

TECHNICAL MEMORANDUM

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Reference No. 21467213.C04.1.B.0

TO Joan Plant
Nalunaq A/S

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TAILINGS STORAGE FACILITY OPTIONS ANALYSIS

1.0 INTRODUCTION

Nalunaq A/S has engaged Golder a member of WSP (WSP UK Ltd) to provide support following comments and recommendations provided by DCE/GINR in relation to the Environmental Impact Assessment dated 1 October 2021 ('EIA draft 2') for the Nalunaq mine in southern Greenland prepared by WSP A/S, and the supporting technical background reports, prepared by Golder Associates (UK) Ltd, for the Nalunaq Gold Project. In relation to this, Golder submitted a proposal (reference CX21467213_Change Order 4, dated January 2022) which details a requirement for the assessment of tailings storage alternatives with reference to the stated minimum design criteria and with particular attention to the post closure phase.

The scope of work for this phase is to review and report an assessment of various potential dry stack tailings storage facility (DTSF) areas for Nalunaq mine. The options analysis detailed herein is submitted to satisfy DCE/GINR requirements for R2.1 and R2.2 as set out in Bach et al (2021).

2.0 METHODOLOGY

The advantages and disadvantages of the different options for the siting of the Nalunaq mine DTSF areas have been assessed using a scoring system to evaluate and determine the preferred option. This qualitative risk screening process was based upon the evaluation of essential and non-essential criteria for each site.

Essential criteria identified in the initial screening phase of the site evaluation were:

- Adequate footprint size – preferably with potential for expansion
- Availability – the site should be available and free from contamination or legal disputes
- Accessibility – the site should be accessible, and access should not ideally require the construction of new roads and associated infrastructure
- Should not jeopardize future mining of potential ore

Other essential criteria such as affordability, political stability and proximity to markets are considered to be equivalent for all sites.

The identification of other desirable (but not essential) criteria is based upon the following areas (Golder, 2002);

- General: tailings and mine rock chemical and physical characteristics; volume; acid producing potential; effluent characteristics; climate; public perception; seismic risk evaluation
- Specific Site Characteristics: accessibility (road construction); distance from the process plant (tailings transport and spill risk); relative elevation from the process plant (gravity discharge vs pumping, avoidance of frequent low points); distance from habitation and areas of human activity; topography (natural containment); existing use of area; property ownership and mineral rights; native land claims; physical constraints; area of watershed and surface area affected; volumetric capacity (function of topography); dam volume storage capacity ratio; geology; construction material availability; potential ore zones; dam foundation conditions; watershed considerations (size and diversions); downstream hazards; hydrology (runoff); hydrogeology (groundwater, contaminant seepage); freshwater diversions
- Environmental Considerations: effluent treatment requirements; surface water contamination (isolate from surrounding watershed); groundwater contamination (hydrogeological containment); historical use of receiving watershed; background environmental conditions; impact on vegetation, wildlife and aquatic life; archaeological considerations; potential dust problems; aesthetic considerations
- Decommissioning / Reclamation Program: flooding or revegetation potential; ease of establishing permanent drainage; methods to control acid drainage; long term treatment requirements
- Development, Operating and Decommissioning Costs (**not included in this assessment**): capital costs; cost of tailings transport; operating and maintenance costs; decommissioning costs; cost per ton of ore

Desirable criteria identified from the above areas is as follows:

- Geology and Hydrogeology: it is preferable that foundations are stable and relatively watertight, and that groundwater level is sufficiently high to inhibit acid generation. Faults and structured rock should be avoided, but if present, should be identified.
- Distance and difference in elevation from the process plant: distance should be as short as possible.
- Topographic relief: Relief should be sufficient for containment, to minimize DTSF construction footprint and ensure a safe site
- Storage capacity / facility volume ratio: A DTSF should be as small as possible, to minimize environmental Impact, reduce requirement for materials and provide optimum safety
- Watershed considerations: If the watershed is small or the site is high up on a watershed, runoff, diversion and spillway costs will be minimized.
- Construction materials: Ideally construction materials should be close to site, to minimize haulage costs and adverse environmental impacts
- Closure: Important considerations are ease of decommissioning, long term liability, monitoring and minimization of environmental impact.
- Cost: Costs include capital, operating and decommissioning costs and are generally compared as costs per ton of ore milled

The above criteria is scored as follows:

