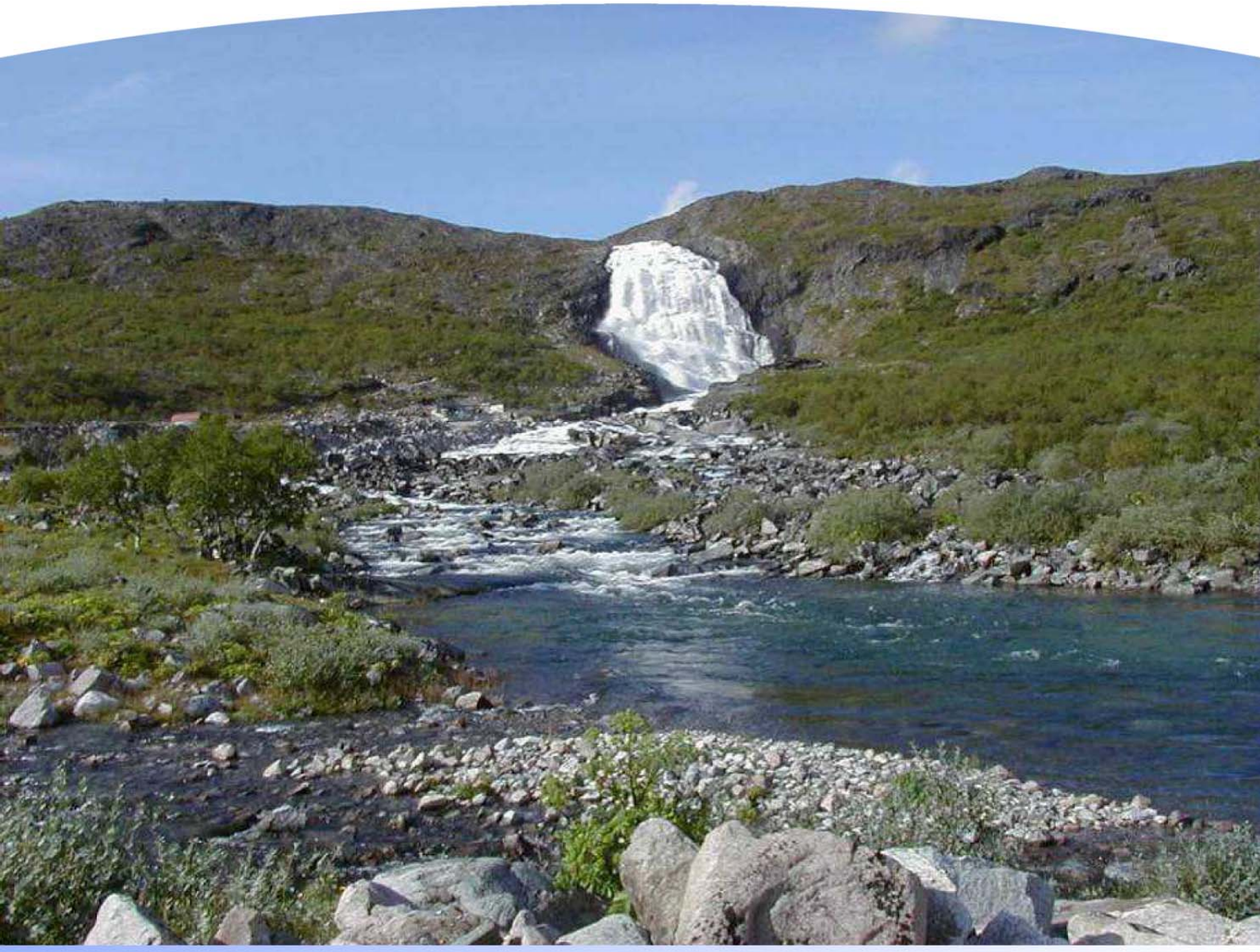
NAMMINERSORNERULLUTIK OQARTUSSAT . GRØNLANDS HJEMMESTYRE

Inuussutissarsiornermut Suliffeqarnermullu Naalakkersuisoqarfik

Departementet for Erhverv og Arbejdsmarked



Greenland Ice and Water for Export

Product catalogue – Bulk water

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1 Summary

In 2005, the government of Greenland decided to promote the export of ice and water from Greenland. A large programme was initiated to investigate the resources and the markets for water products and to inform potential investors about the opportunities.

Investigations of the resources were carried out in 2006 and 2008. These included sampling from glaciers, springs and surface water resources, and the results were presented in the form of a comprehensive analytical programme for water and ice samples.

This product catalogue summarises the results of the bulk water investigations and provides an overview of the resources considered most feasible for development.

The potential for producing bulk water from surface resources, lakes and rivers, was investigated at four locations. Both water quality and the capacity for year-round production are important factors with regard to the feasibility of exporting bulk water.

One of the investigated sites fulfils these criteria. The other sites have low capacity or water which requires purification in order to comply with drinking water standards. If the water, however, can be cleaned/treated before use, or if the water is for industrial use, some of the other surface resources may be potential resources.

2 Eqikkaaneq

Namminersornerullutik Oqartussat 2005-imi aalajangerput sermip erngullu Kalaallit Nunaanit avammut nioqqutigineqarneri siuarsarneqassasut. Isumalluutit imermillu tunisassianut niuerfiit misissorneqarnissaannut kiisalu aningaasaliisinnaasunut periarfissat pillugit ilisimatitsinissamut suliniut annertooq aallartinneqarpoq.

Isumalluutinik misissuinerit 2006-imi aamma 2008-mi ingerlanneqarput. Misissuinerit taakku tassaasimapput sermimiit, puilasuniit nunallu qaavani imeqarfinniit misiligutissanik tigusinerit, inernerillu sermimit imermillu misiligutinik misissuilluni suliniummi annertuumi saqqummiunneqarlutik.

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3 Resumé

Grønlands Hjemmestyre besluttede i 2005 at fremme eksporten af is og vand fra Grønland. Et stort program blev iværksat for at undersøge ressourcerne og markedet for vandprodukter og for at informere potentielle investorer om mulighederne.

Undersøgelserne af ressourcerne blev udført i 2006 og 2008. Disse undersøgelser omfattede prøvetagning fra gletsjere, kilder og overfladevand, og resultaterne blev præsenteret i form af et omfattende analyseprogram for is- og vandprøver.

Denne rapport giver et resumé af resultaterne af undersøgelserne af ressourcer for bulkvand og giver et overblik over de ressourcer, der forekommer mest fordelagtige for videre udvikling.

Potentialet for produktion af bulkvand fra overflade ressourcer, søer og elve, blev undersøgt på fire lokaliteter. Både vandkvalitet og kapacitet for produktion året rundt er vigtige faktorer med henblik på en rentabel eksport af bulkvand.

Én af disse lokaliteter opfylder disse kriterier. De øvrige steder har en lav kapacitet eller vandet må renses for at opnå drikkevandskvalitet. Hvis vandet imidlertid kan renses/behandles før brug, eller hvis vandet er til industriel brug, kan nogle af disse ressourcer være potentielle ressourcer.

4 Introduction

4.1 Background

The history, purity and pristine quality of Greenland's ice and water are expected to provide a good basis for marketing.

In 2005, the government of Greenland decided to promote the export of ice and water from Greenland. A large programme was initiated to investigate the resources and the markets for water products and to inform potential investors about the opportunities.

On this basis, the Greenland Home Rule requested a survey and identification of the glaciers most suitable for the extraction and processing of ice and water, surface water for bulk export and potential springs for the production of bottled water.

