Australian Government

Department of Climate Change, Energy, the Environment and Water

Australian Antarctic Division

AUSTRALIAN ANTARCTIC PROGRAM

INITIAL ENVIRONMENTAL EVALUATION
Traverse, Inland Station & Million Year Ice Core Project 2022-2028

August 2022

Contents

THIS PAGE IS INTENTIONALLY BLANK

1 NON-TECHNICAL SUMMARY

1.1 Introduction

The Australian Antarctic Division (AAD) has prepared this Initial Environmental Evaluation (IEE) to assess the potential environmental impacts associated with the Million Year Ice Core (MYIC) project's field operations commencing November 2022 and extending over the following 6 Antarctic summer field seasons to 2028.

The scientific objective of the Million Year Ice Core Project (MYIC) is to recover a continuous ice core that extends to well over a million years ago. The current oldest continuous ice core is the 800,000 year record from EPICA Dome C. The MYIC aims to extend beyond this period and across the Mid Pleistocene Transition (MPT), during which the pacing of the glacial cycles changed from a periodicity of 41,000 to 100,000 years. Recovery of the MYIC will advance understanding of the physical processes and climate feedbacks involved in this non-linear shift in the climate system. This work is of high scientific and societal value because these same feedbacks (between radiative forcing, ice volume, sea level, atmospheric dynamics and ocean circulation) will determine the response of Earth's climate to rising greenhouse gases. The ice core will offer new opportunities for research into these climate feedbacks and couplings across the entire 1.2 million year plus record, and into their implications for Australian climate variability.

Recovery and interpretation of the million year ice core is a priority outcome of the Australian Antarctic Strategy and 20-year Action Plan and its 2022 update. The project is designed to support achievement of the Antarctic Strategy's goals:

- to maintain the Antarctic Treaty System and enhance Australia's influence within it;
- to protect the Antarctic environment;
- to understand the role of Antarctica in the global climate system and
- to undertake scientific work or practical, economic and national significance.

Deep ice core drilling is the only method to recover a continuous record of Earth's climate and atmospheric composition over the past million years. Previous Antarctic ice core drilling projects have produced the most highly cited records across all fields of Antarctic Science [Fu Ho, 2016] and have been pivotal in scientific understanding on human impact on the climate system [IPCC AR6].

The ice core drilling methods and technology proposed for this project build from many previously assessed ice core drilling activities led by the AAD (e.g. AAS 1236 at Mill Island, AAS 4414 at Mount Brown South, AAS 4075 Aurora Basin North, AAS 4425 at DE08). The methods and deep-drilling technology are also consistent with best practise from other international programs e.g. Beyond EPICA Oldest Ice Core (BE-OIC) and the US South Pole Ice Core Project (SPICE).

1.2 Description of the Proposed Activity

To deliver the MYIC Project, the AAD proposes drilling a ca. 2800 m deep ice core in the Little Dome C (LDC) region at 122.52059°E, 75.34132°S, in the Little Dome C region ca. 35 km SW of Concordia Station and 1100 km inland of Casey Station. This IEE describes the potential environmental impacts associated with the three major components of the activity:

i. Inland Traverse between Casey Station and LDC required to support project logistics.

ii. Installation of the MYIC Drilling Camp ('Inland Station') at LDC and occupation of the camp, from early December to early February only, for the duration of the project.

iii. Ice core drilling using the AAD deep drill system.

A summary of these three components of the project is provided below. Full details given in Section 3.

Inland Traverse and logistics support overview

The AAD's Traverse will depart the Casey Station Traverse staging area early in the austral summer for the MYIC drilling site, returning to Casey Station late in the season. At the completion of LDC field operations each season, the Inland Station will be winterised and the Traverse will depart the Little Dome C site. Traverse departure from LDC is expected in late January to February throughout the campaign, with the exact timing subject to environmental and logistical considerations, predominantly extreme negative temperature. Aviation assets will also support Traverse and the Inland station with a ski landing area to be established at the Inland Station and potentially an ancillary ski landing area along the Traverse route. All aviation activities for this project are addressed under the AAD's IEE for Aviation (2020-2024). It is expected that up to approximately six flights from Casey to the LDC Ski Landing Area (SLA) will occur each season and will be dependent on appropriate weather conditions. It is not intended that there will be a requirement to conduct airdrop activities at LDC.

MYIC Inland Station overview

The MYIC drilling camp 'Inland Station' will be installed around the MYIC borehole coordinates at 122.52059°E, 75.34132°S. The site is 35 km SW of the permanent French-Italian station of Concordia (East Antarctica), on the remote East Antarctic ice sheet. It is not a sensitive environmental site and no vegetation or wildlife is present. The Inland Station is expected to be occupied by up to 26 personnel from November to February of each austral summer field season for the duration of the project. Standard numbers to run the Inland Station and drilling operation are ca. 16 personnel, increasing to up to 26 for shorter periods when the Traverse team are on site. A maximum of 60 – 70 working days in the field is foreseen each season. The Inland Station will not be occupied outside the summer field season.

The Inland Station will consist of the necessary shelter and facilities to support the ice core drilling and ice core processing, along with the supporting shelter, kitchen and mess, workshops, amenities, power generation for the camp and an excavated ice core storage area. The Inland Station structures will remain on site for the duration of the project, with the exception of vehicles and mobile structures that will return with Traverse back to Casey Station at the end of each Field season.

The Inland Station structures are designed for minimal impact, with insulated vans mounted on sleds and removable Weatherhaven tents. All structures will be removed and the camp returned to initial conditions, with the exception of the retention of the bore casing and fluid filled borehole (see Section 3), at the completion of the project.

MYIC ice drilling overview

The MYIC deep drilling activity is planned from the 2022/23 to 2027/28 austral field seasons. The expected final drill depth is ca. 2800 m. Drill camp set up and pilot drilling is planned in 2022/23, followed by target depths of 400 m in 2023/2024, 1000 m in 2024/2025, 2000 m in 2025/26 and 2800 m in 2026/27. The 2027/28 field season is scheduled as a contingency ice drilling season, for

sampling of basal material and for completion of borehole measurements and closure of the drilling camp.

The MYIC core will be drilled with a new AAD deep ice core drill. The drill takes 98 mm diameter cores of up to 3-m length. Ice cores will be transported back to Casey Station, before return to AAD ice core measurement facilities in Hobart.

Ice core drilling beyond a depth of around 200 m requires use of a drilling fluid to prevent borehole closure and enable recovery of ice chips produced by the drill. The project will use ESTISOL 140, a biodegradable ester that is not hazardous to the environment, that has been approved for use in previous AAD ice core drilling projects (Aurora Basin, Mount Brown South) and in IEE's and used for other international ice core drilling projects in Antarctica e.g. the US South Pole Ice Core Project and European Beyond EPICA Oldest Ice Core (BE-OIC) Project.

The upper ca. 120 m of the borehole will be lined with a fiberglass bore casing. The casing prevents seepage of drill fluid into the porous firn layer. The ice at the drill site, according to geophysical measurements, is frozen to the bed rock, so preventing any seepage of drill fluid into the sub-glacial environment.

Subject to further assessment and authorisation beyond the life of this project, the AAD proposes to permanently retain the borehole casing and fluid filled borehole in place. Ongoing scientific access to a borehole high on the Antarctic plateau is of high science value for scientific monitoring of ice sheet processes. The AAD is investigating the retention of an archive of ice core samples in firn cave at the site to provide redundancy in case samples are lost. If this eventuates a variation to the IEE will be submitted.

Closure of the drilling camp is scheduled for 2027/28. With the exception of the proposed retention of the borehole casing, fluid-filled borehole and ice core archive, all other camp equipment and infrastructure will be removed from the site and trenches filled.

1.3 Alternatives to the Proposed Activity

The science and drilling location for MYIC is guided by the International Partnerships in Ice Core Sciences (IPICS) priority goal to recover "a replicated Antarctic ice core record extending at least 1.2 million and preferably 1.5 million years, into the past". The Little Dome C region was chosen as the most promising location to deliver this objective on the basis of over 10 years of site survey work, conducted in collaboration between AAD teams and international collaborators and detailed glaciological modelling. The MYIC drilling coordinates are separated 5.2 km from the BE-OIC ice core drilling activity. This distance, greater than one ice thickness, is consistent with the International Partnerships in Ice Core Sciences (IPICS) goal to recover a replicated record. Replication is essential to verify that recovered climate and atmospheric composition are not affected by flow disturbance or other artefacts.

Where the objective is to recover a continuous record of climate and atmospheric composition spanning 1.2 million years plus, there is no scientific alternative to deep ice core drilling on the Antarctic ice sheet. The Traverse and Inland Station capabilities have, in the first instance, been established to support the MYIC campaign and were designed to minimise as much as possible the impact on the Antarctic environment. There are no alternatives proposed to support this scientific endeavour.

1.4 Impact Assessments

An assessment of the potential environmental impacts is included in this IEE (Section 6.6). The majority of risk and impacts identified are mitigated through fuel and waste management measures, and effective biosecurity procedures, defined in existing Standard Operating Procedures (SOPs) and field management guidelines. A summary of all SOPs relevant to the MYIC activities are summarised in Appendix 2.

The potential impacts predicted are outlined as follows:

Potential Traverse and Inland Station Impacts

- Pollution of the environment caused by inadvertent release of fuel, caused by tank puncture, fuel drum spill or rupture
- Physical disturbance to the environment and degradation of wilderness values through increased noise and vibration from vehicles, plant and equipment
- Wildlife disturbance in Traverse areas closest to Casey Station where transient fauna may be encountered
- Use of drilling fluid Estisol 140 and introduction of drilling fluid into the environment
- Pollution of the environment caused by intentional discharge of liquid human waste and grey water from Traverse and Inland Station activities
- Pollution and emission to the environment from diesel and engine exhaust
- Introduction of non-native species into the Antarctic environment through the movement of cargo, equipment, stores and personnel
- Physical disturbance to environment through the establishment of a temporary station and Ski Landing Areas in a remote inland area of Antarctica.

Potential MYIC Drilling Impacts

- Pollution of the environment and degradation of wilderness values caused by release of drilling fluid into snow and ice
- Pollution and contamination of the ice by leaving drilling fluid in the casing between seasons
- Pollution of snow and ice from ice chip meltwater containing low temperature synthetic drilling fluid
- Physical disturbance to the environment and degradation of wilderness values through increased noise and vibration from drilling activities.

1.5 Mitigation Measures

To address the potential significant impacts described above, there are a number of mitigation measures that will be applied and adhered to, throughout the Traverse Inland Station and drilling activities.

Traverse and Inland Station Mitigations:

- Jet A1 fuel distributed from 10-foot ISO containers, specifically designed to withstand extreme operating and environmental conditions in Antarctica and to minimise the risk of fuel spills. These ISO containers have been designed and built to be top fill/top draw which means there is no penetrator, pipework, flange, gasket or valve at the bottom of the tank.

