaq.

An extension to existing passenger facilities will be required at the existing heliport at Narsaq but the airport at Narsarsuaq is considered to be adequate to handle additional passenger loads resulting from Project construction and operation. Additional commercial and chartered flights between Narsarsuaq and Nuuk, Reykjavik and Copenhagen, and the UK may be necessary for the increased volume of passengers.

The Port-Mine Road will be 7 m wide and approximately 13 km long. It will follow an existing gravel road along the Narsaq river. The Port-Mine Road will be for all transport between Port, Plant and Mine. Specialised fuel trucks will transport fuels from the Port to the Project's Power station at the site of the concentrator. Personnel will generally commute by bus between the Village and the work sites at the Mine and Plant.

Port utilisation will be approximately 20% per year. There will be in excess of 30 vessel arrivals during a typical operating year. It is expected that, each year, the Port will dock:

- 22 Handy-Max Size vessels (40,000 DWT) per annum for containerized and bulk cargo
- 10 Oil tankers per annum carrying fuel.

3.11.4 Electricity and Fuel Supply

The Power station will be located within the Plant. This will allow recovery of Power station waste heat within the Plant.

A 59 MW diesel fired combined heat and power station will be built adjacent to the concentrator. This Power station will service the Plant, the Port and the Village. The Power station will have a waste heat recovery system which will generate hot water that will be used for process heating in the concentrator, as well as heating of buildings in the Plant.

Fuel for the power plant will be stored at the Port and transported to the Power station site in road tankers as required. The tankers will discharge the fuel into day tanks adjacent to the Power station.

An 11 kV overhead power line will deliver power to the Port and Village.

3.11.5 Domestic and industrial waste handling

All combustible solid waste will be pressed into bales and shipped to Qaqortoq for incineration. In the event that an incinerator were to be constructed in Narsaq, this facility would be used instead.

Accumulators, batteries, electronic devices, glass, etc. will be stored in temporary containers and periodically handed over to the Qaqortoq waste handling facility for further disposal according to regulations and after mutual agreement.

3.11.6 Hazardous material handling (hydrocarbons, explosives)

Hazardous waste will be handled in accordance with the Kommuneqarfik Kujalleq regulation concerning hazardous waste (Regulations for disposal of hazardous waste, 2009). In general hazardous waste is shipped to Denmark and handled in compliance with a comprehensive EU initiated legal frame-work. Hazardous waste shall be registered and traced using code standards (EC waste list / EAK koder (Europæiske Affalds Koder)).

3.11.7 Fencing

Fencing around the Project's operations will be constructed for safety and security. Due to the steep topography of the area complete fencing is not required. Vehicle and fauna access will be restricted by the proposed fencing plan. As shown on Figure 18 the fencing will restrict access to the Mine site, Plant site, explosives storage and fresh water dam.

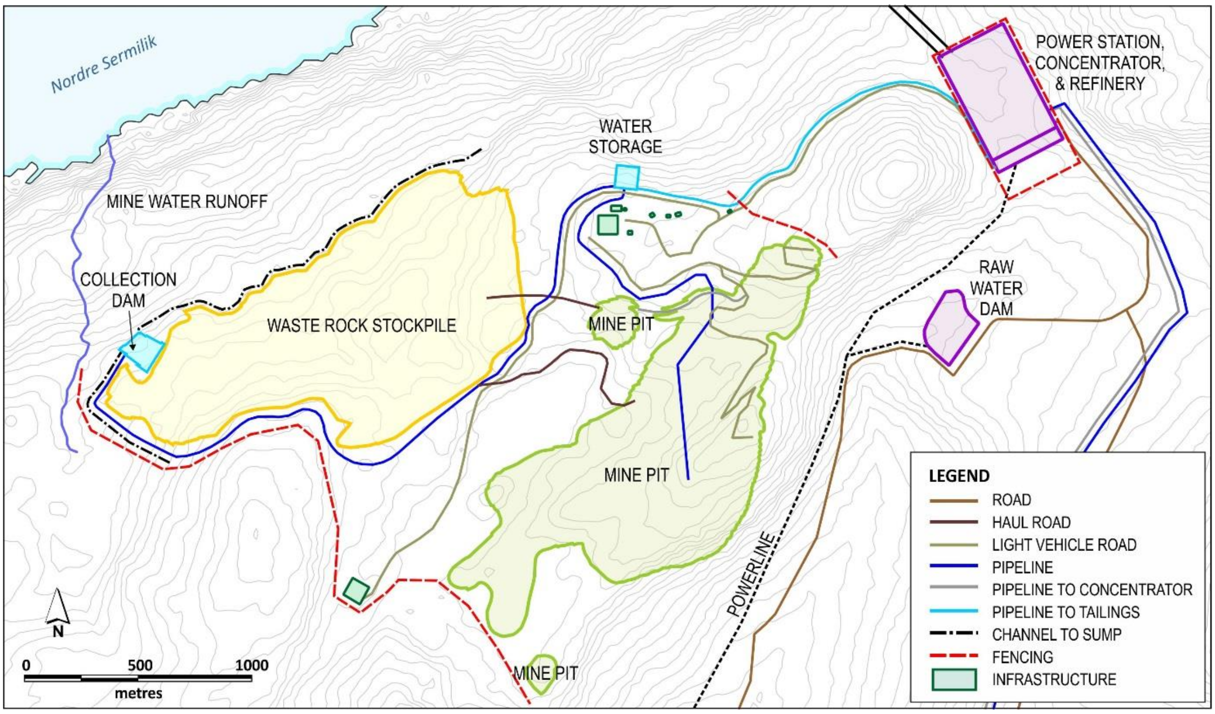


Figure 18 Fencing

3.11.8 Dangerous Goods Storage and Handling

Dangerous goods will be stored at the processing plant in accordance with EU requirements. Dangerous good include reagents such as acids (described in Section 3.12).

The explosives magazine will be located away from the infrastructure at the south end of the pit and will be accessed by a gravel road. Access will be restricted with security fencing and surveillance. The explosives and detonators will be stored separately in an approved explosive magazine building.

3.11.9 Pipelines

Tailings will be pumped to the TSF as a slurry through pipework located in above ground piping corridors and mounted on supports and insulated to prevent freezing.

Recycled water from the TSF will be pumped to the Plant via the tailings piping corridor in pipework mounted on supports, insulated and heat traced to prevent the return waters freezing.

Treated excess plant water will be pumped from the concentrator to Nordre Sermilik (Bredefjord), where possible, above ground in a piping corridor, mounted and insulated.

3.12 Use of reagents

A variety of reagents will be used in the Plant. Table 7 lists the reagents to be used in the Plant together with an estimate of annual consumption of each.

Table 7 Summary of reagents used

Reagent Function	Used for	Purpose	Annual consumption Tons
[redacted]* Concentrator Flocculant	Zinc flotation	Thickener flocculant for zinc sulphide concentrate - to promote particle sedimentation to enable recovery of zinc product from process.	1.2 - 3.0
[redacted] Concentrator Flocculant	REMC flotation	Thickener flocculant for REMC - to promote particle sedimentation to enable recovery of REMC from process.	150-400
[redacted] Refinery Flocculant (Anonic)	Impurity removal - Refinery	Thickener flocculant for anionic impurities - to promote particle sedimentation to enable removal of impurities in the refinery circuit.	75 - 180
[redacted]* Refinery Flocculant (Cationic)	Impurity removal and product recovery - Refinery	Thickener flocculant for cationic impurities and cationic products - to promote particle sedimentation to enable removal of impurities, and recovery of products in the refinery circuit.	20 - 60
[redacted] Refinery Coagulant.	Silica agglomeration	Thickener agglomerate for silica impurities - to promote agglomeration of fine silica particles to enable their removal from uranium product liquor.	60 - 160
[redacted] Flotation Collector	Zinc flotation	To float the zinc sulphides, thereby separating these from the ore.	125 - 320
[redacted] Flotation Activator	Zinc flotation	To activate the surface of the zinc sulphide particles thereby improving the efficiency of their flotation.	25 -60
[redacted] Flotation Collector	REMC flotation	To float the RE-bearing minerals, thereby separating these from the non-value mineral tailings.	1 000 – 2 700
[redacted] Flotation Depressant	Zinc and REMC flotation	Depressant - prevents the flotation of the non-value mineral tailings.	2,300 – 5,800
[redacted] Flotation Frother	Zinc and REMC flotation	To reduce the bubble size and increase froth stability in the flotation process.	110 - 280
[redacted]	RE product precipitation	To precipitate RE intermediate products from process liquors in the refinery circuit.	12,000 – 30,000
Sulphur	Sulphuric acid (H2SO4) production	To produce sulphuric acid, used to leach REs and uranium from the REMC in the refinery circuit.	16,000 – 41,000

Reagent Function	Used for	Purpose	Annual consumption Tons
Sodium Chloride	Hydrochloric acid (HCl) and caustic soda (NaOH) production	To produce hydrochloric acid and caustic soda, used to respectively to leach REs and to raise pH of process liquors (for product precipitation and impurity removal) in the refinery circuit.	35,000 – 87,000
Limestone	Impurity removal	To raise pH of process liquors in the refinery circuit.	30,000 – 77,000
Caustic Flake (NaOH)	Product precipitation and impurity removal	To precipitate cerium product, and to raise pH of process liquors in the refinery circuit.	1,400 – 5,000
Calcium Chloride	Water treatment	To precipitate fluoride from the treated water placement stream entering Nordre Sermilik.	6,900 – 17,500
[redacted]	RE leaching	To oxidise RE species during acid leaching process to improve RE recovery.	300 - 750
[redacted]	RE leaching	To precipitate phosphate species during acid leaching process to improve RE recovery.	0 – 15,000
[redacted]	Product precipitation and Impurity removal	To precipitate uranium product, and to precipitate impurities from refinery process liquors.	125 - 300
Lime	Impurity removal	To raise pH of process liquors in the refinery circuit.	3,800 – 9,500
Barium Chloride	Impurity removal	To precipitate impurities from refinery process liquors.	1,800 – 4,500
Sodium Hydrosulphide	Impurity removal	To precipitate impurities from refinery process liquors.	60 - 200
[redacted] SX Extractant	Uranium SX	To extract uranium species from process liquors in the refinery circuit, thereby removing these from impurities and enabling production of pure uranium product.	2.5 - 10
[redacted] SX Phase Modifier	Uranium SX	To improve the solubility of the extractant in the organic diluent, thereby ensuring effective removal of uranium from the liquor phase.	1.0 – 5.0
[redacted] SX Extractant	RE SX	To extract RE species from process liquors in the refinery circuit, thereby removing these from impurities and enabling production of pure RE products.	70 - 175
[redacted] SX Diluent	RE SX	To provide the organic phase needed to carry the extractant, thereby ensuring effective removal of REs from the liquor phase.	160 - 500
[redacted]	Impurity removal	To remove uranium impurities from the RE process liquor stream in the refinery circuit.	0.1 – 1.0

Reagent Function	Used for	Purpose	Annual consumption Tons
[redacted] Cooling Water Biocide	Cooling water treatment	To prevent the growth and build-up of microbiological organisms in the cooling water system, thereby ensuring optimum performance of process plant cooling systems.	140 - 500
[redacted] Cooling Water Inhibitor	Cooling water treatment	To prevent the formation of rust in equipment associated with the cooling water system, thereby ensuring optimum performance of process plant cooling systems.	5 -30

3.13 Labour and services

The Project will seek to maximise employment for Greenlandic people. Suitably qualified workers will be offered employment and other potential employees will be offered opportunities to train to fill vacant positions.

The Project is expected to employ over 700 people during the construction and operations phases of the Project.

It is anticipated that the existing Greenlandic labour force will not be able to initially meet all of the labour required for the Project for each of these phases. A proportion of workers will therefore have to be sourced from outside Greenland. GML's commitment remains that where a suitably skilled worker can be sourced from within Greenland, that worker will be given preference over a foreign worker. Further detail on labour and services is discussed in the Company's SIA.

3.14 Project footprint

The overall Project footprint is described in Table 8.

Table 8 Project footprint

Element	Area (ha)
Mine	115
Waste Rock Stockpile	130
Tailings Storage Facility	310
Plant	15
Port	15
Other (accommodation, offices etc.)	30
Roads and infrastructure	16
Total	631

3.15 Decommissioning, closure and rehabilitation

The overall closure and reclamation goal is to return the Mine site and affected areas to viable and, wherever practicable, self-sustained ecosystems that are compatible with a healthy environment and with human activities.

In order to achieve this, the following core closure principles will be followed:

Physical Stability

All Project components remaining after closure will be physically stable to humans and wildlife;

Chemical Stability

Any Project components (including associated wastes) remaining after closure will be chemically stable and non-polluting or contaminating. Any deposits remaining on the surface or in lakes will not release substances at a concentration that would significantly harm the environment;

Minimized radiological impact

Long-term radiation exposure of the public due to any radiological contamination of Mine area will be kept "as low as reasonably achievable" (ALARA);

No Significant Change to Baseline Landforms

Baseline landforms and land use prior to mining operations will returned to the same visual amenity and geography. The Post closure landform is shown in Figure 19 and the Closure and Decommissioning Plan is included in Appendix B. A detailed Closure and Decommissioning Plan is required in the next phase of the permitting process.

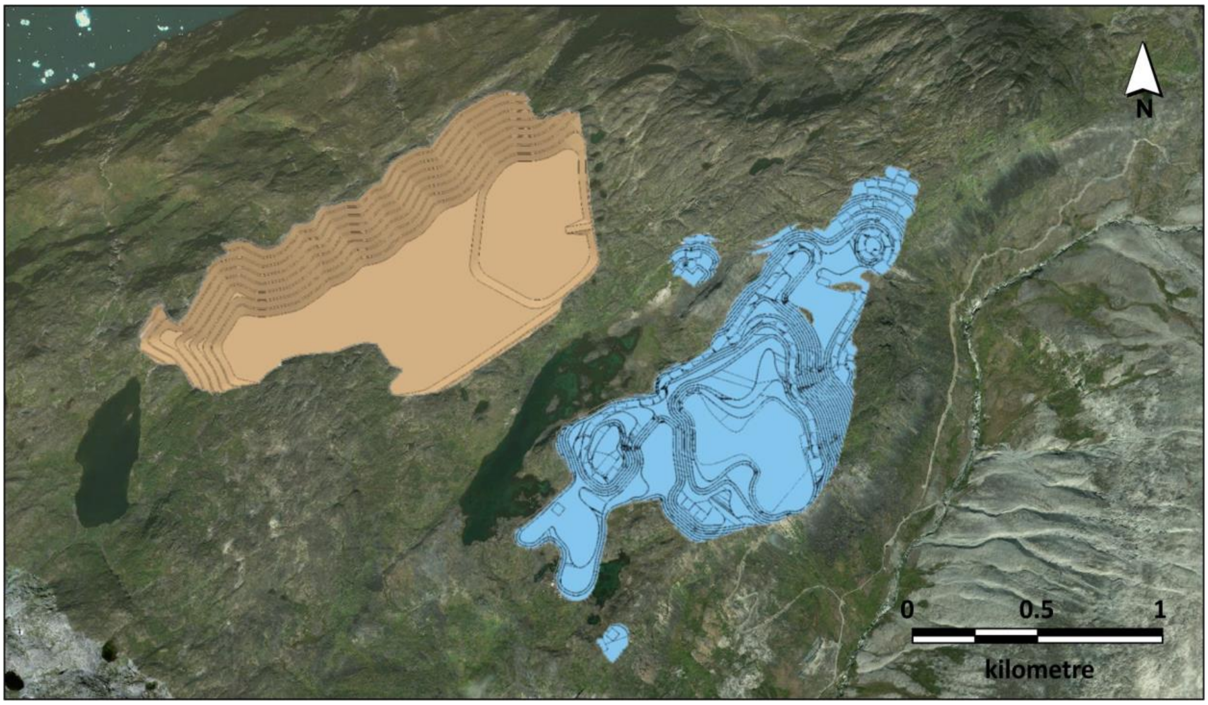


Figure 19 Post closure landform

4. Regulatory Framework

4.1 Introduction

Greenland is part of the Kingdom of Denmark. Autonomous local governance was introduced to Greenland in 1979 followed in 2009 by a new Act of Greenland Self Government, which states that Greenland can take over the administration of natural resources. In 2009, Naalakkersuisut (the GoG) took over mineral resource administration from Denmark, including the administration of environmental issues in relation to mine Projects.

The Environmental Agency of the Mineral Resources Area - EAMRA (Miljøstyrelsen for Råstofområdet) is the administrative authority for environmental matters relating to mineral resources activities, including protection of the environment and nature, environmental liability and environmental impact assessments.

The Mineral Licence and Safety Authority - MLSA (Råstofstyrelsen) is the administrative authority for licence issues and is the authority for safety matters including supervision and inspections.

In addition to the requirements relating to the preparation of its EIA, the Project will also comply with all other applicable Greenlandic and Danish legislation, including conventions to which Greenland is a signatory.

4.2 Greenlandic legislation

Subsequent to the assumption by Greenland of responsibility for regulation and management of the mineral sector, the *Mineral Resource Act* came into force on 1 January 2010 (*Greenland Parliament Act* no. 7 - 7 December 2009). Amendments to the Act were introduced in 2012, 2014 and 2015 and became effective in 2013, 2014 and 2015 respectively

The *Mineral Resource Act* is the backbone of the legislative regulation of the minerals sector, regulating all matters concerning mineral resource activities, including environmental issues (such as pollution) and nature protection.

Three authorities are responsible for the administration of mineral resource areas:

- The Ministry of Mineral Resources (MMR)
- The Ministry of Industry and Energy (MIE)
- EAMRA.

Under this structure, the MMR and the underlying Mineral License and Safety Authority (MLSA) are responsible for mining licence administration, technical and geological matters.

4.3 The Mineral Resource Act

The Act stipulates the conditions which need to be met in order to conduct mining activities in Greenland. Initially, a licensee must apply for and obtain an exploitation license for the area, which can be granted pursuant to Section 29 of the *Minerals Resource Act* upon submission to the authorities of the following documents:

- An application with key information on the proposed mining project;
- A bankable feasibility study
- An environmental impact assessment; and

- A social impact assessment.

An environmental impact assessment should have regard to:

- § 53 - Planning and selection of all activities and construction must take place in a manner to cause the least possible pollution, disturbance or other environmental impacts
- § 52 - The best available techniques must be used, including less polluting facilities, machinery, equipment, processes and technologies should be applied
- § 56 - Impairment or negative impacts on the climate must be avoided)
- § 60 - Impairment of nature and the habitats of species in designated national and international nature conservation areas and species must be avoided.

When an exploitation licence is granted, the licensee needs to apply for and obtain an exploitation plan from the GoG (Section 19 of the Act), which includes submission of a closure plan (Section 43). Provided Section 19 and 43 approvals are granted, all specific constructions, processes, vehicles, devices etc must be individually approved under Section 86 of the Act. Typically, the authorities will request a single application for all Section 86 approvals, which need to be renewed on an annual basis.

4.4 International obligations

Greenland has ratified a number of international conventions regarding nature and biodiversity, either as a direct member or through its membership of the commonwealth of Denmark and the Faeroe Islands. Of particular relevance to the Project are the following:

- The Convention on Biological Diversity (CBD) - on the conservation of biological diversity, sustainable use of its components and fair and equitable sharing of benefits arising from genetic resources. The CBD guides national strategies and policies and implements themes such as sustainable use and precautionary principles. Its application to the Project will be through the implementation of national laws and regulations, in particular the *Mineral Resource Act*
- The Ramsar Convention - on the protection of wetlands of international importance
- International Union for Conservation of Nature (IUCN) - an International organization dedicated to natural resource conservation. IUCN publishes a "Red List" compiling information from a network of conservation organizations to rate which species are most endangered
- UNESCO's World Heritage Convention - a global instrument for the protection of sites of cultural and natural heritage. In 2004, Ilulissat Icefjord was admitted onto UNESCO's World Heritage List.

As uranium is one of the Project's products, the following international guidelines and standards are also relevant in connection with the EIA:

IAEA Safety Standard:

- Occupational radiation protection in the mining and processing of raw materials, IAEA Safety standards series No. RS-G-1.6, Vienna 2004. 95 p. (supersedes IAEA Safety Series No. 26)
- Establishment of Uranium Mining and Processing Operations in the Context of Sustainable Development, IAEA Nuclear Energy Series No. NF-T-1.1
- Best practice in environmental management of uranium mining. IAEA, 2009.

The OECD Nuclear Energy Agency (NEA):

- Managing Environmental and Health Impacts of Uranium Mining. OECD NEA, 2014.

4.5 Shipping regulations

Maritime regulations in Greenland comprise the equivalent Danish regulations which have been supplemented with specific regulations for navigation in Arctic regions. In addition, regulations and codes administered by the IMO (International Maritime Organization), together with international conventions adopted by Denmark, apply in Greenland.

A number of international conventions focus on environmental issues. These include:

- The MARPOL convention and the annexes (1973/78 International Convention for the Prevention of Pollution From Ships)
- The BWM convention (2004 - International Convention for the Control and Management of Ships' Ballast Water and Sediments)
- The OPRC convention (1990 - International Convention on Oil Pollution Preparedness, Response and Co-operation).

As a result of the special navigational conditions pertaining to Greenland waters, a safety package relating specifically to Greenland topics has been issued by the Danish Maritime Authorities. The safety package includes the following orders and recommendations relevant for the Project:

- Danish Maritime Authority Order no. 417 of 28. May 2009:

  "Order on technical regulation on safety of navigation in Greenland territorial waters"
- IMO recommendation A.1024 (26)

  "Guidelines for ships operating in polar waters".

A special agreement has been entered between the MLSA and the Danish Maritime Authority regarding "Guideline on investigation of navigational safety issues in connection with mineral exploitation Projects in Greenland as basis for navigation in the operations phase". The guideline specifies the contents of a navigational safety investigation to be carried out prior to starting the exploitation activities.

Blue Water Shipping has completed a Navigational Safety Study for the cargo requirements for the Project. This study has been reviewed and was accepted for use by the Danish Maritime Authority in October 2017 and is available for review as part of the public consultation process for the Project.

4.6 International Security Obligations

Uranium produced at the Project will be sold to commercial electricity utilities for use as fuel in nuclear power plants. All uranium sales will be governed by export control and nuclear safeguards laws enacted by Greenland and Denmark in 2016:

- ”Tunisassianik marloqiusamik atorneqartartunik avammut annissuinermik nakkutiginninneq pillugu Kalaallit Nunaannut inatsit”
- ”Atomip nukinganik atortussiat sorsunnerunngitsumut atornissaannik nakkutilliineq pillugu Kalaallit Nunaannut anatsit”
- ”Lov for Grønland om kontrol med eksport af produkter med dobbelt anvendelse (Nr. 616 2016)”
- ”Lov for Grønland om kontrol med den fredelige udnyttelse af nukleart material (Nr. 621 2016)”.

5. Project Alternatives

A number of alternative Project configurations have been considered during the course of the Project design phase. This chapter outlines the alternatives that have been considered.

5.1 Not proceeding with Project

Not proceeding with the Project is an alternative in an economic environment subject to falling commodity prices and increasing processing costs. Not proceeding with the Project would mean any environmental and social impacts and benefits would not occur.

The Project has the potential to provide significant short and long term social and economic benefits to Greenland and in particular the Narsaq region including:

- Up to 1,171 direct construction jobs
- 715 direct operations jobs
- Capital expenditure of approximately USD on construction of the Mine, Plant and infrastructure
- Additional investment in associated infrastructure for the Port and Village
- Operational expenditure of approximately USD per annum over the 37 year life of the Project
- Business opportunities for local and national suppliers to provide good and services during construction and operations
- Education and training opportunities
- Revenue for Greenland in the form of production royalties, personal and corporate taxes amounting to per annum.

5.2 Processing Alternatives

Three alternative processing alternative scenarios were examined in detail:

1. Concentrator only option
2. Mechanical (concentrator) and chemical processing (refinery) option
3. Greenland separation plant option.

A summary of the alternatives which were assessed in included below.

5.2.1 Scenario 1: concentrator-only

The concentrator only option involves the separation of minerals using physical separation methods only. This option would produce three products:

1. A REE and uranium bearing mineral concentrate
2. A zinc mineral concentrate
3. A chemical precipitate - fluorspar.

This option would produce the simplest form of REE product which would require further processing outside Greenland. This option avoids the high cost of building and operating a complex chemical processing facility in Greenland.

5.2.2 Scenario 2: Mechanical (concentrator) and chemical processing (refinery)

This option allows RE and uranium bearing mineral concentrate to be treated to produce value added products in Greenland. The treatment of the mineral concentrate produces the following products:

- Lanthanum oxide
- Mixed lanthanum and cerium oxide
- Cerium hydroxide
- Mixed REE Oxide
- Uranium Oxide.

In addition, the following products are also produced in this development option:

- A zinc mineral concentrate
- A chemical precipitate - fluorspar.

This option is aligned with the priority of the GoG to ensure that, as much as practically possible, processing of mineral products takes place within Greenland. As such GML has opted for this as the preferred scenario. Under this development option some of the REE products will require further processing outside Greenland.

5.2.3 Scenario 3: Greenland Separation Plant

This option involves the construction of a RE separation complex in Greenland to produce 15 separated REE oxides. The metallurgical processing of REEs is one of the most complicated processes in the mining and chemical industry and separating individual RE oxides is very difficult.

It requires:

1. Proprietary extraction technology. This technology is not available for purchase or licensing as it is a key commercial advantage for its current holders.
2. Significant capital expenditure in REE separation facilities. This will increase the capital hurdle required for Project financing.
3. Expertise and experience in the operation of separation plants. Limited resources available in Greenland.
4. Support services for maintenance and materials supplies which are not available in Greenland.

Other issues include the fact that developing a REE separation process involves significant technical risk and being located far from customers and markets will increase transportation costs significantly.

For these reasons GML has decided not to develop in-house REE separation technology or pursue the establishment of a separation plant in Greenland.

5.3 Alternative facility locations

Two potential locations for the concentrator and refinery, port and accommodation facilities were considered:

1. Location East - where the processing plant and accommodation facilities would be located at Ipiutaq and the port at Illunnguaq opposite Nunarsarnaq, 15 to 20 km northeast of Narsaq. The ore would be transported by haul trucks through a tunnel from the pit at Kvanefjeld. This scenario requires that the waste rock and tailings be deposited near the Ipiutaq area (see Figure 20).
2. Location West - where all mine facilities would be situated in the Ilua valley and near surroundings, and with the port at Narsap Ilua (Narsaq Bay) (see Figure 21).

The proposed locations are identified in the SIA including details of the public consultation undertaken, which resulted in Location East being abandoned.

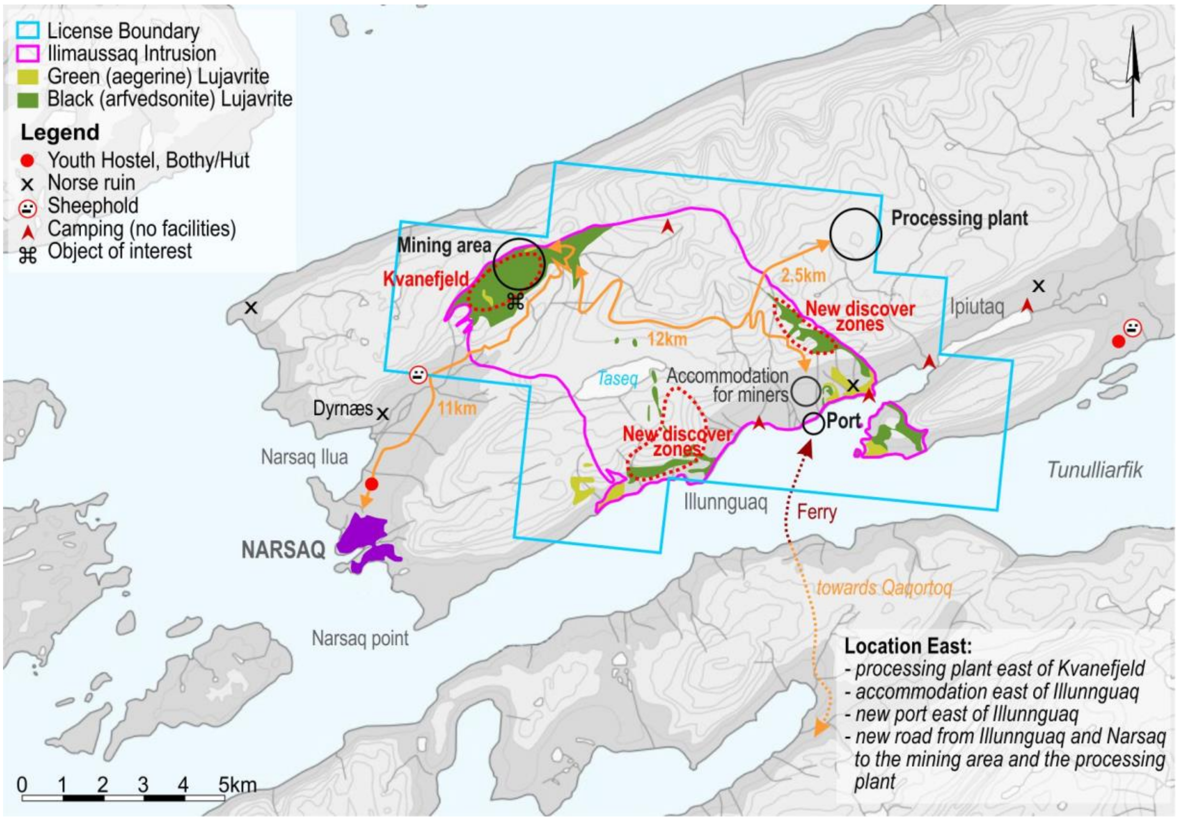


Figure 20 Location East

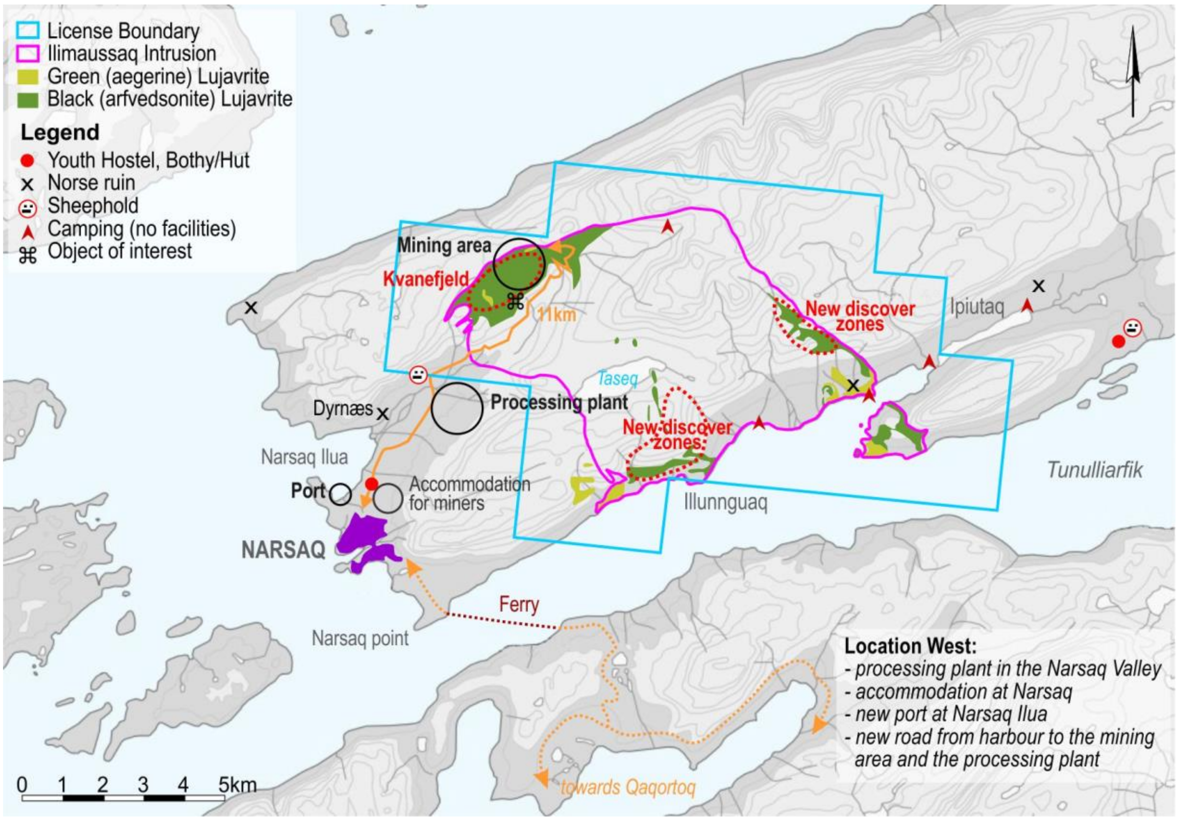


Figure 21 Location West

5.4 Alternative port locations

Two potential port locations were considered within Narsap Ilua bay. The two locations can be seen on Figure 22.

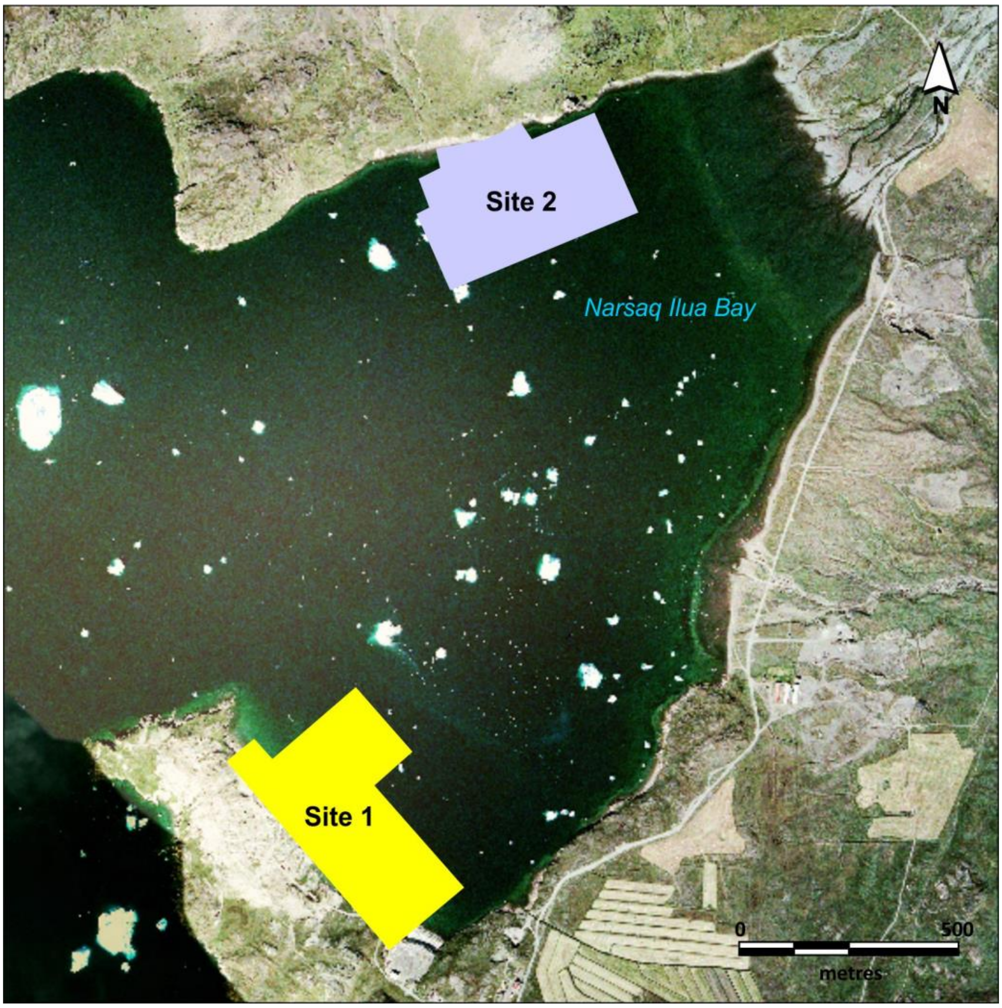


Figure 22 Potential Port Locations

Site 1 (on the Tunu Peninsula) offers good access for vessels and requires minimal dredging. Site 2 would have been closer to the Project area. Site 2 was rejected due to its proximity to a Norse farm ruin and the requirement for large-scale blasting to create space for container stacking and the storage of bulk cargo.

5.5 Accomodation facilities

A number of alternative options were considered for the accommodation of employees during the operations phase of the Project. The choice of a primarily FIFO workforce means that whichever accommodation option was selected, significant and regular turnover of residents would be expected as employees come on and off roster.

The two primary accommodation options which were assessed were:

- Integrating new housing for the Greenland and foreign workforce into the town of Narsaq; and
- Building a security-controlled worker's village on the north-west boundary of Narsaq.

The accommodation strategy needs to balance the benefits brought to Narsaq through revitalisation of town facilities and houses with the potential risk and social change associated with integrating a large foreign workforce into a small town. For these reasons, building a security-controlled worker's village on the north-west boundary of Narsaq was seen to present a better balance for Narsaq, and the workforce. The location of the Village will utilise currently undeveloped land. The development of a connecting road between the Port-Mine Road for the site and the Village will minimise traffic impacts in the town of Narsaq.

5.6 Tailings management alternatives

A review was undertaken to determine the lowest risk TSF location and storage methodolgy. The review concluded that wet storage of tailings in the Taseq basin during the Project's operation and post-closure phases to be lowest risk option.

Mechanical [crushing and grinding] and chemical processing [leaching] are used in mining operations to separate targeted valuable products from host material. Both processes have by-product or waste streams that typically comprise some or all of the following - host material, unrecoverable and uneconomic metals, chemicals, organics and process water.

These waste streams are known as tailings.

Tailings are normally discharged from a processing plant in the form of a slurry and are transported from the process plant to a final storage area commonly known as a tailings storage facility.

The selection of an appropriate storage facility for tailings depends on both geographical options in proximity to a processing plant and the nature of the tailings being stored.

Factors which influence the selection of the tailings disposal method and location include:

- ore types and geochemistry
- the volume of tailings produced
- the metallurgical process producing the tailings
- the quality of process water
- reagents used in the metallurgical process, and
- the environment in which the tailings storage facility is situated.

There are a range of proven approaches to managing the disposal of tailings and the associated tailings storage facilities.

Various designs and operating philosophies exist; however in open cut mining projects, tailings are generally stored on the surface in natural valleys or basins, within purpose built liquid retaining embankments for wet tailings and, for dry tailings, within purpose built embankments designed to contain dry stacks of filter cake.

The selected approach to managing and storing tailings must address 3 important, and closely interrelated questions:

- Where to locate the long term tailings storage facility?

  Considering site-specific factors including proximity to settlements and houses, hydrology, topography, climate, geochemistry and land use

- In what form will the tailings be deposited in the tailings storage facility and how will they be covered during the Project's operations phase?

  A range of options from slurry to filter cake, with either dry or wet cover

- How to manage the tailings storage facility after mining activities have ceased?
  - Whether to place a dry or wet permanent cover on the tailings storage facility

5.6.1 Conclusion

Following assessment and comparison of alternatives, sub-aqueous slurry deposition in the Taseq basin with a wet cover retained for closure/post closure periods has been selected for the management of Project tailings during and after mining operations:

The decision was the result of an assessment conducted in the steps summarized below.

Based on topographical analysis, seven sites were identified as potential tailings storage facility locations for the Project (TSF). The relative merit of each site was ranked by reference to potential environmental, social and technical risks.

The factors considered in the ranking were:

- Catchment/ Water Supply
- Footprint
- Vegetation
- Settlements impact/land use
- Visual impact
- Local ecology and recreation
- Geotech/geology
- Practical accessibility.

After a qualitative assessment considering these 8 criteria, the Taseq basin (referred to as Taseq) emerged as the preferred location for the TSF.

The appropriateness of Taseq as a potential location for the Project's TSF, as submitted in earlier drafts of the EIA, has also been commented upon by the external agencies.

> "The selected site for the tailings facilities is a natural lake. Taseq lake is surrounded by ridges and embankment will be constructed over time to contain the tailings and water cover. The site appears to provide a suitable topographic form for a tailings facility. While we recognize that some regulators limit the use of lakes for tailings facilities, we believe the use of a lake in this instance provides the opportunity to create a more stable landform on closure of the mine and tailings facilities."
>
> *Recommendations for tailings, waste rock and water management for Kvanefjeld Multi-element Project.*
>
> DCE – Danish Centre for Environment and Energy and GINR - Greenland Institute of Natural Resources 11. November 2016.
>
> "Based on DCE's and GINR's collaboration with geotechnical experts from RGC, we conclude that the selected site for the tailings facility, Taseq, as a natural lake provides an opportunity to create a stable landform on closure of the mine and the tailings facility".
>
> *Evaluation of AMEC revised report (Issue No. 4, June 2017) for Kvanefjeld Multielement* Project.
>
> DCE – Danish Centre for Environment and Energy and GINR - Greenland Institute of Natural Resources 23 August 2017.

Having identified Taseq as the preferred location for the TSF, three types of tailings were considered: dry, paste/thickened slurry, and conventional slurry.

Filter Cake Disposal	Dry
Thickened Tailings/Paste	Wet
Conventional Tailings Discharge (Slurry)	Wet

A naturally wet environment (such as Lake Taseq) limits the practicality of producing a dry tailings product for deposition during the Project's operations and the physical properties of the Project's tailings limit the capacity of the Project to produce high density thickened tailings.

Slurry has been selected as the preferred form of tailings for deposition.

Tailings in a slurried form can be deposited either sub-aqueously or sub-aerially. As with the deposition of dry tailings/filter cake, a naturally wet environment limits the practicality of sub-aerial deposition of slurried tailings. Sub-aqueous deposition has therefore been selected and a water cover will be maintained over the tailings during Project operations. The water cover will attenuate radiation exposure, desiccation and dust during Project operations.

Upon closure, a long term cover will be required for the tailings facility. One of the objectives of the long term cover is to minimize ongoing management requirements for the facility. The TSF could be covered with a dry cap or alternatively with water which would constitute the continuation of the approach adopted for the management off the TSF during mining operations

The environmental risks associated with maintaining a dry cover or wet cover for TSF in the post closure period have been assessed to be similar.

Operational complexities associated with preparing and maintaining a long term dry cover post closure were considered sufficient to elect to proceed on the basis of long term water cover for the TSF. These complexities arise from:

- The fact that the naturally wet environment will require drainage diversion measures which, in turn, will require permanent regular maintenance and reinforcement in order to avoid Taseq reverting to a wet system (as would occur naturally in the absence of drainage management); and
- The volume of differentiated construction material required for the dry cover, a significant proportion of which would likely need to be sourced from outside the Project area.

5.6.2 Evaluation of Tailings Deposition and Storage Alternatives

Selection of preferred location of TSF

Potential Locations

A high-level, desktop-based assessment was undertaken to identify all potentially viable tailings storage sites. The assessment was not limited to locations within the Company's current license boundaries.

The assessment had regard, in particular, to:

- Area/volume requirements
- Topography
- Distance from proposed plant site location
- Accessibility

- Avoidance of potential sterilization of future orebodies.

Seven sites were identified by the desktop assessment:

A. Taseq basin area
B. South of the open pit, north east of the town of Narsaq
C. Central valley site, east of the Nakalak range
D. Natural basin, east of the Nakalak range
E. Valley site, west of Mt Naajarsuit
F. Sahannguit Fjord, northwest of Ipiutaq
G. Valley site, east of the Nakalak range.

These alternatives are shown on the two images below.

Figure 23 3D view of tailings alternatives

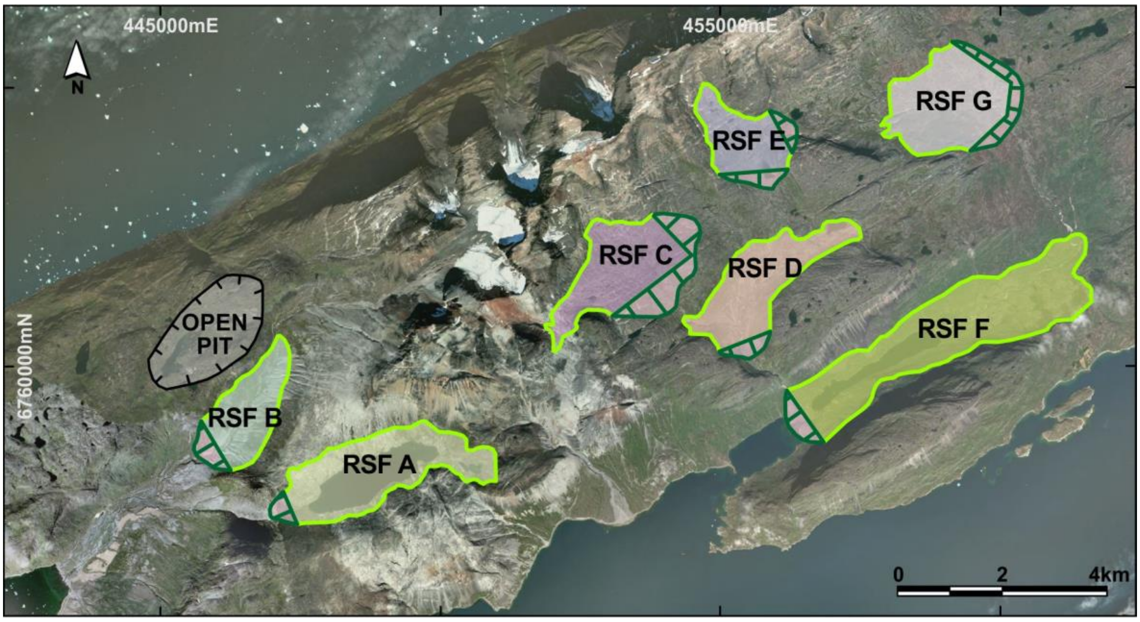


Figure 24 RSF alternatives

Two of the sites identified by the desktop assessment were considered to be non-preferable for the deposition of dry tailings (Taseq basin area (A) and Sahannguit Fjord, northwest of Ipiutaq (F)) as they are both naturally wet environments.

All of the other sites were considered to be appropriate for either wet or dry tailings deposition as set out in the table below.

Table 9 Appropriateness for condition of tailings

Appropriateness for condition of tailings		
Location	**Wet**	**Dry**
A	✓	
B	✓	✓
C	✓	✓
D	✓	✓
E	✓	✓
F	✓	
G	✓	✓

Ranking of potential locations and selection of preferred location

In order to facilitate the development of a method to rank the seven sites, a range of criteria [environmental, social and technical) were identified. Each site was scored for each criteria.

The scores reflect the likelihood of impact from the development based on each factor. The resources necessary to mitigate issues are also reflected in the scores.