40 of Greenland’s approximately 5,000 glaciers were investigated and analysed and the ensuing research resulted in the selection of four glaciers for closer scrutiny and consideration as the location for the production of bottled water from the Greenland ice cap. The glaciers were investigated in 2006 and 2008 and the findings and the results of the water quality analyses are presented at www.iceandwater.gl

In 2006, four lakes and rivers suitable for extraction of bulk water and eight springs were investigated. The results of the bulk water investigation and water quality analyses are presented in this product catalogue. However, the investigation of springs indicated that more investigations are necessary. The investigations have not jet shown whether a production of bottled water, classified as "spring water", is possible from these resources. The springs on the Disko Island is suitable for spring water production, but has not been at part of this investigation and is therefore not mentioned in this catalogue.

Legal preparations

On 1 July 2001, the "Exports of Ice and Water Act" came into force [1]. The objective of this act is to promote the commercial exploitation of Greenland's ice and water resources and all forms of export of ice and water are targeted.

The Act forms a legislative framework. Licences and approvals are adapted to the specific circumstances of the project on the basis of a model licence and a model approval containing all terms, including provisions for royalties. The licence system corresponds to the system applicable in the field of mineral resources as the field of ice and water resources also requires considerable venture capital and a high degree of professionalism in all of its activities and international distribution channels.

The Act allows for the stipulation of detailed rules stating quality categories for Greenlandic ice and water licensed as commercial goods for export.

The Act is administered according to a one-door principle in the Greenland Home Rule, implying that applicants can submit applications to only one authority in the Greenland Home Rule.

Existing projects

The history, purity and pristine quality of Greenland's ice and water are expected to provide a good basis for marketing. For this reason, there is considerable interest in Greenland's ice and water resources from the outside world.

Three companies hold a licence to exploit and export ice and water.

Greenland Spring Water AG plans to exploit water from a spring on Disko Island for the production of bottled spring water.

Greenland Ice Cap Production exports ice to Canada for the production of vodka. The ice originates from the icebergs in a fiord near Narsaq in South Greenland.

Greenland Ice Water A/S exports water from melted icebergs near Ilulissat to a beer production, but they also plan to produce bottled inland ice cap eater.

For an update on companies who holds a licence please see www.iceandwater.gl

4.2 Relations to other parts of the project

The "Greenland ice and water for export" project was initiated by the government of Greenland in the autumn of 2005 based on a strategy for the export of ice and water from Greenland [2]. The strategy was formulated in 2004 and runs until 2013. The project includes the following subprojects:

- Investigation of resources for ice and water from glaciers and water from springs and lakes. The field investigations were carried out by:
  - Geological Survey of Denmark and Greenland (GEUS), investigations of four glaciers in 2006 [3]
  - Ramboll Danmark A/S, investigation of spring and surface water resources in 2006 [4]
  - NIRAS Greenland A/S, investigation of ice growlers in front of one glacier in 2008 [5]
- Market survey, carried out by NIRAS Consultants A/S in 2007-2008 [6]
- Investor survey, carried out by NIRAS and Greenland Mining Services
- Certification and quality proposal, carried out by DNV Industry in 2007-2008 [7]

- Development and registration of origin label for Greenland glacier water, conducted by NIRAS Consultants in 2008
- International classification of Greenland glacier water, carried out by DNV Industry in 2008
- Development of a database containing the results of the field investigations
- Development of a homepage: www.iceandwater.gl

The reports can be downloaded from www.iceandwater.gl.

4.3 Contents of the product catalogue

This product catalogue summarises the field investigations carried out in 2006. In chapter 5, the background for the water resources is described. Chapter 6 deals with the potential for exporting bulk water from lakes in Greenland. In chapter 7, the conclusion and perspectives are presented.

Figure 1

5 Greenland - its ice and water resources

This chapter provides a short introduction to Greenland's geography and geology and describes the water resources suitable for the production of water products. A short description of the infrastructure and logistics is included in Appendix C .

5.1 Greenland's geography and geology

Greenland (In Greenlandic: Kalaallit Nunaat, meaning "Land of the Kalaallit (Greenlanders)") is a self-governing country located between the Arctic and Atlantic Oceans.

Geography

Though geographically and ethnically an arctic island nation associated with the continent of North America, Greenland has close political and historical ties to Europe, specifically Iceland, Norway and Denmark.

Following a referendum, Greenland was granted Home Rule in 1979, making it an equal member of the Danish Realm (or "Rigsfællesskabet"). Please see www.nanoq.gl

Greenland has a population of 56,462 (January 2008), 89% of which has Greenlandic nationality, and it is made up of Kalaallit Inuit and Scandinavian Europeans.

Most towns and settlements are situated along the west coast, with a few small towns to the east and northwest.

The country is divided into 18 municipalities[1], each with a major town. The capital is Nuuk with 14,719 inhabitants. The other municipalities have between 1,500 and 6,000 inhabitants.

The north-eastern part of Greenland does not belong to any municipality but is the site of the world's largest national park, the Northeast Greenland National Park.

The municipalities include a large number of settlements with between 20 and 500 inhabitants. These settlements are called "Nunaqarfik" in Greenlandic and "bygd" in Danish. Smaller settlements include farms, especial in the south, and hunting and weather stations.

[1] From 2009 the existing municipalities will be merged into four municipalities.

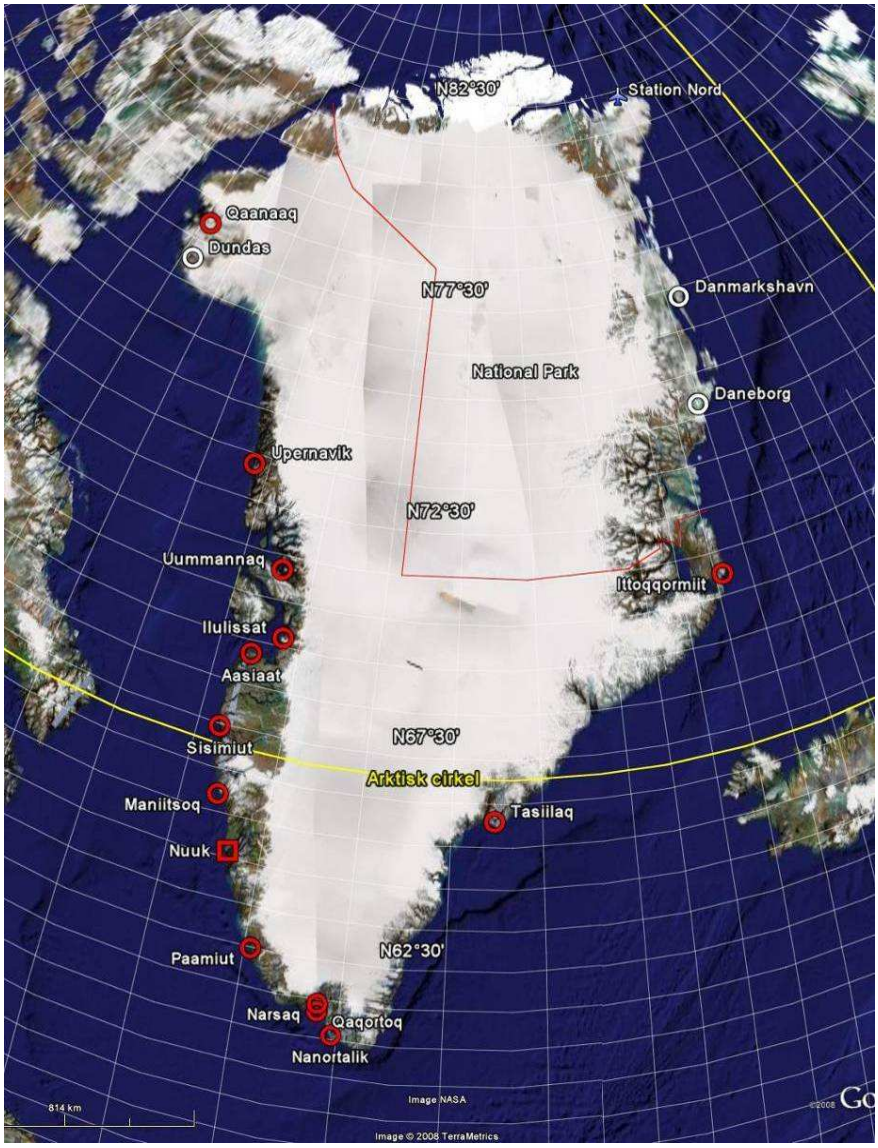

Figure 2 Greenland Geography.
Source: Google © 2008

Geology

The geological development of Greenland spans over four billion years, from the earliest Archaean era to the Quaternary period. Greenland is the largest island in the world with a total area of 2,166,000 km², 82% of which is covered by the Greenland inland ice cap. The adjacent offshore shelf areas, underlain by continental crust, have an area of approx. 825,000 km².