Score	Performance Description	Comment
1	Very Poor	Presents very poor performance against the criteria or is very unlikely to be beneficial to the project
2	Poor	Presents poor performance against the criteria or is unlikely to be beneficial to the project
3	Average / Neutral	Presents average performance against the criteria or is likely to be neutral in respect to project benefits
4	Good	Presents good performance against the criteria or is likely to be beneficial to the project
5	Very Good	Presents very good performance against the criteria or is very likely to be beneficial to the project
-100	Fatal Flaw	The option presents a fatal flaw against this criterion and should not be considered further

Furthermore, a weighting between 1-5 is applied to ensure that higher weight is given to the more important criteria as these apply to environment.

Score	Performance Description	Comment
1	Of low importance	Presents very low importance performance against the criteria or is very unlikely to be beneficial to the project
2	Low	This criterion is of low importance as applicable to environmental issues for the project
3	Average / Neutral	This criterion is of average importance or is likely to be neutral in respect to project benefits
4	High	This criterion is of high importance
5	Very High	This criterion is of very high importance

3.0 DESCRIPTION OF SITES

Seven potential areas (numbered 1 to 7) have been identified and are shown on in Figure 1. Descriptions of Areas 1 to 7 are outlined below. Site 1 (Figure 1) was found to have a fatal flaw due to its presence on an archaeological site (Golder Associates, 2002) and has not been considered further.

3.1 Area 1

Area 1 is located on a broad flat alluvial outwash fan area near the beach landing area. The identified site occupies an archaeological site which is considered a fatal flaw and the site is therefore not considered further.

3.2 Area 2

Area 2 is in the upper part of the Kirkespirdalen, to the north-east of the Repeater Station. This area is situated adjacent to Area 3 but lies within the middle of the valley floor within an area of braided streams. The area is underlain by alluvial deposits of sand and gravel (Golder, 2021).

3.3 Area 3

Area 3 (Figure 2) is situated in the upper part of the Kirkespirdalen, to the north-east of the Repeater Station. The site is accessed via existing gravel roads and lies against the talus slope on the west side of the valley.

Subsurface conditions were investigated by the installation of 5 boreholes and 6 trial pits. The valley floor is underlain by alluvial deposits comprising cobbles and boulders with sand and gravel (alluvium) overlying glacial till and bedrock (Golder, 2021).

3.4 Area 4

Area 4 is located on the southeast side of the valley approximately 1. km – 2 km downstream of the proposed process plant location. The topography of the site is undulating and encompasses several piles of talus near the middle of the valley. The hillsides are steep with exposed rock and there are talus slopes on the southeast side. The ground surface consists of large boulders up to several metres in size, partially covered with grass, shrubs and moss. Above the site several very large, steep talus slopes are present. Weathered bedrock is exposed at higher elevations. Small ravines are present across the site, feeding drainage into the creek.

Subsurface conditions encountered in Borehole 01-06, advanced to 27.4 m below ground level (mbgl), indicated that subsurface conditions consisted of a layer of talus, overlying a cohesionless fluvial deposit and a sand and gravel glacial till deposit (Golder, 2021). Within the cased borehole, the water level was recorded at 0.35 mbgl, 30 minutes after the completion of drilling.

3.5 Area 5

Area 5 is located between a stream and the mountain on the northeast side of the valley. The topography of the site is relatively flat where it is in the middle of the valley and becomes undulating where it is adjacent to the hillside. The existing road passes through the site. The hillside becomes steep to very steep on the northwest side of the site and is covered with talus. Large ravines drop towards the site on the northwest side. The site is partially covered with grass, shrubs and moss within the valley, becoming sparse approaching the hillside and at higher elevations.

Subsurface conditions were investigated by the installation of 3 boreholes; subsoils were found to consist of talus or a cohesionless fluvial deposit overlying silty sand (Golder, 2021). The water level in a monitoring well was measured at 0.9 mbgl in September 2001.

3.6 Area 6

Area 6 is located at a within the valley of the Arpatsivîp stream. A site investigation has not been carried out, however it is considered likely that the Quaternary cover is likely to consist predominantly of talus. The area is greenfield and has not been subject to disturbance by historic mining operations.