A score of 1 is given to minor potential impacts whereas a score of 2 or 3 is used to highlight differences between a minimal effect and more adverse impacts.

Scoring a 3 on any criteria identifies a potentially unacceptable impact to the use of that location as a TSF.

The following ranking categories were defined

1. Water Catchment
2. Footprint
3. Biodiversity
4. Settlements impact
5. Visual impact
6. Local ecology and recreation
7. Geotech/geology
8. Practical accessibility.

1. Water Catchment

Potential impacts to water catchment areas were assessed based on site geology, community water supply abstraction points and surface water sources.

Score 1 No impact to community water supply or surface water sources. Area is downstream of water source

Score 2 Potential impact to community water supply or surface water sources

Score 3 Impacts community water supply.

2. Footprint

The amount of land disturbance was based on the immediate footprint required for each facility and its associated supporting infrastructure, including pipelines and roads required to connect the TSF to the plant location (ranked smallest to largest).

Score 1 Relatively small footprint

Score 2 Of intermediate scale

Score 3 Relatively large footprint.

3. Biodiversity

Impact on biodiversity was assessed based on presence of vegetation, and the intrinsic value of the vegetation and fauna habitat.

Score 1 Area is barren rock or has no particular habitat value

Score 2 Vegetation is evident but common. Habitat value is low. Would result in some degradation of natural environment

Score 3 Vegetation is evident, potentially rare or has commercial value. Habitat value is high.

4. Settlement impact

Impact was assessed by reference to the proximity to local population or communities

Score 1 Relatively distant from any human habitation

Score 2 Located within 4-8 km of human habitation

Score 3 Located closer than 4km to human habitation.

5. Visual impact

Impact was assessed by reference to the proximity to local population or communities

Score 1 Unlikely to be visible from vantage points

Score 2 Visible from at least 1 vantage point

Score 3 Visible from a number of potential vantage points.

6. Ecosystem services and recreation

The Project has the potential to generate impacts to the benefits people derive from ecosystems (referred to as ecosystem services) through the disruption of the existing ecosystem as a result of its activities. Types of potential impact include: impacts to recreational use of areas, impacts to water sources and landform stability (e.g. erosion protection), and impacts to cultural areas (e.g. heritage sites).

Score 1 Limited or no impact to ecosystem services

Score 2 Moderate impact

Score 3 Significant impact from land clearing, noise, dust, access restriction etc.

7. Geotech/geology

The level of porosity in the geological substrate that underlies the potential sites

Score 1 Underlain by non-porous crystalline igneous rock with low permeability

Score 2 Underlain by layers of differing levels of porosity

Score 3 Underlain by medium to coarse grained sandstones.

8. Practical accessibility

The practical accessibility of a potential site considers the physical distance between the site and process plant, the elevation changes between the two sites and the relative ease of construction of the infrastructure corridor between the two facilities (referred to in the descriptors below as topography). The lower the practical accessibility, the greater the environmental impact anticipated from developing and operating the infrastructure corridor.

Score 1 Short distances, storage facilities at similar or lower RLs, benign impact of topography

Score 2 At least one of the three factors identified above having a significantly negative impact

Score 3 Longer distances, storage facilities at higher RLs or requiring traversing of an infrastructure corridor with higher RLs, negative impact of topography.

The assessment of the impact of each of the criteria is has been tabulated below in Table 10.

Table 10 Assessment of impact

Criteria	RSF Site Option						
	A	B	C	D	E	F	G
Catchment / Water Supply	2	2	3	2	2	3	2
Footprint	2	1	2	2	2	3	3
Vegetation	1	3	2	2	1	3	1
Settlements Impact/land use/ownership	2	3	2	1	1	3	1
Visual Impact	2	3	2	2	2	3	3
Local ecology and recreation	2	3	2	2	2	2	3
Geotech / Geology	1	2	2	2	2	2	3
Accessibility	1	1	3	2	3	3	3
Total Score	**13**	**18**	**18**	**15**	**15**	**22**	**19**

After consideration of all factors the preferred site is A – the Taseq basin area.

It scored the lowest overall ranking and no criteria was assessed with a 3 thereby avoiding the risk of an unacceptable impact being associated with the location.

Selection of the form of tailings and deposition method

The Taseq basin is a natural, impermeable basin located on the Ilimaussaq intrusion. The basin does not overlay any potentially valuable mineralization and currently holds a lake. The lake is an alkaline environment and its contents are not potable nor do they support fish life.

The lake is not visible from the fjords or from the town of Narsaq.

The deposition of tailings in a number of physical forms was considered for the Taseq basin:

- Dry tailings deposition — Filter cake
- Wet tailings deposition — Thickened slurry/paste
- Wet tailings deposition — Traditional Slurry
  - subaqueous deposition
  - sub-aerial deposition.

A further alternative, tailings and waste rock co-disposal, was considered to be unsuitable for the Project. With co-disposal, dewatered tailings are stored with waste rock after physically blending up to 10% tailings per unit of waste rock and placing the remaining product into a "void" formed within the waste dump. The void is then sequentially covered with rock. As a result of the potential environmental impacts from dust and radon/thoron exhalation from desiccated tailings, together with the requirement for further materials handling at the Plant and transportation to the WRS, co-disposal was considered unsuitable for the Project.

Dry tailings deposition - Filter cake

Some level of dewatering of Taseq Basin will be required for all the disposal options which have been considered; however, the extent of the dewatering will be greatest for dry tailings deposition.

For dry deposition, slurried tailings are dewatered to produce a filter cake (Cake), typically containing 70 to 85 solids % by weight. The moist Cake is subsequently moved to a storage facility where it is dumped into a heap allowing the tailings to tumble down the free face of the heap to form a slope at the material's natural angle of repose. The angle of repose will vary in accordance with the grading of the material, its cohesion and its moisture content at the point of dumping.

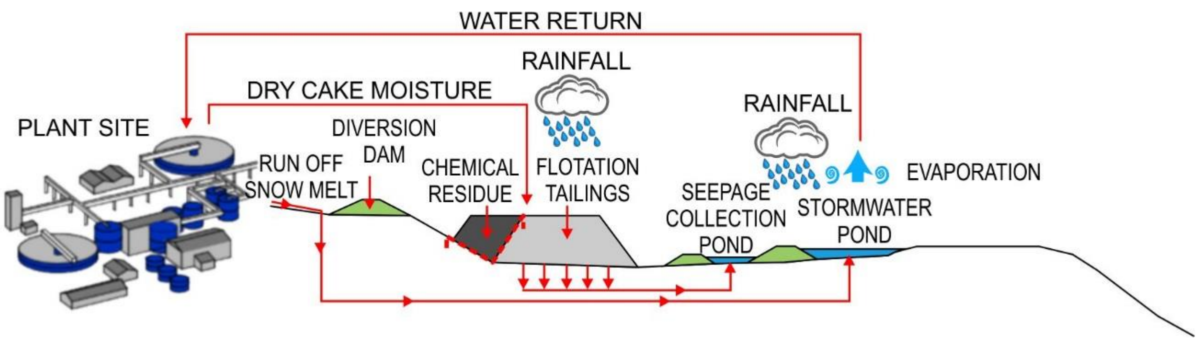


Figure 25 Dry Tailings Disposal design

A return water dam is required downstream to capture any seepage and storm water. For the Project, return water would be recycled during Project operations with any excess water placed into Nordre Sermilik fjord after treatment.

Dry tailings deposition would also require:

- diversion mechanisms to prevent tailings from being exposed to surface water or snow melt, and
- an embankment wall.

Dry tailings deposition is best suited to relatively flat topography.

A stack or heap of Cake cannot be sequentially covered with earth-fill without sterilising a portion of the capacity of the facility. As a consequence, during the Project's operations phase, the stack or heap will be prone to desiccation and dust emissions unless alternative dust suppression technologies are developed and installed. If dust were to be generated it could be an additional source of radioactive emissions.

Wet tailings deposition – Thickened slurry/paste

Thickened slurry/paste deposition involves dewatering tailings to a specific bulk density before depositing the tailings in a storage facility. The final pulp density of the tailings will be a function of operational factors [rheology, pumping capacity, distance to tailings storage facilities].

At the storage facility thickened tailings are discharged from a series of open-end points elevated either above or below the tailings surface and the thickened tailings behave as a plastic viscous fluid and flow either as a series of interconnected streams or as a sheet. When the material's internal friction exceeds the forces causing it to flow, the stream will stop moving and both coarse and fine particles settle out together liberating the interstitial free water.

The resultant beach surface usually comprises in excess of 95% of the discharged solids and is relatively erosion resistant under normal conditions.

Resultant supernatant is typically treated and recycled.

Paste thickened tailings disposal is considered suitable for tailings which exhibit a particle size grading of at least 15% below 20 µm. As this profile is not consistent with the profile of Project's tailings stream this method of tailings deposition was not considered to be appropriate for the Project.

Wet tailings deposition – Traditional Slurry

Slurry disposal of tailings is used extensively in the mining industry.

Slurried tailings can be deposited into a storage facility sub-aqueously or sub-aerially.

a) Sub-aerial (above water) deposition

   Slurry is pumped via pipeline from source to deposition points [spigots, cyclones, open pipes] located above the disposal area located within the storage facility.

   Early separation of interstitial water from the mass is encouraged by sequentially discharging the tailings onto the upstream beach in small layers. Gently sloping beaches of settled material form at the outlets.

   The discharge points are regularly moved and recently deposited layers dry. After an appropriate period a new layer of tailings is then placed over the dried area.

   A transport corridor for discharge and return pipelines will be required.

   A sub aerial slurry tailings storage facility cannot be sequentially covered with earth-fill without sterilising a portion of capacity of the facility. As a consequence, during the operations phase of a project, as material dries it can be prone to desiccation and dust emissions and can be an additional source of radioactive emissions.

Given the potential for dust and the associated radon risk, sub-aerial deposition of tailings is not considered appropriate for the Project.

b) Sub-aqueous (below water) deposition

Tailings storage facilities containing tailings with the potential to produce acid mine drainage are typically covered with water to prevent oxidation. The Project's orebody is not characterized by sulfide mineralization and will not produce acid if oxidized. However, the Project's tailings are mildly radioactive and a water cover provides an effective barrier to this level of radioactivity.

Slurry is pumped via pipeline from the source to open-ended pipe deposition points located below the surface of water covering the tailings storage facility. A floating barge can also be utilised to assist in the distribution of tailings.

The sequential hydraulic deposition of tailings sub-aqueously encourages natural separation with coarse material being deposited on a steep sub-aqueous beach adjacent to the point of deposition and the finer material being transported further into the supernatant pond where, depending on the time of retention, it will settle out and consolidate.

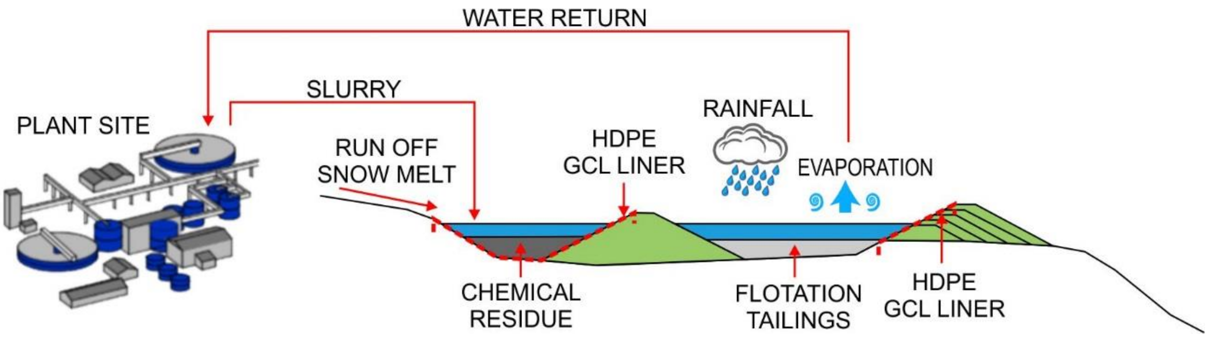


Figure 26 Wet Tailings Deposition design

Due to the potential for high colloidal levels within the supernatant water, direct discharge of excess supernatant to the environment will not be possible and return water is recycled.

A transport corridor for discharge and return pipelines will be required.

Environmental Risk Assessment of Tailings Disposal options

In January 2018, an environmental risk assessment on tailings disposal options in the Taseq basin (ERA) was prepared by Wood plc (Amec Foster Wheeler).

The ERA assumes that the TSF in the Taseq basin would be designed, operated and maintained using best available technology and practice having regard to guidelines and recommendations from the IAEA, the Mine Environment Neutral Drainage (MEND) Program, the Mining Association of Canada and international best practice, including that of the European Commission.

The 2 options for tailings deposition reviewed were: dry stacking of Filter cake and sub aqueous deposition of conventional slurry tailings.

For the review of the dry deposition it was assumed that tailings will be filtered at the process plant and trucked and deposited into a dewatered Taseq basin. It was further assumed that a seepage return water pond will be constructed downstream to capture any seepage and storm water. Excess water will be recycled.

The ERA concluded:

"**The environmental risks associated with wet vs dry deposition during operation are very similar**. Twelve risks were identified with the wet deposition of which four are moderate and ten risks with dry deposition of which four are also moderate and the rest low".

The 4 material risks for dry deposition that were ranked as moderate were:

- Major slope failure of dry stack
- Need to release untreated water to the Bredefjord (Nordre Sermilik)
- Transport of contaminated particulate matter into the valley from the TSF facilities [dust]
- Spillage of return water between TSF and the Water Treatment Plant during transportation.

Mitigation measures for dry deposition were considered in the ERA but are not discussed further as dry tailings was not selected for the Project.

The 4 material risks for wet deposition that were ranked as moderate were:

- Full failure of embankment
- Partial embankment failure
- Spillage of return water during transportation
- Need to release water into the fjord.

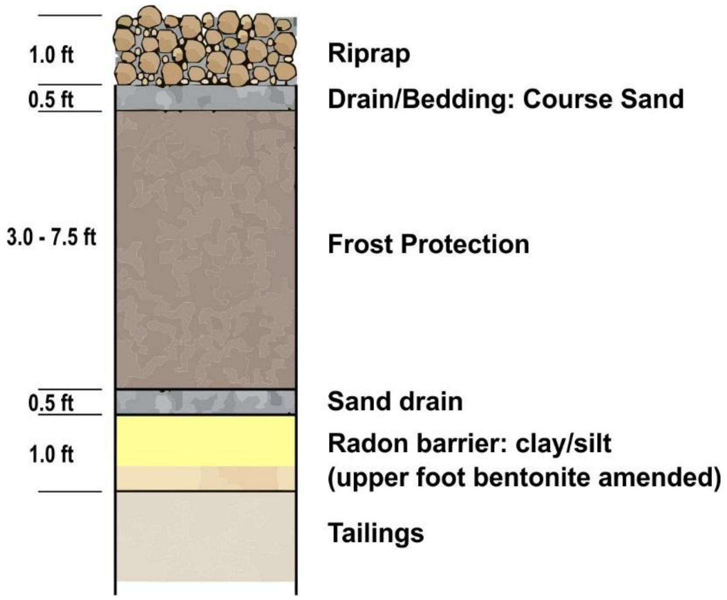
These risks will be managed utilizing a suite of mitigation measures including:

- Designing the embankment in accordance with international best practice and International Commission on Large Dams (ICOLD) design criteria and guidelines.
- Utilisation of best practice for tailings emplacement
- Monitoring of the return water pipelines
- Emergency retention ponds along the pipeline route
- Insulated pump housings to avoid freezing
- An emergency response plan making provision for potential spillages.

Selection of long term cover for TSF post Mine closure

Dry TSF cover at closure/post-closure

Dry cover involves capping the TSF once deposition of tailings has ceased. Typical capping includes a radon barrier immediately on top the tailings, above which are, consecutively, a sand drain layer, a frost protection layer, a drain/bedding layer of coarse sand and a riprap layer as a final surface layer.



International Atomic Energy Agency IAEA (2004) The long term stabilisation of uranium tailings, TECDOC 1403

Figure 27 Section view of dry TSF capping

Diversion channels around the dry TSF would need to be maintained in the long-term to reduce erosion risk. There will be limited treatment (< 6 years) of storm water and seepage but water quality monitoring will be ongoing.

A significant issue for the long term dry cover of the Project's TSF is the requirement for up to approximately 25 Mt [based on the profile in the diagram above] of material to cover the expected area of the facility at the end of the life of the mine.

Acquiring the various categories of capping material is anticipated to be problematic. Long term glaciated products do not include the range of materials that will be required: potentially sand, clay silt and broken rock/pebbles of various sizes. This is particularly the case in the volumes that would be required to cap the Project's storage facility. A number of millions of tonnes of clay and sand, potentially segregated into coarse and fine, would be required and would need to be transported in to the site which in turn has the potential to affect the biodiversity of the area through the introduction of new organisms.

A potential source of some of the capping material, the frost protection and rip rap layers, could be the Project's WRS. However, the material in the WRS is undifferentiated blast product which, without some form of further crushing and or screening, is unlikely to be suitable for any part of the dry cover.

Wet TSF cover at closure/post-closure

Wet cover involves retaining a layer (minimum of 1.5 m) of water on top of the tailings to avoid exposure of the tailings to the atmosphere. If required, a thin layer of shallow, inert sand would be applied sub-aqueously on top of tailings to prevent their re-suspension.

Supernatant water would be treated for a minimum of 6 years after the end of mining and processing activities in order to meet water quality criteria at which point surface water will be allowed to return to the basin.

Once the required water quality has been achieved, the water level in the dam will be allowed to gradually rise until it reaches the level of the embankment wall spillways at which point water will flow over the spillway and into the natural surface drainage system.

Spillways will be maintained however diversion channels will not be maintained post Mine closure and these will be allowed to fill with sediment.

Environmental Risk Assessment of Long Term Cover Options for Tailings Facilities

The January 2018 ERA also included as assessment of closure cover options for the proposed Taseq TSF. The ERA concluded:

"The environmental risks at closure are similar for the wet and dry cover options.

Eight risks were identified associated with wet closure of which two are moderate, while five risks were identified with dry closure of which two are moderate and the rest low.

However, Taseq area is a natural basin making it inherently more suitable for a wet closure. For the dry cover option significant ongoing maintenance of diversion and runoff control structures in perpetuity will be required to minimize the risk of erosion, while for the wet cover option maintenance of the embankment closure spillway will be required."

The two potential environmental risks ranked as moderate for the dry cover at closure option were:

- Long term erosion of the dry cover and stack
- Major slope failure of dry stack.

Mitigation measures for a dry cap were considered in the ERA but have not been detailed here as dry long term cover was not selected for the Project.

The two potential environmental risks ranked as moderate for the wet cover at closure option were:

- Full failure of embankment
- Partial embankment failure.

These risks will be managed utilizing a suite of mitigation measures including:

- Designing the embankment in accordance with international best practice and International Commission on Large Dams (ICOLD) design criteria and guidelines.
- Lining of upstream slopes
- Utilisation of best practice for tailings emplacement
- Utilising a downstream construction method
- The installation of high capacity upstream diversion trenches
- Long term maintenance and monitoring of the embankment post closure through a financial vehicle to be agreed between GML and the Government of Greenland.

5.7 Energy alternatives

Heavy Fuel Oil

The installation of a 59 MW HFO-fired combined heat and Power station was studied for the Project.

On the basis that HFO produces significantly higher levels of sulphur emissions that the generation of equivalent levels of electricity from diesel combustion, the use of HFO for power generation for the Project was abandoned.

Hydro-electricity

The application of hydropower for the Project was first studied by Risø in the 1980s. Johan Dahl Land, located approximately 55 km away, was previously identified as a potentially suitable source for hydropower.

GML commissioned experienced hydropower plant specialists to determine the feasibility of applying hydropower to the Project (Orbicon 2014a). This study identified that to provide the hydropower energy to meet the electrical power requirements (approximately 35 MW) for treating 3 Mtpa of ore would require the damming and diversion of three elevated lakes in the Johan Dahl area. This would also require the construction of a diversion tunnel to be built that feeds lake water to hydro turbines for electricity production. The electricity would then need to be transmitted to the Project site from John Dahl Land by an above ground 55 km power line.

On the basis of the substantial infrastructure construction required this option was not considered feasible for the first stage of development. Future expansion options will consider the use of hydropower as a credible alternative source of energy.

6. Environmental assessment methodology

6.1 Introduction

The Project's EIA takes into account a number of factors as summarised in Section 6.2.

This impact assessment was undertaken in compliance with the *Mineral Resources Act* 2010 and identifies potential environmental impacts associated with construction and operation of the facility, as well as proposed mitigation.

Studies performed by independent consultants include but are not limited to the following:

Physical

- Noise Assessment (Orbicon).

Atmospheric

- Air Quality Assessment (ERM)
- Greenhouse Gasses Assessment (ERM).

Water Environment

- Hydrology and Climate (Orbicon)
- Preliminary Groundwater Impact Assessment from Tailings Facilities (GHD)
- Water Quality Assessment of Tailings Water and Waste Rock Run off (Orbicon)
- Marine Discharges and Fjord Dynamics - Modelling and Interpretation of Ecotoxicology Studies (DHI)
- Life of Mine Modelling (Water, Fluoride and Uranium) (GHD)
- GOLDSIM Life of Mine water Modelling – water fluoride and uranium (GHD)
- Oil and chemicals and assessment of potential impacts of spills (Orbicon)
- Tailings Dam Failure Assessment (ARCADIS Canada).

Biodiversity

- The Natural Environment of the Study Area (Orbicon).

Local Use and heritage

- Local Use Study (Orbicon)
- Archaeological surveys (Greenland National Museum & Archives)
- Social impact Assessment (Shared Resources).

Radiological emissions

- Radiological assessment (ARCADIS Canada)
- Uranium Product Transportation Assessment (ARCADIS Canada)
- Radiation Monitoring Plan Outline (ARCADIS Canada)
- Radon and Thoron Releases (ARCADIS Canada).

Tailings Storage Facility

- Flotation Tailings and Chemical Residue Storage Facilities Feasibility Study Kvanefjeld Rare Earth and Uranium Project, Greenland (Amec Foster Wheeler Earth & Environmental (UK) Ltd.)
- TSF Environmental Risk Assessment Tailings Disposal and Closure Cover Options (Wood Group).

Geochemical Characterisation

- Geochemical/Environmental testwork (SGS Lakefield Oretest).

6.2 Impact assessment methodology and structure

Consistent with the *Guidelines for preparing an Environmental Impact Assessment (EIA) report for mineral exploitation in Greenland* (MRA 2015) and in order to best present the environmental baseline data and the assessment of potential environmental impacts, this report has been structured to consider Project impacts associated with each of the environmental factors set out below:

- Chemical and toxicological factors (pollution) which have been broken down into:
  - Physical Environment (Section 7)
  - Atmospheric Setting (Section 8)
  - Radiological Emissions (Section 9)
  - Water Environment (Section 10)
  - Waste Management (Section 11)
- Disturbance aspects (impacts on flora and fauna) (Section 12)
- Local use and local knowledge (Section 13).

For each of the environmental factors the assessment has been structured to consider:

- Existing environment
- Potential impacts
- Assessment of impacts
- Mitigation
- Predicted outcomes.

6.3 Potential impacts

The potential impacts that are assessed for each environmental factor in this report are summarised in Table 11. The potential impacts include a source (from the mine Project), a pathway and a receptor.

Table 11 Potential impacts

Factor	Impact	Section
Physical Environment	Construction and operation of the Project has the potential to result in physical alteration of the landscape and reduced visual amenity.	7.3.1
	Construction and operation of the Project has the potential to result in erosion.	7.3.2
	Construction and operation of the Project will increase noise emissions and has the potential to result in reduced amenity as a consequence.	7.3.3
	Construction and operation of the Project will increase light emissions and has the potential to result in reduced amenity as a consequence.	7.3.4
Atmospheric Setting	Construction and operation of the Project will generate dust, which has the potential to result in reduced air quality and produce secondary impacts associated with the physical or chemical composition of the dust.	8.3.1
	During the construction, operation and closure phases, the Project will generate gaseous air emissions (oxides of nitrogen, oxides of sulphur, black carbon and polycyclic aromatic hydrocarbons (PAH)) which have the potential to reduce air quality	8.3.2

Factor	Impact	Section
	Construction and operation of the Project will result in increased greenhouse gas emissions.	8.3.3
Radiological emissions	Construction and operation of the Project will release radioactivity, which has the potential to result in contamination of the environment and affect human health .	9.3.1
	There is the risk of accidents during the construction and operation of the Project that may result in the discharge of radioactivity into the atmosphere, soil and water.	9.3.2
	Failure of TSF embankment has the potential to result in the release of tailings water and solids to land and water bodies downstream of the TSF and associated radiological exposure	9.3.3
	Release of aerosols from the TSF has the potential to result in contamination of land and release of radioactivity downwind of the TSF	9.3.4
Water Environment	Construction and operation of the Project will modify the hydrological processes which will potentially affect water quality.	10.3.1
	Operation of TSF has the potential to create contamination outside the TSF as a result of spills, damage to the TSF or wind.	10.3.2
	Release of aerosols from the TSF has the potential to result in contamination of water down wind of the TSF	10.3.3
	Discharge of water from the Project has the potential to affect the water quality of the Norde Sermilik fjord.	10.3.4
	There is the risk of accidents during the construction and operation of the Project that may result in the discharge of chemicals (i.e. oil spills) into the environment.	10.3.5
	There is the risk of accidents during the operation of the Project that may result in the discharge of process water into the environment.	10.3.6
Waste Management	Waste generated during construction and operation has the potential to result in environmental impacts if not appropriately managed.	11.3.1
Biodiversity	Construction and operation of the Project will result in disturbance of terrestrial fauna habitats.	12.3.1
	Construction and operation of the Project will result in disturbance of habitats for freshwater species.	12.3.2
	Construction and operation of the Project will result in disturbance of marine fauna habitat.	12.3.3
	Construction and operation of the Project has the potential to result in contamination of terrestrial fauna habitats.	12.3.4
	Construction and operation of the Project has the potential to result in contamination of freshwater and marine habitats.	12.3.5
	Construction and operation of the Project will involve increased vehicle traffic which has the potential to result in fauna mortality.	12.3.6
	Construction and operation of the Project will involve increased marine traffic which has the potential to introduce invasive non-indigenous species in ballast water.	12.3.7
Local Use and Cultural Heritage	Construction and operation of the Project will restrict local use of the Study Area.	13.2.1
	Construction and operation of the Project has the potential to affect cultural heritage sites.	13.2.2

6.4 Assessment of impact significance

The predicted outcome of each impact is summarised for each environmental factor. The predicted outcome is assessed after consideration of the impact of mitigation measures.

The assessment of the predicted outcomes considers, for each, the spatial scale of the impact, the duration of the impact and the significance of the impact.

Spatial scale of the impact

- Project Area — Direct disturbance by the Project, i.e. confined to the activities, the infrastructure itself and the very close vicinity of the Project
- Study Area — Up to 5 km from the activity
- Regional — From 5 to 75 km from the activity
- National — Greater than 75 km.

Duration (reversibility):

Duration means the time horizon for the impact.

Duration also incorporates the degree of reversibility of the impact, i.e. to what extent the impact is reversible, ranging from completely reversible to irreversible.

- Short term — The impact will last for a short period without any irreversible effects
- Medium Term — The impact will last for a period of months or years but without permanent effects or irreversible effects
- Life of Mine — The impact will last for the life of the Project
- Long term — The impact will potentially go beyond the life of the Project and potentially irreversible effects may result
- Permanent — The impact will be permanent.

Significance of the impact:

- Very low — Very small/brief elevation of non-toxic contaminants in local air/terrestrial/freshwater/marine environments (when concerning emissions) and decline/displacement of a few (non-key) animal and plant species from the sites of Project related activities and/or loss of habitat the sites of Project related activities (when concerning disturbance)
- Low — small elevation of non-toxic contaminants in local air/terrestrial/freshwater/ marine environments and/or very small temporary elevations of toxic contaminants (when concerning emissions) and decline/displacement of key animal and/or plant species and/or loss of habitat in the Study Area (when concerning disturbance)
- Medium — some elevation (above baseline, national or international guidelines) of contaminants, including toxic substances, in local or regional air/terrestrial/ freshwater/marine environments or decline/ displacement of key animal and/or plant species and/or loss of habitat at local level
- High — significant elevation of contaminants, including toxic substances, (above baseline, national or international guidelines) in local and regional air/terrestrial/freshwater/marine environments or decline/displacement of key animal and/or plant species and/or loss of habitat at regional level.

7. Physical environment

7.1 Existing environment

7.1.1 Climate

The climate in south Greenland is influenced by the North American continent and the North Atlantic Ocean, together with Greenland's inland ice and low sea surface temperatures. Average summer temperatures are below 10°C.

Situated only 40 km from the open ocean, weather in the local area is influenced by the ocean resulting in cool summers and relatively mild winters. No long-term weather station data is available for the Project area but data from weather stations in nearby towns provide average monthly temperatures throughout the year. Qaqortoq, located 30 km southwest of the Project and closer to the ocean, has an average temperature of -5.5°C in January and 7.2°C in August and July. Narsarsuaq, located 40 km east of the Project and further inland, has an average temperature of -6.8°C in January and 10.3°C in July. Narsaq is located between these two towns. The mine site is at higher elevation than Narsaq and therefore experiences lower temperatures.

Annual average precipitation in Qaqortoq is 858 mm and in Narsarsuaq 615 mm. The precipitation pattern in the Project Area is more similar to Qaqortoq, with an increase of 3% per 100 m of altitude. Snow depth is typically highest in February, where an average of 20 cm was recorded in Narsarsuaq and 41 cm in Qaqortoq.

Figure 28 displays the wind speed and direction recorded by the weather station at Kvanefjeld between 2010 and 2014. The predominant wind directions are from north east and south east. Most strong winds are recorded in the north east direction.

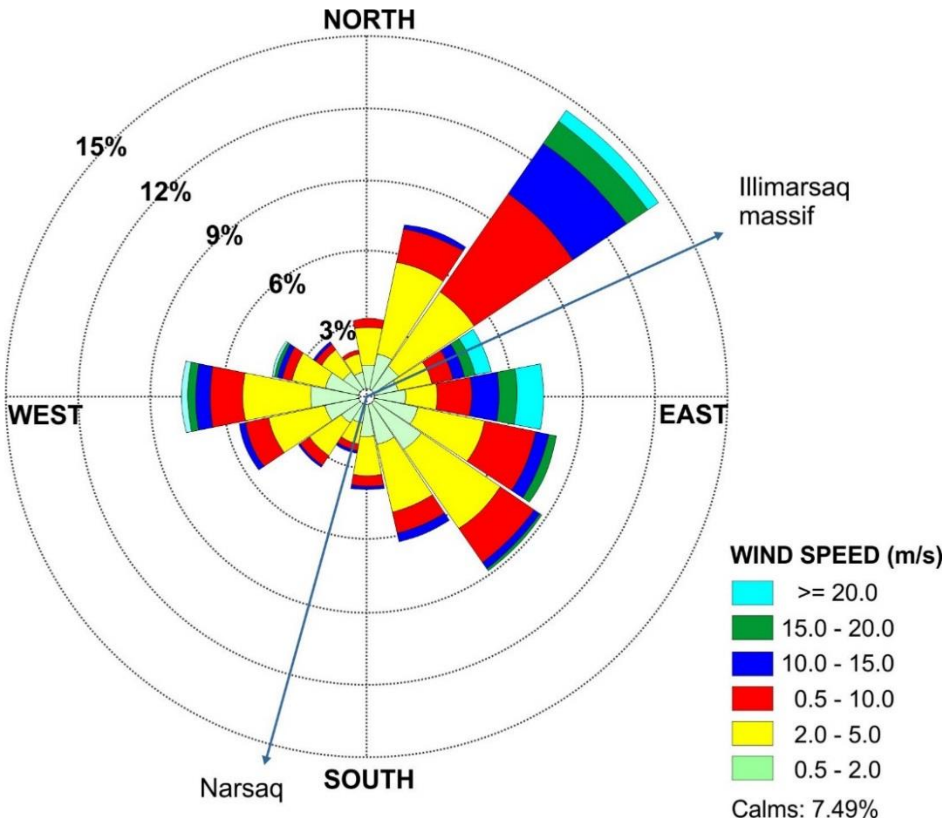


Figure 28 Wind directions and speed recorded from Kvanefjeld weather station

Foehn winds are bursts of dry and relatively warm air and are common in south Greenland and in the area of the Project. Foehns arise as a result of adiabatic compression of air sweeping down from the inland ice cap. When the foehn blows the relative humidity drops to 30-40% and the temperature rises by up to 15-20 °C within an hour and can remain elevated for up to two days. The effect of the foehn is particularly marked in winter, when it can result in rapid melting of snow.

7.1.2 Topography

The landscape in south Greenland is characterised by relatively high and steep mountains and by low islands and peninsulas in the coastal areas. This landscape has been largely formed through glaciation, which has carved long, narrow and deep fjords.

The Kvanefjeld deposit is located on the plateau at an elevation of 600 m, with the orebody outcropping at surface and with the highest grade material occurring in the upper zones. The deposit is situated on the Erik Aappalaartup Nunaa peninsula close to Narsaq town (Figure 29). South of the Kvanefjeld deposit are the Narsaq valley and the Narsaq river which drains into the valley and then to the fjord at Narsap Ilua Bay.

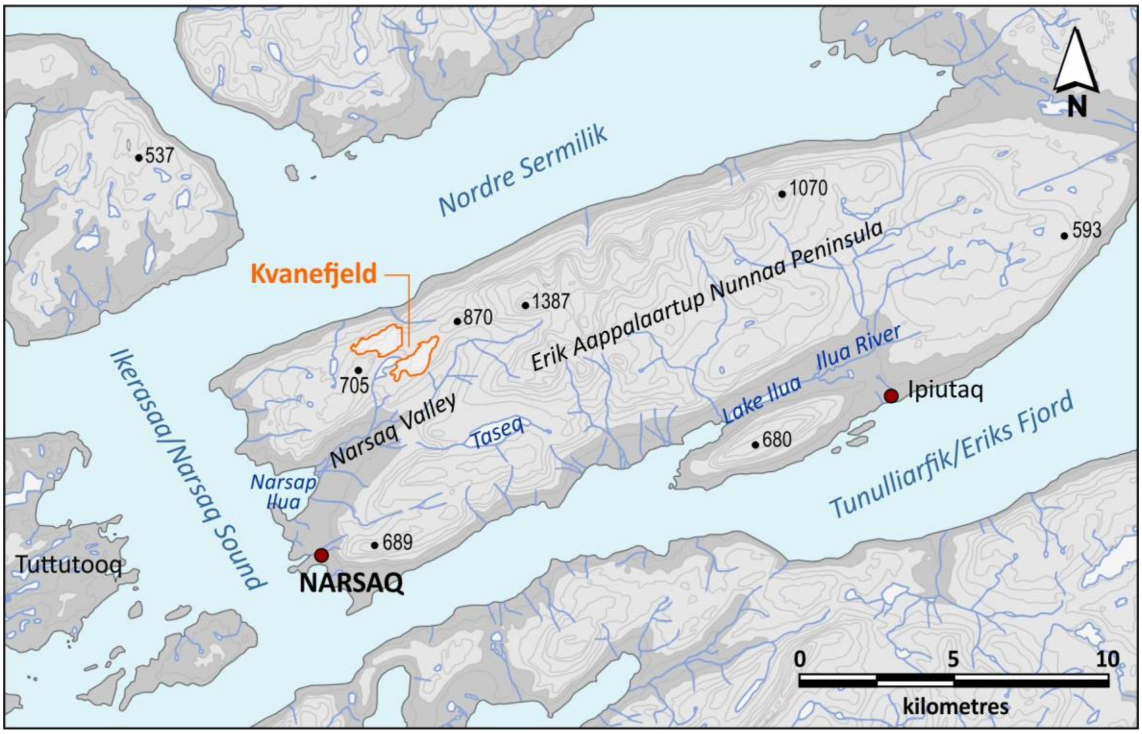


Figure 29 Elevation and contours

7.1.3 Geology and soils

Kvanefjeld has unique geological features, including volatile-rich alkaline magmas containing RE elements lithium, beryllium, uranium, and high-field-strength elements such as niobium and tantalum. Natural occurring radionuclides such as uranium and thorium are present in all soils and rocks.

The Kvanefjeld ore carries significant concentrations of uranium and thorium, approximately 300 and 800 ppm, respectively. Over time natural processes such as glaciation, wind and water erosion have dispersed uranium and thorium into the Narsaq valley and Narsaq town. The ore is located inside the north west margin of the Ilimaussaq intrusive complex, which is one of the intrusive complexes of the Gardar igneous province in south Greenland. Four successive layers of magma discharge formed the complex. The first layer formed the shell, followed by the second, comprised of a sheet of peralkaline granite. The third and fourth layers make up the bulk of the resource.

Steenstrupine is the dominant host to REEs and uranium. It is a complex sodic phospho-silicate mineral containing between 20 to 30% RE oxide, hosting approximately 50% of the uranium in the ore body. Other minerals that are important hosts to REE include the phosphate mineral vitusite, and to a lesser extent, cerite and monazite. Aside from steenstrupine, uranium is also hosted in unusual sodic silicate minerals that are rich in yttrium, heavy REEs, zirconium and tin. Minor uranium is also hosted in uranothorite and monazite. Zinc was identified in sphalerite, which is the dominant sulphide throughout the deposit.

Soil samples in the Narsaq valley indicate slightly elevated concentrations of zinc and lead. No other metal concentrations appear to be elevated from expected background concentrations.

7.2 Potential impacts

The potential impacts to the physical environment are:

- Construction and operation of the Project has the potential to result in physical alteration of the landscape and reduced visual amenity
- Construction and operation of the Project has the potential to result in erosion
- Construction and operation of the Project will increase noise emissions
- Construction and operation of the Project will increase light emissions.

7.3 Assessment of impacts

7.3.1 Visual amenity

The top rock layer of the outcrop at Kvanefjeld will be removed during the construction phase (pre-stripping). The material will be deposited as a rock pile next to the pit. These changes to the topography are permanent. Changes to the topography due to pre-stripping (and the subsequent mining) at Kvanefjeld and the creation of the WRS will have little or no visible impact on the town of Narsaq or the Narsaq valley (Figure 30). Over time, the pit will become deeper with a final depth of 80 m. The height of the WRS will reach 120 m by year 37 of the Project (590 mRL).

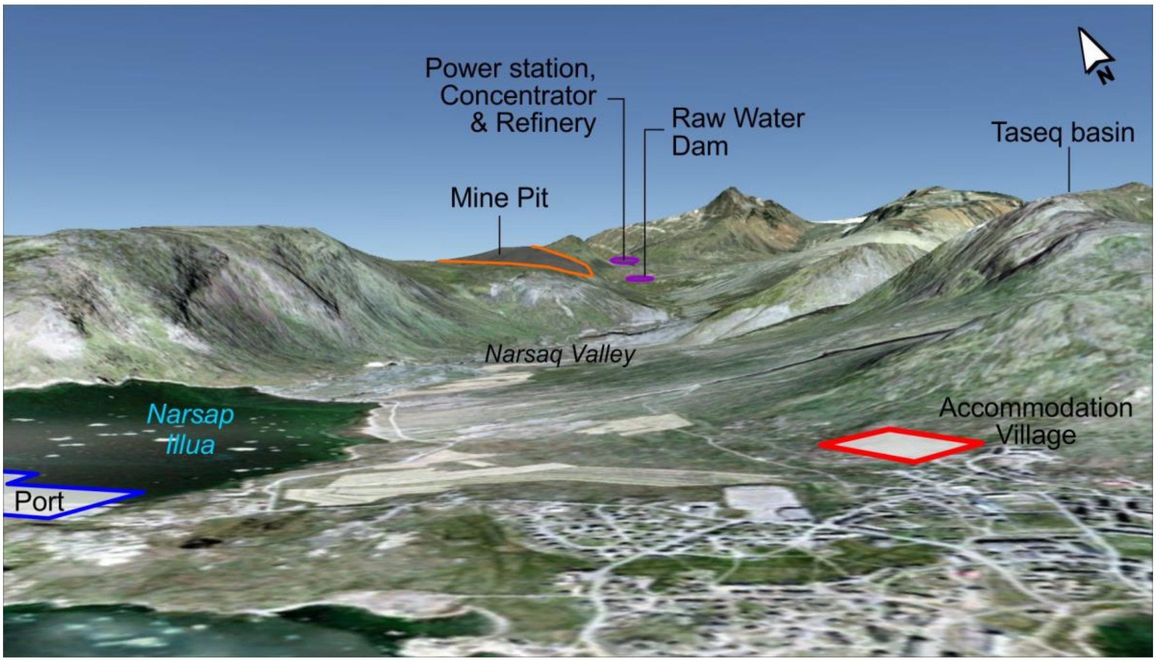


Figure 30 View of the developed Project from the Narsaq Town (Google Earth 2018)

A lined permanent embankment will be constructed across the outlet of Taseq basin and between Taseq basin and the pond to the northeast of the current main Taseq water body. The areas behind the embankments will be used for deposition of flotation tailings and chemical residue tailings. As described in Section 3.7, the height of the embankments will increase during mine life. Diversion channels will be constructed along the shore of both tailings ponds to prevent excess water entering the TSF.

Floating decant barges and a laydown area will be constructed at the edge of the TSF. The changes to Taseq basin and the upstream pond are permanent while the decant barges will be removed at mine closure. An assessment of impacts to surface water bodies is included in Section 10.

Situated high in a narrow valley behind Talut Mountain, Taseq basin is not visible from Narsaq or from most of the valley. After construction of the embankments, the tailings facilities will have little or no visual impact on the town or valley. The embankments and the diversion channels will be visible in the near field but since they will be covered by local materials (rock and gravel), the visible impact is limited. Over time the embankments will also be covered by natural vegetation which will further reduce their visual impact.

The construction of other Project facilities and related infrastructure will require some re-profiling of the landscape. The most important refrofiling will occur where the Plant and the Port are established. The Port-Mine Road will be constructed and a service road will connect the TSF with the Plant. Two pipelines will also connect the Plant with the TSF.

Some of the Project's components, for example the Plant, will be widely visible from the Narsaq valley and the fjord but will not be visible from Narsaq town. The Port and the Port-Mine Road will be visible from the valley but only to a very limited degree from Narsaq town. Following the decommissioning of buildings and machines at mine closure natural vegetation re-growth will occur and over time restore the vegetation cover. There are no current competing land uses and none are expected to develop in the future.

7.3.2 Erosion

In this context erosion is defined as transport of soil, sand and gravel by the forces of water, ice or wind. A number of construction activities have the potential to lead to erosion. These are:

- Preparation of construction sites
- Construction of the Port-Mine Road
- Pipeline alignments
- Stripping of the mine pit area
- Redirection of drainage
- Blasting to provide granular material for construction – e.g. for tailings embankments
- Construction of port.

Generally, erosion is not expected to be an issue or the Project as most construction works will take place in areas with consolidated rock. There are very limited clay or soils in the Project area as a result of to the local geology. Limited local erosion could potentially take place at the Plant and along the Port-Mine Road during construction. Activities during the Project's operations are not expected to cause significant erosion.

7.3.3 Noise and vibration

Noise is usually defined as unwanted sound. The human ear responds logarithmically to sound stimuli. A logarithmic scale, the decibel (dB) scale, is used to measure noise levels.

The perception of noise from a particular source depends, in part, on the level of background sounds in an area. Wind speed is an important parameter affecting natural background sound levels, and sound levels rapidly increase with increasing wind speed. In the Kvanefjeld area, the most common 10-min average wind speed is 2-5 m/sec which occurs 35% of the time. This wind speed range corresponds to a minimum natural background noise level of 30 dB(A).

Construction

During the construction phase significant noise will be generated by:

- Mobile equipment used in connection with excavation and construction of:
  - the Port
  - the Port-Mine Road
  - other roads
  - pipelines
  - the Plant
  - the Mine and associated facilities
- Pre-stripping of the pit area
- Drilling and blasting in the Port area and Mine areas
- Transport of supplies and machinery from the Port to the Plant and Mine area
- Vessel movements.

The noise load from land sources will be temporary wherever construction activities occur.

Ship traffic associated with the construction will increase noise levels at Narsaq. However, due to the low speed and the distance between the Port and Narsaq, the average noise contribution from vessel movements will be below the 35 dB(A) guideline for night time noise in residential areas.

Limited blasting will also take place in the Mine. Grading will take place to prepare level surfaces for lay down areas, access roads and during construction of haul roads. Construction of the Port-Mine Road will sequential, the road will be constructed in steps from the Port to the process plant area.

Blasted rock from Tunu Peninsula and from the mining area will be used as material for land reclamation and revetments. Impacts of noise and vibration on fauna species is discussed in Section 12.3.1.

Overall the noise impact in the Project's construction phase is expected to be at or below the noise loads which have been calculated and modelled for the Project's operations phase as discussed below.

Operations

Activities during the operation phase of the Project will result in an increase in the ambient noise level near several Project facilities (Orbicon 2015a). The noise assessment for the Project used 30 dB(A) as the ambient noise level that characterizes the existing baseline acoustical environment. Project operations activities that generate noise that exceed this value were classified as the "noise footprint" for the Project.

The noise assessment identified the following activity areas as the potentially most significant noise sources during operations:

- The mine area (pit, haul roads, Plant and Power station)
- The Port – Mine Road
- The Port area.

Noise loads for each of these areas were calculated using SoundPlan software. The Danish guideline limit for noise loads in industrial areas of 70 dB(A) was used to assess the noise impact of the Project's operations. The 70 dB(A) limit applies to the property boundary of an enterprise (fence line). Since the Project has no clear boundary line (there will be fenced areas for safety and security), the spatial pattern of noise loads was calculated and described for the entire working area for identified noise sources and the area that surrounds them.

The modelled noise load distribution generated by Project's operations in the open pit area, along the haul roads and at the two plant sites is shown in Figure 31.

Noise loads above the 30 dB(A) background level is limited to the Kvanefjeld areas and the upper parts of the Narsaq valley.