Any failure in pipework, flanges, gaskets or valves will not result in the tank decanting its entire contents into the environment.

- ISO tanks used globally in the transportation of fuel are predominantly single skin tanks. Double skin tanks were investigated as part of the procurement process, to determine if providing bunding was a viable option on Traverse. While double skin tanks for fixed fuel installations are preferred, employing this type of capability on Traverse was significantly heavier resulting in a greater fuel use and potentially required an additional tow vehicle. The Traverse sleds will be subjected to dynamic and torsional forces, some of which will be transferred through the sled, subjecting the cargo to similar dynamic and torsional loads. The effect of these forces and loads between an inner and outer tank (as used in static fixed fuel farms) are not well documented and this uncertainty was considered a potential environmental risk. The traverse ISO have been designed to be 'top draw, top fill' which means there is no piping coming out of the bottom of the tank. Historically, fuel spills in Antarctica in the AAP have emanated from defective pipeline, valves and flanges and not from the tank itself. The design of the traverse ISO containers has been deliberate to remove these historic fuel spill sources as effective bunding on traverse appears unattainable.
- Fuel drums used in the first season will be double chimed (AAD standard reinforced fuel drums) and transported on Traverse sleds. The drums are inspected and certified when returned to Australis for filling and are subjected to a very high maintenance regime. The potential for spills or drum rupture is considered low. Ongoing visual monitoring of the drums during Traverse and while positioned at the inland station will occur.
- There are no flora and fauna in the Little Dome C drilling area. The remoteness (1100km from coast) and extreme negative temperatures ensure no risk of establishment of non-native species unintentionally transported to the area. All equipment and materials required for the project will be thoroughly cleaned before dispatch to Antarctica following standard AAD SOPs.
- All solid waste, including human solid waste, will be double-bagged and packed into empty sealed containers for return to Casey Station for treatment and/or incineration. Liquid human waste will be discharged to the environment as per previous AAD ice core and deep field projects and approved IEEs for other deep drilling projects e.g. BE-OIC.
- Grey water will be discharged to the environment, likely soft snow terrain in the surrounding areas of Traverse park-up areas (overnight stops while transiting) and the Inland station at LDC. For larger deposits (Inland Station), grey water will be discharged below the snow surface into a firn pit and covered each season as part of the Inland station winterisation. Transporting wastewater and greywater back to Casey Station is more logistically challenging requiring significant additional equipment. Furthermore, this approach would introduce potential risk for personnel from leaks and manual handling injury in managing grey-water systems at the extreme negative temperatures on the plateau. Additional fuel would be required to transport additional waste back to Casey Station.
- Due to the inland nature of the Traverse and Inland Station, there are limited sensitive receptors (wildlife, people and other stations) that would be directly impacted by noise and vibration. Wildlife separation distances will be maintained when transient species are encountered in proximity to Casey Station and Traverse Staging Area. Wildlife are not expected to be encountered inland or on the ice sheet.
- Inland station infrastructure such as mobile vans and tents are designed to be self-sufficient and minimise environmental impacts through design for energy efficiency, and ease of removal from the site. The station infrastructure will be completely removed at the completion of the project. The number of people at the inland station is limited to 10–16 personnel each summer operating season. Any additional personnel on site as part of the Traverse are expected to be accommodated in Traverse-based accommodation vans.

Traverse structures (see Section 3.2) will return to Casey Station at the end of each drilling season.

- A ski landing Area will be established during first year of inland station using a Piston Bulley snow groomer. Subsequent years will require maintenance only. Snow surface will return to original condition within a few months due to snow accumulation processes.

MYIC drilling mitigations

- A 260 mm diameter fibreglass borehole casing will be installed in the upper ca. 120m of the ice sheet (see Section 3). The environmental impact of the casing is expected to be minor and its presence is essential to prevent seepage of drill fluid into the firn layer.
- The project expects to use up to 50 m^3 of ESTISOL 140 drilling fluid to reach the depth required to obtain a million-year core. ESTISOL-140 is specifically selected for its minimal environmental impact compared to alternative products (Sheldon et al., 2014a) and has been previously approved for use in other AAD and international ice core drilling projects.
- ESTISOL 140 is not considered hazardous to the environment under the calculation procedure of the 'General classification guideline for preparations of the EU and is biodegradable up to 75% in 28 days according to the international test profile for biodegradability in sea water (i.e marine BODIS tests) (Sheldon et al., 2014a).Personal Protective Equipment must be used when handling ESTISOL 140 against skin and eye irritation.
- ESTISOL 140 is immiscible with water and will be separated from ice chips in a chip melting device and then recycled back into the borehole. Efficiency of this separation in previous projects has been 98-99%. Meltwater, with traces of ESTISOL-140, will be disposed on site by discharge into the firn at a single fixed point. This process is expected to have minimal environmental impact as ESTISOL-140 is non-hazardous to the environment and biodegradable.
- The AAD proposes to retain the fluid-filled borehole as a valuable scientific access point to the ice sheet. Over hundreds of thousands to millions of years the ice will deform plastically and the fluid will become dispersed in a very large volume of ice, before eventual discharge to the sea.
- A ca. 10 m long by 5 m deep and ca. 2m wide firn trench will be excavated using electric chainsaws at the drilling site to allow tilting of the ice core drill and extraction of ice cores. No chain lubricant will be used. Several additional trenches are expected to be excavated to over-winter equipment and store ice cores. The AAD is investigating retention of some ice core samples at the site as an archive and to provide redundancy in case sample are lost. Excepting a potential retained ice core storage trench, other trenches will be filled at the completion of the project. The environmental impact of these backfilled trenches is expected to be negligible.
- Other than the casing and drilling fluid, all drilling infrastructure and equipment will be removed at the completion of the project. Retention of the casing, with an access point for scientific access to the borehole may impact wilderness values, in that its presence has the potential to impact on landscape and wilderness values. The proposed mitigation measures to protect wilderness values are addressed in Section 6.4.5.
- The drill fluid proposed for MYIC is not classified as hazardous to the environment (Appendix 1) and has been specifically chosen for its low environmental impact in terms of greenhouse warming potential, ozone depletion, chemical pollution and biological pollution (see Talalay et al., 2014: 'Environmental considerations of low-temperature drilling fluids').

- The drilling system is specifically designed to minimise losses of ESTISOL 140 to the environment.
- There are no sensitive receptors (wildlife, people or other field camps/stations) in close proximity that would be affected or impacted by increases in noise and vibration caused by the drilling activities.

1.6 Environmental Monitoring and Management

Key environmental indicators, activities and incidents will be monitored to ensure unforeseen and perceived impacts are monitored and managed appropriately, and in accordance with relevant SOPs. The key environmental indicators for the MYIC Project have been identified in this IEE using an environmental risk assessment framework and include, fuel use, consumption and emissions, increased noise and vibration, physical disturbance to the ice sheet, greywater, sewage and waste management, biosecurity management and incident reporting.

Monitoring these activities, through inspections, visual observation and incident reporting will ensure MYIC remain complaint with international standards, the *Antarctic Treaty (Environment Protection) Act* 1980, the AAD's Environmental Policy and commitment to continuous environmental improvement. An environmental monitoring plan has been developed for the MYIC Project and is provided in Appendix 3.

This environmental monitoring and reporting will be undertaken to:

- Ensure ongoing compliance with the *Antarctic Treaty (Environment Protection) Act* 1980
- Ensure impacts are avoided or limited, and are consistent with the environmental principles of the Madrid Protocol
- Evaluate the IEE's conclusion that the impacts of Traverse, establishment of an inland station and MYIC drilling activities are likely to remain minor and transitory
- Inform any changes required to practices or methodologies to comply with any impact thresholds described in the IEE
- Ensure that environmental impacts are not in conflict with the community's expectations in relation to Antarctica's protection, and
- That any unforeseen and potentially significant impacts associated with Traverse, the establishment of an inland station and MYIC drilling activities, as described in this IEE, are captured and utilised for the future management of similar activities within AAD.

1.7 Conclusion

This assessment concluded that the MYIC project including Traverse, Inland Station and drilling activities, as described in this IEE, will result in some environmental impacts. However, provided the mitigation, monitoring and reporting measures described in this document are adhered to, these impacts will be minor or transitory.

2 INTRODUCTION AND SCOPE

2.1 Introduction

MYIC science background

The Antarctic ice sheet contains the oldest ice on Earth—ice that holds unique records of changes in the Earth's climate system [e.g. Petit et al., 1999; Wolff et al., 2006; Yan et al., 2019]. The longest continuous ice core currently attained, EPICA Dome Concordia [Jouzel et al., 2007], reaches back to 800 thousand years (kyr) but it is almost certain that this can be extended to beyond a million years [Parrenin et al., 2017; Young et al., 2017; Lillien et al., 2021].

The central objective of this project is to obtain a detailed and continuous record of climate and atmospheric composition, which extends through the period known as the mid-Pleistocene Transition (MPT). The MPT covers the interval from around 1.2 million years (Myr) to 800 thousand years (kyr) ago. Through this period, the pacing of glacial/interglacial cycles evolved from a dominant 41 kyr to a slower 100 kyr period, and intensified cold (glacial) periods [Ruddiman et al., 1989; Lisiecki & Raymo, 2005]. The cause of the MPT change in climate state is currently unknown and it is unable to be replicated in climate models [Berends et al., 2021].

As long as models cannot accurately reproduce the MPT shift in climate state, they are incomplete and must lack some physical processes. The implication is that tuning model parameters to reproduce, for example, observations of present-day ice-sheet geometry or bedrock uplift rates may result in compensating errors, which undermines the potential validity of future projections of ice-sheet retreat [Berends et al., 2021]. The lack of continuous CO2 records spanning the MPT is currently a major limitation on our understanding of the carbon cycle's role in this long-term climate evolution—with relevance to the long-term consequences of anthropogenic CO2 emissions for global climate [Steffen et al., 2017].

A critical requirement to close this gap in our knowledge of the climate system is a well-resolved and continuous ice core spanning the MPT. Planning and coordinating resources toward the recovery of such a record has been a major goal for the international ice-core science community for over a decade. In its White Paper on Oldest Ice [2020] the SCAR-endorsed International Partnerships in Ice Core Sciences (IPICS) calls on the community to prioritise recovery of "a replicated Antarctic ice core record extending at least 1.2 million and preferably 1.5 million years, into the past". The MYIC project forms the Australian Antarctic Program's response to this IPICS oldest ice challenge.

MYIC site selection

The target drilling location for MYIC (122.52059°E, 75.34132°S) is in the Little Dome C region, ca. 35 km SW of Concordia Station and 1100 km inland of Casey Station (Figure 3 below). The site is 5.2 km S of the European Beyond EPICA Oldest Ice Core (BE-OIC) site, where European pilot drilling commenced in the 2021/22 season.

