NIRB Application for Screening #125765

Mueller's Ice Cap ice core

Application Type:	New
Project Type:	Scientific Research
Application Date:	1/13/2023 11:32:39 AM
Period of operation:	from 0001-01-01 to 0001-01-01
Proposed Authorization:	from 0001-01-01 to 0001-01-01
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DETAILS

Non-technical project proposal description

English: An ice core on Müller Ice CapDr. Dorthe Dahl-Jensen, University of ManitobaWe (a group of scientists from the Centre for Earth Observation Science at the University of Manitoba) plan to drill an ice core through Müller Ice Cap on Axel Heiberg Island. This core will be 10 cm in diameter and ~600 m long and will contain information about climate in Arctic Canada thousands of years ago. This core will help answer: • Did sea ice conditions respond to climate during the past 20,000 years? • What climatic conditions did arctic ice caps experience during the past and how did they respond? • How old is Müller Ice Cap? • How fast is Müller Ice Cap shrinking, and how much is climate warming there?We can use new measurement techniques to address these questions before warming melts the records in the ice cap.The project involves going to Axel Heiberg Island twice, once to pick the exact site of the core and once to drill. In 2023, we plan to have a team of five survey the ice cap with an ice-penetrating radar and collect some small snow samples. The radar does not affect people or animals but will identify the drill site that contains the most information about past climate. In 2024, about 12 people will spend 2-3 months camping on the glacier, drilling the core, and making measurements on the surrounding snow. The core will be sent back to laboratories to determine past temperature, snowfall and sea-ice conditions in the area. The measurements will inform models of the past, present, and future evolution of Müller Ice Cap.The ice and snow we collect will have minimal environmental impact; in total, we plan to collect less than 10 m3, and additional snow melted for camp use will be less than 1 m3 per day. The primary environmental impact will be that we must put a non-freezing fluid in the hole so that it does not close around the drill. We plan to leave the fluid in the hole afterwards to allow future measurements of the ice flow and temperature (and since it is difficult to remove), as is done in Greenland and Antarctica. The fluid will be safely contained in the ice cap and is non-hazardous. In addition, the location of the work is over 400 km from Grise Fiord or Resolute, and will be in the centre of the glacier, far from wildlife.Data will be made available through the Canadian Watershed Information Network (CanWIN), a permanent online archive. An archive of the ice itself will be kept at the Canadian Ice Core Laboratory for future use. The results will be shared through consultations in Grise Fiord and Resolute, where data from the deep past can be integrated with knowledge from the communities. We hope these results can guide future community-led research on glaciers closer to the communities, and we have applied for funding from CFI to help make that possible (evaluation in June 2023). During 2024 we hope to employ 1-2 residents of Resolute or Grise Fiord for work on the ice cap—this could involve logistics, camp management, or cooking.

French: n/a (Project is solely in North Baffin, closest communities are Resolute Bay and Grise Fiord)