During the Quaternary, Greenland was almost completely covered by an ice cap and the present inland ice cap is a relic of the Pleistocene ice ages. Vast amounts of glacially eroded detritus were deposited on the coastal shelves off the shores of Greenland [8].

5.2 Ice and water resources

Precipitation and snow

Recorded precipitation in Greenland generally diminishes with increasing latitude and distance from the coast. There is great seasonal variation, particularly in the South.

The topography and varying altitudes also play a role, as precipitation is heavier on the wind side of the mountains and more sparse on the lee side. The lower the temperature, the lower the moisture content of the air, which also leads to a reduction in potential precipitation.

In the south to south-east, annual precipitation may range from 800 mm to 2,500 mm along the coasts but will be less close to the Greenland ice cap.

In the northern parts of Greenland the level ranges from 125 mm to 250 mm and 'arctic deserts' occur where evaporation during the summer exceeds precipitation. At Kangerlussuaq, annual precipitation is a mere 149 mm.

Towards the north, there is already snow cover in September and it usually disappears in June to July. Some locations even have snow cover in June and July.

The snow depth is greatest in southern Greenland, on average one to two metres through the winter months and sometimes up to six metres.

The snow cover in southern Greenland may temporarily disappear completely during periods with warm Foehn winds.

The inland ice cap

The glaciers of Greenland are a relic of the Pleistocene ice ages, consisting of the large continental ice sheet (the inland ice cap) and local ice caps and glaciers. The inland ice cap covers an area of approx. 1,736,000 km² and reaches an altitude of 3,230 m with a maximum thickness of approx. 3,400 m. The local ice caps and glaciers cover around 49,000 km².

The volume of the inland ice has been estimated at 2,600,000 km³, based on ice thickness measurements by airborne radio-echo sounding. A rough estimate of the volume of local ice caps and glaciers is 20,000 km³ [9].

The temperature of the ice ranges between -32°C and 0°C; with increasing depth, temperatures generally increase due to geothermal heat flux and internal heating caused by ice deformation. In some locations, the temperature at the base of the inland ice cap may reach melting point.

Glaciers

Glaciers are large, slow-moving rivers of ice, formed from compacted layers of snow that slowly deform and flow in response to gravity. Glacier ice is the largest reservoir of fresh water on earth, and second only to oceans as the largest reservoir of total water.

The front of the glacier, the glacier tongue, either rests on the land or floats on the water. If the tongue is floating, the edge will break off (calving) as the glacier moves forward.

Run-off from glaciers

Water from precipitation and melt water from the glaciers collects in lakes in the ice-free area between the coast and the inland ice cap and, from here, it runs into the fiords or the sea.

The run-off from some of these high-lying lakes provides opportunities for hydropower. At present, three hydroelectric power stations are in operation and one is under construction.

The water from the glaciers and the inland ice cap is often brownish to greenish in colour due to the content of sediment from the moraines along the ice or from the bottom of the glaciers. During the summer, blue lakes of pure water are formed on the inland ice cap. The water runs in small rivers along the ice until it disappears through crevasses (moulins) and follows tunnels in the ice or between the ice and the subsurface. When it leaves the front of the ice it is, in most cases, "polluted" with sediment.

Ice-dammed lakes, which form along the glacier tongues, are a special phenomenon. The lakes are filled with melt water while the outlets are dammed by the glaciers. When the water level is high enough to counterbalance the weight of the glacier, the lake will empty below the glacier and run out at the glacier front. This may happen every year or with intervals of up to ten years. When it happens, there may be severe flooding in the area below the glacier or heavy turbulence and increased calving if the glacier front reaches a lake or fiord.

Water supply

Almost all of the water supplies in Greenland come from surface water. Groundwater may exist in significant quantities below the permafrost, however extraction is extremely expensive.

The surface water for the water supply is collected in dams and treated in order to comply with the quality standards of Greenland’s legislation [10], which is comparable with the EU Potable Water Quality Act [11].

Exploitation licence

Preserving the perception of Greenland as a pristine environment with unique nature, natural resources and culture is important in order to maintain a high-quality image across markets around the world. For this purpose, the "Exports of Ice and Water Act" contains a set of requirements for obtaining licences for exploiting ice and water for export [12]. The conditions for award of an exploitation licence relate to the ability and professionalism of the applicant, environmental protection, local employment, quality of the product, traceability, etc.

6 Sources for bulk water

Bulk water is defined as large quantities of non packed water, e.g. water exported in tanks or tank vessels. Bulk water is most likely to originate from surface water from lakes and rivers.

Bulk water is exposed to the same quality criteria as for drinking water, and the regulations for licensing will apply.

Figure 3

Four sites for potential extraction of surface water for bulk water export were investigated in 2006 by Ramboll [4] and samples from lakes and streams were collected and analysed.

The results of the sampling and analyses of the water are presented below. Detailed information of the resources is given in Appendix A and the results of the analyses are listed in Appendix B.

6.1 Investigated sites

During the summer of 2006, field investigations were carried out and water samples were collected from four potential sites (Kangilinnguit, Kangerluarsunnguaq, Qorlortup Qoorua and Saarlup Tasersua) that all met the criteria for the selection of surface water (volume, accessibility, purity etc.)

The catchment area, runoff and reservoir capacity were evaluated in order to assess the production rate.

The findings are reported in the Ramboll report of October 2007 [4]

6.2 Results of analyses

Reference is made to Appendix B.

General water quality	The results of the analyses demonstrate that the water quality is characterised by a very low content of inorganic components and has no buffer capacity[2]. The water quality is generally acceptable for drinking water except for the high content of bacteria, including coliforms, in some samples and the fact that the limit for aggressive carbon dioxide is exceeded.
Solids and turbidity	Samples from two locations showed elevated turbidity, but the content of total solids and non volatile organic carbon (NVOC) is not exceeded in any samples.
BTEX	No samples exceeded the quality criteria for content of heavy metals, PAH, PCB, PCP (pentachlorphenol), pesticides etc. stipulated by Greenlandic and EU water quality standards except for one sample, see section 6.3.3.
Metals and inorganic ions	No samples exceeded the water quality standards.
Microbiology	Almost all samples analysed had a content of coliform bacteria and colony counts were elevated. Only one site had an acceptable microbiological quality, see section 6.3.4.

[2] If a solution has no buffer capacity, addition of a small amount of acid or base will make the solution either acidic or basic. As the pH of drinking water should be maintained between 7- 8.5 (EU 6.5 -9.5), the absence of buffer capacity means that the pH could easily be disturbed.

Figure 4 Sampling of surface water from the lake at Kangerluarsunnguaq (2006)

Conclusion

The results of all analyses demonstrated that only one site complies with Greenlandic, Danish and EU standards for drinking water quality without purification.

6.3 Description of potential sites

Reference is made to Appendix A.

6.3.1 Kangilinnguit

Re. [4: 148]

General description

The reason for considering the utilisation of the resources in this area was the occurrence of springs. On closer inspection, it was determined that the resources were actually surface water.

Comments and conclusion

The flow of “Brewer’s River” (Bryggerens Elv) is estimated at 16.2 million m^3 annually. The area has a lake, “Long Lake” (Langesø), which would be useable as a reservoir. With a variation in the water table in the reservoir of 5 m, a constant extraction of 6 million m^3 per year can be achieved.