3.7 Area 7

Area 7 is situated 2.3 km to the northeast of the fjord on the southeast side of Kirkespirdalen Creek. It is approximately 5 km southwest of the proposed processing plant area and within a kilometer of the existing road bridge. Topography consists of a low-lying flood plain, formed by seasonal flooding of the Kirkespir river. The site varies from relatively flat to gently undulating and with slopes increasing towards the hillside on the

southeastern side. A ravine is located immediately to the southwest of the site, and this connects to the creek further to the west. An archaeological site is approximately 2km further downstream of the site.

Soils at the site consist of a thin cover of topsoil overlying sand and gravel, with boulders, cobbles gravel and sand over silty sand (Golder, 2021). Water level within the drilled holes was approximately at the level of the water in the Creek.

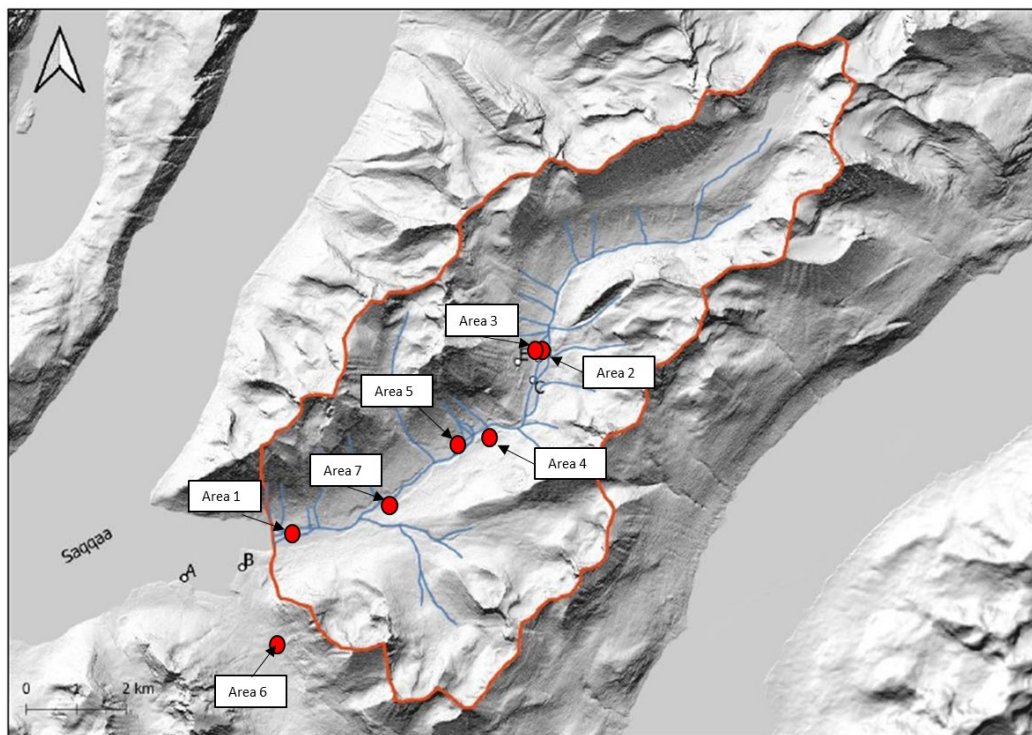


Figure 1: Approximate locations of potential DTSF sites

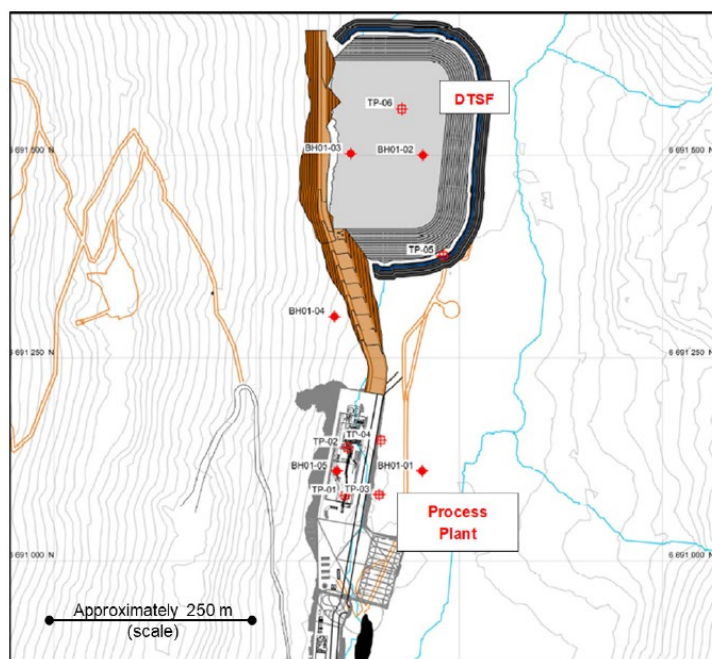


Figure 2: Area 3 Proposed DTSF and Process Plant Layout and investigation locations