Inuktitut: ᓂᓚᒃ ᐋᖅᑕᐅᓂᑯ ᒥᓪᓗᕐ ᐊᐅᔪᐃᑦᑐᖓᓂᑦᓘᒃᑕᖅ. ᑐᐊᑎ ᑕᕼᓪ−ᔮᓐᓯᓐ, ᓯᓚᑦᑐᖅᓴᕐᐱᒡᔪᐊᖓ ᒫᓂᑐᕙᐸᕐᓇᒃᑲᑦᑕ ᓂᐅᖅᑐᕈᒪᓪᓗᑎᒍ ᓂᓚᒃ ᐋᖅᓯᕕᒥᓂᐊᕐᓗᒍ ᒥᓪᓗᕐ ᐊᐅᔪᐃᑦᑐᖓ ᐅᒥᖕᒪᐃᑦ ᓄᓇᖓᓐᓂ. ᑖᓐᓇ ᐋᖅᓯᒪᔪᖅ ᐃᒪᓐᓇᑎᒥᐅᓂᐊᒻᒪᑦ 10 ᓰᓐᑐᒥᑦᑕ ᐅᓚᒥᕐᓂᖅᑲᕐᓗᓂ ᐊᒻᒪᓗ ~600 ᒥᑕᓂᒃ ᑕᑭᓂᖅᑲᕐᓗᓂ ᐊᒻᒪᓗ ᐱᖅᑲᓯᐅᔾᔮᓯᒪᓂᐋᕐᓗᓂ ᑐᓴᐅᒪᔾᔪᑎᒃᓴᓂᑦ ᓯᓚᖓᓂᑦ ᐅᑭᐅᖅᑕᖅᑐᖓᑕ ᑲᓇᑕᐅᑉ ᑕᐃᓴᖕᒥᓐᓂᐋᓗᐊᖅᑐᖅ ᐊᕐᖀᒍᓂ ᐅᐋᑦᑎᐊᕈᕐᓇᓴᕐᓂ. ᑖᓐᓇ ᐋᖅᓯᒪᔪᖅ ᐃᑲᔪᕐᓂᐋᕐᒪᑦ ᑮᐅᔭᐅᑎᑦᑎᓗᓂ: • ᑕᐃᒪᓕ ᐃᒪᕕᐅᑉ ᓯᑯᖓᑕ ᖃᓄᐃᓕᖓᓂᖕᒥᑦ ᒪᓕᖅᑲᑦᑕᓚᐅᖅᐹᑦ ᓯᓚᖓᓃᑦ ᐊᑐᖅᑎᓪᓗᒥᑦ ᐊᓂᒍᓚᐅᖅᑐᑦ 20,000 ᐊᕐᖀᒍᐃᑦ? • ᖃᓄᐃᑦᑐᓂᒃ ᓯᓚᐅᑉ ᖃᓄᐃᓕᖓᓕᕐᓂᖓ ᐅᑭᐅᖅᑕᕐᑐᕐᒥ ᐊᐅᔪᐃᑦᑐᖅ ᐊᑐᖅᑲᑦᑕᓚᐅᖅᐹᑦ ᐊᑐᖅᑎᓪᓗᒥᑦ ᐊᓂᒍᓚᐅᖅᑐᑦ ᐊᒻᒪᓗ ᖃᓄᐃᓕᖅᑲᑦᑕᓚᐅᖅᐹᑦ ᖃᓄᐃᓕᑎᑕᐅᓂᕐᒦᑦ? • ᖃᓄᑎᒥ ᐱᑐᖅᑲᐅᑎᒥᓕᕐᒫᑦ ᒧᓪᓗᕐ ᐊᐅᔪᐃᑦᑐᖔ? • ᖃᓄᑎᒥ ᓱᒃᑲᓕᑎᒋᐊᒥᒃ ᒥᓪᓗᕐ ᐊᐅᔪᐃᑦᑐᖅ ᒥᑭᓪᓕᕙᓪᓕᐋᓂᖅᑲᒃᐹ, ᐊᒻᒪᓗ ᖃᓄᑎᒦᖅᑐᒥᒃ ᓯᓚ ᐅᖅᑰᓯᕙᓪᓕᐊᑎᒥᕚ ᑕᐅᕙᓃ?ᐊᑐᕈᓐᓇᕋᑦᑎᒍ ᓄᑖᑦ ᐆᒃᑐᕋᐃᔾᔪᑏᑦ ᐱᓕᕆᑦᑎᐊᕈᑎᖕᒥᑦ ᐱᓕᕆᐊᕆᓇᓱᐋᕐᓗᒥᑦ ᑕᒻᒃᑯᐊ ᐊᐱᖅᑯᑏᑦ ᐅᖅᑰᓯᕙᓪᓕᐋᓂᖓᓄᑦ ᐊᐅᒃᑎᑕᐅᓚᐅᕐᒥᓐᓂᕐᒥᓐᓂ ᐅᓂᒃᑳᖅᓯᒪᓂᕐᒥᑦ ᐊᐅᔪᐃᑦᑑᑉ.ᐱᓕᕆᐊᒃᓴᖅ ᐱᓕᕆᐋᖅᑲᕐᒪᑦ ᑕᐅᕗᖓᕋᔭᕐᓗᓂ ᐅᒥᖕᒪᐃᑦ ᓄᓇᖓᓐᓄᑦ ᒪᕐᕈᐃᖅᓱᕐᓗᓂ, ᐊᑕᐅᓯᐋᕐᓗᓂ ᐱᔭᖅᑐᕋᓯᐋᕐᓗᓂ ᑕᐃᑦᓯᒥᖓᓪᓗᐋᖅ ᐃᓂᒥᓂᐋᖅᑕᑦᑎᓐᓂᑦ ᐋᖅᓯᕕᒥᓂᐋᕐᓗᒍ ᐊᒻᒪᓗ ᐊᑕᐅᓯᐊᕐᓗᓂ ᓂᐅᖅᑐᕕᒥᓗᒍ. 