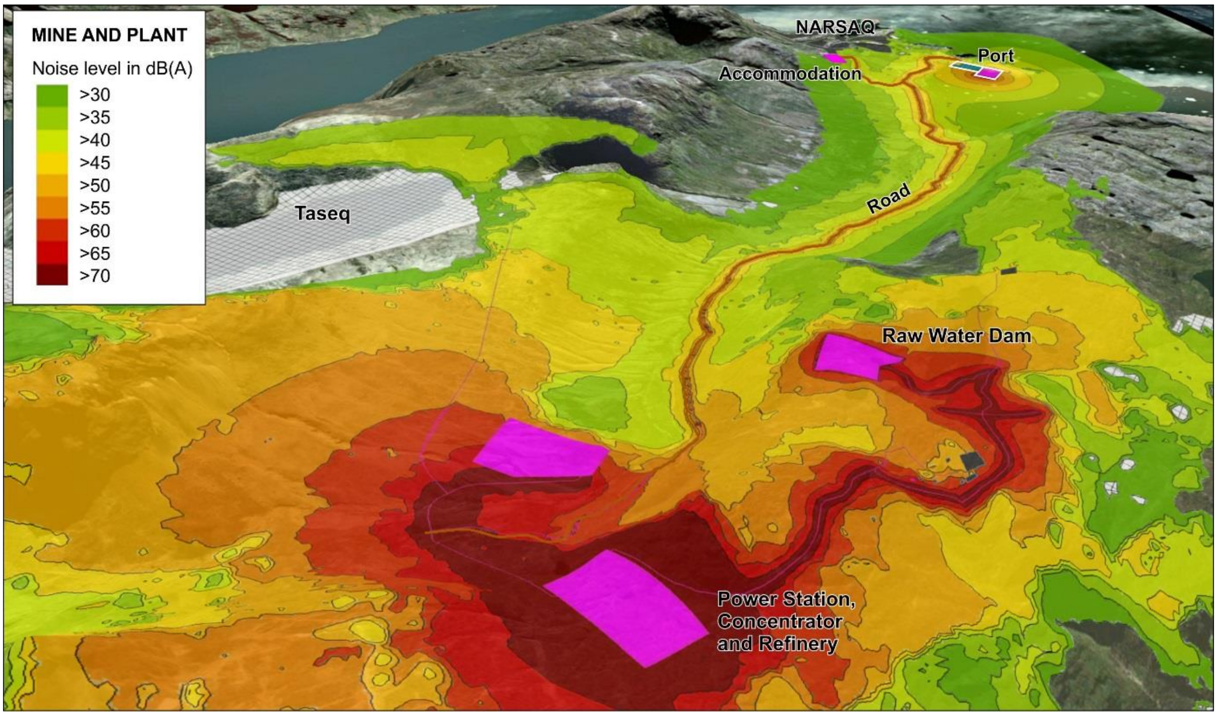


Figure 31 Calculated noise load for mine area and processing plants during operation

The noise footprint caused by trucks, buses and other vehicles traveling on the Port-Mine Road and the Port is shown in Figure 32. Noise levels above the 30 dB(A) background level extend for 800-1,200 meters on both sides of the road, depending on terrain. Traffic on the Port-Mine Road will not increase the noise level in Narsaq town.

The noise-sensitive locations closest to the Port-Mine Road are nine summerhouses situated just north of Narsaq in the Narsaq valley. These summer houses are occupied for a couple of months each year. The Project-related traffic noise level calculated for the houses closest to the road increases to 38.0 dB(A) during the day, 38.3 dB(A) during the evening and 38.7 dB(A) at night, only slightly above the natural background levels (Orbicon 2015a). Compared to Danish noise limits for summer housing during day, evening and night, the calculated noise levels are below the daytime limit (40 dB(A)), but exceed the 35 dB (A) limit for the evening and night.

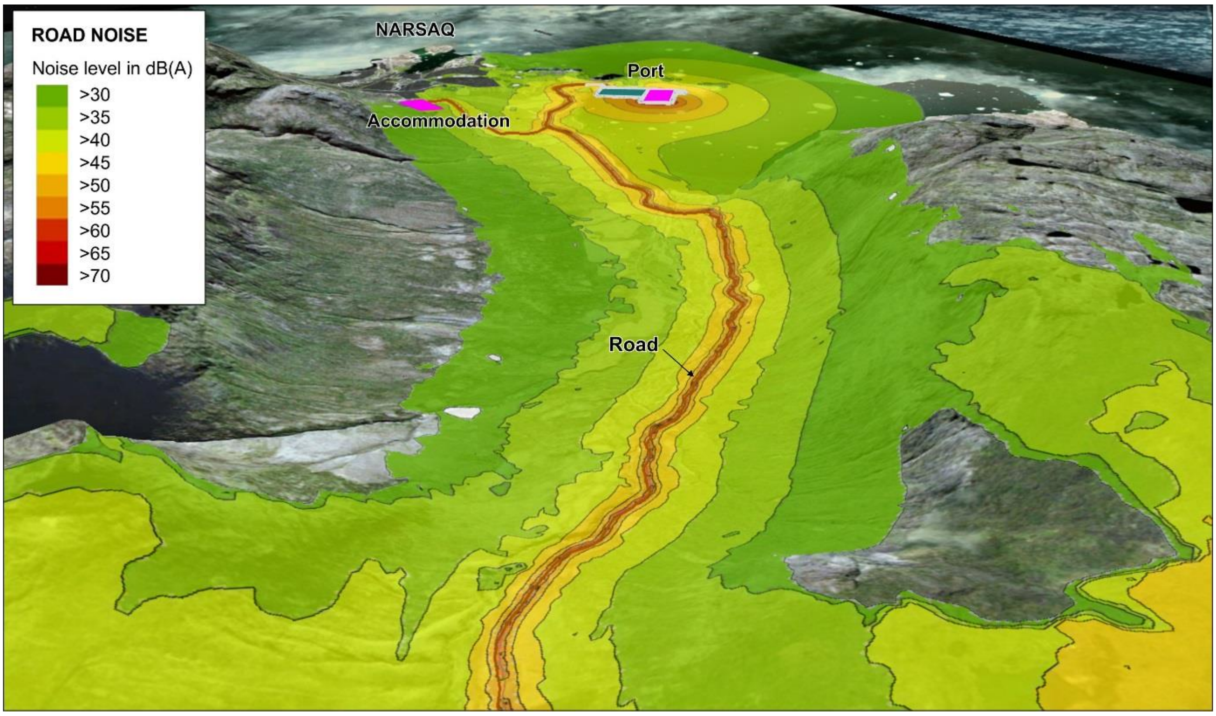


Figure 32 Calculated noise load along Port-Mine Road and in the new port area

The noise footprint for the Project's operations at the Port is shown in Figure 33. The calculated noise load will exceed 70 dB(A) in a small area where containers are unloaded (Orbicon 2015a). The area where the average noise load excees the 30 dB(A) background level extends approximately 1,800 m from the center of the Port.

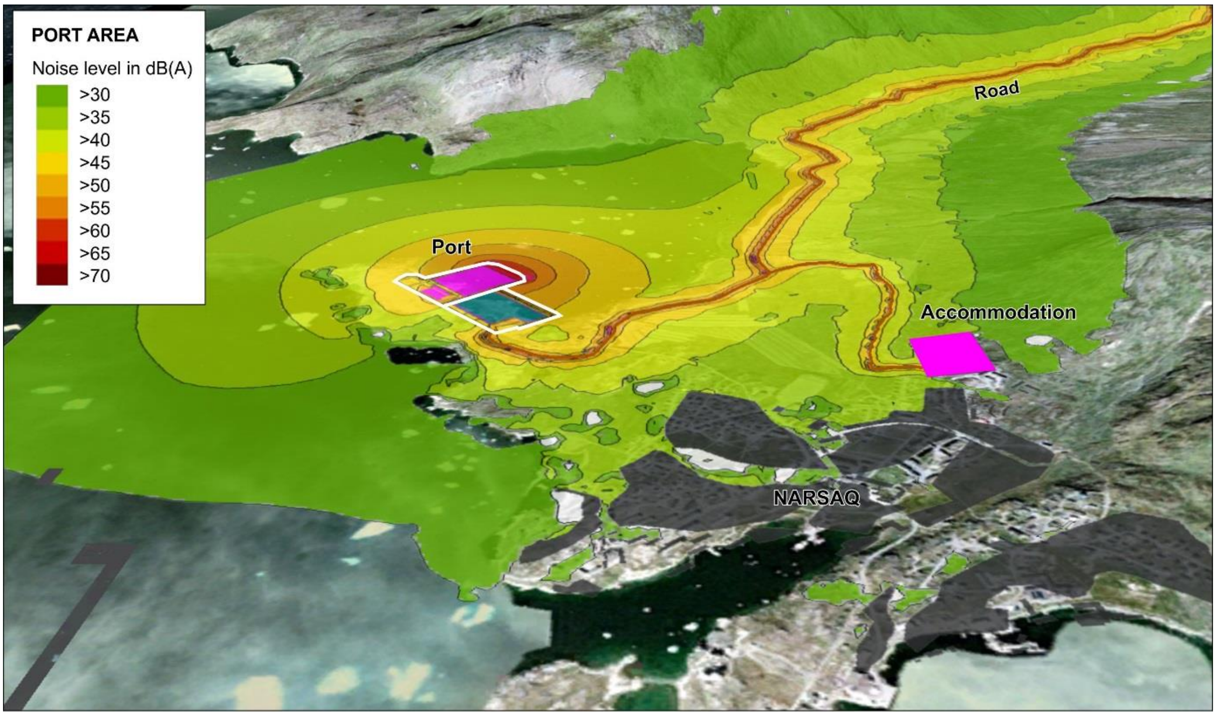


Figure 33 Calculated noise load in and around the new port during the operation phase

The noise level in the residential areas of Narsaq, and at the proposed location of the Village, will be less than 40 dB(A) and will meet Danish noise guidelines for noise levels in towns. The Government of Greenland has not formally adopted guidelines or regulations on noise from industries.

Blasts in the open pit are expected to be fired every two days with the potential for multiple shots to be fired simultaneously.

The nature and magnitude of noise from blasting operations in the pit area will depend on the blasting regime chosen, the nature of the rock to be blasted, the size and depth of the charge, the type of explosive, the local topography and the detonation sequence. As the closest receivers are 8 km from the nearest point of blasting, neither the air blast nor the ground vibration are likely to have any impact on humans or buildings in Narsaq.

The modelled noise load distribution generated by Project operations shows that the area of the 70 dB(A) industrial footprint is very small and limited to the mine area, the Plant, a narrow corridor along the Port-Mine Road and to the Port.

The predicted noise levels associated with the Project will be well below Danish guideline limits in residential areas in Narsaq. Traffic noise will exceed the Danish evening and night limit of 35 dB(A) for summer houses by up to 3.7 dB(A) at two cottages in Narsaq valley. No known sensitive wildlife areas will be impacted by operations noise.

7.3.4 Light emissions

Construction activities will take place day and night, year round, as will activities during the Project's operations phase at the mine, Plant and Port. In periods of darkness, the construction areas will be illuminated. The consequences of such "ecological light pollution" where artificial light alters the natural light regimes in ecosystems are generally not well known.

The serious consequences of light in otherwise dark areas, such as the attraction of migratory birds and the risk of collisions with tall-lighted structures are well described; however, since artificial light will mainly be required during the winter months when almost no bird migration takes place, this is not expected to be a significant impact at Kvanefjeld.

7.4 Mitigations

The following mitigation measures will be applied to reduce the Project's impacts on the physical environment:

- Pre-stripping will be planned to blend, as far as practical, with the surrounding landscape
- Tailings embankments will be planned to blend, as far as practical, with the surrounding landscape
- Roads will be planned to minimize impacts on the surrounding landscape
- Decant barges will be removed at mine closure
- Embankments and diversion channels will covered with local materials (rock and gravel). Over time the embankments will also be covered by natural vegetation which will reduce the visual impact
- Rock and gravel materials will be used where possible for construction
- Blasting to be undertaken between 6 am and 6 pm.

Following decommissioning of buildings and machines at mine closure natural vegetation re-growth will take place through natural plant succession and over time restore the plant cover.

7.5 Predicted outcome

The predicted outcomes for the physical environmental are summarised in Table 12.

Table 12 Predicted outcomes for physical environmental

Impact	Project Phase	Spatial extent	Duration	Significance	Assessment
Visual Amenity	Construction Operation Closure	Project footprint	Permanent	Medium	Several of the facilities will be visible in the Narsaq valley although the footprint of the Project is relatively small. There is no current or future expected competing land use. Natural revegetation will occur over time.
Erosion	Construction Operation	Project footprint	Permanent	Low	Construction methods and routing of infrastructure alignments will limit erosion to the point that no significant erosion is expected.
Noise and Vibration	Construction Operation	Project footprint	Permanent	Low	Noise increases will be well below Danish guideline limits in residential areas in Narsaq. Traffic noise will exceed the Danish evening and night limit of 35 dB(A) for summer houses by up to 3.7 dB(A) at two cottages in Narsaq valley. No known sensitive wildlife areas will be impacted by noise during the Project's operations phase. Noise modeling results identify no significant noise impacts for the Project.
Light Emissions	Construction Operation	Project footprint	Permanent	Very Low	Artificial light will mainly be needed during the winter months, at this time almost no bird migration takes place. Therefore this is unlikely to be an issue.

8. Atmospheric setting

8.1 Existing environment

Baseline levels of dust and gaseous emissions have been monitored in the Study Area since July 2011 (PEL 2017). The monitoring stations are located at the farm in the Ilua valley, in the town of Narsaq and to the south of Narsaq.

Baseline Levels

Nitrogen dioxide (NO_2) levels from transport and combustion technologies were very low. There were slightly higher average NO_2 concentrations at Narsaq town recording station number 1 (NT1) compared to the two stations outside of town (2.7 µg/m^3 as compared with 1.5 and 1.4 µg/m^3). It is likely that this is a consequence of vehicle traffic in Narsaq.

Sulphur dioxide (SO_2) sampling indicated very low concentrations, below the 0.1 µg/m^3 detection limit at the SO_2 passive samplers. The main source of SO_2 is long distance international shipping traffic along the coast of Greenland and shipping traffic within Narsaq harbour.

Ozone (O_3) levels were high and primarily also the result of long-range transport.

Ammonia (NH_3) is highly soluble in water and effectively rinsed from the atmosphere during precipitation. The average NH_3 concentration at the Ilua valley farm station is slightly higher than at the other two stations (1.9 µg/m^3 as compared with 1.2 and 1.5 µg/m^3) reflecting the presence of livestock.

PM_{10} (particulate matter less than 10 µm) annual average concentrations between 2011 and 2013 were approximately 1.0 µg/m^3 at the farm in the Ilua valley. For comparison the EU annual limit value for PM_{10} is 40 µg/m^3.

8.2 Potential impacts

The Project's potential impacts to the atmospheric setting are:

- During the construction, operation and closure phases, the Project will generate dust which has the potential to result in reduced air quality and has the potential, because of the physical or chemical composition of the dust, to result in secondary impacts associated with dust deposition.
- During the construction, operation and closure phases, the Project will generate gaseous air emissions (oxides of nitrogen, oxides of sulphur, black carbon and polycyclic aromatic hydrocarbons (PAH)) which have the potential to reduce air quality.
- Construction, operation and closure of the Project will produce greenhouse gas (GHG) emissions from the combustion of diesel in mobile equipment and at the Power station.

8.3 Assessment of impacts

8.3.1 Dust and air quality

Background

The Project has the potential to generate dust and emissions during all its phases. Combustion of fuel in stationary and mobile equipment, material handling and vehicle movements will create dust and gaseous emissions. Particulates and gaseous emissions have the potential to affect both the environment and human health.

The dust in the atmosphere is referred to as particulate matter (PM). PM is categorized according to size:

- **$PM_{2.5}$** Particulate matter from combustion, typically less than 2.5 microns in diameter
- **PM_{10}** Mechanically generated dust from material handling and road dust, is coarser with particles typically between 2.5 microns and 10 microns in diameter
- **TSP** The combination of all particles up to about 30 microns in diameter.

Gaseous emissions resulting from combustion include:

- **NO_X** Primarily nitrogen dioxide (NO_2)
- **SO_X** Primarily sulphur dioxide (SO_2) and hydrogen sulfide (H_2S)
- **Black carbon** A component of soot emitted because of the incomplete combustion of fuel
- **PAH** Organic compounds produced during combustion.

Construction

In the construction phase, particulate matter will be generated during site preparation for mining and associated activities, including land clearing, topsoil removal, road grading, material loading, hauling, travelling on unpaved roads and wind erosion from exposed areas.

Diesel powered mobile equipment and stationary power generation will produce gaseous emission.

Emissions from construction activities will be local and short term. The construction phase of the Project is expected to take 3 years.

Operations

In the Project's operation phase various mining and processing related activities will produce dust and gaseous emissions. The key emission sources for the operation phase of the Project are identified as:

- Mining operations
- Plant operations (concentrator and refinery)
- On-site power generation
- Port operations (jncluding berthing ships).

Closure

In the closure phase of the Project, water treatment of supernatant from the TSF will continue. This will require diesel powered generation of electrical energy and a limited number of vehicle movements These activities will create exhaust gases from diesel combustion.

Post closure

There is no ongoing activity during the post closure phase that has the capacity to generate measurable emissions.

Preliminary Emission Estimate – Construction, Operation, Closure, Post Closure

Emissions were estimated to show the impact on air quality during the different phases of the Project (PEL 2015a, ERM 2018a). All identified emissions were included and annualized emissions were calculated for each.

Based on the types and sources of emissions, the spatial distribution of these sources and the duration of each phase of the Project, the Project's operations phase has been identified as the period to be modelled in detail in order to establish the maximum extent of the impact of the Project on ambient air quality.

While the annualised TSP emissions from the construction phase (2,650 t/yr) are about 50% higher than those for the operations phase (1,362 t/yr), operational emissions will occur for 37 years presenting a greater potential impact. Emissions for closure and post-closure are less than 10% of the operational emissions.

Detailed air quality modelling was completed for the Project's operations phase. The Project's construction, closure and post closure phases were not subjected to detailed air quality modelling.

In addition, detailed emissions from the construction, closure and post-closure phases of the Project have been quantified for pollutants including TSP, PM_{10}. $PM_{2.5}$, NOx, SO_2, black carbon and PAHs and can be found in the Air Quality Report (ERM 2018a).

Air Quality Modelling and Assessment Method

Air quality modelling focussed on the Study Area. Sources of significant air emissions were identified, emission rates from these sources were estimated and dispersion modelling was undetaken.

Modelled ground level concentrations for the key pollutants (TSP, $PM_{2.5}$, PM_{10}, SOx, NOx, black carbon and PAHs) were compared to ambient air quality assessment criteria to determine potential impact to the physical environment and human health. In addition, TSP dust fall rates were modelled and metal loads estimated.

The assessment considered the potential impacts attributable to the Project in isolation and the cumulative impact of the Project's emissions and existing emission sources in the Study Area.

Air quality emissions were modelled using CALPUFF, a USEPA regulatory model.

For modelling it was assumed that no dust controls were in place at the Project. It is estimated that, were dust control measures provided for in the modelling, dust emissions would be 63% lower.

Sensitive Receptor Locations

In addition to ground level concentrations, concentrations were calculated for 58 *sensitive receptor locations* which were chosen as they are known to be sensitive environmental areas and locations were people may congregate. These locations included:

- Four locations in Narsaq
- the Ilua valley farm
- The five summer houses in the Narsaq valley
- The site of the proposed Village
- 45 archeological sites, and
- The location of the vulnerable round leaf orchid (*Amerorchis rotundifolia*).

Air Quality Assessment Criteria

Greenland has not formally adopted ambient air quality standards. The Guidelines (MRA 2015) recommend consulting other jurisdictions, such as Canada or Denmark (for consistency with European Union guidelines), for relevant standards.

Where appropriate Canadian or Danish criteria were not available, a broader review of assessment criteria was undertaken to identify criteria suitable for determining the potential impact on all values considered important for the Project (i.e. the physical environment, the living environment and land-use, conservation and heritage).

A summary table of the assessment criteria adopted for use in the assessment is shown in Table 13.

Table 13 Summary of air quality impact assessment criteria (ERM 2018a)

Parameter	Limit criteria source	Limit criteria	Units	Averaging period
TSP	Canada NAAQOs	60	µg/m³	Annual Average
		120	µg/m³	24-hr Maximum
PM_{10}	EU Directive 2008/50/EC	40	µg/m³	Annual Average
		50	µg/m³	24-hr Maximum
$PM_{2.5}$	Canada CWS	10	µg/m³	Annual Average
	Canada NAAQOs	15	µg/m³	24-hr Maximum
TSP (Dust Deposition)	Germany	0.35	g/m²/d	Annual Average
	Norway	5	g/m²/m	Monthly Maximum
NO_2	EU Directive 2008/50/EC1	30	µg/m³	Annual Average
		125	µg/m³	24-hr Maximum
		350	µg/m³	1-hr Maximum
H_2S Total Reduced Sulphur	Canada B.C. PCO	7	µg/m³	24-hr Maximum
		3	µg/m³	1-hr Maximum
SO_2	Canada NAAQOs	30	µg/m³	Annual Average
		150	µg/m³	24-hr Maximum
		450	µg/m³	1-hr Maximum
	EU Directive 2008/50/EC2	20	µg/m³	Winter Average
SO_4	Australia NSW DEC Sulfuric Acid (H2SO4)	18	µg/m³	1-hr Maximum
Nitrogen deposition	WHO Guidelines for Europe	5	kg ha^{-1} yr^{-1}	Annual

Particulate Matter (Dust)

The modelling results indicate that the predicted ground level concentrations for TSP, PM_{10}, $PM_{2.5}$ and dust deposition do not exceed the relevant assessment criteria at the sensitive receptor locations (in isolation and cumulatively). All modelled Project emissions are less than 20% of the assessment criteria.

The highest overall dust emissions are expected in the Mine area close to the pit. Material handling, haulage and blasting are the mining activities which are expected to have the greatest impact on dust emissions.

Estimates of annual emissions from the various mining activities are based on data compiled by the US Environmental Protection Agency (EPA). The estimated amounts of dust from mining operations are shown in Table 14 and the table identifies that the haulage of ore and waste rock is the key source of dust generation.

Table 14 Estimated amounts of dust generated per year from the key sources of mining activities

Mining activity	PM_{10}	TSP	$PM_{2.5}$
	(kg/year)		
Material handling	29,056	86,844	8,543
Haulage	257,074	1,046,235	75,580
Blasting	2,090	4,018	614

The highest annual average concentration of $PM_{2.5}$ emissions predicted at key sensitive receptors, (in isolation of background sources) is 4% of the respective assessment criteria. The annual average concentration of $PM_{2.5}$ was 0.4 µg/m^3 compared to limit criteria of 10 µg/m^3 (Canada CWS).

The highest 24-hour maximum concentration of TSP, PM_{10}, $PM_{2.5}$ and TSP dust deposition predicted at key sensitive receptors was 8.5 µg/m^3 for TSP (7% of the relevant Canadian National Ambient Air Quality Objective (NAAQO) value of 120 µg/m^3) and 7.0 µg/m^3 for PM_{10} (14% of the relevant EU Directive 2008/50/EC value of 50 µg/m^3).

For all types of particulates, the highest annual average and 24-hour maximum concentrations and depositions were estimated at the Ilua valley farm. The farm is located close to the Port-Mine road and is the closest receptor to the Mine and Plant.

All particulate emission estimations at the key receptor locations were below the respective assessment criteria.

TSP

Predicted TSP ground level concentrations (24-hour maximum) are shown in Figure 34. The contours show the greatest concentration values close to the Mine area, with concentrations decreasing rapidly further away from the Mine. Greenland's guidelines for air quality do not address airborne TSP. However, Canada's NAAQO has a 120 µg/m^3 standard for maximum acceptable level during a 24-hour period. The modelling study shows that this standard is not exceeded outside the Mine area.

The highest 24-hour TSP concentration was at the Ilua farm at 26.5 µg/m^3. This is well below the assessment limit criterion of 120 µg/m^3. At NT1, the highest 24-hour concentration was 22.5 µg/m^3.

PM_{10}

The highest maximum 24-hour concentration of PM_{10}, 16µg/m^3, is predicted at the Ilua valley farm. At NT1 the concentration is 12.8µg/m^3, of which 9 µg/m^3 is background dust – that is the existing dust level in the town primarily the result of dust from traffic movements on unsealed roads. The predicted 24-hour maximum concentration for all receptors does not exceed the assessment limit criterion of 50µg/m^3.

Figure 35 shows the maximum concentration of PM_{10} during a 24-hour period.

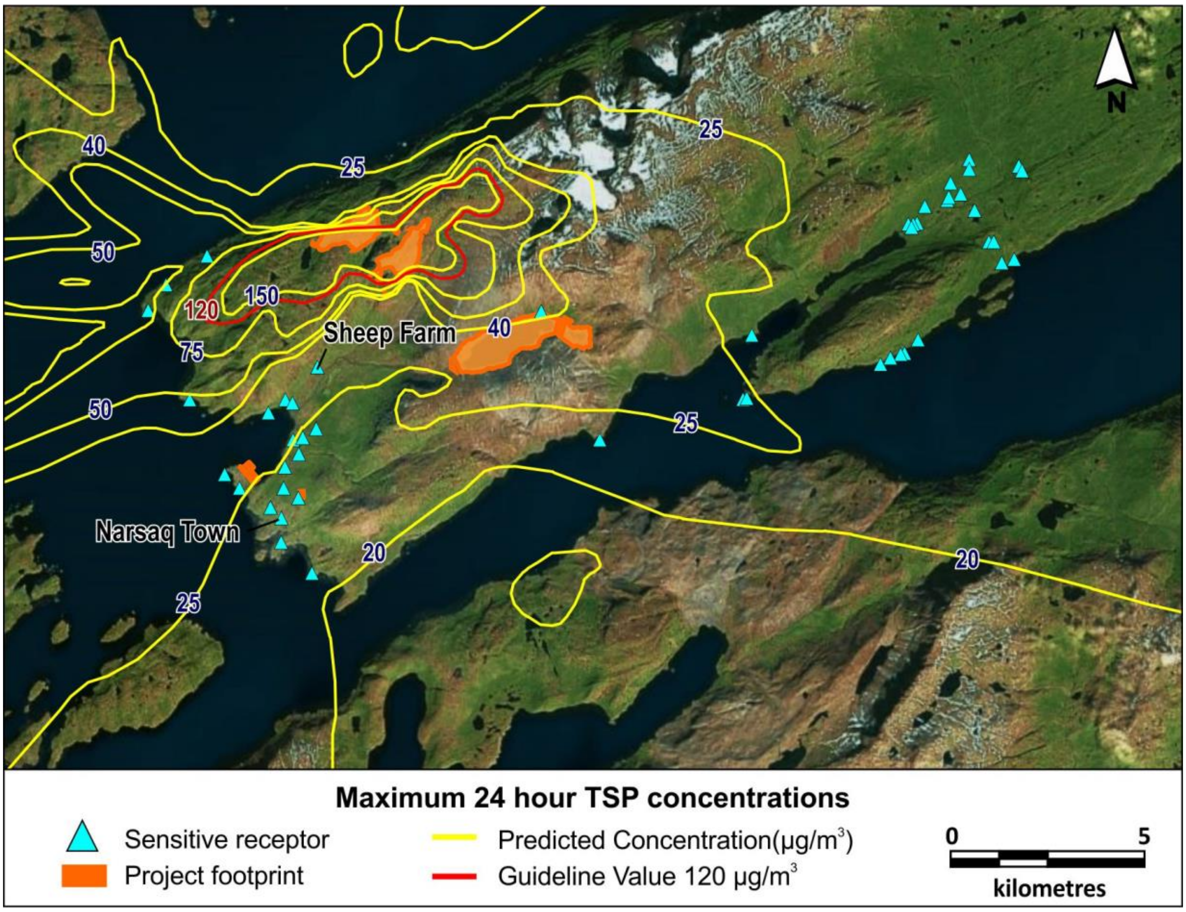


Figure 34 The maximum 24-hours TSP concentrations in µg/m3 (cumulative)

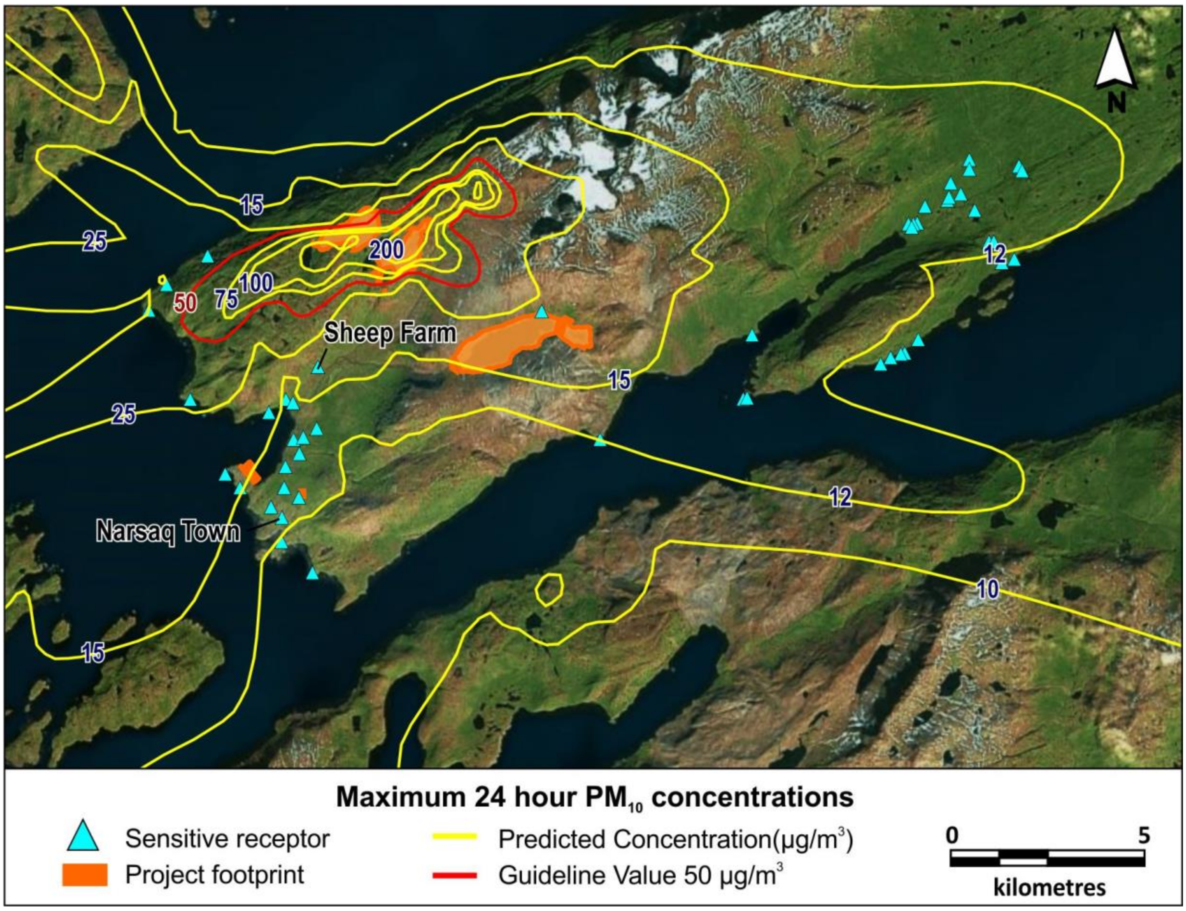


Figure 35 The maximum 24-hours PM10 concentrations in µg/m3

$PM_{2.5}$

The distribution of $PM_{2.5}$ is predicted to be very similar to the distribution PM_{10} (although at lower concentrations) with the highest values recorded close to the Mine.

The highest maximum 24-hour concentration, 6.4 µg/m^3, is predicted at the Ilua valley farm at. At NT1 the concentration is 5.1 µg/m^3. The predicted highest maximum 24-hour concentration does not exceed the assessment limit criterion of 15 µg/m^3.

Figure 36 shows the maximum concentration of $PM_{2.5}$ during a 24-hour period.

Dust Deposition

It is predicted that most of the dust generated by the Project will be deposited on the Project area itself and on the mountainous plateau to the south-west of the open pit. Forecasts of dust deposition are based on several factors including wind speed and direction. The calculated dust figures are determined from predicted maximum 1-hour values and show the deposition in gram per square meter if this maximum value lasted for an entire month.

Figure 37 illustrates the predicted deposition of dust generated by the Project. The highest TSP dust deposition concentration, 0.11 g/m^2/month, is at the Ilua valley farm. At NT1 (and at all other receptors) the deposition concentration is 0.1 g/m^2/month. The predicted TSP annual average and monthly maximum concentrations do not exceed the relevant assessment limit criterion of 5 g/m^2/month. This level of dust deposition is also significantly lower than the Greenland guideline value of 4.0 g/m^2/month (MRA 2015).

Dust deposition from mining and unpaved roads can have an impact on tundra vegetation via the coating of leaves with dust (Auerbach *et al.*, 1997, Myers-Smith *et al.*, 2006). Dust deposited on vegetation might also have an impact on mammals and birds that feed on the affected vegetation.

Researchers in northern Canada have observed a reduction of 50 to 75% in caribou density where calculated dust deposition exceeded about 20 kg/ha/year (5.5 mg/m^2/day) (Boulanger et al., 2012). Caribou density rose quickly to normal frequency at lower dust levels. Caribou are not found in the Study Area, but observations from Canada suggests a dust deposition threshold on the order of 0.16 g/m^2/month might also be relevant for Arctic hare, sheep and birds such as the ptarmigan which feed on vegetation.

The modelling has shown that the area with dust deposition above 0.16 g/m^2/m extends less than a few hundred meters from the Mine's open pit and haul roads. For all sensitive receptor locations dust deposition is below 0.11 g/m^2/m. The potential dust deposition impact on vegetation and mammals (including sheep) and birds is assessed as low.

All particulate concentrations are less than 20% (Project emissions in isolation) and 43% (cumulative, including background emissions) of the assessment criteria. Therefore, the impact of particulate emissions from the Project is assessed to be very low.

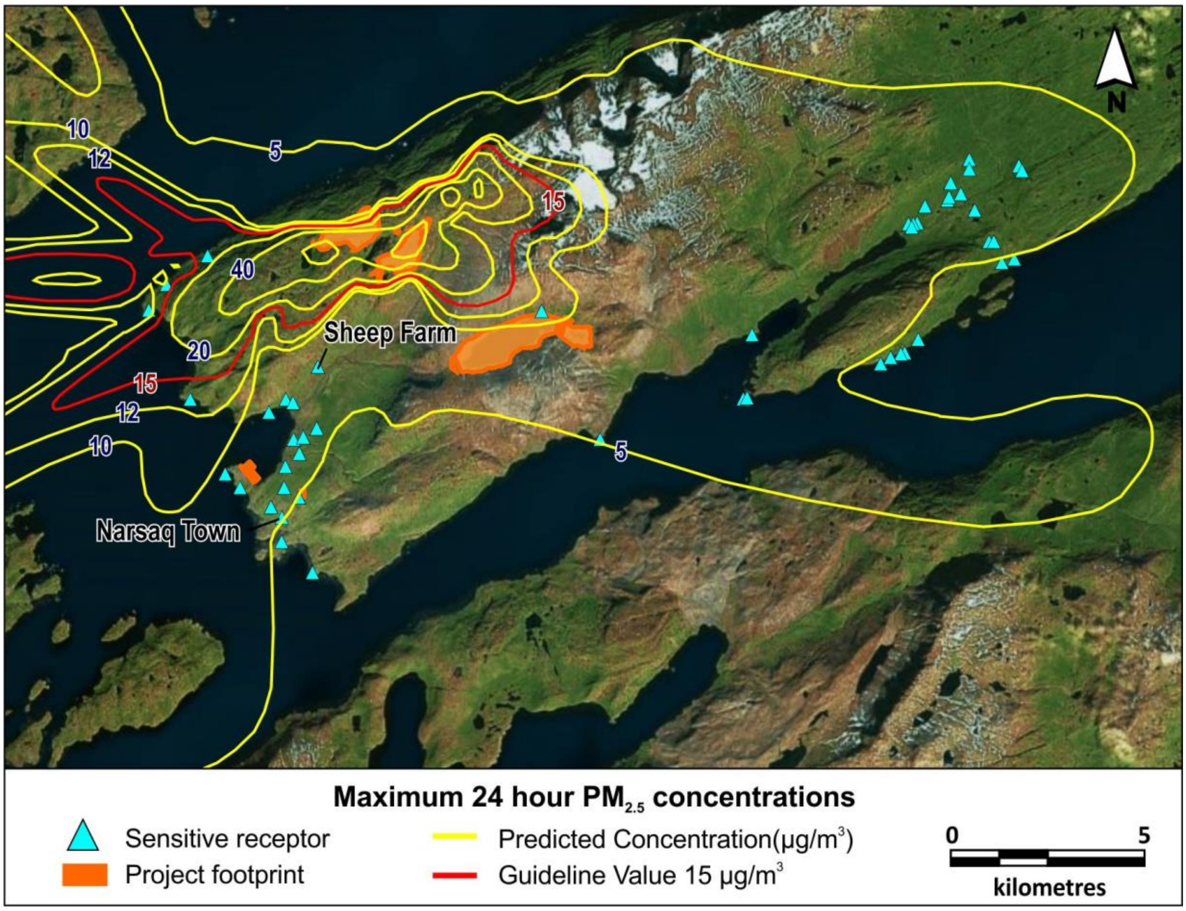


Figure 36 The maximum 24-hours PM2.5 concentrations in µg/m3

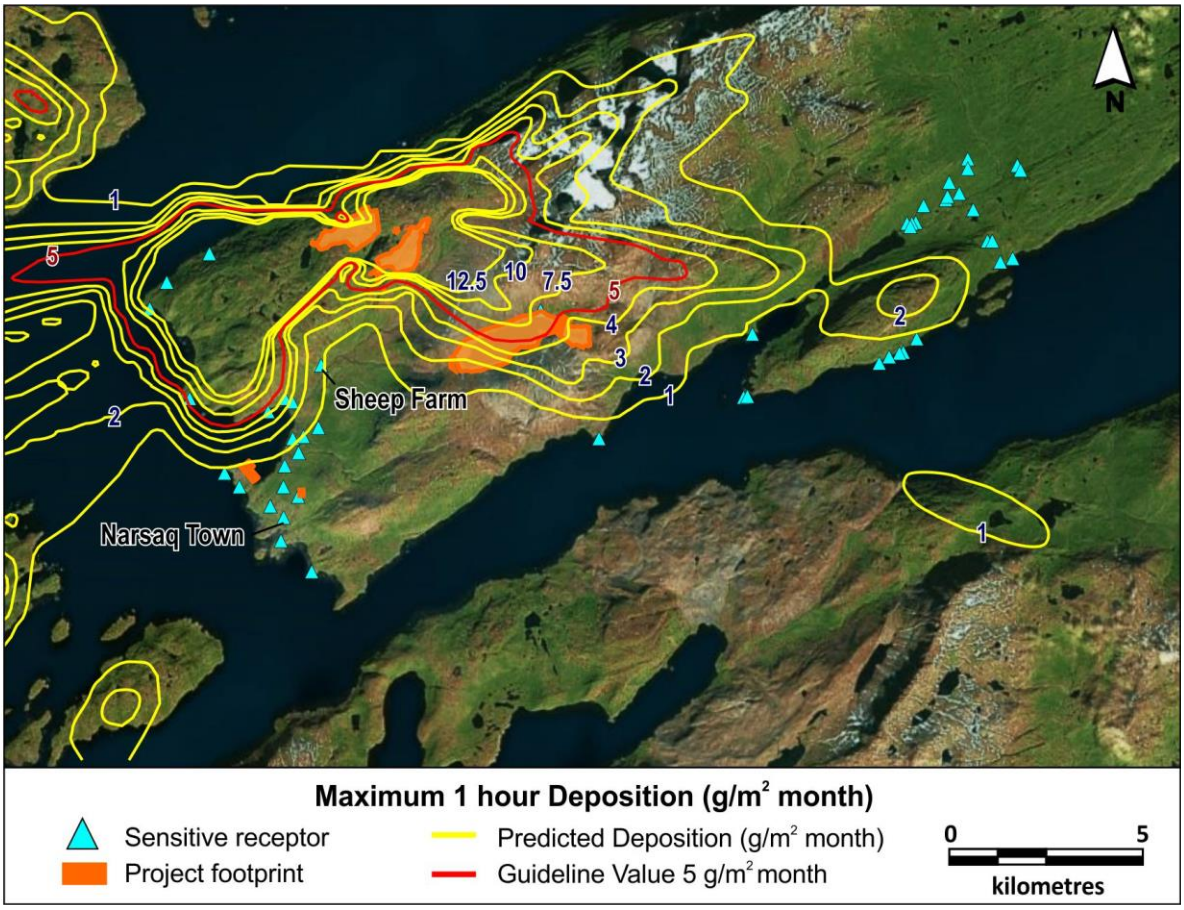


Figure 37 Maximum 1-hour deposition of dust - cumulative (g/m2/month)

Dust Composition

The composition of deposited dust will reflect the composition of the material from which dust is generated. The largest source of dust is the unsealed haul roads (approximately 92% of all dust). The haul roads will be constructed from locally sourced gravel and mined waste rock. The composition of the dust particles will model the road construction material. Dust emanating from ore is not expected to contribute significantly to the haul road dust load.

Dust particles from other mining activities at the mine site will be generated from waste rock and ore. It is assumed that waste rock and ore will contribute to dust emissions equally, each contributing 50%.

To estimate metal deposition load from dust from the Mine the following maximum metal concentrations (dust from ore and dust from waste) were used (Table 15).

Table 15 Maximum concentrations of metals in emitted dust – by source of material

Element	Maximum Concentrations Metals in Dust µg/g (ppm)	
	Ore	Waste Rock
Arsenic (As)	19	5
Cadmium (Cd)	0.5	< 0.5
Cerium (Ce)	6,500	800
Fluorine (F)	19,100	7,591
Lanthanum (La)	4,300	500
Lead (Pb)	474	39
Mercury (Hg)	1	1
Manganese (Mn)	5,758	2,617
Nickel (Ni)	2	10
Thallium (Tl)	3	2
Yttrium (Y)	1,500	200
Zinc (Zn)	3,615	662
Zirconium (Zr)	2,178	1,854

To predict the maximum annual metal deposition load at the Ilua valley farm and at NT1 (Table 16) the higher of the values for each metal in Table 15 (e.g. 19 ppm for As and 10 ppm for Ni) were multiplied by observed TSP deposition rates (Figure 34).

The calculated values for maximum deposition load for 6 key metals at the Ilua valley farm and at NT1 are below the deposition criteria limits for Greenland (MRA 2015).

Table 16 Comparison of maximum metal deposition loads to Greenland limit values (MRA 2015)

Element	Maximum Annual Deposition Load µg/m^2/month		Greenland Deposition Rates Limit Value (MRA 2015) µg/m^2/month
	Illua valley Farm	NT1	
Arsenic (As)	19	> 19	120
Cadmium (Cd)	0.5	> 0.5	60
Lead (Pb)	479	> 479	3000
Mercury (Hg)	1	>1	1.5
Nickel (Ni)	10	>10	450
Thallium (Tl)	3	>3	60

8.3.2 Air quality

Emissions that have the potential to affect air quality will be generated from the combustion of diesel will include solid particles, NO_X, SO_X, black carbon and PAHs.

Emissions of zinc sulfide, calcium fluoride, HCL mist and chlorine gas from the Plant will be very low and well below guidelines. Therefore, these emissions were not further evaluated.

As described below, the cumulative modelling results indicate that the predicted ground level concentrations for nitrogen deposition, NO_2, H_2S, SO_2 and SO_4 do not exceed the relevant limit criteria at the receptor locations. The impact of gaseous emissions from the Project is assessed to be very low.

SOx

For all sulphur compounds, the highest predicted concentration is the 1-hour maximum for SO_2 at 206 µg/m^3 at the accommodation village Option 2 location (Table 17). This is 43% of the respective limit criteria.

The modelled concentrations of sulphur are all below assessment limit criteria. The potential impact from the emission of sulphur compounds from the Project has been assessed as very low.

Table 17 Comparison of predicted sulphur compound emission concentrations to limit criteria for sulphur compounds (cumulative impact)

Compound	Criteria Source	Limit Criteria	Units	Averaging period	Highest Av or Max	% of limit criteria	Receptor
H2S	Canada B.C. PCO	7	µg/m3	24-hr Maximum	>0.001	>1%	Farm
		3	µg/m3	1-hr Maximum	>0.001	>1%	Summer house 4
SO_2	Canada NAAQOs	30	µg/m3	Annual Average	1.3	4%	Farm
		150	µg/m3	24-hr Maximum	17.8	12%	Farm
		450	µg/m3	1-hr Maximum	206	46%	Village
SO_4	Australia NSW Sulfuric Acid (H2SO4)	18	µg/m3	1-hr Maximum	0.007	>1%	Summer house 4

NOx

For NO_2 and nitrogen deposition, the highest predicted concentration is the 1-hour maximum for NO_2 at 143 µg/m^3 at the accommodation village Option 2 location (Table 18). This is 41% of the respective limit criteria.

The modelled concentrations of nitrous oxides are all bellow assessment limit criteria. The potential impact from the emission of sulphur compounds from the Project has been assessed as very low.

Table 18 Comparison of predicted nitrous oxides emission concentrations to limit criteria for sulphur compounds (cumulative impact)

Compound	Criteria Source	Limit Criteria	Units	Averaging period	Highest Av or Max	% of limit criteria	Receptor
NO_2	EU Directive 2008/50/ EC	30	µg/m3	Annual Average	2.9	10%	Farm
		125	µg/m3	24-hr Maximum	30.7	25%	Farm
		350	µg/m3	1-hr Maximum	143	41%	Village
Nitrogen deposition	WHO	5	kg/ha/yr	Annual	1.011	20%	Farm

Black Carbon and Polycyclic Aromatic Hydrocarbons (PAHs)

Black carbon and PAHs are produced during the incomplete combustion of diesel fuel. The main sources of black carbon and PAHs are the Power station and diesel engines in stationary and mobile equipment.

A qualitative assessment of PAHs has been undertaken based on the dispersion modelling predictions for black carbon. As is the case with PAHs the emissions of black carbon are dominantly from combustion sources. For black carbon, the highest annual average and maximum 24-hour concentration is predicted to be at the Ilua valley farm (0.664 µg/m^3) No specific ambient air quality guideline exist for black carbon and could not be compared to assessment criteria.

Based on the annual emissions for black carbon and PAHs, the qualitative maximum PAH impact has been estimated at 0.13 ng/m^3. This is 52% and 13% respectively of the UK Air Quality Objective (0.52 ng/m^3) and EU Target Value (1 ng/m^3). While this is a qualitative assessment only, the predicted PAH concentration is sufficiently below the air quality criteria for the assessment of the risk of exceeding the criteria to be negligible.

The potential impact of black carbon and PAHs from the Project has been assessed as very low.