4.0 ASSESSMENT

A comparison of the sites is presented in Table 1, with scoring in Table 2. On the basis of the scored assessment, Area 3 is the preferred location for the DTSF. Area 2 offers an alternative option, but this scored less favourably due to the location within the braided channel of the Kirkespir river with no buttressing from the hillside.

Table 1: Comparative assessment of DTSF sites 1 to 7

Site Criteria	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7
Site Characteristics: accessibility (road construction); distance from the process plant (tailings transport and spill risk); relative elevation from the process plant (gravity discharge vs pumping, avoidance of frequent low points); distance from habitation and areas of human activity; topography (natural containment); existing use of area; property ownership and mineral rights; land claims; physical constraints; area of watershed and surface area affected; volumetric capacity (function of topography); dam volume storage capacity ratio; geology; construction material availability; potential ore zones; dam foundation conditions; watershed considerations (size and diversions); downstream hazards; hydrology (runoff); hydrogeology (groundwater, contaminant seepage); freshwater diversions							
Access	Site is on flat area at beach and mouth of Saqqaa Fjord. Short access road required.	Due to location in the middle of a floodplain, this would require an access road raised above the floodplain.	Access to the DTSF is provided by existing gravel roads	Construction of facility would involve building access road crossing the creek. Creek is ride and with rapid current and therefore maintenance costs and costs of construction is likely to be significant.	This area contains the existing access road; construction of the tailings facility in this area would necessitate the construction of a new access road and possibly two bridges, at considerable cost.	Site is located within an adjoining valley south of Kirkespirdalen, necessitating crossing of the Kirkespir river. An additional haul road would need to be constructed,.	Access to site may be facilitated by constructing a short haul road from the existing access road south of the existing bridge

Site Criteria	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7
Topography	Generally flat	Site location in flat centre of flood plain and would need a larger foundation pad than for Area 3 and would present a larger impediment to river flow.	Located abutting valley slope. The talus slope which abuts the DTSF is generally stable.	High talus slopes at the site are likely to be unstable; high costs associated with removal of large boulders;	Unstable talus located on steep slopes above the area; large wash-out zones present indicate seasonally high flows, sufficient to transport overburden	Narrow valley with steep talus slopes present above site	Clear of steep talus slopes
Existing use	Site is an archaeological site	River floodplain; within mining license area	River floodplain; within mining license area	Within mining license area	Within mining license area	Within mountain valley, external to mining license area	Site is external to mining license area
Tailings transport (assuming tailings transport by truck)	Approximately 7km downstream of the processing plant	The site is located approximately 250m to the northeast of the processing plant and therefore has a short hauling distance.	The site is located approximately 250m north of the processing plant and therefore has a short hauling distance.	Located downstream of "the waterfall". Tailings must be hauled just over 4km distance from the processing plant.	Located downstream of "the waterfall". Tailings must be hauled approximately 4.5km from the processing plant.	Tailings would need to be transported ~8km to 10km down the valley across the Kirkespir river and up the Arpatsivip valley	Located downstream of "the waterfall". Tailings must be hauled almost 6 km from the processing plant.
Subsurface construction conditions	N/A	No direct information for site, but close proximity to site 3 suggests that foundation ground materials are likely to have favourable	Foundation ground materials appear to have favourable properties for construction.	Talus and constrained footprint likely require large quantities of fill that must be sourced from elsewhere.	The provision of large diversion channels and high freeboard is indicated to be necessary to control high	No investigation carried out, but foundation materials are likely to consist of talus and rock fragments.	Subsoils likely less pervious than Areas 4 or 5 ground conditions variable.