2023−ᒥ, ᐸᕐᓇᒃᑲᑕ ᐱᓕᕆᖅᑎᒦᒃᑐᓂᒃ ᑖᓪᓕᒪᓂᑦ ᖃᐅᔨᓴᖅᓯᔭᖅᑐᕐᑯᔨᓪᓗᑕ ᐊᐅᔪᐃᑦᑐᒥᑦ ᐱᖅᑲᕐᓗᑎᒃ ᓂᓚᖕᒥᑦ ᑕᐃᒧᖕᒫᓇᔪᓐᓇᖅᑐᒥᑦ ᐃᑎᓂᖅᓯᐅᓇᔾᔪᑎᖅᑲᕐᓗᑎᒃ ᐊᒻᒪᓗ ᓄᐊᑦᑎᓗᑕ ᒥᑭᔪᕈᖕᒥᑦ ᐊᐳᑎᒥᒃ ᖃᐅᔨᓴᒐᒃᓴᕐᒥᑦ. ᐃᑎᓂᖅᓯᐅᓇᔾᔪᑎ ᐊᒃᑐᐃᓂᖅᑲᕐᒥᒻᒪᑦ ᐃᓅᖅᑲᑎᒥᓂᒃ ᐅᕙᓗᓐᓃᑦ ᐆᒪᔪᓂᒃ ᑭᓯᐊᓂ ᓇᓗᓇᐃᖅᓯᓂᐋᕐᒪᑦ ᓂᐅᖅᑐᕐᕕᐅᓂᐋᖅᑐᒥᒃ ᐃᓗᓕᖅᑲᕈᓐᓇᓇᐋᕐᓗᒍ ᑐᓴᐅᒪᔾᔪᑎᐅᒃᑲᓐᓂᕈᓐᓇᖅᑐᓂᒃ ᑕᐃᑦᓯᒪᓂᐅᓚᐅᖅᑐᖅ ᓯᓚᒥᕙᓚᐅᖅᑕᖓᓂᒃ. 2024−ᒥ, ᐃᒪᓐᓇᑎᒥᐸᓘᕋᔭᕐᒪᑦ 12 ᐃᓅᖅᑎᒥᑦ ᑕᑉᐹᓂᒃᑲᔭᕐᓗᑎᒃ 2-3 ᑕᖅᑭᓂᒃ ᓯᓂᒃᑕᕐᕕᖕᒦᓪᓗᑎᒃ ᐊᐅᔪᐃᑦᑐᒥ, ᓂᐅᖅᑐᕐᓗᑎᒃ ᐱᖅᓯᕕᐅᓗᓂ, ᐊᒻᒪᓗ ᐆᒃᑐᕋᐃᓗᑎᒃ ᐊᕙᑎᒦᑦᑐᓂᒃ ᐊᐳᑎᓂᒃ. ᐋᖅᑕᐅᓯᒪᔪᖅ ᑐᔫᑎᒥᔭᐅᓂᐊᖅᑐᖅ ᖃᐅᔨᓴᖅᓯᕕᖕᒨᖅᑎᑕᐅᓗᓂ ᐃᓯᒪᓕᐅᕈᑕᐅᕐᑯᓪᓗᒥᑦ ᑕᐃᑦᓯᒪᓂᐅᓚᐅᖅᑐᖅ ᐅᖅᑰᓂᓇᖅᑲᑦᑕᓚᐅᖅᑕᖕᒥᑦ, ᖃᓐᓂᖅᑲᑦᑕᕐᓂᒥᓂᖓᓂᒃ ᐊᒻᒪᓗ ᐃᒪᕕᐅᒃ−ᓯᑯᖓᑕ ᖃᓄᐃᑦᑑᖅᑲᑦᑕᓂᒥᓂᖓᓂᒃ ᑕᒫᓂ ᖃᓂᒥᔭᖓᓂ. ᐆᒃᑐᕋᐃᔪᑎᒥᔭᐅᔪᒥᓃᑦ ᑐᑭᓯᓇᖅᓯᑎᑦᑎᒐᔭᕐᒪᑦ ᖃᓄᐃᓕᖓᖅᑲᑦᑕᐅᓂᖕᒥᓂᒃ ᑕᐃᑦᓯᒪᓂᐅᓚᐅᖅᑐᖅ, ᒫᓐᓇᐅᔪᖅ, ᐊᒻᒪᓗ ᓯᕗᓂᒃᓴᒥ ᐊᓯᑭᒃᐸᓪᓕᐊᓂᖓᓂᒃ ᒥᓪᓗᕐ ᐊᐅᔪᐃᑦᑐᖓᑕ.ᓂᓚᐃᑦ ᐊᒻᒪᓗ ᐊᐳᑏᑦ ᓄᐊᑕᕗᑦ ᒥᑭᓚᒥᒃ ᐊᕙᑎᑦᑎᓐᓂᒃ ᐊᒃᑐᐃᓂᖅᑲᓂᐋᒪᑕ; ᑲᑎᓗᒥᑦ, ᐸᕐᓇᒃᑲᑦᑕ ᓄᐊᑦᑎᔪᒪᓪᓗᑕ ᒥᑭᓂᖅᓴᓂᒃ 10 m3 ᑕᕝᕙᓪᓚᓇᐅᔮᓗᓂ, ᐊᒻᒪᓗ ᐃᓚᖅᑲᒃᑲᓐᓂᖅᓗᓂ ᐊᐳᑎ ᐊᐅᒃᓯᒪᔪᒥᒃ ᓯᓂᒃᑕᕐᕕᒥᔾᔪᑎᓐᓂᑦ ᐊᑐᖅᑕᑦᑎᓐᓂᒃ ᒥᑭᓂᖅᓴᐅᓚᔾᔪᓂ 1 m3

