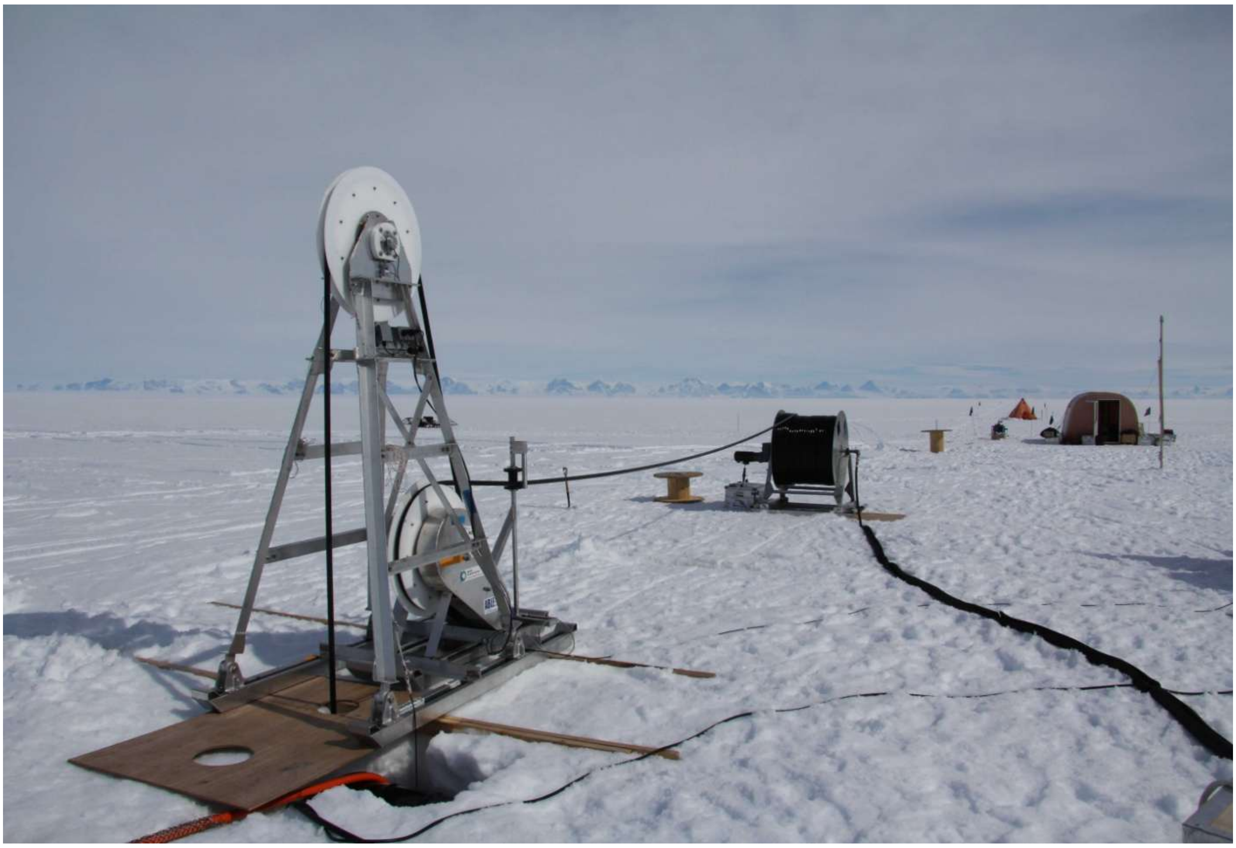
Initial Environmental Evaluation

British Antarctic Survey *Prescient Site 5* Hot Water Drilling Project 2026/27 to 2036/37



Submitted to the Polar Regions Department, Foreign, Commonwealth and Development Office, as part of an application for a permit / approval under the Antarctic Act 1994.

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Cover image: Hot water drilling through an Antarctic ice shelf. Source: British Antarctic Survey

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Acronyms and Abbreviations

ACBR	Antarctic Conservation Biogeographic Region
ADCP	Acoustic Doppler Current Profiler
AGM	Absorbent Gas Mat (Lead-acid battery)
ApRES	Autonomous phase-sensitive Radio Echo-Sounder
ATCM	Antarctic Treaty Consultative Meeting
ATCP	Antarctic Treaty Consultative Party
ATS	Antarctic Treaty Secretariat
ALE	Antarctic Logistics and Expeditions
ASPA	Antarctic Specially Protected Area
ASMA	Antarctic Specially Managed Area
BAS	British Antarctic Survey
CCAMLR	Commission for the Conservation of Antarctic Marine Living Resources
CEE	Comprehensive Environmental Evaluation
CEP	Committee for Environmental Protection
CO_2	Carbon Dioxide
COMNAP	Council of Managers of National Antarctic Programs
CTD	Conductivity-Temperature-Depth
EIA	Environmental Impact Assessment
DTS	Distributed Temperature System
Flubber	Flexible water container
FCDO	Foreign, Commonwealth and Development Office
GHG	Greenhouse Gas
GIS	Geographical Information System
GPS	Global Positioning System
HSM	Historic Site and Monument
IBA	Important Bird and Biodiversity Area
IEE	Initial Environmental Evaluation
Kg	Kilograms
km	Kilometres
km^2	Kilometres square
km/h	Kilometres per hour
kW	Kilowatts
L	Litre(s)
Mkm^2	Million square kilometres
m	Metre(s)
m/sec	Meters per second
S	South
SCAR	Scientific Committee on Antarctic Research
tCO2e	Tonnes of Carbon Dioxide Equivalent
SDA	Royal Research Ship Sir David Attenborough (also RRS SDA)
UN	United Nations
UOM	Unit of Measure
V	Volts
°C	Degrees Centigrade

Non-Technical Summary

Introduction

The British Antarctic Survey (BAS) is the UK's national Antarctic operator, responsible for much of the UK's scientific research in Antarctica.

This Environmental Impact Assessment (EIA) reviews the significance of the environmental impacts that will or could arise from the proposed hot water drilling and instrumentation deployment below the Ronne ice shelf at *Site 5*, during the 2026/27 season.

This EIA identifies mitigation measures to minimise identified environmental impacts.

Legal context and guidance material

All activities in Antarctica are subject to the provisions of a series of international agreements that constitute the Antarctic Treaty System.

The Protocol on Environmental Protection to the Antarctic Treaty (the Protocol) was adopted by the Antarctic Treaty Consultative Parties in 1991. It entered into force in January 1998.

The EIA provisions of the Protocol are enacted in UK law through the Antarctic Act 1994 and Antarctic Act 2013 and Antarctic Regulations 1995/490 (as amended). The Act applies to both governmental and non-governmental activities in Antarctica.

The EIA documented here has been undertaken to meet the requirements of the Protocol and relevant UK legislation.

Scope of the EIA

Proposed work

The *Site 5* project proposes to drill through Ronne Ice Shelf, approximately 750 m, to the ocean (Weddell Sea), inserting oceanographic instrumentation on a mooring line, using hot water drilling during the 2026/27 Antarctic summer season. The surface equipment will be in place for approximately ten years (2026/27 to 2036/37) and will be visited and maintained every two years. The oceanographic equipment will remain in the ocean.

The principal scientific objective is to continue the time series (first started in the 1998/99 season) of ocean properties at a key location for monitoring the response of the ocean cavity beneath the ice shelf to climate forcing.

The proposed work is led by BAS with a collaboration with the United States on the IceNode instrument deployment, which will be within a second, BAS drilled, borehole. This borehole will be at the same depth and drilling method as the first, and drilled by BAS drillers, using the BAS drill.

Geographical scope

The proposed site is approximately 12 km west of the southwest coast of Berkner Island on the Ronne ice shelf (see Figure 1).

The location of this site has been determined by previous works identified as Site 5, Site 5a, Site 5b, and Site 5c. This project proposes redrilling at the original geographic Site 5 location (-80.33603,-54.77333), as shown on Figure 1.

Figure 1: General Location of Proposed Site 5 Drilling Project, Indicated by Red dot. Produced by the Mapping and Geographic Information Centre, British Antarctic Survey, 2026

Temporal scope

The proposed drilling and deployment will take place in the 2026/27 Antarctic field season, with follow up maintenance every two years for ten years (2026/27 to 2036/37). As with previous deployments at this location, surface equipment will be removed once the equipment is no longer functional (usually ten years), but the oceanographic equipment will remain in the ocean.

In total, field camp set up, preparation of equipment, and drilling, followed by testing and deployment of equipment will occur for approximately six weeks. Two access holes (BAS and IceNode), and two ancillary holes (each connected to a main borehole) will be drilled. The hot water drilling will be a continuous 24-hour operation over one to two days for each hole.

Logistical Scope

This EIA also includes consideration of logistics needed to facilitate the proposed *Site 5* project, in the form of DASH-7 and Twin Otter flights from Rothera Research Station to the field site, alternative travel from Union Glacier to the field site, travel on the *RRS Sir David Attenborough* (SDA) if any, and the use of skidoos.

A third-party contractor (ALE) was procured to fly in equipment and fuel to the site during the 2025/26 season, this is not assessed in this EIA, as their activities have been covered by a separate EIA (*Site 5 Drill Positioning PEA*).

Proposed Approach

Drilling

Hot water drilling uses hot water gained from snow, heated and pumped to a nozzle which then allows drilling into the ice. The water is recycled back up an ancillary bore hole (which contains the bore hole pump) to allow reuse of the heated water and reduce the amount of snow melting required.

Drilling Camp

The drill team will be input along with any remaining equipment at the *Site 5* location.

The camp will include up to five personnel tents (pyramid or clam tents), for up to eight people and related infrastructure, including a Weatherhaven tent for working in.

Deployment of Equipment

Once the boreholes are drilled, oceanographic equipment will be deployed to the ocean. The BAS equipment will be moored to the surface and left in situ, monitoring ocean conditions for up to 10 years. The IceNode equipment will release from its mooring and move though the water column, eventually leaving the ice shelf.

For each mooring, some equipment will remain on the surface including data loggers, ApRES[1] and solar panels. For the BAS equipment borehole, these will be maintained and raised above snow level every two years. The deployed instruments will eventually be lost to the ocean floor, once they melt out of the ice. For IceNode, the surface equipment will be removed at the first maintenance cycle, however there is uncertainty if the IceNode will be recovered once it leaves the ice, as it will only transmit its position for a limited time.

Area of Disturbance

The area likely to be impacted by the drilling and camp activities is 50 x 150 m.

The boreholes will descend to a depth of approximately 750 m to the ocean (ancillary boreholes will be to 90 m) and will be up to 35 cm in diameter.

The area impacted by the deployed instruments will depend on the way the ice shelf flows and where they melt out of the ice and are deposited to the ocean floor. It is expected they will have local impacts.

The IceNode will travel out from under the Ice Shelf but there is uncertainty where it will end up. It is likely that it will be lost to the ocean floor. It is expected to have local impacts if not recovered.

Environmental Aspects

A number of environmental aspects have been identified for this proposed project, including:

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[1]ApRES phase-sensitive radar is a low-power, light-weight instrument developed in a collaboration between BAS and University College London

- input/uplift and maintenance flights of personnel and equipment
- SDA operations, proportional to the amount of equipment/number of personnel transported, and duration on board (if any).
- skidoo, personnel movements, and drilling activities to the ice sheet surface;
- impacts of camp set up and living on the snow/ice surface (e.g., tent footprints and wastewater discharge);
- impacts to the marine environment;
- emissions from generators (petrol), burners (aviation fuel), skidoos (petrol), and cooking equipment (kerosene);
- potential for spills of fuel, glycol and other liquids;
- wastes produced by the project, and their transportation to Rothera;
- inadvertent loss of waste;
- potential for introduction of non-native species and biosecurity concerns;
- loss of equipment (planned and unplanned); and
- potential impact on wilderness values.

Alternatives

Several alternatives were considered in the environmental impact process.

Do Not Drill – Do Nothing

Not drilling would eliminate all associated environmental impacts; including those that arise from aircraft operations.

Such an approach would also assist in maintaining perceptions of Antarctic wilderness.

This alternative has been considered and rejected on the grounds of the predicted value of the information from the instrument deployment being scientifically valuable in climate research.

Not to Redeploy the Mooring

The alternative strategy is not to redeploy a mooring, but to continue maintaining the Site 5a mooring until the last instruments cease to work. The ApRES at the site would continue to be maintained, which will provide a time series of ice shelf basal melt rates.

This alternative has been considered and rejected on the grounds that relying wholly on Site 5a is not a sustainable strategy, as the instruments continue to fail and move further out of position.

Deploying Instruments using Scientific Cruises

It could be possible to deploy oceanographic instruments from a ship and moor them in the open ocean near the ice front.

This alternative has been considered and rejected as mooring instruments in the open ocean reveals little about changes in the circulation beneath the ice shelf, and the constant northward motion of the ice front would result in the need to routinely retrieve and redeploy the moorings and would be expensive in terms of ship time and carbon.

The Proposed Approach

The proposed approach enables BAS to maintain its long-term observatory on Ronne Ice Shelf, thereby allowing the scientific community to monitor conditions in the sub-ice shelf cavity, driven by processes over the continental shelf. The proposed approach also allows the opportunity to trial the IceNode equipment and gather additional data to that available with current BAS instrumentation.

Current Environmental State

Physical Environment

The proposed project site is located on the Ronne ice shelf near Berkner Island on the Antarctic Peninsula. Ronne Ice Shelf is flowing in a generally northward direction towards the Weddell Sea, at a rate of 374 m per year, moving parallel to the nearby Berkner Island coast.

The proposed site is located in Environmental Domain, Environment P – 'Ross and Ronne-Filchner ice shelves'. As the proposed site is on ice shelf, it is outside of recognised ACBRs.

Climate

The summer air temperature ranges between -4, and near zero, with wind generally below 40 knots. Snow accumulation varies greatly from year to year, but averages around 0.5 m per year. There is very little melting across the ice shelf, with no visible ice layers when digging.

Nearer the ice front, during summer the air temperatures are occasionally high enough to allow misty rain but, in general, higher summer temperatures tend to be between -3 and -5 degrees.

Areas of interest:

The *Site 5* drilling activities are confined to snow and ice-covered terrain and therefore will not be visiting any ice-free areas.

The *Site 5* project is not near any known wildlife concentrations.

The proposed project is 326 km away from the nearest IBA (Antarctica Marine 20); 241 km from the nearest ASPA (Davis Valley and Forlidas Pond, Dufek Massif); 876 km from the nearest ASMA (Amundsen-Scott South Pole Station, South Pole); and 502 km from the nearest HSM (Belgrano station's cross).

The drilling will take place in an area that has been subject to previous human activity and has previously had research projects there.

Cumulative Impacts

There has been previous activity at this site (see Section 3.1.1, page 15), drilling and oceanographic equipment deployment has been occurring at this location since the 1990s.

Additionally, since the first installations, there have been ongoing visits to site every two-seasons to raise and maintain equipment. Work at Site 5 was recently assessed by an IEE (2014/18) and regular PEAs (2020/12, 2021/22, 2024/25) for maintenance. Additionally, input of fuel and equipment in the 2025/26 season (PEA) should be considered in regard to cumulative impacts.

The emissions generated from the project, which contribute to cumulative impacts, will be calculated as part of the BAS carbon reporting, with estimates provided in Section 8.5.

The cumulative impacts identified for this project are contributions to:

a) Contamination of the glacial environment
b) Contamination of the marine environment
c) The release of gases, including greenhouse gases
d) Loss of wilderness values in Antarctica

Assessment of Environmental Impacts

Given that all activities associated with the proposed *Site 5* drilling project will be constrained to the ice and snow surfaces, the glacial environment has the potential to be most heavily impacted. However, the nature of the project means that oceanographic equipment will remain in the ocean indefinitely and will therefore have an impact on the marine environment.

Use of aircraft, skidoos, generators and cooking equipment create heat, gas and particulate emissions that may impact the immediate snow and ice environment through the release of particulates.

Physical disturbance will occur through drilling, skidoo use and movement of snow for the camp. Deployment of the oceanographic equipment will result in lost equipment over time. Any accidental releases of hazardous substances or waste materials will contaminate the ice shelf or marine environments.

Waste will need to be managed and removed, except for human liquid waste and sieved grey water, which will be disposed to the ice sheet.

All human activity could impact on perceptions of Antarctic wilderness.

The Assessment of Risk

Risk is evaluated, and given a score (as used by Oerter, 2000), using the significance of a given potential impact, the spatial extent, duration, severity, and likelihood of the identified potential impacts. A low-risk impact (1 to 15) would be local in extent, short term, have a minimal severity affect, and be unlikely to occur. Medium-risk (16 to 35) would have a more than local extent, would be over a medium term would have an effect on the environment, and be possible but unlikely. While a high-risk (36 to 143) impact would have a major extent, be long term, have high severity, and be likely to occur or be probable. With the most potential for harmful impact, very high-risk (144 to 256) activities would have a large-scale impact, be permanent, irreversible, and unavoidable.

With no treatments in place, five of the activities are assessed as 'high-risk', one as 'medium-risk' and three as 'low-risk'; however, once the mitigations are considered three are 'medium risk' and the remaining six are 'low-risk' predominantly due to the scale and duration of the activity.

Therefore, the proposed activities are classified as no more than minor or transitory.

Mitigations

Generally, BAS aims to prevent or reduce potential environmental impacts from activities through careful planning, pre deployment training, and effective execution of field programmes. Also, for almost all sources of impact, practicable treatment options to mitigate those impacts have been identified.

Key mitigation identified in this EIA include:

- Limiting the number of people on, and flights to/from, site
- Effectively managing and removing waste
- Effectively managing fuel, oils, and glycol
- Limiting the footprint of the drilling and camp

Provided the mitigation measures identified in this EIA are adhered to, the environmental impacts of the planned activities are considered to be largely avoidable or can be minimised and therefore are no more than minor or transitory.

Monitoring and Record Keeping

This assessment has not identified the need for dedicated monitoring to be undertaken. Nonetheless, records will be maintained for post-season reporting purposes.

Every effort will be made to avoid unnecessary impacts. Where an incident results in impacts, such as lost equipment or fuel spills, this will be documented and reported to the BAS Environment Office and to the FCDO in accordance with the conditions of the BAS Operational Permit. Post season reporting will also be undertaken.

Gaps in Knowledge and Uncertainties

Due to the extreme, changeable, and unpredictable environmental conditions, drilling activities will need to retain a degree of flexibility to accommodate changing weather, logistical (including potential transport via third party contractors) and scientific requirements.

The uncertainties are assessed as being unlikely to have significant implications for the identified environmental impacts nor for the overall conclusion of the EIA.

Summary and Conclusions

Overall, this environmental impact assessment considers that the potential environmental impacts arising from the *Site 5* drilling programme will have **no more than a minor or transitory impact** on the environment.

It is concluded that this level of predicted impact is acceptable given the significant scientific knowledge that will be gained as a result of BAS' ongoing research and the anticipated knowledge gained during the *Site 5* project.

1 Introduction

1.1 British Antarctic Survey

The British Antarctic Survey (BAS) is the UK's national Antarctic operator, responsible for much of the UK's scientific research in Antarctica.

The BAS Vision is: To be a world-leading centre for polar science and polar operations, addressing issues of global importance and helping society adapt to a changing world.

The BAS Mission is a research-driven organisation recognised for:

- commitment to excellence in science.
- operational professionalism and innovation in everything we do.
- a partner of choice for science, operations and business wherever polar expertise can be applied.
- safely delivering complex operations in extreme environments.
- commitment to environmental stewardship of the polar regions.
- developing our staff to reach their full potential.
- sustaining an active and influential presence in Antarctica on behalf of the UK, and playing a leadership role in Antarctic affairs.
- engagement with policy makers, government and the public.

Operationally, BAS' strategic aim is to provide and operate world-leading research infrastructure that enables scientists from the UK, and colleagues from many nations, to work safely and effectively in the polar regions. A key goal is for BAS to be recognised nationally and internationally as a partner of choice for polar operational expertise wherever it can be applied.

BAS currently operates the year-round Rothera Research Station 'Rothera' on Adelaide Island to the west of the Antarctic Peninsula (Figure 2).

BAS also has a summer only locations at Fossil Bluff (used for refuelling) and at Sky Blu, which has a permanent blue ice runway, is used mainly for refuelling for deep field operations, and is the closest infrastructure to the proposed *Site 5* drill site.

In relation to the proposed project, BAS also operates the *Royal Research Ship (RRS) Sir David Attenborough* (Figure 3) and an aircraft fleet which currently includes a DASH-7 and four De Havilland Twin Otter aircraft (Figure 4).

The *Site 5* project team (and any remaining equipment) will be input into the project site from Rothera with Twin Otter aircraft (alternatively via Union Glacier to the field site with a third-party contractor). Some equipment arrived at Rothera by Dash in 2025/26, ready to be flown by Twin Otter to site, however the majority of equipment and fuel has been flown from Union Glacier to site by a contractor in 2025/26.

In 2026/27 the teams and equipment will likely transit through the Fossil Bluff and/or Sky Blu locations but may only refuel there. The input of equipment, including fuel, has mostly occurred in 2025/26 season and is not covered by this EIA, as it assessed under the *Site 5 drill positioning* PEA.

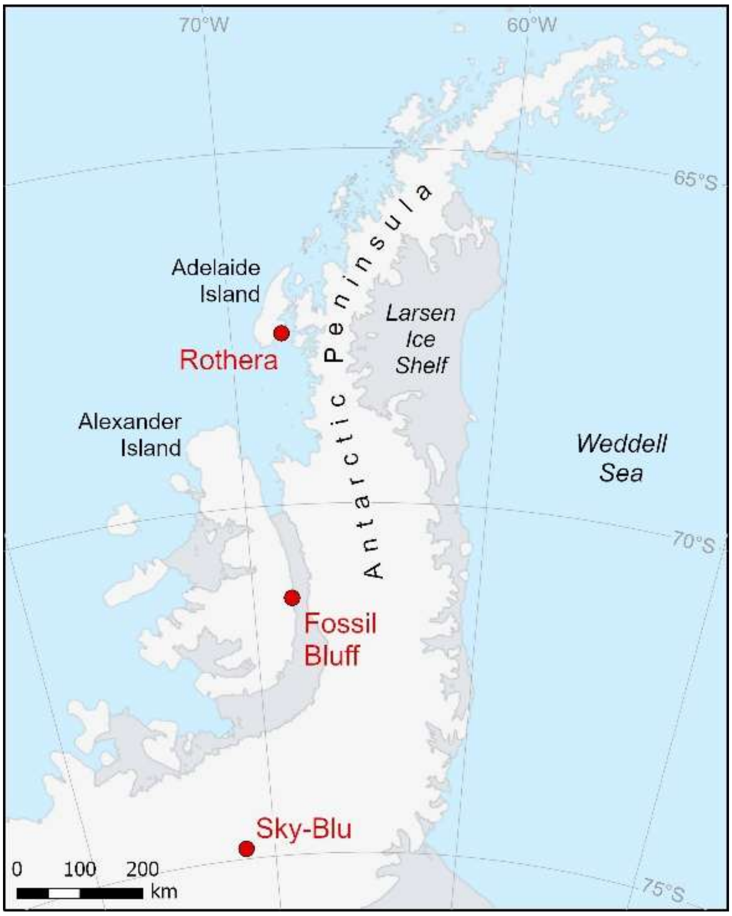

Figure 2: BAS Rothera Research Station and hub Locations potentially used by Site 5. Produced by the Mapping and Geographic Information Centre, British Antarctic Survey, 2024.

Figure 3: Royal Research Ship Sir David Attenborough.

Figure 4: BAS Twin Otter.

1.2 Antarctic Research

In the context of its published Science Strategy ‘Polar Science for a Sustainable Planet’, BAS facilitates an array of multi-disciplinary research programmes to investigate and monitor environmental change in Antarctica and the Southern Ocean.

The vision over this 10-year strategy is to deliver the scientific evidence needed by decision-makers in policy, industry, and society, to move us towards a sustainable future. The strategy focuses on five key themes of global significance, almost all of which require some degree of deep field research.

Theme 1: ‘Climate Change Science for Developing Resilience’ - targets how the Arctic and Antarctic respond to and mitigate climate change.

Theme 2: ‘Conserving Polar Biodiversity’ - focusses on how biodiversity at the poles responds to change.

Theme 3: ‘Protecting Coastal and Technical Infrastructure’ - addresses the impact on infrastructure and societies of sea level rise and space weather.

Theme 4: ‘Sustaining Livelihoods and Societies’ - considers environmental changes across Earth’s frozen regions and how these affect societies and livelihoods.

Theme 5: ‘Safeguarding our Future’ - addresses potential severe impacts of reaching thresholds and triggering extreme changes in the polar environment.

2 Legal Context and Guidance Material

All activities in Antarctica are subject to the provisions of a series of international agreements that constitute the Antarctic Treaty System. These international agreements are enforced through domestic legislation enacted by those countries with active Antarctic involvement, achieved through, for example, the mounting of regular research expeditions and/or establishing a presence in Antarctica through the operation of Antarctic stations or bases.