8.3.3 Greenhouse Gas

Greenhouse gases (GHG) play an important role in regulating the earth's temperature. Anthropogenic greenhouse gases, for example those produced from burning of fossil fuels (e.g. coal and oil), cause the GHG levels in the Earth's atmosphere to increase.

The GHGs evaluated for the Project are carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4) (ERM 2015b, ERM 2018). The GHG emissions have been estimated using methods outlined in the 2006 Intergovernmental Panel on Climate Change (IPCC) guidelines for national greenhouse gas inventories. Estimates are based on conservative assumptions (e.g. maximum plant power load, 100 % reactivity for the conversion of limestone to CO_2 during the limestone neutralisation of acid process). As such, they represent the maximum expected emissions for the activities identified in this assessment.

During all phases of the Project, diesel machinery, power generation, heating, road and ship transport will generate GHG emissions.

During construction GHG emissions will mainly arise from diesel combustion in mobile equipment such as excavators, bulldozers and trucks.

Emissions sources during the operations phase will be:

- Mobile combustion — Primarily from diesel combustion in mobile sources
- Stationary combustion — Primarily from diesel combustion for power generation
- Direct emissions — Primarily carbon dioxide from the refinery

Mobile combustion

Diesel will be combusted in haul trucks, mining equipment (i.e. wheel dozers, excavators, front-end loaders and drills), light vehicles and service vehicles. The total vehicle fuel consumption is estimated to be 6.4 MLpa and the forecasted fuel economy value to 2.4 km/L.

Emissions of CO_2 were calculated by multiplying estimated fuel consumption with a default emission factor (see Table 19) and an energy content factor of 0.00363 GJ/L; whereas CH_4 and N_2O emissions were calculated using the kilometers travelled and the fuel economy technology approach.

Table 19 IPCC emission factors

Diesel consumption – mobile consumption	Emission factor	Units
CO_2	74.1	Kg CO_2-emissions/GJ
CH_4	5×10^{-05}	Kg CO_2-emmisions/km
N_2O	3×10^{-05}	Kg CO_2-emissions/km

Total GHG emissions arising from fuel combustion in mobile sources during operations is estimated to be 18,346 tonnes per year of which 99% are CO_2 emissions (ERM 2018b). Construction and closure emissions are 56,475 tonnes per year of which in excess of 50,000 tonnes per year is in the construction phase.

Stationary combustion

GHG emissions from the Power station were calculated using 2006 IPCC guidelines. For operations, a total of 175,313 tonnes of GHG emissions per year was estimated (ERM 2018b). For closure, emissions were estimated at 16,572 tonnes per year. More than 99% of the GHG's are CO_2.

Emissions from the refinery

The refinery will produce emissions of CO_2 and CH_4 & N_2O. Assuming the refinery is operating 24 hours and 365 days a year, the estimated GHG emissions will 33,014 tonnes of CO_2 per year.

Total GHG emissions

A total of 0.24 million tons CO_2 emissions per year is estimated for the Project. The combined CH_4 and N_2O emissions are 14.5 tonnes GHG per year.

The annual CO_2 emissions in Greenland were 0.56 million tonnes in 2013 (Grønlands Statistic 2015). The Project will increase Greenland's CO_2 emissions by 43%.

The population of Greenland is very small and any new energy intensive industries will alter per capita emission levels significantly. In the Project's operations phase, CO_2 emissions in Greenland will increase from the current level, approximately 9.7 t CO_2 per capita per year, to 13.9 t CO_2 per capita per year.

By way of comparison, the annual Danish CO_2 emission (2015) from energy consumption is approximately 49 million tonnes CO_2. The current level of CO_2 emissions in Greenland is approximately 1% of that in Denmark. In the operations phase of the Project, this will increase this to approximately 2% (assuming all other quantities remain constant).

The 517 t of uranium oxide produced by the Project annually will be used to produce electricity at nuclear power plants outside Greenland. This will lead to a reduction in CO_2 emissions of approximately 7,000,000 tpa compared to power produced by an average European power station (GML 2015a).

8.4 Mitigations Measures

GML has developed a Dust Control Plan (GML 2015b) which describes dust suppressing activities that will be implemented during operations.

Mitigation measures in the Dust Control Plan include:

- Wetting of rock stockpiles, concentrates and waste materials with water sprinkler systems (summer) using excess water captured for recycling
- Wetting of haul roads with water spray trucks (summer)
- Salting of haul roads in the winter to melt ice and snow from the roads. The salt can also increase surface moisture by drawing moisture from the atmosphere
- Vehicle speed limits, regular road grading and maintenance
- Drilling dust containment (capturing dust generated during drilling operations)
- Blasting dust mitigations (wetting down the blasting area, the use of a “fog cannon” which generates fine water mist in the blasting region (summer))
- Vehicle washing systems at the exit point of the mining area (to minimize dispersal of dust along roads outside mine area)

It is expected that the mitigation measures proposed will significantly reduce the dust generation from mining activities. The level of dust concentration and deposition is expected to significantly lower than the modelled values.

Air quality and GHG mitigation measures include:

- Using vehicles and equipment with energy efficiency technologies to minimize emissions rates
- Maintaining power plant, vehicles and other fuel powered equipment in accordance with manufacture’s specifications to minimize on emissions

8.5 Predicted outcome

The predicted outcomes for atmospheric setting are summarised in Table 20.

Table 20 Predicted outcomes for the atmospheric setting

Impact	Project Phase	Spatial extent	Duration	Significance	Assessment
Dust and Air Quality	Construction Operation	Study area	Life of Mine	Low	The modelling shows that high concentrations of dust in the air are only recorded close to the haul roads in the mine area. Outside the mine area, the concentrations are well below Greenland guideline values. It is predicted that most dust will be deposited on Kvanefjeld and on the mountainous plateau to the south-west of the mine. Outside this area deposition levels are well below Greenland guidelines.

Impact	Project Phase	Spatial extent	Duration	Significance	Assessment
Greenhouse gas	Construction Operation	Study area	Long term	Low	The Project will increase Greenland's CO_2 emissions by 43%. The existing CO_2 emission from Greenland is approximately 1% of Denmark emissions. During the operations phase of the Project, this will increase to 2%.

9. Radiological emissions

9.1 Existing environment

Radionuclides occur naturally in the environment and are present in all soils and rocks. Worldwide, the normal range of exposure to natural background radiation has been reported to range between 1 and 13 mSv/year, with an average of 2.4 mSv/year (UNSCEAR 2008).

Uranium and thorium are two of a number of naturally occurring radioactive elements that are widely distributed on earth. Kvanefjeld ore contains high concentrations of uranium and thorium, approximately 300 and 800 ppm respectively. Over time, natural processes such as glaciation and wind and water erosion have dispersed radionuclides into the Narsaq valley and Narsaq. Radionuclides around the Project are higher compared to global average soil levels (Arcadis 2015a) as a result of this shedding from the Kvanefjeld ore.

Naturally occurring radionuclides are found in dust. Dust in the Narsaq valley and other areas surrounding the Project is likely to contain naturally elevated levels of radioactive particles. Ambient dust concentrations at four locations in and around Narsaq were monitored and tested for a number of radioactive elements (Arcadis 2018a). Concentrations of these elements in ambient air is set out in Table 21. Concentrations have been determined to be low.

Table 21 Concentrations of Radioactive Elements on Particles (ambient air) (Arcadis 2018a)

Location	Uranium Concentration (ng/m3)	U-238 (µBq/m3)	Thorium Concentration (ng/m3)	Th-232 (µBq/m3)
Narsaq Farm (2012)	0.021	0.26	0.142	0.58
Narsaq Town (2012)	0.005	0.06	0.098	0.40
Narsaq Point (2012)	0.006	0.07	0.068	0.28
Narsaq Town (2014)	0.033	0.41	0.11	0.45
Narsaq Town (2015)	0.019	0.24	0.071	0.29
Average	0.017	0.21	0.098	0.4

Note: 1 g Uranium = 12,350 Bq of U-238 and 1 g Thorium = 4,100 Bq of Th-232

The presence of naturally occurring radionuclides in the ground can result in external gamma radiation exposure. To quantify the gamma radiation level in the Project area, in the Narsaq valley and in Narsaq, a survey was carried out in 2014 (Arcadis 2018a). It was found that levels in the town of Narsaq were low but levels tend to be higher near some sections of the road to the mine. Gravel used for road fill, landfill and house foundation concrete in Narsaq includes material from the Narsaq river that has been transported from the Kvanefjeld Plateau and is high in uranium and thorium content

The coastal areas show slightly higher gamma radiation levels than in Narsaq. Gamma radiation tends to increase in the Narsaq valley area primarily the result of the movement of mineralized material from higher elevations. The highest gamma radiation levels in the valley tend to be adjacent to the Narsaq river.

Gamma radiation levels in the Study area are generally higher than in the surrounding area, reflecting the radionuclide content of the deposit.

Soils in the Narsaq valley, marine sediment from Narsap Ilua and sediment from the Narsaq river display, relative to typical background levels, high combined thorium and uranium levels, typically between 2 and 15 ppm. The ratio of thorium to uranium ranges between 2.5 and 2.7.

This indicates some influence of the Kvanefjeld resource possibly resulting from erosion (Table 22).

Table 22 Results of background radioactivity measurements of soil and sediment from the study area (Arcadis 2018a)

Parameter	Unit	Soil	Marine sediment	Freshwater sediment Lower Narsaq river	Freshwater sediment Upper Narsaq river close to Kvanefjeld
Thorium (Th)	ppm	78	30	61	190
Uranium (U)	ppm	29.5	9.5	30	56
Uranium-238a	Bq/g	0.36	0.12	0.37	0.69
Radium-226	Bq/g	0.44	-	0.23	-
Lead-210	Bq/g	-	-	0.24	-
Polonium-210	Bq/g	-	-	0.23	-
Thorium-232b	Bq/g	0.32	0.12	0.25	0.78
Radium-228	Bq/g	-	0.099	0.34	0.61

Radioactivity measurements in water showed low concentrations of uranium in freshwater and seawater, with averages of 0.003 and 0.002 mg/L, respectively. Thorium was consistently below detection limits. The only detectable measurement of thorium was in the Narsaq river at 0.002 mg/L.

Radium-226 and lead-210 concentrations in rivers and fjords in the Study Area were lower than the Canadian drinking water guidelines.

Samples of lichen, plants, seaweed, mussels, fish and seals were analyzed to determine the natural background concentrations of radionuclides in representative species of the resident flora and fauna. With the exception of snow lichens, thorium was not found in any of the organic samples. Snow lichens from Narsaq valley show accumulation of radionuclides, likely the result of dust dispersion from exposed rock and soils in the Narsaq valley. This is more evident in samples from the upper Narsaq valley closer to the Kvanefjeld orebody. Lichens collected close to the fjord showed a lower value (Table 23).

Lichens from a reference station 28 km south southwest of Kvanefjeld showed very low values.

Analyses of Arctic char from the Narsaq river as well as marine fish and ringed seals from the fjords around Narsaq indicated no significant concentration of radionuclides.

Radionuclides, with one exception, are also below detection levels in ringed seals from Bredefjord/Nordre Sermilik. The exception, polonium-210, was found in seal meat (0.040 Bq/g) and seal liver (0.16 Bq/g). Polonium is known to biomagnify through the aquatic food chain and higher trophic level animals that consume fish (such as seals) are known to have naturally elevated levels of polonium. This is particularly the case for sedentary seal species living in an area with slightly elevated concentrations of radionuclides, such as ringed seal in the fjords around the Kvanefjeld. For comparison, Polonium-210 levels in a (migratory) harp seal from the Bylot Sound at Thule were found to be 0.008 Bq/g fresh weight in flesh and 0.043 Bq/g fresh weight in liver (Nielsen 2015).

Table 23 Results of radioactivity measurement of snow lichens and grass from Narsaq valley and reference station (Arcadis 2018a)

Parameters	Unit	Snow lichen		Snow lichen reference station	Grass Lower Narsaq valley
		Lower Narsaq valley	Upper Narsaq valley		
Thorium	ppm	1.2	4.7	<0.1	<0.1
Uranium	ppm	0.6	1.6	<0.1	0.53
Uranium-238a	Bq/g	0.007	0.020	<0.0012	0.0065
Radium-226	Bq/g	0.029	0.088	<0.01	0.01
Lead-210	Bq/g	0.26	-	-	-
Polonium-210	Bq/g	0.21	0.45	0.26	<0.01
Thorium-232b	Bq/g	0.005	0.019	<0.0004	<0.0004
Radium-228	Bq/g	<0.05	-	-	-

Note: (a) 1 g U = 12350 Bq of U-238; (b) 1 g Th = 4100 Bq of Th-232; all wet weight basis

9.2 Potential impacts

The potential impacts associated with radiological emissions are:

- Radioactivity, with the potential to result in contamination of the environment and affect human health, may be released during the Project's construction, operation, closure and post closure
- There are potential risks of accidents during Project operations which may result in the radiological emissions
- Failure of TSF embankment has the potential to result in the release of tailings water and solids to land and water bodies downstream of the TSF and associated radiological exposure
- Release of aerosols from the TSF has the potential to result in contamination of land and release of radioactivity downwind of the TSF.

9.3 Assessment of impacts

9.3.1 Release to air, land and water

Some Project activities may result in the release of radioactivity to the air, land and water that potentially may be harmful to animals, plants and humans.

Radioactive releases from the Project will primarily take the form of radon emissions and the dispersion of radioactive dust.

In radiological studies undertaken by Arcadis (2015a, 2018a), the potential for radiological contamination was assessed. Project related radionuclide concentrations in receptors (soil, water, plants and animals) at different locations within the Study Area were calculated. Potential impacts to key animal species as well as human health were considered including the assessment of a range of habitats and potential contaminants across the food chain.

Effects on the health of wildlife were determined by comparing the total dose (natural background dose and dose arising from Project activities) to a selected protective dose limit. If the dose received was below the protective dose limit, then it can be concluded that the health of the species was not at risk.

To calculate the radiological concentrations and dose exposure to animals, plants and humans Arcadis used the INTAKE pathways model, a proprietary model used to simulate environmental transfer, uptake and risk due to exposure to radionuclides released to the environment (e.g., air, water, soil).

Contaminants of potential concern (COPC) for the Project were identified as being the following long-lived radionuclides in the uranium and thorium decay chains:

- uranium-238
- thorium-230
- radium-226
- lead-210
- polonium-210
- radon-222 (radon)
- thorium-232
- radium-228
- thorium-228 and
- radon-220 (thoron).

Human health aspects are assessed in the GML Social Impact Assessment 2018.

Radon

During each phase of the Project activities will take place which have the potential to release radon emissions.

The dispersion of radon released as a result of Project activities was calculated and was combined with an estimated radon emission rate for mining of 1.5 $Bq/m^2/s$. The total increase in radon emissions amounted less than 2% to the outdoor radon concentration in the town of Narsaq.

Dust

The modelling of dust dispersion identified the sources of dust during the Project's operation and estimated the concentrations at different locations within the Study Area. Using dust deposition modelling and data on the content of uranium and thorium in the source material of the dust, concentrations of COPC at different locations in the Study Area were estimated.

The levels of COPC in the dust estimated to have been generated by Project activities was then used to predict the change in concentrations of radionuclides in receptors as a result of the deposition of Project related dust.

As an example, the estimated concentration of COPC in lichens at different locations in and around the Study area is shown in Table 24. Estimated concentrations in the Table are the sum of the background level and the Project dust related impact.

Based on the predicted concentrations of COPC in soil and plants (i.e. background and Project related), the predicted concentrations in selected animals that inhabit the various terrestrial habitats of the Study Area were determined.

Table 24 Modelled concentrations of COPCs in lichen in the Study Area

COPC	Unit	Narsaq valley	Taseq	Narsaq	Tuttutooq
Uranium	µg/g	4.9	2.2	2.4	2.4
Uranium-238	Bq/g	0.061	0.028	0.03	0.03
Thorium-230	Bq/g	0.061	0.028	0.03	0.03
Radium-226	Bq/g	0.061	0.028	0.03	0.03
Lead-210	Bq/g	0.061	0.028	0.03	0.03
Polonium-210	Bq/g	0.061	0.028	0.03	0.03
Thorium	µg/g	15	8.7	9.1	9.1
Thorium-232	Bq/g	0.062	0.035	0.037	0.037
Radium-228	Bq/g	0.062	0.035	0.037	0.037
Thorium-228	Bq/g	0.062	0.035	0.037	0.037

The calculation of the concentration of COPC in each species was determined by considering the species' diet, the time spent in the Study Area and the estimated concentrations of radionuclides in the diet.

Modelled concentrations for selected terrestrial birds and mammals at a number of locations within the Study Area is shown in Table 25.

Table 25 Modelled concentrations of COPCs in mammals and birds at different locations in Study Area

COPC	Unit	Narsaq valley		Ipiutaq		Narsaq town
		Ptarmigan	Arctic fox	White-tailed eagle	Sheep	Glaucous gull
Uranium	µg/g	0.021	1.8x10-5	0.007	2.8x10-4	0.0029
Uranium-238	Bq/g	2.6x10-4	2.2x10-7	1.6x10-3	3.4x10-6	3.6x10-5
Thorium-230	Bq/g	2.6x10-6	2.0x10-7	2.9x10-5	1.1x10-6	4.7x10-7
Radium-226	Bq/g	1.8x10-5	9.7x10-7	6.5x10-5	1.3x10-4	1.4x10-6
Lead-210	Bq/g	0.002	2.2x10-7	1.1x10-3	2.8x10-5	2.2x10-5
Polonium-210	Bq/g	0.005	5.7x10-6	5.8x10-3	7.6x10-6	1.1x10-4
Thorium	µg/g	5.2x10-4	4.0x10-5	4.4x10-3	2.1x10-4	8.7x10-6
Thorium-232	Bq/g	7.1x10-6	1.6x10-7	1.8x10-5	8.6x10-7	3.5x10-8
Radium-228	Bq/g	1.4x10-5	7.9x10-7	5.2x10-5	1.0x10-4	1.1x10-7
Thorium-228	Bq/g	2.1x10-6	1.6x10-7	1.8x10-5	8.6x10-7	3.5x1008

Based on the concentrations of COPC the radiation dose for these species was then estimated, the dose being the amount of radiation energy absorbed.

The dose was estimated using the calculated concentration of COPC in plants and animals and a dose co-efficient, which accounts for radiation and tissue weighting factors, metabolic and bio kinetic information. Values for dose co-efficients were sourced from international agencies.

Examples of estimated doses for plants and animals in and around the Study Area is shown in Table 26.

Table 26 Estimated dose (mGy/d) for Snow Lichen, a selection of plant groups, mammals and marine fish

Species	Estimated dose (mGy/d)				
	Narsaq	Narsaq valley	Ipiutaq	Tuttutooq	Nordre Sermilik
Snow Lichen	0.24	0.40	0.26	0.24	-
Grasses and herbs	0.0025	0.013	0.013	0.0083	-
Arctic hare	-	3.6x10-4	3.2x10-4	-	-
Arctic fox	-	8.6x10-5	5.2x10-5	-	-
Sheep	-	-	5.2x10-4	-	-
Reindeer	-	-	-	0.0018	-
Ringed seal	-	-	-	-	0.009
Marine Fish	-	-	-	-	0.015

It is not expected that the Project will contribute to any external radiation in the form of additional gamma doses to wildlife in the area. However, radionuclides deposited in body tissue can potentially lead to internal radiation exposure and the dose from this can continue long after the intake has ceased.

To determine if calculated doses are harmful they are compared to a dose for which it is known that there are no negative effects. Reference dose values or benchmark values, where no harmful effects have been observed in natural populations, are published by international organizations. The reference dose values used for this assessment are shown in Table 27. The values differ between animals and plants associated with aquatic and terrestrial environments.

The final step in this radiological assessment is the calculation of the screening index value. This is calculated by dividing the total dose rate (background plus Project) received by a receptor (for example a bird) by the relevant reference dose limits from Table 27.

Table 27 Reference dose limits used in the assessment (Arcadis 2018a)

	Value	Units
Aquatic biota (background + Project)	9.6	mGy/d
Terrestrial biota (background + Project)	2.4	mGy/d

If the screening index value is below 1 i.e. the calculated dose is below the reference dose limit, there will be no adverse effects to animals or plants.

Table 28 shows the screening index values for marine animals and plants at two points in Nordre Sermilik. The screening index value to all receptors are well below 1. In other fjords, the values are even lower.

Table 28 Screening index values for marine animals and plants

Species	Stream run off	Discharge	Nordre Sermilik
Benthic fish	0.002	0.002	0.002
Pelagic fish	0.002	0.002	0.002
Benthic/crustacean	0.003	0.004	0.003
Vascular plant	0.001	0.001	0.001
Ringed seal	-	-	0.001
Humpback whale	-	-	0.001

Screening index value for terrestrial plants and animals are given in Table 29. Again, the values for all receptors are well below 1 implying that there will be no adverse effects to animals or plants. The values outside the Study Area, for example at Qassiarsuk are even lower.

Table 29 Screening index values for terrestrial mammals and plants

Species	Narsaq	Narsaq valley	Ipiutaq	Tuttutooq Island
Snow lichen	0.10	0.17	0.10	0.10
Grasses and herb	0.001	0.005	0.005	0.003
Arctic hare	-	<0.001	<0.001	-
Arctic fox	-	<0.001	<0.001	-
Sheep	-	-	<0.001	-
Reindeer	-	-	-	<0.001

Screening index values are shown for a selection of birds in Table 30. The values for all species are well below 1 and are lower outside the Study Area.

Table 30 Screening index values for birds

Species	Narsaq	Narsaq valley	Ipiutaq	Nordre Sermilik
Brünnichs guillemot	-	-	-	<0.001
Common eider	-	-	-	0.003
Purple sandpiper	-	-	-	<0.001
Ptarmigan	-	0.002	0.001	--
Snow bunting	-	<0.001	<0.001	-
White-tailed eagle	-	-	0.004	-
Glaucous gull	<0.001	-	0.008	-
Peregrine falcon	-	<0.001	-	-

The Project is expected to release only small amounts of additional radioactivity to the environment and is not expected to result in an adverse effect, or significant harm, to wildlife or people that live or visit the area. The potential radiological impacts of the Project on plants and animals in marine, freshwater and terrestrial habitats are assessed as very low. The estimated dose to all these receptors is below benchmark values.

9.3.2 Spills to land or water

The uranium product (yellow cake), will be packed in sealed 200-litre steel drums at the refinery which will then be loaded into standard containers before being transported to the Port on flatbed trucks as per IAEA Safety Standards. The containers will remain sealed throughout the journey from the refinery to final point of delivery. Containers containing yellow cake drums will be unloaded from trucks at the Port and moved to a specified storage area. The storage area will have a gate and a standard of security that meets/exceeds the requirements of International Ship and Port Security Codes. The containers will be moved around the Port with a reach stacker and then will be loaded into a vessel using a ship mounted crane.

The amount of uranium product transported will be 517 tpa with approximately 12.5 t contained in each standard container. Approximately 40 containers of drummed yellow cake will be transported from the refinery to the Port each year.

A specific uranium transport assessment has been carried out for the Project by Arcadis (2015a). The assessment identified the following potential scenarios for transportation incidents involving uranium products:

- Spill of yellow cake into rivers or harbour
- Spill of yellow cake on land and associated gamma radiation exposure.

While site clean-up will occur within a short time after an accident, it is unlikely that recover efforts will recover 100% of the released material, especially in the event of a spill into water.

Spill to water

In the event of a traffic accident (rollover or crash) containers and drums could potentially be breached and yellow cake could be spilled into rivers. An accident in connection with the handling and loading of containers onto ships could lead to a spill into the marine environment. The amount of the spill depends on the amount of force applied to the container and the ability of the container and drums to withstand the force.

Two comprehensive risk assessments of release into surface waters (rivers, lakes, and fjords) and land during transportation across Arctic Canada were completed by ARCADIS-SENES Canada in 2014 (SENES 2014a,b). The studies considered similar potential receptors as would occur in the Study Area.

The potential impact on water quality (freshwater and the marine environment) as a result of the release of yellow cake was assessed using fate and transport modelling of the released yellow cake as well as exposure pathway modelling and risk characterization for various receptors. The assessment assumed that a major clean-up effort will remove the majority (> 90%) of the released materials. Both assessments included the release of yellow cake on sites that are similar to southern Greenland with respect to meteorology and winter conditions.

Two types of exposures were identified:

- where it is possible that populations of selected animals and plants would be affected, and
- where only small numbers of individuals would be affected.

Based on the results of the radiological assessment from the Arctic region of Canada for similar radioactive material, it can be inferred that a spill of yellow cake into the Narsaq river or Narsap Ilua may, when not frozen, may have short-term and long-term implications.

In the short-term the affected water may have an impact on aquatic life. In this context short-term for water quality is defined as the time between spill and the point that the affected water is diluted sufficiently to meet the water quality guidelines for uranium. This period varies between water bodies but is usually in the order of days or weeks.

In the long term, the released material should be contained, removed and the area remediated. Depending on the effectiveness of the response to the spill, the long-term quality of sediment in the area of the spill may be adversely affected with the result that biota may be exposed to contaminated water and sediments.

Based on data from the Arctic Canada transport risk assessment, the risk of a spill into water is calculated to be extremely low (less 1 in 50 million event per year).

Spill on land

A traffic accident (rollover or crash) could result in a spill on land from a container or drum breach. The amount of the spill depends on the amount of force applied to the container and the ability of the container and drums to withstand the force. Part of the spilled product could become airborne due to the impact of the accident. If the accident is followed by fire, the buoyant effect of fire could contribute to the airborne release of yellow cake particles.

In case of an accident involving the release of uranium products on land, both flora and fauna and members of the public (and workers) could be exposed to external gamma radiation as well as inhalation of airborne yellow cake particles.

Arcadis (2015a) modelled a vehicle accident where half of the transported yellow cake was spilled onto the ground. If workers were exposed to gamma radiation from the yellow cake during 10 hours of clean-up, the maximum dose received would be 0.026 mSv, which is well below the incremental dose benchmark of 1 mSv (over natural background level).

An accident can also potentially lead to yellow cake dust being suspended in air as an aerosol or gas. Assuming an accident where half of the transported yellow cake was dispersed in a hemisphere with a radius of 10 m for 30 seconds, the immediate and very short duration concentration in the air near the accident area would be 63 mg/m^3. If a person exposed to this yellow cake dust concentration, the total inhalation dose will be 0.164 mSv. This dose is well below the recommended radiation dose limit of the public of 1 mSv per years (over natural background level).

A review of road transportation accident statistics for Canada and the U.S. showed that the probability of an accident and release of yellow cake into the environment is extremely unlikely (1 in every 4,300,00 years for probability of release of yellow cake).

9.3.3 Release resulting from TSF failure

Potential radiological impacts resulting from a TSF embankment failure were assessed for the release of tailings water and solids to land and water bodies downstream of the TSF (Arcadis 2018c).

The tailings solids will contain some uranium and thorium-based radionuclides. Tests conducted on flotation tailings indicate that the levels of U-238 and Th-232 are 1.8 Bq/g and 3.7 Bq/g respectively.

Tailings pore water at 60% solids was measured to contain 2.15 mg/L of uranium and 0.037 mg/L of thorium. Five years after end of Project operations, the water covering the TSF is predicted to contain 2 µg/L of uranium and practically no thorium. If the tailings at 60% solids is fully mixed on a 1:1 basis with the surface water, the concentration of dissolved uranium and thorium would decline to 0.62

mg/L and 0.01 mg/L respectively. The slurry created by 1 for 1 mixing would, on average, approximately 37% solids.

For an overtopping event, where only tailings water is released downstream into the Taseq and Narsaq rivers, the potential radiological impact is assessed to be very low. There are possible effects to aquatic biota due to the level of radionuclides during the release period. However, once the release has ceased the levels are expected to decline and the doses would also decrease. No effect on human health is expected.

A partial or catastrophic failure of the TSF embankment would result in the release of water and tailings material downstream into the Taseq and Narsaq rivers and into Narsap Ilua.

As for the overtopping event, the release of water may have a limited impact on the aquatic environment due to the level of radionuclides which would begin to decline and dose levels decrease. The release of tailings material will potentially have a greater impact. Where tailings are deposited in the terrestrial environment, although there may be some areas impacted as the result of smothering by tailings, the overall population of terrestrial receptors is not expected to be affected long term by residual radionuclides. Tailings will potentially deposit along the rivers and in the fjord. The maximum estimated radiological impact is to birds. Potential issues were also identified for other trophic levels.

After time, dried tailings could dessicate, releasing dust and potentially allow the slow release of radon gas. Assuming that terrestrial receptors re-established in the areas where tailings were deposited, the dose to non-human biota was estimated using the ERICA model (Arcadis 2018c).

However, as the tailings will smother the existing biota, species will need to re-colonize the area. This could be difficult.

The maximum risk quotient was estimated to be 1.9 for lichen and bryophytes, other receptor groups were below 1. Therefore, although there may be some areas with impact the overall population of terrestrial receptors is not expected to be affected by residual radionuclides.

The potential radiological impact to the natural environment if the TSF embankment were to fail has been assessed as medium. However, given that there is an extremely low risk of a TSF embankment failure the overall impact has been assessed as low.

9.3.4 Release from TSF aerosol spray

An impact assessment was conducted to assess the likely concentration of uranium and other pollutants in the Taseq and Narsaq rivers (at three sampling points A, B and C) after deposition of aerosols originating from the TSF (Orbicon 2018c). The impact of uranium is discussed in this section (details of the assessment method and discussion of the potential impact of other pollutants are described in Section 10.3.3).

Water for the town of Narsaq is sourced from three rivers (combined annual flow 6 Mm^3). At this flow rate the estimated annual baseline mass transport of uranium is 1 kg. Using this volume of water flow, WHO guidelines for drinking water (1993) have a critical load of uranium of 180 kg/year. This denotes a margin of 179 kg/year as maximum 'buffer load', i.e. the safety margin between the background limit and the critical limit.

The estimates of deposition of uranium in the Narsaq drinking water catchment set out in Table 31 indicate that the maximum buffer load will not be exceeded in any of the modelled scenarios.

Table 31 Quantity of Uranium (kg/year) deposited in the Narsaq drinking water catchment under the assumption of 1 %, 10 %, 25 % and 100 % of the released aerosols will be blown from the tailing ponds to the 6 km2 area

Foehn Events	Drawdown	Deposition of Uranium (kg/year)			
		1%	10%	25%	100%
1 event/ year	3.7 mm/year	0.02	0.24	0.61	2.44
3 event/ year	12 mm/year	0.08	0.8	1.99	7.95
6 event/ year	41 mm/year	0.29	2.9	6.8	29.3
Maximum buffer load (WHO 1993)		179 kg/year			

Even in the worst case scenario i.e. 100% of the aerosol lands within the water catchment zone and that all wind directions are towards the catchment for at least 6 foehn events, the buffer load will not be exceeded.

An average of 3 foehn events per year have occurred in Southern Greenland between 2010 and 2016. The duration of these events lasted between 17 and 64 hours. 24 hours was the median duration.

The topography and wind direction during storms will, to a large extent, determine where water spray is deposited and, therefore, the potential influence on the water supply catchment area for town drinking water.

Given prevailing wind directions (East and North East), topography and the marked mountain ridge separating Taseq valley from the area used for abstraction of raw water to Narsaq water supply (the ridge south of the valley is more than 200 m above Lake Taseq), deposition of uranium bearing aerosols from the TSF is considered to be unlikely.

Peak concentrations for uranium were calculated for the raw water intake of the Narsaq water plant and compared with WHO (1993) Water Quality Guidelines. The highest estimated concentration of uranium from the TSF in Year 37 was applied. The estimated peak concentration of uranium at 25% deposition for a 24 hour event was 3.89 µg/L and for a 64 hour event the concentration was 10.31 µg/L. Both concentrations are below the WHO guideline limit of 30 µg/L.

It is considered unlikely that contamination of Narsaq drinking water with uranium from the TSF, such that WHO guideline will be breached, will occur.

9.4 Mitigations

Mitigation measures include:

- Management of dust through the DCP
- The transportation and packaging of the yellow cake will be in accordance with IAEA Safety Standards - yellow cake packed in drums and strapped inside the sealed sea containers
- During and after operations tailings solids will be stored underwater to prevent dust and radon emissions
- The Plant will be designed to minimise radiation emissions through engineering considerations.

9.5 Predicted outcome

The predicted outcomes resulting from radiological emissions are summarised in Table 32.

Table 32 Predicted outcomes for radiological emissions

Impact	Project Phase	Spatial extent	Duration	Significance	Assessment
Radioactivity from dust	Operation	Study area	Life of mine	Very Low	The radiological impacts on plants and animals in marine, freshwater and terrestrial habitats in the Studies Area as well as residents and visitors of Narsaq and Ipiutaq are very low. The estimated dose to all these receptors is well below benchmark values.
Radioactivity from spills	Operation	Study area	Life of mine	Very Low	Transport and packaging of the yellow cake will be in accordance with IAEA Safety Standards.
Radioactivity from aerosol release from TSF	Operation Closure	Study area	Long term	Very Low	Deposited mass load and calculated peak concentrations of uranium in water spray during a 24 hour and 64 hour storm event were below WHO water quality guidelines.
Release of radioactivity from TSF embankment failure	Closure	Study area	Long term	Low	TSF embankment failure risk is considered extremely low and very unlikely. After the release period, levels of radionuclides will decline and dose levels decrease.

10. Water environment

10.1 Existing environment

10.1.1 Surface water

The hydrology of the Project area is characterized by a precipitation dominated catchment with an area of 30 km^2. Most of the catchment is without vegetation and as a result, has a rapid runoff rate.

The two major tributaries to the Narsaq river are influenced by the lake in the Taseq basin and by Kvane lake, respectively. The Narsaq river originates from a small glacier at the top of Narsaq valley. From the glacier, the river runs for 10 km through the Narsaq valley before discharging into the sea at Narsap Ilua. The flow varies during the year with most runoff occurring between April/May and October. The river is typically covered by ice and snow in winter but continues to flow below the ice cover.

Taseq basin connects to Narsaq river through the Taseq river. The Taseq basin contains the largest lake in the Narsaq river catchment area. It is situated 520 m above sea level and is 2.5 km long, between 0.5 and 0.7 km wide and over 30 m deep at its deepest point. In winter the lake is covered by ice and the outflow stops. However, groundwater from the surrounding slopes feeds into the Taseq river and resulting in overland flows, even during mid-winter.

Other than the presence of invertebrates, there is no biological life in the Taseq basin due to the high fluoride content.

A number of smaller lakes on the plateau drain through the Kvane river into the Narsaq river.

Figure 38 shows the Narsaq river catchment area and Table 33 identifies the characteristic discharge values for Narsaq river and its main tributaries.

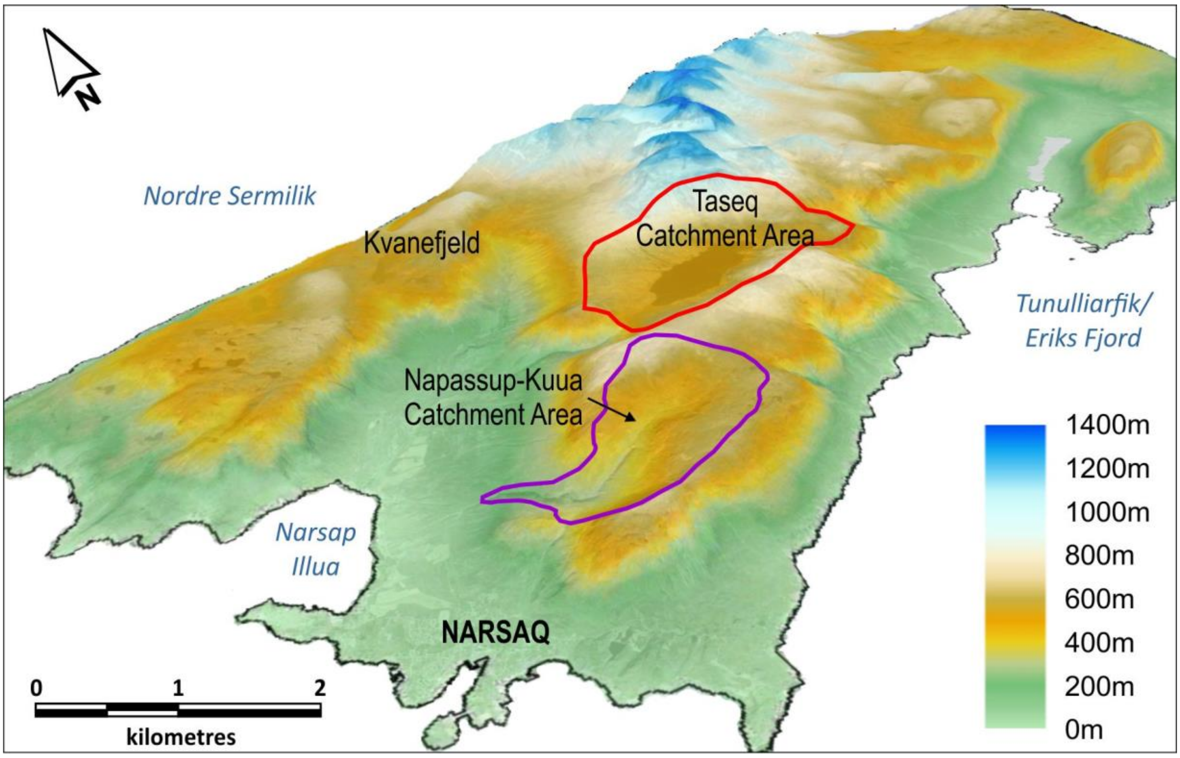


Figure 38 Narsaq river catchment area

Table 33 Characteristic discharges (Q) at selected sites in the Narsaq river catchment (daily average discharge values modelled for the 50-year period 1964-2013 (Orbicon 2014))

Source	Location	Area km²	Altitude m. asl	Q min m³/s	Qmm m³/s	Q25% m³/s	Qavg m³/s	Qmax m³/s
Mine water runoff	Outlet Bredefjord	2.3	0	0	0	0.004	0.07	1.1
Narsaq river	Raw water dam	8.4	490	0.05	0.01	0.04	0.33	3.2
Narsaq river	Hydro station	14.9	110	0.01	0.03	0.1	0.52	5.2
Kvane Outlet	Lake outlet	1.8	525	0	0.001	0.007	0.06	0.8
Kvane river	Hydro station	3.1	105	0	0.002	0.01	0.09	1.2
Taseq Outlet	Old hydro station	8.3	510	0	0.02	0.06	0.25	3
Taseq river	Hydro station	12.1	65	0.005	0.03	0.09	0.37	4.4
Narsaq river	Outlet Narsap Ilua	36.6	0	0.035	0.105	0.3	1.15	12.4

Water Quality

Water quality of the Narsaq river, Kvane river and lake and Taseq river and basin were assessed (Orbicon 2015b). Due to the significant quantity of the water-soluble mineral villiaumite (NaF) in the geological environment, the Narsaq and Taseq rivers and water in the Taseq basin have elevated natural concentrations of fluoride. In the Narsaq river, the fluoride content increases significantly from the upper reaches of the river to the mouth of the fjord. (Figure 39).

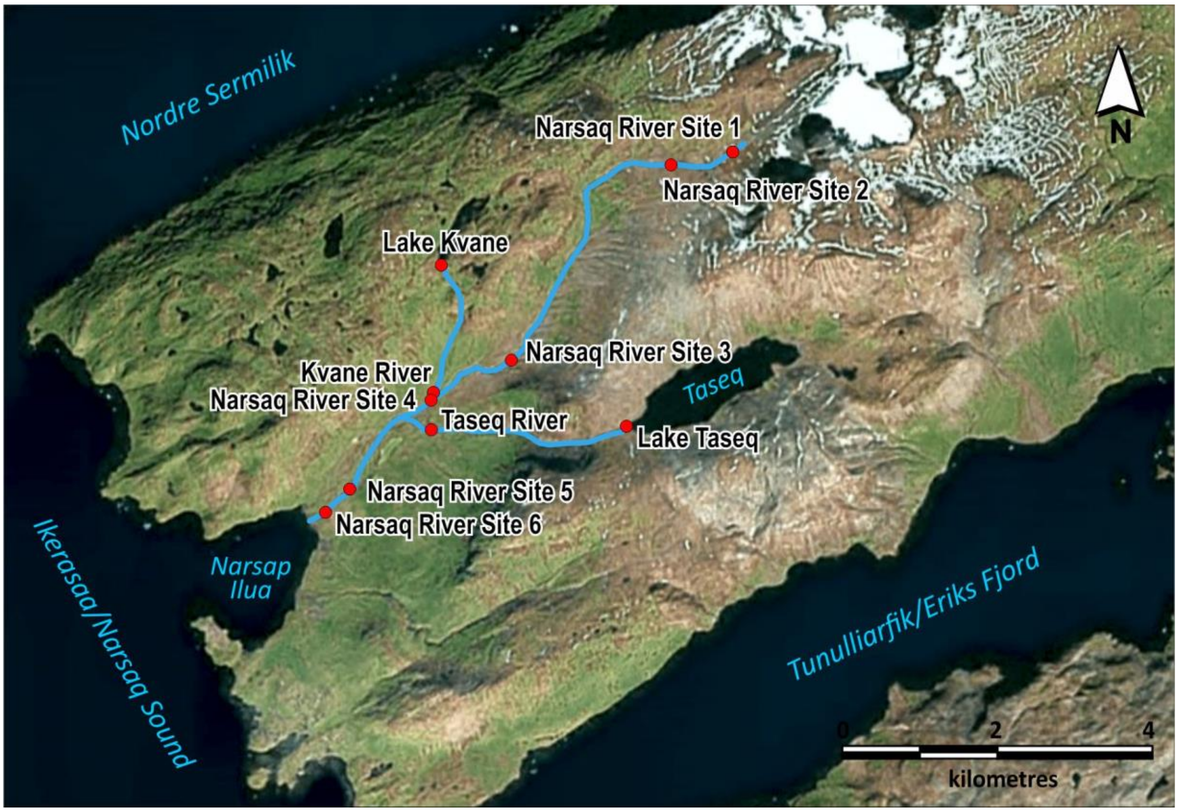


Figure 39 Location of water quality monitoring sites

Table 34 Surface water Fluoride concentrations mg/L

Locality	Fluoride (F) mg/L
Narsaq river site 1	0.58
Narsaq river site 2	0.88
Narsaq river site 3	2.7
Narsaq river site 4	2.9
Narsaq river site 5	2.9
Narsaq river site 6	3.0
Taseq basin	2.0
Taseq river	1.7
Kvane lake	0.83
Kvane river	5.6
Canada Freshwater Quality Criteria 2015	**0.12**
WHO Drinking Water Standard 1993	**1.5**

- The annual fluoride concentration varied between 1 and 28 mg/L, with a median value of 15 mg/L in the Narsaq river upstream of the Kvane river
- Uranium concentration varied between ~0 and 2.8 µg/L, with median values around 0.5 µg/L. The level is well below international guidelines (e.g. the Canadian guidelines of 15 µg/L)
- The baseline level of uranium and thorium in the Narsaq river is higher than the levels in the Kvane lake and Taseq basin
- Baseline level of arsenic (As), except one in Narsaq river, is below the Greenland Water Quality Criteria – GWQC (4 µg/L)
- Concentration of cadmium (Cd), chrome (Cr(III)), copper (Cu), and lead (Pb) is below the GWQC at all sites
- Concentration of zinc is typically below GWQC in Narsaq river but above GWQC in Kvane lake
- Despite the fact the maximum recorded concentration of phosphorus (Tot-P) in the Narsaq river exceeded the GWQC (20 µg/L), the median value is well below the GWQC at 0.5 µg/L
- Very significant seasonal variations in concentrations were observed. In the summer period with high run off the concentration of salts was very low. In winter periods with low flow (mainly groundwater influenced) much higher concentrations of around 100 µg/L of dissolved phosphorous were observed. This indicates that the origin of the river water determines the dissolved element content
- All results from all sites exceed international guidelines for freshwater environments including the World Health Organization (WHO) drinking water guidelines.

The water quality study concludes that baseline concentration levels of fluoride are 100 times above Canadian freshwater quality guidelines in parts of the Narsaq river and ten times above WHO drinking water standards.

All sampling sites in Narsaq river, Kvane lake and Taseq basin have median values that exceed the ambient water quality criteria by at least a factor of five. Baseline concentrations of arsenic, zinc, and phosphorus at some locations exceeded ambient water criteria (Orbicon 2018). The variations are likely a result of seasonal differences between summer and winter runoff sources.

In Greenland drinking water is primarily supplied from lakes and rivers. Narsaq is supplied with water from the Napasup Kuua, Kuukasik and Langnam rivers. Total annual consumption is approximately 80,000 m^3. Water is collected in a town reservoir with a capacity of 280,000 m^3. The water is filtered and treated with chlorine. The supply of drinking water to Narsaq is managed by Nukissiorfiit.

The Project will not affect the supply of drinking water to Narsaq Town.