ᑕᕝᕙᓪᓚᕆᐅᔾᔪᓂ ᐊᑐᓂ ᐅᓪᓗᕐᒥ. ᐱᒻᒪᕆᐅᓛᖅ ᐊᕙᑎᑦᑎᓐᓂᑦ ᐊᒃᑐᐃᓂᖅ ᐃᒪᓐᓇᐅᓂᐋᕐᒪᑦ ᐃᓚᓯᔭᕆᐋᖅᑲᕐᓂᐋᕐᔪᑕ ᕐᑯᐋᕿᓐᓇᖕᒥᑦᑐᒥᒃ ᑯᕕᓰᒥᒃ ᓂᐅᖅᑐᖅᓯᒪᔪᒧᑦ ᒪᒥᕐᑯᓇᒍ ᐊᖅᒪᔫᔭᓐᓃᕐᔪᓂ ᓂᐅᖅᑐᖅᑕᐅᓯᒪᓂᖓ. ᐸᕐᓇᒃᑲᑦᑕ ᐊᑕᐃᓐᓇᖅᑎᑦᑎᔭᒪᓪᓗᑕ ᑯᕕᓯᖅ ᓂᐅᖅᑐᖅᓯᒪᔪᒦᖕᒥᓐᓇᕐᓗᓂ ᑭᖑᓂᖓᒍᑦ ᓯᕗᓂᒃᓴᒥ ᐆᒃᑐᕋᑕᐅᒃᑲᓐᓂᖅᑲᑦᑕᕐᑯᓪᓗᒍ ᓂᓚᐅᑉ ᐃᖕᒥᕐᕋᐸᓪᓚᐋᓂᖓ ᐊᒻᒪᓗ ᓂᒡᓚᓇᓂᖅᓯᐅᕈᑎᖓ (ᐱᔭᕐᓂᒥᑦᑐᐋᓗᖓᒪᑦ ᐲᕋᓯᒥᐋᖓ), ᑕᐃᒪᓐᓇᐃᓘᖅᑕᐅᓚᐅᓂᖕᒥᓐᓄᑦ ᐊᑯᑭᑦᑐᓂ ᐊᒻᒪᓗ ᐊᑖᓂᖓᖅᑐᖅ ᐅᑭᐅᖅᑕᖅᑐᕐᒥ. ᑯᕕᓰᕋᔭ ᐊᑦᑕᕐᓇᖅᑎᑦᑎᔫᖕᒥᑦᑐᖅ ᐃᓗᐋᓂᑦᑐᖅ ᐊᐅᔪᐃᑦᑑᑉ ᐊᒻᒪᓗ ᐅᓗᓇᐊᓇᖅᑑᓇᓂ. ᐃᓚᒥᔭᐅᒃᑲᓂᕐᓗᓂ, ᐃᓂᒥᓂᐋᖅᑕᖓ ᐃᖅᑲᓇᐃᔭᕐᕕᐅᔪᑉ ᐅᖓᑖᓂᒻᒪᑦ 400 ᑭᓛᒥᑐᑦ ᐊᐅᓯᐃᑦᑐᕐᒥᑦ ᐅᕝᕙᓘᓐᓃᑦ ᖃᐅᓯᐃᑦᑐᕐᒥᑦ, ᐊᒻᒪᓗ ᕿᑎᖓᓃᓐᓂᐊᕐᒪᑦ ᐊᐅᔪᐃᑦᑑᑉ, ᐅᖓᓯᒡᓗᓂ ᓂᕐᔪᑎᓂᑦ.ᖃᐅᔨᒪᔾᔪᑎᒃᓴᐃᑦ ᐱᔭᒃᓴᐅᓚᖅᑎᑕᐅᓂᐋᖅᑐᑦ ᑲᓇᑕᒥ ᐃᒪᖅᑲᕐᕕᐅᔪᓂᑦ ᑐᓴᐅᒪᔾᔪᑎᒃᓴᓚᕆᓂᕐᒧᑦ ᐱᓚᕆᖅᑲᑎᒥᒻᕕᖓᓂᑦ (CanWIN), ᐋᖅᑭᒃᓯᒪᐃᓇᖅᑐᖅ ᖃᕋᑕᐅᔭᒃᑰᕈᑎ ᑎᑎᕋᒃᓯᒪᔪᓚᐊᖑᓯᒪᔪᖅ. ᑎᑎᕋᒃᓯᒪᔪᓚᐊᖑᓯᒪᔪᑦ ᓂᓚᒃ ᑖᓐᓇ ᐱᓯᒪᔭᐅᓂᐋᕐᒪᑦ ᑲᓇᑕᒥ ᓂᓚᖕᒥᑦ ᐲᖅᑕᐅᓯᒪᔪᓂᒃ ᖃᐅᔨᓴᖅᓯᕕᖕᒦᑎᑕᐅᓗᓂ ᓯᕗᓂᒃᓴᒥ ᐊᑐᖅᑕᐅᔪᓐᓇᓛᕐᑯᓪᓗᒍ. ᐱᔭᓅᒃᑕᐅᔾᔪᑎᖕᒥᑦ ᐱᕐᑲᑎᕐᑲᕈᑕᐅᓂᐊᖅᑐᑦ ᐊᐱᖅᓱᕐᑲᑦᑕᕐᓂᒃᑯᑦ ᐊᐅᓯᐃᑦᑐᕐᒥᒃ ᐊᒻᒪᓗ ᖃᐅᓯᐃᑦᑐᕐᒥᒃ, ᑕᕝᕙᓂ ᖃᐅᔨᒪᔾᔪᑎᒃᓴᑦ ᑕᐅᕙᖔᖅᓯᒪᔪᑦ ᐃᑎᔪᑦ ᐊᓂᒍᖅᓯᒪᔪᑐᕐᑲᕐᓂᑦ ᐃᓚᓕᐅᑎᔭᐅᔪᓐᓇᕐᓂᐊᕐᒪᑕ ᖃᐅᔨᒪᓂᓇᓴᐅᔪᓄᑦ ᓄᓇᓚᓃᖔᖅᓯᒪᔪᓂᑦ. ᓂᓇᐅᒃᑐᒧᑦ ᑕᒪᒃᑯᐊ ᐱᔭᓅᒃᑕᐅᔾᔪᑦ ᒪᓚᒃᑕᐅᑎᑦᑎᔭᓐᓇᕐᑯᓪᓗᒥᑦ ᓯᕗᓂᒃᓴᓇᓂᐊᖅᑕᑦᑎᓐᓂ ᓄᓇᓚᖑ–ᓯᕗᓚᖅᑕᐅᓗᓂ ᖃᐅᔨᓇᓯᐋᕐᓂᐅᔪᓂᑦ ᐊᐅᔪᐃᑦᑐᓂᒃ ᖃᓂᒃᓴᓂᖅᓴᐅᔪᓂᑦ ᓄᓇᓚᖕᓂᑦ, ᐊᒻᒪᓗ ᑐᒃᓯᕋᐅᑎᓚᐅᖅᓯᒪᓚᖅᓄᑕ ᑮᓇᐅᔭᖃᒃᑎᑕᐅᔾᔪᑎᒃᓴᓂᒃ ᐅᑯᓇᖔᖅᑐᓂᑦ ᑲᓇᑕᐅᑉ ᑐᙵᕕᖓ ᐱᓚᕆᔾᔪᓯᐅᓚᖅᑐᒧᑦ (CFI) ᐃᑲᔪᕈᑕᐅᕐᑯᓪᓗᒍ ᑕᒪᓐᓇ ᐊᔪᕐᓇᕈᓐᓃᖅᑎᑕᐅᕐᑯᓪᓗᒍ (ᖃᐅᔨᓴᖅᓯᓂᖅ ᔫᓂ 2023–ᒥ). ᐊᑐᖅᑎᓪᓗᒍ 2024 ᓂᓇᐅᒃᑐᒧᑦ ᐃᖅᑲᓇᐃᔭᖅᑎᑦᑎᓚᔭᕆᒪᓪᓗᑕ 1-2 ᓄᓇᓚᖕᒥᐅᑖᖕᓂᒃ ᖃᐅᓯᐃᑦᑐᕐᒥᑦ ᐅᕝᕙᓘᓐᓃᑦ ᐊᐅᓯᐃᑦᑐᕐᒥᑦ ᐃᖅᑲᓇᐃᔭᕋᔭᕐᓗᑎᒃ ᐊᐅᔪᐃᑦᑐᒥ–ᑕᒪᓐᓇ ᐱᓚᕆᐊᖑᑎᑦᑎᑐᐃᓐᓇᕆᐊᖅᑲᕐᒪᑦ ᐱᕐᑯᑎᓚᕆᓂᕐᒥᑦ, ᓯᓂᒃᑕᕆᐊᕐᕕᐅᓯᒪᔪᒥᒃ ᐊᐅᓚᑦᑎᓂᕐᒥᒃ, ᐅᕝᕙᓘᓐᓃᑦ ᓂᕿᓚᐅᕐᓂᕐᒥᑦ.