The navy base, Kangilinnguit, provides a local infrastructure; however its use would depend on arrangements with the military authorities.

Substances of BTEX group compounds (can originate from petroleum products or emissions) were found, although these were below drinking water directive quality levels. Microbiological analyses and tests for aggressive carbon dioxide have not been carried out.

In spite of the existing infrastructure, the poor water flow means that the area is hardly suitable for commercial bulk water production.

6.3.2 Kangerluarsunnguaq (Kobbefjord)

Re. [4: 122]

General description

The resource has a catchment at the bottom of the Kangerluarsunnguaq of 26 km^2. Annual flow is estimated at 14 million m^3.

The limited opportunities for a reservoir mean that the constant extraction level is estimated at only 3 million m^3 annually.

There is no existing infrastructure, but the distance to Nuuk is only 23 km.

Comments and conclusion

The water has an elevated turbidity and content of aggressive carbon dioxide as well as a low pH. Furthermore, the water contains coliform bacteria.

Due to the poor water quality, the resource is not considered acceptable as drinking water without treatment. However, the resource may be used as processed drinking water or for industrial use.

6.3.3 Qorlortup Qoorua

Re. [4: 109]

General description

This resource has drawn some attention as the water flows directly into Nuup Kangerlua via a waterfall from the catchment. Therefore, it has been suggested that the water be extracted directly from the waterfall and into the ship.

The annual flow is estimated at 10 million m^3 and it is reported that the water flows continuously throughout the year. There are only limited options for storage.

Comments and conclusion

There is no existing infrastructure and the viability of commercial exploitation is linked to the possibility of extraction directly from the waterfall into the ship.

The low content of PAH in the lake may be explained by pollution from helicopter combustion fumes prior to the sampling [4:118] as it is not found in the waterfall after the lake. However, further verification is required.

The water sample from the waterfall had a high content of coliforms and other bacteria, but only one sample was taken and contamination of the sample may have occurred. Therefore, it can not be determined whether the water can be utilised with or without treatment.

6.3.4 Saarlup Tasersua (Akia)

Re. [4: 96]

General description

This resource is provided by the catchment surrounding Lake Saarlup Tasersua on Akia near Nuup Kangerlua.

Comments and conclusion

There is no infrastructure in the area, but shipping facilities can be established relatively easily in Nuup Kangerlua. The lake is situated approx.

5 km from the coast. The establishment of a township on Akia is currently being considered as is the construction of an international airport to the south west of the lake. However, feasibility is still uncertain.

The water resource is considered of commercial relevance with high capacity but the water may require some treatment to achieve drinking water quality. A content of bromide excludes the use of ozone treatment.

Figure 5 Sampling of water from the Qorlortup Qoorua waterfall (2006)

6.4 Conclusion

The four investigated surface water resources were evaluated and the various different factors (quality, capacity, infrastructure, logistics and environment and nature) rated on a scale from 1 (worst) to 5 (best). The ratings for the different sites and for each factor can be found in appendix A. Each rating is multiplied by a weight: quality (5), capacity (5), infrastructure (4), logistics (4), environment and nature (2) and the results are then added, providing the final results presented in the table below.

Name	Location	Rating
Kangilinnguit	Kangilinnguit	(66)[3]
Kangerluarsunnguaq	South of Nuuk	56
Qorlortup Qoorua	Nuuk Fjord	63
Saarlup Tasersua	Akia	81

Tabel 1

[3] No microbiological analyses has been taken.

The rating in the table can only be used for a relatively assessment of the site, the water quality, the infrastructure etc. A high rating means that the site is more feasible for a bulk water production compared to sites with lower rating.

Saarlup Tasersua is considered to be the most, feasible resource for the commercial exploitation of clean, untreated surface water resources. Qorlortup Qoorua may also be feasible if further sampling and analyses indicate an acceptable water quality or if the water is treated.

Further analyses of the water from Kangerluarsunnguaq and Kangilinnguit may indicate whether the water can be used with or without treatment; alternatively the resources can be used for industrial purposes.

Figure 6

7 Conclusion and perspectives

The objective of this catalogue is to provide an overview of the potential for commercial exploitation of Greenland's bulk water resources.

The resources described are bulk water from surface water resources.

The results are based on investigations, sampling and analyses which took place in 2006.

7.1 Bulk water from surface resources

The investigation of four surface water resources showed that commercial production of bulk water from Greenland's lakes and rivers may be feasible under certain conditions.

Water quality The analyses showed, however, that not all resources have a water quality that is good enough for the production of drinking water without treatment. Further investigations and analyses must be carried out to localise adequate resources with sufficient capacity and water quality, or the water may be used as drinking water after treatment or for industrial purposes.

Production of bulk water

Apart from the water quality, infrastructure and logistics are key elements of commercial production. The high investment required for infrastructure for resources in remote locations may prove prohibitive. The production of bulk water from lakes and rivers is, in most cases, considered environmentally sustainable; the resources are renewable as they originate from precipitation.

References

1 The Home Rule Parliament Act No 7 of May 31st 2001 on the exploitation of ice and water for exploitation (*The Ice and Water Exportation Act*)

2 *Statement regarding the government of Greenland's strategy for exporting ice and water*. FM 2004/22. The Bureau of Minerals and Petroleum. March 2004

3 GEUS: *Greenland Ice as resource for freshwater export. Investigation of four glaciers from the Greenland Inland Ice. Field Work and Analysis*. GEUS Report 2007/14

4 Ramboll: *Greenland Ice and Water. Exploration of water resources (option 1).* Virum October 2007

5 NIRAS Greenland: *Greenland ice and water for export, Sampling of glacier ice at Narsap Sermia*. Nuuk September 2008

6 NIRAS Consultants: *Export of Greenland ice and water, Market survey*. Århus May 2008

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9 Anker Weidick: *Greenland*. Satellite image atlas of glaciers of the World. U.S. Geological professional paper 1386-C. Washington 1995

10 Greenland Home rule: *Order No. 7 of 17 March 2008 on water quality and inspection of water supply plants*

11 European Union: *The Council directive 98/83/EC of 3 November 1998 on quality of water intended for human consumption*. 1998

12 *Executive order No. 7 of 22 April 2004 on the processing by the authorities of application filed pursuant to the Ice and Water Exportation Act*. Government of Greenland. 22 April 2004

Datasheets for bulk water resources

Appendix A

Product catalogue

Results of surface water analyses

Appendix B

Transport by sea

The Royal Arctic Line (RAL) owns the concession for container liner traffic between Greenland's towns and the Greenland harbour in Aalborg, Denmark, as well as for liner traffic between towns and settlements in Greenland.

The frequency with which the major ports, Nuuk, Sisimiut and Aasiaat, are serviced by international traffic 7-10 days depending on the season. The other harbours on the west coast of Greenland are served by feeder routes from the major ports or occasionally by international calls.[4]

All ports on the west coast, south of the Arctic Circle, are ice-free all year round. Some harbours on the south west coast are closed occasionally in June and July due to multi-year ice (drift ice of Arctic Ocean origin), called "storis".