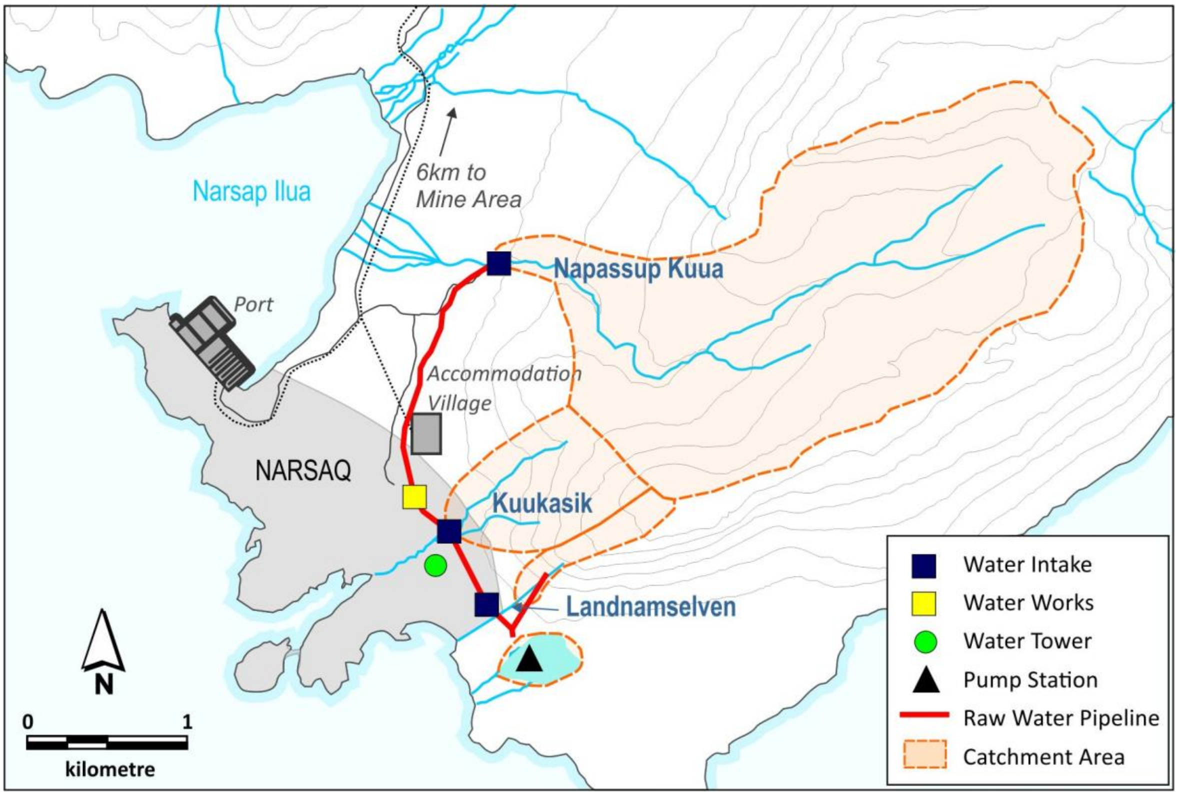


Figure 40 Narsaq Town drinking water sources

10.1.2 Marine environment

The seas off south and west Greenland, north to 65-67° N, are ice-free throughout the year. This open water area (Åbenvandsområdet) is primarily a result of the relatively warm north or northwest flowing West Greenland Current. However, three types of sea ice can occur in the marine area surrounding the Erik Aappalaartup Nunaa peninsula (Figure 41):

- Short-lived fast moving ice may occur in the inner part of the fjords during winter. This type of ice cover is extremely variable both within each winter period and between winters

  In recent years, fast ice has mostly been limited to the heads of the fjords, with the remaining parts of the fjords otherwise ice-free during winter

- Icebergs and growlers originating from glaciers in the Ikersuaq/Bredefjord – Sermilik system, but also at the head of Tunulliarfik/Eriks Fjord, are common all year

  During summer icebergs and growlers can cover large parts of Nordre Sermilik and sometimes Ikersuaq/Bredefjord

- Multi-year sea ice/drift ice (Storis), flowing with the East Greenland Current, moves southwards along the east coast of Greenland, turns westwards at Cape Farewell and then northward along the south-west coast of Greenland.

  In some years, wind and waves cause "Storis" to fill up the mouths of the larger fjords of south Greenland including Ikersuaq/Bredefjord and Narlunaq/Skovfjord during spring.

Like most fjords in south and west Greenland, the three fjords in the area surrounding the Project are old glacial valleys (Ikersuaq/Bredefjord, Nordre Sermilik and Narlunaq/Skovfjord, shown on Figure 41). These fjords are generally deep, with maximum water depths up to 680 m.

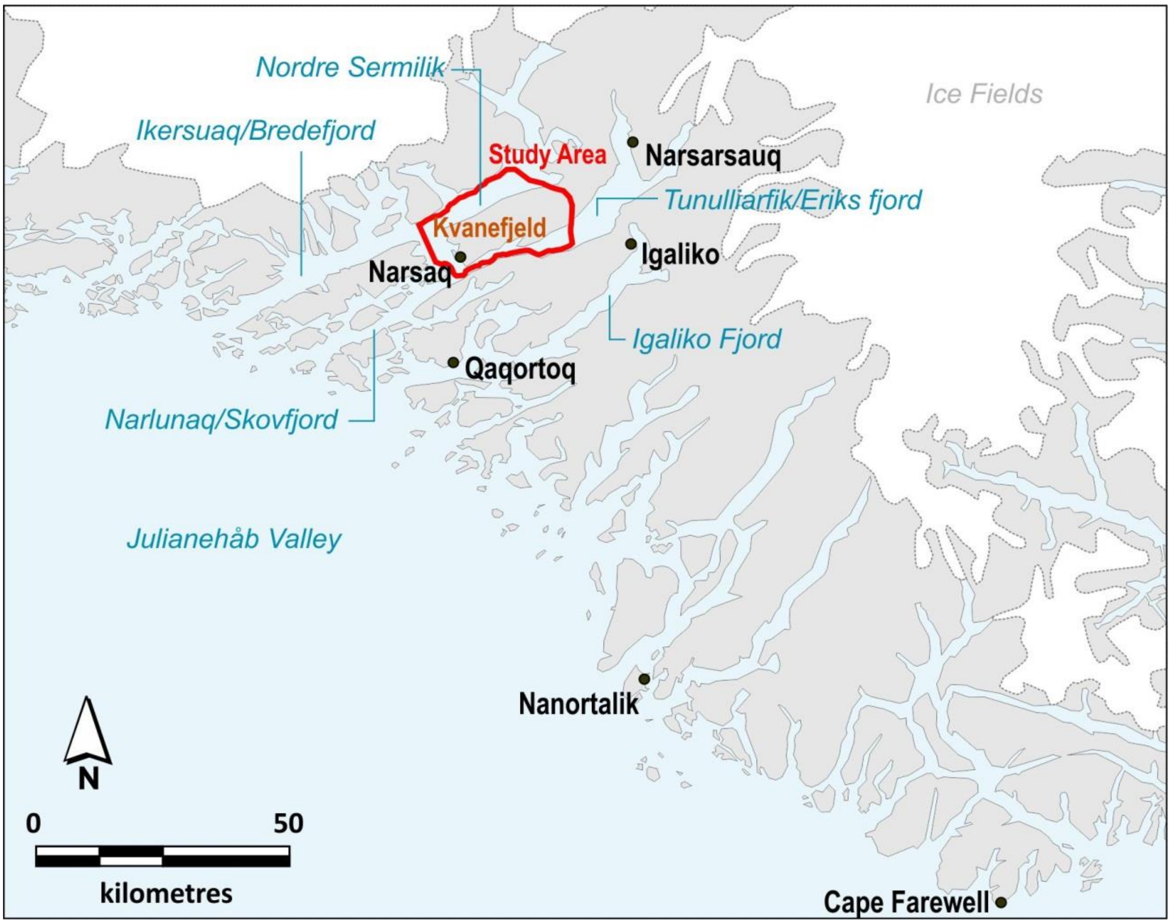


Figure 41 Marine environment

Ikersuaq/Bredefjord and Narlunaq/Skovfjord are also "sill fjords" where low water depths at the mouth of the fjord prevent the free ingress of oceanic water. At the mouth of the Ikersuaq/Bredefjord the depth at the entrance is 140 m, while depth at the mouth of Narlunaq/Skovfjord is only 70 m. As the sill strongly limits the exchange of water between the deeper parts of the fjords and the open sea, large-scale circulation of water in the fjords mostly depends on the supply of freshwater. The freshwater input comes mainly from rivers, such as the Narsaq river, but also from icebergs that have calved from glaciers.

In these sill fjords, the inflow of freshwater forms a brackish surface layer of water that causes a higher water level in the fjords than outside (Mosbech et al. 2004). This difference in water level forces the brackish surface water out of the fjords. As the water flows out towards the mouth of the fjord, the brackish water becomes increasingly saline due to the surface water mixing with the underlying water. In order to replace the saline water entrained by the surface current, an undercurrent of more saline water flows into the fjords at intermediate depths (Mosbech et al. 2004).

During winter, the fresh water inflow to the fjords is reduced because lakes and rivers freeze and the precipitation on land falls as snow rather than rainfall. The reduced inflows of fresh water cause the surface salinity in the fjord to increase to the levels found in the coastal waters outside the fjord. The reduced difference in salinity decreases circulation within the fjord to a minimum.

As a result of the reduced exchange of salt water with the ocean, sill fjords are fragile marine ecosystems. In addition, the quantity and quality of freshwater inflow from rivers are of particular importance to the marine flora and fauna, as these water sources are one of the main drivers of the water exchange in these fjords.

10.1.3 Groundwater

The TSF will be constructed in the Taseq basin, which is currently drained by Taseq River, a tributary of the Narsaq River. Surface runoff to the TSF will be reduced by the construction of diversion channels. The TSF will remain flow-through as is the current Taseq basin.

Existing groundwater hydrology data for the Taseq basin and surrounds was assessed to determine the likely presence of water in the groundwater systems and the potential for seepage from the TSF into the groundwater systems. (Orbicon 2018, GHD 2018)

Groundwater storage

The potential for groundwater storage in the Taseq basin is limited as a result of steep slopes, bare rock and limited layers of soil and sediments. The rock and sediment in the basin is not considered to be suitable for groundwater storage.

Given pressure gradients from the higher surrounding terrain, groundwater from the limited storage will tend to be push any groundwater into the Taseq lake.

There will however be a local increase the hydraulic pressure head (30 to 50 m above the current levels) which may create conditions for facilitating transfer of solutes to underlying groundwater.

It is assumed existing seepage from the upper few meters of the confined western part of the lake where the outlet is located. However, this subsurface water is currently not interacting with other groundwater bodies.

Geology

Tectonic activities can result in open fractures. In the Taseq catchment tectonic activity was associated with magmatic activities which creates relatively few open fractures.

The basement rocks underlying the base of tailing facilities are composed of the Ilimaussaq naujaite (Orbicon 2012) and a smaller extent of Gardar basalts to the southwest of the outlet from the Taseq basin. Naujaite is a crystalline igneous rock that is more broadly classified as a syenite. While there has been no targeted hydrogeological drilling or hydraulic testing done in this area, shallow geotechnical drilling (6 holes ranging from 17-33 m) at the outlet of the basin suggests that the degree of weathering would be considered low and consequently the permeabilities associated with the host rock are also considered low. A continuous drill core from a 500 m exploratory hole (DDH-V001) drilled from adjacent to the lake within Taseq Basin further demonstrates that naujaite continues for 233 m below current water levels, with minimal weathering and fractures. From 233 m downhole, lenses of lujavrite occur between naujaite.

Since the matrix permeability is considered negligible, the transmissivity would be of secondary nature driven by the fracture sets. Hydraulic testing from the future mining area at Kvanefjeld suggests low transmissivities in the order of several m2/d, which would indicate very low bulk permeability values in the range of 0.001 to 0.01 m/d for the full section of the host rock (lujavrite). The mine area features a significantly greater variety of rock types and is more structurally complex than the area underlying

Taseq, which in contrast is dominated by massive naujaite. It is therefore reasonable to consider the hydraulic testing from the future mine area as a conservative comparison to Taseq.

On the assumption that similar permeability values apply in the TSF area and the likely groundwater gradients in the basin being relatively low, the groundwater flow rates underneath the basin will be low, estimated at a rate of several metres per year. The presence of fractures may locally increase the groundwater flow rates (advection) to several tens of metres per year.

These estimated advection rates indicate potentially low contaminant transport prospects through the groundwater pathway assuming that the hydraulic properties of the Taseq basin are similar to lujavrite of the mining area, and as such are considered low risk.

In addition to this the digital elevation model indicates a potential presence of the fault/fracture zone that crosses the CRSF area in WSW-ENE direction. Assessment of drill cores from exploratory drilling suggest there has been negligible offset or movement along the fault-fracture zone within the Ilimaussaq intrusion. There is currently uncertainty about the hydraulic function of this potential fault/fracture zone which may be an outlying expression of the prominent fault zone in the Napassup Kuua catchment area to the southeast of the Taseq basin.

Catchment water balance

The water balance in the Taseq catchment was calculated using data from the Danish Metrological Institute, from local meteorological data and from local hydrological monitoring data.

The water balance describes the circulation of water in the catchment area and indicates whether any water is being lost to groundwater systems.

inputs = outputs and losses to the system

precipitation = surface run-off + evaporation + loss to groundwater

Data for the Narsaq river for the 50-year period 1964 to 2014 show the following annual averages:

- precipitation = 1,120 mm
- surface run-off = 990 mm
- evaporation = 160 mm.

Based on these data water output from the catchment exceeds water input to the catchment by an annual average of 30 mm. This difference is within the order of accuracy of the data recording and modelling and is indicative of limited or no loss of water from Taseq to ground water systems.

The assessment of existing hydrogeological data concludes that the potential for groundwater storage and movement is limited. Basement geology underlying the basin (and the proposed TSF) is characterized by crystalline rock with minimal weathering. The rock types beneath the Taseq basin will demonstrate similar characteristics to the surrounding geology and are likely to be impermeable with limited interaction with groundwater systems.

The risk of significant seepage from the proposed TSF is considered to be low.

Further hydrogeological investigations may be required to constrain the conclusions that have been made in respect of the presence and movement of groundwater.

10.2 Potential impacts

The potential impacts to the water environment are:

- Construction and operation of the Project will modify hydrological processes, potentially affecting water quality
- Operation of TSF has the potential to result in contamination outside the TSF arising from spills, damage to the TSF or wind-blown dispersion of material from the surface of the TSF
- Release of aerosols from the TSF has the potential to result in contamination of water down wind of the TSF
- Discharge of treated excess water from the Project has the potential to affect water quality in the Norde Sermilik fjord
- There is the risk of accidents during the construction and operation of the Project that may result in the discharge of chemicals (i.e. oil spills) into the environment
- Risks of accidents which result in the discharge of hydrocarbons and chemicals
- Risks of accidents which result in the discharge of Project process water.

10.3 Assessment of impacts

10.3.1 Modification of hydrological processes

The major hydrological changes that will take place during the Project are:

- Outflow from the Taseq basin will be blocked by embankments constructed for the TSF

  Water that enters the basin will be pumped through a pipeline to the Plant. This water will be recycled and treated (to remove fluoride) prior to placement of a proportion of it into Nordre Sermilik fjord

  Diversion channels will be constructed to direct rainwater and water from melting snow away from the TSF. Some of this water will be directed to the Taseq river
- The flow of Kvane river will be gradually reduced and will no longer report to the Narsaq river

  Water from the Kvane river will pass through mine dewatering and be pumped through a pipeline to the Plant
- A culvert will be installed across the lower section of Narsaq river
- An embankment with a sluice will be built across the Narsaq river at the raw water dam site to create a raw water storage source for the Project.

The reduced flow of the Kvane river into the Narsaq river will have limited impact on the flow in Narsaq river, the Kvane contributes only 5 % of the average annual flow in the Narsaq river (Orbicon 2014a). The construction of the embankments at the Taseq basin will reduce the inflow in Narsaq river by approximately 17 %. These figures refer to the average flow throughout the year.

During winter the hydrological changes will have very little or no impact on the flow in Narsaq river because very little or no water flows out of the Kvane lake and Taseq basin during winter.

The construction of the raw water dam will have little impact on the hydrology of Narsaq river.

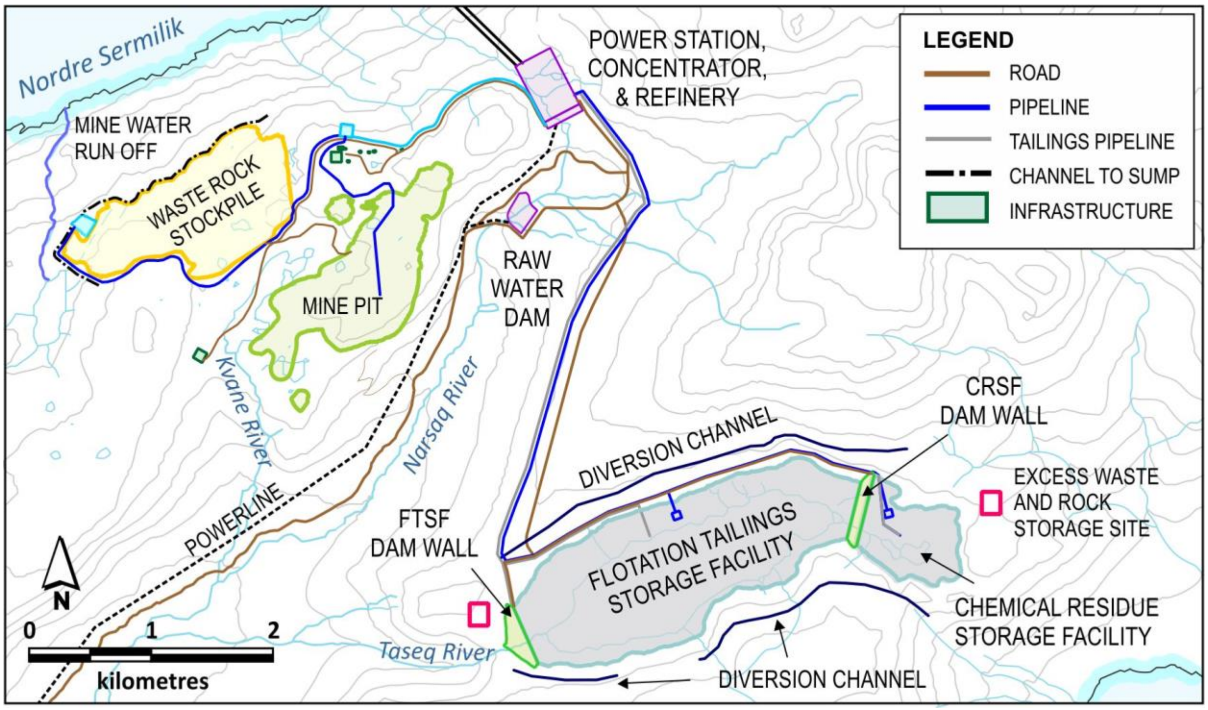


Figure 42 Location of Raw Water Dam

Culverts will be constructed as required, including one across the Narsaq river. These will be designed to cause no significant flow constrictions to the river. An example of the culvert is shown in Figure 43. During culvert construction, water flow in the Narsaq river will be maintained by pumping water around construction activities which will also help to ensure that a dry construction site will be maintained.

Figure 43 Culvert type

Approximately 191 m^3/h of freshwater will be sourced from Narsaq river for the Plant. With an average flow of 1200 m^3/h at this site and 4100 m^3/h downstream near the outlet into Narsap Ilua, the impact on flow will be limited.

The changes to the hydrology of rivers and lakes will have limited impact on the overall hydrology of the area but will have a significant impact on the Kvane and Taseq rivers, which will have significantly reduced flow in their upper sections.

10.3.2 Operation of TSF

The design and the operations of the TSF comprising the FTSF and the CRSF are detailed in Section 3.7. Water quality issues related to the deposition of tailings during the lifespan of the Project have been modelled and detailed in technical reports covering the Project's operations (year 1 - 37), closure (year 38 - 44) and post-closure (beyond year 44) phases (Orbicon 2015b, Orbicon 2018b, GHD 2018).

The majority of the tailings produced in the Project's operations phase will originate from the physical extraction of zinc, uranium and REE (~90% of total tailings) from the ore. These tailings will be disposed as a wet slurry in the FTSF. The balance of the tailings is the residue left after refining the REEs and uranium. It is also disposed as a wet slurry in the CRSF. Both tailings streams will be deposited subaqueously.

The FTSF and CRSF utilize the natural topography of the valley of the Taseq basin. Two embankments will be constructed within the basin, one for the FTSF and one for the CRSF. The height of each embankment will be increased in stages to cater for the increasing requirements for tailings storage capacity during the Project's operations phase.

Inflow from the catchment area to the TSF will be reduced by constructing diversion channels before the prior to the commencement of processing operations. The channels will partly divert the run off to the Taseq river downstream of the FTSF embankment.

There will be no discharge from the FTSF and the CRSF to the Taseq river during the operations or closure and decommissioning phases. Post-closure, when the water covering the FTSF and the CRSF meets quality criteria, water will be allowed to overflow the embankments into the Taseq river.

Due to precipitation and natural run-off, the water levels in the from the FTSF and the CRSF will increase at the beginning of the Project's post-closure phase. The level in the FTSF will continue to increase until water starts to flow over the embankment spillway into the Taseq river.

The water quality in the Taseq river downstream of the tailings facilities will have to comply with GWQC at a control point downstream of the mixing zone of the junction between the Taseq and Narsaq rivers. From a practical point of view, the control point in the river will be easily accessible for future monitoring.

Water quality in the FTSF and CRSF has been assessed to identify:

- The concentration and flows in the facilities and their interactions with the Plant during the Project's operations phase
- The concentration and flows of the discharge to the freshwater bodies of the Taseq and Narsaq rivers during the post-closure phase.

A dynamic process simulation model has been developed for this purpose using an the software. The software has simulated three Project phases through a lifespan of almost 100 years.

The sequences and milestones in the phases are summarized in Table 35. Calendar year 2021 has been selected as the notional start date of the Project.

The model has been validated with check calculations performed by Orbicon (Orbicon 2018) using excel and by GHD (GHD 2018) using the Goldsim® modelling package. There was very good agreement between all three modelling methods, therefore all are valid to use to show the impact.

Table 35 Timeline and milestones in the tailings facilities management

Phase	Mining Year	Calendar Year	Remarks
Operations (37 years)	1	2021	Start of operations phase.
	1 – 37	2012 – 2057	Tailings stored continuously in FTSF and CRSF. Excess water (supernatant) decanted and re-used in Plant. No discharge to Taseq river. Tailings volume capacity and height of embankments increased several times.
	37	2057	End of operations phase. Tailings production ceases.
Closure (6 years)	38	2058	Start of closure phase.
	38 – 43	2058 – 2063	Water in the FTSF and CRSF decanted to the Plant and treated to remove fluoride and discharged to Nordre Sermilik following treatment. No discharge to Taseq river. Water level in ponds gradually lowered. Precipitation and run off will partly compensate decanted water volume. Water quality gradually improved.
	43	2063	End of closure phase.
Post – closure (>44 years)	44	2064	Start of post-closure phase.
	44 – 48	2064 – 2068	Precipitation and run-off to the FTSF and CRSF will increase the water level. Maintenance of diversion channels has stopped and as a result run off to the FTSF and CRSF gradually increased. The effect of diversion channels in model has been terminated in 2073.
	48	2068	Water from CRSF starts overflow the rim of the embankment to FTSF. No discharge to Taseq river.
	49	2069	Water quality criteria is met. Water from FTSF starts overflow the embankment to the Taseq river. Post-closure phase completed.
	59	2079	Water quality results presented 10 year after commencement of the discharge to Taseq river.
	93	2113	Time horizon for model runs of

Specific information from geochemical assays of the tailings slurries, from chemical processes in the Plant, hydrological development of the TSF have been used to develop a process model (Orbicon 2015b).

The process model predicts the behaviour of over 400 different chemical species and elements through the flotation and refinery processes, including the REEs, uranium, thorium, reagents and impurities.

Specific attention has been devoted to the elements included in the list of ambient water quality criteria for Greenland. This includes, in addition to elements found in the Study Area with elevated concentrations relative to continental crustal average, elements identified as of 'environmental concern'.

In respect of identification of reagents/consumables for modelling, the following criteria were used:

- the fate of the reagents in the process
- eco-toxicity properties
- bio-accumulating properties and quantities.

In total 46 elements and 15 reagents and consumables used in the processes have been modelled.

Baseline concentrations from the rivers and lakes were also included in the model. Measured baseline concentrations obtained from the Narsaq, Taseq and Kvane rivers and from Kvane lake and Taseq basin since 2007 indicate persistent high levels of fluoride exceeding international ambient water quality guidelines by up a factor of 100.

Natural background concentrations of arsenic, zinc and phosphorous also regularly exceed GWQC. The natural geological features within Narsaq valley are the likely cause of the variations and the elevated concentrations of rare elements in water. The origin of run-off (surface near run-off or groundwater) and the geological variation within the individual sub-catchments are determining baseline water quality. Existing baseline water quality will be a factor for consideration when future water quality is assessed against water quality guidelines.

The concentration of certain elements and reagents present in the FTSF and CRSF during the operations phase will exceed ambient water quality criteria. However, during the operations phase no water from the FTSF and CRSF will discharged to the natural environment. Instead water will be re-used as process water in the Plant and any excess water will be pumped to the water treatment facility in the Plant for treatment prior to being placed into the Nordre Sermilik fjord.

During the Project's closure phase the concentrations of all elements and reagents in the FTSF and CRSF supernatants will be significantly reduced by water treatment and by dilution resulting from precipitation and runoff to the FTSF and CRSF. This will effectively reduce the concentrations of almost all elements and reagents to below ambient water quality criteria or PNEC. The outflow from the FTSF to the Taseq river starts in the early stages of the post-closure phase.

Downstream of the convergence point of the Taseq and Narsaq rivers all elements and reagents will be below the ambient water quality criteria and PNEC, with the exception of fluoride. The Canadian ambient water quality guideline for fluoride is 0.12 mg/L, which is exceeded by baseline fluoride concentrations in the Narsaq river (ranging between 1 and 28 mg/L depending on time of year).

Examples of the concentration of uranium and fluoride in the tailings dam water are presented in Figure 44 and Figure 45. Figure 44 details the uranium concentration pattern in the CRSF with fluctuations in the first five years (due to the low volume of material in the CRSF) together with the quarterly values that have been used for the hydrological input in the first five modelling years.

In the Project's operations phase there will be a slow increase in the concentration levels of fluoride in the FTSF, caused by constant input of tailings slurry. This rise in concentration plateaus before it will fall dramatically during the closure phase.

In the CRSF, concentrations of uranium and fluoride will be lower than in the FTSF; however the concentration of sulphate and chloride salts will be elevated. As a consequence, the contents of the

CRSF will have to be completely isolated from the surrounding environment. The CRSF will be fully lined.

In the Project's closure phase there is a significant decrease in the concentrations of dissolved salts in the CRSF. This occurs because the water soluble metal from the tailings slurry is no longer entering the CRSF and because of the recycling of supernatant water to the water treatment facility at the Plant. The water also becomes more diluted from run-off and precipitation.

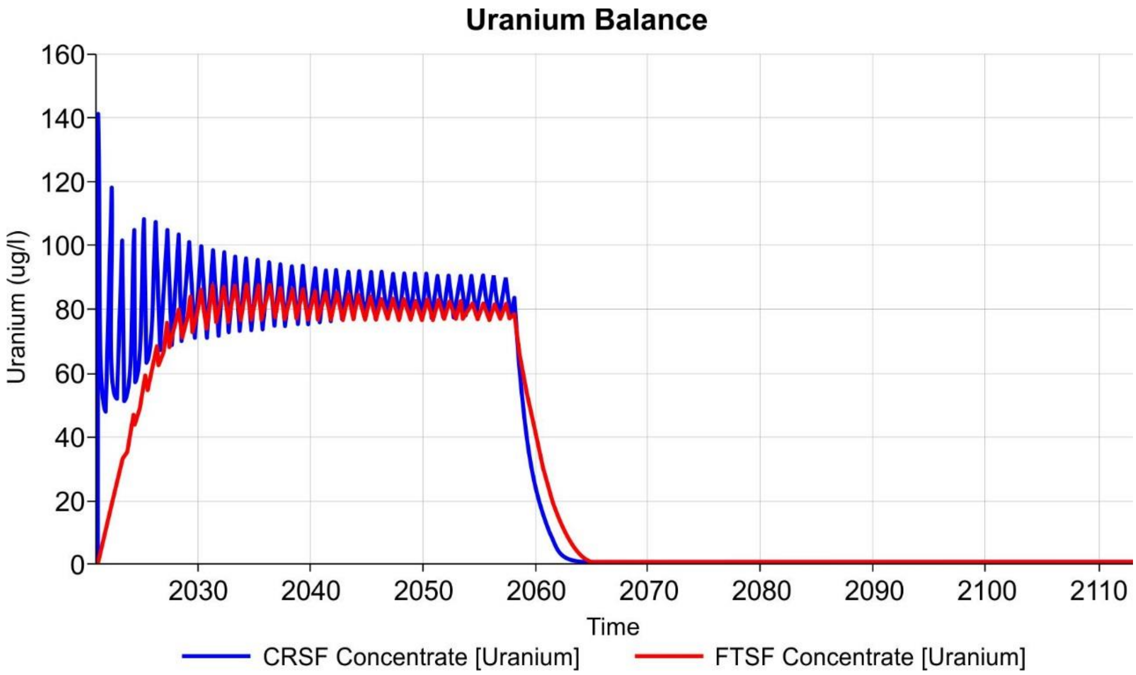


Figure 44 Uranium (U) Concentration in both Tailings Facilities over the life of the project as predicted by Goldsim.

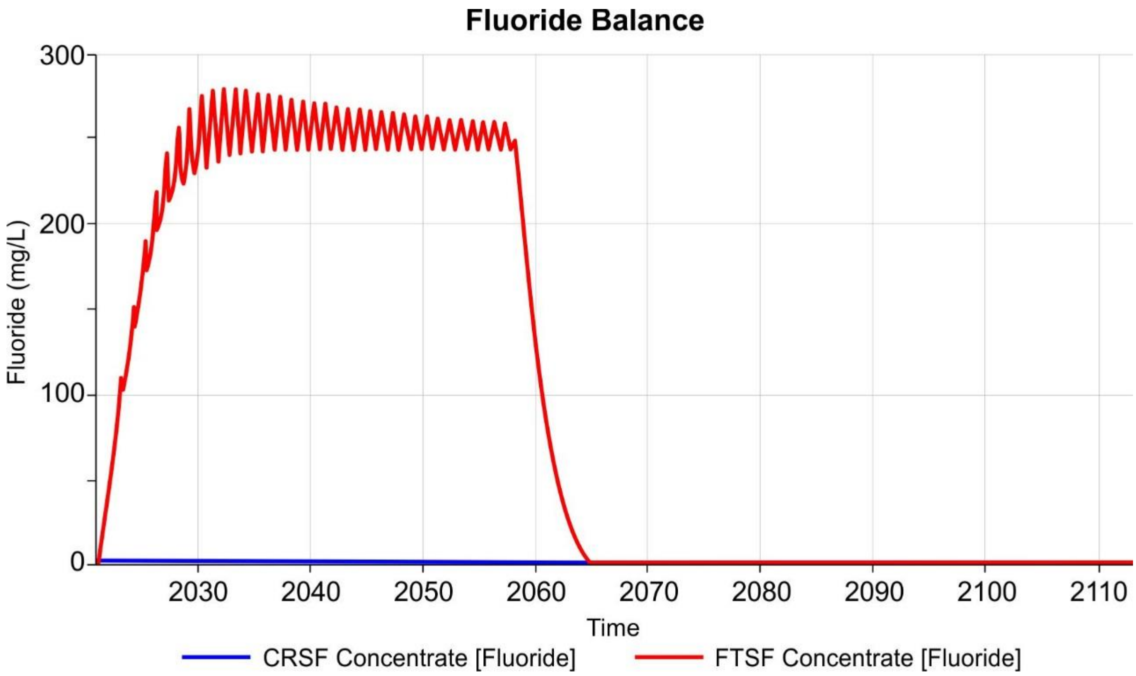


Figure 45 Fluoride (F) Concentrations in both Tailings Facilities of the life of the project as predicted by Goldsim

During the Project's operations phase, the concentration of flotation reagents in the FTSF increases sharply initially, and then gradually levels out over time. During the closure period there is a sharp decrease in the concentration of these reagents with the decline in concentration continuing in the post closure period.

Flotation reagents used in the flotation process are not present in the CRSF.

Table 36 summarizes the results of the [redacted] modelling of concentrations of metals and elements downstream of the Narsaq river and Taseq river merge point. The modelling results are shown alongside the relevant Canadian guidelines and the baseline values used in the modelling. Table 37 summarizes the results of the [redacted] modelling for reagents.

Table 36 Model results from [redacted] at years 49,59 and 93 downstream of the Taseq river confluence in Narsaq river (Orbicon 2015b)

Elements River Narsaq	Criteria	Baseline (used in model)	Year 49 outlet from FTSF starts	Year 59-10 year after outlet from FTSF starts	Year 93
Arsenic (µg/L)	4	0.52	0.47	0.47	0.48
Cadmium (µg/L)	0.1	0	0.001	0.002	0.001
Chromium (µg/L)	3	0	0	0	0
Copper (µg/L)	2	0	0.002	0.003	0.002
Iron (µg/L)	300	22.18	17.39	17.39	17.4
Lead (µg/L)	1	0	0.000003	0.000006	0.00004
Mercury (µg/L)	0.05	0	0	0	0
Nickel (µg/L)	5	0	0.003	0.006	0.004
Zinc (µg/L)	10	3.1	3.0	3.0	3.1
Phosphorous (µg/L)	20	2.3	5.5	5.8	4.3
Solids (ppm)		0.0	1.0	1.3	1.3
Fluoride (mg/L)	0.12*	2.7	5.6	4.7	3.8
Potassium (mg/L)		0.3	0.3	0.3	0.3
Sulphur (mg/L)		1.0	1.9	2.8	2.2
Chloride (mg/L)	120*	4.3	7.0	9.8	8.2
Sodium (mg/L)		5.2	12.0	13.7	10.6
Sulphate (mg/L)		3.1	5.6	8.3	6.5
Calcium (mg/L)		1.5	1.5	1.7	1.6
Uranium (µg/L)	15*	0.4	0.9	0.9	0.7
Thorium (µg/L)		0.0E+00	2.6E-05	5.2E-05	3.5E-05
Manganese (µg/L)		0	15.24	30.93	20.67
Molybdenum (µg/L)	73*	0	0.35	0.32	0.19
Lithium (µg/L)		0	9.85	7.39	4.17
Thalium (µg/L)	0.8*	0	0.00	0.01	0.00
Radium-226 (Bq/L)	0.5**	0	6.8E-05	1.3E-04	1.0E-04

For some elements modelled, the baseline concentration was very low and were modelled as zero rather than a very low number, as shown in Table 36.

The baseline values are defined for the control point C, i.e. after the merge point of Narsaq river and Taseq river.

Table 37 Comparison of Predicted no Effect Concentrations (PNEC) criteria for reagents and modelled concentrations downstream of merge point (Orbicon 2015b)

Reagents river Narsaq	Criteria PNEC	Year 49 outlet from FTSF starts	Year 59 – 10 year after start of outlet	Year 93
Total Flocculant (µg/L)	10	0.00	0.00	0.00
SIBX (µg/L)	268	0.08	0.01	0.00
Copper Sulphate (µg/L)	0.1	0.00	0.01	0.01
Aero 6494 (µg/L)	0.33	0.03	0.00	0.00
Sodium Silicate (µg/L)	2470	774	396	324
Frother (µg/L)	0.24	0.06	0.01	0.00
Barium Chloride (µg/L)	220	0.00	0.00	0.00
NaHS (µg/L)	10	0.01	0.01	0.01
Alamine 336 (µg/L)	0.014	0.00004	0.00002	0.00001
Isodecanol (µg/L)	10	0.00	0.00	0.00
PC88A (µg/L)	4.2	0.01	0.00	0.00
Shellsol Diluent (µg/L)	2	0.01	0.00	0.00
CW Biocide (µg/L)	0.2	0.00	0.00	0.00

In general, the modelled concentration patterns over time for reagents and elements downstream of the merge point of Taseq river and Narsaq river can be summarized as follows:

- Concentrations for all elements included in the GWQC (2015) are well below criteria values
- Uranium is not included in the GWQG
- As an alternative criterion the Canadian guideline (Canada, 2015) concentration of 15 µg/L has been used. The concentration is 1/16 of the Canadian guideline criterion
- The concentration of fluoride exceeds the Canadian Guidelines of 0.12 mg/L by a factor of nearly 50.

  The baseline fluoride concentration already exceeds this guideline value by a factor of 22, hence the Canadian Guidelines are not applicable to the Study Area.

  When compared to typical variations in the baseline fluoride concentration in Narsaq river upstream of control point C, between 1 and 28 mg/L, the expected peak fluoride level at control point C during Year 49 of 5.6 mg/L is well within normal conditions for this site

  The Project, in terms of fluoride concentration, will have no noticeable impact on the existing environment
- Reagent concentrations are well below PNEC values for all reagents.

The content of fluoride in TSF water will reach 250 mg/L during the Project's operations. This concentration will be reduced significantly in a specific precipitation circuit in the Plant. Fluorspar, a commercial product, will be reclaimed from this circuit.

During the Project's closure phase the concentrations of all elements and reagents in the outlet to the fjord will be less than during operations as no additional flotation and refining tailings will have been added after year 37.

The potential impact in the marine environment in the 6 year closure phase will consequently be lower than the operations phase.

Tailings supernatant overflow

Embankments for both the FTSF and the CRSF will be constructed to withstand extreme inflows of water, for example due to exceptional snow melting under føehn wind event. A conservative 10 m freeboard has been chosen for both tailings ponds designs. Large diversion channels will be constructed to capture water ingress to the Taseq basin and lead it away from the TSF. These channels will significantly reduce the likelihood for an overflow of the TSF.

The capacity of the TSF has been designed to cater for a range of extreme weather scenarios, such as a 1 in/ 10 000 year rainfall event.

An overflow of the CRSF embankment into the FTSF would have no immediate consequences. Supernatant water from the CRSF would be contained FTSF. The FTSF embankment will have 10 m free board designed to accommodate a major inflow of water from the CRSF or from the surrounding environment.

Were supernatant to overflow, it would overflow the FTSF embankment at the designated spillway point. Water would first flow into the Taseq river and then into the lower part of Narsaq rivers before reaching the fjord at Narsap Ilua.

The impact of an overflow on the freshwater biota and marine life will depend on the amount and quality of water that overflows the FTSF embankment. Were a major overflow to occur during the Project's operations phase, supernatant with high concentrations of several elements would enter watercourses in the Narsaq valley and would have a severe impact on the aquatic life in the impacted areas.

If the supernatant overflow were to result from extreme rainfall or snow melt, the supernatant will be diluted be prior to overflowing and as a result the impact would be significantly lower.

The impact on the Taseq and Narsaq rivers would most likely be short term, lasting days or weeks. The impact of an overflow on marine life is likely to be local only (limited to Narsap Ilua).

To minimize the risk of an overflow event it is essential that the diversion channels are kept well maintained during the operations and closure phases.

Given that there is a low risk of an overflow event and that the overflow water would be highly diluted, the impact from an overflow is assessed as low.

TSF Embankment failure

Three different scenarios for a potential failure (complete or partial) of the TSF embankment were assessed to determine the impact of a failure on the downstream environment (Arcadis 2018c). The assessment considered the impact of a failure to contain tailings in and the water cover of the FTSF in the Project's closure and post closure phases. During these phases the volume of tailings would be at its maximum.

Overtopping - Containment failure resulting from the degradation of the upper embankment area.

The 5 m water cover on the TSF is released but the tailings remains behind the embankment. Approximately 15 Mm^3 of water would be discharged.

It is assumed that the discharge occurs over a period of 3 months at an average rate of 6,900 m^3 per hour. It is also assumed that the failure might occur at any time of the year and that all tailings would be retained in the FTSF.

The main impact of an overtopping event would be caused by the large and extended water flow. Immediately following failure, the depth of water flow in the upper Taseq river area will be relatively high because of the steep sloping stream bed channel of the Taseq river and the narrow and steep valley side walls immediately downstream of the embankment. The flow from the release of water is likely to overwhelm the natural river flow and there would be significant scouring and biota such as fish could be swept away with the flow.

The grass fields at the fan zone (where Narsaq River fans out as it approaches Narsap Ilua) would be expected to flood for a period of time and it is likely that terrestrial species of flora and fauna would be overwhelmed in the affected area.

Partial failure – Containment failure resulting from a partial breach of the embankment.

An example of this would be a piping failure, the deterioration of the sealed diversion conduit constructed prior to FTSF embankment construction. This could result in the loss of 100% TSF water cover and a significant quantity of tailings into the Taseq and Narseq Rivers.

It is assumed that all of the surface water (15 Mm^3) and 25% of the flotation tailings stored above the orginal Taseq lake saddle (15 Mt) are lost over a period of 1 month. The discharge is assumed to start with tailings only discharge at 60% solids which quickly changed to a lower % solids condition as the surface water is mixed in.

A partial failure of the TSF embankment will produce similar results to those experienced with overtopping but with greater impacts. The difference arising from the impact of depositing tailings solids. The flow from the release of water is likely to overwhelm the natural river flow and biota would be swept away with the flow.

The area immediately downstream of the FTSF, the low depth and high velocity combined with the rough river bed create a highly turbulent flow which would prevent settling of tailings solids in these areas. Except for some small recessed pockets where the flow could slow-down, significant deposition would not occur. With progressively shallower stream gradients and side slopes, the rate of deposition of tailings would increase and the area over which deposition takes place would expand to cover larger portions of the valley surfaces.

It is estimated that approximately 65% of the tailings material, particularly coarser particles, would settle in the lower reaches of the Narsaq river. The majority of the balance of the tailings would settle in Narsap Ilua with only a small proportion reaching the fjord.

It is likely that terrestrial specis of flora and fauna would be overwhelmed in the affected area.

Catastrophic failure - Containment failure resulting from a full breach of the embankment.

It is assumed that breach 100 m wide occurs in the embankment (full dam height of 40 m) and that the height of tailings is 30 m above the natural saddle on which the FTSF is constructed.

Under these circumstances, approximately 15 Mm^3 of free water, approximately 4 Mm^3 of tailings and approximately 2 Mm^3 of tailings pore water would be released. Of the 21 Mm^3 released 80% to 90% would be released in the first 24 hours.

Assuming 90% of the material is released in the first 24hr, 787,500 m^3 would be released each hour (13,125 m^3/min, 218.75 m^3/sec). At a velocity of 3 m/s, this would result in a cross-sectional area of approximately 73 m^2. If the velocity of the material 1 m/s, this would represent a cross-sectional area of approximately 219 m^2.

The most obvious effect of a TSF embankment failure is deposition of tailings solids and dam material over a wide area downstream of the breach. Due to the steep sloping stream bed channel of the Taseq river and the narrow and steep valley side walls immediately down stream of the dam, the depth of tailings and water flow would be relatively high in this location immediately following failure. Progressively shallower stream gradients and side slopes of Taseq river would result in the tailings deposition expanding to cover larger portions of the valley surfaces.

At the rate of release in the event of a embankment breach, it is expected that the entire width of the fan zone would be flooded with the released tailings. With the average width of 400 m, the depth of flow would be of the order of 0.74 m and 0.24 m for the velocities of 1 m/s and 3 m/s, respectively.

In the upper and lower parts of Taseq river, the low depth and high velocity of the released tailings, combined with the rough river bed create a highly turbulent flow which would prevent settling of tailings solids in these areas.

With the calculated stream velocity and the assumed particle sizes, the tailings flow at the Narsaq drainage area causes mostly erosion of Narsaq river bed and transportation of suspended solids downstream towards the Narsap Ilua. Overall, it expected that between 75 to 85% of tailings solids deposit in Narsap Ilua with the rest enters the Fjord.

It is estimated that for all failure scenarios, the release of tailings water along with tailings solids and associated porewater would result in exceedance of water quality guidelines for several elements in Taseq and Narsaq Rivers and in the ocean, at the Skovfjord. However, the most significant effect would be the physical impact of sudden release burst flows of high velocity and solids into the receiving environment.

There will be short and long term impacts to the environment associated with any failure of the TSF embankment. Terrestrial and aquatic flora and fauna will be impacted physically from the rush of water and/or tailings into the water courses and surrounding landscape. There are potential impacts from the quality of the tailings water and the tailings that may result in local contamination of receiving surface waters and the landscape. Ongoing natural erosion will reduce these impacts over time. Selective remediation efforts may help reduce the level of impact. No tailings are expected to reach Narsaq town or other settled areas.

The risk of a TSF embankment failure is considered extremely low and very unlikely. The TSF design incorporates highly engineered, lined, and rock filled embankments, designed to International Commission on Large Dams (ICOLD) criteria, Best Available Technology and appropriate statutory requirements.

Embankments will be developed using the “downstream” construction method. The use of the “downstream” construction technique builds the tailings dam away from the containment. This ensures the tailings wall is only built on existing stable ground rather than placed tailings. The TSF will be constructed on a solid rock base which provides additional assurance of long-term stability of the embankments.

Slope stability analysis has been completed to evaluate the Factor of Safety (FoS) of the embankments under both static and pseudo-static (simulating earth quakes) loading conditions. The potential for embankments physically moving along the ground has also been analysed. The embankment design will be stable both under static and pseudo-static (seismic) conditions.

The potential impact to the natural environment if the TSF embankment were to occur has been assessed as medium. However, given that there is an extremely low risk of a TSF embankment failure of any magnitude the overall impact has been assessed as low.

Pipeline rupture and plant failure

Tailings mixed with water will be transported as slurry through a pipeline from the Plant to the TSF. A pipeline rupture will lead to a localised spill of slurry containing tailings or process water. Pressure sensors and block valves will be installed on all pipelines to detect spills. Emergency procedures and programmed interlocks will be activated to minimize the leak or rupture.

The wastewater treatment plant will continue operating during the 6 year closure and decommissioning phase. The water in the FTSF and the CRF will be pumped to the Plant as was the case in the operations phase. The treated water will be disposed of in Nordre Sermilik via the use of a specially engineered pipeline and diffuser. If the treatment plant fails during the operations or closure phases, production will stop immediately and water disposal into Nordre Sermilik fjord will cease. There is significant water storage capacity in the TSF and at the Plant site. A large volume of untreated water can be contained in the event of a water treatment plant failure.

In the post-closure phase, no wastewater from the tailings ponds or the treatment plant is discharged to the fjord.

10.3.3 Aerosol spray from TSF

An assessment of the impact of the deposition of aerosols originating from the TSF (Orbicon 2018c) was conducted to determine the likely concentration of pollutants in the Taseq and Narsaq rivers arising from aerosol deposition.

The assessment of the impact of the deposition of uranium is discussed in Section 9.3.4.

Concentrations were estimated at 3 points located sequentially downstream of the TSF (Figure 46).