The MYIC site selection rests on a large body of collaborative airborne and ground-based surveys and modelling work conducted over many years. The MYIC target coordinates were informed on the broad and medium scale by collaborative (US-Australia-France) ICECAP surveys, which established the Little Dome C region as the most promising area for the recovery of oldest ice for the Australian MYIC and BE-OIC projects. The bed elevation in this region is higher than at Dome C, giving an ice

thickness of around 2800 m. The thinner ice sheet indicates a colder base than at Dome C, and ice which is frozen to the bed.

The MYIC site was selected in December 2021, in the sub-region known as South Patch, following workshops and consultation with representatives from BE-OI and other researchers in the oldest ice community. See Figure 1 for bedrock topography in the region and location of the two drill sites. Our ice dynamical modelling, constrained by isochrones traced to Dome C in the ICECAP and ground-based radar data indicates an age above the basal ice at the Australian site of at least 1.4 million years and resolution better than 14,000 years per metre.

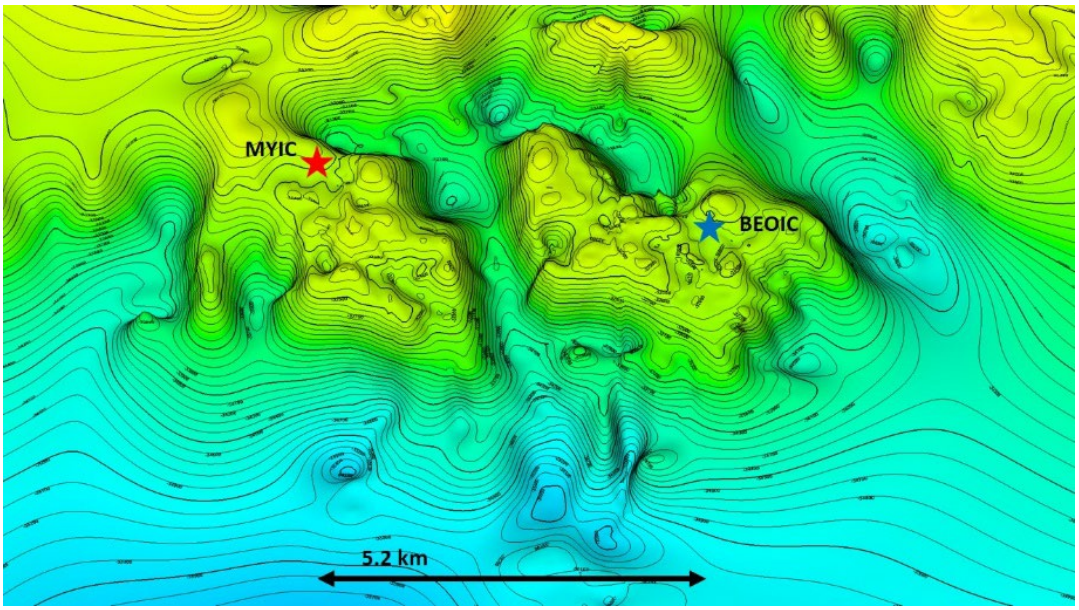

Figure 1: Locations of the MYIC target site and the Beyond EPICA Oldest Ice Core (BE-OIC) site at Little Dome C, shown plotted over bedrock topography (Figure courtesy R. Mulvaney, British Antarctic Survey).

The final site selection involved consideration between MYIC and BE-OI researchers of the added value of the parallel drilling efforts at Little Dome C in overall risk mitigation across the two drilling efforts. The 5.2-km separation between the sites exceeds one ice thickness (ca. 3 km in this region), is separated by a bedrock valley, and was chosen with the objectives of securing independent records for joint replication and verification.

MYIC links to Australian Government and Australian Antarctic Program priorities

The MYIC project is prioritised in the Australian Government's Antarctic Strategy and 20-year Action Plan (2016) and its 2022 Update. The Strategy includes directives to:

- "Establish an overland Traverse and mobile inland station, and commence involvement in a major scientific research undertaking to retrieve a million-year old ice core."
- "Work with international partners to interpret the findings from the completed project to retrieve a million-year ice core."

MYIC will contribute to delivery of the Australian Antarctic Program Partnership (AAPP). MYIC is tasked to deliver against two of five key objectives of AAPP Project 2. Specifically:

- "What does the ice core record of past climate and carbon dioxide concentrations spanning more than 800,000 years reveal about climate and climate-carbon feedbacks?"

- "How did the partitioning of carbon between different sinks (ocean, terrestrial, atmosphere) change (in volumes and rates) in the past (as resolved by isotopes of CO_2 and CH_4)?"

The MYIC project is collaborating with AAPP partners Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the University of Tasmania (UTAS) on delivery of these outcomes.

The MYIC project, in conjunction with existing and new data from high resolution coastal ice cores, will contribute to ice core reconstructions that identify Australia's climate variability and risk and advance Australia's leadership and excellence in Antarctic science.

2.2 Project Background

Deep ice core drilling is the only method to recover a continuous and detailed record of Earth's climate and atmospheric composition over the past 1.2 plus million years. Previous Antarctic ice core drilling projects have produced the most highly cited records across all fields of Antarctic Science [Fu Ho, 2016] and have been pivotal in scientific understanding on human impact on the climate system [IPCC AR6]. The ice core drilling methods and technology proposed for MYIC build from many environmentally approved ice core drilling activities led by the AAD (e.g. AAS 1236 at Mill Island, AAS 4414 at Mount Brown South, AAS 4075 Aurora Basin North, AAS 4425 at DE08) and are consistent with best practises from other approved Antarctic ice core projects from other nations (e.g. EPICA Dome Concordia, EPICA Dronning Maud Land [EDML], South Pole [SPICE], West Antarctic Ice Sheet Divide Ice Core [WAIS]).

2.3 Statutory Requirements

To ensure the protection of the Antarctic environment, the Antarctic Treaty nations adopted the Protocol on Environmental Protection to the Antarctic Treaty, which came into force in 1998. Australia enforces the provisions of the Environmental Protocol through the Antarctic Treaty (Environmental Protection) Act 1980 and Environmental Impact Assessment Regulations 1993. The Antarctic Marine Living Resources Conservation Act 1981 implements the Convention on the Conservation of Antarctic Marine Living Resources.

2.4 Purpose and Scope of the Document

The purpose of this IEE is to provide details of the MYIC project, the potential environmental impacts and measures to minimise or avoid these impacts. This assessment covers the MYIC project details.

This document contains the following sections:

- Section 3 describes the proposed activities,
- Section 4 describes the alternates considered,
- Section 5 describes the local environment,
- Section 6 describes the environmental impacts and the measures proposed to minimise or avoid them, and
- Section 7 provides the conclusions of the IEE.

A non-technical summary has been included at the beginning of the document to provide an overview of the IEE.

3 DESCRIPTION OF THE PROPOSED ACTIVITY

To deliver the MYIC Project, the AAD proposes drilling a ca. 2800 m deep ice core in the Little Dome C (LDC) region at 122.52059°E, 75.34132°S, ca. 35 km SW of Concordia Station and 1100 km inland of Casey Station. There are three major components to the activity:

i. Inland Traverse between Casey Station and LDC required to support project logistics.

ii. Installation of the MYIC Drilling Camp ('Inland Station') at LDC and occupation of the camp (summery only) for the duration of the project.

iii. Deep ice drilling using the AAD deep drill system.

Inland Station

The MYIC drilling camp 'Inland Station' will be installed around the MYIC borehole coordinates, with set up scheduled to commence in December 2022/23. The Inland Station will provide the infrastructure to enable MYIC drilling and support ca. sixteen Inland Station and MYIC personnel. The field season at LDC is expected to begin in early December of field each season and run for a maximum of 60–70 working days. At the completion of each season the Inland Station will be winterised and left unoccupied. Subject to further assessment and authorisation beyond the life of this project, the AAD proposes to permanently retain the borehole casing and fluid filled borehole in place. Ongoing scientific access to a borehole high on the Antarctic plateau is of high science value for scientific monitoring of ice sheet processes. The AAD is investigating the retention of an archive of ice core samples in firn cave at the site to provide redundancy in case samples are lost. If this eventuates a variation to the IEE will be submitted. The remainder of the Inland Station will be completely removed and the site retuned to initial conditions. The Inland Station structures are designed for minimal impact, with insulated vans mounted on sleds and removable Weatherhaven tents.

A seasonal breakdown of Inland Station operations is provided in Section 3.1 and details of the infrastructure elements of the Inland Station are provided in Section 3.2.

Traverse

The Traverse will deliver the Inland Station to the MYIC site and conduct re-supply and support MYIC drilling activities. Traverse will be staffed by ten personnel. While Traverse is at the Inland Station there may be up to ca. twenty-six personnel on site at LDC. Traverse is expected to arrive at the LDC site in December and depart in late January to early February. Two return Traverses Casey Station – LDC are planned for the 2023/24 season.

The Traverse and Inland Station plant, equipment and infrastructure will be staged from the staging area, approximately 3 kms from the Casey Ski Landing Area (Figure 2).

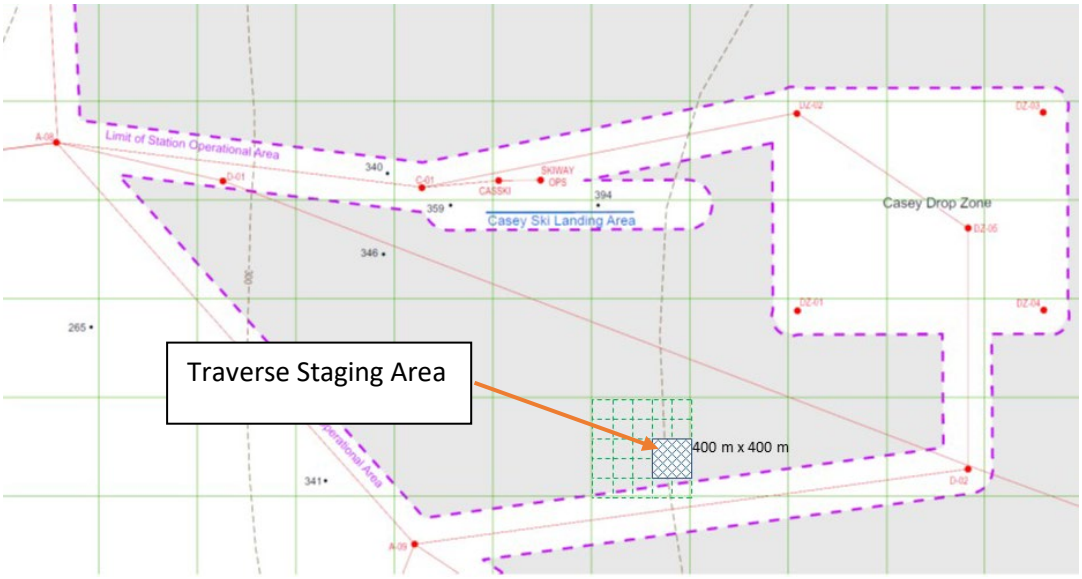

Figure 2: Traverse staging area in relation to the Casey Ski Landing Area.