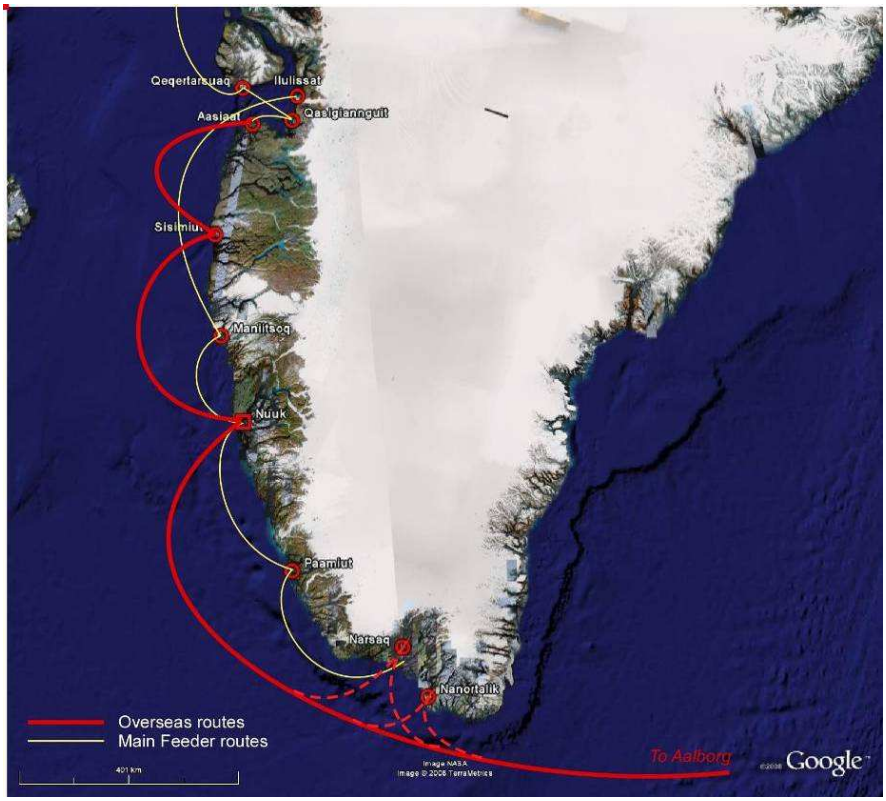


Figure 7 Map of sea destinations

Transport by air

Air Greenland[5] has international, scheduled flights from Copenhagen to two destinations in Greenland: Kangerlussuaq 4-7 days a week and Narsarsuaq 1-2 days a week, depending on the season.

[4] www.royalarcticline.com

[5] http://www.airgreenland.gl/index.php?pageid=1&new_language=1

Scandinavian Airlines (SAS) have scheduled flights from Copenhagen to Kangerlussuaq 1-3 times a week during the summer.

Mid-east coast destinations and Narsarsuaq are serviced from Akureyri and Reykjavik, Iceland, during the summer.

The domestic service net includes 24 destinations. The routes are operated by Air Greenland and mainly serviced by Dash-7 turboprop and helicopter.

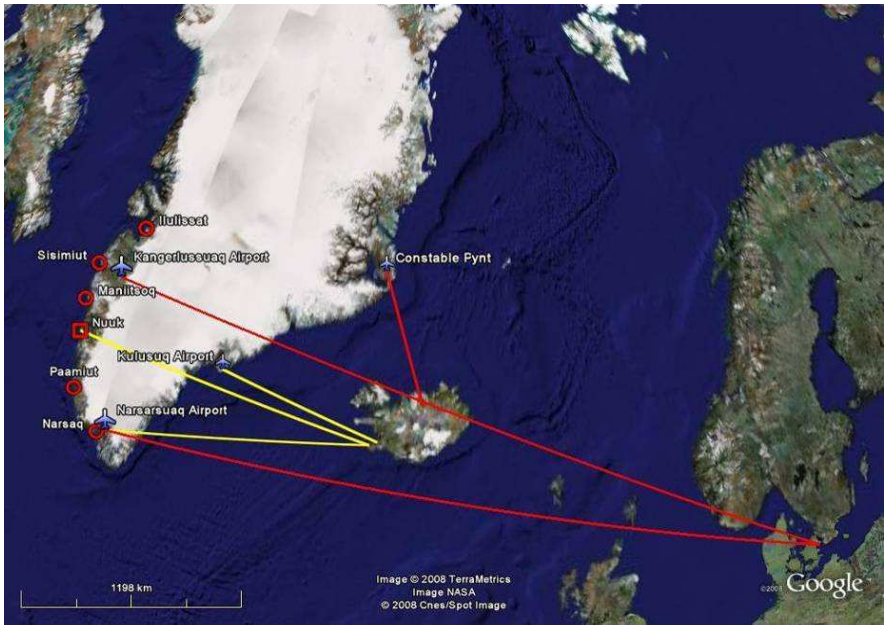


Figure 8 Map of air destinations
Air Greenland
Air Iceland (summer only)

Telecommunications

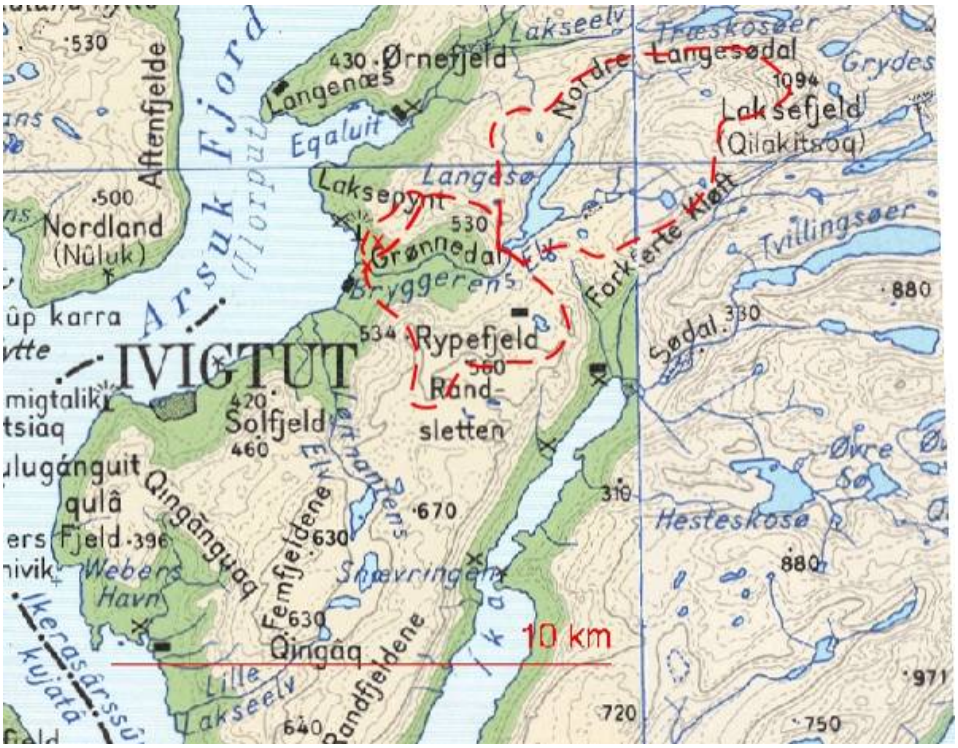
The Greenland Tele-Post telecommunications company provides terrestrial lines, internet and mobile (GSM) network communications services covering the most populated areas of the country.

All towns and most settlements are internally connected by a microwave radio link carrying data, telephone and television signals. The radio network is connected to the outside world by a number of satellite stations.

From 2009, two high capacity data communication cables from Greenland to Newfoundland and Reykjavik will be in operation.