Site Criteria	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7
		properties for construction.			surface water flow, as is evidenced by presence of washouts. construction of DTSF would likely require large quantities of fill that must be sourced from elsewhere.	Narrow valley likely requiring considerable engineering to protect river.	
Environmental Considerations: effluent treatment requirements; surface water contamination (isolate from surrounding watershed); groundwater contamination (hydrogeological containment); historical use of receiving watershed; background environmental conditions; impact on vegetation, wildlife and aquatic life; archaeological considerations; potential dust problems; aesthetic considerations							
Archaeological considerations	Archaeological site	No special considerations	No special considerations	No special considerations	No special considerations	No special considerations	No special considerations
Potential for dust generation	High dust generation from transport of tailings to site	Low; site has short haul route from processing plant	Low; site has short haul route from processing plant	High; site has long haul route from processing plant	High; site has long haul route from processing plant	High; site has long haul route from processing plant and will additionally require a further haul road to be constructed to the potential DTSF site.	High; site has long haul route from processing plant

Site Criteria	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7
Natural hazards	Low risk of avalanche, rockfall or debris flow. Potential to flood.	Clear of steep slopes above, with river either side. DTSF would need to be protected from scour during periods of high river flows. River would flow on both sides of the DTSF and therefore scour protection would be required on 3 sides.	Although there is risk of rockfall, no surface features indicative of slope instability have been identified. DTSF area is at risk of avalanche from slopes above; risk management and mitigation will be required. A debris flow has been mapped to the north of the site. River would flow on eastern side, therefore scour protection on 2 sides is required.	Risk of rockfall, avalanche and debris flow due to steep slopes above site, all of which could have the potential to damage the DTSF and cause uncontrolled seepage, high sediment discharge and release of tailings	Risk of rockfall, avalanche and debris flow due to steep slopes above site, all of which could have the potential to damage the DTSF and cause uncontrolled seepage, high sediment discharge and release of tailings	Risk of rockfall, avalanche and debris flow due to steep slopes above site, all of which could have the potential to damage the DTSF and cause uncontrolled seepage, high sediment discharge and release of tailings	Clear of steep slopes above, thereby lessening the potential for damage to the DTSF (and subsequent environmental damage)
Risk of groundwater or surface water contamination	Alluvial fan deposits likely unmitigated risk moderate given distance to water courses.	Quaternary deposits likely unmitigated risk moderate siting in mid of braided river channel.	Quaternary deposits likely unmitigated risk low given location at valley side and distance to river.	Quaternary deposits likely unmitigated risk moderate - high given short distance to river.	Quaternary deposits likely unmitigated risk moderate - high given short distance to river.	Quaternary deposits likely unmitigated risk high given confined setting	Quaternary deposits likely unmitigated risk moderate - high given short distance to river.

Site Criteria	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7
Seepage control	No information on soils, but likely to be sands and gravels.	Gravel and sandy soils are less pervious than at sites 4 or 5.	Gravel and sandy soils are less pervious than at sites 4 or 5.	Due to pervious nature of talus and rock fragments on ground surface, a geomembrane liner may be required to control seepage	Due to pervious nature of talus and rock fragments on ground surface, a geomembrane liner may be required to control seepage	Due to pervious nature of talus and rock fragments on ground surface, a geomembrane liner may be required to control seepage	Gravel and sandy soils are likely less pervious than at sites 4 or 5.
Rockfall potential	Rockfall unlikely	Low potential for rockfall - no steep adjoining slopes	Potential hazards associated with rock falls could include spillage of tailings or recirculating water; rock falls could damage DTSF embankment and/or diversion channels and take up space in tailings basin.	Potential hazards associated with rock falls could include spillage of tailings or recirculating water; rock falls could damage DTSF embankment and/or diversion channels and take up space in tailings basin.	Potential hazards associated with rock falls could include spillage of tailings or recirculating water; rock falls could damage DTSF embankment and/or diversion channels and take up space in tailings basin.	Potential rockfall hazard due to position in valley	Relatively flat area above potential location of tailings facility so lower rockfall hazards than at 4 and 5.
Avalanche potential	Low potential	Low avalanche potential	The DTSF area is at risk of avalanche from slopes above; risk management and mitigation will be required.	Steep hillsides at high elevations and therefore high avalanche potential.	Steep hillsides at high elevations and therefore high avalanche potential.	Avalanche potential due to position in valley.	Potential of snow avalanches is less than at Areas 4 and 5.