This Chapter of the EIA:

- describes the relevant international agreements and domestic legislation that applies to BAS field activities, and
- summarises relevant measures agreed under the Antarctic Treaty System.

2.1 International Requirements

The Protocol on Environmental Protection to the Antarctic Treaty (the Protocol) was adopted by the Antarctic Treaty Consultative Parties (ATCPs) in 1991. It entered into force in January 1998.

Article 3 of the Protocol sets out environmental principles for the conduct of activities in Antarctica. Article 3 provides that the protection of the Antarctic environment and the intrinsic value of Antarctica, including its wilderness and aesthetic values and its value as an area for the conduct of scientific research, in particular research essential to understanding the global environment, shall be fundamental considerations in the planning and conduct of all activities in the Antarctic Treaty area.

Article 3 also requires that activities in the Antarctic Treaty area are planned and conducted so as to limit adverse impacts on the Antarctic environment and that those activities must be planned and conducted on the basis of information sufficient to allow prior assessments of, and informed judgments about, their possible impacts on the Antarctic environment. Such judgements must take account of:

i. the scope of the activity, including its area, duration and intensity;
ii. the cumulative impacts of the activity, both by itself and in combination with other activities in the Antarctic Treaty area;
iii. whether the activity will detrimentally affect any other activity in the Antarctic Treaty area;
iv. whether technology and procedures are available to provide for environmentally safe operations;
v. whether there exists the capacity to monitor key environmental parameters and ecosystem components so as to identify and provide early warning of any adverse effects of the activity and to provide for such modification of operating procedures as may be necessary in the light of the results of monitoring or increased knowledge of the Antarctic environment and dependent and associated ecosystems; and
vi. whether there exists the capacity to respond promptly and effectively to accidents, particularly those with potential environmental effects.

Article 8 of the Protocol formalises these requirements by requiring an environmental impact assessment to be prepared in advance of any activity taking place in the Antarctic Treaty area. The level of the environmental impact assessment is determined by whether the activity in question is identified as having 'less than', 'no more than' or 'more than' a 'minor or transitory' impact on the environment.

The detailed procedures for preparing and processing environmental impact assessments are set out in Annex I to the Protocol. If a proposed activity is determined, by means of a preliminary assessment, to have less than a minor or transitory impact, then it may proceed. If an activity is determined as being likely to have no more than a minor or transitory impact, then an Initial Environmental Evaluation (IEE) must be prepared. If a preliminary assessment or IEE indicates the potential for the activity to have more than a minor or transitory impact, or if such an impact is otherwise determined to be likely, then a Comprehensive Environmental Evaluation (CEE) must be prepared.

Preliminary assessments and IEEs are processed within the domestic legal and administrative systems of each Antarctic Treaty Party. Draft CEEs are, however, required to be made publicly available, and to be made available for consideration by the Antarctic Treaty System's Committee for Environmental Protection (CEP). The CEP's advice on the quality of a draft CEE is provided to the Antarctic Treaty Consultative Meeting (ATCM). Comments and advice provided by other Antarctic Treaty Parties and the ATCM must be addressed in a final CEE, which is used as the basis for making a decision about whether and how the activity in question will be conducted.

The CEP has prepared guidance material to assist those preparing EIAs. The most recent version of these guidelines was adopted by the 39th ATCM (Resolution 1 (2016)). These guidelines have been consulted in the preparation of this EIA.

2.2 National Requirements

The EIA provisions of the Protocol are enacted in UK law through the Antarctic Act 1994 and Antarctic Act 2013 and Antarctic Regulations 1995/490 (as amended). The provisions of the legislation apply to any person who is on a British expedition to Antarctica, where a British expedition is defined as an expedition "that is organised in the United Kingdom, or the place of final departure for Antarctica of the persons on the expedition was in the United Kingdom". The Act applies to both governmental and non-governmental activities in Antarctica.

The Act is administered by the Foreign Commonwealth and Development Office (FCDO) and the Secretary of State makes the final determination on whether an activity may proceed taking into account the FCDO's recommendations. It is an offence under the Act to enter Antarctica without a permit issued by the Secretary of State.

The Act also prohibits the following activities unless a Specialist Activity permit is obtained:

- undertaking mineral resource activities;
- intentionally, killing, injuring, capturing, handling or molesting any native mammal or native bird;
- intentionally disturbing native mammals or native birds;
- removing or damaging any native plant so as to significantly affect its local distribution or abundance, or significantly damaging a concentration of native plants;
- causing significant damage to the habitat of any native mammal, bird, plant or invertebrate;
- introducing any species of non-native animal or plant;

- entering an Antarctic Specially Protected Area (ASPA), or an area designated as protected by the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR); or
- damaging, destroying or removing a designated historic site or monument.

Logistical activities are covered by the BAS Operating Permit, which, for BAS-led activities is organised directly between BAS and the FCDO.

The Secretary of State has discretion under the Act to set conditions regarding the proposed activity. Such conditions may relate to, for example, managing compliance, undertaking environmental monitoring and post-activity reporting. Under the provisions of the Act, non-compliance is an offence carrying a penalty of up to two years imprisonment or a fine or both.

2.3 Applicable ATCM Measures and Resolutions

In addition to the general provisions of the Protocol outlined above, the ATCM has, over time adopted a suite of additional agreements (in the form of Recommendations, Resolutions or Measures) several of which are pertinent to the proposed activities in that they relate specifically to the issue of Antarctic logistical and operational activities, or environmental management.

Relevant agreements are highlighted here for completeness and will be considered in this environmental impact assessment and in the conduct of the planned activities.

2.3.1 Environmental Management in Antarctica

Measures related to environmental management in Antarctica that may be relevant to the proposed *Site 5* drilling project include:

- Recommendation XV-5 (1989) – Environmental Monitoring Activities
- Resolution 2 (2005) – Guidelines for Environmental Monitoring
- Resolution 1 (2016) – Revised Guidelines for Environmental Impact Assessment in Antarctica
- Resolution 4 (2016) – Non-native Species manual (revised 2019)
- Resolution 1 (2023) – Consideration of Mitigation Measures in Environmental Impact Assessment

2.4 COMNAP Guidance Material

The Council of Managers of National Antarctic Programs (COMNAP) provides a forum for cooperation among National Antarctic Programmes that have responsibility for delivering and supporting scientific research in the Antarctic Treaty area on behalf of their respective governments. COMNAP guidance material that may be relevant to the proposed *Site 5* drilling operations include:

- Checklists for Supply Chain Managers for the Reduction of Risks of Introduction of Non-native Species; and
- COMNAP Guidelines for Emergency Response and Contingency Planning

The above obligations and guidance material, along with BAS guidance materials, have been considered in the preparation of this EIA and, where relevant, in the control measures identified to minimise the impacts of activities undertaken in Antarctica.

3 Scope Of The EIA

This Environmental Impact Assessment evaluates the environmental consequences that will or could arise from the proposed *Prescient Site 5* (*Site 5*) project hot water drilling and oceanographic equipment deployment activities for the austral summer season 2026/27.

This IEE is proposed to cover the ten year install and maintenance period for *Site 5* and continued maintenance at Site 5a (2026/27 to 2036/37).

The aim is to continue a patchy but valuable time series of ocean properties at a key location for monitoring the response of the ocean cavity beneath the ice shelf to climate forcing.

The proposed project is BAS led with a collaboration on some equipment deployment with the United States, which will use a second BAS drilled borehole. This EIA covers hot water drilling for two boreholes, deployment, maintenance for BAS, (and recovery, where relevant) of both BAS and US oceanographic and related surface equipment.

This Chapter describes the scope of the EIA.

3.1 Hot Water Drilling in Antarctica

British Antarctic Survey leads the world in hot water drilling through ice, having developed and applied the technique of hot water drilling to provide subglacial access for more than 40 years. This technique enables direct observations and sampling of the ocean and seabed beneath floating ice shelves and sediments beneath grounded ice. These observations are central to characterising sub ice shelf oceanographic processes, ice-ocean and ice-bed interactions, benthic biology, biogeochemical processes, subglacial ecosystems, and revealing recent ice history captured in subglacial sediments (BAS, 2026).

BAS hot water drills have reliably provided numerous subglacial access holes up to 941 m deep through Filchner-Ronne, Larsen-C, and George VI ice shelves, Fimbul Ice Shelf, Nansen Ice Shelf, Thwaites Glacier and Petermann Glacier (Greenland), and up to 2154 m on Rutford Ice Stream (BAS, 2026).

3.1.1 History of Site 5 drilling

The proposed work is part of a longer timeseries of data collection with ApRES installation and drilling covered by *an IEE* (*Initial Environmental Evaluation Science Projects on the Filchner-Ronne Ice Shelf, Antarctica 2014-2018*) and included Hot Water Drilling at *Site 5* (three boreholes, 5a, 5b, 5c), and over-snow traverse support. Recently, the ongoing ApRES and surface equipment maintenance was covered by PEAs for 2020/21, 2021/22 and 2024/25.

Research in this general area of the Ronne ice shelf began in the 1990/91 field season at Site 1 (see Figure 5 and Table 1). Site 5 was first occupied in the 1998/99 field season when BAS were trying to understand the circulation beneath the Ronne ice shelf. It was one of several sites that were drilled across the Ronne, and it was ideally suited to long term monitoring: it was a single site that was able to sample the two principal inflows of water from Ronne Ice Front.

Early hot water drilling made access holes for CTD profiling, and, initially, only thermistor cables were installed at Sites 1 (1990/91) and 2 (1991/92), giving a time series of temperature throughout the ice and water column, with these thermistor cables being left under the ice.

At Site 3 (1995/96), CT instruments and current meters were also deployed. Following this at Sites 4 (1998/99) and 5 (1998/99), a similar arrangement, without the thermistor cables, was used. As in previous years, equipment was left under the ice for long term monitoring.

The 1998/99 season (the original Site 5) involved an access hole being drilled; and instruments deployed beneath the ice shelf, with a surface logger [2](data collection and transmission that remained on the ice surface).

Oceanographic instruments were deployed to hang beneath the ice shelf on a mooring, (which consists of a long wire lowered through a hot water drilled borehole with a heavy ballast weight attached to the bottom), to monitor ocean salinity, temperature and currents Those instruments ran for about five years before their internal batteries became exhausted. The surface logger and associated equipment was then recovered during a later season.

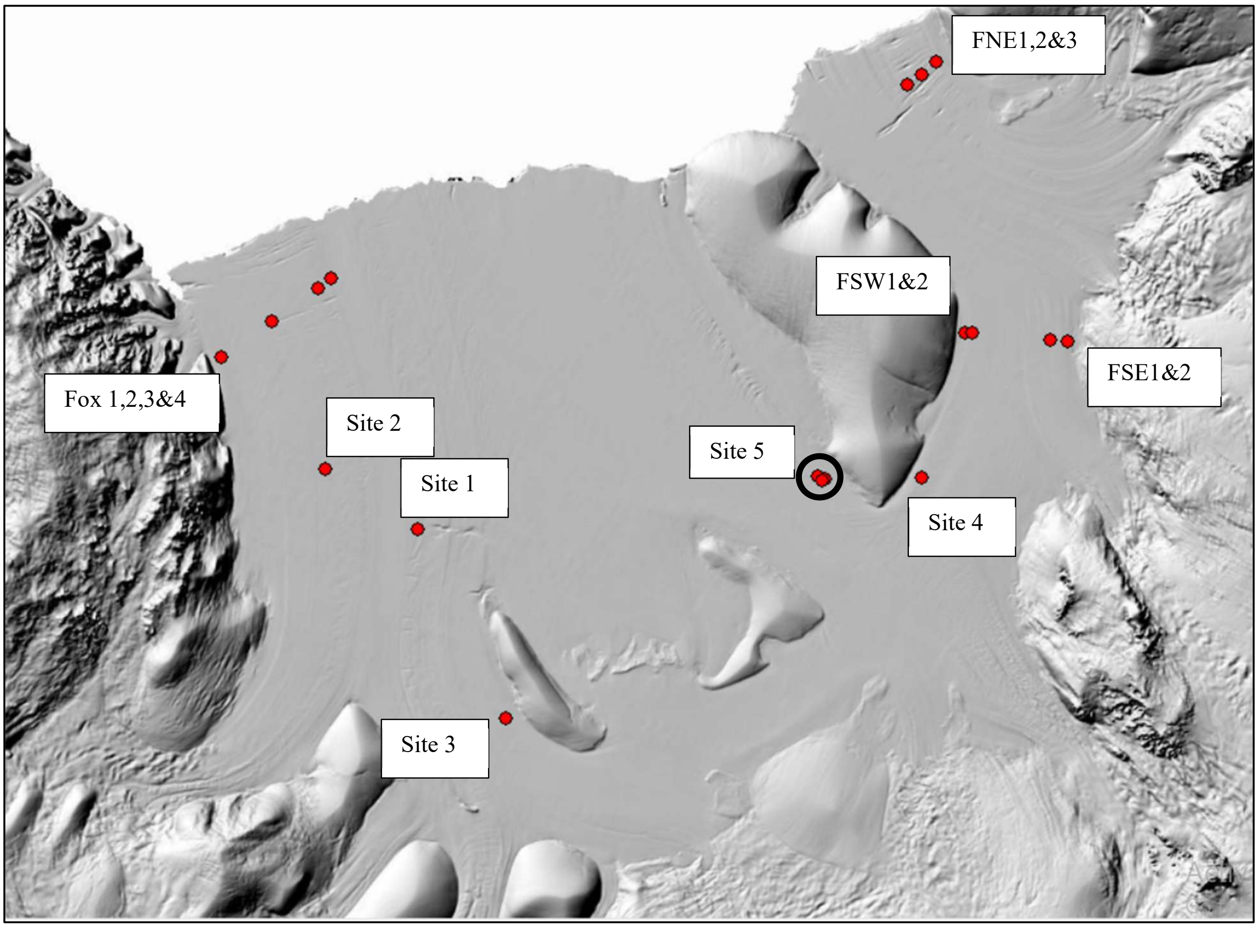

Figure 5: Showing the current and past drilling activities on the Ronne and Filchner ice shelves. Site 5 to the ice front is approximately 360 Km.

[2] The instruments are controlled by a data logger, which also stores the data locally, and transmits it via an Iridium datalink.

In the map above (Figure 5), each red dot indicates a borehole that has been drilled and instrumented on the Ronne and Filchner ice shelves. Over the decades the instrumentation has changed, but generally the same approach has been used with hot water drilling and oceanographic instrument deployment under the ice.

Table 1: Timeline for Deployment of instrumentation related to Site 5

Site name	Field season	Instruments
Site 1	1990-91	Thermistor cables
Site 2	1991-92	Thermistor cables
Site 3	1995-96	Thermistor cables; current meters; CT instruments
Site 4	1998-99	Current meters; CT instruments
Site 5	1998-99	Current meters; CT instruments
Site 5a	2014-15	Current meters; CT instruments, surface-powered.
Site5b	2014-15	Thermistor cable and DTS
Site 5c	2014-15	Current meters; CT instruments
Fox 1	2003-04	Current meters; CT instruments
Fox 2	2003-04	Current meters; CT instruments
Fox 3	2003-04	Current meters; CT instruments; temperature sensor string
Fox 4	2003-04	Current meters; CT instruments
FSW1	2015-16	Current meters; CT instruments
FSW2	2015-16	Surface-powered current meter; thermistor cables
FSE1	2015-16	Surface-powered current meter; thermistor cables
FSE2	2015-16	Current meters; CT instruments
FNE1	2016-17	Current meters; CT instruments
FNE2	2016-17	Surface-powered current meters and CT instruments
FNE3	2016-17	Current meters; CT instruments

In the 2014/15 season the original geographic location of *Site 5* (from 1998/99 season) was revisited, three access holes were drilled and three moorings were deployed a few km apart. Three new moorings were used to distinguish between changes due to the motion[3] of the sites and those due to long term environmental change. The sites were identified as Site 5a, 5b and 5c.

Site 5a was at the original geographical location of Site 5, and Site 5c was near the location that Site 5 had moved to in 2014/15 – about 6 km downstream of Site 5a. Site 5b was about 3 km east of Site 5c (towards the Berkner Island coast). A sub-ice shelf mooring was deployed at each location, with associated surface loggers. At Sites 5a and 5c CT instruments and current meters; at Site 5b a thermistor cable and DTS cable[4] were deployed.

Except for Site 5a, whose moored instruments are powered from the surface[5], the instruments at the other sites (5b and 5c) had stopped working by the 2025/26 season. Surface instrumentation (e.g. logger and solar panel) at Site 5b were recovered in 2024/25 during routine site visits.

[3] The observations will change as a result of temporal changes in the ocean environment, and spatial variation in the ocean environment that the site moves through. We need to disentangle the temporal environmental change, which we want, from the change solely due to the motion of the site.
[4] DTS is a fibre optic cable, which gives a coarser temperature profile, but at higher spatial resolution.
[5] This mooring was supplied by a collaborator so instruments were different to other BAS sites

A small depot was also previously (present in 2019) maintained near Site 5c, storing fuel for aircraft use.

Information from some past projects has been used to inform this EIA.

3.2 Geographical Scope

The proposed *Site 5* drilling site is in the region of-80.33603, -54.77333 (UTM 541719.51 1080108.46 (21Z - WGS 84)). This is about 12 km west of the southwest coast of Berkner Island on Ronne Ice Shelf. The ice here is approximately 750 m thick.

The proposed location will be entirely on ice shelf with no ice fee ground in the vicinity.

Figure 6: General Location of Proposed Site 5 Drilling Project. Produced by the Mapping and Geographic Information Centre, British Antarctic Survey, 2026.

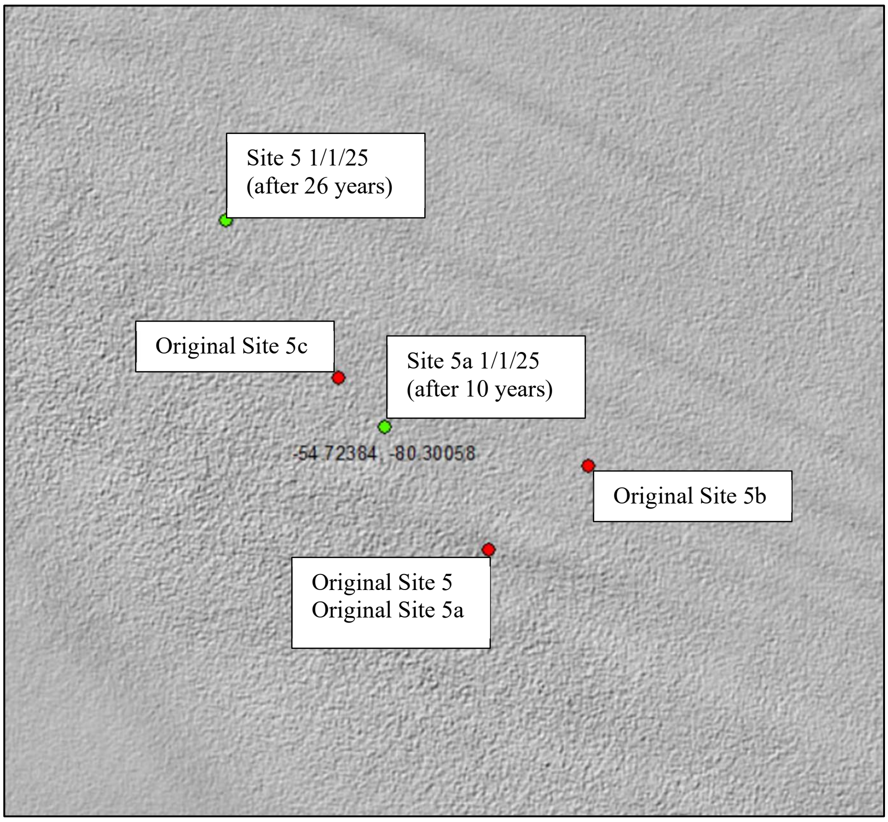

Figure 7: Enlargement of Site 5 area highlighted on previous map. For reference, the distance from Site 5a to Site 5c is 5.2 km

3.3 Temporal Scope

This assessment covers one season of proposed hot water drilling activities in the 2026/27 austral summer (January to February), and the subsequent ten years (2026/27 - 2036/37) of maintenance to both Site 5 and Site 5a. At the time of writing there is no plan to overwinter equipment, other than the installations themselves.

For the following ten years (or until the equipment fails), every two years surface equipment will be raised above the snow surface and maintained by a visiting team for up to five hours. Once the surface equipment fails, or the location is no longer required, surface equipment will be removed from the site.

BAS oceanographic equipment will remain under the ice and in the ocean, it will eventually stop working and will remain on the ocean floor. The US collaboration IceNode instrument will detach from its mooring after a couple of weeks and move to the ice front, continuing to take measurements. The surface equipment will be recovered during the next maintenance cycle, however the IceNode may not be able to be recovered and will remain on the ocean floor.

During the 2025/26 season, a Basler aircraft, operating out of Union Glacier, deployed drilling equipment and fuel to *Site 5*. In 2026/27, the remainder of the fuel and equipment (final amount of additional fuel and equipment required to be determined at time of writing) will be flown using Dash/Twin Otters from Rothera.

In early 2027, up to eight personnel will be flown to the site, using Twin Otters, from Rothera (or via Union Glacier, to be confirmed). The fieldwork will last for 4-6 weeks, and then the personnel and equipment will be uplifted to Rothera (or via Union Glacier if logistics require). There is a potential for final uplift of equipment to occur later than personnel uplift if there are logistical constraints. Additionally, every other year site visits would take 2-3 people 5 hours to complete.

The timeframe of this IEE falls within the timeframe of the current BAS Operating Permit granted under Section 3, Section 4, Section 6, Section 7, Section 8, Section 9 and Section 10 of the Antarctic Act 1994, which is valid from 1 October 2022 to 30 September 2027. Future site visits for raising, maintenance and recovery of equipment will be covered by the subsequent operating permits.

3.4 Logistical Scope

The *Site 5* drilling project will rely on a number of logistics to facilitate the project. These will also be assessed and include:

- travel by ship or DASH 7 (remaining equipment and people). Equipment, and potentially team members will move to Rothera by the SDA, or the DASH 7 aircraft in the 2026/27 season (or via Union Glacier);
- input into, and uplift from the field by Dash (to Sky Blu) and/or Twin Otter aircraft (equipment and people) (or via Union Glacier);
- use of two snowmobiles on site.

Due to logistical requirements and capacity, a third-party contactor delivered equipment and fuel to the *Site 5* location during the 2025/26 season.

The number of input/uplift flights in 2026/27 is as yet undetermined. However, it is estimated that 12-15 Twin otter flights would be required between December 2026 and early February 2027.

One flight to the field by Twin Otter (or Dash/Twin Otter combination) for maintenance will be required every two years (2028/29 – 2025/36).

3.4.1 Third Party Contractor input

Between the 18th November 2025 and 30th Jan 2026, a third party contractor delivered fuel and equipment over four Basler flights, in approximately 18 flight hours to the *Site 5* location (-80.33603, -54.77333). Although this logistical input is not assessed in this IEE, the delivery is listed here for completeness:

- 7027 kg Cargo
- 26 x 200L Avtur
- 24 x 60L Petrol

The listed fuel and equipment was cached ready for the project. Two pieces of equipment did not travel on the Basler and were taken to Rothera by Dash for onward travel to *Site 5* (a pump and melt water tank). This activity was fully supported by the contractor, with no BAS involvement on the ground. This transport is included in the Carbon Assessment in Section 8.5.

3.4.2 Equipment on Site

The following equipment will be on site for the duration of the project, with borehole equipment being installed and remaining on site:

- Living units (tents) for a team of between six and eight people
- Hot water drill
- Fuel for the drill and camp (aviation fuel and petrol) and glycol
- ApRES and associated battery (to remain on site for 10 years)
- Borehole logging instruments and associated equipment (removed before mooring installed):
  - CTD profiler plus spare;
  - Logger unit for CTD profiler;
  - CTD winch + tether;
  - Sediment corer with pressure sensor and camera;
  - Sediment winch + tether.
- Borehole mooring instrumentation (BAS borehole):
  - Three/Four Nortek Aquadopp Acoustic Doppler Current Profiler (ADCPs) (Lithium Thionyl battery) current meters;
  - Three/Four RBR CTDs (Lithium Thionyl battery) – deployed as a pair with Nortek Aquadopp;
  - mooring cable and fiber optic tether;
  - ballast weight (50 kg steel ballast weight);
  - surface loggers (surface);
  - AGM batteries (surface);
  - solar panel (surface).
- IceNode Instrument (second borehole):
  - IceNode fiber optic mooring tether;
  - Acoustic Doppler Current Profiler (ADCP) (related to IceNode) (lithium thionyl chloride battery.);
  - turbulence instrument cluster;
  - IceNode deck unit and logger (surface);
  - AGM (sealed lead-acid) Batteries (surface);
  - solar panel (surface).

Other than the deployed instruments, the present plan is for equipment to be returned to Rothera using BAS Twin Otters at the end of the 2026/27 season.