Inuinnaqtun: n/a (Project is solely in North Baffin, closest communities are Resolute Bay and Grise Fiord)

Personnel

Personnel on site: 12
Days on site: 90
Total Person days: 1080
Operations Phase: from 2023-03-26 to 2024-08-25

Activities

Location	Activity Type	Land Status	Site history	Site archaeological or paleontological value	Proximity to the nearest communities and any protected areas
Area of Muller ice cap which we will survey--we plan to camp and drill an ice core at one point in this area.	Scientific/International Polar Year Research	Crown	The centre of Muller Ice Cap has, to our knowledge, been visited only by scientists. There were scientific surveys performed from 1959-1962 by McGill University. The site has a weather station installed by Queen's University in 2021.	Although Inuit have inhabited Axel Heiberg Island in the past, the available evidence suggests that was far from our proposed site, near the east coast of the island and not on the ice cap. Our proposed site has no known archaeological value, and is more than 50 km from the closest archaeological sites near Buchanan Lake.	Axel Heiberg Island is currently uninhabited. The proposed site is about 50 km from the Napaqtulik/Napurtulik Proposed Territorial Park. It is about 440 km from Grise Fiord and 580 km from Resolute Bay, the two nearest communities.

Community Involvement & Regional Benefits

Community	Name	Organization	Date Contacted
Grise Fiord	Marty Kuluguqtup, Senior Administrative Officer	Hamlet of Grise Fiord	2022-07-06

Authorizations

Indicate the areas in which the project is located:

North Baffin

Authorizations

Regulatory Authority	Authorization Description	Current Status	Date Issued / Applied	Expiry Date
Nunavut Water Board	We have forwarded the NPC conformity description to NWB and are in the process of applying for a Type B license.	Not Yet Applied		
Nunavut Research Institute	We are preparing an application for a Research License, and will be submitting that application shortly.	Not Yet Applied		

Project transportation types

Transportation Type	Proposed Use	Length of Use
Air	We will reach the site by Twin Otter from Resolute and Eureka	
Land	On site, we will use snowmobiles for surveying. We will use two snowmobiles pulling sleds to do this work.	

Project accomodation types

Temporary Camp

Material Use

Equipment to be used (including drills, pumps, aircraft, vehicles, etc)

Equipment Type	Quantity	Size - Dimensions	Proposed Use
Drill	1	1x2x6 m	Needed to drill an ice core through Mueller Ice Cap. Drill designed to recover a 4 inch diameter core in 1-2 meter sections. Will also be used to recover a small sample of rock beneath the ice.
Ice-penetrating radar	1	2x2x2 m	Needed to determine optimal site to drill. Will be driven across the surface of the ice behind a snowmobile in order to measure ice thickness and layering in the ice.
Snowmobile	2	1x1x2 m	Used for moving around the ice cap and towing radar.
Basler or Twin Otter	1	21x29x5 m	Transportation from Eureka or Resolute to the ice cap.
Large tents	3	8x4x5 m	Shelter while drilling, eating, working, etc.
Personal tents	12	2x2x1 m	Sleeping during work.
Generator	3	1x1x2 m	2 gasoline and 1 diesel generator, used to power radar, drill, and camp.
Ice core analysis unit	1	0.5x0.5x0.5m	Used to measure some basic properties of the ice while we are on the ice cap (the majority of analyses will take place back in a laboratory). This analysis melts ice, with no waste other than the resulting water.