A. Taseq river, immediately downstream of TSF

B. Taseq river, close to the Narsaq river

C. Narsaq river.

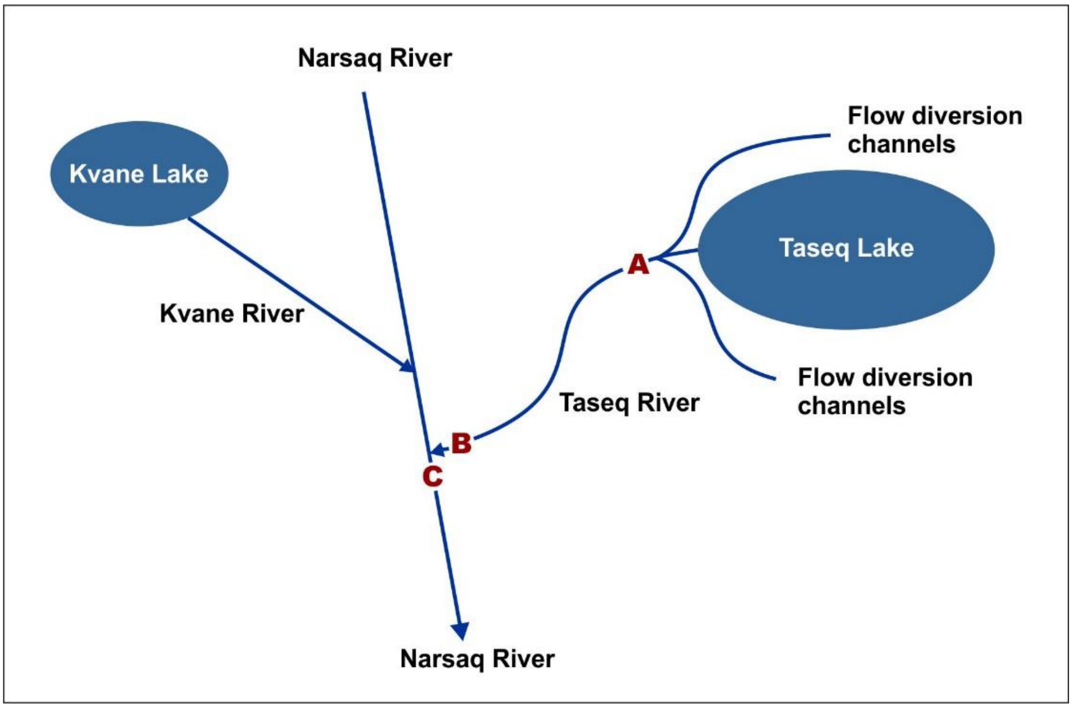


Figure 46 Location of 3 points for concentration assessment – A, B and C

Five elements (fluoride, uranium, cadmium, phosphorus and chloride) and seven reagents were estimated to have concentrations in the TSF water exceeding the ambient water quality criteria. These pollutants were included in screening level calculations and compared to Greenlandic (or Canadian) water quality criteria.

The assessment considered the following:

- Quantities of liquid lost from the TSF under strong wind conditions
- Concentrations of selected elements and reagents in the aerosols lost from the TSF
- The fate of elements and reagents if the aerosols are deposited
- Areas likely to be affected, including an assessment of the Narsaq water supply.

Based on Southern Greenland foehn data, over a 7 year period (2010 – 2016) there were an average of 3 foehn events each year in the ice free months (May – November). These events lasted between 17 and 64 hours.

Two potential scenarios were assessed to determine the drawdown in surface water (net loss of aerosols) from the TSF when wind speeds exceed 32m/s for 10 minutes:

- A 24 hour storm event 4 mm water loss
- A 64 hour storm event 13 mm water loss.

Wind direction data indicate that all strong foehn winds blow from the east and the northeast. Consequently, the focal point for potential deposition of aerosols was downstream in the Taseq and Narsaq rivers.

Water for the town of Narsaq is sourced from three rivers (combined annual flow 6 Mm^3). At this flow rate the estimated annual baseline mass transport of fluoride of 4,500 kg/year. WHO guidelines for drinking water (1993) have a critical load of fluoride of 1.5 g/m3, which corresponds to 9,000 kg/year. This denotes a margin of 4,500 kg/year as maximum ‘buffer load’, i.e. the safety margin between the background limit and the critical limit.

Table 38 sets out the estimated deposition of fluoride in different scenarios. The data shows that the maximum buffer load will be exceeded under the following conditions amongst those that were modelled:

- 3 storm events per year, each with 100% deposition in the catchment area

  Assuming that 100% of the aerosol lands within the Narsaq water catchment zone and that all wind directions are towards the catchment.

- 6 storm events with 25% deposition in the catchment area.

  6 storm events with 100% deposition in the catchment area.

  Assuming that 25% or 100% of the aerosol lands within the Narsaq water catchment zone and that all wind directions are towards the catchment.

Given prevailing wind directions (easterly and north easterly), local topography and the marked mountain ridge separating Taseq valley from the area used for abstraction of raw water to Narsaq water supply (the ridge south of the valley is more than 200 m above Lake Taseq), deposition of aerosols from the TSF is considered to be unlikely.

Table 38 Quantity of fluoride (kg/year) deposited in the Narsaq drinking water catchment under the assumption of 1 %, 10 %, 25 % and 100 % of the released aerosols will be blown from the tailing ponds to the 6 km2 area

Foehn Events	Drawdown	Deposition of fluoride (kg/year)			
		1%	10%	25%	100%
1 event/ year	3.7 mm/year	31	309	772	3087
3 event/ year	12 mm/year	100	1000	2500	10000
6 event/ year	41 mm/year	346	3460	8650	34600

Note: Red denotes exceedance of criteria

The results for the 24 and 64 hour storm events indicate that peak incremental concentrations of fluoride exceed the water quality criteria at points A, B and C (Table 39).

Phosphorus exceeds the water quality at points A and B, for both 24 and 64 hour storm events and at point C for the 64 hour event. Cadmium and chloride meet water quality guidelines.

Table 39 Peak concentrations of elements at 3 points downstream of the TSF

Element	Water quality criteria (GoG or Canadian)	Storm Event duration	Point A Taseq river	Point B Taseq river	Point C Narsaq river
Fluoride (mg/L)	**0.12**	24 hour	47	26	7.5
		64 hour	151	84	24
Cadmium (mg/L)	**0.1**	24 hour	0.0087	0.0047	0.0014
		64 hour	0.028	0.015	0.004
Phosphorus (ug/L)	**20**	24 hour	50	27	8
		64 hour	161	89	26
Chloride (mg/L)	**120**	24 hour	14	7.6	2.2
		64 hour	44	24	7.1

Note: Red denotes exceedance of criteria

The natural baseline concentration of fluoride has a mean value of 2.7 mg/L. In winter monitoring the fluoride baseline concentration in Narsaq river has been observed as high as 28 mg/L (Figure 47) exceeding the water quality criteria by a factor of 230.

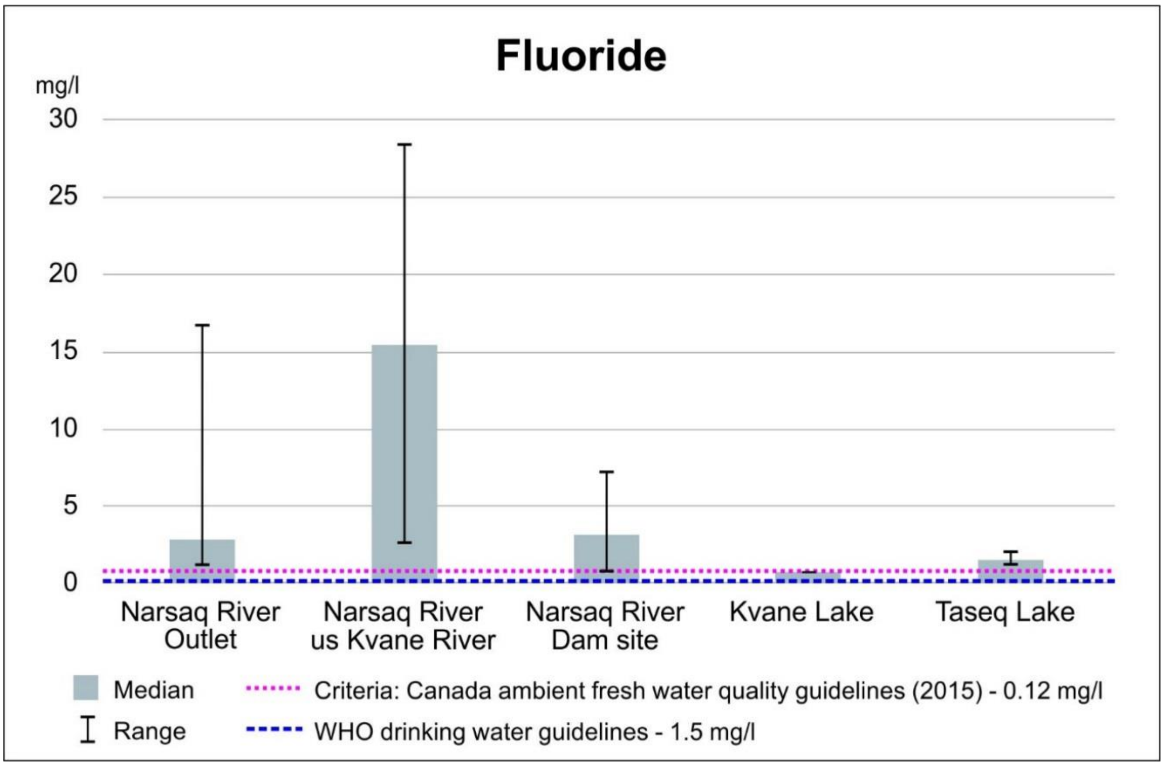


Figure 47 Background fluoride values in Narsaq river (Orbicon 2014)

As can be seen in Table 39 at point C the peak concentration will still be below the highest observed baseline concentration.

The peak concentrations of all reagents decreases between point A and C as a result of dilution as the water moves downstream. For a 24 hour event, six reagents are estimated to slightly or moderately exceed the PNEC values at points A and B (Table 40). At Point C, four reagents are below PNEC values.

The assessment of aerosol spray from the TSF estimates concentrations of selected elements and reagents if the aerosol lands in the water catchment area of the Narsaq water supply. Concentrations of all elements and reagents decrease with increased distance from the TSF.

Baseline levels of fluoride exceed water quality criteria contributing to exceedances of water quality criteria in the modelling.

Given the conservative settings for the modelling in respect of the rate of aerosol deposition (25-100%) and location of deposition (in the water catchment area) potential impact from aerosol spray is assessed as low.

Table 40 Reagent peak concentrations at 3 points downstream of the TSF

Reagent (ug/L)	PNEC (ug/L)	Storm Event duration	Point A Taseq river	Point B Taseq river	Point C Narsaq river
Copper sulphate	**0.1**	24 hour	0.058	0.032	0.0093
		64 hour	0.186	0.102	0.030
Alamin 336	**0.014**	24 hour	0.064	0.035	0.0103
		64 hour	0.206	0.113	0.033
PC88A	**4.2**	24 hour	8.7	4.8	1.4
		64 hour	28	15	4.5
Shellsol	**2**	24 hour	9.5	5.2	1.5
		64 hour	31	17	4.9
Aero 6494	**0.33**	24 hour	12	6.5	1.9
		64 hour	38	21	6.1
Sodium silicate	**2470**	24 hour	12514	6894	2023
		64 hour	40464	22480	644
Frothers	**0.24**	24 hour	27	15	4.4
		64 hour	89	49	14.1

Note: Red denotes exceedance of criteria

10.3.4 Excess water management

Two streams of excess water from the Plant will be discharged to Nordre Sermilik:

- Treated recycled water from the FTSF and CRSF and a treated sulphated rich solution from the refinery
- Barren chloride liquor.

The treated recycled water and the barren chloride liquor will be piped in separate pipes from the Plant to a common discharge point in Nordre Sermilik. The potential impact of the discharge is:

- Risk to the marine pelagic environment
- Impact on sediment dwelling organisms (marine benthic community)
- Accumulation in the food web.

To assess these potential impacts the Danish Hydraulic Institute (DHI 2015a) developed a hydro-dynamic model for the local fjord system and modelled the quality and quantity of all major contaminants in the streams in terms of temperature, concentration and flow. Initially, the contaminants from the effluent were reviewed and ranked according to the required dilution in order to obtain concentrations in the marine environment below PNEC levels. This is the highest concentration in the marine environment at which no effects on the pelagic environment are expected. The PNEC-values were derived by DHI based on the eco-toxicity of the individual contaminants.

All chemical species in the effluent were assessed to determine if they are persistent bioaccumulative toxic (PBT) or very persistent very bioaccumulative (vPvB). To complete the understanding of the effluents, ecotoxicology testing was carried out using acute and chronic testing of algae, copepods and fish (DHI 2015b).

The estimated concentrations of contaminants were then compared to Greenland's marine and freshwater guidelines. Table 41 shows the Greenland marine and freshwater guidelines and information on the baseline concentrations in the fjord water. When no Greenland guidelines are available, Canadian guidelines are included (these have been marked with an *).

The excess water streams will only be released to the environment when it is not possible to recycle the water any further for use in the Plant. The following streams contribute to this flow:

- Excess concentrator process water, after water treatment has removed the fluoride.

  This stream is a saline water containing sodium chloride. It is less salty than sea water and its average flow is 466 m^3/hour

- Excess refinery water – after water treatment to remove organic materials and radionuclides.

  This is a barren sodium and calcium sulphate bearing water which has been neutralized. The average flow for this stream is 304 m^3/hour

- Barren chloride solution after REs have been recovered in the refinery.

  This is a saline solution containing other contaminants.

  This water is neutralized and treated to remove contaminants, in particular organic contaminants (GML 2018). The average flow for this stream is 103.05 m^3/hour.

The composition of these streams is shown in Table 41 below with the total weighted average composition of all three streams mixed. These combined streams represent the only environmental exposure to Plant water streams.

The water has been treated to ensure the water meets GWQC and is therefore compatible for discharge into the fjord.

Table 41 Greenland (and Canadian *) water guidelines and baseline concentrations in Nordre Sermilik

Elements	Freshwater Criteria	Marine Criteria	Nordre Sermilik Water	Excess concentrator Water (a)	Excess refinery Sulphate Water (b)	Barren Chloride Solution (c)	Weighted Average a, b, c
			µg/L				
Arsenic	4	5	2.6	1	1	1	1
Cadmium	0.1	0.2	0.11	0.1	0.1	0.1	0.1
Chromium	3	3	0.2	<1	<1	<1	0.5
Copper	2	2	1	1	1	1	1
Iron	300	30	3.4	<5	<5	<5	2.5
Lead	1	2	5	<1	<1	<1	0.5
Mercury	0.05	0.05	0.3	<0.5	0.05	<0.5	0.170
Nickel	5	5	0.5	5	<1	<1	3
Zinc	10	10	14	<5	<5	<5	3
Phosphorus	20		88	<50	<50	1600	175
			Mg/L				
Fluoride	0.12*		1.3	24	12	0.2	17
Potassium			392	11	180	139	84
Sulphur			884	30	13000	17	4662
Chloride	120*		18,980	1840	397	40400	4995
Sodium			10,561	1290	16900	19400	8590

Predicted No Effect Concentration values

PNEC values for the low concentration chemical species in the effluent process water were derived relevant official publications. This is a methodology accepted and used within the European Union (ECHA 2008). The PNEC values and the required dilution are shown in Table 42 for the chemical species in the process water that requires the highest dilution.

The elements that require high dilution factors are reagents essential to producing suitable quality products. The reagent Caprylic acid requires the highest dilution (1252) to reach PNEC.

Table 42 'Predicted No Effect Concentrations' for selection of chemical species and the required dilution to meet the PNEC limit

Chemical species	PNEC (µg/L)	Required dilution factor
Caprylic acid	1.4	1252
[redacted]	0.0143	796
Alkyl Hydroxamic acid	0.26	674
Manganese	0.4	607
Uranium	1	365
W22	1	350
[redacted]	2	228
Beryllium	0.03	71
Fluorine	19.6	71
Decanoic Acid	36	49
Barium	11.5	39
Rubidium	52	28
Copper	5.2	27

Ecotoxicology

Ecotoxicology testing was undertaken using acute and chronic testing with several organisms.

The conclusion is that algae and fish appeared to be unaffected by the effluent, even at high concentrations. Under certain high concentrations the effluent may impact copepods (DHI 2015b).

None of the chemical species in the discharged process water was assessed to be Persistent Bio-accumulative Toxic (PBT) or very Persistent very Bio-accumulative (vPvB).

Modelling of discharge plume and assessment of optimum depth of discharge

At the time of modelling, the reagent that required the greatest dilution factor to achieve the PNEC was [redacted] which required a dilution factor of 2,282. Subsequent engineering controls in the Plant have been incorporated to reduce the concentrations of [redacted] and [redacted] in solution by a factor of 10.

As shown in Table 42, to achieve the PNEC for Caprylic acid of 1.4 µg/L would require a dilution factor of 1252. While Caprylic acid is biodegradable, the modelling is conservative and, as such, does not account for any biodegradation of reagents.

The modelling outputs (shown in Figure 48 and Figure 49) have been designed to show where a dilution factor of 2500 is achieved (based on the original dilution factor required for [redacted]).

However, as the concentration of [redacted] in Project effluent has been reduced and, given that caprylic acid which requires a dilution factor of 1252, is biodegradable, the extent of the plume within the PNEC is achieved is likely substantially smaller than that plotted. For example [redacted] requires a dilution factor of 796, which will be within the yellow discharge contour.

The fate and the extent of spreading of chemical species contained in the treated water introduced to the fjord was modelled for summer and winter. The modelling investigated the optimal position for the submerged discharge, and, after evaluating a range of insertion depths (surface, -10 m, -20 m, -30 m and -40 m), identified that the discharge of treated water below 40 m would achieve the greatest mixing and therefore most rapid dilution.

In Figure 48 the discharge plume spreads in a narrow band westward along the coast. The modelling shows that a dilution of 2500 times is achieved rapidly. The plume is approximately 3 km^2 that extends up to 700 m from the coast at depths between – 20 and – 50 m. Beyond this the water quality is below PNEC for all contaminants.

The vertical distribution is shown in Figure 49, and shows that the plume remains between – 20 and – 40 m depth in summer. During the winter the band is narrower and ranges between – 35 and – 45 m depth.

The area affected by the thermal plume (12^{o}C) was negligible and little or no impacts on marine life in the fjord is expected. The modelled temperature differences were around 0.5^{o}C within a radius of approximately 250 m from the release point.

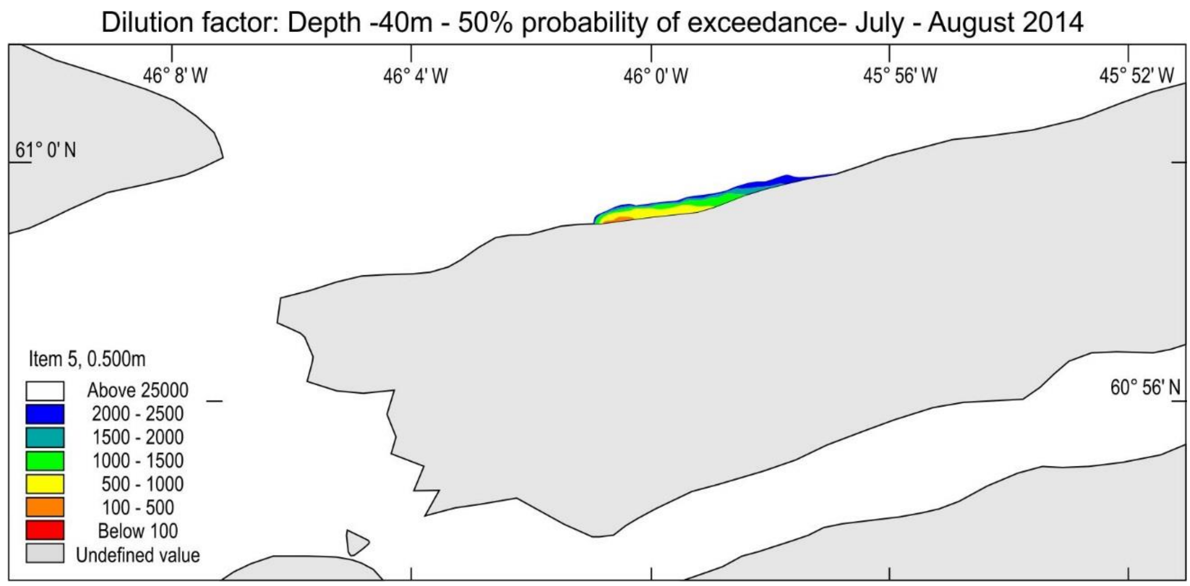


Figure 48 50th percentile dilution factors at an insertion depth of -40 m for summer (the winter plume is slightly smaller). The green area denotes the extend of area for dilution point for pollution no effect concentration of all contaminants)

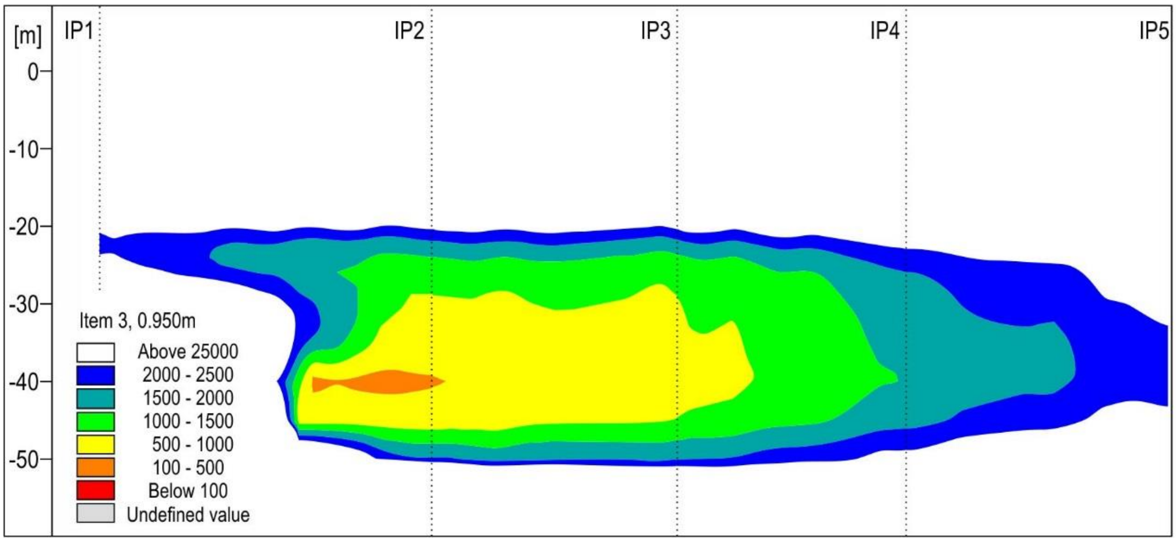


Figure 49 Vertical profile of 50th percentile dilution factors at discharge depth of -40 m for summer. The green area shows the extent of PNEC for all contaminants.

Assessment of marine impacts

Based on the modelling DHI (2015a) assessed the potential marine impacts of the discharge and concluded the following:

- Regarding bioaccumulation and bio-magnification, it is assessed that:
  - Lanthanum and Yttrium may bio-magnify to a small degree in the food-webs
  - Manganese will bio-magnify in the food-web and an excess manganese concentration in the food-web is expected arising from the discharge
- The potential impact on the primary production of phytoplankton in fjords in south Greenland and potential impact on fish is expected to be very limited
- The copepods/crustaceans are likely to be the most sensitive to the release of these chemical species but with the modelled dilution regimes no acute and no chronic effects should be expected.

  The copepod Calanus finmarchicus, which is an important component of the marine ecosystem, is assessed only to have very limited contact with the chemical in the effluents as it migrates vertically in the broader water column (50 - 600 m)
- The pelagic commercially relevant species of deep sea shrimp (*Pandalus borealis*) are also assessed to have only limited contact with the chemical species in the effluent.

  Locally, larvae from the female red deep sea shrimp may come into contact with the chemicals species in the effluent.

A dilution factor of ~1300 will be required to obtain no effects levels for the most critical parameters including safety margins. The required dilution can be obtained in the marine area on local scale of 1 – 3 km^2 and in a vertical confined lens of water when the outlet is constructed sub-surface.

On this basis the placement of the water in the Nordre Sermilik fjord is unlikely to significantly affect water quality or the marine ecosystem.

Waste rock runoff

The composition of run-off from the WRS was calculated from 50 samples using the DCE's assessment method. Results show the mine area run-off water composition requires little dilution to reach the composition of sea water.

The composition for the waste rock run-off was determined for each year of operations based on the expected proportions of waste rock mined with ore. The following table identified the concentration in solution for each of the elements modelled.

Table 43 Composition of waste rock runoff

Element	Units	Concentration
F	mg/L	4.91
U	µg/L	10
Th	µg/L	1.39
S	mg/L	1.1
As	µg/L	1.12
Cd	µg/L	0.02
Cr	µg/L	0.13
Cu	µg/L	0.1
Fe	µg/L	4.2
Pb	µg/L	0.4

The level of dissolved salts in WRS run-off water is low and this water will be used in the concentrator as process water. This will reduce the Narsaq river water requirements by 30% to 310 m^3/hour from 440 m^3/hour.

Post closure the runoff will not be used and is will be released into the surrounding environment.

10.3.5 Hydrocarbon and Chemical Spills

During the Project's operations, chemicals and hydrocarbons will be used for processing. These products will be shipped to Greenland and then moved to the Project location where they will be stored and used.

The saleable mine products will be transported by truck to the Port where they will be stored before shipment.

During operations the following activities/events have the potential to result in spills of chemicals and hydrocarbons.

- Shipping in the fjords
- Unloading from ships to land based storage
- Fuel storage tank ruptures or leaks
- Spills of chemicals and oily products during land transport
- Spills from pipelines
- Spills from fuelling mobile equipment at tank farms.

Spills at the Port

Oil storage tanks for diesel are located on the western boundary of the Port, at an appropriate distance from Port facilities and administrative buildings.

Approximately 56,000 m^3 of organic fuel will arrive to the port site each year in tankers. In addition, approximately 270,000 tons of chemicals will arrive at the port annually and 71,000 tons of mine products will be exported.

Fueling of mobile equipment will take place at the fuel farm in the Port.

A major shipping accident such as a vessel collision or grounding could give rise to major spills of oil, chemicals or mine products. If a fuel tanker were involved in an accident a significant spill could result. Due to currents in the fjords, oil leaked to the marine environment will be transported over long distances quickly, and the narrow fjords will make shoreline contamination likely. Potential impacts of these spills include marine and shoreline fouling.

The consequences of an oil spill to the marine life, including birds may be significant. Birds are extremely vulnerable to oil spills. Most fatalities typically result from the oiling of a birds plumage but many birds also die from intoxication. Marine mammals are generally less sensitive to oiling.

Only a few small bird colonies are located near the shipping routes to the Port while quite large numbers of sea duck (eiders) winter in the fjords and thereby are vulnerable to oil spills. Most of the fjords close to Narsaq have rocky shorelines and the intertidal organisms found here are commonly exposed to the scouring effects of sea ice. As wave action can clean away spill residue, wave-exposed shores are less sensitive to oil spills. However, sheltered rocky shores will be in contact with spills for longer, and effects on the invertebrate fauna can potentially affect the ecology of the shore.

Large spills of chemicals can also have adverse effects, depending on the toxicity and bioaccumulation of the spilled chemicals. However, the quantities potentially released will likely be quite small, and the large volume of the fjords would mean that dilution and dispersal would likely mitigate the effects of the spill.

Shipping though the fjords to and from the Port creates potential hazards. These hazards are, however, not different from other shipping routes in Arctic coastal areas, including routes to other Greenlandic towns and settlements. If all maritime regulations are followed, and shipping lanes are well placed, the likelihood of a significant incident of this nature occurring happening during Project operations is considered to be very low.

Fuel arriving to the port will be pumped from the tankers through underground fuel pipelines to the storage tank farm at the port. The fuel storage in the port area consists of two main diesel oil tanks (total capacity 10,417 m^3) and one smaller diesel oil tank (2,065 m^3). Smaller fuel storage tanks are also located at the concentrator/power plant, next to the refinery and in the mine area.

Chemicals will also arrive by sea. Reagents transported in containers or ISO tanks will be unloaded onto the using spreaders and moved to the container storage yard for stacking. Chemicals transported as bulk cargo (sodium chloride, limestone, sulphur and sodium carbonate) will be unloaded using clamshell bulk grabs and transferred to one of four bulk storage buildings.

Most spills from tankers result from routine operations in connection with loading, discharging and bunkering. This type of operations spill is typically small and localised. The impact on marine life will be local and can be removed using the oil spill combat equipment available at the Port.

All fuel storage tanks will have geotextile containment berms that can contain a full spill in case of total tank rupture. The containment berms eliminate the potential spread of an oil spill.

Traffic accident resulting in spill

Traffic accidents involving fuel tankers and flatbed trucks transporting containers containing chemicals and mine product has been identified as a potential hazard. The relatively small number of individual tank trucks and containers will limit the potential spills and hence the impacts of accidents during truck haulage.

Most chemicals and the mine products are transported in dry form, reducing the consequences of spills. Spills of fuel products and liquid chemicals will typically not affect large areas, unless seepage into nearby waterways occurs, or steep slopes at the spill site causes the spill to spread downhill.

Effects of oil spills on the Arctic vegetation will likely be localised, but as Arctic flora has very slow growth rates, effects can be long lasting, stretching into decades. As terrestrial spills likely only will affect relatively small areas, it will be easier to prevent terrestrial mammals being exposed to the spills. It is also unlikely that terrestrial bird populations will be significantly affected. Spills into freshwater ecosystems can cause an impact on diversity and abundance of invertebrates, plants and fish.

The likelihood of an accidental spill during land transport is low. In case of a spill it is most likely that it can be limited to affecting terrestrial habitats.

Mine and processing spills

The areas of the highest spill probability are adjacent to the Plant, where immediate action can be taken to mitigate the effects of any spill. The likelihood of a major accidental spill occurring on land at the mine (limited fuel or chemical storage) or into local fresh water resources (due to distance from the plant) is low.

In case of spills on land, it will likely be managed by mechanical removal, possibly in combination with either natural or accelerated in situ degradation (of oil). Chemicals and mine product should be mechanically removed to the extent possible and disposed of appropriately.

Mobile equipment at the mine site (mine trucks, excavators, etc.) will be refuelled at the mine pit area. A spill associated with refuelling and handling of fuel in the mine area generally will be small and the impact on the environment will be limited.

The environmental impacts of chemical or fuel spills on land are confined to the Study Area or to a narrow corridor of a few km around the Project activities. Spills affecting Narsaq river (or other watercourses) in summer periods with high flows might spread downstream of the spill location and reach the fjord, if no mitigating measures are in place.

10.3.6 Risk of process water spills

During the Project's operations phase excess water that cannot be recycled is treated before being discharged into Nordre Sermilik. During the closure phase water from the TSF will be pumped to the treatment plant before discharge into Nordre Sermilik. A malfunction or overflow of the treatment plant could potentially lead to a minor release of untreated water into the fjord. The release of untreated water could potentially have an impact on marine life near the discharge point in Nordre Sermilik.

In case of a malfunction of the treatment plant during the closure phase, the discharge of water will immediately be stopped, preventing untreated water from the TSF from being released to the fjord. It is unlikely that significant quantities of untreated process water or water from the TSF would be discharged to the fjord. Since the discharge of water into Nordre Sermilik will be immediately stopped in case of a malfunction of the treatment plant, exposure of the fjord to untreated water is unlikely.

10.4 Mitigations

The following mitigation measures will be applied to minimise the risk and consequence to the water environment:

- Water flow will be maintained utilising generators during Narsaq river culvert construction, with water taken from one side and returned to the other side to ensure a dry construction zone
- Tailings embankments will be constructed in accordance with best international practice
- Rock fill and a conservative wall design will be used, with embankments equipped with a double liner to protect against seepage.

  Both embankments will be constructed to withstand extreme inflow of water, for example due to exceptional snow melting under a føhn wind event. A cut-off trench and leak detection also form part of best available technology to obviate seepage
- In the extremely unlikely event of an embankment wall break or collapse, repair work will be initiated immediately.

  Mobile equipment normally used to extract and move ore will be employed in the repair work. A rapid repair of the embankment is facilitated by the large amounts of rock and gravel that are stored near each embankment.

  To keep the surface of the tailings wet (to avoid wind dispersal of solids) water cannons will be used that shoot a high-velocity stream of water over long distances.

  As soon as possible the water cover will be restored
- To minimise the risk of unplanned TSF overflow diversion channels will be well maintained during the operations and closure phases
- If the water treatment plant fails during the operation or closure phases the refinery production will be stopped immediately.

  This will prevent untreated water from being discharged to the fjord
- No discharge to the Taseq river will take place in the operations or closure phases
- Pipelines and control system will be well maintained
- Low speed limits will be mandated to avoid transport accidents
- To reduce the risk of spills of fuel and chemicals in the fjords during operations the following mitigating measures will be implemented:
  - Conduct a navigational safety survey
  - Impose navigational speed restrictions
  - Compulsory pilotage
  - Separation of shipping lanes
  - Procedures for loading and unloading of ships
  - At the Port
    - Appropriate equipment for combating operations spills, including containment booms available for berthed ships, extra booms and skimmers
    - Oil spill combat equipment will always be available and fully stocked
    - Contingency plans and procedures for detecting and combating operations spills, including procedures for operations spills in sea ice
    - Incident and season related contingency plans and training
    - Prepare contingency plans with authorities for managing large scale spills
    - All fuel storage tanks will have geotextile containment berms that can contain 110% of total tank volume in case of complete tank rupture
    - The containment berms eliminate the potential spread of an oil spill
    - The geotextile containment berms must be inspected regularly to ensure that they are intact.

10.5 Predicted outcome

The predicted outcome of the Project on the water environment is detailed in Table 44 below.

Table 44 Predicted outcomes for water environment

Impact	Project Phase	Spatial extent	Duration	Significance	Assessment
Modification of hydrological processes	Construction	Study area	Permanent	Low	Changes to the hydrology of rivers and lakes during construction are expected to be minor. While reduced flows will be experienced in the upper sections of the Kvane and Taseq rivers, flows in the lower sections of these watercourses is expected to be maintained.
Operation of tailings dam	Operations	Study area	Life of mine	Low	No water will be released from the TSF during operations. After closure the water will be treated for a period of six years to ensure that discharged water meets appropriate water quality criteria.
Waste Rock Runoff	Operations Closure	Study area	Long term	Low	Studies show the waste rock runoff composition will require little dilution to reach the composition of sea water.
Discharge of excess water to Nordre Semilik	Operations	Study area	Life of mine	Low	A dilution factor of ~ 2500 will be required to obtain no effects levels for the most critical parameters including safety margins. The required dilution can be obtained in the marine area on local scale of 1 – 3 km^2 and in a vertical confined lens of water when the outlet is constructed -40m sub-surface.
Spills	Construction Operations	Study area	Life of mine	Low	The impact of spills is expected to be limited based on the application of international best practice standards.
Aerosol spray from TSF	Operations Closure	Study area	Long term	Low	Impact to the water catchment area is low due to prevailing wind directions, topography and low rate of deposition.
Release of tailings water and solids from TSF embankment failure	Closure	Study area	Long term	Low	TSF embankment failure risk is considered extremely low and very unlikely.

11. Waste management

11.1 Existing environment

In Narsaq, waste suitable for incineration is collected and transported to Qaqortoq for treatment at the incinerator. Qaqortoq is the regional waste collection centre. All hazardous waste and scrap metal is forwarded from Qaqortoq to Denmark.

Putrescible waste, including food waste and animal carcasses, is deposited in a Narsaq landfill. The landfill has no drainage collection system for waste streams. Outfall from the landfill is understood to flow through to the ocean. Under certain wind conditions, the landfill can be smelled in Narsaq, creating a highly unpleasant environment.

A Narsaq town waste facility exists on the proposed site of the Port. The Port layout will be designed to minimise the impact on the existing waste facility. The Port development will create the opportunity for rehabilitation and improvement in the waste management system at Narsaq.

11.2 Potential impacts

The potential impacts associated with waste management are:

- Waste generated during construction and operations has the potential to result in environmental impacts if not appropriately managed.

11.3 Assessment of impacts

11.3.1 Waste management

During the construction and operations phases the Project will produce domestic waste, used tyres from mobile equipment and various types of hazardous waste, for example oily waste, chemical waste and batteries. Waste, in particular waste classified as hazardous, has the potential to lead to significant contamination of the environment.

All combustible solid waste will be pressed into bales and shipped to Qaqortoq for incineration. Hazardous waste will be handled according to the Kommuneqarfik Kujalleq regulations regulating management of hazardous waste (Greenland Government, 2009). Hazardous waste in the municipality is shipped to Denmark and handled in compliance with the EU initiated legal framework.

Accumulators, batteries, electronic devices, glass, etc. will be temporarily stored in containers and periodically forwarded to the Qaqortoq waste handling facility for further disposal according to regulations and, where appropriate, after agreement with relevant authorities.

Sewage from all buildings in the Port, the Village and vessels alongside the wharf will be treated in a sewage treatment facility which will apply mechanical, biological and chemical treatment processes to the waste. Treated effluent will be discharged to the fjord at the north end of the Tuna Peninsula. Tanker trucks will be used to transport wastewater and sewage from holding tanks in the mine area and the Plant for treatment and disposal.

The impact of waste on the environment is assessed to be very low.

11.4 Mitigations

- Development of waste handling procedures and a waste management manual
- Installation of a sewage treatment package plant

- Remediation of any contamination as a result of the Project.

11.5 Predicted outcome

The predicted outcome of the Project resulting from waste is detailed below.

Table 45 Predicted outcomes for waste management

Impact	Project Phase	Spatial extent	Duration	Significance	Assessment
Contamination resulting from waste	Construction Operation Closure	Study area	Life of mine	Very Low	With proper waste handling procedures in place, the impact of waste production to the environment is assessed to be very low.

12. Biodiversity

12.1 Existing environment

12.1.1 Vegetation

The presence and distribution of native vegetation in south Greenland is largely determined by temperature and precipitation, both of which follow oceanic-inland/continental and altitude gradients. Such gradients are obvious when moving inland through long narrow fjords towards Narsaq. In the outer fjord area, vegetation growth is inhibited by cold ocean currents, drift ice, salt spray and wind. Dense birch and willow scrub is common below 200 m altitude on south-facing exposures at the head of the fjords and inland.

In the Narsaq valley – Kvanefjeld area, the length of snow cover, water supply, temperature, soil type and wind exposure further limit the distribution of plant communities.

Field surveys conducted by Ernberg Simonsen (2014) in August 2013 and September 2014 identified three vegetation communities (Table 46).

Table 46 Vegetation communities

Community	Description
Narsap Ilua Bay and lower Narsaq valley (0 – c. 200 m altitude)	The dominant vegetation type in this lowland was dwarf-shrub heath made up mainly by bog bilberry, crowberry, glandular birch and northern willow and with patches of mosses, grasses and sedges. On some southern exposure slopes, more species rich plant communities were present, with species such as common harebell and alpine meadow-rue. Northern green orchid grows commonly along most of the streams in the lowland. An unusual vegetation community was found close to the Narsaq river mouth, which included rarely recorded species such as autumn gentian, golden gentian, alpine gentian and common butterwort. Autumn gentian is rare in Greenland, know only from three sites.
Higher reaches of Narsaq valley and the Kvanefjeld plateau (c. 200 – 680 m altitude)	With increasing altitude, different types of dwarf-shrub and lichen-grass-sedge heaths dominated, but open rocky terrain, snow beds and smaller fens were also widespread. Herb slopes with high plant species diversity grew along some of the streams. The dwarf-shrub heath at medium altitude was dominated by crowberry, glandular birch, bog bilberry and northern willow with stiff sedge, northern bent grass, and alpine club moss in the lower vegetation layer. Mosses and lichens also covered large areas. One individual of bog rosemary was found on the Kvanefjeld plateau. This species is very rare in Greenland with only two previous records from south Greenland. On some north facing slopes a snow bed plant community occurred, dominated by dwarf-willow, hare's-foot sedge, starwort mouse-ear, starry saxifrage and pigmy buttercup. The aquatic plant common mare's-tail was found in some of the ponds and smaller lakes on the Kvanefjeld plateau. The round-leaved orchid - Greenland's rarest orchid - has previously been recorded between the existing gravel road and the Narsaq river at c. 300 m altitude. However it was not recorded during the survey in 2014.
Upper northern slopes of Narsaq valley and Lake Taseq (c. 350 – 650 m altitude)	At high altitude on the north facing slope of Narsaq valley much of the ground is covered with loose stones and rock. This area has very limited plant cover with the most common species being three-leaved rush, moss campion, trailing azalea, purple saxifrage and stiff sedge. Locally, northern green orchid and small white orchid grow close to streams. The slopes surrounding Taseq were mostly without vegetation and have very few species of vascular plants. In a few places with more even terrain, higher plant diversity was found. To the northeast of Taseq the terrain increases gradually in height creating a smooth south facing slope without scree. This area was covered by grasses and sedges as well as many species of herbs, such as alpine lady's-mantle, alpine meadow-rue, dandelions and procumbent sibbaldia.

12.1.2 Fauna

Terrestrial fauna

A survey undertaken by Orbicon (2014) identified the Arctic fox (*Alopex lagopus*) and the Arctic hare (*Lepus Arcticus*) as the only wild terrestrial mammals in the Study Area.

The Arctic fox is the only terrestrial carnivore in south Greenland and has previously been recorded in the Kvanefjeld area. The Arctic Fox is an opportunistic feeder, eating birds in summer and fish found along the shore of the fjord in winter.

The Arctic hare is a relatively uncommon mammal in south Greenland however the population shows large fluctuations in numbers. The hare has been recorded in small numbers at high altitude in the mountains surrounding the Narsaq valley. Little seems to be known about the hare's general life cycle Greenland. However sedges, grasses, willow and other plants are believed to be the primary food sources.

The terrestrial and freshwater bird fauna in south Greenland is relatively poor in species with only five species of passerine birds being both common and widespread.

The seas and coastal areas have a richer bird fauna, both with respect to species numbers and the numbers of individuals. This bird fauna includes birds that breed in Greenland and also large numbers of birds from other breeding sites in the northern Atlantic, that overwinter off the coast of west and south Greenland. Most seabirds that breed in Greenland are colonial breeders, but no large colonies are known from the south coast of Greenland between Ivituut and Nanortalik, which includes the Study Area, and neighbouring waters.

The sea off south Greenland is a hot spot for wintering sea birds (Boertmann *et al*. 2004). Most of the wintering sea birds remain off shore, but some move into the fjords and have been recorded in the fjords at Erik Aappalaartup Nunaa peninsula (Figure 50).

The birds entering the fjords in the greatest numbers are the common eider and Brünnich's guillemot. A few small sea bird colonies are found in the glacier fjords at Akullit Nunaat, to the north of the central part of Brede Fjord. The sea birds breeding at these colonies are black guillemot and various gull species (Boertmann 2004). A few of these birds may occasionally forage in the fjords that surround the Erik Aappalaartup Nunaa peninsula.

Table 47 summarises the bird species that may be found regularly on and around the Erik Aappalaartup Nunaa peninsula (breeding and/or wintering). Other than where being specifically noted otherwise, all the species are listed as being of 'Least Concern' on the Greenland Red List of threatened species (the Red List).

In addition, snow bunting, common wheatear, redpoll and Lapland bunting are common breeders in the Narsaq valley and at Kvanefjeld. These birds are common and widespread throughout south and west Greenland. The raven is probably also breeding in small numbers in the area but no definite information is available.

Table 47 Bird species potentially occurring

Species	Distribution
Mallard	The only dabbling duck that regularly breeds in south Greenland. It is a widespread and relatively common breeding bird at lakes and shallow coasts. In south Greenland, the mallard is mainly sedentary, but moves to the outer coast in winter. Mallards are regularly observed throughout the Erik Aappalaartup Nunaa peninsula, mostly along the coast. It is likely that a few mallards breed at wetlands in the area.
Common eider	A widespread and common breeder in Greenland. It typically breeds on small islets and skerries along the coast. No breeding colonies of eiders are known along the shore of the Erik Aappalaartup Nunaa peninsula but very large numbers winter off south Greenland. In addition several hundred eiders regularly spend winter on the fjords at the Erik Aappalaartup Nunaa peninsula. Usually, most are seen in Tunulliarfik/ Skovfjord south of the peninsula, where they feed on mussels. The west Greenland population of common eider is listed as "Vulnerable" in the Red List. Its numbers have declined dramatically over the last 50-100 years due to intensive, non-sustainable harvesting. In recent years there have been signs of a recovery of the population in some areas.
Red-breasted merganser	A rather common species along the Greenland south and west coasts and part of the east coast. It breeds at lakes and shallow fjords and bays and feeds primarily on fish. Small flocks are quite common in the fjords around the Erik Aappalaartup Nunaa peninsula and on Lake Ilua. It is likely that a few breed along the shores of the peninsula – particularly in the Ilua area, but definite proof is not available.
Ptarmigan	Widespread and common throughout Greenland, but it is subject to marked annual fluctuations in numbers. On the Erik Aappalaartup Nunaa peninsula, it mainly occurs in up-land areas where it feeds on plant material.
White-tailed eagle	Confined to Greenland's south and west coasts north to Upernavik. In recent years the population has increased and now numbers 150-200 pairs. But since the breeding population is still relatively small it is listed as Vulnerable on the Red List. White-tailed eagles are mainly found in coastal areas where they feed on fish. The nest is typically placed on ledges on steep cliffs. The adults normally remain within the breeding areas throughout the year while the young birds move to the outer coastal areas during winter. Breeding white-tailed eagles nest from around March to early September. Egg laying typically takes place at the beginning of April. During the breeding period, eagles are known to be very sensitive to disturbance. White-tailed eagles are commonly observed at the Erik Aappalaartup Nunaa peninsula, most frequently along the coast. No breeding sites are known from this area, but several pairs undoubtedly breed in the region.
Peregrine falcon	Quite common in south Greenland where it typically nests on ledges on steep cliffs in the inland. One pair regularly breeds on a ledge on a steep mountain side near the mouth of Narsaq river, and peregrines are a common sight throughout the Erik Aapplaartup Nunaa peninsula. Peregrines feed mainly on medium-size birds. The falcon is a migrant that arrives in May and departs August-November.

Species	Distribution
Gyrfalcon	Occurs throughout Greenland, but is not common. It nests on ledges on steep cliff sides and primarily feeds on large birds such as gulls. The size of the Greenland breeding population is estimated to c. 500 pairs and due to the small population it is listed as Near Threatened in the Red List. No breeding sites of this falcon are known from the Study Area but single birds have been observed at Killavaat Alannguat a few times during field work between 2007 and 2014.
Ringed plover	Breeds almost all over Greenland, but is most common in high Arctic areas. It typically breeds on sand beaches and gravel fields along coastlines. It arrives to Greenland in May and the last birds leave in early October. One, perhaps two pairs of Ringed Plovers breed regularly in the Narsaq river delta.
Purple sandpiper	A relatively common and widespread wader in low Arctic Greenland. It breeds in dwarf-shrub heath along the fjords or near the coast. Outside the breeding season, it occurs mostly along the coast, where it forages in the intertidal zone. Small numbers of this wader might breed on the Erik Aappalaartup Nunaa peninsula, although definite proof is missing.
Iceland gull, glaucous gull, great black-backed gull, lesser black-backed gull, hering gull and black-legged kittiwake	Occur in the fjords around the Erik Aappalaartup Nunaa peninsula and have their nearest breeding sites in the glacier fjord at Akullit Nunaat, north of the central parts of Brede Fjord. Iceland gull and glaucous gull are by far the most common gulls the Study Area. Lesser black-backed gull and the kittiwake are migratory and leave the Greenlandic fjords in winter. Black-legged kittiwake is listed Vulnerable on the Red List because of large scale decline likely the result of a combination of non-sustainable harvesting and climatic factors.
Black guillemot	The most widespread auk in Greenland and breeds along most of the coasts in south Greenland. It is usually strictly sedentary, leaving the breeding areas only when forced away by ice. It feeds mostly on small fish. This auk is not breeding at the coast of the Erik Aappalaartup Nunaa peninsula, but several small colonies are found in neighbouring fjords.
Brünnich's guillemot	A common and widespread auk in Greenland. No breeding colonies are found in the fjords near Narsaq but single birds or small flocks are some-times observed in the fjords around Erik Aappalaartup Nunaa during winter. It is listed as Vulnerable on the Red List due to the large decline of the Greenland breeding population. The decline is likely the result of non-sustainable harvesting.