The Traverse staging area is a designated zone where Traverse machinery, sleds and infrastructure can reside when not in use and enable the capability to be mobilised as required for Traverse tasking. This area will allow six Traverse trains to be assembled, loaded with cargo and tested prior to departure. On completion of a season's Traverse, the staging area will allow the Traverse trains to be demobilised near Casey, laid up and provide an area for this equipment to be stored throughout the non-traversing months of the year.

The Traverse route from Casey Station to LDC:

- Casey to Law Dome (but avoiding the summit to reduce soft snow, diverting B001-B004)).
- Law Dome along the 'A' Line from A005 to A028.
- Great circle from A028 to the Million Year Ice Core (MYIC site) at Little Dome C (LDC).

Additionally, there is a slight deviation around the existing BE-OIC camp to respect their operating space.

A seasonal breakdown of Traverse operations is provided in Section 3.1, and details of the infrastructure elements of the Traverse system are provided in Section 3.2.

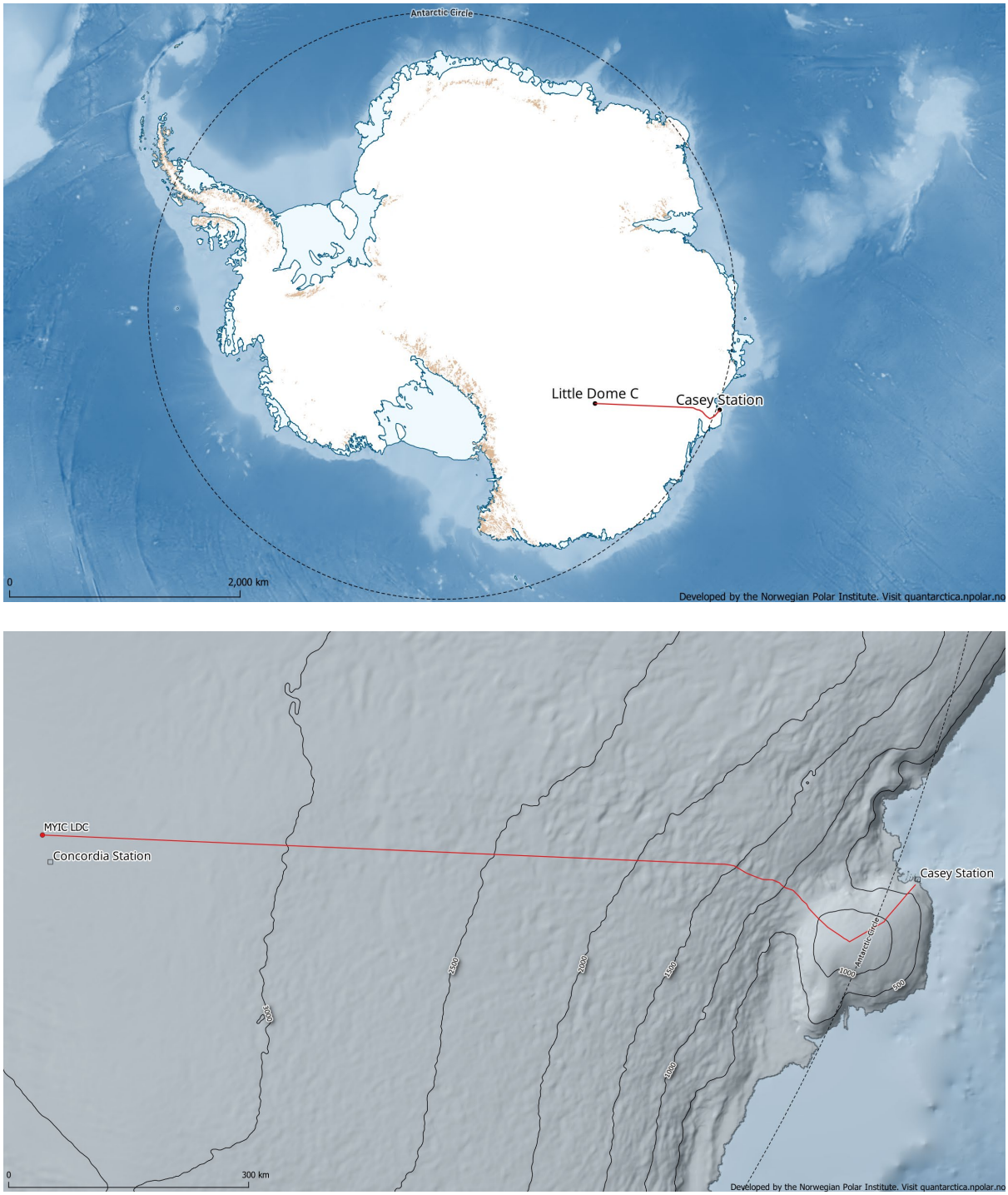

Figure 3: Traverse route from Casey Station to the MYIC site at Little Dome C (LDC). Top) full continent view. Bottom) Wilkes Land Sector, East Antarctica. The maps also show the location of Concordia Station.

MYIC ice drilling

MYIC deep drilling is planned from the 2022/23 to 2027/28 austral field seasons. The expected final drill depth is ca. 2800 m. The 2027/28 field season is scheduled as a contingency drilling season and for completion of borehole measurements and closure of the drilling camp. The 2027/28 field season is scheduled as a contingency ice drilling season, for sampling of basal material and for completion of borehole measurements and closure of the drilling camp.

The MYIC core will be drilled with a new AAD deep drilling system. The drill is based on the US Ice Drilling Program's (IDP) FORO 3000 drill design, which itself is a derivative of the well-proven Danish ISTUK ice drill. AAD collaborated closely with US-IDP on the drill design. The drill takes 98 mm diameter cores of up to 3-m length. Supplemental to the main drill, a lighter ECLIPSE drill will be used for pilot drilling and reaming of the upper ca. 120 m of the borehole.

Supplemental to the main ice core borehole, the project will require a number of shallow cores of tens to a few hundred metres depth from within ca. 200m of the main borehole. These shallow cores are required for overlap where parts of the main core are typically lost or damaged near the surface and around the base of the bore casing. The shallow cores will not require drilling fluid and will be drilled within the camp footprint.

Ice core logging and minimal non-destructive ice core measurements will be conducted on site (e.g. electrical conductivity, di-electric profiling). Ice cores will be transported back to Casey Station via cold-chain for return to AAD ice core measurement facilities in Hobart. The AAD is investigating the retention of an archive of ice core samples in firn cave at the site to provide redundancy in case samples are lost. If this eventuates a variation to the IEE will be submitted.

A seasonal breakdown of the MYIC Drilling Operation is provided in Section 3.1 and complete details of the infrastructure elements of the Drill system are provided in Section 3.2.

Drilling fluid

Ice core drilling beyond a depth of around 200 m requires use of a drilling fluid to prevent borehole closure, maintain core quality and enable recovery of ice chips produced by the drill. The fluid must meet specific criteria for density and kinematic viscosity to be suitable for drilling at the conditions encountered on the East Antarctic ice sheet. The international ice core drilling community and the AAD have paid special attention to minimising the potential environmental impacts of drilling fluids (see Sheldon et al., 2014a; Talalay et al., 2014). The project will use ESTISOL 140 (E-140), an aliphatic synthetic ester produced by EstiChem A/S Denmark. E-140 is not classified as hazardous to the environment under the "General Classifications guideline for preparations of the EU", see Material Safety Data Sheet attached at Appendix 1. It is non-explosive, does not require special handling or labelling for transport and is biodegradable and non-ozone depleting (Sheldon et al., 2014a). It does require use of personal protective equipment against skin and eye irritation. To fine tune the density of the ESTISOL 140 and in challenging conditions of warmer ice near the bed, the project may use small quantities of ESTISOL 165, ESTISOL 240 and COASOL (2 – 6% by weight). These are fatty acid esters like ESTISOL 140, but with slightly different temperature, density and viscosity characteristics, they are selected as they are not classified as hazardous to the environment under European Communities criteria and are biodegradable according to EU safety tests (see Sheldon et al., 2014b; Talalay et al., 2014)

ESTISOL 140 has previously been approved in Environmental Assessments for AAD ice core drilling projects (Aurora Basin, Mount Brown South) and in IEE's for other international ice core drilling

projects in Antarctica e.g. the US South Pole Ice Core Project and the European Beyond EPICA Oldest Ice Core Project (BE-OIC). The BE-OIC project will also use small quantities of ESTISOL 165, ESTISOL 240 and COASOL for fluid density adjustment. MYIC will require a total of up to 50 m^3 of ESTISOL 140, as estimated from usage in previous projects.

The upper ca. 120 m of the borehole will be reamed to a diameter of 260 mm and lined with a fiberglass bore casing of 255 mm outer diameter of type also used for potable water. The casing prevents any seepage of drill fluid into the porous firn layer. The fibreglass casing contains glass fibre which is not biodegradable. The ice at the drill site, according to geophysical measurements, is frozen to the bed rock, so preventing any seepage of drill fluid into the sub-glacial environment. The BE-OIC project is using the same bore casing as proposed here.

During the course of the project the AAD will explore options for replicate drilling of the several hundred metres of the very oldest ice close to the bed, i.e. by deviation from the main borehole.

The AAD proposes to permanently retain the borehole casing and fluid filled borehole in place, and will be subject to further environmental assessment and authorisation. Retaining ice core boreholes as a permanent access point to the ice sheet is extremely valuable for ongoing monitoring and measurement of ice sheet processes. The environmental impact of re-drilling a deep access point to the ice sheet is many orders of magnitude larger than leaving the fluid in place. Over hundreds of thousands to millions of years the ice will deform plastically and the fluid become dispersed in a very large volume of ice, before eventual extremely diluted discharge to the sea, where ESTISOL 140 is biodegradable up to 75% in 28 days according to marine BODIS test [Sheldon et al., 2014a].

Drill cleaning and drill unstick

A small amount (<20 L per season) of isopropanol will be required to clean the drill between runs. Isopropanol is not classified as environmentally hazardous (it is the main ingredient in hand sanitizer) and is 100% biodegradeable (https://echa.europa.eu/brief-profile/-/briefprofile/100.000.601).

In the event of a stuck drill, up to ca. 100 L of glycol (1-2-ethanediol) may be introduced to the borehole to aid in freeing the drill by melting drill chips/obstructions. Ethylene glycol is not classified as environmentally hazardous (see Safety Data Sheet: https://www.merckmillipore.com/AU/en/product/msds/MDA_CHEM-100949) and is readily biodegradeable according to OECD criteria (see e.g.: https://www.echa.europa.eu/web/guest/registration-dossier/-/registered-dossier/15973/5/3/2).