Detail Fuel and Hazardous Material Use

Detail fuel material use:	Fuel Type	Number of containers	Container Capacity	Total Amount	Units	Proposed Use
Propane	fuel	5	100	500	Lbs	Cooking, heating tents.
Gasoline	fuel	3	205	615	Liters	Power snowmobiles and small generators.
Diesel	fuel	30	205	6150	Liters	Power 12 kW generator for ice-core drilling. Approximately 2000 hours at 3 L/hr.
Estisol 140	hazardous	48	205	9840	Liters	This is a chemical, but is generally considered non-hazardous. It will

						be used as fluid to fill the drill hole.

Water Consumption

Daily amount (m3)	Proposed water retrieval methods	Proposed water retrieval location
0	Drinking water will be obtained by melting hand-shoveled snow. We plan to collect ice-core samples and snow samples using ice-core drills (0.15 m3/day drinking water, 0.1 m3/day science samples).	Drinking-water snow will come from the surface of Muller Ice Cap. Scientific samples will be collected from the surface of the ice cap and from the subsurface.

Waste

Waste Management

Project Activity	Type of Waste	Projected Amount Generated	Method of Disposal	Additional treatment procedures
Camp	Combustible wastes	9800 L	We plan to leave the drill liquid, which is a generally safe chemical, in the borehole. This allows future scientists to access the hole if additional measurements are desired. Leaving the fluid like this is standard practice in ice-core drilling, including in sensitive areas. Since the fluid is contained in the hole, and only rises to a level where the ice is impermeable, it does not leak out. At this remote site, there is no risk of it affecting drinking water or impacting wildlife.	The hole will have a cap/casing on top, which prevents anything from getting in and liquid from leaking away.
Camp	Greywater	15 cubic meters	Sump in glacier, buried after use.	n/a
Camp	Non-Combustible wastes	3 cubic meters	All non-human camp waste will be flown out.	n/a
Camp	Sewage (human waste)	2 cubic meters	We plan to leave only urine in a sump in the glacier.	Feces will be flown out in buckets.

Environmental Impacts:

Potential water quality impacts stem from the drill fluid and from fuel use. Drill fluid is needed to keep the hole open during drilling. Leaving this fluid in the hole is standard practice including in sensitive areas (e.g., it is allowed under our permit in the Northeast Greenland National Park). The fluid will be contained in the hole, is not hazardous, and allows for future scientists to make additional measurements if desired. The impact will be mitigated by ensuring that fluid remains within the hole; while safely encased in the hole, the fluid will not harm water quality. Given the distance from the nearest communities, there is no risk of the drill fluid affecting people. The choice of a non-hazardous fluid is a backup in case the fluid escapes, for example due to climate change destabilizing the ice cap. Risk of fuel spills will be mitigated through the use of berms for all drums, and sufficient spill kits for cleanup; we will fly out any contaminated cleanup materials. There will be some noise from aircraft, generators, and snowmobiles; we will mitigate these effects by eliminating extra flights, using small generators only when needed, and driving at low speeds. Negative impacts on polar bears will be mitigated by minimizing scents in camp and bring non-lethal deterrents in addition to firearms; we expect no other biological impacts. We hope for a positive economic impact by employing a community member for work in our camp during 2024.

Additional Information

SECTION A1: Project Info

SECTION A2: Allweather Road

SECTION A3: Winter Road

SECTION B1: Project Info

SECTION B2: Exploration Activity

SECTION B3: Geosciences

SECTION B4: Drilling

SECTION B5: Stripping

SECTION B6: Underground Activity

SECTION B7: Waste Rock

SECTION B8: Stockpiles

SECTION B9: Mine Development

SECTION B10: Geology

SECTION B11: Mine

SECTION B12: Mill

SECTION C1: Pits

SECTION D1: Facility

SECTION D2: Facility Construction

SECTION D3: Facility Operation

SECTION D4: Vessel Use

SECTION E1: Offshore Survey

SECTION E2: Nearshore Survey

SECTION E3: Vessel Use

SECTION F1: Site Cleanup

SECTION G1: Well Authorization

SECTION G2: Onland Exploration

SECTION G3: Offshore Exploration

SECTION G4: Rig

SECTION H1: Vessel Use

SECTION H2: Disposal At Sea

SECTION I1: Municipal Development

Description of Existing Environment: Physical Environment

The proposed site is near the highest point of Muller Ice Cap. This portion of the ice cap is relatively flat with a surface elevation of 1600-1800 m. To the east, the ice cap slopes away gently to land-terminating glaciers. The site is bordered on the west by mountains, with some of the icecap draining through large outlet glaciers that transect the mountain range. Satellite radar data indicate that the ice in the area is moving less than 3 m/yr, with low enough strain rates that crevasses are not expected (and no crevasses are visible in satellite images of the study area). Airborne radar data indicate that the ice is 500-800 m thick in the area, and is underlain by relatively steep topography underneath. The geology directly beneath the site is unknown, but the exposed rock to the west suggests that it is underlain by folded and faulted Triassic and Tertiary sedimentary rocks of the Sverdrup Basin. The site is far enough from the mountains to the west and flat enough that neither rockfall nor avalanches are possible. The site is near the hydrological divide between eastern and western Axel Heiberg Island, and directly on the ice divide between the east and west.Satellite data (from laser altimeters and photogrammetry) indicate that higher areas of the site (<1800 m) have a nearly stable surface elevation at present, with changes in glacier thickness that are indistinguishable from zero. Areas between 1600 and 1800 m are thinning at up to 10 cm/yr. There is substantial thinning of the glaciers that drain the ice cap in all directions (over 1 m/yr at places), suggesting that the proposed site will experience large changes over the coming decades as its outlets retreat and thin. The site is entirely in the dry-snow portion of the accumulation area of the ice cap (i.e. the annual snowfall has sufficient capacity to accommodate the annual melt in its pores). Ground-based observations from 1959-1960 and satellite radar data indicate that there are very few days with substantial snowmelt each year at this site, though this is also likely to change due to a warming climate. The elevation is such that no melt ponds form, although some are seen much lower down on the icecap.This site is well removed from sensitive areas. Because it is on top of the ice cap, we expect no interaction with flora or fauna. The site is 50 km from the site of the Napaqtulik/Napurtulik Proposed Territorial Park, which has a unique fossil forest. It is over 50 km from the archaeological sites near Buchanan Lake on the eastern part of Axel Heiberg Island.