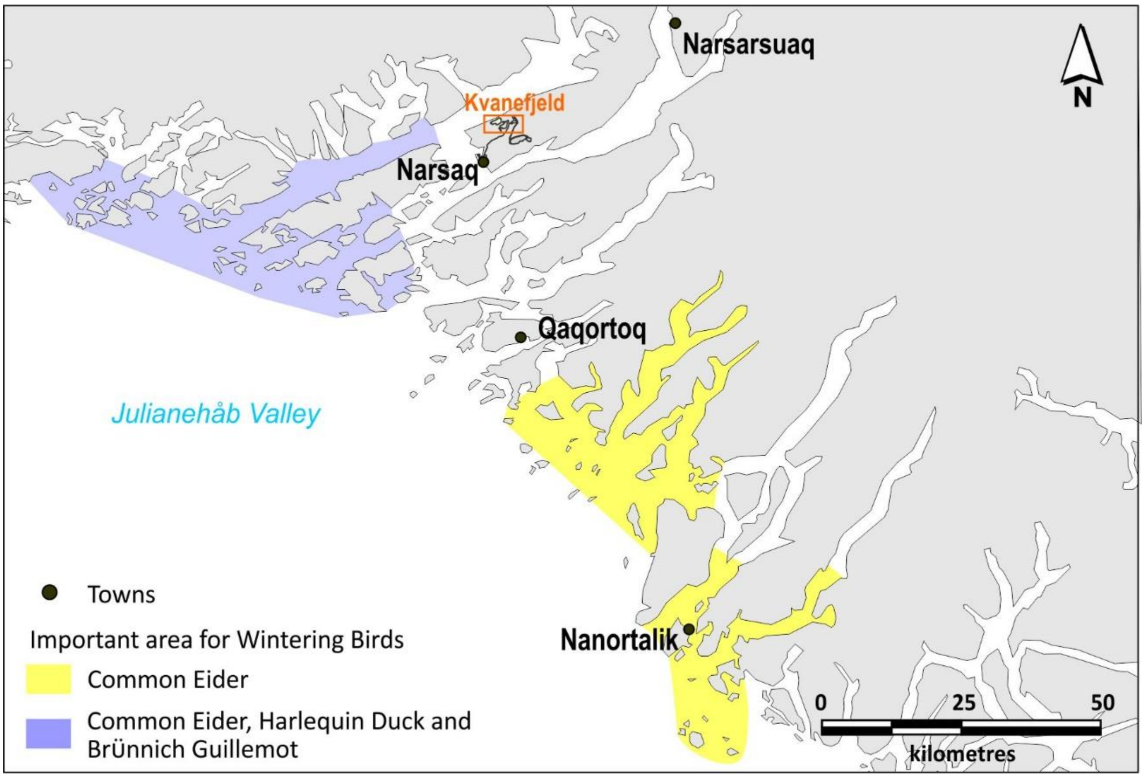


Figure 50 Important areas for wintering sea birds off south Greenland and in neighbouring fjords

Marine fauna

Orbicon (2015) identified 17 species of marine mammals, mainly whales and seals, which are present in the south-eastern David Strait, off the coast of south Greenland. Most of the whales, and at least one seal species, usually remain offshore and only occasionally enter the fjords. Similarly, occasional polar bears that arrive in south Greenland between February and May with the drift ice (Storisen). Polar bears rarely make it into the fjord area before they are culled and are as are not discussed further.

The species likely to be found in the waters around the Project Area are summarised in Table 48.

Table 48 Marine species potentially occurring

Species	Distribution
Ringed seal	Generally common in Greenland waters, but less so along the south-western coastline. It is believed to be mainly stationary in south Greenland, where it favours fjords with ice. Ringed seal haul-out and moult on fast-ice and drift ice, and they maintain several breathing holes in ice during winter. Ringed seals typically breed at the head of fjords, where fast ice forms during winter. The pups are born in snow dens on the sea ice in March/April. It feeds on a broad range of prey, including fish and crustaceans. Ringed seals are common in the fjords around Erik Aappalaartup Nunaa, particularly in Nordre Sermilik north of the peninsula, where they probably also breed. Ringed seals are subject to large-scale unregulated hunting and are regularly on sale at the local market "Brættet" in Narsaq. It is listed as "least concern" on the Red List.
Hooded seal	A large seal. During the summer months, small numbers of hooded seals are regularly encountered in the fjords at Erik Aappalaartup Nunaa where they feed mainly on larger fish, such as Atlantic cod, Greenland halibut and in particular redfish caught at large depths (down to 800 m or even deeper). Hunting of Hooded seal is unregulated in Greenland. It is listed as "Least concern" on the Red List.
Harp seal	A common non-breeding visitor to Greenland fjords during the summer months. In late autumn – early winter, the harp seals leave Green-land waters again and return to the breeding grounds. The harp seal is the most numerous seal species in south Greenland fjords during summer, when it penetrates deep into the fjords. During this time of the year, harp seals typically form feeding groups of 5 – 20 animals, which mostly forage on capelin. It is also common in the fjords at Erik Aappalaartup Nunaa from May until autumn. It is regularly on sale at the local market "Brættet" in Narsaq. The hunting in Greenland is unregulated. It is listed as "Least concern" on the Red List.
Bearded seal	A large seal which occurs in small numbers throughout Greenland waters. It is usually associated with sea ice but in particular young seals often remain in the fjords in south Greenland during summer. Bearded seal hunting in Greenland is unregulated. Little is known about the status of this seal in Greenland and it is listed as "Data deficient" on the Red List of (Boertmann 2007) but globally it is considered "not threatened".
Minke whale	Common along Greenland's south and west coasts. It arrives at south Greenland in spring and early summer, from wintering grounds in the Atlantic ocean and leaves Greenland waters in November. It is a regular visitor to the fjords of southern Greenland and within the Study Area. Minke whales sometimes occur at the Qaqortup Ikera/Julianehåbsfjorden and in Qaqortup Imaa where they are hunted. The hunting of minke whales in Greenland waters is regulated by a quota system. It is listed as "Least concern" on the Red list.
Fin whales	Summer and autumn visitors to south Greenland typically between June and October. They usually remain offshore, along edges of banks, where they feed on krill and small schooling fish. However, they are also a regular visitor to the fjords of south Greenland, and within the Study Area. Fin whales sometimes occur at the Qaqortup Ikera/Julianehåbsfjord and occasionally even in Qaqortup Imaa where they are hunted. The hunting of fin whales in Greenland waters is regulated by a quota system. It is listed as "Least concern" on the Red list.

Species	Distribution
Humpback whale	In recent years the population of humpback whales in Greenland waters has increased significantly. It is now quite common in some fjords of west Greenland during summer where it feeds on krill and small fish e.g. capelin and sand eels. In south Greenland it is less numerous but in some years small numbers appear in the fjord. In 2008 at least three different animals were observed at Narsaq. Subsistence harvest has recently been permitted again in Greenland, which follows an annual quota system. It is listed as “Least concern” on the Red List.
Harbour porpoise	A small toothed whale that occurs throughout the year in the waters of south Greenland. It is generally quite common in Greenland waters, but most porpoises remain offshore, with only few penetrating into the fjords. Harbour porpoises feed on fish in the upper water layers. Hunting in Greenland of the species is unregulated. It status on the provisional Red List is not assessed due to lack of data. Little exact knowledge is available about its status in the fjords around Erik Aappalaartup Nunaa, but it is probably a relatively common visitor in small numbers.

Fish species

The Arctic char is a habitat generalist found in streams, at sea and in all habitats of oligotrophic lakes throughout Greenland. Arctic char life cycles are very variable, both within and between localities. The Arctic char population in Greenland rivers typically consists of resident fish (non-anadromous) and anadromous fish that migrate to the sea during summer when they have reached a certain age.

The distribution and general biology of the Narsaq river population of Arctic char was studied in 1981 (Grønlands Fiskeriundersøgelser 1982). Orbicon (2014) reassessed the distribution in the Narsaq river by means of electrofishing and determined the current distribution of char in the Narsaq and Ilua rivers. Arctic char are very common in the lower part of the Narsaq river but are absent from the lakes connected to the river including Taseq. Another char population inhabits the Ilua river system (Figure 51). Surveys by Orbicon (2014) suggest that char is absent from the other streams and lakes of the Erik Aappalaartup Nunaa peninsula.

The Arctic char populations in the Narsaq and Ilua rivers are believed to be mainly anadromous. These sea going populations co-exist with resident populations of Arctic char.

The seagoing Arctic char in the Narsaq river start to migrate into the fjords at about 4 years of age when that are circa 15cm long. The seaward migration probably starts at ice break-up in the river with the fish returning from the fjords towards the end of July.

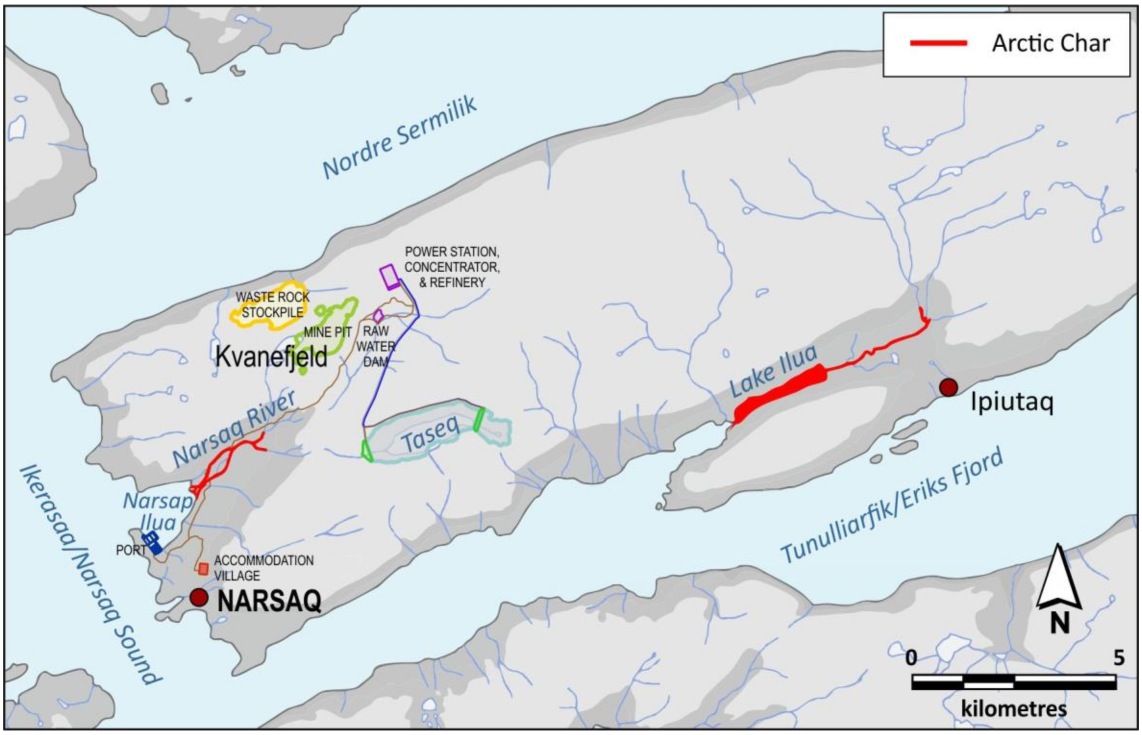


Figure 51 Distribution of Arctic char in rivers, streams and lakes on Erik Aapplaartup Nunaa peninsula

Arctic char in the Narsaq river typically reach sexual maturity when they are around 5 years old i.e. after their first sea run. Spawning in the Narsaq river occurs from late August to the beginning of October. Most char spawn in the main stream in places 30 to 35 cm deep, a with gravel bedbottom and subject to modest currents. Females create a depression in the river bed into which eggs are laid. Once the eggs are fertilised the char uses its tail to cover the eggs with gravel. The eggs hatch the following spring.

During winter, most of the Greenland's rivers are covered by thick ice and the water flow is significantly restricted. Char spend winters in pools in the larger rivers. In the Narsaq river, the chars are likely to in the deepest sections of the river. In spring, the fish spread out to utilize all water-covered areas below the rapids which are located approximately 5 km upstream.

Studies of aquatic life in the Narsaq river have shown that the smaller fish mainly eat chironomid larvae while the larger fish mostly feed on chironomid pupae and adults. It is also likely that some cannibalisation takes place.

While in rivers where the main food is insect larvae, char generally have a very slow growth rate. Non-anadromous fish will typically grow less than 2 cm per year and reach a maximum length of around 25 cm.

Anadromous char feed on planktonic amphipods, cope-pods and fish during the summer. Their food intake, when compared with intake in the river environment, increases and as a result growth rates are much higher than for non-anadromous char. The 1981 study found that the average length of seagoing char was 23 cm, 28 cm and 33 cm for 4, 5 and 6 year old fish, respectively.

In October 1981, at a time when all the seagoing fish were believed to have returned to the river, an attempt was made to assess the number of char in the Narsaq river. At this time some of the shallow parts of Narsaq river were dry and the char population limited to the main stream in an area covering 20,800 m^2. The char population was estimated at 31,000 of which 8,300 were 3 years old or older i.e. potentially seagoing. The stock of anadromous char in August was estimated to be 1,200. Char stock in the Narsaq river today is believed to be of the same order of magnitude.

The Arctic char is the only fish known to occur in freshwater in the Narsaq – Kvanefjeld area. This contrasts with the fjord where many fish species occur. However, where a species is not utilized commercially or utilised in connection with local subsistence fishery, generally little is known about it. The following accounts therefore focus on key fish species that are utilized in the fjords at Narsaq.

Atlantic cod is currently quite common in fjords around the Erik Aappalaartup Nunaa peninsula but throughout the 20th century, it's numbers and distribution have fluctuated widely as a result of climatic changes. It is possible that the cod population around the Erik Aappalaartup Nunaa belongs to a local fjord stock.

Lumpsucker spends most of the year in deep offshore waters but in the late winter it migrates to shallow water to spawn. During this period lumpsucker are common along the coasts of the fjords in the Narsaq area. The fish that are common along the coast are mainly female and fished for roe.

Greenland cod or uvak occurs along the coasts and fjords north to Upernavik and is common in the fjords around the Erik Aappalaartup Nunaa peninsula. In commercial fisheries the Greenland cod is considered inferior to the Atlantic cod however it has significance for subsistence fishing.

Spotted wolffish probably occurs in all deep parts of the fjords around the Erik Aappalaartup Nunaa peninsula. Its numbers have decreased in recent years but it still has considerable importance for subsistence fishing.

Atlantic salmon occurs along Greenland's coast from August to about November during foraging migration from the American and European continents. In some years the Atlantic salmon is quite common in Narlunaq Skovfjord, and in Qaqortup Ikera/Julianehåbfjord and small numbers probably also enter the fjords around the Erik Aappalaartup Nunaa peninsula.

Capelin is an ecological critical species because of its role as an important food resource for larger fish, seabirds and marine mammals. It is also exploited both commercially and for subsistence purposes.

There are indications that individual fjord systems contain separate capelin populations. Capelin is believed to common along the shore of the Erik Aappalaartup Nunaa peninsula although no precise data is available.

Redfish are quite common in the deep parts of the fjords that surround the Erik Aappa-laartup Nunaa peninsula although no precise data is available.

12.1.3 Threatened species and significant communities

Of the animals and plants recorded from the Erik Aappalaartup Nunaa peninsula five species of birds and one orchid species are listed as "Vulnerable" or "Near threatened" on the Red List (Boertmann 2007).

These species were targeted in the survey (Orbicon, 2014, 2018a) and the significance of the survey area to the threatened species was assessed, based on known distribution and preferred habitat (Table 49).

Table 49 Threatened species recorded from the Erik Aappalaartup Nunaa peninsula

Species	Status in Study Area	Main habitat	Greenland red-list status	Importance of Erik Aappalaartup Nunaa peninsula to population
Common eider	(Winter) visitor	Offshore (winter), outer coast, fjords	Vulnerable (west Greenland population)	Low
Gyrfalcon	Visitor	Inland, coastal	Near threatened	Low
White-tailed eagle	Potentially part of territory	Inland, coastal,	Vulnerable	Medium
Black-legged kittiwake	Visitor	Offshore, coastal, fjords	Vulnerable	Low
Brünnich's guillemot	Visitor	Offshore, coastal fjords	Vulnerable	Low
Round-leaved orchid	Recorded once (date unknown)	Dwarf shrub heath close to stream	Vulnerable	Unknown

Round-leaved orchid (*Amerorchis rotundifolia)*, Greenland's rarest orchid has previously been recorded at between the gravel road and just south of the "test piles" at c. 300 m altitude. This site was visited in September 2014 but no signs of the rare orchid were found. This species may still be present in the area.

The survey identified the protected northern green orchid (*Platanthera hyperborean*) growing along the streams in the lowland areas and around Lake Taseq.

An unusual vegetation community on gravel was also identified, comprising of moisture demanding species common butterwort (*Pinguicula vulgaris)* and deergrass (*Scirpus caespitosus)* and drought tolerant species Arctic eyebright (*Euphrasia frigida*), mother-of-thyme (*Thymus praecox*), lesser clubmoss (*Selaginella selaginoides*) and simple bog sedge (*Kobresia myosuroides*).

This population also included autumn gentian (*Gentiana amarella* ssp. *Acuta*), golden gentian (*G. aurea*), Alpine gentian (*G. nivalis*) and northern green orchid. This is a species composition that is rarely seen in this part of Greenland. Autumn gentian has also never been found on the Narsaq peninsula before and is only recorded at two sites in south Greenland (Feilberg 1984).

The lowland road stretch has a small fen on the mountainside of the road turn that is dominated by mountain bog-sedge (*Carex rariflora)*, single-spike sedge (*C. scirpoideaA* and carnation sedge (*C. panacea)*. The latter is an uncommon species in Greenland.

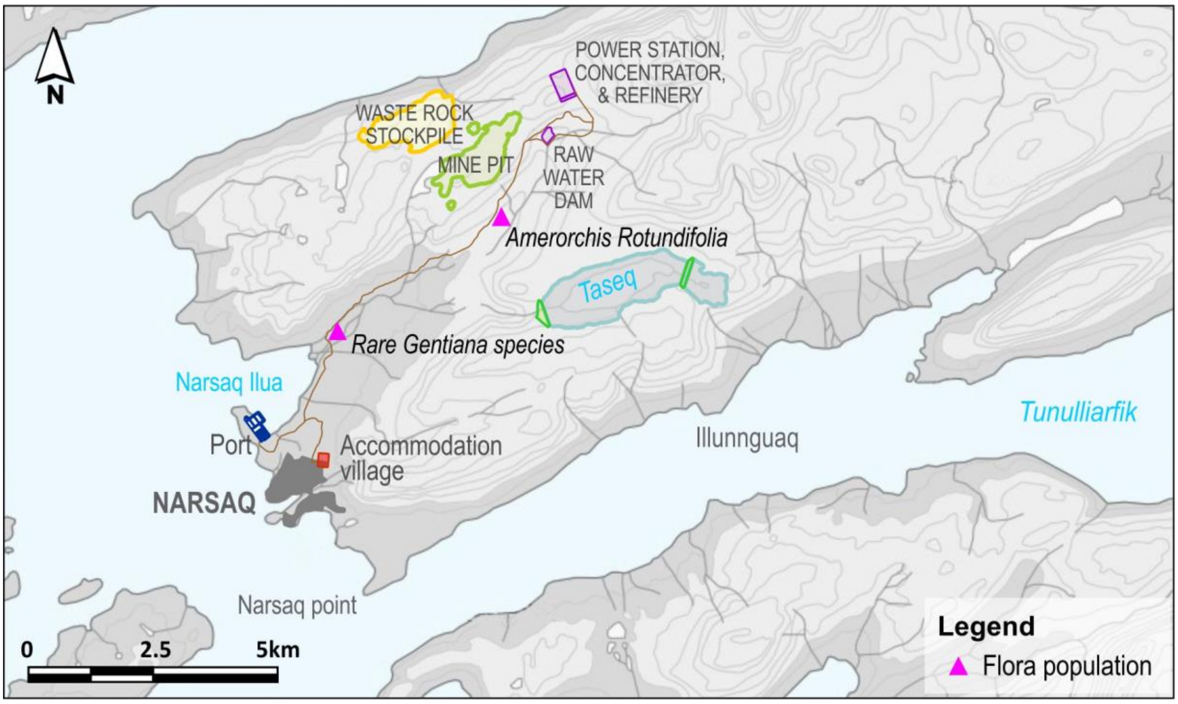


Figure 52 Rare flora in Project area

Protected areas

No areas designated as protected are close to the Erik Aappalaartup Nunaa peninsula. The closest protected areas are shown in Figure 53.

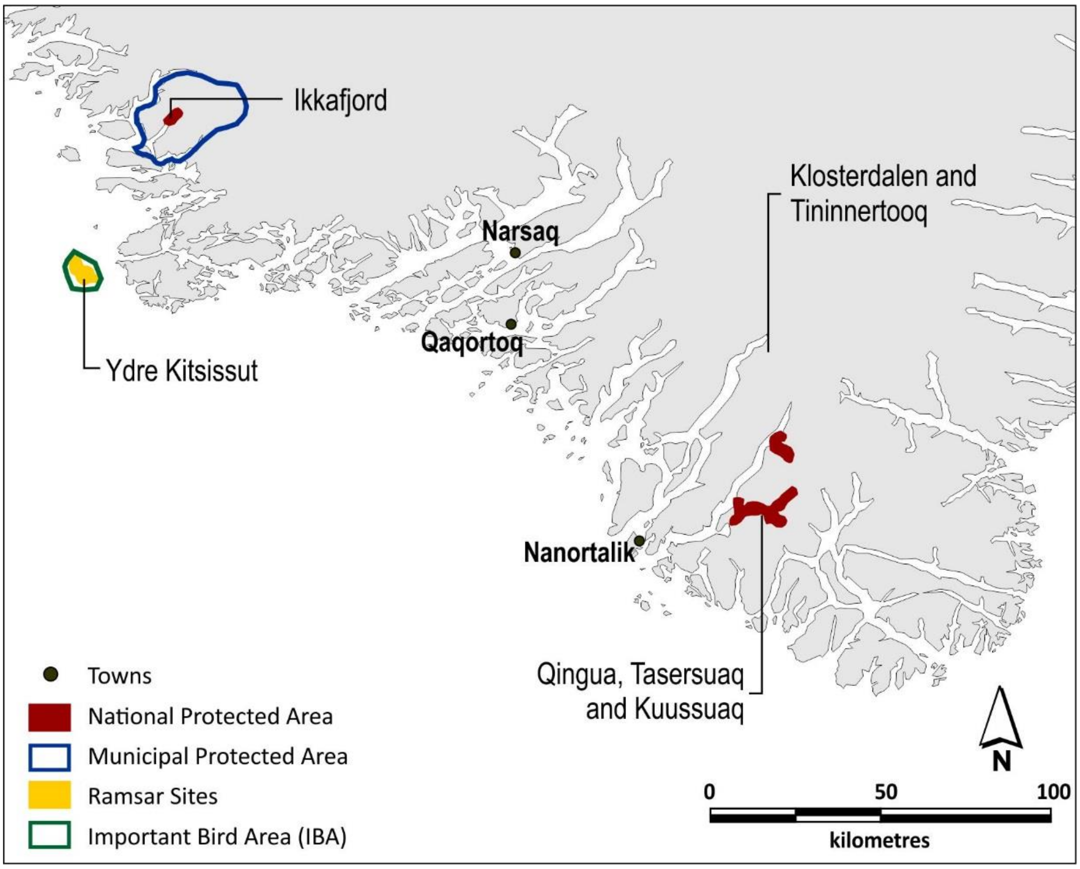


Figure 53 Protected areas in south Greenland

12.2 Potential impacts

Construction and operation of the Project:

- Will result in the disturbance of:
  - habitat for terrestrial fauna and flora
  - habitat for freshwater fauna
  - marine fauna habitats
- Has the potential to
  - contaminate terrestrial fauna habitat
  - contaminate freshwater and marine habitats
- Will increase vehicular traffic which has the potential to result in fauna mortalities
- Will increase sea-borne traffic which has the potential to result in the introduction of invasive non-indigenous species in ballast water and fauna collision.

12.3 Assessment of impacts

12.3.1 Disturbance of habitat for terrestrial fauna and flora

Several construction activities can potentially disturb animals, particularly mammals and birds:

- Noise and vibration, in particular the intermittent blasting noise from the mine has the potential of startling mammals and birds
- Visual disturbances from personnel, vehicles, buildings and other Project structures which might cause mammals and birds to avoid habitats in the mine area.

Bird and mammal species react very differently to noise and visual disturbances. The white-tailed eagle is known to be affected by disturbances close to its nest during the breeding season. Although the white-tailed eagle is commonly observed in the Study Area, no nesting sites are known to exist in the area.

Among the birds that breed in the Study Area, only the raven is known to be sensitive to noise or visual disturbance. Ravens will therefore probably avoid breeding within 1 to 2 km of the mine and Plant area. Ravens are generally low-density breeding birds in Greenland and the Project is not expected to lead to a significant reduction in the population of nesting pairs in the region.

Two terrestrial mammals occur in the Kvanefjeld area, the Arctic fox and the Arctic hare. These animals usually adapt well to human activities in locations where they are not hunted. As hunting pressure in south Greenland is generally high, foxes and hares will most likely avoid Project facilities and activities.

Rock movements required for construction of the Port, the Plant, roads and associated infrastructure and to prepare the mine for operations, will lead to loss of natural vegetation and will displace most terrestrial animals from the mine area.

The vegetation in the Study Area is mostly dominated by terrestrial habitats and plant species, which are common and widespread in south Greenland.

A botanic study was performed which identified:

- One rare plant species found on the northern side of the mouth of the Narsaq river, *Gentiana Amarella*, is rare in Greenland. 50 individual plants have been counted at this location. An unusual vegetation community was also recorded at this location.

- Round-leaved orchid, *Amerorchis rotundifolia*, Greenland's rarest orchid has previously been recorded between the gravel road and just south of the "test piles" at c. 300 m altitude. This site was visited in September 2014 but no signs of the rare orchid were found. Seed for this species may still be present in the area.
- The lowland road stretch had a small fen on the mountainside of the road turn in the lowlands that is dominated by mountain bog-sedge (*Carex rariflora*), single-spike sedge (*C. scirpoidea*) and carnation sedge (*C. panacea*). The latter is a rare species in Greenland.
- The protected northern green orchid (*Platanthera hyperborean*) growing along the streams in the lowland areas and around Taseq.

No construction works will take place in the areas of rare plants or vegetation communities. The overall footprint of the mine infrastructure is small compared to the distribution of similar habitat in south Greenland. Typically, low densities of animals occur in these habitats none of which are known to be rare or threatened in Greenland. Overall the significance of lost terrestrial habitat due to the Project is assessed to be very low.

The noise disturbance from machines and blasting will be the same in the construction and operations phases.

Noise and visual disturbance during operation will cause only localised disturbance of terrestrial birds and mammals. Since no breeding sites are known for the white-tailed eagle inside or close to the Study Areas, the disturbance impact of terrestrial mammals and birds is assessed as low.

12.3.2 Disturbance of habitat for freshwater species

A significant population of Arctic char lives in the Narsaq river where char spawn in autumn in the main stream in sections of the river with sites with gravel river beds. In summer, many of the char leave the river to feed in the fjords, but during winter the entire population is present in the lower section of the river.

In years with long periods of sub-zero temperatures the water flow in Narsaq river is significantly reduced and a further reduction in the flow due to Project related changes to the hydrology could impact the survival of the wintering char.

Construction works in connection with the culverts across Narsaq river and the building of embankments at Taseq may cause short-term increases in the turbidity in Narsaq and Taseq rivers. This could disturb freshwater organisms including Arctic char in Narsaq river. Most construction will take place in the summer months when a significant proportion of the the Arctic char leave the Narsaq river for the fjords. Any rise in turbidity due to these construction works will be temporary (and short term) during summer. As such the disturbance of the Arctic char and the freshwater ecosystem due to turbidity is considered very low significance.

At certain times of the year Project activities will reduce the flow in the Narsaq river. Water to be used in the Plant will be taken from the Narsaq river during times of high flow. The flows in the Taseq and Kvane rivers will either be stopped significantly reduced.

The Project related changes to the flow patterns of Kvane and Taseq rivers will lead to an average reduction of the flow in the main spawning area in the Narsaq river by about 15%. This is a minor flow reduction which will not have significant impact on the breeding success of the Arctic char population in the Narsaq river.

During winter no water will be drawn from the Narsaq river or its tributaries. This is because at that time of the year there is no significant outflow from Kvane or Taseq lakes (because the outlets are normally frozen).

Project related changes in hydrology of the Narsaq river and its tributaries is unlikely to have a significant impact on the population of Arctic char in the Narsaq river.

12.3.3 Disturbance of habitat for marine fauna

Construction works at the Port at Narsap Ilua will cause temporary underwater noise from blasting and ramming and increased turbidity of the sea water close to the Port. Ships bringing machinery, materials etc. to the Port site during construction will generate noise both above and below water and visual disturbance above water. This could potentially result in disturbances for and displacements of marine mammals, sea birds and fish.

Of significance are:

- Ringed seals all year and harp seals during summer
- Sea bird colonies at Akullit Nunaat
- Flocks of wintering eider duck
- Arctic char during summer.

Existing data suggests that few marine mammals, if any, regularly occupy the Narsap Ilua. The data also suggests that seals and, occasionally, whales are found in Narsap Ikerasaa and adjacent fjords. Flocks of sea birds, mainly the eider duck, winter in the fjords around Narsaq, including in Narlunaq/Skovfjord and Narsaq Ikerasaa/Narsaq Sund. If vessels traverse the Bredefjord, as an alternative to the more regularly used Skovfjord, they have the potential to disturb sea bird colonies. Arctic char that migrate through Narsap Ilua to the surrounding fjords during summer to feed may also be disturbed.

Seals are common in the fjords at Narsaq. However, severe disturbance from blasting and ramming is considered unlikely, as seals in general display considerable tolerance to underwater noise. Vessels moving to and from the Port using Bredefjord, as opposed to Skovfjord, will pass several small sea bird colonies at Akullit Nunaat at a distance of a few kilometers. This is unlikely to disturb the sea birds breeding since experience from other parts of Greenland has shown that breeding seabirds are only disturbed if a vessel is within a few hundred meters of the colony (Christensen et al. 2012).

Flocks of wintering eider ducks that rest and forage in the fjords might be temporarily disturbed by vessel calling at the Port. However, this disturbance is considered insignificant due to the low number of expected vessel arrivals and departures (1 or 2 per week).

Char migrating from Narsaq river into the fjords in spring and back in late summer-autumn pass close to the Port site. Noise and increased turbidity in Narsap Ilua during Port construction could potentially disturb migrating char. Since the construction works are temporary with infrequent blasting and ramming and with increased turbidity limited to a small area, the disturbance to migrating char during the construction period is considered insignificant.

The construction works at the Port will be local and temporary taking place in an area with low numbers of marine animals. The impact of the construction works is therefore considered to be low.

Due to the low number of vessels serving the Project during construction (and operation) disturbance from shipping in the fjords is considered low.

The Port will require reprofiling of a section of the shore. The re-profiling will be permanent. This will lead to the loss of some intertidal habitat and could potentially impact populations of marine animals and plants. The species potentially affected includes Arctic char from the Narsaq river population that migrates into the fjord during the summer months. Little specific knowledge exists about the marine flora and fauna of Narsap Ilua. Observations during the ecological baseline sampling (Orbicon 2014b) suggest that no marine mammals or sea birds are specifically associated with this part of the fjord. The loss of foraging ground for Arctic char due to the construction of the Port is expected to be insignificant as very large areas of similar habitat are common along the fjords in the region.

The number of vessels calling in at the Port during the operations phase will be small and disturbance is considered minimal.

12.3.4 Contamination of terrestrial fauna habitat

Project activities can potentially cause direct contamination of terrestrial habitats:

- Accidents in connection with transport, storage and handling of hazardous materials such as fuel and chemicals
- Failure of the TSF embankment resulting in water and tailings material released onto land.

Spills of chemicals or hydrocarbons

The most serious contamination of terrestrial habitats would result from a hydrocarbon spill. Contamination of the surface soil and vegetation by oil or other hazardous materials potentially poses a risk to animals, plants and their habitats. Hydrocarbons can have toxic effects.

Due to their organic nature, small spills of hydrocarbons are generally broken down by bacteria in the soil; however, this process is much slower in the Arctic climate and even small oil spills can kill the vegetation which subsequently requires decades to re.-establish.

The likelihood of a major spill occurring on land is low. During operations small spills are more likely to occur, but the effects would be localized and comparatively easy to remediate.

The environmental impacts of fuel and chemical spills on land are assessed to be confined to the Project Area (i.e. local scale). The potential loss or depletion of terrestrial habitat due to contamination is considered low.

Tailings embankment failure

A tailings embankment failure (overtopping, partial or catastrophic) would impact terrestrial and aquatic ecosystems in the Narsaq valley and the marine life in Narsap Ilua (Arcadis 2018c). The potential TSF failure scenarios are described in Section 10.

Overtopping of the water in the TSF would result in minimal long term effects to the terrestrial environment. The major immediate impact would be from the large and extended water flow, which would most likely flood the grass fields of the fan zone. Immediately following failure, the depth of water flow would be relatively high due to the steep sloping stream bed channel of the Taseq river and the narrow and steep valley side walls immediately downstream of the embankment. The flow from the release of water is likely to overwhelm the natural river flow. There would be significant scouring and biota such as fish could be swept away with the flow.

A partial failure of the TSF embankment would result in a similar but greater impact, the primary difference being that a significant volume of tailings would be mixed with the water. In this scenario, approximately 60 to 70% of the tailings, particularly the coarser particles, are expected to settle in the lower stretch of the Narsaq river. Approximately 30 to 40% would settle in Narsap Ilua and only a small proportion of solids would move beyond Narsaq Ilua and enter the fjord. Where tailings are deposited in the Narsap Ilua, there is not expected to be population-level changes to the biota present. However, the tailings would likely smother the existing biota to some degree and the species would need to re-colonize.

A catastrophic failure of the TSF embankment would result in all water (pore water and water covering the tailings) and an estimated 4 Mm^3 of tailings material being released over a wide area downstream of the breach. Approximately 80 to 90% of this material would be released within 24 hours of the breach. Of the tailings material that reaches Narsap Ilua, approximately 80% is estimated to settle in the bay and the balance would transported into the fjord. The flow from the tailings would overwhelm the natural river flow and there would be significant scouring. Biota such as fish would be swept away with the flow. As with a partial failure, tailings would likely smother the existing biota.

The greatest estimated radiological risk is to birdlife. Potential issues were also identified for other trophic levels (molluscs, zooplankton). For marine species there is the possibility of effects on aquatic biota during the release as a result of the levels of contained radionuclides. After the release, radionuclide levels are expected to decline and the doses would decrease. Terrestrial receptors are not expected to be affected by residual radionuclides.

Given the topography and nature of the release, ongoing natural erosion would reduce these impacts over time. Selective remediation efforts would help reduce the level of impact. The assessed impact to terrestrial and aquatic biota in the event of a TSF embankment failure is considered medium. However, when combined with the extremely low risk of an embankment failure, the overall potential impact to biota is considered low.

12.3.5 Contamination of freshwater and marine habitats

Accidents in connection with transport, storage and handling of building materials such as fuel, grease, paint and chemicals can potentially cause contamination of nearby freshwater bodies. Contamination of lakes and rivers by oil or other hazardous materials from Project activities could potentially pose a risk to animals, plants and their habitats. Hydrocarbons, such as jet fuel and Arctic diesel, can have toxic effects.

12.3.6 Increased vehicle strikes of terrestrial fauna

The Project could potentially lead to increased direct mortally among animals and birds due to traffic collisions.

The movement of trucks and other vehicles along the haul and service roads represents a risk for animals. However, given the layout of the road system within the Study Area, this is unlikely to be a major danger for wildlife. Furthermore, since a speed limits of 40 km/hour will be introduced and drivers are instructed to be aware of animals moving close to roads this risk is considered low.

12.3.7 Invasive non-indigenous marine species

Vessels berthing at the Port will discharge ballast water before loading cargo. The ballast water can contain non-indigenous species that could potentially establish themselves in the south Greenland fjords. When introduced in new areas, these species could thrive and become a threat to indigenous species and the local ecosystem.

The BWM Convention aims to prevent the potentially devastating effects of spreading harmful aquatic organisms carried by ships' ballast water. The BWM requires all ships to implement a Ballast Water and Sediments Management Plan. All ships are required to carry out ballast water management procedures to a given standard. To minimize a potential introduction of non-indigenous species, regulations of the BWM Convention will be followed for the Project.

Provided vessels that call in at the Project port follow the BWM regulations, the risk of introducing invasive non-indigenous species with ballast water is unlikely.

12.4 Mitigations

- Restrict the movement of staff members outside the Project Area during spring and summer to minimize the general disturbance of wildlife
- Minimise the disturbance of the water in the Narsaq and Taseqs river when building culverts and embankments by keeping construction as short as practically possible
- Maintain a minimum Narsaq river flow during winter

  This will require additional water recycling of Plant water in the winter to reduce fresh water consumption
- Mandate low vessels speeds while in fjords
- Vessels to maintain good distance to flocks of wintering sea birds (when possible)
- Minimize the area to be disturbed, infrastructure to have as small a footprint as possible
- Prepare spill contingency plans in collaboration with appropriate authorities.

  Spill equipment to be appropriate to spill risk and readily available
- Develop of waste handling procedures and a waste management manual
- Mandate and enforce speed limits across the Project
- Report fauna strikes
- Develop a Ballast Water and Sediments Management Plan.

12.5 Predicted outcome

The predicted outcome of the Project on biodiversity is detailed below.

Table 50 Predicted outcome for biodiversity

Impact	Project Phase	Spatial extent	Duration	Significance	Assessment
Disturbance of terrestrial fauna and flora habitat	Construction Operation Closure	Study area	Life of mine	Low	Noise and visual disturbance during operation will only cause localised disturbance of terrestrial birds and mammals. As no breeding sites of the disturbance sensitive white-tailed eagles are known inside or close to the Study Areas, the disturbance impact of terrestrial mammals and birds is assessed as low.

Impact	Project Phase	Spatial extent	Duration	Significance	Assessment
Disturbance of freshwater species habitat	Construction Operation Closure	Study area	Life of mine	Very low	The changes to hydrology because of the Project will be minimal. During winter no Project related flow reduction is expected for any freshwater sources.
Disturbance of habitat for marine fauna	Construction Operation Closure	Study area	Life of mine	Low	The impact on marine fauna and habitat is expected to be limited based on the application of international best practice standards.
Contamination of terrestrial fauna habitat	Construction Operation Closure	Study area	Life of mine	Low	The impact on marine fauna and habitat is expected to be limited based on the application of international best practice standards.
Contamination of freshwater and marine habitats	Construction Operation Closure	Study area	Life of mine	Medium	The impact on marine fauna and habitat is expected to be limited based on the application of international best practice standards.
Increased vehicle strikes of terrestrial fauna	Construction Operation Closure	Study area	Life of mine	Very Low	The impact on terrestrial fauna and habitat is expected to be limited based on the application of international best practice standards.
Invasive non-indigenous marine species	Construction Operation Closure	Study area	Life of mine	Very Low	The impact on marine fauna and habitat is expected to be limited based on the application of international best practice standards.

13. Local use and cultural heritage

13.1 Existing environment

With more than 2,150,000 km^2 of coastline, Greenland is the largest island in the world. However, because of the combination of a cold climate, large ice cap and remote location, Greenland is only sparsely populated. The current population of Greenland is estimated to be 57,000 (Shared Resources 2018).

There is no private right of land ownership in Greenland, with land considered "commons" to be shared responsibly by all Greenlandic people. Where access to land is required by a specific group, for example sheep farmers, the Government requires the group to be jointly responsible for agreeing to the terms of the right to use the land. Where individuals build houses, they can own the building but will only rent the land upon which it is built.

Most of Greenland is covered by an ice cap and it is estimated only 0.6% of the Greenland's landmass is used for agriculture, most in Kommune Kujalleq. In 2014, of the 41 sheep farms operating in Greenland, 35 were in the areas of Narsaq, Narsarsuaq and Qaqartoq in Kommune Kujalleq.

The Kvanefjeld deposit is located approximately 7.5 km north-east of Narsaq. Narsaq, 1600 inhabitants, is located at the southern tip of the Erik Aappalaartup Nunaa peninsula and is the town nearest to the Project. Qaqortoq (approximately 3,000 inhabitants) located 28 km south south-east of the Project is the second-closest town.

Other settlements in the vicinity of the Project include a cattle farm and summerhouses in the lower part of the Narsaq valley.

Local use studies were undertaken in 2011 and 2015 (Orbicon 2015c). Orbicon identified hunting and fishing as important livelihood activities in the Narsaq area, providing an important source of income and subsistence to many families. Most local fishing vessels are small-scale operations in the fjords around Narsaq. Around 30 persons in Narsaq have fishing as their primary source of income. In addition, 10-15 people have a commercial licence and supplement their income with fishing. In most years Atlantic cod, redfish, Arctic char and wolfish are the most significant commercial fish species. In late winter and spring fishing for roe is very important.

Although less significant as a commercial activity, seal hunting is an important source of income, mainly through private sale and distribution of meat. It is also important for subsistence for many families in Narsaq. Seals are hunted in the fjords around Narsaq, particularly in Bredefjord and Nordre Sermilik. The most important species is the ringed seal, but during the summer months, many harp seals are also hunted.

During winter ptarmigan and hare hunting is popular with many citizens of Narsaq. This is primarily recreational hunting that takes place high in the mountains to the north-east of Narsaq.

Gem fossicking for the creation of commercial jewellery or personal souvenirs takes place throughout the Study Area. The semi-precious stone "Tuttupit" is by far the most popular target and is predominantly found on the Kuannersuit. A small number of people in Narsaq conduct small-scale stone collection in the Study Area. An additional 4 to 5 people sell stones collected elsewhere in the area, either polished into jewellery or as raw rocks to collectors or jewellers.

Tourism in and around Narsaq is quite limited. Most tourists usually arrive at Narsaq as part of a south Greenland tour, and the focus of the visit is activities within the town. However, some tourists come on their own, stay at the small hotel in town and visit the Narsaq valley.

Berry picking in autumn and hiking in the mountains around Narsaq is very popular among Narsaq citizens. Some angling for Arctic trout in occurs in the Narsaq river.

13.1.1 Archaeology and cultural heritage

The Greenland National Museum and Archives have investigated the sites of archaeological interest in the territory around Kvanefjeld (Kapel 2009, Myrup 2010).

Many archaeological sites are found along the shore of Erik Aappa-laartup Nunaa peninsula (Figure 54). The majority of these are Inuit remains from the Thule culture (1300 A.D.- Historical times) and historical Inuit settlements. The sites include traces of permanent winter settlements in the shape of turf-wall houses and tent foundations.

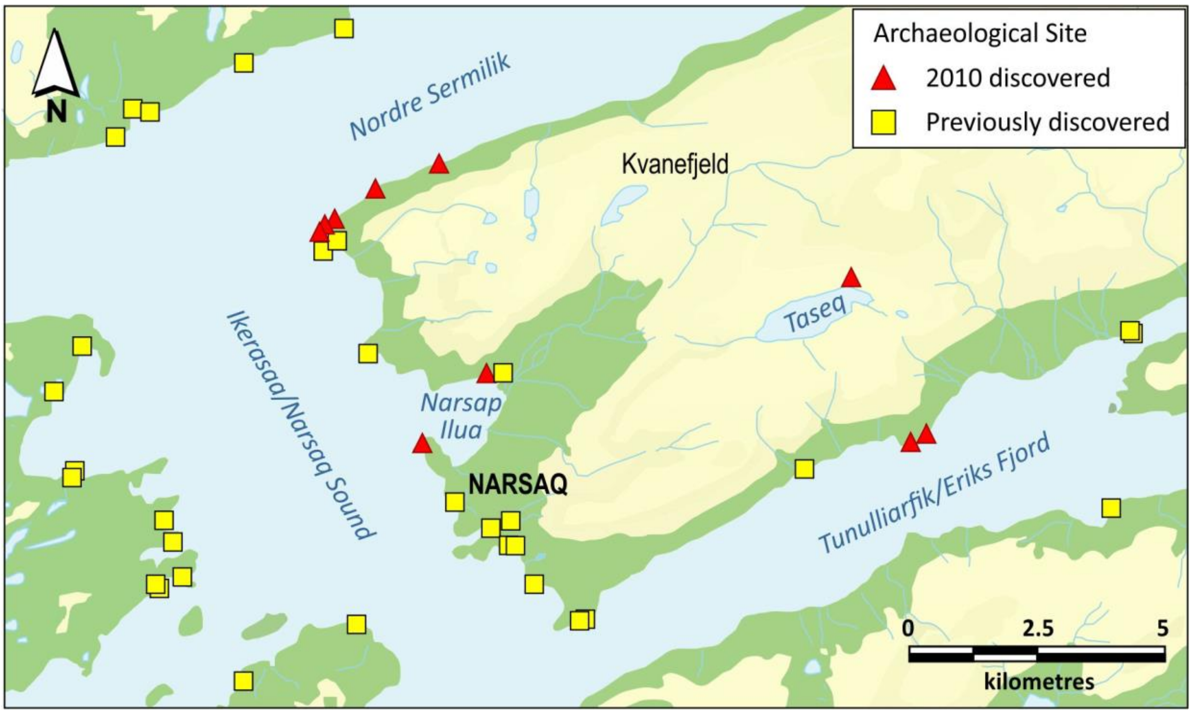


Figure 54 Archaeological sites at Narsaq/Kvanefjeld

A Norse settlement, established for about 500 years to 1500 AD, included a large farm and a church at Narsap Ilua/Dyrnæs just north of the mouth of Narsaq river. Today it consists of 18 individual constructions (including remains of several stone buildings with surrounding turf walls).