This method has proven effective for removal of stuck drills in previous deep drilling projects.

If all options for extracting a stuck drill fail then the contingency is to leave the drill sonde in the borehole and move the drill tent (up to ca. 50 m) and start the process again from the surface. This would be a major setback for the project and is considered unlikely. The drilling SOPs focus in detail on good practise and technology minimise the risk of drill stick.

3.1 MYIC Project Details

The sequence of MYIC project activities is summarised in Table 1 below. The MYIC proposed project tasks are scheduled to occur during the austral summer field season. The Traverse is expected to depart Casey Station early in the season (nominally November) and take 2 to 3 weeks to arrive to LDC. Traverse departure from LDC is expected in late January to February throughout the campaign, with the exact timing subject to environmental and logistical considerations, predominantly extreme

negative temperature. Two Traverses are planned for the 2023/24 season to support transport and installation of the complete MYIC Inland Station.

Field operations at LDC are expected to span a maximum of 60 – 70 days each season. Throughout the project, there will be supporting activities at Casey Station, including Traverse staging at the Traverse staging area and cargo and sample handling.

Some flexibility with the completion/carry-over of the tasks each year is required due to unexpected changes in the climate, environment and any problems associated with the machinery.

Table 1: Summary of MYIC project timing, activities and personnel numbers.

Year (austral season)	**2022/23**	**2023/24**	**22024/25**	**2025/26**	**2026/27**	**2026/27**
Traverse (T)	T1	T2 and T3	T4	T5	T6	TBA
LDC field activities	Inland Station start set up Pilot drilling Ice core processing and RTA Prep LDC ski-landing area for aviation	Install Inland Station Borehole casing and drilling up to ca. 400 m Ice core processing and RTA	Drilling to ca. 1200 m Ice core processing and RTA	Drilling to ca. 2000 m Ice core processing and RTA	Drilling to ca. 2800 m (bed) Ice core processing and RTA	Contingency season Completion of drilling Sampling of basal material Removal of Inland Station Science on bore hole
Fixed-wing aviation support	Yes	Yes	Yes	Yes	Yes	TBA
PAX at Inland Station	10	16	16	16	16	TBA
PAX on Traverse	10	10	10	10	10	TBA
Days at LDC	60 – 70	60 – 70	60 – 70	60 – 70	60 – 70	TBA

3.2 Equipment, Logistics and Methods

Traverse

The AAD Traverse capability comprises the following core pieces of plant, equipment and infrastructure:

- 6 x Challenger Traverse tractors.
- 3 x Pisten Bully 300 polar snow groomers.
- 23 x 7.5m sleds.
- 5 x 12.5m sleds.

- 2 x vehicle recovery skis.
- 54 x 10,000 Lt Jet A1 ISO fuel containers (Traverse & Inland station).
- 500 drums of Jet A1 fuel for first year operation only, and 25 drums of SAB
- 12m Traverse living, kitchen and amenities van.
- 12m Traverse 10 berth accommodation van.
- Generator container (2 x Cat generators).
- Ancillary generator container (2 x 15 KVA generators).
- Traverse Medical Facility (Traverse & Inland Station).
- + 4 and -18 food containers.
- Parts and storage containers.

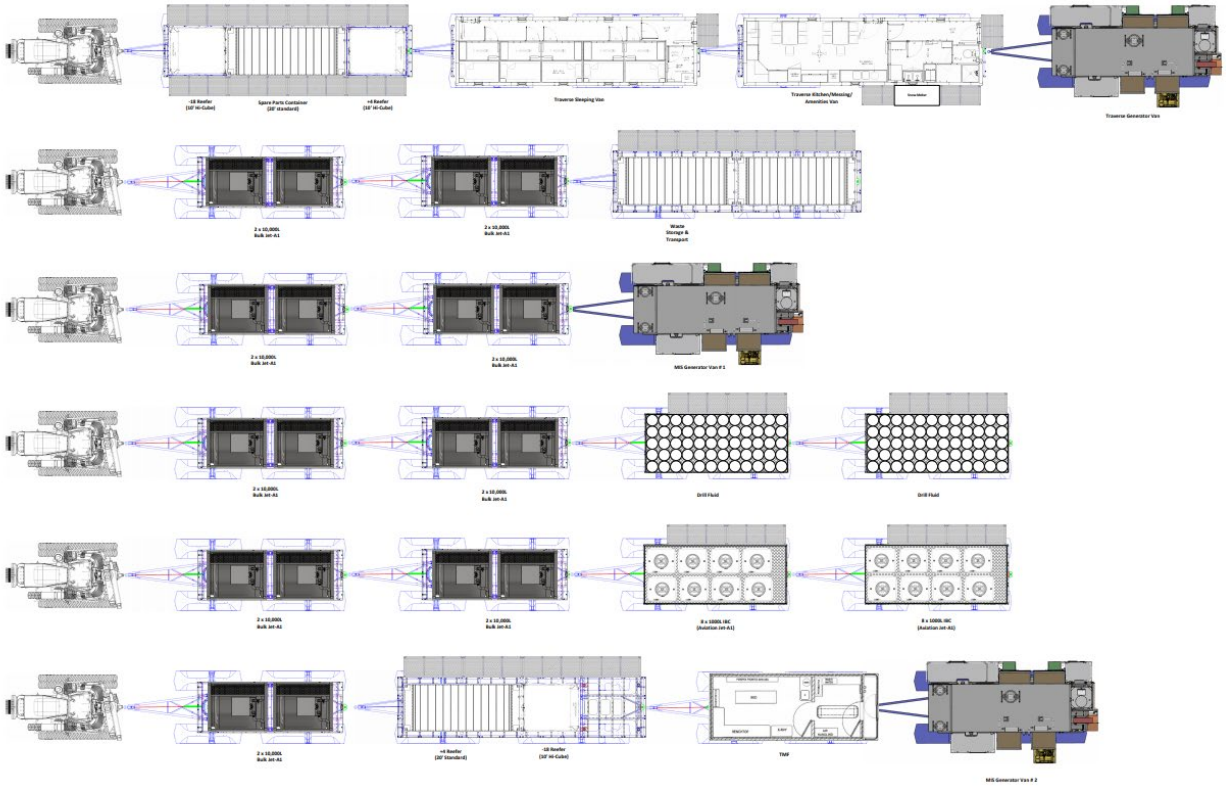

Figure 4: AAD Traverse System

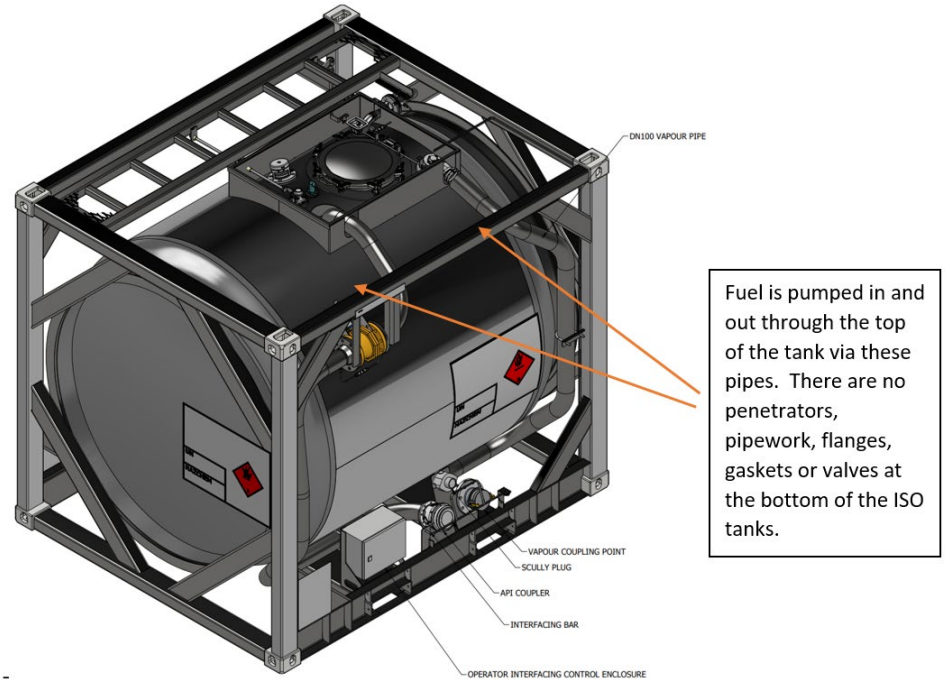

Figure 5: Traverse and Inland Station fuel ISO containers.

Use of Fuel Drums in first year

The AAD originally planned for the Traverse and Inland station ISO fuel containers to be delivered to Antarctica in the 2021-22 season to enable the 2022-23 Traverse to operate. For a number of reasons this did not occur, mostly due to material and shipping delays disrupting the manufacturing process (as a consequence of COVID 19) and engineering complexities associated with the 'top draw/top fill' design. Subsequently, the only viable way to operate the 2022-23 Traverse is with 500 drums (containing 200 litres each) of Jet A1 fuel. These drums are standard AAD double chimed Jet A1 fuel drums already in position at Casey to support aviation operations from previous re-supply. The drummed fuel will be stored and transported on traverse sleds for the duration of the 2022-23 traversing activities. An additional 25 drums (approx.) of SAB will also be taken on the 2022-23 traverse for power generation.

Throughout the MYIC campaign and while the Inland Station is in operation at LDC, it is envisaged that 25 drums (approx.) of Jet A1 will be transported on Traverse each season to support aviation operations at the Inland Station Ski Landing Area.

Inland Station

The AAD mobile Inland station capability includes the following equipment and infrastructure:

- Expandable 6m kitchen and dining containers (joined).

- Amenities van.
- Water services container.
- 4 x accommodation vans (4 berth).
- 2 x Inland station generator containers (4 x Cummings generators).
- + 4 and -18 Food containers.
- Expandable 6 m operations and communication container.
- Expandable 6 m workshop.
- Mobile machinery workshop (soft shelter).
- 27 m drill tent.
- Ice core processing tent.
- Ice core storage facility.
- Parts and storage containers.
- Cat skid steer loader.