4 BAS *Site 5 Hot Water* Drilling Activities – Proposal

The proposal for the *Site 5* activities is presented in this chapter as well as a detailed description of the typical components of drilling equipment used, equipment deployed and the associated camp. The chapter also considers associated activities including waste and fuel management, and future maintenance and removal of surface instrumentation, over the following ten years

This chapter also identifies the environmental aspects that will or may arise from the various activities. These aspects or outputs are the ways in which the planned activity will or may interact with the environment. The consequences and significance of these aspects are then assessed in **Chapter 8**.

4.1 Purpose

The purpose of the hot water drilling operation is to enable BAS to maintain its long-term observatory on the Ronne ice shelf, thereby allowing the scientific community to monitor conditions in the sub-ice shelf cavity, driven by processes over the continental shelf.

The Weddell Sea is a key region for the production of Antarctic Bottom Water, and it is a region that is changing. Modelling suggests that the changes are heading in the direction of a regime shift, that could see the move from an ice shelf lying in cold water, to one lying in relatively warm water.

4.2 Proposed Activities

The project will take place at an established location, where previous hot water drilling and deployment of oceanographic monitoring equipment has occurred. The proposed work will follow similar methods.

Due to ice movement, previous deployments have moved downstream from their original locations.

The proposal is to re-drill at the original geographic location of Site 5 (1998/99), to allow continued monitoring of the health of the entire southwestern Weddell Sea continental shelf. Site 5a (2014/15), which was drilled at the same geographic location, will then become the downstream mooring of a pair of moorings (allowing scientists to distinguish between geographic and temporal gradients in ice properties). Some of Site 5a's instruments are now failing, and the site is also now downstream (~4 km) of its original location. Site 5a surface instruments (ApRES and surface logger) will be serviced to prolong use as a pairing with the new Site 5.

Other activities while on site will include removing the surface presence of Site 5c by recovering the surface logger and associated infrastructure.

4.2.1 Hot Water Drilling

The proposed hot water drilling aims to drill through the ice shelf to the ocean below, a distance of approximately 750m at the *Site 5* location. Two deployment boreholes are proposed, one for BAS oceanographic equipment, the second for the US collaboration for the IceNode equipment.

Hot water drilling uses water, heated, and pumped into the borehole through a nozzle, under pressure, to drill down through the ice. Drilling speed averages 0.75 m/min, but it is quite variable due to ice depth and temperature changes, and the speed of cycling the water back to the drill.

The drill team will be input into *Site 5*, and a temporary camp set up. The first few weeks will involve checking and testing the equipment to be deployed followed by 24-48 hours of hot water drilling and deployment of equipment, per borehole.

A hot-water drill will make an access hole to the ocean below the iceshelf. A CTD profiler will be used to obtain a detailed record of the ocean properties, and then an instrument mooring will be deployed into the ocean and secured at the surface. The instruments will be controlled by a data logger, which will also store the data locally, and transmit it via an Iridium datalink back to Cambridge. A logger, battery and solar panel will stay at the surface on an aluminium pole, together with the mooring cable deployed through the ice shelf.

Two bore holes (one for BAS and one for the US IceNode collaboration) will be drilled into the ice shelf to enable deployment of monitoring equipment, each with an ancillary hole for the borehole pump. This project will use the BAS hot water drill.

BAS hot water drills are designed in modules, to fit into Twin Otter aircraft. The drill uses petrol-fuelled generators, and water-heaters powered by aviation fuel to heat the drill water to around 90 °C. The hot water drill system uses high pressure pumps to deliver water to the drill nozzle.

BAS hot water drills have reliably provided numerous subglacial access holes up to 941 m deep through Filchner-Ronne, Larsen-C, and George VI ice shelves, Thwaites Glacier and Petermann Glacier (Greenland), and up to 2154 m on Rutford Ice Stream (BAS, 2026).

4.2.1.1 The drill set-up

The hot-water drill is distributed over a 25 x 25 m area, and consists of :

- • hose winch
- • capstan
- • three or four 10 kW generators
- • three 250 kW heat burners/exchangers[6]
- • one 60kW burner/heat exchanger
- • three water pumps

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[6] heat exchanger, coils of hose, copper, and burner is oil pump with burner jets flame into enclosed, the water comes out hot

- • borehole pump

There is one, small open-sided drill shelter located by the capstan. The drill will be powered by generators, and burners are used to heat the water. The drill site will have different units (generators, burners, pumps and the drill) around the site with hoses and power cables running between them (see Figure 8).

The drill consists of a set of high-pressure pumps which pump cold water through the heat exchangers and down the hose to the nozzle. The winch lowers the drilling nozzle into the ice to form the borehole.

At the start of the drilling approximately 10 tonnes of snow will be shovelled from the snow surface (approximately 1 spade depth), over a large area, into the flubber (flexible water storage container), giving the starting 10 tonnes of water. This water will be heated and pumped to the drill. A borehole pump will be lowered to 90 m (in the ancillary bore hole) and will be used to pump the hole dry and refill the flubber.

It will take approximately one week to set up the equipment, build and test everything. Once this is complete, a dummy hole will be drilled which consists of a relatively shallow borehole (approximately 10 m) that will be used for practice deployment of instruments that are lowered into borehole. This dummy hole will become the start of the borehole pump hole, which will then be continued to the required depth (90 m).

The project will then drill another hole about 60 cm away to the same 90-m depth. The nozzle will be left at that depth until the two holes become connected (break through). The main hole will then be continued until the ocean is reached, with the borehole pump returning water to the flubber for re-use. Reusing the water will mean no further snow will need to be melted, reducing the fuel requirement by about 50%. There is no significant residual heat in the water returned from the borehole - it is at around 0°C. The key benefit is in not having to melt more ice to generate more water[7].

After the sediment coring (including pressure testing at sea floor and camera inspection of the hole), CTD profiling and associated activities are complete these instruments are then removed from the borehole. The drill will be run down the hole relatively quickly to re-widen it after the freezing that will have occurred since the initial drilling. The mooring supporting the oceanographic equipment will then be deployed.

Once the first borehole is completed (BAS instruments), the drill will be moved up to 100m away for the IceNode borehole to be drilled by BAS drillers. Equipment deployment may continue concurrently if there are sufficient team members available.

The drilling is an intense period of activity and will run over a period of about 24 hours, for each of the two main boreholes. Drilling cannot stop or the borehole will freeze up. During this time the burners and generators must be continually refuelled.

Once the team has ensured all the equipment is working, clear up will then begin ready for uplift.

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[7] Every degree of warmth in the recovered water provides 1.2% of the benefit of not having to melt ice to provide the water. And one degree C is much warmer than we would expect.

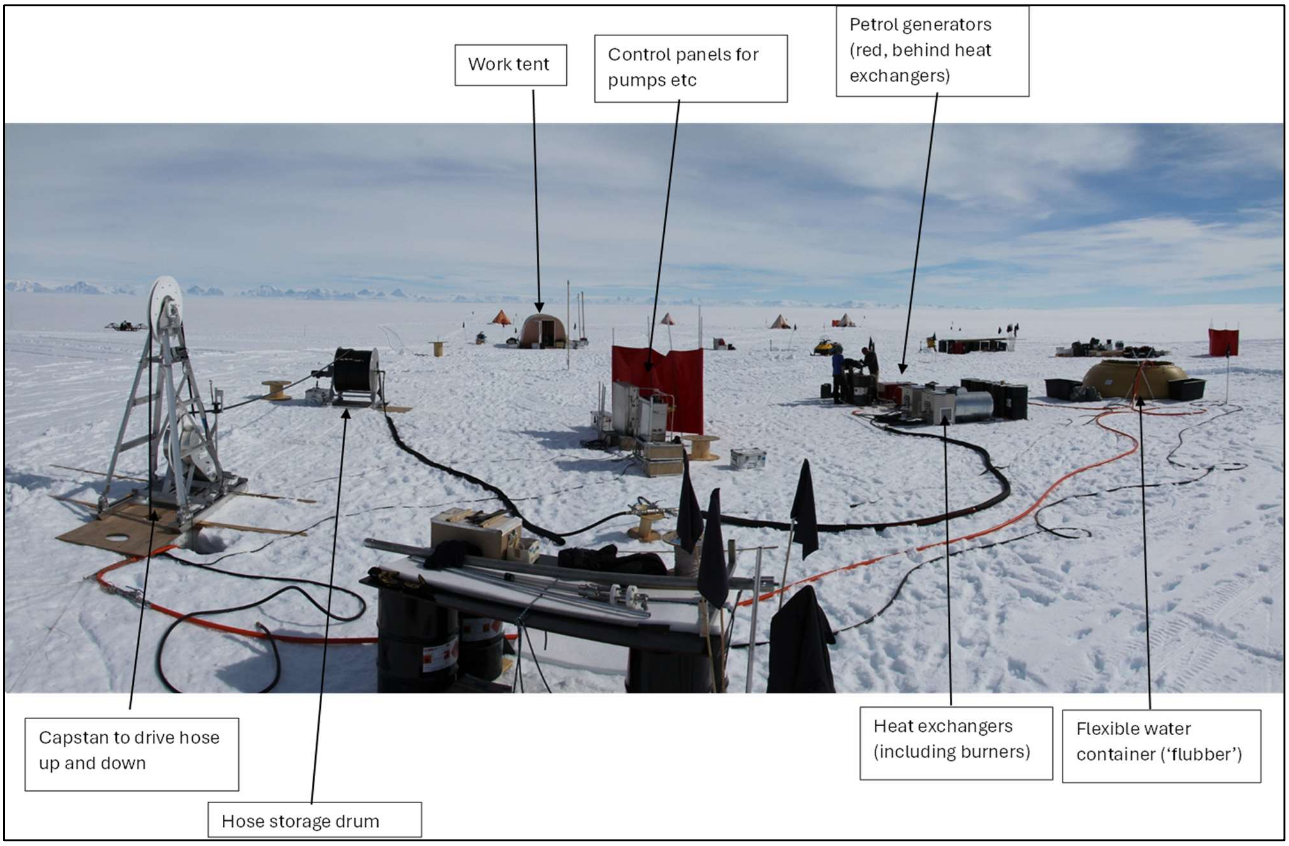

Figure 8: Arrangement for the 2011-12 drilling season on Larsen C Ice Shelf. In the background are the three living tents (six personnel) and one toilet tent, as an example of a BAS drilling set up

4.2.2 Drilling Camp

The logistical operation to establish the camp will be via Dash/Twin Otter aircraft operating out of Rothera (or via Union Glacier). The camp will include up to four pyramid tents accommodating eight people, up to two tents for living functions (cooking and eating), and working (for science and equipment) which could be a Weatherhaven with the possibility of a clam tent for cooking/eating, keeping the Weatherhaven for working, and a toilet tent (pyramid tent with inner removed).

The total work and living footprint will be approximately 50x150 m (including the borehole for the IceNode collaboration).

There will be three or four 10Kw drilling generators. While the drill is running, those generators power the camp. When the drill is not running, the camp will be powered by one small 1-2 kw Honda 'handbag' generator, with another as a backup.

4.2.3 Deployment of Instrumentation

The purpose of this work is to deploy oceanographic instrumentation under the Ronne ice shelf. The boreholes will allow the deployment by giving access to the under-ice environment.

Surface based equipment will also be deployed at the site including ApRES (see 4.2.3.2), a downward-looking radar that monitors the motion of the ice base and internal layers within the ice. It allows measurement of ice deformation, and the time series of basal melt rates.

The aim of the oceanographic equipment is to monitor water currents at three or four depths, and the water temperature and conductivity. The pressure, temperature and conductivity data will be used to calculate the salinity of the water.

For monitoring currents an Aquadopp current meter, manufactured by Nortek will be used. For temperature and conductivity instruments from RBR will be used (see Figure 9). Each Aquadopp will be paired with a CTD.

Figure 9: Nortek Aquadopp

All the instruments are powered by lithium thionyl chloride batteries, and they communicate with the data logger on the surface of the ice shelf (at the top of the borehole) using an inductive loop. For this, a single dyneema rope, with a loop of conductor (polyurethane coated, multicored copper wire) will be mechanically fixed to the ballast weight (rebar or welded steel lengths).

The following equipment will be deployed on the moorings:

<u>Site 5 – BAS borehole</u>:

- Instrument cluster (lithium thionyl chloride battery) five moored instruments each between 5 and 10 kg weight - current meters, and CTDs (stainless steel and titanium);
- Three/Four Nortek Aquadopp Acoustic Doppler Current Profiler (ADCPs) (Lithium Thionyl battery) current meter
- Three/Four RBR CTDs (Lithium Thionyl battery) – deployed as a pair with Nortek Aquadopp
- Mooring/fibre optic tether
- Ballast weight (50 kg steel ballast weight).

<u>Site 5 – Collaboration borehole</u>:

- IceNode instrument;
- Acoustic Doppler Current Profiler (ADCP) (lithium thionyl chloride battery);
- Mooring tether – fibre optic;
- Turbulence instrument cluster.

Figure 10: RBR CTD instrument, to be used in the Drilling project

The instruments will be moored to the ice shelf (surface mooring) with a steel cable hung through the bore hole to just above the sea floor. The cable will have a ballast weight on the bottom which gives a taught line to hang instruments and moves with the ice shelf.

Instruments communicate with an inductive loop. A wire goes down the borehole, which is in the form of a loop, a current running through this loop and a transformer can communicate with the instruments. This technique allows Instruments to be clipped anywhere on this mooring.

4.2.3.1 IceNode (US collaboration)

In addition to the BAS instrumentation, a second borehole will be used to deploy the IceNode profiling drifter in collaboration with US scientists. As with the other mooring this will include a through ice tether and data logger system with batteries.

Once deployed, IceNode will sit on the ice base taking turbulence measurements for a few days, before detaching and performing a CTD profile. It will again sit on the ice base for more turbulence observations. It will repeat the cycle a few times, and eventually un-tether itself and drift out of the sub-ice shelf cavity, continuing to collect data as it drifts.

Once out from under the ice, IceNode will be programmed to have enough power left in the batteries to signal its position so it may be retrieved. However, there is a high likelihood that it will be lost to the environment, as it might take several years to appear at the ice front, and even if its location is known it is quite likely that a vessel will not be available to retrieve it due to logistical constraints. Therefore, it should be assumed that it will be lost and will sink to the ocean floor.

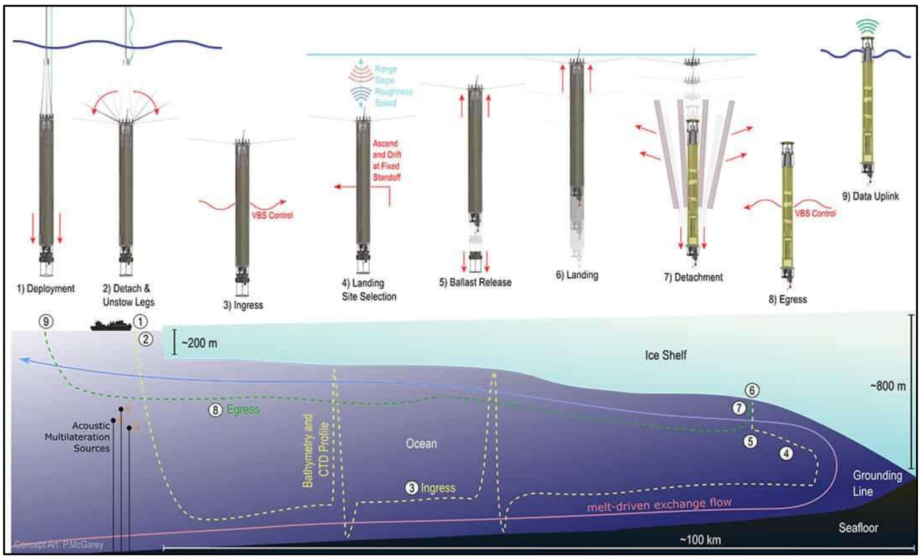

Figure 11: The concept of operation for IceNode. Illustration: NASA / JPL-Caltech (source: https://polarjournal.net/icenode-nasa-robots-to-document-melting-under-antarctic-ice-shelves/)

4.2.3.2 ApRES

To complement the oceanographic data, ApRES will be installed at *Site 5*.

ApRES is a downward-looking frequency modulated continuous wave (FMCW) radar, transmitting a chirp at 100mW, sweeping from 200 to 400 MHz over a period of 1 second. It does this 25 times every two hours. This chirp is a low power radio transmission (less than a mobile phone) and is directed downwards through the ice, reflecting of the ice base.

The electronics are housed in a yellow Pelicase (~400 x 350 x 150 mm, 4.5 kg). The battery is typically a 95 Ahr, AGM lead acid battery (~26 kg), and each of the two radar antennas has an aluminium reflector plate and copper elements, housed in a snow-proof plastic (Correx) carton (600 x 600 x 300 mm, 4 kg).

A four-metre aluminium pole marks the ApRES hole, and has a 15 W solar panel, an Iridium antenna and a GNSS antenna attached. The antennas are connected to the ApRES via two 5-metre coaxial cables; the solar panel is connected to the battery via a 5 m power cable. The battery is also connected to the ApRES by a short power cable.

The battery, ApRES and antennas are buried in the snow in the logger pit, with a plywood cover over the hole for the ApRES and battery.

If the marker (aluminium pole) falls over the site could be lost. To prevent this, the marker is thoroughly guyed. Loss of the marker due to falling over has never happened on any of the many ApRES sites deployed around this and many other ice shelves. At some sites in the Amundsen Sea sector there has been loss of an installation because of excessive accumulation burying the marker. In the southern Ronne Ice Shelf accumulation rates are an order of magnitude lower, and so burial is a highly unlikely scenario.

The ApRES will remain on site for up to 10 years and will be raised above snow level and serviced every two years. Currently the intention is to also maintain the ApRES at Site 5a.

4.2.3.3 Use of Glycol

Glycol will be on site to maintain the drill system to ensure that no ice can form in the drill, causing blockages and mechanical damage.

Ethylene glycol is used at 40% dilution (60% water, 40% glycol). It is initially stored in 20 L plastic containers (as supplied) and then diluted into 250 L tubs.

When drilling stops, the intake for the drill is placed in the 250 L tub and the some of the diluted glycol mix sucked into the system. Once the system is full of the mix, an air compressor is fitted to the inlet, and the mix is blown out of the drill, with the nozzle located in the tub to re-capture the full volume. Any glycol that gets spilled onto the snow stains the snow blue, and this is recovered by shovelling the snow into the tub. The process is carefully watched to reduce the chance of spillage.

When the drill is restarted, with the intake in the water flubber, any residual glycol in the system is returned by directing the nozzle into the tub until the colour of the jet changes from blue to clear. Once it is running clear, the nozzle may be used for drilling.

At the end of the drilling activities the dilute glycol is transferred back into the plastic tubs, and any excess into an empty fuel drum for return back to Rothera.

4.2.4 Planned Equipment Loss

Once deployed the moorings and equipment are unrecoverable.

Table 2: Deployed equipment that is proposed to be 'lost' under the ice

Equipment	**Dimensions**	**Mass**	**Components**	**Batteries**
IceNode	2.9 m long x 280 mm wide	130 Kg	Mainly titanium	2Kg Lithium
Four Norteks Aquadopps	82 mm diameter, 623 mm long (each)	7.6 Kg (each)	Titanium housing	1.14 Kg Lithium (each)
Four sub surface modems (sit beside the Aquadopp to interface with the cable).	60 mm diameter x 310 mm long (each)	300g (each)	Titanium housing	4 AA lithium batteries (each)
Four RBR CTD instruments	60 mm diameter, 500 mm long (each)	2.8 kg (each)	Titanium housing	8 AA lithium batteries (each)

The equipment has an expected life of 5-10 years, based on previous deployments at the same location. Once equipment stops working and is lost, it will be recorded in the BAS lost equipment log.

At the original Site 5 deployed in 1998/99 season instruments were deployed and functioned for about five years before the batteries were exhausted. They had moved downstream (approximately 2 km) by that time. As of the 2025/26 season, the instruments are thought to still be hanging beneath ice.

Site 5a, deployed in 2014/15 season, ran for a year, and then had power supply problems. Those were resolved and several years of data were subsequently recovered. More recently, the surface logger has failed and will be replaced during the 2026/27 field season. Site 5a is now approximately 4 km downstream of its original location.

Site 5b, deployed in 2014/15 season collected data for approximately 10 years, but most of the site has been cleared (associated surface equipment including: solar panel, aluminium pole, battery, plywood sheet, data logger, GPS and Iridium antennas, surface cables), although a deployed logging unit which controlled data acquisition from the thermistor cable and transmitted the data to the surface data logger via the inductive link, remains underwater as well as the cable through the ice shelf.

Site 5c also deployed in the 2014/15 season will be cleared in the 2026/27 season, however the cable and instruments remain under the ice and the underwater batteries are now failing at 5c. The instruments will fall to the sea floor and be sedimented over once they melt out of the ice.

The equipment is designed to be lost, due to the nature of the research. The batteries are mostly lithium thionyl chloride and are contained in pressure-proof enclosures. However, there is a risk that the older boxes may fail under extreme pressure (Site 5c instruments are rated to over 2000 m of water, whereas the new instruments are rated to over 6800 m). With flow speed at *Site 5* estimated to be 3-400 m/year (increasing near the ice edge), and the ice edge approximately 360 km away, it would be expected to take 500 years before calving, followed by iceberg disintegration and the release of the instruments in the deep ocean, descending to the ocean floor with the wire and tether (see Jenkins and Doake 1990, for similar flowline further west), and the rating of the new instruments means it is unlikely they will fail under pressure.

If the housings did fail, there is a chance that lithium from the batteries would be released into the ocean environment. Under the ice this would impact a relatively small local area due to low flow rates, whereas in the open ocean, where there is more current, this may have more of an impact on ocean ecosystems. However, this potential impact is largely unstudied and specific literature is uncommon. The instruments themselves would change the ocean floor profile, be sedimented over and may provide strata for marine life to colonise.

The site is continuously moving, due to being on an ice shelf which is flowing towards the Weddell Sea, redrilling is needed to maintain a consistent record of the below ice conditions. The instruments deployed at the site are coming to the end of their battery life, and some of the sensors are no longer performing well.

Over time, the sites move towards shallower ground, and eventually the bottom instruments start to drag on the seafloor and are lost. The time it takes for the instruments to hit bottom depends on the depth of the ocean beneath the ice, and the rate of the ice shelf movement.

In addition to the BAS instrumentation, an IceNode (see Figure 11 for the original concept) profiling glider will be deployed by US scientists at the same site, this will be tethered but they are typically lost after about two years. *Site 5* offers an opportunity to prove the instrument's operation in the realworld setting. IceNode will provide valuable data (turbulence observations), which is otherwise not available, to the larger PRESCIENT project, of which *Site 5* is a part. As the IceNode will be using the same logistics and a BAS drilled borehole it is included in this environmental assessment.

The principal long-term environmental impact of the proposed *Site 5* project will be the eventual loss to the environment of the sub ice shelf instruments and the mooring wire. However, there is a theoretical possibility of retrieval once the instruments end their operation (~10 years). At the present time, the scientific opinion is that the potential environmental impact of attempting to recover the system by drilling a larger hole, guided by the frozen in mooring wires, outweighs the impact of leaving the instruments in place.

4.2.5 Conclusion of Drilling Operations

Once the borehole drilling is complete, the oceanographic equipment will be deployed and left under the ice, where it will eventually be lost to the environment. Surface instrumentation required to collect and transmit data will also be left on site. All other equipment will be removed and returned to Rothera and the UK.

It is anticipated that the instruments will operate for ten years before batteries are exhausted.

The site will be maintained at two-year intervals, so the site is not lost to snow accumulation. Site 5a will also continue to be maintained until failure. The site will need to be revisited every two years, as in the past, with a maximum life expectancy of ten years. Each visit will require two to three people to visit the site and raise the instruments above accumulated snow level and complete any maintenance. Typically, this would be a five-hour job, including raising the ApRES.

4.3 Area of Disturbance

4.3.1 Drilling

The area of disturbance at the drill sites is estimated at a maximum of two areas of 50 m^2 (with the two deployment boreholes approximately 100 m apart) or approximately 50x150 m including the field camp.

The two deployment boreholes (BAS and IceNode) will descend to a depth of approximately 780 m (depending on the thickness of the ice shelf) to ocean and will be 300 - 350 mm in diameter over most of their depth. The two ancillary bore hole pump holes will remain at approximately 90 m depth in the ice (just below sea level), approximately 60 cm from each deployment hole.

Each drilling area will be subject to a few days of intense activity, with travel between the locations (only one will be worked on at a time). Once completed each area will be tidied up and activity will centre around the camp location.

4.3.2 Drilling Camp

On arrival at site, the drilling camp will be set up and will consist of tents, infrastructure and life support for the team of up to eight people (including the US collaborators) and will be close to the drilling area. This will include, at a maximum, four or five living tents (e.g. pyramid tents); a work tent; and a toilet tent.