Description of Existing Environment: Biological Environment

The proposed site is all on top of the ice cap and largely devoid of life. There is no vegetation on the ice cap. While some mammals and birds are seen regularly on glaciers, the location of our site away from the ice edge means that there are no food sources for animals near where we plan to work, and thus animal encounters are unlikely.There are four species under the Species at Risk Act whose nominal range includes Axel Heiberg Island: polar bears, Peary caribou, ivory gulls, and the islandica subspecies of Red Knots. Since the site is away from the ocean, at high elevation, and on ice, we expect that Polar bears do not regularly occupy the study site, though it is possible that they occasionally visit. According to the species' recovery plan, community information and surveys agree that the primary Peary Caribou sites on Axel Heiberg Island are east and south of the ice cap, and the migrate from there to the southeast. Environment and Climate Change Canada indicates that they do not generally enter the interior of the ice cap. While the ivory gull range map includes Axel Heiberg Island, Environment and Climate Change Canada indicates no known nesting areas or critical habitat on the island. The gulls nest in a variety of locations, but have not been observed to nest on glaciers or ice caps. According to Environment and Climate Change Canada, Red Knots generally nest in dry south facing areas near water, which are not found at our site. When not nesting, they favor coastal areas, which again do not overlap with our site. In short, while the large-scale maps indicate that four species at risk have ranges that include Axel Heiberg Island, more detailed

information shows that only polar bears might ever go to the interior of the ice cap. We expect such visits to be very infrequent due to the lack of food on the ice cap.

Description of Existing Environment: Socio-economic Environment

The site is far from the closest communities; 440 km from Grise Fiord and 580 km from Resolute Bay. From consultations between our collaborators and community members, the large distance means that this is not an important hunting/fishing area for residents of Grise Fiord and Resolute Bay given the large distance from the communities. The nearest other people are at the McGill Arctic Research Station and Eureka; the McGill station is closest at about 50 km away, and we do not expect our work to have any negative impact on those scientists. Some tourism has taken place in the sounds east of Axel Heiberg Island; this is 75 km from our proposed site. Some tourism reaches the fossil forests 50 km from our site. Besides being distant from other human uses, the site is entirely on the ice cap at high elevation so it is a second step away from areas of socioeconomic importance.The site contains no archaeologically significant areas, and is more than 50 km from the known sites on the eastern part of Axel Heiberg Island. There is no currently protected area in the region, and the proposed site is 50 km from the Napaqtulik/Napurtulik Proposed Territorial Park.

Miscellaneous Project Information

A safety data sheet for the drilling fluid, indicating low risk to human health, is attached.

Identification of Impacts and Proposed Mitigation Measures

The measurements on the core in the field will not leave any chemicals, and the radar operates at frequencies not hazardous for human or animal life, so there should be no impact from making the measurements themselves.The primary impact will be the ice-core borehole, which will contain the drill fluid needed to keep the hole open during drilling. Leaving this fluid in the hole is standard practice including in sensitive areas, since it is difficult to remove and it allows future scientists to return and measure deformation and temperature (e.g., it is allowed under our permit in the Northeast Greenland National Park). The fluid will be contained in the hole, is not hazardous, and allows for future scientists to make additional measurements if desired. The impact will be mitigated by ensuring that fluid remains within the hole and that the hole is clearly marked; while safely encased in the hole, the fluid will not harm water quality. Given the distance from the nearest communities, there is no risk of the drill fluid affecting people. The choice of a non-hazardous fluid is a backup in case the fluid escapes, for example due to climate change destabilizing the ice cap.Risk to water quality from fuel spills will be minimized by keeping all drums within temporary plastic berms. We have already requested cleanup kits and berms from the Polar Continental Shelf Project. Any contaminated cleanup materials will be flown out.There will be some noise from aircraft, generators, and snowmobiles. This noise will have minimal impact because of the location of the work at the centre of the ice cap. We will further mitigate these effects by eliminating extra flights, using small generators and running them only when needed, and driving at low speeds.We think it most likely that we will have no impact on wildlife, since there is generally little life on the ice cap. However, interaction with a polar bear is possible but unlikely. The negative impacts of a possible polar bear encounter will be mitigated by minimizing scents in camp (storing food in sealed containers as much as possible, cooking away from sleeping tents) and bring non-lethal deterrents (bear bangers and spray) in addition to firearms.We hope for a positive economic impact by employing a community member for work in our camp during 2024.