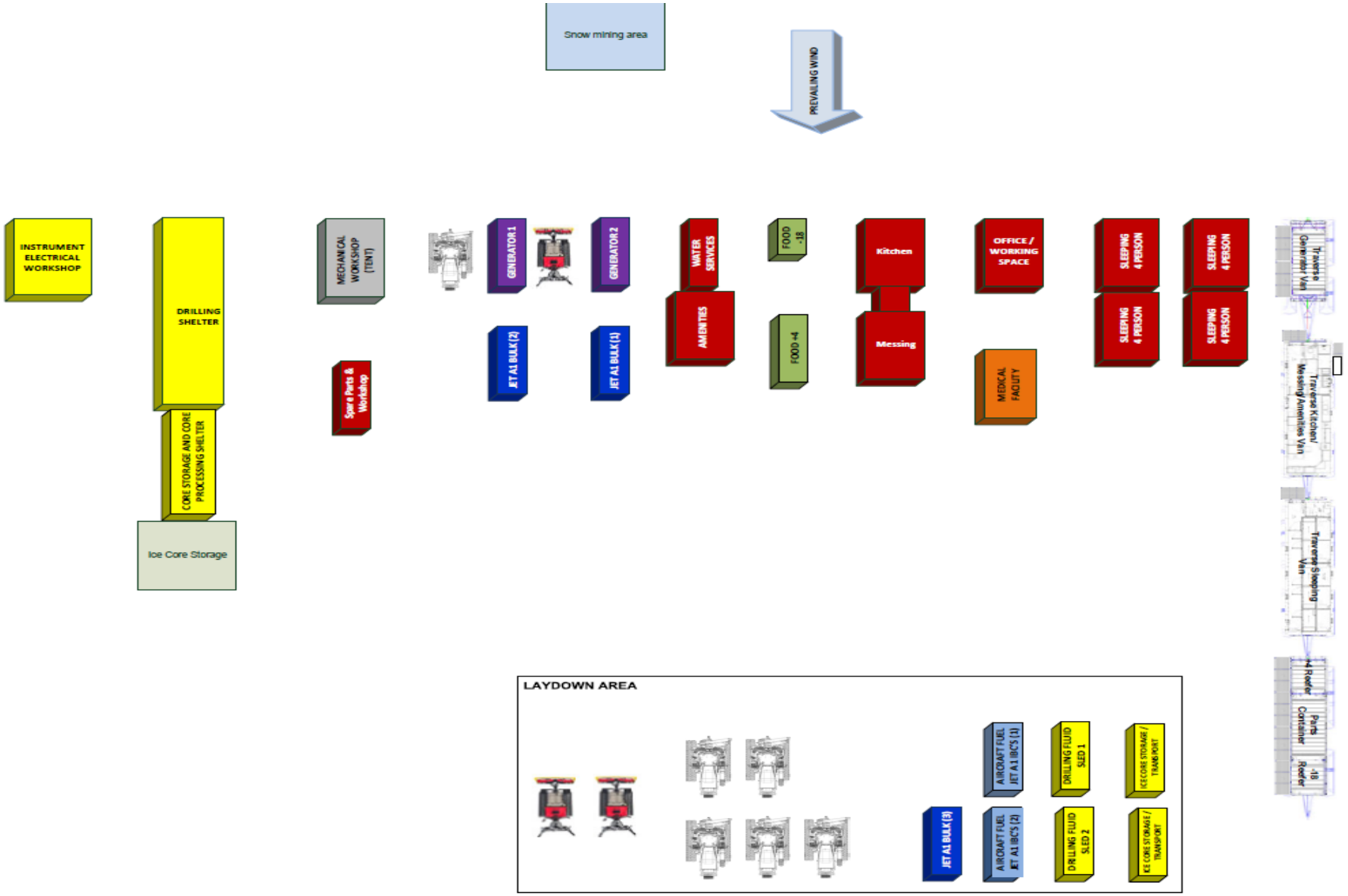

Figure 6: Proposed inland station layout. Some minor changes in relative locations of structures may occur.

MYIC Drilling System

The AAD deep ice core drilling capability includes the following systems:

- Drill sonde:
  - Anti-torque section.
  - Motor section.
  - Chips chamber.
  - Core barrel & outer tube.
- Operators cabin:
  - Drill sonde control and logging hardware.
  - Winch user interface.
  - Drill sonde user interface.
- Change room.
- Drill winch (3000 m twisted pair cable).
- Drill tower.
- Electrical enclosures for winch and power distributions.
- ESTISOL fume extraction and fluid containment and management system.
- Drill ice shaving/ESTISOL mixture recovery and recycling system.
- Ice core recovery and processing systems.
- Supporting Eclipse drill system with reaming kit.

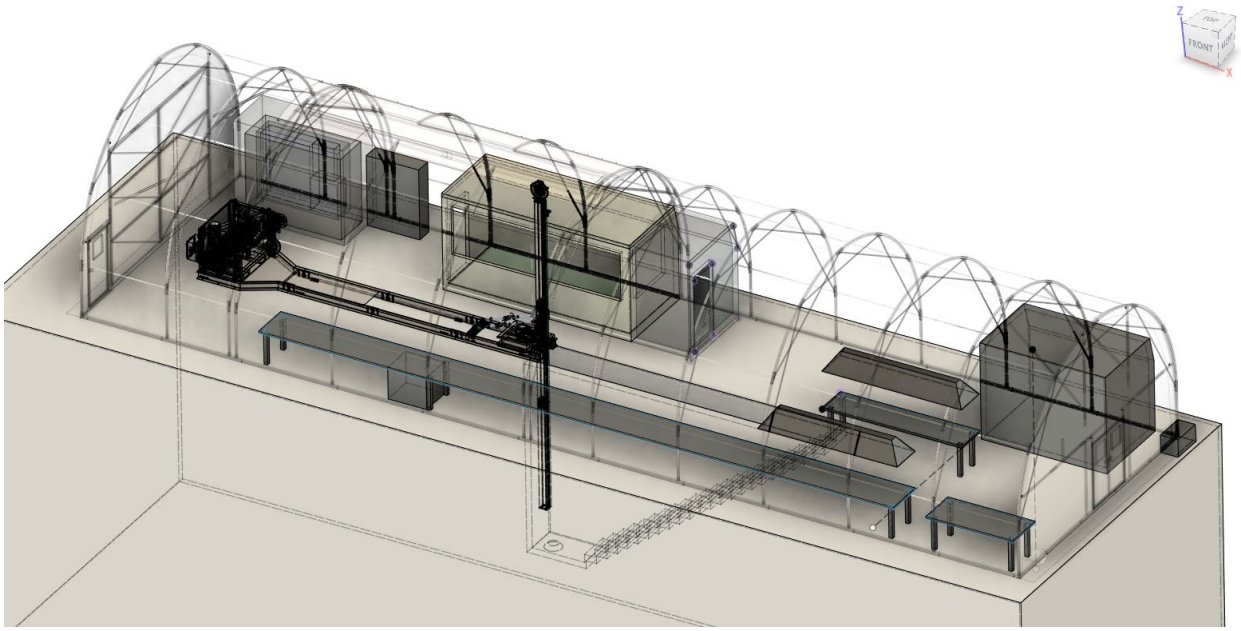

Figure 7: AAD deep drill system, drill trench and drilling shelter.

3.3 Location of the proposed activity

The target drilling location for MYIC is 122.52059 E, 75.34132 S in the Little Dome C region. The inland station will be installed around these coordinates. The location is ca. 35 km SW of Concordia Station and 1100 km inland of Casey Station and 5.2 km S of the European Beyond EPICA Oldest Ice Core (BE-OIC) site, see Figure 8.

The Traverse operates between the Traverse Staging area located approximately 3 kms from the Casey Ski Landing Area (SLA), and 10 km east of Casey Station (Figure 3). The Traverse extends ca. 1300 km across extensive ice sheet to the LDC location via the Traverse route illustrated in Figure 3.

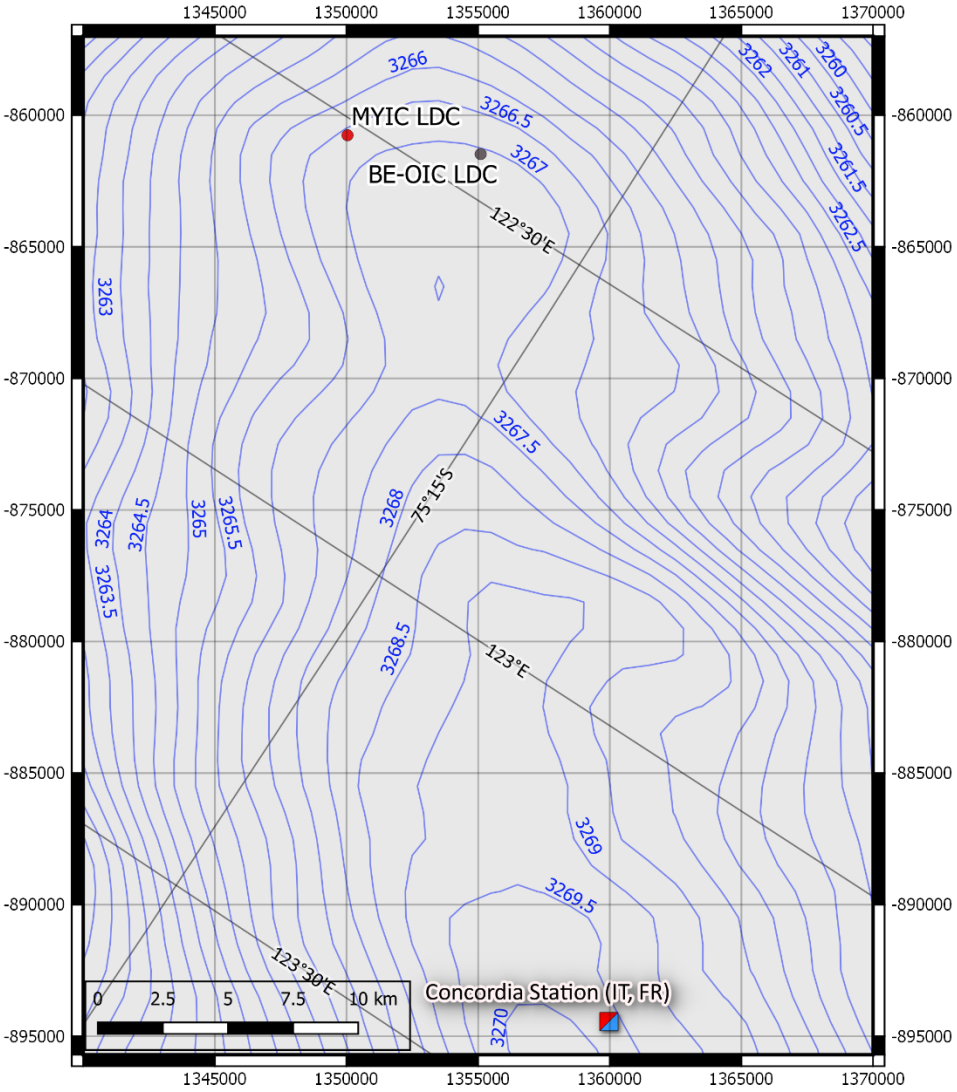

Figure 8: Map showing the MYIC drilling and Inland Station site at Little Dome C (LDC), in relation to the European Beyond EPICA Oldest Ice Core (BE-OIC) drilling camp and the permanent Concordia Station. The Little Dome C region is 1100 km inland of Casey Station.