The personnel will be on site for 4 to 6 weeks (depending on weather, logistics and equipment performance). However, some personnel may leave as their elements of the project are completed.

There will be two Skidoos based at the drilling camp. They will be used to move the drill approximately one hundred metres for the second borehole which will be used by the US collaborators to deploy the IceNode instrument. Skidoos will also be used as required for towing equipment from the small depot, about 20 m from camp (containing equipment, supplies and fuel) to the drill sites.

The area of disturbance for the drilling camp is included in the 50 x 150m.

4.4 Deployment of Equipment

Deployed BAS oceanographic equipment will be under ice on a single mooring line, at approximately 750 m below the surface, and in the ocean water. The US IceNode will be tethered on a single line to a surface mooring for the first part of its deployment and will then release and move freely through the water column (see Section 4.2.3.1).

Both boreholes will have equipment deployed until end of life, as detailed in Section 4.2.3. Apart from the surface instrumentation (logger, solar panel, aluminium pole and ApRES) all deployed equipment is in or under the ice.

4.5 Maintenance of Surface Equipment

Once the equipment is deployed, maintenance and raising of the equipment above snow level will be required every two years (at both *Site 5* and Site 5a) for up to ten years.

Maintenance visits will be of short duration and impact, with Twin Otter landings on the snow/ice surface, hand digging to free any snow-covered equipment, and reinstalling the mast if required. Batteries may be replaced, and any failed equipment may be switched out.

These visits will be confined to two to three people over a few hours and will not require any camping.

4.6 Duration of Proposed Activity

The proposed drilling project is planned to be undertaken over four to six weeks during one austral summer season, January to February 2026/27. This assumes that the field party can be successfully input to the field site in early 2027 (during the 2026/27 field season).

A temporary field camp will be established when the team and equipment arrive. The camp will be used for the one summer over the duration of the project, after which the camp will be removed.

A cache is already in place, from the contractor delivery of fuel and equipment in the 2025/26 season. This will have overwintered by the time the team arrive in 2026/27.

The full duration of the proposed work includes the ten years from drilling at *Site 5* in the 2026/27 season, to the end of the scheduled maintenance in the 2036/37 season.

5 Environmental Aspects

This section identifies the Environmental Aspects that may impact the environment during this project. Section 8 later describes and assesses the impacts these aspects may have.

A number of environmental aspects have been identified for this proposed project, including:

- input/uplift and maintenance flights of personnel and equipment
- SDA operations, proportional to the amount of equipment/number of personnel transported, and duration on board (if any).
- skidoo, personnel movements, and drilling activities to the ice sheet surface;
- impacts of camp set up and living on the snow/ice surface (e.g., tent footprints and wastewater discharge);
- impacts to the marine environment;
- emissions from generators (petrol), burners (aviation fuel), skidoos (petrol), and cooking equipment (kerosene);
- potential for spills of fuel, glycol and other liquids;
- wastes produced by the project, and their transportation to Rothera;
- inadvertent loss of waste;
- potential for introduction of non-native species and biosecurity concerns;
- loss of equipment (planned and unplanned); and
- potential impact on wilderness values.

These aspects have been examined here in the context of the activities they are associated with for the proposed *Site 5* project.

5.1 Drilling

The hot water drill setup for this project uses water from melted snow and water pumped from the borehole pump (including recycled melt water) to a flexible container ('flubber') which is then heated by burners and returned to the drilling borehole.

The hot water facilitates the deepening of the borehole and is then cycled around rising back up through the auxiliary borehole, re-enters the 'flubber' and is reheated to re-enter the cycle.

No drilling fluids are used in hot water drilling.

There will be three or four 10 Kw petrol generators powering the drilling activity, one 1-2 kW 'handbag' generator for camp activities, and a second as backup. There are also 250 kW burners that heat the water, which run on Avtur.

Minor spills and leaks of fuel (petrol, diesel, oils and lube), are possible. The maximum quantity of fuel that is likely to be spilled at any one time is 205 L, due to a punctured drum. Spilled fuel would pass quickly through the surface layer of snow. Some may also evaporate.

Glycol is diluted and used in the HWD system for maintenance, but no more than 10 L is used at one time. Glycol is captured in a designated tub as it passes through the system using compressed air. Glycol is not introduced into the borehole.

5.1.1 Environmental Aspects from Drilling

The aspects of drilling that may interact with the environment include:

- input and uplift (and maintenance) flights of people and equipment (glacial and atmospheric);
- disturbance of the ice environment by drilling into firn and ice layers (glacial);
- release of glycol to the environment (failure of storage container or released to firn layer when maintaining the HWD system) (glacial and marine);
- emissions from generators (atmospheric);
- spills of fuels/oils (petrol, diesel, oils and lubes)(glacial and marine); and
- loss of equipment, including as a result of drill failure/sticking (glacial and marine).

5.2 Drilling Camp

The drilling camp is the main location for the project. Living accommodation, drilling and storage will all be located in an approximately 50 m x 150 m area for the duration of the work.

5.2.1 Environmental Aspects from Drilling Camp

The aspects from the establishment and operation of the drilling camp that will or may interact with the environment include:

- disturbance of snow and ice surfaces from setting up and living in camp (glacial);
- release of fuels/oils from cooking, heating and lighting equipment (glacial and marine);
- release of fuels (petrol, diesel, oils, lubes) from skidoos, or generators (glacial and marine);
- particulate emissions from generators, skidoos when used for moving equipment or personnel around camp, cooking and heating apparatus (atmospheric);
- potential inadvertent release of waste to the environment (glacial and marine); and
- discharge of human liquid waste and sieved wastewater (glacial and marine).

5.3 Deployment of Instrumentation

Deployment of the instrumentation will involve the planned loss of equipment.

All the deployed oceanographic instrumentation and the mooring line/tether will be lost to the environment as it will freeze into the ice shelf, move with the ice and eventually melt out and be lost to the ocean floor. The equipment is likely to stop collecting data due to battery failure before it melts out of the ice shelf and is eventually lost to the seafloor. Recovery is not thought to be currently possible as the boreholes would have to be redrilled, and the mooring lines traced through the ice to reach the instruments, which could have more environmental impact (fuel use and glacial disturbance) than leaving the equipment in situ.

An ApRES, logger, battery and solar panel will be deployed at the surface on an aluminium pole which will also act as a marker. The loggers will use sealed lead-acid (AGM) battery (evaluated to be the safest in the conditions, with low risk of damage/leaks), and logger pits (2 pits at 800 x 500 x 800 mm deep) will be covered with plywood. The loggers will transmit coordinates and can be relocated on subsequent visits, as they move with the ice movements.

All instruments contain a mix of metal and plastic; the instrument cases, to protect the instruments from the environment and prevent release of substances, are either titanium or stainless steel. The cases dominate the weight of the instruments and are between 5 and 10 kg each.

5.3.1 Environmental Aspects from The Deployment of Instrumentation

The aspects from deployment of instrumentation that will or may interact with the environment include:

- surface disturbance from working around the drill (glacial);
- surface disturbance from deployment of instruments (glacial);
- loss of batteries in the instruments to the ocean (e.g. impacts of lithium on marine life) (marine);
- equipment that will be lost to the ocean includes (marine):
    - Instrument cluster (Lithium Thionyl battery) five moored instruments each between 5 and 10 kg weight - current meters, and CTDs (stainless steel and titanium)
    - Three or four Aquadopp ADCPs (Lithium Thionyl battery)
    - Three or four RBR CTDs (Lithium Thionyl battery) (paired with an Aquadopp)
    - Mooring tether (polyurethane-coated 3/16th inch steel wire.)
    - Ballast weight (50 kg steel ballast weight)
    - IceNode
    - ADCP (Lithium Thionyl battery)
    - Fibre-optic tether
- potential future impacts on science projects in the region (glacial)

5.4 Waste Management

In accordance with the provisions of Annex III to the Protocol, BAS have well-established procedures for separating and retrieving waste from the field to minimise releases to the environment.

In the first instance any excess packing material is removed before going to the field and transport of materials is minimised to those essential to the project.

Waste is separated into different waste types as it is generated during the fieldwork and is returned to Rothera.

Clean plastics, metals, glass, paper and other recyclable wastes are separated by type and stored appropriately.

Waste batteries, oils, chemicals, and other hazardous materials (where used) are returned to Rothera in suitable UN containers, ideally their original packaging, and clearly marked as hazardous.

'Poo' bins will be used for solid human waste in the toilet tent. Food wastes are added to the solid human wastes and are returned to Rothera in UN plastic drums ('poo bins') for incineration. Liquid human waste and sieved grey water are disposed of in the field and the location recorded.

Medical and sanitary wastes are stored in yellow bags and then added to the human (solid) waste drum for incineration at Rothera.

Clean separated waste is stored in FIBC bags or vented, cleaned and topped fuel drums for ease of storage and transport.

Any waste materials from the drilling camp, such as wooden sheets will be reused where possible.

All waste, including nibbled empty fuel drums, will be returned to Rothera for managing in line with the BAS Waste Management Handbook.

Any waste that will be disposed of in the UK by a licensed waste contractor will meet the requirements of the Waste (England and Wales) (Amendment) Regulations, 2014, the Duty of Care Regulations, 1991, and the Hazardous Waste Regulations, 2005.

5.4.1 Environmental Aspects from the Generation and Management of Waste

The aspects from the waste generation and management that will or may interact with the environment include:

- the potential release of waste materials to the environment if inadequately managed (glacial and marine); and
- the potential mis-consignment of waste, incorrect segregation of waste, mixing of hazardous with non-hazardous waste.

5.5 Fuel Management

A storage depot will be located close to the camp (approximately 20 m away), which will house any fuels, oils, lubes, equipment, generators, and the skidoos when not in use. Fuels are needed for the drill generators, auxiliary generators and skidoos, as well as life support functions such as cooking.

Burning of fuel contributes to greenhouse gas emissions, and are considered in BAS carbon calculations (see Section 8.5).

The anticipated variety and quantity of fuels, oils, lubes and chemicals onsite include:

- Petrol (drill and generators)– five drums (205 L barrels = 1,025 L);
- Glycol concentrate– 120 L, stored in 6 x 20 L drums, (to be diluted prior to use);
- Aviation fuel (250 kW burners) – 26 drums (205 L barrels = 5,330 L)
- Two stroke oil – 1 x 25-Litre drum
- Oil – heat exchangers and skidoos – 1 x 25 L;
- Kerosene for primus cooking stoves and Tilley lamps, or butane/propane bottles – approximately 2 x 25 L jerry cans.

All fuel use will be recorded in a fuel log detailing volume and type of fuel used.

Skidoos will be refuelled directly from jerry cans.

5.5.1 Environmental Aspects from Fuel Handling

The aspects from fuel handling and storage that will or may interact with the environment include:

- release to ice or snow environment due to spills (e.g., barrel failure) (glacial and marine);

- release to the environment due to operational failure (e.g., fuel movement/refuelling) (glacial and marine); and
- release to the environment due to equipment malfunction (glacial and marine).

5.6 Biosecurity

Biosecurity can be an issue when projects move equipment around Antarctica, due to similar work happening in different regions with the same equipment.

As with all cargo that leaves the UK for Antarctica, biosecurity checks will be carried out prior to the equipment being shipped. This check is essential to ensure that the equipment does not contain any plant material such as seeds, roots, leaves, or any animals, such as spiders, rodents, and flies. Introduction of any non-native species to Antarctica has the potential to cause a substantial environmental impact.

Timber to cover the logger pits will be sourced from Rothera and will have previously been through biosecurity checks. One 8x4 sheet of plywood would be needed for this project, which will then be returned to Rothera for re-use.

The BAS Biosecurity Regulations manage the Biosecurity risk when working in Antarctica, for cargo and personnel luggage. The most relevant section to this project is *Section 10 – Field Work in Antarctica and South Georgia*, which is included as Appendix 2.

5.6.1 Environmental Aspects from Poor Biosecurity

The aspects associated with poor biosecurity practices include:

- introduction of non-native species – altering the biodiversity and potentially outcompeting native species

6 Alternatives

The EIA process needs to consider alternatives in order to identify the optimal way of meeting the need and purpose of the proposal, by enhancing the environmental benefits of the proposed activity or by reducing or avoiding potentially significant negative impacts.

Due consideration of alternatives ensures that the EIA is not simply defending a single project proposal. Instead, the EIA provides the opportunity for an unbiased, proactive consideration of options.

Examples of alternatives include use of different locations or sites for the activity; opportunities for international cooperation; use of different technologies in order to reduce the outputs (or the intensity of the outputs) of the activity, and different timing for the activity.

The alternative of not proceeding with the proposed activity should always be included in any analysis of environmental impacts of the proposed activity (CEP EIA Guidelines, 2016).

This chapter describes the alternatives that have been considered as part of the proposed drilling activities.

6.1 Do Not Drill: 'Do Nothing' Alternative.

Not having a drilling project would assist in maintaining perceptions of Antarctic wilderness.

This alternative has been considered and rejected on the grounds of the predicted value of the information from the instrument deployment being scientifically valuable in climate research.

6.2 Not to Redeploy the Mooring

An alternative strategy is not to redeploy a mooring, but to continue maintaining the Site 5a mooring until the last instruments cease to work. The ApRES at the site would continue to be maintained, which will provide a time series of ice shelf basal melt rates. The ApRES provides an excellent indication of conditions near the ice base but little about conditions deeper in the water column.

Site 5 is a location where two different inflows of water coalesce, and from this location it is possible to monitor the two principal inflows that dominate the entire Ronne ice front. It will not be possible to understand the strength and character of those inflows from the basal melt rate alone (which would be provided by ApRES).

This alternative has been considered and rejected on the grounds that relying wholly on Site 5a is not a sustainable strategy, as the instruments continue to fail and move further out of position. Some of those instruments (notably the salinity sensors) have never worked well (part of a collaboration which specified these instruments), and BAS have published based mainly on the instruments deployed at Site 5c, which performed better.

6.3 Deploying Instruments Using Scientific Cruises

Monitoring the conditions in the under-ice cavity by deploying moorings over the continental shelf to the north of the proposed site would be a direct way of studying the processes remotely driving melting beneath Ronne Ice Shelf, but the necessary ship time makes it very expensive in terms of carbon and financial costs.

Acquiring time on the ship as well as the ship time to search for the moorings would be anticipated to equate to more than the carbon cost of flights to the ice shelf and deploying the equipment.

The history of deployments from ships at the ice front has taught us that the sea ice conditions routinely deny access; fast ice at the ice front often covers the moorings, making them unrecoverable in any given season; if a redeployment is missed, and the ice shelf moves over the mooring before there is a chance to recover it and turn it round, then we would have to wait an unknowable amount of time before an iceberg calves and it becomes accessible again. At that time the acoustic release will have failed, and the mooring would need to be dredged for, with very uncertain outcomes. The biggest problem, however, is guaranteeing time on a ship routinely (e.g. every two years for 10 years) to venture into the southwestern Weddell Sea to service the moorings.

Coordinating ship time, with the ship being in the correct location at the required frequency to complete install and servicing of the moorings, would rely on many factors aligning perfectly. Cruising to the location, alone, if as a standalone objective would be incredibly time and carbon expensive, engaging the entire ship. The SDA has not operated in the relevant part of the Weddell Sea to date, and it would likely need a full ice breaker to reach the Ronne ice front, which may involve a circuitous route to avoid sea ice. Having the right ship with the right schedule for retrieving the moorings before the ice shelf extends out over them would also be very difficult as a multiyear commitment.

This alternative has been considered and rejected as mooring instruments in the open ocean reveals little about changes in the circulation beneath the ice shelf, and the constant northward motion of the ice front would result in the need to routinely retrieve and redeploy the moorings. The potential costs and use of fuel to reach the right area in multiple years would be high in terms of both fuel use and carbon.

6.4 Proposed Approach

The proposed approach enables BAS to maintain its long-term observatory on Ronne Ice Shelf, thereby allowing the scientific community to monitor conditions in the sub-ice shelf cavity, driven by processes over the continental shelf.

Scientifically, this method additionally gives an indirect indication of changing conditions over the continental shelf north of the ice front.

6.5 Summary

Alternative locations would have all the same disadvantages, with not fulfilling the project objective: continuation of the time series.

BAS will continue to consider environmental impacts of hot water drilling and deployment of oceanographic instrumentation in Antarctica. However, given the alternatives considered, it accepts that the proposed *Site 5* project techniques are the most appropriate in this instance.

7 Current Environmental State

A thorough understanding of the pre-activity (or current) state of the environment is an essential basis for predicting and evaluating impacts, and for identifying relevant and effective mitigation measures.

The EIA process requires consideration of the environment including relevant physical, biological, chemical and anthropic values in the area where, and when an activity is proposed, and that the proposed activity might influence.

This chapter describes the nature and characteristics of the Ronne ice shelf where the planned hot water drilling and oceanographic instrument deployment activities will occur.

7.1 The Physical Environment

The Antarctic continent is divided into East and West Antarctica, both of which are covered by ice. West Antarctica, to the west of the Trans-Antarctic Mountains, covers an area of approximately 1.97 M km^2. The Antarctic Peninsula is situated in West Antarctica.

The proposed hot water drilling site is on the Ronne ice shelf, off the southwest corner of Berkner Island, and is located on open ice shelf, with no exposed rock.

The ice shelf is flowing in a generally northward direction towards the Weddell Sea, at a rate of 374 m per year, moving parallel to the nearby Berkner Island coast.

For ice free ground, the proposed drill site is closest to a rock outcrop at -50.520957, -82.398556. This feature is approximately 240 km from the proposed site and is likely to be the closest area with the potential for terrestrial biological communities.

7.2 Environmental Domains

Environmental Domains are a system for classifying or organising subsets of environmental and geographic characteristics such as different types of ecosystem, habitat, geographic area, terrain, geology, and climate into environmental or geographic regions. Each region is distinctive or in some way different from other regions, but some might have characteristics in common (Morgan et al., 2007).

The proposed project site (shown as the red dot on Figure 12 below) fits into Environment P – 'Ross and Ronne-Filchner ice shelves'.

Environment P is a large ice shelf environment that encompasses the two largest ice shelves on the continent, the Ross and the Ronne-Filchner ice shelves. At 926 631 km^2 it is the fifth largest environment. It consists entirely of ice shelf land cover, apart from the only mapped area of rumples (known as Doake Ice Rumples) located on southern Ronne Ice Shelf. The environment contains no mapped geology. Climatically the environment is cold when compared with other environments with an average air temperature of –22.23°C and the third largest seasonal range at –26.39°C. The wind speed for the environment is moderate at 11.70 m/sec. As one would expect within this large ice shelf environment the slope is quite flat at an average slope across 926 631 km^2 of only 0.97°, making it the flattest environment on the continent (Morgan et al. 2007).

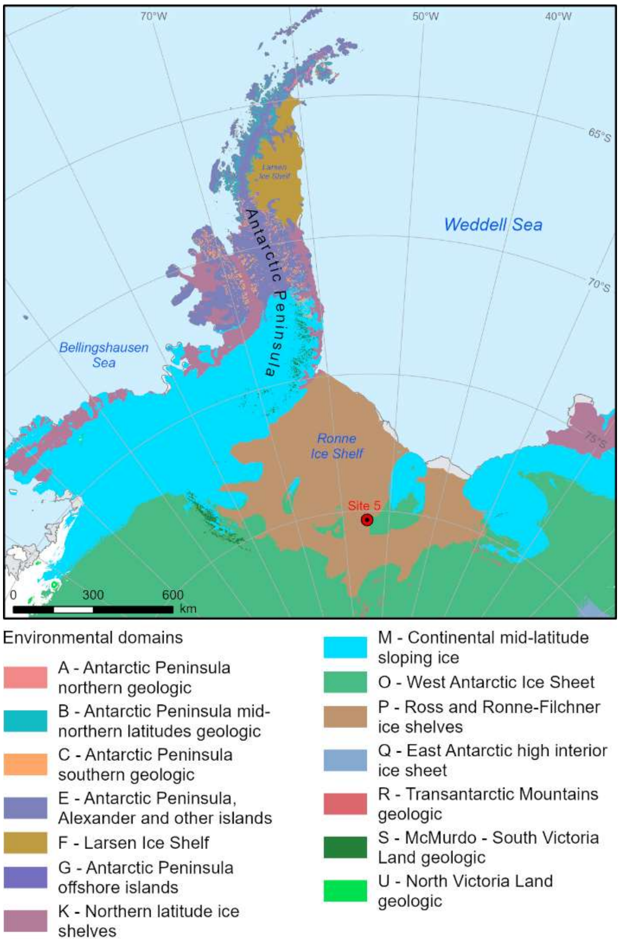

Figure 12: Environmental Domains. Produced by the Mapping and Geographic Information Centre, British Antarctic Survey, 2026.

7.3 Antarctic Conservation Biogeographic Regions

The use of quantitative analyses to combine spatially explicit Antarctic terrestrial biodiversity data with other relevant spatial frameworks has identified 16 biologically distinct ice-free regions encompassing the Antarctic continent and close-lying islands within the Antarctic Treaty area (Terauds and Lee, 2016). ACBRs are used in conjunction with the Environmental Domains, as shown in Section 7.2, to give a full picture of properties and species of the different areas of Antarctica.

The proposed project is shown with the red dot in Figure 13, and is entirely on Ice Shelf, outside of the mapped biogeographic regions.

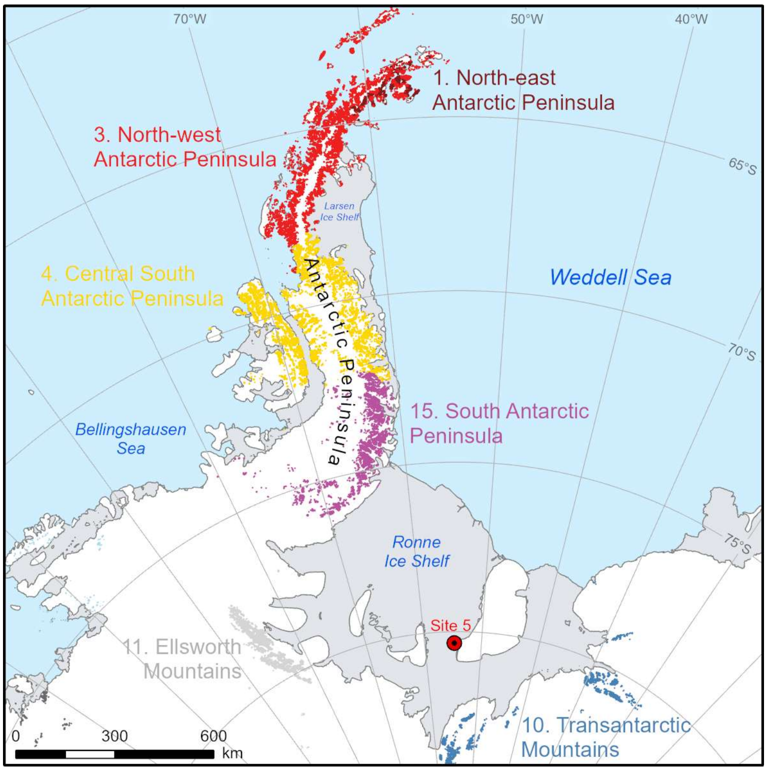

Figure 13: The Antarctic Conservation Biogeographic Regions. Produced by the Mapping and Geographic Information Centre, British Antarctic Survey, 2026

7.4 Climate

Antarctica is the coldest and driest continent on Earth. Across the continent, high elevations, the prolonged absence of sun, and the high albedo of the ice surface account for low temperatures, and reduced precipitation through the low moisture-holding capacity of the air.

Antarctica's average annual temperature ranges from about −10 °C on the coast to −60 °C at the highest parts of the interior. West Antarctica is generally warmer than East Antarctica due to its lower elevation (Figure 14). The mean annual air temperature at *Site 5* is around -25 degrees.

Antarctica's environment has special conditions that make it the windiest continent on Earth. Antarctica is usually surrounded by a belt of low pressure which contains multiple low centres. This is called the 'circumpolar trough'.

Low-pressure systems near the coast can interact with katabatic winds to increase their strength. Resulting wind speeds can exceed 100 km/h for days at a time and wind gusts well over 200 km/h have been measured.

The dry, subsiding air over the interior of Antarctica creates little cloud. Around the coast, however, more moisture is available, and low-pressure systems have a greater influence. This means that cloudy conditions are more common near the coast, particularly in the region of the Antarctic Peninsula.

Rain has been observed near the coast, but most precipitation over Antarctica is in the form of snow or ice crystals.

Windy conditions make it difficult to measure snowfall accurately. The average accumulation of snow over the whole continent is estimated to be equivalent to about 150 mm of water per year. Over the elevated plateau, the annual value is less than 50 mm. Near the coast, it generally exceeds 200 mm, the heaviest being over 1,000 mm for an area near the Bellingshausen Sea.

The proposed project site, located on the Ronne ice shelf near Berkner Island on the Antarctic Peninsula, where snow accumulation varies greatly from year to year, but averages around 0.5 m per year. There is very little melting across the ice shelf, with no visible ice layers when digging.