LOCATION	Name	ID	Type	Municipality
	Kangilinnguit	04.A	Surface Water	Ivittuut
Coordinates	UTM 22 (1) N: 6792536 E: 656048 (2) N: 6791918 E: 655891		Geographic 61°14' N, 48°06' W	

Water Quality	Bulk Water Contain elements from the BTEX group, but below the limit value of the Drinking Water Act. Content of bacteria and aggressive carbon dioxide is not analysed.	Rating (3)
Quantity	The catchment area of Bryggerens elv (2) is 28 km², which gives an annual runoff of 16.2 hm³ (million m³). (Rambøll 2007: 152). Langesø, which is the only reservoir in the area, has a catchment area of 16 km² and an annual runoff of 9.3 hm³. The area of Langesø is 0.75 km², and anticipating an average depth of 5 m the volume will be 3.8 hm³. An even, guaranteed water supply from the reservoir is estimated to 6 hm³/a. In years with high runoff and during summer a much higher runoff from the river "Elven" (The River) (1) is water supply for the marine station Kangilinnguit (Grønnedal). The annual runoff is calculated to 0.17 hm³ (Rambøll 2007: 150).	3
Infrastructure	The rivers are located close to Kangilinnguit. The harbour has a quay , 90 m long and with 6.5-11 m draft. Distance by air from Kangilinnguit heliport to Narsarsuaq int. Airport is 144 km.	4
Logistics	The harbour is normally open year round, but thin sea ice may occur. Kangilinnguit has helicopter connection to Narsarsuaq once a week. Cargo supply is by feeder ship from Nuuk approx. every second month.	4
Nature end environment	There are no recorded areas of interest for wildlife. Kangilinnguit is a military installation, and restrictions regarding use of the area may be expected.	2
Total rating		(66)

LOCATION	Name	ID	Type	Municipality
	Kangilinnguit	04.A	Surface Water	Ivittuut
Coordinates	UTM 22 (1) N: 6792536 E: 656048 (2) N: 6791918 E: 655891		Geographic 61°14' N, 48°06' W	
Map of the Area Scale: 1:150.000 Source: Grønlands Topografiske Kortværk © KMS				

LOCATION	Name	ID	Type	Municipality
	Kangerluarsunnguaq (Kobbefjord)	06.A	Surface Water	Nuuk
Coordinates	UTM 22W N: 7111636 E: 481803		Geographic 64°08' N, 51°22' W	

Water Quality	Bulk Water Turbidity and Aggressive carbon dioxide are high Total bacterial count and coliforms are too high	Rating 2
Quantity	The catchment area of Lake A is 26 km² and the annual runoff in a normal year is calculated to 14 hm³ (million m³) (Rambøll 2007: 126). It is estimated that using the upper 2-3 m of the lake as reservoir a volume of 2 hm³ can be obtained. An even, guaranteed water supply from the reservoir is estimated to 3 hm³ per year. During summer and in years with high precipitation the runoff will be considerably higher.	2
Infrastructure	There are no existing infrastructure in the area. The distance to Nuuk (14.719 inhabitants) is 17 km by air and 23 km by sea. The harbour of Nuuk has two quays: the newest being 102 m long with 10 m draft. Distance by air to the nearest town with airport, Nuuk (950 m runway), is 16 km. Nearest int. airport is Kangerlussuaq; distance 320 km.	3
Logistics	In Kangerluarsunnguaq sea ice may occur, but it is anticipated that the fiord can be navigated year round with ice strengthened vessels. Nuuk Harbour has weekly connection to Aalborg, Denmark, year round. Nuuk airport has connections to Kangerlussuaq int. Airport 4-6 days a week and to other destinations in Greenland, depending of season.	4
Nature and environment	There are no records of areas sensitive to wildlife or nature. Kangerluarsunnguaq is used as recreation area for the citizens of Nuuk.	4
Total rating		56

LOCATION	Name	ID	Type	Municipality
	Kangerluarsunnguaq (Kobbefjord)	06.A	Surface Water	Nuuk
Coordinates	UTM 22W N: 7111636 E: 481803		Geographic 64°08' N, 51°22' W	

Map of the area

Scale:

~1:260.000

Source:

Grønlands Topografiske Kortværk

© KMS

Map of the location

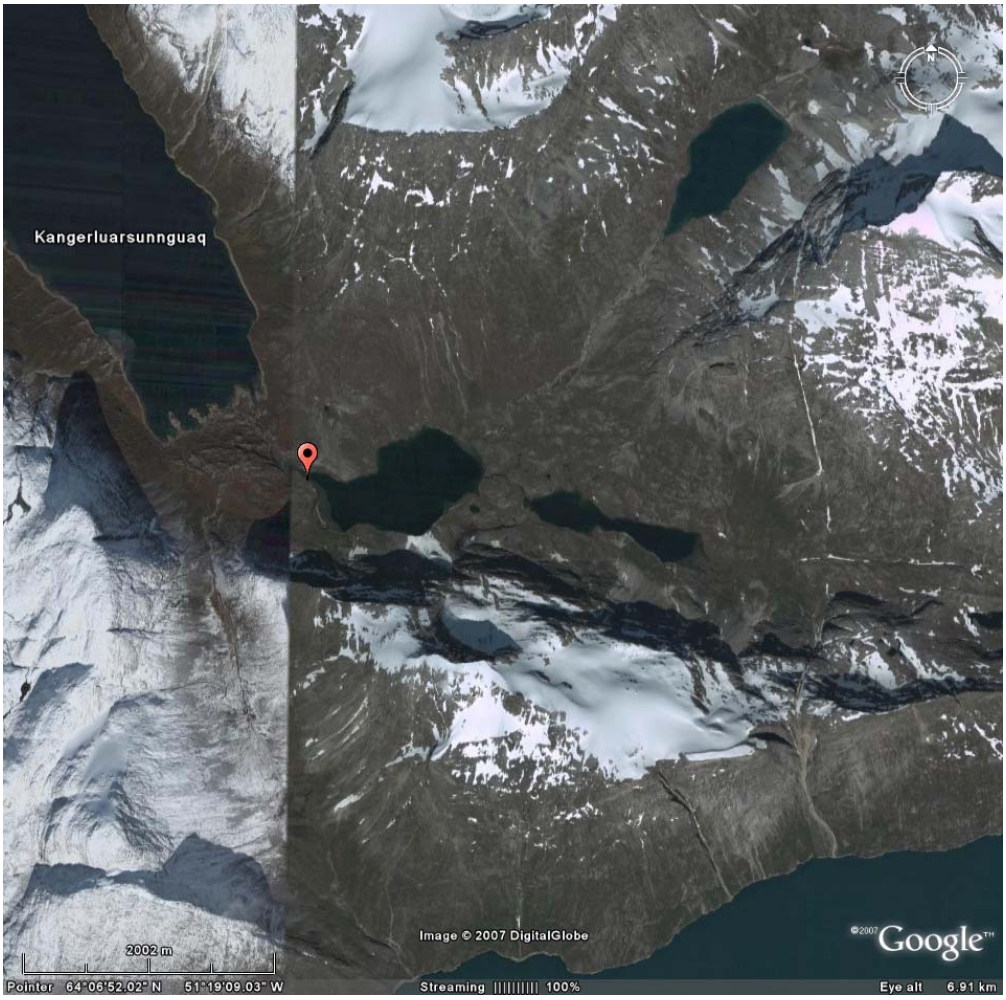
Scale:

~1:87.000

Source:

Grønlands Topografiske Kortværk

© KMS

LOCATION	Name	ID	Type	Municipality
	Kangerluarsunnguaq (Kobbefjord)	06.A	Surface Water	Nuuk
Coordinates	UTM 22W N: 7111636 E: 481803		Geographic 64°08' N, 51°22' W	
Satellite photo Source: © Google Earth Pro				

LOCATION	Name	ID	Type	Municipality
	Qorlortup Qoorua	06.B	Surface water	Nuuk
Coordinates	UTM 22W (L) N: 7121899 E: 496338 (W) N: 7122182 E: 495309		Geographic 64°13' N, 52°05' W	

Water Quality	Bulk Water. Content of PAH and too high bacterial count and coliforms. Low pH, and high aggressive carbon dioxide	Rating 2
Quantity	Catchment area for the lower lake is approx. 19 km², and the runoff in a normal year is estimated to 10 hm³ (million m³) (Rambøll 2007: 113). The drain form the area is a high, steep water fall directly into the Nuup Kangerlua (Godthåbsfjord). Local people report that the water is running year round. The lower lake can only to a limited extend be used as a reservoir, but it is estimated, that an even, guaranteed water supply of 3 hm³ per year can be obtained.	3
Infrastructure	There is no existing infrastructure in the area. The distance by sea to Nuuk is approx. 40 km. The harbour of Nuuk has two quays: the newest being 102 m long with 10 m draft. Nearest Airport I Nuuk (950 m runway), 26 km. Nearest int. airport is Kangerlussuaq; distance 310 km.	3
Logistics	In Nuup Kangerlua some glacial ice occurs especially during autumn. Nuuk and the area off the waterfall can be navigated year round. Nuuk Harbour has weekly connection to Aalborg, Denmark, year round. Nuuk airport has connections to Kangerlussuaq int. Airport 4-6 days a week and to other destinations in Greenland, depending of season.	4
Nuup Kangerlua	There are no records of areas sensitive to wildlife or nature.	5
Total rating		63