4 ALTERNATIVES TO THE PROPOSED ACTIVITY

4.1 Do Nothing

Recovery and analysis of a continuous 1.2 million year plus ice core record of climate and atmospheric composition will improve scientific understanding climate feedbacks, forcings and climate and ice sheet stability. The results will help to improve projections of the climate, ice sheet and sea level response to rising greenhouse gases. Doing nothing would forfeit the opportunity for the Australian Antarctic Program to significantly contribute to this science.

4.2 Alternative locations and timing

The science and drilling location for MYIC is guided by the International Partnerships in Ice Core Sciences (IPICS) priority goal to recover "a replicated Antarctic ice core record extending at least 1.2 million and preferably 1.5 million years, into the past". The Little Dome C region was chosen as the most promising location to deliver this objective on the basis of over 10 years of site survey work, conducted in collaboration between AAD teams and international collaborators and detailed glaciological modelling. The MYIC drilling coordinates are separated 5.2 km from the BE-OIC ice core drilling activity. This distance, which is greater than one ice thickness, is consistent with the International Partnerships in Ice Core Sciences (IPICS) goal to recover a replicated record. Replication is essential to verify that recovered climate and atmospheric composition are not affected by flow disturbance or other artefacts.

The timing of the project represents 5-6 years of drill, Traverse and Inland Station capability development, and over a decade of site survey work. It is beneficial for collaboration on science and logistics that the project overlaps with the timing of the European BE-OIC project, located 5km away.

4.3 Alternative methods and technologies

Where the objective is to recover a continuous record of climate and atmospheric composition spanning 1.2Myr plus, there is no scientific alternative to deep ice core drilling. The Traverse and Inland Station capabilities have, in the first instance, been established to support the MYIC campaign. There are no alternatives proposed to support this scientific endeavour.

The project Team will be investigating potential renewable energy sources for power generation at LDC to reduce fuel consumption. Technologies such as solar are expected to be introduced.

5 DESCRIPTION OF THE ENVIRONMENT

5.1 Physical Characteristics of Staging Area, Traverse and Little Dome C Inland Station

The Traverse staging area for machinery, sleds and infrastructure is comprised of a 400 m x 400 m area located approximately 3 kms from the Casey Ski Landing Area (SLA), and 10 km east of Casey Station. The staging area is located on continental ice that is several hundred m thick. From this location, the Traverse extends ca. 1300 km across extensive ice sheet to the LDC location via the Traverse route illustrated in Figure 3.

The physical environment for both the staging area and Traverse is comprised of continental ice sheet and contains no mapped geology[1].

The Little Dome C Inland Station site is located at is 122.52059 E, 75.34132 S in the Little Dome C region at ca. 3300 m above sea level. The location is ca. 35 km SW of Concordia Station and 1100 km inland of Casey Station and 5.2 km S of the European Beyond EPICA Oldest Ice Core (BE-OIC) site as shown in Figure 1. The ice thickness is ca. 2800 m and there is near zero surface slope. The surface is slightly undulated due to small snow sastrugis and dunes, typically of less than 30 cm height. The area is not protected.

5.1.1 Wildlife

The Traverse Staging Area and Traverse route are located on continental ice sheet away from the coastline where there is no resident flora or fauna. Transient wildlife may be encountered from time to time, but is expected to be minimal and only to occur in areas within a few kilometres from the coast. The AAD has extensive experience and established procedures and guidelines for working in and around wildlife. These are regularly reviewed and updated based on new information, research or investigations into past incidents. These will be applied should transient wildlife be encountered.

No flora or fauna are present at Little Dome C due to the harsh environmental conditions and location ca. 1100 km from the coast.

5.1.2 Meteorology and Climate

The mean annual temperature in the Little Dome C region is -55°C. During the December to January field we expect temperature maxima of -20 to -30°C and minima of -30 to -40°C. The prevailing wind is SSW with a mean annual wind speed of 2.8 m/s and maximum daily surface wind speeds are typically less than 8 m/s (15 knots) [Aristridi et al., 2005]. The region does not experience katabatic winds as it is located on the high plateau at near zero surface slope. There is never any surface melting of snow. Mean annual snow accumulation rate is very low, 2 –3 cm ice equivalent per year.

5.1.3 Human Presence

The largest human presence in the Little Dome C region is the French-Italian station of Concordia, which is 34 km from the MYIC Inland Station. Concordia Station was built in 2005 and is operational year-round. The station accommodates around 14 people over winter and up to 50 people during summer.

The European Beyond EPICA Oldest Ice Core (BE-OIC) inland station is 5.2 km to the north of the MYIC target drilling location. Under the BE-IOC program drilling occurs for approximately 60 -70 days in the field from November-January, with expected completion by season 2024-2025. The BE-OIC camp accommodates up to 15 people.

[1] AAD Aviation IEE 2020-2025; Physical characteristic descriptions, pp 26-28.

6 ASSESSMENT OF ENVIRONMENTAL IMPACTS

6.1 Methodology

The Assessment process involve four key stages consistent with the objectives of Annex I of the protocol on Environmental protection to the Antarctic treaty and AAD's Environmental Management System approach to managing the AAD's interaction with the environment.

The assessment of environmental impacts has followed the following staged approach:

1. Identify the key activities of the project,
2. Identify the environmental aspects – how the activities interact with the environment,
3. Identify the environmental impact –change in environmental value or resource as a result of the activity, and
4. Assess the significance of impact –including spatial extent, duration, and environmental consequences.

The assessment of significance is based on the likelihood and consequence of a particular impact or group of impacts occurring because of an activity. This assessment has incorporated past knowledge and experience in conducting Traverse and inland ice core drilling activities (including the AAD's Aurora Basin North, DEOH and Mount Brown South projects). Additional information and advice has been sought from subject matter experts within the AAD operations, and science areas.

6.2 Proposed Activities

The information used to assess the environmental risk of drilling activities and inland station establishment has been sourced from previous AAD drilling activities at Aurora Basin North and Mount Brown South, as well as knowledge gained from the European Beyond EPICA Oldest Ice Core (BE-OIC) program, which commenced in the season 2019-2020. The potential environmental impacts for the MYIC project are consistent with BE-OIC in that AAD are using the same drilling technologies, drill fluid and similar inland station design. As for BE-OIC, all structures are designed to be removed as temporary tents or ski-mounted vans/containers.

A detailed description of the scope and locations of the activities associated with the MYIC project is addressed in Section 3 of this document. These activities have been summarised for the impact assessment process:

- Traverse from Staging Area to Little Dome C (LDC)
  - Transportation, storage and use of fuel, including fuel drums in the first year
  - Noise and vibration
- Establishment of inland station at LDC
  - Fuel and waste management
  - MYIC drilling activities
  - Contamination risk management
- Emergency Response
  - Incident management

6.3 Environmental Aspects

Environmental aspects are the element of an organisation's activities, products or services that interact or can interact with the environment (ISO-14001). As described in the Guidelines for Environmental Impacts Assessments in Antarctica (ATCM 2916), an environmental aspect may include emission of pollutants / noise / light, human presence, transfer of native or non-native species, direct contact with wildlife / vegetation, leak or spill of hazardous substances etc. Environmental aspects may also involve removal from the environment of organic or inorganic material including, collection of fauna and flora and the removal of water, ice or rocks.

The AAD uses the following definitions in its Environmental Management System (EMS) Environmental Aspects and Impacts Register.

- Energy Use - includes the use of electricity, non-renewable resources, refrigerants, water and release of exhaust, gaseous and radioactive emissions.
- Physical Disturbance - includes human activities, introduction of non-indigenous species, parasites and diseases, disturbance to soils, flora, fauna, communities and ecosystems, building and infrastructure maintenance and construction and station activities.
- Hazardous Chemicals - includes the storage, use and disposal of chemicals and hazardous materials.
- Waste Management - includes the management of combustible, hazardous, sewage and domestic liquid and solid waste products.

6.4 Potential Impacts and Mitigation Measures

This section outlines the potential environmental impacts resulting from the proposed activities described in Section 3 and 6.2. The potential impacts, inherent and residual risk and mitigation measures are presented in Section 6.6 MYIC Traverse and Inland Station - Environmental Impacts matrix.

The following categories of environmental impact have been used in this assessment:

- Biological change,
- Habitat change,
- Disturbance of fauna,
- Degradation of wilderness values,
- Landscape change,
- Degradation of heritage/cultural values,
- Noise pollution,
- Pollution of sea water/sediments and
- Pollution of the air.

The potential for these environmental impacts to occur is assessed against the key activities listed in Section 6.2.

6.4.1 Biological Change and Habitat Change

The loading of cargo, equipment, stores and personnel in Hobart for transport to Antarctica has the potential to introduce non-native species to Antarctica.

There are no perceived changes to biodiversity or habitat from activities associated with this project as all activities will be undertaken on the ice sheet from the Casey Ski Landing Area (SLA) to remote inland areas of the continent. An increased biosecurity risk from invasive species is therefore considered unlikely. This is due to the extreme climatic conditions encountered on the inland ice sheet and existing biosecurity procedures implemented by AAD prior to departure.

Mitigation(s) include:

- The harsh conditions of the site (permanently negative surface temperatures) guarantee that there is no risk of introduction of non-native species.
- Biosecurity SOP includes procedures, staff training, emergency response and maintenance of buildings, external work areas and equipment.
- Mandatory training for all AAP expeditioners to complete eLearning - Introduction to Environmental Management in Antarctic/sub-Antarctic and to attend an Environmental Management pre-departure session. Both presentations cover biosecurity.
- Cargo, equipment and stores quarantined are at AAD head office/CBC before being loaded in *RSV Nuyina*.
- The CBC has an approved arrangement with the Australian Government to manage biosecurity risks on the Government's behalf. The AAD maintains an incident reporting system to monitor, respond and learn from biosecurity issues and threats, in a timely and effective manner.
- AAD policies and procedures will be followed to ensure that all equipment is thoroughly cleaned of organic matter prior to arriving in Antarctica. Items will be secured to avoid windblown debris.
- All equipment and materials will undergo biosecurity inspection prior to commencement of Traverse.

6.4.2 Disturbance of Fauna

The MYIC Traverse and Inland Station activities commence from the Casey Station Ski Landing Area and conclude at the inland station location at LDC. The disturbance of fauna as a result of these activities is expected to be minimal. Transient wildlife may be encountered when closest to Casey Station, but is unlikely as the Traverse continues to inland and more remote areas of the ice sheet.