Nearer the ice front, during summer the air temperatures are occasionally high enough to allow misty rain but, in general, higher summer temperatures tend to be between -3 and -5 degrees. Wind speeds rarely exceed 40 knots during the summer, and usually only the occasional blow comes through.

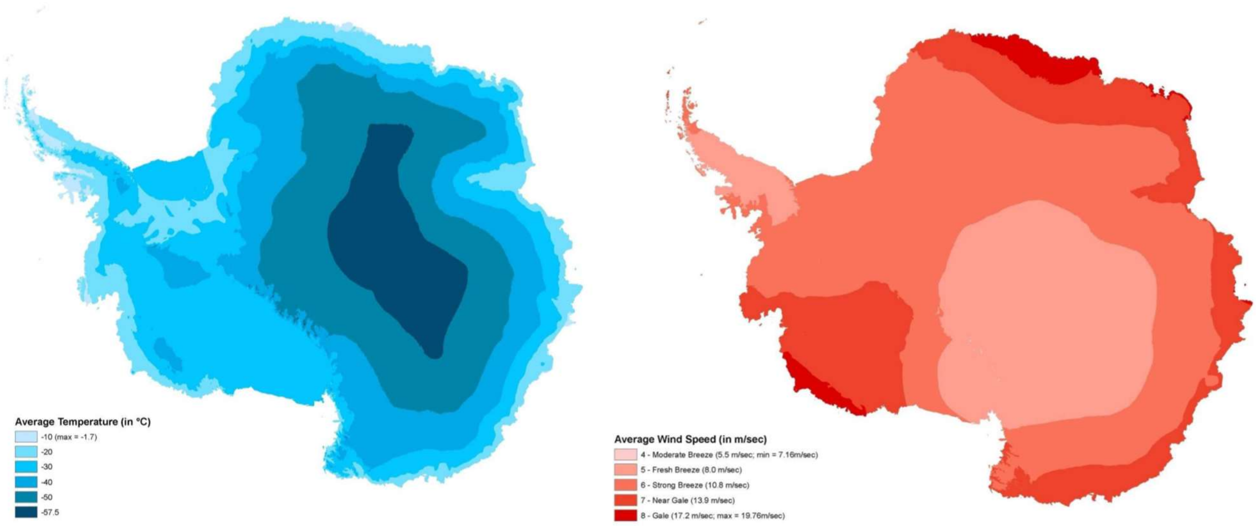

Figure 14: Mean Temperatures and Wind Speeds Across the Antarctic Continent (Source: Morgan, 2007).

7.5 Glaciology –Ronne Ice Shelf

The proposed hot water drilling project is located on the Ronne ice shelf, in West Antarctica.

The Ronne ice shelf is formed from several large ice streams flowing into the embayment in the southwestern Weddell Sea. The ice goes afloat at the grounding line and flows roughly northeast towards the open Weddell Sea.

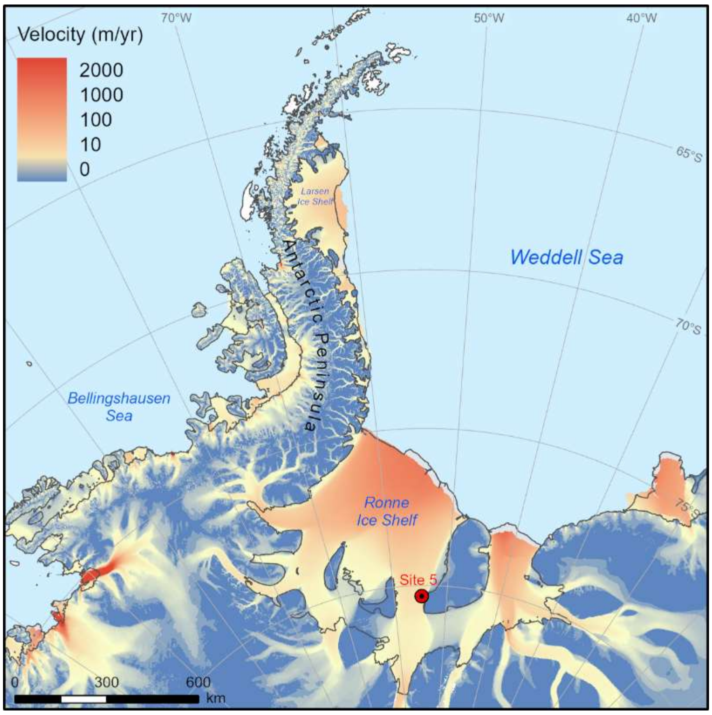

Figure 15: Ice velocity of the Ronne Ice shelf

The thickness of the ice at the various grounding lines of the contributing ice streams, varies between about 1000 m and 1800 m; whereas at the ice front it is around 400 m thick.

The ice gradually accelerates as it flows towards the ice front, from a few hundred meters per year up to about 1.4 km per year at the central part of the ice front.

7.6 Ice Free Areas

The operational area for drilling activities is constrained to snow and ice. The closest ice-free area is a rock outcrop 240 km from the proposed hot water drilling location.

7.7 Wildlife

As the proposed project is on the Ronne ice shelf, no wildlife concentrations are in the vicinity. However, during a summer field season on the ice shelf, occasional skua can be observed.

7.7.1 Important Bird and Biodiversity Areas

Important Bird and Biodiversity Areas (IBAs) represent identified significant bird breeding (as opposed to foraging) locations (Figure 16).

The closest IBA to the proposed project is Antarctica Marine 20, which is designated for its breeding emperor penguins. This IBA is 326 km from the proposed *Site 5* project area.

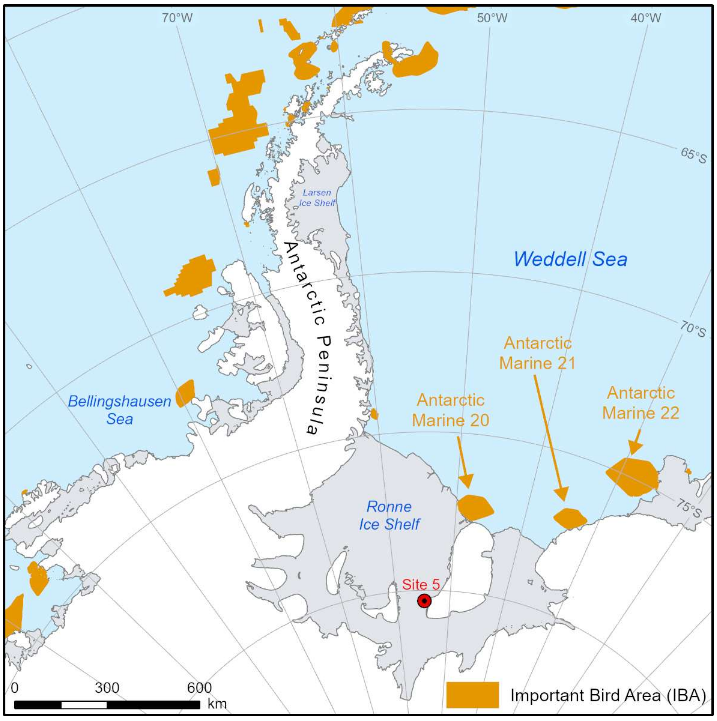

Figure 16: Important Bird and Biodiversity Areas (IBAs), Showing those Closest to the Proposed Site 5 Project Site. Produced by the Mapping and Geographic Information Centre, British Antarctic Survey, 2026.

7.8 Protected / Managed Areas and Historic Sites

Antarctic Specially Protected Areas (ASPAs), Antarctic Specially Managed Areas (ASMAs) and Historic Sites and Monuments (HSMs) can be established under the provisions of Annex V to the Protocol.

7.8.1 Protected Areas

An Antarctic Specially Protected Area (ASPA) can be designated to protect outstanding environmental, scientific, historic, aesthetic or wilderness values, any combination of those values, or ongoing or planned scientific research (ATS, 2024a).

The nearest ASPA to the planned activities is ASPA 119: Davis Valley and Forlidas Pond, Dufek Massif, Pensacola Mountains (see Figure 17), 241 km from *Site 5*. Davis Valley and Forlidas Pond are situated in the north-eastern Dufek Massif of the Pensacola Mountains, part of the Transantarctic Mountain range. The area contains some of the most southerly freshwater ponds known in Antarctica

Table 3: Closest features to Site 5 (Produced by the Mapping and Geographic Information Centre, British Antarctic Survey, 2026)

Feature	**Name**	**Distance**
ASPA	119 - Davis Valley and Forlidas Pond, Dufek Massif	241 km
ASMA	5 - Amundsen-Scott South Pole Station, South Pole	876 km
HSM	43 - Belgrano station's cross	502 km

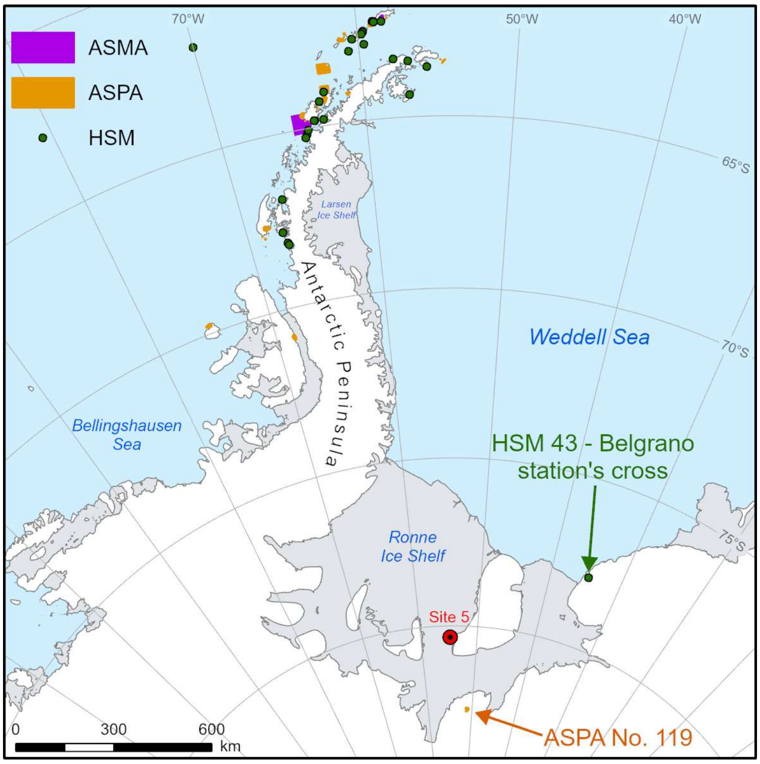

Figure 17: Antarctic Outline Showing the Location of Designated ASPAs, as Orange. Pink Squares Represent ASMAs, and Green Dots are HSMs. Produced by the Mapping and Geographic Information Centre, British Antarctic Survey, 2026.

7.8.2 Managed Areas

An area where activities are being conducted or may be conducted in the future may be designated as an Antarctic Specially Managed Area (ASMA), to assist in the planning and co-ordination of activities, avoid possible conflicts, improve co-operation between Parties or minimize environmental impacts (ATS, 2024a).

The nearest ASMA to the project site is ASMA 5: Amundsen-Scott South Pole Station, South Pole ASMA 5 is 876 km from the proposed activity.

7.8.3 Historic Sites or Monuments

There are no HSMs close to the planned drilling activities (Figure 17). The closest HSM 43 Belgrano station's cross, which is 502 km away. No Historic Sites and Monuments (HSMs) will be visited by the proposed hot water drilling project.

7.9 Human Activity and Antarctic Wilderness

Leihy et al. (2020) estimated that 99.6% of the Antarctic continent can still be considered wilderness, but pristine areas, free from human interference cover a much smaller area (less than 32% of Antarctica) and are declining as human activity escalates (Figure 18).

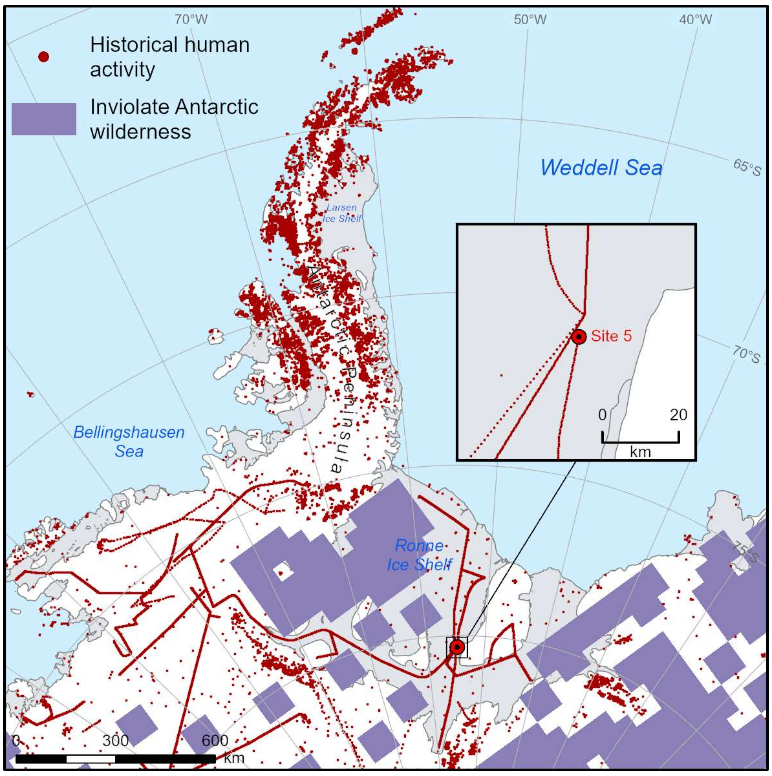

Figure 18: Inviolate Wilderness Areas, Showing Human Activity in the Region of the Proposed Site 5 Project Site. Produced by the Mapping and Geographic Information Centre, British Antarctic Survey, 2026.

The proposed hot water drilling location on the Ronne ice shelf has had previous human activity in the region, as can be seen indicated in red on Figure 18 above.

The Ronne ice shelf has had several previous scientific activities (see Section 3.1.1), which included air and traverse support. The particular area of *Site 5* has recorded activity since the 1990/91 field season.

Prior to the *Site 5* projects, the area was visited and traversed, for example in the 1980s, there were over-snow traverses, mainly by BAS, and in the 1970s, the Soviet Union completed several air-supported seismics campaigns on the ice shelf (pers. comm. Nicholls, 2026).

The proposed project is not in an inviolate wilderness area.

8 Assessment of Environmental Impacts

Having described the nature and scale of the proposed activity and reviewed the current environmental state, this chapter assesses the actual or potential impacts that will, or could, occur as a result of the proposed drilling and oceanographic equipment deployment activities for both boreholes related to the BAS and collaboration instruments.

Consideration is also given here to the cumulative impacts of the planned activities in conjunction with other past, current, and reasonably foreseeable activities in the region.

8.1 Methods and Supporting Information

The actual or potential environmental impacts of the activity are assessed by means of a four-step analysis involving:

1. identifying the **aspects** i.e., the physical change imposed on, or an input released to the environment as the result of an action or activity such as emissions, dust, mechanical action on the substrate, fuel spills, noise, light, wastes, heat, introduced species, etc., arising from the proposed activities described in Chapter 4;
2. identifying the **exposure** i.e., the interaction between an identified potential output and the environment including flora and fauna, freshwater, marine, terrestrial and atmospheric environments;
3. identifying the **impacts** i.e., the change in environmental values or resources attributable to the activity;
4. assessing the **significance** of the identified impacts by considering the spatial extent, duration, intensity and likelihood of occurrence of the potential impacts to each environmental element – with reference to the three levels of significance identified by Article 8(1) of the Protocol (i.e., 'less than', 'no more than', or 'more than' a 'minor or transitory' impact).

Information to support the impact assessment is drawn from a number of sources including academic literature, BAS on-line information and manuals, BAS experts, the Antarctic Treaty Secretariat website, and the SCAR website.

8.2 Environmental Aspects

As recorded above, an environmental aspect is a physical change (*e.g.,* movement of sediments by vehicle passage or noise) or an entity (*e.g.* emissions, an introduced species) imposed on or released to the environment as the result of an action or an activity (CEP EIA Guidelines, 2016).

For the purposes of this environmental impact assessment the proposed activities have been divided into the following elements:

- hot water drilling;
- drilling camp;
- skidoo use;
- deployment of instruments; and

- logistics.

The environmental aspects of these elements were highlighted in Chapter 5 and are summarised in Table 4. This table records that expected environmental aspects of hot water drilling and instrument deployment activities will include atmospheric emissions, noise, heat, mechanical action on snow and ice surfaces, marine interaction, as well as presenting a risk of fuel leaks, which will potentially generate hazardous waste.

Field camps will also produce atmospheric emissions, noise, heat and disturbance to snow and ice surfaces. Fuel spills may also occur at camp locations and camping activities will generate wastes including human waste, which includes the deliberate release of grey water and human liquid waste to the ice sheet.

Table 4: Summary of Environmental Aspects that will or could Arise from the Proposed Activities.

	Atmospheric emissions (burning fossil fuels)	Noise emissions	Heat emissions	Mechanical action (physical disturbance to substrate)	Fuel or hazardous substances release	Wastes (Including unrecoverable equipment)	Introduction of non-native species or relocation of native species	Presence / visual disturbance
Drilling	✓ Fuel burn for generators	✓ Noise of drilling operations	✓ Heat from generators and burners	✓ Drilling into ice surface	✓ Potential for spills of fuel and glycol	✓ Potential for loss of drill, waste wood	✓ Potential for introduction of species	✓ Visual and audible presence of drilling
Drilling camp	✓ Fuel burn for generators and cooking equipment	✓ General camp operations and generators	✓ From generators and cooking equipment	✓ Setting up camp and walking around area	✓ Potential for spills related to generators and cooking equipment	✓ Food, wastewater and biological wastes	✓ Potential for introduction of species	✓ Visible presence of camp
Skidoo use	✓ Fuel burn	✓ Sound of engines	✓ Heat from engines	✓ Disturbance of snow surface	✓ Potential for refuelling spill		✓ Potential for introduction of species	✓ Visible presence on the ice shelf
Deployment of instruments					✓ Loss of batteries and instruments to the sea floor (e.g. lithium)	✓ Instruments and mooring cable will be unrecoverable		✓ Instruments will be present on surface and subsurface
Logistics[8]	✓ Fuel burn from SDA[9] and Twin Otter aircraft	✓ Noise of SDA and Twin Otters landing	✓ Heat from engines of SDA and Twin Otters	✓ Twin Otter landings on snow surface	✓ Potential for fuel spills/hydraulic leaks	✓ Potential for equipment loss	✓ Potential for SDA to transport	✓ Visual presence of ship and aircraft

[8] At the time of writing it is unlikely the SDA will be used for transporting personnel or equipment, although a third party contractor may be used for additional flights.
[9] SDA would be operating as part of regular operations, transporting equipment and personnel to Rothera. A portion of any potential impact is attributed to this proposed project.

A summary of identified environmental aspects (from Section 5) include:

- input/uplift and maintenance flights of personnel and equipment;
- SDA operations, proportional to the amount of equipment/number of personnel transported, and duration on board (if any).
- skidoo, personnel movements, and drilling activities to the ice sheet surface;
- impacts of camp set up and living on the snow/ice surface (e.g., tent footprints and wastewater discharge);
- impacts to the marine environment;
- emissions from generators (petrol), burners (aviation fuel), skidoos (petrol), and cooking equipment (kerosene);
- potential for spills of fuel, glycol and other liquids;
- wastes produced by the project, and their transportation to Rothera;
- inadvertent loss of waste;
- potential for introduction of non-native species and biosecurity concerns;
- loss of equipment (planned and unplanned); and
- potential impact on wilderness values.

8.3 Environmental Exposures

Exposure is the process of interaction between an identified potential aspect and an environmental element or value (CEP EIA Guidelines, 2016).

The aspects described in Section 8.2 may interact with the environment in several ways. As described above, all drilling activities will occur on snow or ice surfaces and away from ice-free areas and concentrations of wildlife.

The main environmental aspects are linked to the drilling operation, physically disturbing the ice and ice surface via drilling and skidoo movements, and the deployment of non-retrievable equipment under ice, in the ocean. The presence of the field camp will also have impacts on the ice and snow surfaces.

Drilling to the ocean and interacting with the ocean water, gives a potential conduit for any contamination or non-native species interaction from the deployed equipment.

Skidoo movements and use of generators and burners result in carbon emissions, potential for particulates and heat emissions. Carbon calculations are considered in Section 8.5.

Human presence in Antarctica inherently has visual impacts on the wilderness and aesthetic values of an area, with aircraft, skidoo and drilling operations adding noise impacts. Human biological wastes are also produced and disposed of as appropriate according to waste type (liquid released to ice sheet, solid returned to Rothera).

When fuel and liquids (petrol, aviation fuel, oils and lubes, or glycol) are introduced to an environment there is a risk of spills and leaks, and if these are cleaned with spill kits then hazardous waste will have been produced (e.g., used spill absorbents) and will need storage and disposal. An overwintering depot was established by a third-party contractor in the 2025/26 season on site ready for the project to start in 2026/27 season. The contractor delivered fuel and equipment directly into the *Site 5* project location (see Section 3.4.1).

Although considered of low likelihood, the accidental loss of drilling equipment including the drill itself is a risk, especially if there are changes to the field schedule and a shorter season is required.

For this project there is also the intentional loss of deployed instrumentation, which will remain on and under the ice. Although not well studied, the potential for breakdown of the equipment, could lead to loss of lithium to the ocean environment, which could impact marine life and ecosystems. Equipment has been designed to withstand water pressure at depths not expected to be reached, however there is uncertainty around when the equipment would eventually fail (e.g. decades to centuries).

Logistical activities are also considered; including the input of fuel and equipment by the third-party contractor as part of the cumulative impacts, and although the SDA would be following routine operations, a portion of emissions and potential impact, such as impacts to marine life, would be attributed to this proposed project (proportional to the amount of cargo, or number of people that are transported, if any).

No exposures to, terrestrial or freshwater environments are identified from the proposed project.

8.4 Impacts and Mitigation Measures

This section reviews the potential environmental impacts that will or may occur to each of the identified environments as a consequence of the identified aspects and exposures recorded in Sections 8.2 and 8.3 above.

This impact assessment considers the potential worst-case impacts.

The actual or potential impacts are summarised in Table 12 (page 66) which assesses the level of risk associated with the actual or potential impacts according to the spatial extent, duration, severity and likelihood of the impact occurring.

The following predicted impacts and mitigating measures are based upon BAS experience of operating at the same location since the early 1990s for Site 5, 5a, 5b, and 5c.

The following definitions are used to describe the different types of impact:

A **direct impact** is a change in environmental values or resources that results from direct cause-effect consequences of interaction between the exposed environment and an activity or action (e.g., decrease of a limpet population due to an oil spill, or a decrease of a freshwater invertebrate population due to lake water removal) (EIA Guidelines, 2016).

An **indirect impact** is a change in environmental values or resources that results from interactions between the environment and other impacts – direct or indirect (e.g., alteration in gull population due to a decrease in limpet population which, in turn, was caused by an oil spill) (EIA Guidelines, 2016). Indirect impacts may not be known until a direct impact occurs.

A **cumulative impact** is the combined impact of past, present and reasonably foreseeable activities. Cumulative impacts may occur over time and should be assessed by looking at other human activities occurring in the proposed locations. As with indirect impacts, cumulative impacts may not be identified until a direct impact has occurred (EIA Guidelines, 2016).

Cumulative impacts are considered in more detail in Section 8.6.

Mitigation is divided into categories as defined in the mitigation hierarchy, there are various versions of this wording depending on the industry, but in general the levels are:

Avoid – do not do the activity, and therefore there is no potential impact.

Minimise – make changes to the design, technologies used, or location chosen to reduce the amount of potential impact.

Mitigate – use technology, practices, and other methods to mitigate for the predicted impacts.

8.4.1 Impacts That Will or May Occur to the Glaciological Environment

Given that all activities associated with the proposed drilling activities will be constrained to the ice and snow surfaces, the glaciological environment has the potential to be most heavily impacted.

Aspects that will or may give rise to impacts to snow / ice environments have been identified as:

a. particulates and other organic compounds released in exhaust emissions from burners, skidoos, generators, cooking and heating equipment settling on the snow and ice surface;
b. mechanical action and physical disturbance to snow and ice from drilling activities, the movement of skidoos, and from field camp operations;
c. potential for the accidental release of hazardous substances (e.g., spills of fuel); and
d. potential for the accidental release of wastes and the deliberate release of human liquid waste and sieved grey water at field camp locations, as well as the risk of release of other items and equipment through accidental loss (e.g., stuck drill).
e. Planned loss of equipment for scientific research

8.4.1.1 Release of particulates and organic compounds to the glacial environment

Impact description

The burning of fossil fuels in skidoo engines, and in burners and generators will result in emissions to air of a range of gases as well as other compounds including volatile organic compounds, heavy metals and particulates such as black carbon (arising from incomplete combustion of fossil fuels).