In 2017, five areas representing sub-Arctic farming landscapes in Greenland, collectively referred to as Kujaata, were admitted to the UNESCO World Heritage. The areas are located in the fjord system around Tunulliarfik and Igaliku Fjord (Figure 55), and comprise:

- Area 1 – Qassiarsuk
- Area 2 – Igaliku
- Area 3 – Sissarluttoq
- Area 4 – Tasikuluulik (Vatnahverfi)
- Area 5 – Qaqortukulooq (Hvalsey).

The five parts of Kujataa together represent the demographic and administrative core of two farming cultures, a Norse Greenlandic culture from the late 10th to the mid 15th century AD and an Inuit culture from the 1780s to the present. Area 5 is the closest to the Project, approximately 18 km from the boundary of the area to the Project.

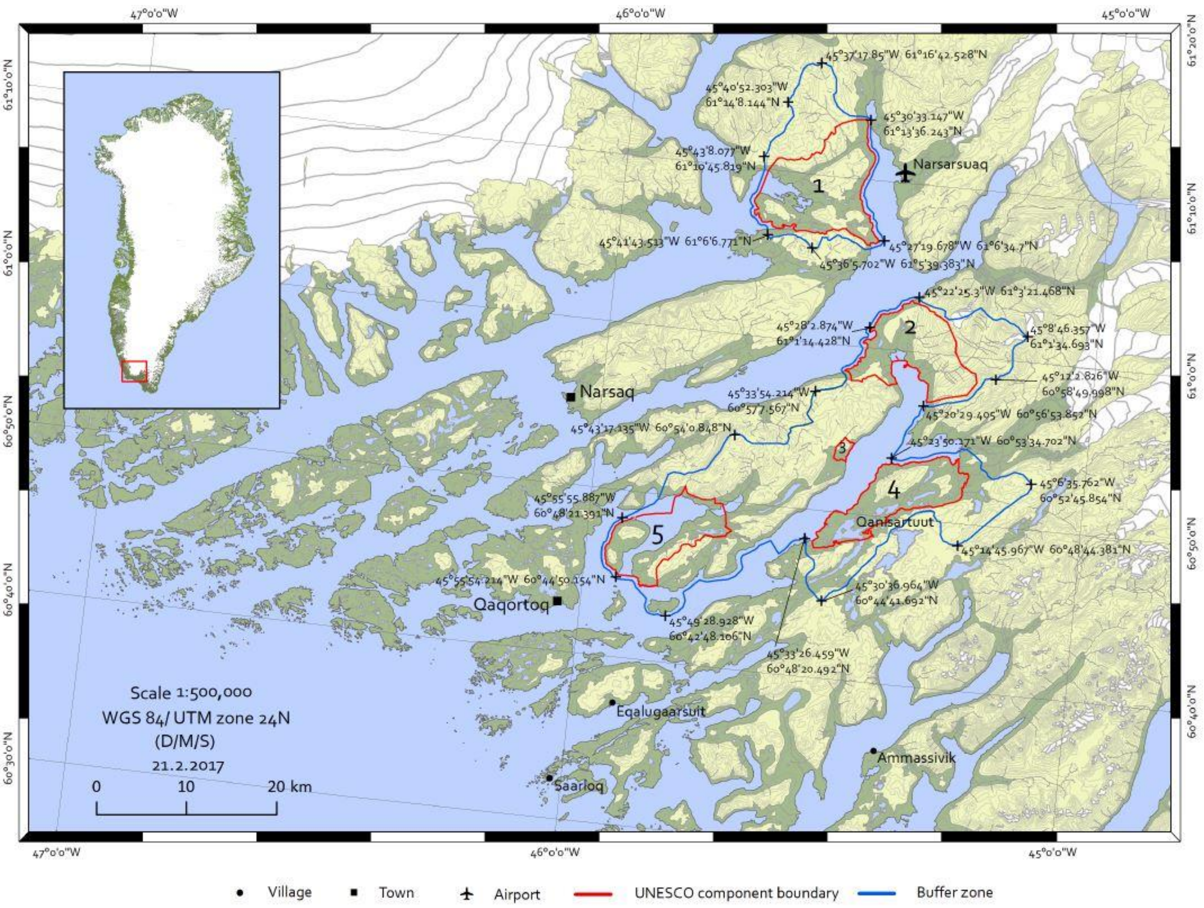


Figure 55 Kujaata UNESCO World Hertiage Sites (UNESCO, 2017)

13.2 Potential impacts

The potential impacts on local use and cultural heritage are:

- Construction and operation of the Project will restrict local use of the area
- Construction and operation of the Project has the potential to affect cultural heritage sites.

Broader social impacts are assessed in the Company's SIA.

13.2.1 Restriction in local use

The farm in the Narsaq valley is the only farm which has been active in recent years. [redacted]

Some hunting of hare and ptarmigan takes place in the Study Area, but most hunting of these animals is in the mountains further away from Narsaq. During the construction and operation phases there will be a 'no hunting' security zone on land to avoid shooting accidents. The exact area to be included in this zone will be agreed with relevant local authorities.

Women from Narsaq pick crowberries and bilberries in late summer and autumn. The favoured sites are southeast of Narsaq and on the hills to the north. Some also pick berries in the lower parts of Narsaq valley. Except within the working area of the Port-Mine Road, berry picking will continue as before. Currently a small number of Narsaq residents conduct small-scale collection of semi-precious gemstones (Tuttupit) at Kvanefjeld. It is believed that 3 other Narsaq residents regularly search for gemstones in the area. For security reasons access to the mine and Plant area will not be permitted during the construction and operation phases of the Project.

There are other locations in the area where these semi-precious gemstones are also found.

Seal hunting takes place in Nordre Sermilik and in some parts of the other fjords around Narsaq. No significant restrictions in the seal hunting is expected, except for 'no hunting' security zones in Narsap Ilua and in the immediate vicinity of the discharge point of treated Plant water in Nordre Sermilik. The extent of these zones will be agreed with relevant local authorities. The impact of this will be low, as the areas are rarely used for seal hunting.

Some professional and recreational fishing takes place in the fjords around Narsaq, including in Nordre Sermilik (Orbicon 2014c). Char fishing in the lower parts of Narsaq river is popular among Narsaq residents. Fishing will generally be unaffected by construction activities. Only very locally, close to the Port, will fishing not be possible. There will also be a 'no-fishing' zone around the discharge point of treated Plant water in Nordre Sermilik. This will probably have no impact as fishing in this area is usually difficult due to the number of small icebergs. Char fishing in the Narsaq river will continue during the construction period.

Walking, running, hiking and, to a lesser extent, driving are currently popular recreational uses of Narsaq valley among Narsaq residents and tourists. For security reasons driving and hiking on the Port-Mine Road will not be permitted. The mine and Plant area and a zone around the various Project facilities, including the TSF, will also be closed for the public.

Most of the valley will remain unaffected by the Project and open for recreational use.

13.2.2 Disturbance of heritage sites

The Greenland National Museum & Archives have identified several heritage sites within the Study Area including the Norse farm, Dyrnæs, on the shore of Narsap Ilua and several Inuit settlements (Kapel 2009, Myrup 2010). The Port location was chosen, in part, to avoid affecting the Norse farm .

Two of the sites will be affected by construction works: a rock shelter along the shore of the Taseq river (Taseq 60V2-0IV-071) and a tent foundation and shooting blind situated on the tip of the Tunu peninsula (Nuugaarmiut 60V1-00I-169) close to the location of the Port (Myrup 2010) (Figure 56).

The rock shelter is likely to be flooded, and the shooting blind will be demolished.

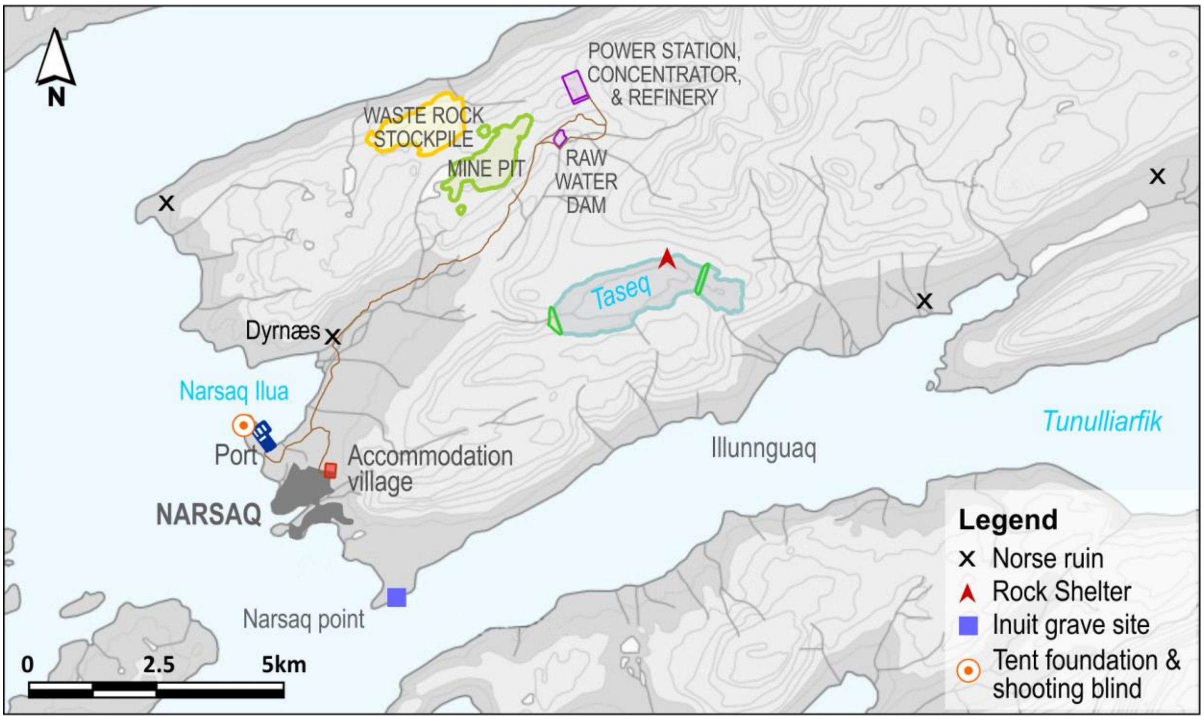


Figure 56 Archaeological sites.

Before any construction works take place, the sites will be recorded and registered by Greenland National Museum and Archives.

The closest UNESCO World Heritage site (Qaqortukulooq) is located 18 km from the Project. The Project will have no impact on this or any of the UNESCO sites.

13.3 Mitigations

- Greenland National Museum & Archives will record and register archaeological structures
- During the construction and operation phases implementing a 'no hunting' security zone on land
- During the construction and operation phases implementing a 'no hunting' security zone in Narsap Ilua
- During the construction and operation phases implementing 'no-fishing' zone around the water discharge point in Nordre Sermilik.

13.4 Predicted outcome

The predicted outcome of the Project on land use and cultural heritage is detailed below.

Table 51 Predicted outcome on local use and cultural heritage

Impact	Project Phase	Spatial extent	Duration	Significance	Assessment
Disturbance of heritage sites	Construction	Study area	Permanent	Low	Disturbance of a rock shelter along the Taseq river and a tent foundation and shooting blind on the tip of the Tunu peninsula.
Disturbance of UNESCO World Heritage sites	Construction Operation	Study area	Life of Mine	Very Low	No disturbance or impact is expected due to distance from the Project.

Impact	Project Phase	Spatial extent	Duration	Significance	Assessment
Local use	Construction Operation	Study area	Long term	Very Low	Local access for hunting, fishing and traditional uses will only be subject to minor restrictions, such as close to the Port site and in the no-fishing zone around the discharge port in Nordre Sermilik. However, this will probably have no practical importance as here is usually impossible due to the high number of small icebergs.

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Appendices

Appendix A - Environmental Management Plan

14.1 Introduction

An environmental management plan for a Project describes how the Project proponent intends to manage the environmental issues identified in the proponents environmental impact assessment. The EMP also identifies who is responsible for each commitment.

14.2 Kvanefjeld Environmental Management Plan

The Project's environmental management plan (EMP) includes commitments and management measures that GML will implement to ensure the Project environmental risks are managed to an acceptable level.

The EMP outlines for each Project phase as relevant:

- The management objectives under each category of impact identified in the EIA
- The potential impacts to the environment
- The mitigation measures for each impact
- The person responsible for each commitment

The commitments outlined in the EMP aim to provide a basis for which environmental performance and compliance can be measured for the duration of the Project.

The EMP and work procedures will be periodically reviewed and updated over the life of the Project. Environmental management commitments detailed in the EMP will be included in relevant contract documents and technical specifications prepared for the Project. All GML's employees, contractors and other personnel employed on the Project will be made aware of the EMP through the site induction process. During all phases of the Project, compliance with environmental management measures will be regularly monitored, any non-compliances addressed and improvement actions will be implemented.

The EMP presented below is a framework and comprises:

- A management program that specifies the activities to be performed in order to minimize disturbance of the natural environment and prevent or minimize all forms of pollution;
- A definition of the roles, responsibilities and authority to implement the management program.

The EMP framework has been tabulated below. The table includes information related to:

- Project activity

  The activity associated with the Project which has been identified as having the potential to have an impact on or pose a risk to environment.

- Environmental impact

  A description of the impact of the activity (such as pollution or disturbance of natural environment)

- Action

  The mitigating measure or actions identified to prevent or minimize the adverse environmental impact; and

- Responsibility

  The party or parties responsible for ensuring the mitigation is put in place.

Responsibility for meeting some of the management commitments in the tables will be transferred to GML's contractors. Through the development of a code of responsible environmental practice which will be included in all tender documents and contracts, GML will commit the contractors to meeting the relevant management responsibilities.

GML understands that this will not be absolved from those management responsibilities by securing the relevant commitments from contractors. Ultimate responsibility for meeting all commitments lies with the relevant GML staff member, typically be the resident mine manager and/or the company environmental manager.

GML's Environmental Management System

Prior to the commencement of operations GML is committed to developing and implementing an Environmental Management System (EMS) consistent with the International Organization of Standardization's ISO 14001 guidelines for managing an EMS.

The purpose of an EMS is to formalize procedures for managing and reducing environmental impacts from the a project. The EMS will assist GML to maintain compliance with Greenland's environmental regulations, lower environmental impacts, reduce risks, develop indicators of impact and improve environmental performance.

The ISO 14001 (2004) is based on the methodology - Plan-Do-Check-Act:

- **Plan**

  Establish the objectives and processes necessary to deliver results in accordance with the organization's environmental policy.

- **Do**

  Implement the processes.

- **Check**

  Monitor and measure processes against environmental policy, objectives, targets, legal and other requirements, and report the results.

- **Act**

  Take actions to continually improve performance of the environmental management system.

GML's EMS will ensure that the environmental obligations associated with the Project are managed in a manner that is planned, controlled, monitored, recorded and audited. Environmental incidents will be reported, investigated, analyzed and documented. Information gathered from the incident investigations will be analyzed to monitor trends and to develop prevention programs, which include corrective and preventative actions taken to eliminate the causes of incidents. All employees, contractors and sub-contractors will be required to adhere to the EMS and the non-conformance and corrective action system in place at Kvanefjeld.

EMP - Construction Phase

Ref. no.	Project activity	Environmental Impact	Action	Responsibility
8.1.1	Stripping of the mine pit area	The mining activities can have aesthetic impact	Plan the pre-stripping to blend as far as practical with the surrounding landscape	Project Manager
8.1.2	The use of Taseq and adjacent pond for tailings deposition	The mining activities can have aesthetic impact	Plan the tailings embankments to blend as far as practical with the surrounding landscape	Project Manager
8.1.3	Re-profiling of landscape for other mine facilities and infrastructure construction	Re-profiling of terrain for infrastructure can have aesthetic impact	Plan roads to blend as far as practicable with the surrounding landscape	Project Manager
8.1.4	Construction activities could cause erosion	Loss of soil, sand and gravel by the forces of water, ice or wind	Take erosion into account when selecting construction methods and routing of the alignments	Project Manager
8.1.5	Mobile equipment, drilling and blasting, land transport and shipping make noise	Increased noise load could disturb wildlife and people	Plan noise activities such as blasting to take place when noise impact is least	Project Manager
8.1.6	In dark periods the construction areas will be illuminated	"Ecological light pollution" can distract wildlife, in particular migrating birds	No action required since problem is negligible	Project Manager
8.2.1	Blasting, excavation and shipping in fjords generate dust and air emissions	Potential pollution of water and land	Plan construction works to minimize dust generation and air pollution	Project Manager
8.2.2	Mobile equipment such as excavators, bulldozers and trucks generate greenhouse gasses	Climate change	Limit the amount of fuel combusted as much as practical possible	Project Manager
8.3.1	Construction works will lead to changes of natural flow pattern and capacity of freshwater resources	Impact freshwater ecology including fish population	Limit mitigation possible except minimizing the impact as much as practically possible	Project Manager

Ref. no.	Project activity	Environmental Impact	Action	Responsibility
8.4.1	Noise and visual disturbances from personnel	Disturbance of terrestrial mammals and birds	Restrict the movement of staff members outside the construction areas	Mine Manager
8.4.2	Construction works at port and shipping in fjords	Disturbance of marine mammals and birds	Low speed while in fjords and keep good distance to flocks of wintering sea birds (when possible)	Project Manager
8.4.3	Construction of bridges and embankments	Disturbance of freshwater organisms including fish	Minimise the disturbance of the water in when building new bridges and embankments by keeping the construction period as short as practically possible	Project Manager
8.4.4	Re-profiling to accommodate buildings	Loss of terrestrial habitat	Minimize the area to be disturbed by planning infrastructure to have as small a footprint as possible	Project Manager
8.4.5	Deposition of tailings in Taseq	Loss of freshwater habitat	No mitigating possible	Mine Manager
8.4.6	Re-profiling for shore to accommodate port	Loss of marine habitat	Minimize the area to be disturbed	Project Manager
8.4.7	Accidents can lead to spill of oil and chemicals on land	Impact on terrestrial habitats and biota	Prepare contingency plans for oil and chemical spills including efficient combat readiness training	Mine Manager
8.4.8	Accidents can lead to spill of oil and chemicals	Impact of freshwater and marine habitats and biota	Prepare contingency plans for oil and chemical spills including efficient combat readiness training	Mine Manager
8.5	Contamination of environment from domestic and industrial waste	Waste – and in particular hazardous waste - can lead to significant contamination of the environment	Handle waste according to procedure detailed in waste management manual and according to good environmental practice, with high degree of re-use and re-cycling	Mine Manager
8.5.1	Traffic along haul- and service roads	Road kills of animals	Ensure speed limits are enforced and that all staff are aware of animal hazards	Mine Manager

Ref. no.	Project activity	Environmental Impact	Action	Responsibility
8.5.2	Shipping in the fjord	Introduction of invasive alien species with ballast water	Follow regulations of the International Convention for the Control and Management of Ships' ballast water and Sediments	Project Manager
8.6.1	Safety regulations at mine area	Hindrance of traditional land use	Keep the area closed to the public and the no-hunting zone as small as possible	Mine Manager
8.6.2	The new road between the port and the mine area will be closed for the public	Limit recreational use and tourism	No mitigation possible. Roads will be available for emergency use and planned special occasions.	Mine Manager
8.6.3	Construction work at port and Taseq	Disturbance of heritage site	Contact staff member of the Greenland National Museum and Archives	Project Manager

EMP covering the Operational Phase

Ref. no.	Project activity	Environmental Impact	Action	Responsibility
9.1.1	Landscape alterations at pit and embankments	Aesthetic impact	Plan the activities to blend as far as possible with surrounding landscape	Project Manager
9.1.3	Noise from project operations, blasting at pit	Disturbance of wildlife and people	Avoid blasting during evenings and at night	Mine Manager
9.2.1	Mine activities cause air emissions	Increased air emissions (concentration and deposition of dust, NOx, SOx & Black carbon)	Minimize dust generation by implementing GML's Dust Control Plan Choose vehicles and other equipment based on energy efficiency technologies to optimize emissions rates Maintain power plant, vehicles and other fuel powered equipment in accordance with manufacture's specifications to minimize on emissions	Mine Manager
9.2.2	Mobile and stationary fuel combustion generates greenhouse gas emissions	Climate change	Choose vehicles and other equipment based on energy efficiency technologies to optimize emissions rates Maintain power plant, vehicles and other fuel powered equipment in accordance with manufacture's specifications to minimize on emissions	Mine Manager
9.3	Some mine activities cause release of radioactivity	Radiological emissions	Minimize dust generation (which can be radioactivity bearing) by implement GML's Dust Control Plan	Project Manager
9.5.1	People and machines work at mine area	Visual (and noise) disturbance of terrestrial animals	Restrict the movement of staff members outside the Project area during spring and summer to minimize the general disturbance of wildlife	Project Manager
9.5.2	Discharge of water from mine operations to the fjord	Pollution of marine environment	Optimization of diffusor outlet (possible engineering challenge as it shall be implemented 80 m below sea level)	Project Manager

Ref. no.	Project activity	Environmental Impact	Action	Responsibility
9.5.3	Mine activities change hydrology	Impact on fish population in Narsaq River	No mitigation needed	Project Manager
9.5.4	Accidents can lead to spill of oil and chemicals	Pollution of terrestrial, freshwater and marine habitats	Prepare contingency plans for oil and chemical spills including efficient combat readiness training	Project Manager
9.5.5	Traffic along haul- and service roads	Increased mortality among terrestrial animals	Ensure speed limits are enforced and that all staff are aware of animal hazards	Project Manager
9.5.6	Shipping in the fjord	Introduction of invasive alien species with ballast water	Follow regulations of the International Convention for the Control and Management of Ships' ballast water and Sediments	Project manager
9.6	Many project activities generates waste	Contamination of environment	Strict enforcement of waste handling procedures; and Continue updating waste management manual.	Project manager
9.7	Access to mine area not possible and no hunting security zone introduced	Restrict local peoples (and visitors) traditional use of area	Minimize no go and no hunting zones as much as possible	Project manager

EMP covering the Closure and Post Closure Phases

Ref. no.	Project activity	Environmental Impact	Action	Responsibility
10.1.	Discharge of water from mine operations to the fjord	Pollution of marine environment	None, except continuous monitoring of effluent	Project Manager

Appendix B - Conceptual Closure and Decommissioning Plan for the Project

15.1 Introduction

The closure and the post-closure phases are integral parts of a mining project and the environmental management of a mining project. This part of the EIA summarizes the legal framework for project closure and describes broadly how each individual component of the Project will be decommissioned. Since this conceptual plan has been prepared before Mine operations have started the plan will be expanded and refined during the Project's operations phase.

15.2 Closure obligations

The Mineral Resources Act of 2009 (amended in 2012 and 2014) specifies that a closure plan (the Plan) shall be prepared and approved before exploitation begins (Part 10, section 43).

In the Act it is stipulated that: "*the licensee must submit a plan for steps to be taken on cessation of activities in respect of facilities, etc. established by the licensee, and how the affected areas will be left (Plan). If the licensee plans to leave facilities, etc. in the area that for environmental, health or safety reasons will require maintenance or other measures after the closure, the Plan must include plans for the maintenance or the measures and monitoring thereof*".

15.3 The Kvanefjeld Project Closure and Reclamation Plan

The Plan is based on the current open pit mine configuration and production rates and assumes that mining operations will cease after 37 years, at which stage mine closure activities will commence. However, temporary suspension and possibly premature closure may be required if the operations become unviable due to a change in Project economics or other difficulties.

Since the Plan will be prepared before the mine is constructed it contains broadly identified tasks of closure activities which will be refined and expanded before the closure date for mining and processing operations.

The Plan covers the closure phase, which is estimated to take approximately six years. During this phase the decommissioning of equipment, buildings and other structures will take place. Throughout the closure phase the TWP will continue to operate to treat water from the TSF prior to discharge into the fjord.

Post-closure follows decommissioning and rehabilitation and is a monitoring phase. During post-closure, no active care will be required except minor maintenance of gravel roads and TSF spillways. Access to the Mine and TSF will be maintained to ensure access for inspections and monitoring activities.

Post-closure is managed through a monitoring plan and with liaison with the authorities. Towards the end of the life of the Project, the post closure objectives will be refined to accommodate the site conditions prevailing at the time.

15.4 Purpose and Scope of the Closure and Reclamation Plan

The overall closure and reclamation goal is to return the mine site and affected areas to viable and, wherever practicable, self-sustained ecosystems that are compatible with a healthy environment and with human activities.

In order to achieve this, the following core closure principles will be followed:

Physical Stability

All project components that remain after closure will be physically stable to humans and wildlife;

Chemical Stability

Any project components (including associated wastes) that remain after closure will be chemically stable and non-polluting or contaminating meaning that any deposits remaining on the surface or in lakes will not release substances at a concentration that would significantly harm the environment;

Minimized radiological impact

It will be ensured that the long-term radiation exposure of the public due to any radiological contamination of mine area is kept "as low as reasonably achievable" (ALARA)*;* and

No Significant Change to Baseline Landforms

Baseline landforms and land use prior to the mining operations will returned to similar visual amenity and geography.

15.5 Closure implementation

The closure works e.g. how each individual project component will be decommissioned is broadly described below. As mentioned above, the Plan is at this early stage conceptual and it will be expanded and refined during the Project's operations phase.

Open pit mine workings

The open pit will be fenced off to restrict access for humans, livestock and wildlife (for safety reasons). The pit will be allowed to fill naturally from precipitation. When the pit is full, water will flow through water courses into a lake to the south west of the Mine. Here the water will be diluted in the natural catchment before flowing naturally into Nordre Sermilik.

Waste rock stockpile

During the operations phase, the WSR will be constructed and managed in such a way that it will remain physically and geo-technically stable in the long-term. Any risk from erosion, thaw settlement, slope failure or collapse after mine closure is expected to be negligible.

The geochemical test work that has already been undertaken shows that following the six-year closure phase, no significant acid rock drainage or metal leaching will occur from the WRS or surface runoff. The water quality of seepage from the pile will be similar to baseline conditions for the Mine area river flows. WRS run-off will be diverted into natural water courses which flow into the lake to the south west of the Mine. Here the waste rock run-off will be significantly diluted with precipitation catchment before naturally flowing into Nordre Sermilik.

Water management systems

This incorporates embankments and diversion channels at the TSF, embankment and diversion channel on Kvanefjeld, the TWP pipelines and the raw water dam at the Refinery.

The TSF embankments and diversion channels are retained. After six years, water treatment of water covering the TSF ceases, the return water pipelines are removed and the TSF are left to fill naturally with water from groundwater inflows and precipitation. Water will initially overflow from the CRSF into the FTSF and, when the FTSF fills, will eventually overflow into the Taseq River. Water discharge into Nordre Sermilik, from the water treatment plant, will cease at this point.

The embankment of the raw water dam is left as a bridge across Narsaq River, to permit future inspections and monitoring activities at Taseq. The natural flow of the river is re-established.

Tailings Closure

The TSF will be closed as wet lakes contained within the Taseq basin by the embankment walls and natural rock features. This will be a permanent structure designed to the highest standards using BAT.

A layer of water will be retained on top of the tailings to avoid dust generation and eliminate radiation exposure. The water layer will be deep enough to prevent tailings solids from being exposed under all circumstances.

The tailings solids will remain as a compacted layer of fine solids at the bottom of the tailings lake. These solids will act as a liner obviating seepage issues.

Buildings and equipment

Including the crusher facility, concentrator plant, refinery, acid plant, power plant, fuel tanks, maintenance shops, offices, ware houses, accommodation village, reagent and explosive storage, mobile equipment and tailings and return water pipelines.

Except for the Village at Narsaq, all buildings and major structures will be dismantled and removed. Where possible foundations will be removed otherwise covered by natural materials to blend into the natural surroundings.

On the assumption that the local authorities require it, the Village will be left as constructed.

For aesthetic reasons, and because a cover of vegetation will help control erosion and dust dispersal together with providing food and shelter for wildlife, an active re-vegetation program will be considered once the buildings and mine facilities are removed. However, this will not be focused on the rapid establishment of a green cover on disturbed areas, for example by seeding grasses. These measures sometimes meet the short-term expectations for aesthetic improvement and sometimes erosion and dust control, but do not address the longer-sighted requirements for habitat restoration. Instead, the species selected for re-vegetation will reflect the site's ecological variables, as well as the nature of the mining-related disturbances and will follow the principle; "the best species for planting on a mine site are the ones that can be found growing nearby" /Withers 1999/.

Mine infrastructure

Including on-site roads, electrical power supply system (including power lines to the port), bridges, culverts and the Port.

The haul roads will be reclaimed as soon as the mining operations no longer require them. The roads will be ripped to encourage re-vegetation (see above).

The power line connecting the on-site plant with the port area will removed and any culverts that could potentially act as hydraulic conduits at closure will be removed.

The Port-Mine road (including the bridges across Narsaq River) as well as the track between the Mine and Taseq will be left intact to facilitate future inspections and monitoring activities.

The Port will be left as constructed (if agreed with the Greenland authorities) and will be offered for use for the local community and industry.

Possible contaminated materials/areas at the mine site

Given the comprehensive monitoring that will be take place throughout operations Project's phase it is unlikely that a significant contamination of soil, rock or groundwater in and around the mine area will remain undetected until the remediation phase during mine closure.

Furthermore, because of the uranium production, procedures will be introduced for controlling any contamination of equipment, buildings and the surroundings. In addition all plant and equipment will be contained within a bunded building area minimizing the risk of soil contamination outside the facilities. It is therefore very unlikely that there will be a need to remove or isolate contaminated soil, rock, equipment or building materials at the end of operations. However, if such a need should arise, at any time, the contaminated material will be isolated in the tailings facility.

15.6 Identification and management of closure issues

To insure that the closure and post-closure phases of the Project will meet the principles listed in section 2.6 each project domain has been analysed carefully to identify if there are issues for specific attention. This assessment identified the following:

Potential acid rock drainage and metal leaching from waste rock pile

Acid rock drainage and metal leaching from the weathering of undisturbed waste rock is a potential issue in connection with mine closure. Although the low temperatures in Greenland will slow the chemical weathering processes during a large part of the year, there is potentially a seasonal flush of accumulated contaminants during spring melt.

Static and kinetic acid rock drainage and metal leaching prediction tests have shown little metal release and no acid release. However, during the first years of the closure phase some leaching of fluoride is expected. Field tests and monitoring on site will further characterize the mine waste water including the concentration of fluoride. To prevent Narsaq river exposure to seepages (mainly fluoride) from the waste rock water, ditches and berms will be constructed to divert the waste rock water away from the Narsaq River.

Potential radiological contamination of mine area

It is an objective of the Plan to ensure that there is no unacceptable radiological health risk to people, livestock and wildlife after Project closure. This will be achieved by managing radiation in compliance with the "as low as reasonably achievable" or ALARA principle and the "Best practicable technology" principle.

The mine components potentially associated with elevated radiation following mine closure are identified as the Mine area and the TSF.

From the Mine area, there may still be releases of radon and dust (from any waste barren rock piles deposits that are uncovered). These releases are expected to be very small and will not result in any measurable change in the receiving environment.

The tailings deposited in the TSF will contain uranium and thorium and their decay products. The tailings will emit radiation. To ensure that none of this radiation will be of any health risk to humans, livestock or wildlife the tailings will remain deposited under permanent water cover. This will ensure no radiation release.

In the post-closure phase of the Project there will be some small amount of radioactivity released to the freshwater environment, however concentrations will be low and exposure will be low, close to background levels. Overall, it is not expected that there will be any radiation issues associated with tailings.

Iteration of the hydrology and flow of surface water (Narsaq River)

All modifications to the hydrology of the Narsaq river and its tributaries, which are required during mining, will be reversed at the end of the mine closure phase. This will include the controls imposed in the upper reaches of Narsaq River to supply water to the raw water dam and the moderating of outflow from the Taseq basin during the Project’s operations and closure phases.

The water that overflows the pit 50 years after mine closure will be lead to Nordre Sermilik.

15.7 References

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Appendix C – Conceptual Environmental Monitoring Program for the Project

16.1 Introduction

GML will develop and implement an Environmental Monitoring Program (EMP) in accordance with Greenlandic guidelines to monitor the predicted residual environmental effects of the Project and the effectiveness of implemented mitigation measures. The EMP will encompass all phases of the Project (construction, operation, closure and post-closure) and will identify any variances from predictions that occur and whether such variances require action, including any additional mitigation measures.

16.2 Content of GML's Environmental Monitoring Program

The Project's EMP will be a best practice, multiple lines of evidence approach comprising grab sampling of water, air, soil, lichens, plants, mussels, fish and seals from numerous locations in and around the Mine and tested to confirm that environmental protection systems are effective. The monitoring results will be submitted to regulatory authorities for review.

The EMP for the Kvanefjeld Project will cover:

1. Air quality (including Greenhouse gases) and dust
2. Sea and freshwater
3. Soil and terrestrial biota
4. Tailings Facility
5. Meteorological; and
6. Narsaq Drinking Water.

Each of the program elements will include:

- Description of design and objectives
- Specific monitoring stations
- Schedules for monitoring activities
- Sampling procedures, sample preservation requirements, and analytical methods, as applicable
- Procedures for comparison of monitoring results against baseline data, environmental standards and environmental quality objectives
- Actions to be implemented when requirements set out in regulations or permits have not been met
- Procedures for reporting results to Greenlandic authorities
- Roles and responsibilities of key staff, for internal and external reporting of monitoring activities and results, as well as management of the EMP
- Quality assurance and quality control processes; and
- Procedures for reviewing and updating the monitoring program.

As uranium is a by-product of the Project the MSP will include radiological as well as non-radiological parameters[1]. For this conceptual MSP, Arcadis has prepared a specific Radiation Monitoring Plan Outline /Arcadis 2015/, which proposes the environmental media to be measured or sampled. The

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[1] The monitoring should include Actinium (227Ac)

Arcadis outline follows the principles defined by the Canadian Standards Association (CSA) /2010/ that the media to be monitored will:

- Provide information to assess the dose
- Be close to the receptor
- Consider the expected fate in the environment, and
- Recognize the variability of the media.

The EMP will be developed and updated throughout the mine life.

16.2.1 Conceptual Monitoring Program

Prior to Project operations, a more detailed study design will be developed for each of the EMP's elements. This will be undertaken in co-operation with Greenlandic authorities. Set out below are descriptions of the proposed approach for each element of the EMP. In addition to the studies outlined below, supplementary studies may be conducted for specific, well-defined objectives and are not expected to continue throughout the program (e.g. indoor radon monitoring).

1. Air Quality and Dust Monitoring

Air quality and dust monitoring will continue at established stations in the town of Narsaq and in the Narsaq valley using high-volume samplers and dust fall jars and/or stack sampling. Mill stacks will have scrubbers to remove particulate matter and contaminants from the air stream before discharge. The results will be compared to baseline values as well as applicable guidelines to determine if there has been a change as a result of mine activities. The parameters to be monitored will be agreed with the Greenlandic authorities but are expected to include:

- Dust deposition

  The monthly collection of samples at the baseline stations and along a gradient relatively close to the source. Depending on the deposition results, selected dust fall jars may be provided for analysis of radiological parameters;
- Concentration levels of Particulate Matter (PM_{10} and $PM_{2.5}$)
- Radionuclide content of dust

  Collection of samples from an area close to the operations as well as other locations such as Narsaq town site and a reference location. Quarterly composite samples will be sent for analysis of radionuclides. If sufficient mass for obtaining low detection limits is not available then chemical analysis will be conducted and secular equilibrium will be assumed.
- Radon, thoron and relevant decay product

  Monitoring (integrated semi-annual sampling) at locations near the mine area boundary and at other specific locations such as the Narsaq town site, within the Narsaq Valley, Ipiutaq and a reference location.
- Gamma detectors will be deployed at the same locations as the radon and thoron monitors.
- Nitrogen oxides (NOx) from a selection of stations.
- Greenhouse gasses

  Estimating emissions from a variety of activities such as burning fossil fuels and energy production.

The sampling periods, the trace elements, major ions and radioisotopes to be analyzed and reporting requirements are to be agreed with the Greenlandic authorities.

2. Sea and Freshwater Monitoring

Water quality

Baseline water quality has been characterized from a large number of stations in the fjords at Narsaq and in watercourses, lakes and ponds on the Kvanefjeld plateau, Narsaq Valley, at Taseq lake and a reference area. Sediment samples have also been collected and analyzed from the rivers and lakes in and around Narsaq Valley.

Monitoring of water quality and sediment will continue at the same sites during all phases of the mine project. The sampling frequency, reporting requirements, parameters to be monitored will be defined both for field monitoring activities and laboratory activities in cooperation with the Greenlandic authorities.

It is expected that the water and sediment sampling will include radiological as well as non-radiological parameters. Also the radionuclide content of supernatant of tailings pond water will be monitored to confirm modelled predictions.

When Project operations commence effluent monitoring (chemistry) will be carried out at the discharge point into Nordre Sermilik. Monitoring of the mine water runoff from the WRS and pit that discharges to Nordre Sermilik will be performed.

Results of the monitoring will be compared to baseline values as well as applicable guidelines to determine if there has been a change in water quality as a result of Project. Detailed quality assurance procedures will be provided, and will include calibration and validation of field measurement equipment as well as sampling measures. Data will be reviewed to update loading assumptions in the site water balance and verify water quality models.

Marine and freshwater biota

The marine and freshwater biota component of the EMP will provide detailed information regarding metal and radioisotope concentrations in selected key plant and animal species.

Since 2007 samples of indicator plant and animal species have been collected from a large number of stations to determine the background level of metals. Stations were located in the vicinity of the fjords that surround Narsaq, the Narsaq river and references areas. The target species were ringed seal, short-spined sea scorpion, Arctic char, blue mussels and bladder wrack seaweed.

It is proposed to continue monitoring of fish and seal samples on an annual basis and analyze for radionuclides. In addition, select or composite samples of blue mussels and seaweed will be provided for analysis on a periodic basis.

Monitoring of these species will continue at the same sites during all phases of the Project and the metal loads compared to baseline values to determine if there has been a change as a result of Project activities.

Hydrology

Surface water flow monitoring will be maintained at established stations in the Study Area (Narsaq, Taseq and Kvane rivers) to:

- Monitor seasonal and annual flow patterns
- Support water management measures
- Refine the water balance, and
- Inform water quality modeling.

Water levels will be recorded continuously with a pressure transducer at automated stations, with calibration discharge measurements conducted at a range of flows during scheduled site visits.

3. Soil and Terrestrial Biota Monitoring

To establish background concentrations of metals and radioisotopes in terrestrial habitats, samples of soil, lichens, grass and leaves of bushes have been collected since 2007 from stations at Kvanefjeld, Narsaq Valley and in a reference area.

Monitoring will continue at the locations identified in the baseline study and include soil, snow lichen, grass and leaves of dwarf shrubs including Northern Willow (e.g. once every 3 years). This frequency is consistent with the approach adopted at uranium mining operations in Canada for these types of media where any changes would be expected to be gradual.

The results will compared to baseline values to determine if there has been change as a result of Project activities.

4. Tailings Facility Monitoring

The objective of the TSF monitoring is to provide on-going characterization of water quality in the TSF during the Project's operations, closure and post-closure phases in order to confirm the predicted concentrations of metals in the TSF.

TSF monitoring will include radiological as well as non-radiological parameters.

The monitoring will also cover the embankments including seepage.

5. Meteorological Monitoring

Collection of meteorological data will continue at an established weather station on Kvanefjeld plateau. Ongoing meteorological data collection is required to verify design assumptions for water management systems and dust dispersal modelling.

Reporting of meteorological monitoring will include a summary of the measured parameters, including temperature, precipitation and wind.

The collected data will be compared with the predictions for extreme events or for performance predictions; results will be used to revise operations procedures as necessary. The results will also be used in the air quality monitoring.

6. Narsaq Drinking Water

Drinking water quality in Narsaq is already monitored by the Greenland authorities. It is recommended that this be extended to include relevant radiological parameters, total organic carbon, phosphorus and a number of bacteria.

16.3 References

Arcadis. 2015. Radiation Monitoring Plan Outline, Kvanefjeld Multi-Element Project, Narsaq Area, Greenland. 7 pp

Canadian Standards Association (CSA). 2010. *Environmental monitoring programs at Class I nuclear facilities and uranium mines and mills.* N288.4-10.

The tables below show a framework for the monitoring parameters and sampling locations proposed. The suggested sampling frequency for each parameter will ensure validity of actual environmental conditions at the Project site and surroundings. Defined monitoring durations identify which phases of the mining project will generate the potential impact that requires sampling and monitoring. Where relevant the programme includes control sites where no expected Project impacts are likely to be experienced.

Monitoring aspect	Sites/activities to be monitored	Parameter to be monitored	Frequency	Duration	Assessment criteria[2]	Reporting
Dust deposition	High-Volume dust sampler stations and along a gradient relatively close to the source	Dust fall	Continual	Construction, operations and closure phases	To be defined in cooperation with GoG	Annual Monitoring Report
Concentration level of Particulate Matter	High-Volume dust sampler station locations	Concentration of TSP	Continual	Construction, operations and closure phases	To be defined in cooperation with GoG	Annual Monitoring Report
Radionuclide content of dust	High-Volume dust sampler station locations	Selection of relevant radionuclides	Continual	Construction, operations and closure phases	To be defined in cooperation with GoG	Annual Monitoring Report
Radon, thoron and relevant decay products	Location near the mine area boundary and in Narsaq town, within the Narsaq Valley, Ipiutaq and a reference location	Radon, thorium and decay gases	Semi-annual	Construction, operations and closure phases	To be defined in cooperation with GoG	Annual Monitoring Report

Monitoring aspect	Sites/activities to be monitored	Parameter to be monitored	Frequency	Duration	Assessment criteria[3]	Reporting
Gamma radiation	Location near the mine area boundary and in Narsaq town, within the Narsaq Valley, Ipiutaq and a reference location	Gamma	Semi-annual	Construction, operations and closure phases	To be defined in cooperation with GoG	Annual Monitoring Report

[2] The assessment criteria will be based on the water and air quality criteria for Greenland (and Canadian if no Greenland values are available)

[3] The assessment criteria will be based on the water and air quality criterias for Greenland (and Canadian if no Greenland values are available)

Monitoring aspect	Sites/activities to be monitored	Parameter to be monitored	Frequency	Duration	Assessment criteria[3]	Reporting
Nitrogen oxides	High-Volume dust sampler stations	NOx concentration	Semi-annual	Construction, operations and closure phases	To be defined in cooperation with GoG	Annual Monitoring Report
Metal incl. radionuclide concentrations in rivers	Narsaq, Taseq and Kvane Rivers (at baseline stations)	Metals incl. radionuclides in water	Monthly Semi-annual in post closure	Construction, operations, closure and post closure phases	To be defined in cooperation with GoG	Annual Monitoring Report
Metal incl. radionuclide concentrations in rivers	Narsaq, Taseq and Kvane Rivers (at baseline stations)	Metals incl. radionuclides in sediment	Annually (August)	Construction, operations, closure and post closure phases	To be defined in cooperation with GoG	Annual Monitoring Report

Monitoring aspect	Sites/activities to be monitored	Parameter to be monitored	Frequency	Duration	Assessment criteria[4]	Reporting
Supernatant of tailings ponds	Water of FTSF & CRSF	Relevant elements, reagents and radionuclide concentrations	Continual during operations and closure phases Semi-annual in post closure phase	Operations, closure phases and post-closure	To be defined in cooperation with GoG	Weekly in operations and closure phases. Annual Monitoring Report in post-closure phase
Treatment Water Placement	TWP	Relevant elements and radionuclide concentrations	Continual	Operations and closure phases	To be defined in cooperation with GoG	Weekly and annual Monitoring Report

[4] The assessment criteria will be based on the water and air quality criteria for Greenland (and Canadian if no Greenland values are available)

Monitoring aspect	Sites/activities to be monitored	Parameter to be monitored	Frequency	Duration	Assessment criteria[4]	Reporting
Water stream to Nordre Sermilik from waste rock deposit and pit	Outflow to fjord	Relevant elements including radionuclides in water and sediment	Continuous (sample and analyses)in operations and closure phases Annual in post closure phase	Operations, closure and post-closure phases	To be defined in cooperation with GoG	Annual Monitoring Report

Monitoring aspect	Sites/activities to be monitored	Parameter to be monitored	Frequency	Duration	Assessment criteria[5]	Reporting
Metal incl. radionuclide content in marine fish and mammals	Baseline stations in fjords and reference stations	Metals incl. radionuclides in Ringed seal, Short-spined sea scorpion and Arctic char	Annually (August)	Construction, operations, closure and post-closure phases	To be defined in cooperation with GoG	Annual Monitoring Report
Metal incl. radionuclide content in mussels	Baseline stations in fjords and reference stations	Metals incl. radionuclides in Blue mussels	Annually (August)	Construction, operations, closure and post-closure phases	To be defined in cooperation with GoG	Annual Monitoring Report
Metal incl. radionuclide content in seaweed	Baseline stations in fjords and reference stations	Metals incl. radionuclides in Bladder wrack seaweed	Annually (August)	Construction, operations, closure and post-closure phases	To be defined in cooperation with GoG	Annual Monitoring Report
Surface water flow	Narsaq, Taseq and Kvane Rivers	Seasonal and annual flow patterns	Continuously at automated stations Annual calibration discharge measurements	Construction, operations and closure phases	To be defined in cooperation with GoG	Annual Monitoring Report

[5] The assessment criteria will be based on the water and air quality criteria for Greenland (and Canadian if no Greenland values are available)

Monitoring aspect	Sites/activities to be monitored	Parameter to be monitored	Frequency	Duration	Assessment criteria[6]	Reporting
Metal incl. radionuclide contents in higher plants	Baseline stations and reference stations	Metal incl. radionuclide content in snow lichen, grass and leaves of Northern Willow	Annually (August) or once every 3 years	Construction, operations and closure phases	To be defined in cooperation with GoG	Annual Monitoring Report
Metal incl. radionuclide contents in soil	Baseline stations in and around mine area and reference stations	Metals in soil	Annually (August) or once every 3 years	Construction, operations and closure phases	To be defined in cooperation with GoG	Annual Monitoring Report
Local climate	Weather station at Kvanefjeld	Temperature, precipitation and wind speed and direction	Continual	Life of mine	-	Annual Monitoring Report
Higher fauna	Mine area and near surroundings	Ad hoc observations of birds and mammals in connection with other monitoring activities	Annually (August)	Life of mine	To be defined in cooperation with GoG	Annual Monitoring Report

[6] The assessment criteria will be based on the water and air quality criteria for Greenland (and Canadian if no Greenland values are available)

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