Cumulative Effects

The ice cap has only seen sporadic scientific work over the last 65 years, and to our knowledge there have only been two visits to our study are during the last few decades. The last time people camped within the study area was in 1962. We thus expect no cumulative impacts on the ground.The project will add a small number of flights to the cumulative aircraft operations in the area, but since the total number of flights is still small we expect the cumulative effect to be low. To the extent possible, we will maximize space on flights and minimize cargo so that there are no more aircraft movements than strictly necessary to complete the work.

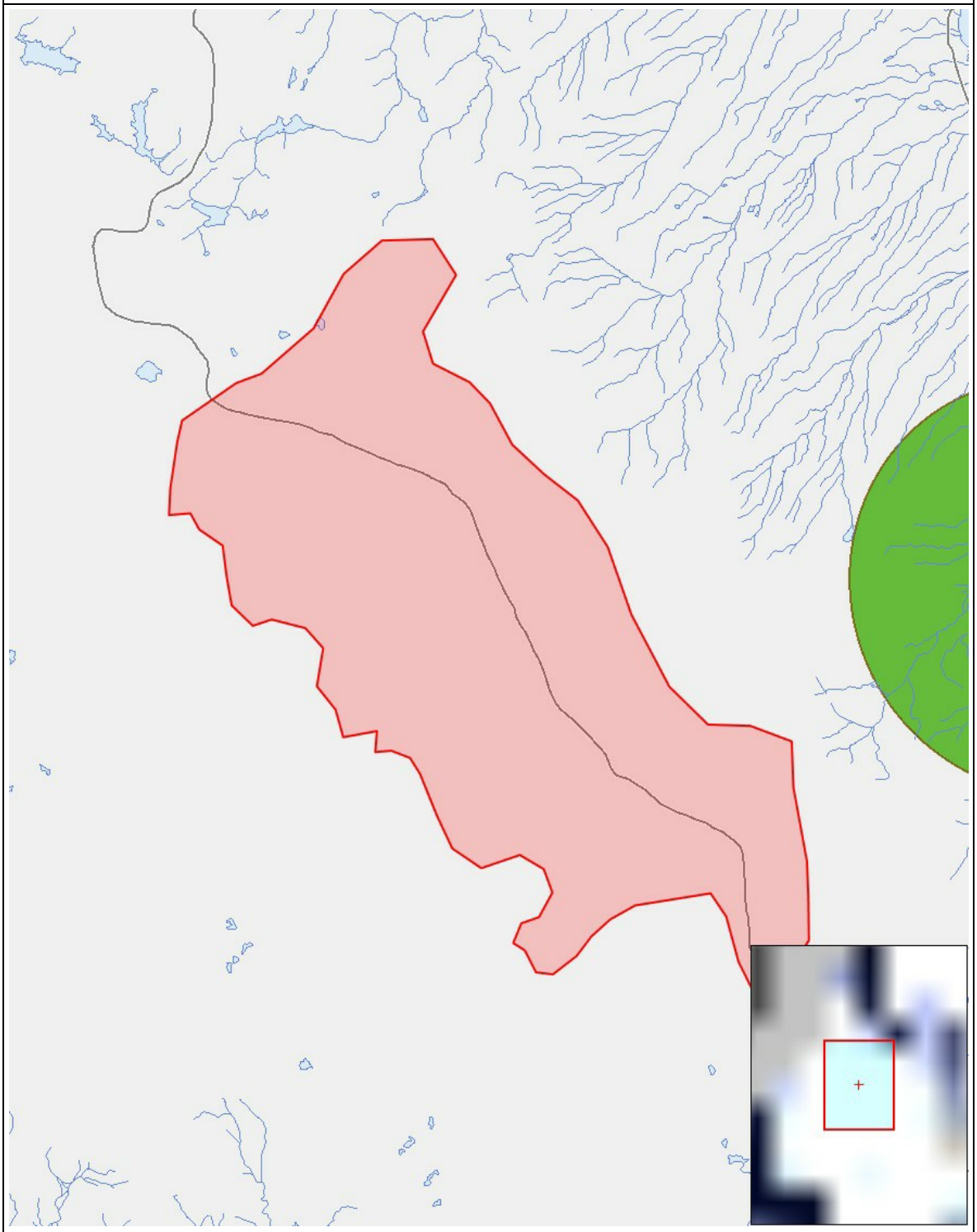
Impacts

Identification of Environmental Impacts

	PHYSICAL	Designated environmental areas	Ground stability	Permafrost	Hydrology / Limnology	Water quality	Climate conditions	Eskers and other unique or fragile landscapes	Surface and bedrock geology	Sediment and soil quality	Tidal processes and bathymetry	Air quality	Noise levels	BIOLOGICAL	Vegetation	Wildlife, including habitat and migration patterns	Birds, including habitat and migration patterns	Aquatic species, incl. habitat and migration/spawning	Wildlife protected areas	SOCIO-ECONOMIC	Archaeological and cultural historic sites	Employment	Community wellness	Community infrastructure	Human health
Construction																									
-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-		-	-	-	-
Operation																									
Scientific/International Polar Year Research			-	-	-	-	M	-	-	-	-	-	-	M		-	M	-	-	-		-	P	-	-	-
Decommissioning																									
-			-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-		-	-	-	-	-

(P = Positive, N = Negative and non-mitigatable, M = Negative and mitigatable, U = Unknown)

Project Location



List of Project Geometries

1	polygon	Area of Muller ice cap which we will survey--we plan to camp and drill an ice core at one point in this area.