Particulates, heavy metals and organic contaminants will deposit on and contaminate the local snow and ice surface with the spatial extent of deposition largely determined by wind conditions.

Long-range atmospheric transport and ocean current transport from other continents are generally considered to be the principal source of contaminants that can be detected in Antarctic snow and ice (Vecchiato et al., 2015; Cheng et al., 2013).

Contaminant concentrations in Antarctic snow and ice are generally low and have little direct impact other than providing evidence of human presence (Xie, et al., 2020). Black carbon deposited on snow and ice can decrease albedo and increase surface melting. However, concentrations of black carbon in Antarctic snow and ice are also generally very low (Kang et al., 2020).

The additional contributions to snow and ice contamination from the proposed *Site 5* drilling activities are considered to be negligible.

Impact type: Direct and Cumulative

Particulate emissions to the snow and ice surface will be a direct source of contamination of the ice shelf and add to any contamination already captured by the ice from local and global sources.

Treatment and Mitigation

- Skidoo engines and generators are regularly serviced and maintained to maximise efficiency of operation;
- Skidoo engines, burners and generators will be allowed a 'warm up' period prior to engaging any load;
- The fuel types selected are the most efficient for use in low temperature conditions;
- All fuel burning will be minimised to the extent practicable.

Monitoring or Record keeping

Snow and ice contamination levels will not be monitored as part of hot water drilling activities.

Volumes and types of fuel uses will be recorded and reported back to be included as part of BAS' annual fossil fuel and carbon emissions monitoring.

8.4.1.2 Mechanical action and physical disturbance to the glacial environment

Impact description

The surface of the ice shelf will be physically disturbed during drilling operations, including from: drilling into the ice self; the movement of skidoos; the movement of snow when establishing camps and filling the flubber for the first time; tracking caused by people walking around camp sites, and landing of aircraft.

Such physical disturbance will be temporary. The surface of the ice shelf is a highly dynamic environment as a result of ice movement, precipitation and wind action.

Accordingly, evidence of disturbance to the snow surface is likely to be erased in timeframes ranging from minutes to weeks depending upon the weather conditions – wind conditions, in particular. Wind flow across the ice shelf can attain hurricane force and blow for several days. Snow lifted from the surface and carried aloft by wind is known as drifting snow (snow transported at heights <2 m) or blowing snow (snow transported at heights >2 m) (Palm et al., 2018).

In some areas it is feasible that tracks made in the snow can become raised as a consequence of less tightly bound snow being blown away from the more compressed snow where tracks have been made. Eventually, the hardened snow will also be eroded, though this can take days or weeks depending upon conditions.

Evidence of the dynamic conditions can be seen when returning to raised berms when they are used to store equipment. Although at *Site 5* the snow accumulation is lower than at the ice front, a three-metre-high berm could be lost in four winters if not dug out. While the proposed project does not plan to construct overwinter depots for fuel or equipment, site revisits will be required to raise the surface ApRES and loggers every two years, over the next ten years due to the extent of moving snow and snowfall possible.

Leaving instrumentation under ice may impact future drilling activity in the same area as *Site 5*, however with studied ice shelf movement, it is unlikely that the same location would be drilled twice. The instruments will be tracked and monitored, so their relative position to the original drill site is understood.

The boreholes will close, and the mooring line will be frozen in place and thus move with the ice shelf. The loggers for both of the boreholes, and the ApRES equipment will remain on or near the surface for up to ten years, marking the site location.

Consequently, the impacts for the ice shelf from the physical disturbance to otherwise highly dynamic snow and ice surfaces is considered to be less than minor and transitory.

Impact type: Direct

Disturbance will occur from skidoo tracks, walking around camp and setting up of tents, drilling and drilling infrastructure, deployment of instrumentation, and aircraft landings, though effects will be transitory.

Treatment and Mitigation

- Keep movement around ice shelf and tent numbers to a minimum.
- Keep flights to a minimum.
- Recycle drilling waters so 'new' snow is not needed to be dug and melted

Monitoring or Record keeping

Records will be maintained on drill location, camp sites, and any skidoo travel outside of camp.

8.4.1.3 Accidental release of hazardous substances (fuel, oils, lubes, glycol)

Impact description

Accidental releases of fuel, or other hazardous substance, could occur either when transferring the liquids between containers (e.g., during refuelling) or as a result of damage to equipment, or failure of a fuel drum or container.

The fate of fuel or other liquid substances accidentally released to the glacial surface will depend upon the nature of the snow or ice. Any liquid substances spilt on lightly packed snow or firn is challenging to recover. Liquids can penetrate quickly into the firn layer and their distribution will depend upon the conditions at the time. During warmer temperatures the ice is more porous, and liquids will flow quickly through the firn. Under colder conditions the ice is less porous and spilt fuel will migrate less (Raymond et al., 2017).

Any liquid substances spilt on to hard, blue ice, which is much less porous than snow or firn, may be easier to recover.

Unrecoverable liquids will remain in the snow/ice as a contaminant and will add to previous fuel spill events that have occurred in Antarctica. Contaminated sites could be detectable in any future scientific ice coring or sampling programme with negative implications for the research in question, though the likelihood of a glaciological research programme encountering a historic spill event is considered to be extremely low. Recording the location of the event is also important for this reason.

Any spill event is also likely to create hazardous waste items such as contaminated spill response equipment.

Impact type: Direct and Cumulative

Any hazardous liquid spilt on snow and ice will directly contaminate the area that it penetrates to.

If a spill event were to occur, any unrecoverable liquid will add to previous fuel spill events that have occurred in Antarctica.

Treatment and Mitigation

- Volumes of hazardous liquid substances, including fuel taken into the field, will be minimised to the extent that is safe and practicable.
- Drum (including fuels and glycol) storage will be kept away from the boreholes
- All fuel and other hazardous substances will be managed in the field in accordance with standard BAS procedures, as set out in the BAS Field Manual (Appendix 3).
- Hazardous liquid substances (fuel, oils and glycol) will have regular checks on the integrity of their drums and storage containers.
- Trained and experienced drillers will oversee equipment and manage skidoo, burner and generator refuelling activities.
- Maintenance of skidoos will be conducted by a vehicle mechanic.
- Fuel spill response training will be provided to those undertaking fuel handling in the field.
- Spill kits (containing suitable absorbents) will be readily available at locations where fuel is stored, transported or transferred. Any fuel (except petrol) spilt will be cleaned up to the extent practicable in accordance with the BAS Field Manual (Appendix 3). Recovered liquids and contaminated absorbents will be treated as hazardous waste and will be contained, marked as hazardous and transported to Rothera for appropriate handling and disposal in accordance with the Protocol.

Monitoring or Record keeping

Any fuel or other hazardous liquid substances spill events will be recorded and reported in accordance with BAS requirements, including volume and type of substance spilt, the location of the spill and the approximate volume that was recovered.

8.4.1.4 Accidental and deliberate releases of wastes to the glacial environment

Impact description

Any unrecovered items lost to the environment are likely to become buried in snow and lost to the ice shelf environment. Such items will gradually become encapsulated in the ice. This will have no immediate impacts on the ice shelf itself other than any local contamination that may occur. Over long timeframes (around 500 years) such lost equipment will be transported to the Weddell Sea in accordance with natural rate of flow of the ice.

Human waste and grey water

BAS policy requires all solid human waste to be removed from the field. Plastic UN approved drums ('poo bins') are provided for this purpose. Solid human waste is returned to Rothera for incineration. There is negligible risk of solid human waste being released to the glacial environment.

Liquid human waste will be disposed of to the ice environment at controlled locations.

Small volumes of sieved grey or wastewater will also be disposed of at field camp sites. Such grey water is generated from cleaning plates and dishes, brushing teeth, etc.

Human liquid waste and grey water will be disposed of to the ice/snow at identified and recorded locations. It is normal BAS practice to dig small pits for such disposal. The disposed liquid waste will melt into the ice pit but quickly freeze over. Once the field camp is disestablished the pits will quickly fill in as a result of ice movement, precipitation and wind-blown snow.

Food and general waste

Food waste and general waste, such as food packaging, paper and glass as well as (potentially) some hazardous wastes such as medical wastes and batteries, will be generated at field camps and during drilling operations. If unmanaged, such items could be released to the glacial environment, where they are likely to blow around or become trapped in the ice causing localised contamination.

Annex III to the Protocol provides for Parties to reduce the quantity of waste produced and removal of wastes in Antarctica in order to minimise any impact on the environment. Emphasis is placed on the removal of waste from the Antarctic Treaty area, as well as recycling and source reduction.

BAS complies with the requirements of the Annex by means of conditions attached to the Operating Permit granted by the FCDO.

BAS has prepared a Waste Management Handbook that guides the management of waste on its ships, stations and in the field in accordance with best practice and UK waste legislation.

Lost Equipment

There is potential that the drill or related equipment may be lost to the ice, due to malfunction. While every effort is made to release and retrieve equipment, some circumstances may result in loss to the environment (See Appendix 1 for drilling best practice).

Additionally, there is planned loss of equipment in this project, so scientific measurements can continue to be collected over the next ten years.

Impact type: Direct and Cumulative

Any equipment or waste released to the environment will have a direct localised impact and will add to the volumes of items, equipment and materials lost to the Antarctic environment over the decades of human activity in the region.

Treatment and Mitigation

- Waste generated in the field, including any hazardous waste, will be managed in accordance with the provisions of Annex III to the Protocol, the BAS Waste Management Handbook and BAS Field Operations Manual.
- All food and general waste will be separated into waste streams and removed from the field for correct handling at Rothera.
- Human liquid waste and sieved grey water will be disposed of in ice pits at specifically identified locations only. Solid human waste is removed from the field.
- Grey water production will be minimised to the extent practicable.
- Careful planning shall be undertaken to minimise the materials and items taken into the field that will generate waste.
- Staff involved in the *Site 5* Drilling Project will comply with BAS waste management policy and will follow the procedures outlined in the BAS Waste Management Handbook (BAS, 2025).
- The camp will be cleared of any rubbish or debris each day.
- Open burning of waste is prohibited.
- Accepted drilling practices will be followed at all times to reduce risk of loss of drill (See Appendix 1)
- Only experienced operatives will use the drill.
- All BAS field parties are supplied with a copy of the Field Operations Manual, colour coded waste sacks for the separation and disposal of wastes, and solid human waste drums that are UN approved for clinical waste.
- Only the designated equipment will be deployed under the ice, and at the surface, to remain in-situ.
- Old equipment collected from other sites during maintenance and servicing visits will be removed from site and disposed of appropriately.
- Two-yearly maintenance visits will be scheduled to prevent the loss of surface equipment (due to accumulation), and allow the replacement of non-working surface instrumentation

Monitoring or Record keeping

Any items accidentally released to the environment, and which are unrecoverable, will be recorded and reported in accordance with BAS incident reporting requirements.

All waste generated (including amount of released and returned human waste) will be recorded and reported back to BAS Environment Office.

Any items intentionally released into the environment (including oceanographic equipment) will be recorded and reported back to BAS Environment Office.

8.4.2 Impacts That Will or May Occur to the Marine Environment

Given that oceanographic equipment and associated infrastructure will be deployed beneath the ocean surface, and will be lost to the ocean eventually, this element needs to be considered. Under the ice there is not expected to be any marine mammals present, however some marine life is likely.

Aspects that may, or will impact the marine environment include:

a. Release of lithium and other components (e.g. thionyl chloride and plastics) as a result of eventual breakdown of the equipment housing and batteries
b. Release of the mooring and associated equipment to the ocean floor

8.4.2.1 Release of Lithium and other components

Impact Description

While the deployed equipment is designed to withstand up to 6000 m of water pressure, it is not inconceivable that there may be circumstances that mean the equipment fails. The equipment contains lithium thionyl chloride ($Li\text{-}SOCl_2$) batteries. The housing of the equipment is made from Titanium and designed to prevent release of substances (e.g. lithium) to the marine environment. It must be considered though, as the equipment will be on the ocean floor.

Impact Type: Direct/Cumulative

Should the housings and batteries breakdown this would have a direct impact on the local environment. Lithium is considered toxic to life when in water, while thionyl chloride is noted as toxic[10]. However the quantities would mean this would likely be a local impact (c. approx. 10 m with local flow considerations, however, more in open ocean) (pers comm D.Barnes, 2026). This is likely to be cumulative overtime especially if several pieces of equipment fail at the same time, and in the same location.

Treatment and Mitigation

There is no current treatment of mitigation available, other than attempting to remove the equipment after the ten-years of data collection, which is currently considered more environmentally damaging than leaving the equipment in situ.

Monitoring and Record Keeping

The location of the equipment when it stops functioning will be recorded and reported in the BAS lost equipment log.

8.4.2.2 Release of mooring and equipment to ocean floor

Impact Description

The BAS oceanographic equipment and IceNode that will be deployed, once released from the ice will sit on the ocean floor for the rest of its (undetermined) life. The equipment will include all items related to the in ice and under ice portions including the physical equipment, mooring lines, under ice loggers, and weights. All these items once on the ocean floor will accumulate sediment and be buried.

Impact Type: Direct

Equipment sedimentation may lead to local impacts for marine life, including providing settlement stratum.

Treatment and Mitigation

There is currently no mitigation available

Monitoring and Record Keeping

The location of the equipment when it stops functioning will be recorded and reported in the BAS lost equipment log.

8.4.3 Impacts That Will or May Occur to the Atmospheric Environment

There are a number of aspects that will or may give rise to impacts on the atmosphere (see Section 8.2 and Table 3). These include:

a. Release of gases including greenhouse gases as a result of the combustion of fuel in aircraft, ships, skidoos, burners, generators, cooking and heating equipment;
b. The release of heat from engines, burners, generators, cooking and heating equipment.

8.4.3.1 Release of gases and greenhouse gases.

Impact description

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[10] https://uniross.com/the-complete-guide-to-lithium-thionyl-chloride-li-socl%E2%82%82-batteries/

Emissions to air from the burning of fossil fuels will occur through planned drilling activities. Exhaust gases will be quickly dispersed depending upon the weather and particularly wind conditions at the time. The emission of gases will pass into the atmosphere and add to regional and global atmospheric pollution.

Air pollution will result from the input of the field party by aircraft, and the use of petrol generators and aviation fuel burners at the drilling camp. Fuel consumption from the generators (10 kW and 1-2 kW) used on-site is predicted to be five barrels of petrol and the burners (250 kW) are estimated to need 26 barrels of aviation fuel.

Emissions will include carbon monoxide, carbon dioxide, nitrous oxides, sulphur dioxide, heavy metals and particulates. Using UK Government Guidelines for Greenhouse Gas Reporting, carbon calculations are included in Section 8.5.

Emissions resulting from the fuel used associated with the projects logistics (ship and aircraft) will be calculated and reported as part of the overall BAS carbon footprint.

Emissions will generally be rapidly and thoroughly dispersed by the strong and regular winds. There will be some fallout of pollutants in the local area. Heavy larger particles, such as soot, are likely to have relatively short maximum transport distances, with background levels in surface snow samples probably being reached within 2 km downwind of the drill site.

Heavy metals would have greater transport distances. Based on monitoring results from Halley IV Station, it is possible that background levels of heavy metals (e.g. lead) in surface snow samples would be exceeded up to a maximum of 10 km downwind of the site (Suttie and Wolff, 1993).

Releases of gases from Antarctic activities make only a minor contribution to global pollution, and current technology has yet to provide sufficiently reliable alternatives to the burning of fossil fuels in the harsh Antarctic environment (particularly for remote field activities), although sustainable energy options continue to be explored (Dou et al., 2019; Bustos et al., 2021).

It is now well established that anthropogenic releases of greenhouses gases from the burning of fossil fuels and other sources, is the major contributor to measurable changes in the global climate (IPCC, 2014).

The climate change implications for Antarctica and Antarctic biodiversity are a major focus of the ATCMs and the CEP.

Impact type: Indirect and Cumulative

This will be an unavoidable impact. Emissions of gases from the burning of fossil fuels will occur and will be transported into the atmosphere and indirectly and cumulatively contribute to regional and global atmospheric pollution, and climate change, although the contribution from BAS hot water drilling activities will be negligible.

Treatment and Mitigation

- All engines, generators, burners and fuel burning equipment are routinely serviced and maintained to ensure they run and operate as efficiently as possible.
- Maximum efficiency of logistics, using minimum flights and most efficient routes.
- Emissions minimised by only burning fossil fuels when required. Equipment is not left idling unnecessarily.
- Skidoo engines, burners and generators are allowed a ‘warm up’ period prior to engaging any load.
- The fuel types selected are the most efficient for use in low temperature conditions.
- All fuel use will be minimised to the extent practicable.
- Daily visual checks are to be made of burner and generator exhausts. Any maintenance to reduce atmospheric emissions will be carried out as required.
- The burners and generators will be shut down when not required.

Monitoring or Record keeping

Volumes and types of fuel used are routinely recorded as part of BAS’ annual fossil fuel and carbon emissions monitoring.

8.4.3.2 Release of heat.

Impact description

Heat will be generated from a range of sources due to the planned drilling activities, including from skidoos, burners, generators and cooking and heating equipment. Any heat generated will rapidly dissipate in the cold Antarctic atmosphere, particularly so at times when the wind is blowing.

No discernible impacts are likely to arise from heat emissions.

Impact type: Direct

Heat will be lost directly to the atmosphere, but with no discernible impacts.

Treatment and Mitigation

- Fuel burn will be kept to the minimum required.
- Burners and generators will be turned off when not required.
- Skidoos will be used only when necessary for moving heavy loads.
- Cooking and heating equipment will only be used for specified purposes.

Monitoring or Record keeping

None required.

8.4.4 Impacts That Will or May Occur to Antarctic Flora and Fauna

Impacts to Antarctic flora and fauna will not occur as a result of BAS *Site 5* drilling activities. All drilling activities, and the field camp will occur on snow and ice surfaces and will avoid ice-free locations where wildlife and plant life occur. Marine life may be encountered by under ice equipment, either directly under the once, or once it reaches open ocean. Marine flora and fauna may interact with the equipment as it descends to the ocean floor, or once it sits in the sediment, forming a stratum for growth.

Impact description

The drilling activities will occur on the Ronne ice shelf and well away from any known wildlife concentrations, and approximately 240 km from any ice-free ground. However, under ice and open ocean ecosystems may interact with the deployed equipment.

No terrestrial plants are resident in the proposed project area. Interactions with terrestrial wildlife are considered to be unlikely, however interactions with some marine life is considered likely.

Impact type: Direct and indirect

Disturbance events are assessed as being highly unlikely above the ice, however, under ice and in the open ocean there is likely to be interaction, potentially as a change in the substrates available as habitat.

Treatment and Mitigation

- All drilling activities, including the field camp are conducted on ice and snow surfaces.
- Oceanographic equipment is contained in pressure tested housings, so interaction is limited to the physical presence of the equipment under the ice and on the ocean floor.
- All *Site 5* drilling activities will be constrained to the defined areas that have been identified in this EIA.
- Biosecurity measures (including actions such as ensuring equipment is free of debris, visual checks/inspections of cargo and personnel luggage prior to landing in Antarctica) are used when moving equipment between Antarctic and global locations, to prevent any potential impact on local species (see Appendix 2, for field specific requirements).

Monitoring or Record keeping

Any observed disturbance events or biosecurity breaches will be recorded and reported in accordance with BAS incident reporting requirements.

8.4.5 Introduction of Non-Native Species or Artificial Relocation of Native species

Non-native species can be introduced into Antarctica due to equipment being contaminated with plant material or animals being transported in or on equipment, such as in non-sterile soil. Once they reach Antarctica, some species can adapt and outcompete the native species, so it is a priority to prevent non-native species arriving.

The most significant impacts are if non-natives arrive at ice free areas where they can grow, or survive with other flora and fauna, and potentially be spread on the wind, or feet and feathers of birds.

All *Site 5* drilling activities will be confined to ice and snow surfaces and will not be on or near ice-free areas, where non-native species are more likely to be able to establish.

Consequently, the proposed *Site 5* drilling activities are assessed as posing very low to no risk for the introduction of non-native species. There is a risk of the introduction of non-native biota, particularly micro-organisms, because of the importation of materials. However, the closest ice-free ground is approximately 240 km from the proposed project. While in the 2026/27 field season the drilling team and equipment may transition through the Sky Blu field depot, located near the Sky Hi Nunataks, the Nunataks will not be visited. It is possible that team members will travel via Union Glacier (depending on final operational plans), however, they would not be visiting any ice-free ground. The equipment that was already cached on site arrived via Union Glacier and not via any ice-free ground.

Emphasis will be placed on the importance of pre deployment screening and cleaning of all clothing and equipment prior to deployment to Antarctica. Any equipment, cargo or waste packaging must be checked before they are loaded onto the aircraft from snow/ice-free areas (e.g. Rothera Research Station) to ensure that they are not contaminated with any soil, plant fragments, or invertebrates.

Impact type: Direct

The introduction of non-native species due to this proposed drilling project is a very small possibility; however, if it did occur, and non-native biota were able to establish, this could be detrimental for the Antarctic ecosystem.

Treatment and Mitigation

- All equipment and materials required for the *Site 5* drilling project will be thoroughly cleaned before dispatch to Antarctica.
- All items of cargo will be checked for soil or non-native species prior to being flown from Rothera.
- The advice and procedures contained within the BAS Biosecurity Regulations will be followed where applicable (see Appendix 2).

8.4.6 Impacts on Antarctic Wilderness Values

Antarctica is considered wilderness, but human presence can impact the wilderness and aesthetic values.

Aspects that will or may give rise to impacts to wilderness and aesthetic values have been identified as:

a. Visible or recorded human presence at locations across the Ronne ice shelf.
b. Changes in local topography and wilderness/aesthetic values.

8.4.6.1 Visible or recorded human presence

Impact description

The Protocol provides for the "*protection of the Antarctic environment …. And the intrinsic value of Antarctica, including its wilderness and aesthetic values*" and requires that such values "*shall be fundamental considerations in the planning and conduct of all activities in the Antarctic Treaty area*".

Activities must be planned and conducted so as to avoid "*degradation of, or substantial risk to, areas of …. aesthetic or wilderness significance*".

However, the term 'wilderness' is not defined in the Protocol and to date the Antarctic Treaty Parties have not formed a collective view as to how the term should be defined. This makes it challenging to assess the impacts of activities on wilderness values in an Antarctic context.

Leihy et al. (2020) assembled a comprehensive record of human activity and used it to quantify the extent of Antarctica's wilderness. Drawing from definitions determined in the academic literature Leihy et al. showed that 99.6 % of the continent's area can still be considered wilderness, even when transitory human activity and cumulative impacts are taken into account. They noted however that pristine areas, free from recorded human interference, cover a much smaller area (less than 32% of Antarctica) and are declining as human activity escalates.

As recorded above, BAS drilling activities have the potential to impact upon wilderness values as a consequence of visible human presence.

The proposed drilling activities and associated camp will only be transitory, and the surface of the Ronne ice shelf is highly dynamic. Following the removal of the drill, skidoos and camp, any disturbed areas will be covered or weathered in a short period of time. However, records of human presence will cumulatively add to all past records of human presence with potential to further erode areas that can be regarded as pristine.

Impact type: Indirect and Cumulative

Recorded human activities (e.g., drill sites, camp site) have the potential to impact on perceived wilderness values in Antarctica and cumulatively add to the erosion of pristine areas of the Antarctic continent. Loss of pristine areas (even due to records of human presence) could be regarded as permanent.

Treatment and Mitigation

There are few mitigation measures that can be used to reduce the impacts on wilderness values. However, drilling activities and equipment deployment will be constrained to the areas that have been identified in this EIA and all practicable efforts will be made undertake the steps listed below.

- Minimise, to the extent possible, the areas used when establishing field camp
- Minimise disposal to the ice environment and ensure all waste materials (except for human liquid waste and sieved grey water) are removed from the field.
- Maintain a log of drilling locations (2 deployment boreholes), camp and any overwintering depot to be kept at BAS for future reference.
- Maintain a log of the equipment deployed and locations of deployments, including in relation to other previously deployed equipment.
- Maintain a log equipment positions until end of transmissions
- Care will be taken to avoid loss of equipment and waste at the field camp/drill site, and any accidental loss will be recorded on the BAS incident reporting system.

Monitoring or Record keeping

All locational information will be recorded and reported at the end of each operational season. This includes drill sites, camp site location, disposal sites of human liquid waste and sieved grey water and any overwinter depot. This information will be recorded in BAS' GIS.

It should be noted that the area of the Ronne ice shelf has been frequently visited as explained in Section 3.1.1.