LOCATION	Name	ID	Type	Municipality
	Qorlortup Qoorua	06.B	Surface water	Nuuk
Coordinates	UTM 22W (L) N: 7121899 E: 496338 (W) N: 7122182 E: 495309		Geographic 64°13' N, 52°05' W	
Map of the area Scale: ~1:370.000 Source: Grønlands Topografiske Kortværk © KMS				
Map of the location Scale: ~1:150.000 Source: Grønlands Topografiske Kortværk © KMS				

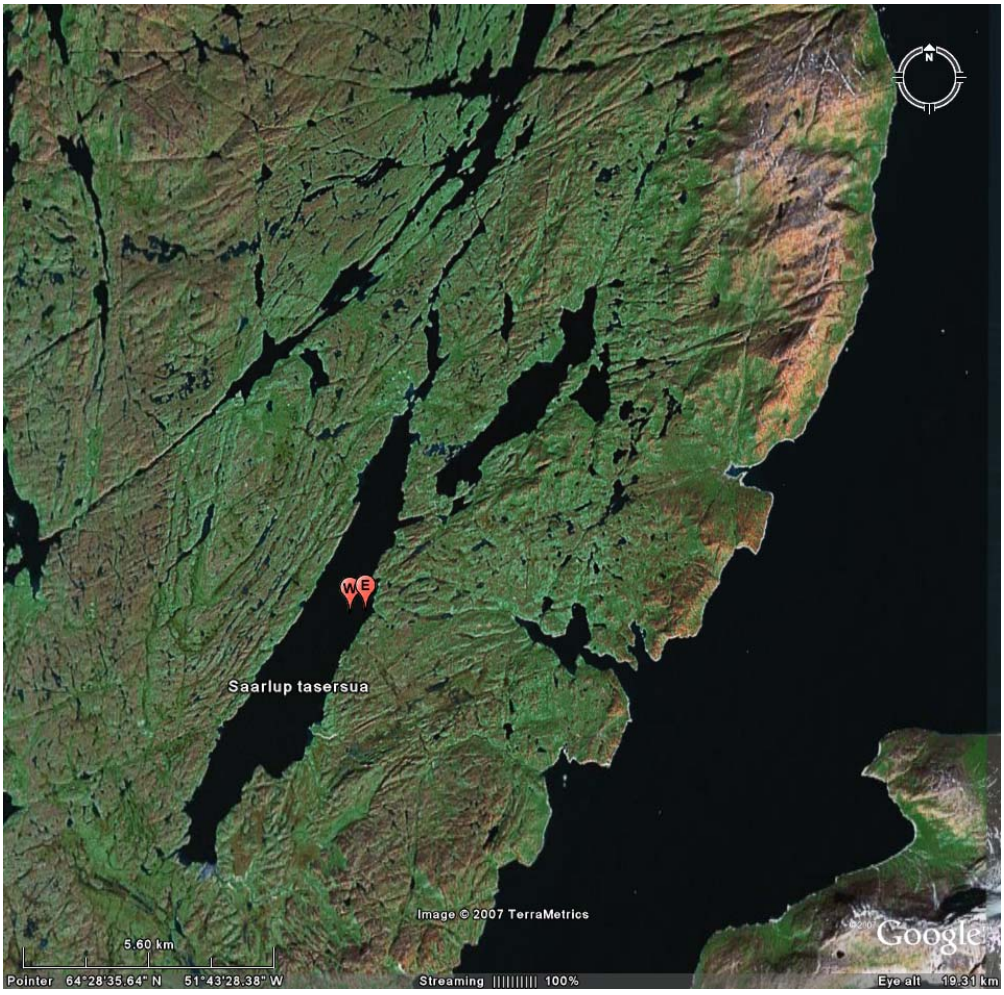
LOCATION	Name	ID	Type	Municipality
	Qorlortup Qoorua	06.B	Surface water	Nuuk
Coordinates	UTM 22W (L) N: 7121899 E: 496338 (W) N: 7122182 E: 495309		Geographic 64°13' N, 52°05' W	
Satellite photo Source: © Google				

LOCATION	Name	ID	Type	Municipality
	Saarlup Tasersua (Akia)	06.C	Surface water	Nuuk
Coordinates	UTM 22W N: 7147805 E: 467437[1]		Geographic 64°27' N, 51°40' W	

Water Quality	Bulk water Acceptable microbiological levels Low pH and high aggressive carbon dioxide. Ozone treatment is not possible because of bromide content.	Rating 4
Quantity	The catchment area of Saarlup tasersua is 115 km², and the runoff for a normal year is calculated to 60 hm³ (million m³) (Rambøll 2007: 100). Lowering the lake surface by 5 m gives a reservoir volume of 55 hm³. An even, guaranteed water supply is estimated to approx. 50 hm³. In years with high precipitation the runoff could be considerably higher.	5
Infrastructure	There is no existing infrastructure in the area. The distance by sea to Nuuk is approx. 37 km. The harbour of Nuuk has two quays: the newest being 102 m long with 10 m draft. Nearest Airport I Nuuk (950 m runway), 26 km. Nearest int. airport is Kangerlussuaq; distance 290 km. Long distance to fjord.	2
Logistics	In Nuup Kangerlua some glacial ice occurs especially during autumn. Nuuk and the fiord can be navigated year round. Nuuk Harbour has weekly connection to Aalborg, Denmark, year round. Nuuk airport has connections to Kangerlussuaq int. Airport 4-6 days a week and to other destinations in Greenland, depending of season.	5
Nature and environment	There are no records of areas sensitive to wildlife or nature. Akia (Nordlandet) is used by the citizens of Nuuk for recreation and hunting. An international airport is considered to be established on Akia, southwest of the lake. In the case, airplanes may cross the lakes in low altitude during take off and landing. It is not known if the airport plans will be actualised.	4
Total Rating		81

[1] The most west point of sampling

LOCATION	Name	ID	Type	Municipality
	Saarlup Tasersua (Akia)	06.C	Surface water	Nuuk
Coordinates	UTM 22W N: 7147805 E: 467437[1]		Geographic 64°27' N, 51°40' W	
Map of the area Scale: ~1:340.000 Source: Grønlands Topografiske Kortværk © KMS				

LOCATION	Name	ID	Type	Municipality
	Saarlup Tasersua (Akia)	06.C	Surface water	Nuuk
Coordinates	UTM 22W N: 7147805 E: 467437[1]		Geographic 64°27' N, 51°40' W	
Satellite photo Source: © Google Earth Pro				