Site Criteria	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7
Control of surface water / snowmelt	DTSF would need to be raised and protected from scour.	DTSF will need to be protected from scour on three sides; diversion of river is unlikely to be practical.	A sidehill cut and fill may be used to construct a catch bench / diversion channel	Steep slopes above site, so potential for excessive snowmelt accumulation and therefore potential requirement for large diversion channels for control of runoff	Washout zones above site indicate seasonally high flows, sufficient to transport overburden. Control of surface water would require large diversion channels and high freeboard (increasing fill requirement)	Steep slopes and confined valley will require significant engineering control.	No steep slopes above site, so less potential for excessive snowmelt accumulation and therefore less requirement for large diversion channels for control of runoff
Impact to ecology - flora and fauna	Likely high due to high construction costs of raised base and defence from surface water flows.	Previously developed area. Potential impact upon flora and fauna due to construction of raised road and DTSF within flood plain, including excavation of borrow pit.	Previously developed area. Potential impact upon flora and fauna due to construction of road and DTSF adjoining flood plain, including excavation of borrow pit. However, the impact is likely to be less than for Area 2, as the design requires fewer materials.	Larger construction area and fill required when compared to area 7 - therefore higher impact upon surface ecology	Larger construction area and fill required when compared to area 7 - therefore higher impact upon surface ecology	Potential impact to flora and fauna due to construction of road and DTSF; high potential for dust generation due to long hauling distance and excavation of suitable construction materials in the valley below.	Less construction area and therefore less fill required when compared to areas 4 and 5 - therefore less impact upon surface ecology

Site Criteria	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7
Decommissioning / Reclamation: flooding or revegetation potential; ease of establishing permanent drainage; methods to control acid drainage; long term treatment requirements							
All aspects	High potential for flooding and therefore environmental impact potential. Permanent revegetation challenging due to wind and surface water erosion, although monitoring access would be good.	Elevation is above level of year-round running water; therefore, post-closure flooding is not likely.	Elevation is above level of year-round running water; therefore, post-closure flooding is not likely.	Elevation is above level of year-round running water; therefore, post-closure flooding is not likely.	Elevation is above level of year-round running water; therefore, post-closure flooding is not likely.	Elevation is above level of year-round running water; therefore, post-closure flooding is not practical. Rockfall damage and avalanche impact likely. Monitoring access and long-term care more problematic than other options due to uphill access road.	Elevation is above level of year-round running water; therefore, post-closure flooding is not likely.

Table 2: Scoring of potential DTSF sites

Site criteria	Weight	Site 1		Site 2		Site 3		Site 4		Site 5		Site 6		Site 7	
		Score	SxW	Score	SxW	Score	SxW	Score	SxW	Score	SxW	Score	SxW	Score	SxW
Access	5	5	25	4	20	5	25	2	10	2	10	1	5	3	15
Foundation suitability	5	4	20	4	20	4	20	2	10	2	10	2	10	3	15
Groundwater	2	3	4	3	6	3	6	1	2	1	2	1	2	2	4
Distance and difference in elevation from Process plant	4	1	4	5	20	5	20	3	12	3	12	1	4	2	8
Topographic relief and suitability for construction	4	2	8	3	12	4	16	1	4	1	4	2	8	3	12
Rockfall and/or avalanche risk to site	5	5	25	4	20	2	10	1	5	1	5	2	10	3	15
Environmental Impact	5	-100	-500	2	10	4	20	3	15	3	15	1	5	2	10
Storage capacity / dam volume ratio	3	2	6	4	12	4	12	2	6	2	6	3	9	3	9
Receiving watershed considerations	3	1	3	3	9	3	9	3	9	3	9	2	6	3	9
Construction materials	3	4	12	2	6	4	12	2	6	2	6	2	6	4	12
Closure	3	3	9	3	9	3	9	2	6	2	6	2	6	3	9
Total Score		-384		144		159		85		85		71		118	

5.0 REFERENCES

- Bach, L, Juncher Jørgensen, C, Bomholt Dyrholm Jacobsen, I, Jia, Y and Nymand, J. 2021. DCE/GINR – Review of “Nalunaq Gold Project. Environmental Impact Assessment 2021. Version 01-10-2021” – draft 2. Aarhus University, DCE - Danish Centre for Environment and Energy. – Scientific note. 26 November 2021
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- Golder, 2021. Nalunaq Gold Mine, Greenland: Preliminary Geotechnical Report - Mine Surface Infrastructure. Reference 20136781.615.A1, dated February 2021.

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