8.4.7 Summary of Proposed Mitigations

The following is a summary of recommended mitigations to reduce any potential impact from the proposed *Site 5* project (for a full list of mitigation measures, see Table 12):

- Maximum efficiency of logistics, using minimum flights and most efficient routes.
- The fuel types selected are the most efficient for use in low temperature conditions;
- All fuel burning will be minimised to the extent practicable
- Volumes of hazardous liquid substances, including fuel taken into the field, will be minimised to the extent that is safe and practicable.
- Spill kits (containing suitable absorbents) will be readily available at locations where fuel and glycol is stored, transported or transferred. Any fuel (except petrol) spilt will be cleaned up to the extent practicable in accordance with the BAS Field Manual (Appendix 3).
- Waste generated in the field, including any hazardous waste, will be managed in accordance with the provisions of Annex III to the Protocol, the BAS Waste Management Handbook and BAS Field Operations Manual.
- Skidoo engines and generators are regularly serviced and maintained to maximise efficiency of operation;
- Accepted drilling practices will be followed at all times to reduce risk of loss of drill (See Appendix 1)
- Only the designated equipment will be deployed under the ice, and at the surface, to remain in-situ.
- Two-yearly maintenance visits will be scheduled to prevent the loss of surface equipment (due to accumulation), and allow the replacement of non-working surface instrumentation
- All drilling activities, including the field camp are conducted on ice and snow surfaces.
- Oceanographic equipment is contained in pressure tested housings, so interaction is limited to the physical presence of the equipment under the ice and on the ocean floor.
- Biosecurity measures (including actions such as ensuring equipment is free of debris, visual checks/inspections of cargo and personnel luggage prior to landing in Antarctica) are used when moving equipment between Antarctic and global locations, to prevent any potential impact on local species (see Appendix 2, for field specific requirements)
- Maintain a log of drilling locations (2 deployment boreholes), camp and any overwintering depot to be kept at BAS for future reference.

8.5 Carbon Calculations

8.5.1 Carbon Assessment

The carbon emissions for this project have been estimated using a combination of approaches, depending on the data available. BAS have developed a range of activity-based carbon metrics to help estimate project level carbon footprints and these are based on annual baseline activity data models and sets of assumptions, therefore provide an indicative[11] figure of estimated carbon emissions for the project.

8.5.2 Carbon Summary

Table 5 below shows the tonnes of carbon dioxide equivalent (tCO2e) from the main activities of the proposed project for which there are estimated emissions available.

Table 5: Summary of Estimated Total Project Carbon Emissions (tCO2e) by Activity

Activity Data Included within Estimated Footprint:				
Category	**Pre-season (2025/26)**	**2026/27 Season**	**Maintenance (per 2 years)**	**Total tCO2e**
BAS/Contractor Aircraft	134.6	321.6	30.4	**487.7**
Business Travel North/South	0.0	48.6	9.3	**57.8**
Rothera	0.0	20.3	3.3	**23.6**
Field	0.0	22.2	0.0	**22.2**
Total	**134.6**	**412.7**	**34.0**	**581.3**

Most of the carbon emissions for the project relate to the aircraft as there are a planned 12-15 flights to and from the Field site in the 2026/27 season (assumed 15 flights) with pre-season delivery from ALE and ongoing maintenance flights, every two years over ten years.

Table 6 below provides a breakdown of the carbon associated with the activities listed by GHG Protocol scope. Scope 1 relates to direct carbon emissions resulting from combustion of fuels, Scope 2 emissions relate to carbon emissions associated with Purchased Energy and Scope 3 relate to carbon emissions associated with the wider value chain (including emissions from Business Travel, Purchased Goods and Services and several other categories).

Table 6:Estimated Project Carbon Emissions by GHG Protocol Scope

Scope	Total tCO2e	Percentage Split
1	532.5	90.2%
2	0.0	0.0%
3	57.8	9.9%
Total	**590.3**	**100.0%**

The majority (90.1%) of the estimated emissions for this project fall within Scope 1, as they are the emissions resulting from BAS owned Aircraft, transporting equipment via SDA, the fuel used at Rothera and by the field team.

The Scope 3 emissions shown are the result of the Business Travel required for the project teams to travel to Antarctica and back to the UK for the season and for each maintenance trip.

8.5.3 Assumptions and Metrics

Standard Assumptions:

- Twin Otter flying hour is treated as using 330 litres of fuel per flying hour.

Project Assumptions:

- Assumed Twin Otter flights to field site are from Rothera and using Rothera bulk fuel.
- Assumed Twin Otter flights from field site to Rothera use drummed fuel from Sky Blu (collected en route to Field Site).
- Twin Otter flight time from Rothera to Field Site has been estimated as 3 hours.
- Assumed ALE flights refuelled at Rothera (as there is no available carbon metric for Union Glacier).
- Business Travel route has been estimated as using the MOD business travel input metric (Brize Norton -> gateway port) for 8 people.
- Sky Blu fuel drums used for field camp (including drilling, skidoos and camp).

Table 7: Metrics / Carbon Factors Used

Metric Used	UOM Final Unit	Metric (tCO2e per UOM)	Metric Version
Rothera Bulk (inc. Fuel Transportation Emissions - SDA to Rothera)	TO Flying Hours	0.537	BAS V2
Sky Blu Drum (inc. Fuel Transportation Emissions - SDA to Rothera, TO to FB)	TO Flying Hours	3.423	BAS V2
Total tCO2e per Brize Norton - Gateway flight (per PAX)	# PAX	1.542506626	Bespoke
Dash - Airbridge Transit (One PAX - One way)	# PAX	2.986663612	BAS V1
Rothera Accommodation	# bednights	0.181	BAS V2

[11] Not necessarily assessing the detailed activity, but the metric is used as a proxy for the purposes of estimating the carbon emissions

English Coast - Field Equipment from UK to English Coast[12] via SDA	Cubic meters	4.042	BAS V2

8.5.4 Exclusions From Carbon Calculation

The below activities have been excluded from the carbon calculation for this project for the reasons shown. If the reasons for exclusion change over time, then emissions from the activities may be included in a later period of reporting.

Table 8: Exclusions from Carbon Calculations.

Activity Data Outside Scope of Calculation:	
Activity	**Reason for Exclusion**
Antifreeze	No carbon factor available
Glycol/water premix	No carbon factor available
Grease	No carbon factor available
Oil - generators	No carbon factor available

[12] Note that there are no plans to visit the English Coast, this is a proxy for equipment transport on the SDA (if any required).

8.6 Cumulative Impacts

Cumulative impacts occur as a result of the combined impacts of past, present and reasonably foreseeable activities. Cumulative impacts may occur over time and should be assessed by looking at other human activities occurring in the proposed locations. As with indirect impacts, cumulative impacts may not be identified until a direct impact has occurred (EIA Guidelines, 2016).

Cumulative impacts may occur during the *Site 5* drilling project as well as in combination with past and reasonably foreseeable activities in this region of Antarctica.

Accessing information to support cumulative impact assessments in an Antarctic context can be challenging given that the international community has placed limited emphasis on monitoring and assessing incremental, but nonetheless cumulative impacts, across broader spatial and temporal scales (Tin et al., 2009).

The qualitative method used here to assess cumulative impacts has been to:

- identify activities that have occurred or are ongoing in the area covered by this EIA;
- identify activities that are planned to take place in the area covered by this EIA, over the same time period as this EIA; and
- identify the primary impacts that have occurred or are anticipated to occur from these past and planned activities.

Sources that were used to assess past, current and planned activities in the area covered by this EIA include:

- BAS's internal database of EIAs;
- the Environmental Impact Assessment database (EIA database) maintained by the Antarctic Treaty Secretariat (ATS)[13];
- a general web search;
- subject matter experts; and
- the BAS Mapping and Geographic Information Centres (MAGIC) mapping group.

A number of general terms were used for internet searches, including, for example: 'Ronne Ice Shelf', 'Berkner Island', and 'Antarctic Peninsula'.

Previous drilling and equipment deployment

There has been previous activity at this site (see Section 3.1.1), drilling and oceanographic equipment deployment has been occurring at this location since the 1990s.

Additionally, there are ongoing visits to site every two-seasons to raise and maintain equipment, covered by PEAs.

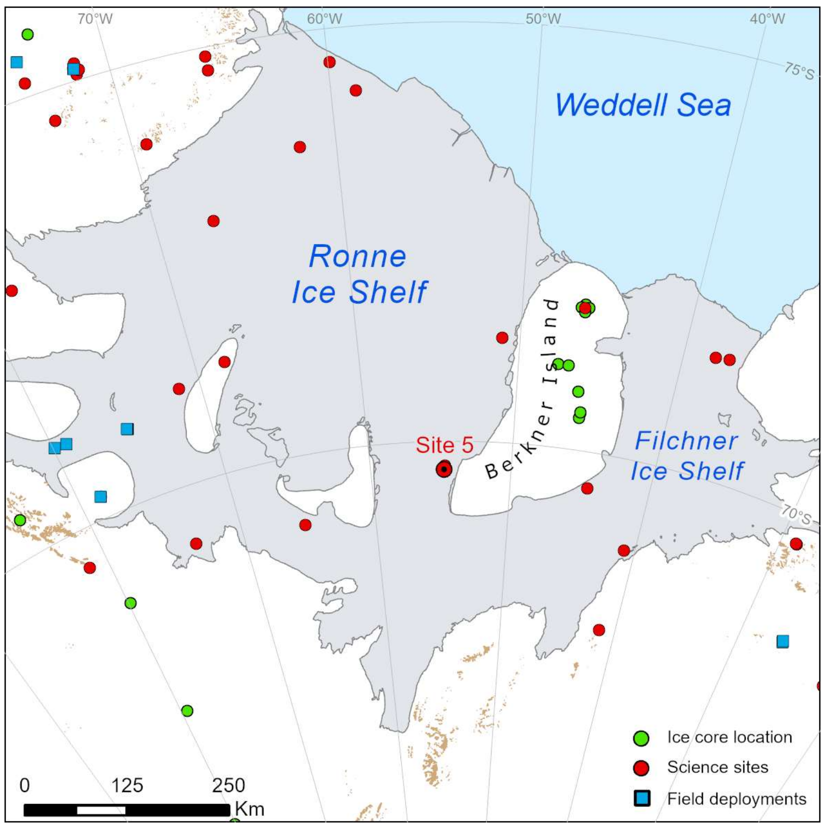

Figure 19: Project Locations Previous to the Proposed Site 5 Project. Produced by the Mapping and Geographic Information Centre, British Antarctic Survey, 2026.

Table 9: Previous Projects in the vicinity (within 300 km) of Site 5 (source: Mapping and Geographic Information Centre, British Antarctic Survey, 2026)

Distance (km)	Name	Year
0.676212721	FISS Drill site servicing	2018/19
0.676212721	FISS Drill site servicing	2019/20
2.908067031	FISS Drill site servicing	2018/19
2.908067031	FISS Drill site servicing	2019/20
5.275790219	FISS Drill site servicing	2018/19
5.275790219	FISS Drill site servicing	2019/20
191.9423737	FISS ApRes uplift/data fit	2022/23
191.9423737	FISS ApRes uplift/data fit	2018/19

[13] https://ats.aq/devAS/EP/EIAList?lang=e

191.9423737	**FISS ApRes uplift/data fit**	**2019/20**
191.9423737	**FISS ApRes uplift/data fit**	**2021/22**
192.93961	**INCISED GPR Survey Work**	**2021/22**
192.93961	**FISS - Drill site servicing (Filchner/Support Force Sites)**	**2022/23**
193.2451153	**Ice Core Chem/Iso**	**Unknown**
193.4725598	**BER11C95_25 Ice core**	**1992**
193.5487323	**Ice Core Chem/Iso UK-B25**	**Unknown**
197.5937503	**Ice Core Chem/Iso Berkner Island 07**	**2007**
197.5937503	**Ice Core Chem/Iso UK-03/T2**	**Unknown**
197.7179938	**Ice Core Berkner Island 07**	**Unknown**
199.7364011	**FISS ApRes uplift/data fit**	**2021/22**
199.7364011	**FISS ApRes uplift/data fit**	**2022/23**
199.7956685	**FISS ApRes uplift/data fit**	**2018/19**
199.7956685	**FISS ApRes uplift/data fit**	**2019/20**
207.1158431	**Ice Core UK-94/R8**	**1994**
207.4766649	**Ice Core UK-94/R10**	**1994**
216.5215928	**Ice Core UK-94/R9**	**1994**
263.9221572	**Tango**	**2021/22**
263.9221572	**FISS - Drill site servicing (Filchner/Support Force Sites)**	**2022/23**
282.3060365	**Ice Core UK-94/R7**	**1994**
283.954391	**Ice Core UK-94/R5**	**1994**
286.0084854	**Ice Core UK-94/R1**	**1994**

Other Activities in the Area

No other concurrent activities were identified in the vicinity of *Site 5*. The only regular activities identified were the bi-annual ongoing maintenance of the previously deployed sites, 5a and 5c.

8.6.1.1 Activities subject to EIA

A review of the ATS and BAS EIA databases did not reveal any recent or proposed activities in the area of the proposed *Site 5* location.

8.6.1.2 Potential future activities

A review of information available on the internet, including EIES, did not reveal any proposed activities for the area around *Site 5*.

Additional future research in this area is possible, if either the project does not deploy all the instrumentation as planned, or further work is required. Additionally, maintenance will be required approximately every two years for the next 10 years.

Should a continued timeseries be needed for further research, another drilling campaign may be needed in the same geographic location in the future.

Future activities by BAS or other nations are possible due to the large amount of science that has occurred around this region.

8.6.1.3 Summary of cumulative impacts arising from this proposed project

The assessment in Section 8.6 above shows that from the available information, the proposed hot water drilling and instrument deployment is not in the region of other proposed work for the duration of the drilling project.

There are a number of cumulative impacts that can be identified, to which the *Site 5* project activities will contribute including (see also Table 12 below):

a) **Contamination of the glacial environment** with particulates from the combustion of fossil fuels in skidoo engines, burners and generators, BAS drilling activities will contribute to particulates that become trapped in the ice from other local as well as global sources.

b) **Contamination of the glacial environment** from the accidental release of hazardous substances including spillage of fuels. With effective implementation of the identified mitigation measures, this should not occur in the case of BAS drilling activities, but if a spill event were to occur then the contamination would add to other spill events that have occurred historically across Antarctica (e.g., Aislabie et al., 2004). It is noted that there are poor records for such events on a continental scale.

c) **Contamination of the glacial and marine environments** from the planned deployment of oceanographic equipment. The instruments are made of metals and plastics and contain batteries, which will be lost under the ice and eventually to the ocean floor. Should this equipment breakdown (housing failure), these elements will be released. This equipment is designed to withstand up to 6000 m of water pressure, and it is not anticipated to expose the batteries to the ocean environment. Should it break down due to an unforeseen circumstance, there is a risk of lithium and other components entering the marine environment from the batteries. Once this equipment reaches the end of its research life, it will add to any other losses of equipment in the Weddell Sea and be recorded in the BAS lost equipment log.

d) **Contamination of the glacial environment** through the release of waste, including the accidental release of waste items, such as a lost drill. With effective implementation of the identified mitigation measures this should not occur in the case of BAS drilling activities, other than the deliberate release of small volumes of human liquid waste and grey water. Items released to the environment, will add to other losses that have occurred historically across the Peninsula. Here also there are no readily available records of such events that are maintained on a continental scale.

e) **The release of gases, including greenhouse gases** from the combustion of fossil fuels will add to other atmospheric releases from stations, bases, vehicles, and vessels in the same seasons and from previous activities in the region.

f) Human presence in the areas of activity, and any equipment (such as the surface loggers) left in situ, has the potential to add to the further **loss of wilderness values in Antarctica**. However, this location has been previously visited and is not an inviolate wilderness area.

There are no comprehensive databases of human impacts in Antarctica that can be accessed to support an effective quantification of cumulative impacts. Accordingly, cumulative impacts can only be qualitatively assessed based on available information at the time of writing.

Using the assessment criteria set out in Table 10 and Table 11 below, the following points are noted:

Spatial extent of cumulative impacts: Whilst human activities have been undertaken across the Ronne ice shelf, impacts that have occurred are likely to be constrained to the immediate areas of activity. No impacts from the proposed *Site 5* drilling activities are likely to have widespread impact. Any marine impact from the unforeseen break down of equipment would likely be local to the location of that equipment, e.g. to around 10 m, under ice, however this may be wider in the open ocean, depending on associated currents.

Duration of cumulative impacts: Most impacts to the ice sheet will be of short duration, e.g., physical disturbance of snow and ice surfaces. However, some impacts will be much longer lasting, e.g., loss of equipment, and contamination of snow and ice surfaces from the burning of fossil fuels will be detectable for years to decades as well as the loss of perceptions of wilderness value. However, as the proposed project is on a relatively small spatial scale (approximately 50 x 150 m) and human presence duration (4-6 weeks), if mitigation is followed then the potential impacts will be short term. However, in the case of atmospheric emissions and particulates, surface equipment presence, and as oceanographic equipment will be lost, this would result in a long-term impact.

Severity of cumulative impacts: Previous impacts from human activities across the ice shelf, are considered unlikely to have caused any disruption to the natural functions and processes of the environment. However, potential release of components to the marine environment could have locally severe impacts to marine life (if the titanium housing breaks down and releases the lithium batteries). If instruments from previous deployments have also released batteries, the addition of more lithium could increase the severity of the cumulative impact. The proposed project will not alter the severity of on-ice the cumulative impacts.

Likelihood of cumulative impacts: Impacts from activities across the Ronne ice shelf are known to have occurred (including previous drilling, oceanographic and surface equipment deployments, seismic surveys, and traverse and aircraft activities) and further impacts are likely, including those that will be contributed by the proposed *Site 5* drilling activities. The planned deployment of under ice equipment, which will be left in situ, with no current plans for recovery (and potential for failure with release of components), increase the risk. Surface equipment will be maintained and recovered once it reaches the end of its usable life but will be on the ice shelf for approximately ten years, contributing to cumulative impacts in the area. However, as the project is of a relatively small scale, this is considered to be a low to medium risk if mitigations are followed.

Overall, the cumulative impacts of past, present and reasonably foreseeable activities across the Ronne ice sheet are considered to be **'no more than minor or transitory'.**

While evidence of human activity will continue to erode perceptions of Antarctic wilderness, the contribution of the proposed BAS drilling activities to these cumulative impacts is considered to be **'no more than minor or transitory'**.

8.7 Summary and Evaluation of Impact Significance

Section 8.4 has identified the potential (direct, indirect and cumulative) impacts of the proposed drilling activities. This section evaluates the significance of the identified actual or potential impacts taking into account the three levels of significance identified in Article 8(1) of the Protocol.

In order to evaluate the significance of a given potential impact, the spatial extent, duration, severity (which also includes a level of reversibility) and likelihood of the identified potential impacts are considered so as to evaluate the overall significance of the identified impact of each activity.

Table 10 outlines the assessment criteria and definitions that have been used when evaluating the spatial extent, duration, intensity and likelihood of the identified potential impacts for the environmental elements (table and methodology modified from Oerter, 2000 in Gilbert, 2022).

In each case, the spatial extent, duration, severity and likelihood are scored 1 to 4, depending on whether each is considered to be 'low', 'medium', 'high' or 'very high' against the described criteria. An overall risk score (before and after treatment) is then calculated as follows:

Risk score = spatial extent score x duration score x severity score x likelihood score

The risk score determines whether the overall risk level is 'low', 'medium', 'high' or 'very high' as set out in Table 10.

Table 12 summarises the findings by setting out the identified impacts, assessing the raw risk without control measures in place and the residual risk after the control measures have been applied. The residual risk level is then compared to the three levels of significance set out in Article 8(1) of the Protocol as per Table 12.

Table 10: Assessment Criteria for Evaluating the Spatial Extent, Duration, Severity, and Likelihood of the Potential Environmental Impacts (modified from Oerter, 2000).

		Criteria for assessment			
Impact	***Environment Element***	***Low (1)***	***Medium (2)***	***High (3)***	***Very High (4)***
SPATIAL EXTENT OF IMPACT		*Local extent*	*Partial extent*	*Major extent*	*Entire extent*
	Freshwater Marine Terrestrial Atmosphere	*Confined to the site of the activity.*	*Some parts of an area are partially affected.*	*A major sized area is affected.*	*Large-scale impact; causing further impact.*
Area or volume where changes are likely to occur	***Flora and Fauna***	*Confined disturbance of fauna and flora within site of activity, e.g., individuals affected.*	*Some parts of the community are disturbed.*	*Major disturbance in community, e.g., breeding success is reduced.*	*Impairment at population level.*
		Short term	*Medium term*	*Long term*	*Permanent*

DURATION OF IMPACT Period of time during which changes in the environment are likely to occur	***Freshwater*** ***Marine*** ***Terrestrial*** ***Atmosphere***	*Several weeks to one season; short compared to natural processes.*	*Several seasons to several years; impacts are reversible.*	*Decades; impacts are reversible.*	*Environment will suffer permanent impact.*
	Flora and Fauna	*Short compared to growth period/ breeding season.*	*Medium compared to growth/ breeding season.*	*Long compared to growth/ breeding season.*	*Permanent*
SEVERITY OF IMPACT A measure of the amount of change imposed on the environment due to the activity		*Minimal Affect*	*Affected*	*High*	*Irreversible*
	Freshwater ***Marine*** ***Terrestrial*** ***Atmosphere***	*Natural functions and processes of the environment are minimally affected. Reversible.*	*Natural functions or processes of the environment are affected but are not subject to long-lasting changes. Reversible.*	*Natural functions or processes of the environment are affected or changed over the long term. Reversibility uncertain.*	*Natural functions or processes of the environment are permanently disrupted. Irreversible or chronic changes.*
	Flora and Fauna	*Minor disturbance. Recovery definite.*	*Medium disturbance. Recovery likely.*	*High levels of disturbance. Recovery slow and uncertain.*	*Very high levels of disturbance. Recovery unlikely.*
LIKELIHOOD *Chance of the occurrence of the impact*	***All elements***	*Should not occur under normal operation and conditions.*	*Possible but unlikely.*	*Likely to occur during span of project. Probable.*	*Certain to occur / unavoidable.*

Table 11: Risk Assessment Criteria

Risk score	Risk level	Description	Ref Article 8(1) of the Protocol
1 to 15	Low	Acceptable under most circumstances. Impact likely to be managed through normal operating procedures.	Less than minor or transitory
16 to 35	Medium	May be acceptable under certain circumstances. Impact requires ongoing monitoring and possible further treatment.	No more than minor or transitory
36 to 143	High	Unacceptable in most circumstances. Senior Management to be notified. Further treatment options must be explored.	More than minor or transitory
144 to 256	Very High	Unacceptable. Senior management to be alerted. Significant further treatment must be explored. Only senior management can approve proceeding if risk cannot be further treated to reduce risk level.	

Table 12: Summary of identified impacts and assessment of impact significance before and after mitigation measures are applied.

Environment type	Environmental Aspect	Potential Impact(s)	Type of Impact (Direct, Indirect, Cumulative)	Pre-treatment risk assessment: Extent	Duration	Severity	Likelihood	Raw Risk Level	Treatment (Preventative or Mitigating Measures)	Post-treatment risk assessment: Extent	Duration	Severity	Likelihood	Residual Risk Level	Ref Article 8 of the Protocol
Glacial Environment	Burning of fossil fuels in aircraft, skidoos, burners, generators etc. releasing particulates to snow / ice surface	Contamination of snow / ice surface around camp sites	Direct / Cumulative	1	4	3	3	36 High	• Skidoo engines, burners and generators are regularly serviced and maintained to maximise efficiency of operation; • Skidoo engines, burners and generators will be allowed a 'warm up' period prior to engaging any load; • The fuel types selected are the most efficient for use in low temperature conditions; • All fuel burning will be minimised to the extent practicable. • Input and uplift flights will be kept to a minimum • Only one generator will run at a time, were possible • Skidoos are only used for some equipment movements, not every-day use	1	4	1	4	16 Medium	No more than minor or transitory
Glacial Environment	Mechanical action on snow / surface from: vehicle use; camp establishment;	Physical disturbance to snow / ice surface	Direct	1	1	1	4	4 Low	• Keep movement around ice shelf and tent numbers to a minimum. • Keep flights to a minimum. • Snow used for filling the flubbers will be dug to one spade depth and then recycled by the borehole pump to reduce the need for continuous digging	1	1	1	4	4 Low	Less than minor or transitory
Glacial Environment	Accidental release of hazardous liquid substances e.g., from glycol or fuel spill events	Contamination of local ice environment	Direct / Cumulative	1	4	3	3	36 High	• Volumes of hazardous liquid substances, including fuel taken into the field, will be minimised to the extent that is safe and practicable. • Drum (including fuels and glycol) storage will be kept away from the boreholes • All fuel and other hazardous substances will be managed in the field in accordance with standard BAS procedures, as set out in the BAS Field Manual (Appendix 3). • Hazardous liquid substances (fuel, and oils and glycol) will have regular checks on the integrity of their drums and storage containers. • Trained and experienced personnel will oversee equipment and manage skidoo, burner and generator refuelling activities. • Maintenance of skidoos will be conducted by a vehicle mechanic. • Fuel spill response training will be provided to those undertaking fuel handling in the field. • Spill kits will be readily available at locations where fuel and fluids are stored and transferred • Any hazardous substance spilt[14] will be cleaned up to the extent practicable in accordance with the BAS Field Manual • Recovered liquids and contaminated absorbents will be contained, labelled as hazardous and flown to Rothera for disposal • Glycol stored on site will be in limited quantities • Glycol will be diluted with water and mixed in batches • Detailed records need to be kept of equipment deployment locations and losses (including any hazardous materials contained in them).	1	4	1	2	8 Low	Less than minor or transitory

[14] Other than petrol. Generally, it is BAS policy not to contain and recover petrol but allow it to evaporate. Petrol spills must be reported to review whether a passive response is the correct response (this depends on volume/sensitivity of spill site).