		Greenland and EU criteria [i,ii] Tap water	Danish criteria [iii] From water works	Kangilinn-guit (04.A)		Kangerluar-sunnguaq (06.A)	Qorlortup Qoorua (06.B)		Saarlup Tasersua (06.C)
				Stream 1	Stream 2		Lake	Water-fall	
Sampling date				23-08-2006		22-08-2006	21-08-2006		18-08-2006
Colour	mg Pt/l		<5	1.2	1.3	None	None	None	None
Turbidity	FTU	(<1)	<0.3	0.13	0.20	**0.74**	0.29	0.21	0.40
Conductivity	mS/m	<250	(>30)	**4.9**	**5.0**	**<5.0**	**<5.0**	**<5.0**	**5.2**
Conductivity (field measurement)				…	…	**15**	**12**	**12**	**47**
pH		6.5-9.5	7-8.5	7.8	8.0	7	**5.9**	**6.6**	**6.7**
pH (field measurement)				…	…	…	**6.34**	**7.16**	…
NVOC (non-volatile organic carbon)	mg/l		<4	0.46	0.40	0.73	0.4	0.63	1.1
Total solids at 105°C (non evaporable residue)	mg/l		<1,500	30	24	<10	36,8	<10	<10
TOC				.	.	0.7	0.4	0.6	1.1
Inorganic ions									
Calcium, Ca^{++}	mg/l		(<200)	6.1	6.9	<1.0	<1.0	<1.0	<1.0
Magnesium, Mg^{++}	mg/l		<50	<1.0	<1.0	<0.5	<0.5	<0.5	0.71
Total hardness	dH		(5-30)	1.0	1.1	<0.5	<0.5	<0.5	<0.5
Sodium, Na^{+}	mg/l	<200	<175	2.4	1.9	1.8	1.6	1.6	5.8
Potassium, K^{+}	mg/l		<10	0.90	<0.20	0.63	0.41	0.38	0.54
Ammonium, NH_4^{+}	mg/l	<0.5	<0.05	<0.006	0.012	<0.010	<0.010	<0.010	<0.010
Iron, Fe	mg/l	<0.2	<0.1	<0.010	<0.010	<0.005	0.006	0.007	<0.005
Manganese, Mn	mg/l	<0.05	<0.02	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Hydrogen carbonate, HCO_3^{-}	mg/l		(>100)	29.2	29.6	6	3	5	7
Chloride, Cl^{-}	mg/l	<250	<250	1.6	1.1	3.5	2.5	2.7	9.8
Sulphate, SO_4^{--}	mg/l	<250	<250	1.4	1.1	1.39	0.70	0.84	3.70
Nitrate, NO_3^{-}	mg/l	<50	<50	<0.05	<0.05	<0.010	<0.010	0.021	0.235
Nitrite, NO_2^{-}	mg/l		<0.01	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Total phosphorous, P	mg/l		<0.15	<0.005	<0.005	<0.01	<0.01	<0.01	<0.01
Fluoride, F^{-}	mg/l	<1.5	<1.5	0.085	0.14	0.22	<0.02	<0.02	0.11
Bromide, Br^{-}	µg/l			<5.0	<5.0	<0,1	<10	<10	33
Oxygen, O_2	mg/l		>5[iv]	**2.2**	**<2.0**	**1**	**2**	**<1**	**1**
Aggressive carbon dioxide, CO_2	mg/l		<2	.	.	**5**	**5**	**4**	**5**
Methane	mg/l		<0.01	.	.	<0.01	<0.01	<0.01	<0.01
Silicic acid (Silicium**)	mg/l			2.2**	1.0**	0.57	1.2	1.2	0.83
Hydrogen sulphide	mg/l			<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Metals									
Aluminium, Al	µg/l	<200	<100	7.2	7.4	7.0	8.6	5.6	7.7
Antimony, Sb	µg/l	<5	<2	<0.2	<0.2	0.032	0.031	0.093	0.071
Arsenic, As	µg/l	<5	<5	<0.03	<0.03	<0.06	<0.06	<0.06	<0.06
Barium, Ba	µg/l		<700	2	16	2.7	1.8	1.8	2.2
Boron, B	µg/l	<1000	<1000	<10	<10	<50	<50	<50	<50
Cadmium, Ca	µg/l	<5	<2	0.005	0.005	<0.03	<0.03	<0.03	<0.03
Chromium, Cr	µg/l	<50	<20	0.08	0.09	<0.5	<0.5	<0.5	<0.5
Copper, Cu	µg/l	<2000	<100	0.18	0.19	0.9	1.0	1.8	1.4
Cyanide, Cn	µg/l	<50	<50	<1	<1	<1	<1	<1	<1

		Greenland and EU criteria [i,ii] Tap water	Danish criteria [iii] From water works	Kangilinn-guit (04.A)		Kangerluar-sunnguaq (06.A)	Qorlortup Qoorua (06.B)		Saarlup Tasersua (06.C)
				Stream 1	Stream 2		Lake	Water-fall	
Lead, Pb	µg/l	<10	<5	0.032	0.073	0.09	0.11	0.18	0.065
Mercury, Hg	µg/l	<1	<1	<0.05	<0.05	<0.02	<0.02	<0.02	<0.02
Nickel, Ni	µg/l	<20	<20	<0.030	<0.030	0.4	0.1	1.1	0.3
Selenium, Se	µg/l	<10	<10	0.06	<0.05	<0.3	<0.3	<0.3	<0.3
Silver, Ag	µg/l		<10	<0.1	<0.1	<0.1	<0.1	<0.1	0.56
Zinc, Zn	µg/l	<100	<100	0.9	1.1	3.2	3.3	4.2	2.6
Beryllium, Be	µg/l			<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Cobalt, Co	µg/l			<0.040	<0.040	<0.1	<0.1	<0.1	<0.1
Niobium, Nb	µg/l			<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Strontium, Sr	µg/l			.	.	4.2	3.1	3.5	8.6
Tantalum, Ta	µg/l			.	.	<0.1	<0.1	<0.1	<0.1
Uranium, U	µg/l			0.76	0.26	0.3	<0.1	0.10	<0.1
Vanadium, V	µg/l			<0.5	<0.5	<1	0.12	<1	<1
Zirconium, Zr	µg/l			<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
PAH, PCB, pesticides and PCP [v]									
Sum of Benzo(b+k)fluoranthen	µg/l	<0.1	<0.1	0	0	0	**0.140**	0	0
Benzene	µg/l	<1	<1	0.056	0.18	0	0	0	0
Toluene	µg/l		<1	1.8	2.5	0.04	0	0	0.08
Ethylbenzene	µg/l		<1	0.14	0.17	0	0	0	0
M+p-xylene	µg/l		<1	0.64	0.64	0	0	0	0.04
o-xylene	µg/l		<1	0.10	0.12	0	0	0	0
Bacteria and spores									
Total coliforms	/100ml	0	0	.	.	**10**	.	**97**	-
E. coli	/100 ml	0	0	.	.	-	.	-	-
Colony counts 37°C	/ml	<20 [vii]	<5	.	.	1	.	**20**	-[vi]
Colony counts 22°C	/ml	<100 [vii]	<50	.	.	**58**	.	**100**	1
Faecal streptococcus	/100 ml	0	0	.	.	.	.	.	.
Clostridium perfringens	/100 ml	0	0	.	.	-	.	-	-
Clostridium perfringens (spores)	/100 ml	0	0	.	.	.	.	.	.
Pseudomonas aeruginosa	/100 ml	0 [vii]		.	.	-	.	-	-
Laboratory		Miljølaboratoriet, DK (2006)		Eurofins, DK (2006)			Dronning Ingrids Hospital (DIH), Nuuk (2006)		

[i] Greenland Home Rule: Order No. 7 of 17. March 2008 on water quality and inspection of water supply plants. Criteria for water at the users' tab

[ii] European Union: The Council directive 98/83/EC of 3 November 1998 on quality of water intended for human consumption. Criteria for water at the users' tab

[iii] The Danish Environmental Ministry: Order no. 1449 of 21st. December 2007 on water quality and inspection of water supply plants. Criteria for water leaving treatment plant

[iv] Oxygen content at the consumer tap should be greater than 5 mg/l, ref. [iii]

[v] All analyses are below detection limit except mentioned

[vi] Sample from 30-08-3006 shows 4 counts/ml

[vii] Bottled water

Bold figures indicate that DK quality criteria for water from treatment plant are exceeded; figures in **bold and red** indicate quality criteria for water at the user tap are exceeded

. No analysis

… No information available

0 Below detection limit

- Zero

Ad [iii] For water leaving the water works (values in parenthesis are recommended)

Ad [ii] Some values are indicator parameters and if exceeded a risk assessment of consequences for human health should be made. For microbiological and chemical parameters (heavy metals, contaminants) the maximum values must be complied with