				Pre-treatment risk assessment						Post-treatment risk assessment					
Environment type	Environmental Aspect	Potential Impact(s)	Type of Impact (Direct, Indirect, Cumulative)	Extent	Duration	Severity	Likelihood	Raw Risk Level	Treatment (Preventative or Mitigating Measures)	Extent	Duration	Severity	Likelihood	Residual Risk Level	Ref Article 8 of the Protocol
Glacial Environment	Release of human liquid waste and grey water, or accidental loss of wastes and items of cargo or equipment (e.g. stuck drill)	Contamination of local ice environment	Direct / Cumulative	1	4	4	4	64 High	• Waste generated in the field, including any hazardous waste, will be managed in accordance with the provisions of Annex III to the Protocol, the BAS Waste Management Handbook and BAS Field Operations Manual. • All food and general waste will be separated into waste streams and removed from the field for correct handling at Rothera. • Human liquid waste and sieved grey water will be disposed of in ice pits at specifically identified locations only. Solid human waste is removed from the field. • Grey water production will be minimised to the extent practicable. • Careful planning shall be undertaken to minimise the materials and items taken into the field that will generate waste. • Staff involved in the *Site 5* Drilling Project will comply with BAS waste management policy and will follow the procedures outlined in the BAS Waste Management Handbook (BAS, 2025). • The camp will be cleared of any rubbish or debris each day. • Open burning of waste is prohibited. • Accepted drilling practices will be followed at all times to reduce risk of loss of drill (See Appendix 1) • Only experienced operatives will use the drill. • All BAS field parties are supplied with a copy of the Field Operations Manual, colour coded waste sacks for the separation and disposal of wastes, and solid human waste drums that are UN approved for clinical waste. • Only the designated equipment will be deployed under the ice, and at the surface, to remain in-situ. • Old equipment collected from other sites during maintenance and servicing visits will be removed from site and disposed of appropriately. • Two-yearly maintenance visits will be scheduled to prevent the loss of surface equipment (due to accumulation), and allow the replacement of non-working surface instrumentation • Number of people on site will be minimised • Careful planning seeks to minimise the materials and items taken into the field that will generate waste • All equipment (except those deployed), wastes and fluids will be removed from the field site by Twin Otter aircraft at the end of the season (Ops to request permission if an overwintering depot required)	1	4	1	3	12 Low	Less than minor or transitory

Atmospheric Environment	Release of gases including greenhouse gases from combustion of fossil fuels in aircraft, ship, skidoos, burners, generators, cooking and heating equipment	Pollution of atmosphere and contribution to climate change	Direct / Cumulative	4	4	2	4	128 High	• All engines, generators, burners and fuel burning equipment are routinely serviced and maintained to ensure they run and operate as efficiently as possible. • Maximum efficiency of logistics, using minimum flights and most efficient routes. • Emissions minimised by only burning fossil fuels when required. • Equipment is not left idling unnecessarily. • Skidoo engines, burners and generators are allowed a 'warm up' period prior to engaging any load. • The fuel types selected are the most efficient for use in low temperature conditions. • All fuel use will be minimised to the extent practicable. • Daily visual checks are to be made of burner and generator exhausts. Any maintenance to reduce atmospheric emissions will be carried out as required. • The burners and generators will be shut down when not required.	1	4	1	4	16 Medium	No more than minor or transitory
	Release of heat from aircraft, ship, skidoos, burners, generators, cooking and heating equipment	Highly localised and temporary heating of air adjacent to equipment	Cumulative	1	1	2	4	8 Low	• Fuel burn will be kept to the minimum required. • Burners and generators will be turned off when not required. • Skidoos will be used only when necessary for moving heavy loads. • Cooking and heating equipment will only be used for specified purposes	1	1	1	4	4 Low	Less than minor or transitory

Environment type	Environmental Aspect	Potential Impact(s)	Type of Impact (Direct, Indirect, Cumulative)	Pre-treatment risk assessment: Extent	Duration	Severity	Likelihood	Raw Risk Level	Treatment (Preventative or Mitigating Measures)	Post-treatment risk assessment: Extent	Duration	Severity	Likelihood	Residual Risk Level	Ref Article 8 of the Protocol
Marine Environment	Deployment of equipment under ice, loss to the sea floor. Potential SDA (if used) interaction with marine life.	Potential for break down of equipment components (including batteries) into the marine environment	Direct/Cumulative	2	4	3	2	48 High	•Titanium housings can withstand 6000 m of pressure (unlikely to breakdown) •SDA follows strict wildlife distance requirements •Equipment will be frozen into the ice and not lost to the sea floor until calving at the ice edge/the ice shelf melts. • Last know position of equipment will be recorded and reported to the BAS lost equipment log	2	4	2	1	16 Medium	No more than minor or transitory
Native Antarctic Flora and Fauna	Noise emissions from equipment and vehicles and human activity; introduction of non-native species, impacts to native species	Disturbance resulting in acute or chronic effects	Direct / Indirect	2	1	4	1	8 Low	• All drilling activities, including the field camp are conducted on ice and snow surfaces. • Oceanographic equipment is contained in pressure tested housings, so interaction is limited to the physical presence of the equipment under the ice and on the ocean floor. • All *Site 5* drilling activities will be constrained to the defined areas that have been identified in this EIA. • Biosecurity measures (including actions such as ensuring equipment is free of debris, visual checks/inspections of cargo and personnel luggage prior to landing in Antarctica) are used when moving equipment between Antarctic and global locations, to prevent any potential impact on local species (see Appendix 2, for field specific requirements). • All equipment and materials required for the *Site 5* drilling project will be thoroughly cleaned before dispatch to Antarctica. • All items of cargo will be checked for soil or non-native species prior to being flown from Rothera. • The advice and procedures contained within the BAS Biosecurity Regulations will be followed where applicable (see Appendix 2). • The project will not visit any ice-free areas • Biosecurity training is given to field crews • Biosecurity checks will be undertaken on all equipment prior to field deployment	1	1	1	1	1 Low	Less than minor or transitory
Antarctic Wilderness	Human presence and all activities associated with the research project	Reduction in wilderness values in these areas of Antarctica	Indirect / Cumulative	1	2	2	4	16 Medium	• Minimise, to the extent possible, the areas used when establishing field camp • Minimise disposal to the ice environment and ensure all waste materials (except for human liquid waste and sieved grey water) are removed from the field. • Maintain a log of drilling locations (2 deployment boreholes), camp and any overwintering depot to be kept at BAS for future reference. • Maintain a log of the equipment deployed and locations of deployments, including in relation to other previously deployed equipment. • Maintain a log equipment positions until end of transmissions • Care will be taken to avoid loss of equipment and waste at the field camp/drill site, and any accidental loss will be recorded on the BAS incident reporting system • Noisy activities will be confined to drilling operations, and skidoo use • Number of personnel and tents will be kept to a minimum • Use of burners, generators and skidoos will be kept to key tasks	1	2	2	2	8 Low	Less than minor or transitory

									• All activities will be constrained to areas identified in this EIA • A small amount of equipment (ApRES, solar panel, logger), will remain visible, all other trace of human presence will be removed at the end of the project • All available methods will be used to free stuck equipment (see Appendix 1)						

9 Monitoring and Record Keeping

This assessment has not identified the need for dedicated monitoring to be undertaken. Nonetheless, records will be maintained for post-season reporting purposes, which are listed below.

- Volumes and types of fuel used will be recorded and reported back to be included as part of BAS' annual fossil fuel and carbon emissions monitoring.
- Records will be maintained on any skidoo travel outside of camp
- Any spill events (including, fuel, glycol) will be recorded and reported in accordance with BAS requirements, including volume and type of substance spilt, the location of the spill and the approximate volume that was recovered
- Volumes and types of fuel used are routinely recorded as part of BAS' annual fossil fuel and carbon emissions monitoring
- Any observed disturbance events or biosecurity breaches will be recorded and reported in accordance with BAS incident reporting requirements
- Digital records (such as GPS) of drilling sites, camp sites and any overwintering depot location, including the equipment stored, volumes of fuel stored and types and volumes of waste stored (if any), should overwintering, other than for deployed equipment be needed (i.e. in the case of logistical requirements).
- Records of equipment deployed (oceanographic and surface), and last location at end of life (to be added to lost equipment log)
- Digital records (such as GPS) of the locations of, as well as volumes of human liquid waste and grey water disposed to, the ice sheet.
- Quantities of fuel burned, which may include hours of operation for skidoos, burners and generators.
- Records of the types and quantities of any materials or equipment that is accidentally lost to the environment (e.g., plywood, flags, bamboo, stuck drill) and reported through BAS incident management system.
- Observations of any other environmental incidents, such as inefficient burning of fuel resulting in excessive release of airborne pollution.
- Number of flights to input and uplift the equipment, and personnel (and routing, e.g. Rothera or Union Glacier).
- Route of the Twin Otter flights to the field location, i.e., Rothera to Sky Blu, to site.
- Records of amounts and types of waste generated, and storage methods used.

Every effort will be made to avoid unnecessary impacts. Where an incident results in impacts, such as fuel spills, this will be documented and reported to the BAS Environment Office via the BAS Incident Reporting System (Maximo) and to the FCDO in accordance with the conditions of the BAS Operating Permit.

Post activity reporting will be undertaken in accordance with BAS requirements and the conditions placed on the BAS Operating Permit (2022-2027), and subsequent permits issued by the FCDO.

10 Gaps in Knowledge and Uncertainties

No activity in Antarctica can be planned with absolute certainty, due to the extreme, changeable and unpredictable environmental conditions.

Within the areas identified in this EIA the project will need to retain a degree of flexibility to accommodate changing weather, and logistical requirements.

Accordingly, there remain a number of gaps in knowledge and uncertainties. These are discussed below.

10.1 Field Season Uncertainties

Due to ongoing construction and modernisation programmes at Rothera Research Station, limited bed spaces are available for research scientists for the upcoming seasons.

The drilling season may be altered (e.g., timelines shifted, season shortened) due to the need to transit through Rothera.

The potential for equipment failure is also a factor that causes uncertainty in a field program.

These are currently unknowns that could severely impact the drilling project's ability to reach the desired deep drill depth, to deploy the oceanographic equipment

Field season uncertainties have implications for some environmental aspects including:

- deferred project, outside of IEE identified timelines;
- additional field seasons needed to complete proposed drilling and deployment of instruments;
- additional flights over a shortened period;
- only part of the work taking place;
- unforeseen overwintering of equipment (i.e. for subsequent drilling seasons).

The uncertainty associated with the unknown implications of the field season planning, is unlikely to have significant implications for the identified environmental impacts nor for the overall conclusion of the EIA.

10.2 Route for input in 2026/27 season

At the time of writing the planned input route is from Rothera to *Site 5* via Sky Blu, by Twin Otter (or DASH7/Twin Otter combination) aircraft, however due to uncertainties around logistics, it is possible that personnel may be flown in by third party contractor from Union Glacier instead.

The proposed timeline in the field would remain the same, however anticipated time at Rothera to check and service equipment would be impacted, as would the potential for field training for the team.

The uncertainty associated with input route is unlikely to have significant implications for the identified environmental impacts, nor for the overall conclusion of the EIA.

10.3 Implications of Antarctic Weather

The weather in Antarctica can be highly variable both within and between summer seasons. Conditions can also change dramatically in short periods of time. This variability and unpredictability may require a number of adjustments to plans.

Weather conditions have the potential to impact on the schedule of the drilling programme in a number of ways. Inter- and intra-continental flights, as well as ship itineraries, may be delayed due to poor weather conditions at points of departure or destination, which may have implications for the location and timing of aircraft input in the field.

Weather conditions may also influence the extent of any travel that can be achieved (particularly during storm events). Seasons with poor weather may also limit what can be achieved in any one season with the implication that some objectives will need to be moved to another season.

Weather uncertainties have implications for some environmental aspects including the:

- timing and location of input of personnel and equipment, and therefore the length of the available field season;
- number of drilling days available (and therefore the ability to deploy equipment) due to unfavorable weather conditions on site;
- volumes of fuel burnt and the impacts on glaciological and atmospheric environments;
- potential for early extraction due to forecast storm events, and necessity to leave equipment behind, until it is able to be removed at a later date; and
- volumes and types of materials and equipment, as well as waste that will need to be overwintered, if necessary due to logistical issues.

The uncertainty associated with the unknown implications of Antarctic weather, is unlikely to have significant implications for the identified environmental impacts nor for the overall conclusion of the EIA.

10.4 Future seasons

Although the project plan includes raising and servicing of the on-ice equipment every two years for up to ten years, this is subject to suitable logistics being available and access to the project site. Should equipment be left for more than two years, there is a risk for it to be buried.

Conversely as with Site 5a, which was installed in 2014/15, it may be decided that the equipment is still in a suitable position after 10-years to provide valuable data, and continued maintenance will be suggested.

At the time of writing no further drilling is planned at *Site 5*, but should this change, the use of equipment be extended beyond 10-years, or methods developed to retrieve the under-ice equipment and moorings, then further assessment under suitable EIAs will be required.

11 Summary and Conclusion

This EIA has considered alternatives to BAS drilling and instrument deployment activities, described the preferred approach to be taken; described what is known about the current environmental state in the planned areas of activity; assessed the potential environmental impacts that will or could arise; outlined the mitigation measures to prevent or minimise any potential environmental impacts that may occur; described the records that will be maintained of any environmental impacts that do occur; and identified remaining unknowns and uncertainties.

Use of drilling equipment, skidoos, burners, generators and cooking equipment creates heat, gas and particulate emissions that impact the immediate snow and ice environment, and local air quality. Vehicle tracking (skidoos) and movement of snow will also occur. These expected impacts will be minor or transitory, with the exception of the cumulative impact of greenhouse gas emissions and the accumulation of particulates in glacial surfaces.

The use of Twin Otter aircraft for input and uplift of personnel, and equipment will produce particulate emissions, greenhouse gas emissions, and impact air quality. The expected impacts of flights for the *Site 5* project are moderate in relation to greenhouse gas impacts to climate and accumulation of particulates in glacial surfaces.

The potential for loss of equipment in the glacial environment, e.g. stuck drill, would have an impact on the immediate environment. If unable to be retrieved, a stuck drill would stay in the ice until it either reaches the ice front or melts out (should the ice sheet melt down to the level of the drill). This, along with the planned equipment losses (oceanographic equipment) would contribute to cumulative impacts of other lost equipment on the ice sheet and the marine environment, and through Antarctica, since human presence started.

Oceanographic equipment, once it melts out of the ice, could result in strata for marine species to establish, and changes in sedimentation patterns. In the unlikely event of a breakdown of the equipment housing under pressure, lithium batteries maybe exposed to the marine environment, this could cause impacts to the local environment in low flow conditions, or wider impacts in the open ocean. Although considered unlikely, lithium contamination could have a lasting and cumulative effect on the marine ecosystem.

This assessment was undertaken on a worst-case scenario evaluation. Once mitigations and adjustments are considered, all the proposed activities are considered of a low-medium risk of environmental impact.

As a general rule BAS aims to prevent or reduce potential environmental impacts from its activities through careful planning, training, execution and the availability of highly experienced personnel. For almost all sources of impact, practicable treatment options to mitigate those impacts have been identified.

The British Antarctic Survey has many decades of experience of operating in the region. Provided the mitigation measures described in Section 8.4 (summarised in Table 12) are adhered to, the environmental impacts of the planned activities are considered to be largely avoidable or can be minimised to an acceptable level.

Overall, this EIA considers that the potential environmental impacts arising from the BAS drilling and instrument deployment activities will have **no more than a minor or transitory impact** on the environment.

It is concluded that this level of predicted impact is acceptable given the significant scientific knowledge that is likely to be gained as a result of the BAS ongoing programme of globally-relevant research, and the additional information gathered by the collaboration.

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Mapping References

Mapping in this IEE was Produced by the Mapping and Geographic Information Centre, British Antarctic Survey, 2026, unless otherwise stated.

Appendices

Appendix 1: Controls to reduce potential for lost drills

The following actions are taken during the hot water drilling to ensure the drill nozzle does not become stuck and lost in the borehole.
Hot water drilling will take place over a continuous 12-24 hours (depending on the speed of the drill and thickness of the ice) to ensure the borehole is drilled and equipment is deployed effectively.

1) Water pressure issues:
   a. If water pressure is lost, immediately start reeling hose in
   b. Reeling the hose in prevents the nozzle dropping onto the bottom of the hole and freezing on due to lack of water flow.
2) Frozen nozzle:
   a. The nozzle has been carefully designed so that if tip does freeze on there are ancillary jets a few cm above the nozzle tip that will still allow hot water to flow
3) Frozen borehole:
   a. If the hole above the nozzle has refrozen and prevents nozzle retrieval, valves will open automatically to allow the nozzle to drill itself upwards.
4) Hose tension
   a. hose tension should always be monitored to make sure the tip never bounces on the ice at the bottom of the borehole.
   b. Bouncing the nozzle will cause a non-vertical hole, which can be a serious problem when deploying instruments.
5) Hose coupling failure:
   a. failure of hose couplings will cause the loss of the lower section of the hose.
   b. Ropes are tied across any couplings so that the hose can still be recovered should the coupling fail.

FIELD WORK IN ANTARCTICA AND SOUTH GEORGIA

○ Field activities

Individual responsible	• Field Operations Manager • Traverse Leader • Project Manager/Principal Investigator

- **Key biosecurity risks**

The BAS area of operation extends over much of Antarctica and scientist and support staff operate in many different types or terrain, including ice-free habitat. Therefore, there are several main biosecurity risks:

- The introduction of non-native species to Antarctica (as discussed earlier)
- The movement of existing non-native species to new areas of Antarctica (see Appendix 9)
- The movement of species native to one Antarctic region, to another Antarctic region

• To reduce the risk associated with BAS field work activities, all cargo should be free of soil and non-native species before being transported to polar regions, and as far as possible, re-checked on station before deployment to the field.

• Personnel in the field must take steps to prevent local wildlife accessing food. For example, personnel should keep foods within boxes or inside tents. Waste food should be stored so that it cannot be accessed by wildlife. No poultry products other than egg powder shall be supplied to field camps working near bird colonies.

The field operations manager is responsible for ensuring field personnel are aware of non-native species issues. The project Principal Investigator is responsible for ensure all cargo and equipment is free of non-native species and soil, and that the field team is informed of biosecurity issues, in accordance with the Environmental Impact Assessment for the field project.

- **Antarctic locations already colonised by non-native species**

Visitors must take particular care to ensure clothing and equipment is free of seeds and soil when leaving areas where non-native species are known to have established (see Figure 2 in Section **Error! Reference source not found.**). Where washing facilities are not available, the outside of boots can be washed in seawater and clothing can be brushed down to remove soil and organic material. If travelling to another Antarctic location, outer clothing should be washed using available facilities (e.g., ship washing machines) and footwear cleaned before arrival.

○ Movement of BAS field equipment between BAS stations

Field equipment (e.g., tents, boxes, sledges, etc.) may trap soil and organic material while being used in the field. In general, field equipment is repaired and serviced at Rothera Research Station and distributed, for use in locations on South Georgia and Antarctic, by ship or aircraft. At the end of the season, most equipment is returned to Rothera in preparation for the following season. Therefore, the potential exists for soil and organic material attached to equipment used at a variety of locations to be transported to Rothera.

- Field equipment sent from Cambridge to stations in South Georgia and Antarctica must be free of soil and propagules.
- Appreciating the limitations incurred by operating in the field, to the maximum extent practicable, field GAs should try to ensure their field equipment, sledges and skidoos have as little adhered soil and organic material as possible before they are returned to Rothera.
- Particular care should be taken to remove soil and organic material if camping on ice-free ground, with special attention paid to tent valances, ground sheets and pegs.
- If field equipment that is heavily contaminated with soil and organic material is returned to Rothera Research Station, it should be cleaned carefully indoors, with the soil and organic material collected and incinerated. In general, to ensure soil and organic material are contained adequately, in the first instance, vacuuming or dry brushing may be the most appropriate cleaning technique. As appropriate, vacuum cleaner waste should be incinerated using station facilities or bagged and incinerated on the ship.
- Where resources and logistic planning allow, field equipment used in one region should be reallocated to that region in subsequent seasons. For example, it may be possible for equipment to be allocated for use in South Georgia each season.

○ Antarctic field activities – further regulations

Visitors undertaking terrestrial field research, as a minimum standard, should apply the guidelines detailed in the Scientific Committee on Antarctic Research's (SCAR) *Environmental Code of Conduct for Terrestrial Scientific Field Research in Antarctica*, which includes advice on biosecurity (see Appendix 2).

Visitors undertaking activities within terrestrial geothermal environments should also apply the guidelines detailed in the *SCAR Code of Conduct for Activities within Terrestrial Geothermal Environments in Antarctica* (see Appendix 3).

Appendix 3: Relevant Extracts from Field Operations Manual

5.20 Waste management

All rubbish should be separated for recycling before being sent back to station. Rubbish should be separated into cardboard, metal, plastic, food waste and glass (try to avoid taking glass jars/bottles into the field for obvious reasons). Uneaten food can go into the poo bins but packaging soiled with food will need to be incinerated back on station so will have to be bagged separately.

It can be challenging to separate all rubbish in the field, especially while on a travelling project. In such cases where it is simply not practical to have several bags for different rubbish you will need to separate it back on station – do not leave this job for someone else! It is your rubbish and therefore your responsibility to sort. If you think this may be the case with your project discuss with those on station responsible for waste management prior to deployment.

For detailed info on this topic refer to the Waste Management Handbook which is available on stations and speak to those employed to manage waste on stations.

5.21 Conservation of flora and fauna

Under the Antarctic Act (1994, 2013) the following specialist activities are prohibited without a permit issued by the Foreign and Commonwealth Office or under delegated authority by BAS:
• Mineral resourced activities for the purpose of scientific research
• The taking of, or harmful interference with flora or fauna
• The intentional introduction of non-native species
• Entry into an Antarctic Specially Protected Area (ASPA)
• Entry to a CCAMLR Ecosystem Monitoring Programme (CEMP) site
• Temporarily removing objects from an Antarctic Historic Site and Monument (HSM) for conservation or repair

Conducting activities in Antarctica without first obtaining a permit, or breaching of permit conditions, or breach of a prohibition, is an offence punishable by up to two year's imprisonment and an unlimited fine.

Killing or harmful interference with Antarctic wildlife is prohibited, except in accordance with a permit issued under the Antarctic Act 1994.

The following points should be observed:
• Do not feed, touch or handle any wildlife
• Do not approach or photograph wildlife in a way that causes them to alter their behaviour. As a guide, keep a minimum distance of five metres from any animal. A permit is needed to handle, tag or kill animals, collect eggs or collect significant quantities of plants
• Do not walk or drive vehicles on vegetation, particularly extensive moss or lichen-covered areas
• Do not use aircraft, vessels, small boats or vehicles in a way that disturbs wildlife. Avoid taking aircraft, particularly helicopters, within 200m of bird or seal colonies. The noise of low-flying aircraft can cause them to panic
• Do not collect biological or geological specimens unless they are taken as part of an approved BAS science project and in accordance with a specialist activities permit issued under the Antarctic Act. It is illegal to collect or remove any biological or geological specimens unless you have been specifically issued a permit. Items collected under permit and brought back to the UK, such as plant specimens or seal and whalebone, will also require import licenses, which must be arranged in advance of their departure from Antarctica. Ensure that Cambridge and your Station Leader are aware that your project requires such licenses – the lead scientific investigator on a project is ultimately responsible for this
• Do not use a UAV in the field, particularly over wildlife, unless the activity has been specifically reviewed and approved as part of an Environmental Impact Assessment
• Do not leave any sign of your visit. This includes cairn building, snow pits, graffiti on rocks etc.

18.2 **Uses and colour codes**

Fuel	Colour	Container(s)	Uses
Petrol	Red	205 Drums (black drums with red tops) 20 litre jerries	Snowmobiles Generators Snow blowers Capstan winch Multi-fuel stoves
50:1 Petrol mix	Red/Yellow	2 litre jerries	Chainsaws Older models of two-stroke snowmobile
Paraffin/Kerosene	Blue	205 Drums (black drums with blue top) 20 litre jerries 1 litre Sigg bottles	Vapalux lanterns Primus stoves Multi-fuel stoves Refleks stoves
AVTUR/Jet A1	White	205 Drums (black drums with white tops) 20 litre jerries	Aircraft Refleks stoves in some huts/ cabooses
Meths	Silver	5 litre plastic containers 1 litre Sigg bottles, Meths dispensers	Priming lanterns and stoves