Mitigation(s) include:

- The AAD has extensive experience and established procedures and guidelines for working in and around wildlife. These are regularly reviewed and updated based on new information, research or investigations into past incidents. These will be applied should transient wildlife be encountered.
- All personnel will be made aware of wildlife and separation distances in AAD mandatory Pre-departure training.
- Aviation operations at the Casey SLA will comply with the existing guidelines and separation distances to reduce impacts on wildlife, identified in the existing IEE for AAD Aviation operations (2020-2025).

6.4.3 Noise Pollution

Throughout Traverse activities, noise and vibration created by vehicles will occur. As there are no sensitive receptors (wildlife, stations or inland field camps) on the ice sheet, impacts are considered negligible.

At the inland station at LDC, noise emissions will be generated from the drilling activities, vehicles, power generation and day-to-day operations of the inland station. Due to the remote location and low numbers of AAD personnel, the impacts from noise are considered minimal.

Mitigation(s) include:

- There are no sensitive receptors in the proposed drilling site that would be impacted by noise from drilling activities.
- Concordia Station is located ~35 km from the site and can be considered the biggest source of human impact in the area.
- The European Beyond EPICA Oldest Ice Core (BE-OIC) inland station is 5.2 km to the north of the MYIC target drilling location and will be undertaking similar drilling activities. Both Concordia Station and BE-OIC activities are distanced enough as to not cause cumulative noise impacts.

6.4.4 Pollution of Sea Water/Sediments, Snow and Ice

The risk of polluting sea water/sediments from activities associated with this project is considered low. All activities will be undertaken on the ice sheet from the Casey SLA to remote inland areas of the continent.

There is the potential for polluting activities to occur as a result of fuel and oil spills during Traverse. Spills of this nature may be due to accidental spills from fuel drums (first year only), vehicle related incidents, refuelling error, machinery failure or incorrect use of machinery and equipment. Similarly, fuel spills and impacts from waste may also occur at the inland station from daily activities and operation of the inland station.

Grey water, during Traverse and at the inland station will be discharged to the environment, but impacts will be minimal and managed in accordance with field waste management guidelines and authorisation conditions. Grey water will be discharged in soft snow terrain in the surrounding areas of Traverse overnight locations. Transporting wastewater and greywater back to Casey Station would generate more negative impacts to the environment. The volume of grey water produced over the ca 6-week drill camp and ca. 4 week (return) Traverse legs would be logistically challenging and require significant additional equipment. Furthermore, this approach would introduce potential risk for personnel from leaks and manual handling injury in managing grey-water systems at the extreme negative temperatures on the plateau. Additional fuel would be required to transport greywater back to Casey Station. All solid human waste will be returned to Casey Station for incineration.

A 120 m long 260 mm diameter borehole casing will be installed in the upper ca. 120m of the ice sheet. The environmental impact of the casing is expected to be minor and its presence is essential to prevent seepage of drill fluid into the firn layer.

The project expects to use up to 50 m^3 of ESTISOL 140 drilling fluid. This is the same product as approved for usage in previous AAD and international ice drilling projects. The AAD proposes to retain the fluid-filled and borehole as a valuable scientific access point to the ice sheet. Over

hundreds of thousands to millions of years the ice will deform plastically and the fluid become dispersed in a very large volume of ice, before eventual extremely dilute discharged to the sea, where ESTISOL 140 is biodegradable up to 75% in 28 days according to marine BODIS test (. Sheldon et al., 2014a). ESTISOL 140 is immiscible with water and will be separated from ice chips in a chip melting device and then recycled back into the borehole. Efficiency of this separation in previous projects has been 98-99%. Meltwater, with traces of E-140, will be disposed on site by discharge into the firn at a single fixed point. This process is expected to have negligible environmental impact as ESTISOL-140 is non-hazardous to the environment and biodegradable.

A ca. 10 m long by 5 m deep and ca. 2m wide firn trench will be excavated at the drilling site using electric chainsaws to allow tilting of the ice core drill and extraction of ice cores. Several additional trenches may be excavated to over-winter equipment and store ice cores. The AAD is investigating the retention of an archive of ice core samples in firn cave at the site to provide redundancy in case samples are lost. If this eventuates a variation to the IEE will be submitted. Remaining trenches will be filled at the completion of the project. The environmental impact of these backfilled trenches is expected to be minimal.

During drilling, ice chips will be generated which contain ESTISOL 140 (E-140), which is non-hazardous to the environment in its concentrated form. Ice chips will be melted outside the drilling tent and disposed on site by discharge into the environment at a single fixed point. E-140 is immiscible with water and will be separated from the meltwater for reuse. AAD has designed the ice chip melting device for maximum efficiency of separation, previous projects have achieved 98-99% separation. The drilling fluid is identical to the fluid used by BE-OIC (EPICA) and the same as used previously by the AAD at the Aurora Basin North and Mount Brown South ice core drilling projects.

Other than the casing and drilling fluid, all drilling infrastructure and equipment will be removed at the completion of the project. Retention of the casing, with an access point for scientific access to the borehole may impact wilderness values.

Mitigation(s) include:

- All fuel drums used in the first year of MYIC are double chimed drums which are more robust and strengthened to prevent fuel leaks. Fuel drums will be transported and stored on the deck of a traverse sled. The quantities of fuel in each drum is 200 litres, which is comparatively smaller to larger storage containers. Any potential fuel spill or leak will therefore be limited to a 200 litre quantity, which can be readily isolated and contained using AAD spill response procedures.
- All 18 ISO fuel tanks have been designed and build specifically for Antarctic use, to engineer out known fuel spill sources and have been manufactured to relevant standards.
- ISO tank fill/top draw is best practice for fuel system design (COMNAP Fuel Manual).
- AAD Refuelling procedures and equipment including bunds and spill mats will be used when refuelling at both sites. If a spill occurs, all reasonable steps will be taken to contain the spill as quickly as possible and to minimise environmental damage.
- AAD Standard Operating Procedure Operations and training of all personnel in spill procedures and response.
- During Traverse and at LDC, all station waste including solid human waste, will be double-bagged and packed into empty sealed containers for return to Casey Station for treatment and/or incineration.

- All Traverse and Inland Station materials and equipment will be secured and stored in a manner that prevents windblown debris.
- Grey water will be discharged in soft snow terrain in the surrounding areas of Traverse overnight locations. At the inland station, grey water will be discharged below the snow surface and covered each season as part of the inland station winterisation.
- Drilling fuel will be appropriately stored in sealed drums/tanks until use and managed to limit the possibilities of contamination to the environment.
- Drilling fluid contained in casing therefore minimal environmental risk. Leaving the fluid in place allows the drill hole to remain viable to return to in the future for ongoing scientific monitoring.
- Ice chips melted outside the drilling tent in a chip melting device. Meltwater with traces of E-140 disposed on site into the firn at a single fixed point. E-140 is non-hazardous in its concentrated form. Trace quantities do not present an environmental risk in the ice sheet environment.

6.4.5 Degradation of Wilderness Values

Human presence in Antarctica has the potential to impact on landscape and wilderness values. This is an unavoidable consequence of operating in an environment characterised by the lack of human activity. The presence of the MYIC Traverse and Inland Station on the East Antarctic inland ice sheet represents a short term and minimal degradation of wilderness values. The potential impacts from the presence and operation of the inland station are considered both minor and transitory, due to the short-term operation over the summer seasons, low numbers of personnel on site and snow accumulation process in this remote area of Antarctica.

Mitigation(s) include:

- Inland Station is temporary in nature and will be established over 5 seasons. On completion of the project, all infrastructure will be returned to Casey Station with the exception of the bore hole casing which will remain in situ for future research opportunities.
- Number of people limited to 10-16 personnel on site each season.
- Due to remote area, any surface impacts to ice sheet caused by inland station, SLA and MYIC activities will be both minor and transitory. Snow surface will return on original condition within a few months due to snow accumulation processes.
- Any berms will be allowed to naturally attenuate. Flattening berms using machinery is considered more environmentally impactful than natural attenuation over multiple seasons.
- Winterisation of the drilling camp will occur each season after summer operations are complete, minimising disturbance to ice areas on an annual basis.
- Traverse structures (highlighted in grey in Figure 4) will return to Casey Station at the end of each drilling season.

6.4.6 Impacts on Other Programs or Projects

The European Beyond EPICA Oldest Ice Core (BE-OIC) inland station is 5.2 km to the north of the MYIC target drilling location and will be undertaking similar drilling activities. Concordia Station is located ~35 km from the site and can be considered the biggest source of human impact in the area. Both Concordia Station and BE-OIC activities are distanced enough from the MYIC project and activities as to not cause cumulative impacts to the environment. Both ice core projects are temporary in nature and will be completed over 5 seasons. The BE-OIC drilling project will be completed in the 2024-25 season, two years ahead of the MYIC project.

6.4.7 Cumulative Impacts

The European Beyond EPICA Oldest Ice Core (BE-OIC) inland station is 5.2 km to the north of the MYIC target drilling location and will be undertaking similar drilling activities. Concordia Station is located ~35 km from the site and can be considered the biggest source of human impact in the area. Both Concordia Station and BE-OIC activities are distanced enough from the MYIC project and activities as to not cause cumulative impacts to the environment. Both ice core projects are temporary in nature and will be completed over 5 seasons. The BE-OIC drilling project is scheduled for completion of drilling activities in the 2024-25 season, two years ahead of the MYIC project.

6.5 Evaluation of Environmental Impacts

6.5.1 Methodology

This section evaluates the impacts identified in Section 6.4 for their significance. In order to determine the overall significance and risk, each potential impact has been assessed using the following criteria:

(i) **Likelihood of the impacts occurring**

Likelihood Guide	
Almost Certain	Is expected to occur in most circumstances. Has occurred in the AAD or similar in the past year.
Likely	Will probably occur. Has occurred in the AAD or similar in the past two years.
Possible	Might occur (**COULD HAPPEN**) at some time in the future. Has occurred in the AAD or similar in the past five years.
Unlikely	Could occur but considered unlikely or doubtful. Has occurred in the AAD or similar in the past ten years.
Remote	May occur in exceptional circumstances. Has not occurred in the AAD or similar in the past ten years.

Figure 9 Likelihood description

(ii) **Consequence of the impact occurring**

Consequences Guide	
Insignificant	Minor incident of environmental damage that can be reversed.
Minor	Isolated but significant instances of environmental damage that could be reversed with intensive efforts.
Moderate	Significant instances of environmental damage that could be reversed with intensive efforts.
Major	Major loss of environmental amenity and real danger of continuing.
Catastrophic	Severe widespread loss of environmental amenity and irrecoverable environmental damage.

Figure10 Consequence description

In determining significance, the following additional criteria are used to take into consideration the range of potential consequences resulting from an activity or impact.

- Spatial extent,
- Reversibility,
- Intensity /magnitude, and
- Duration.

Where activities may result in a combination of impacts and consequence rating the highest rating has been used in the impact assessment.

Additional Guidance for Environmental Consequences.					
Environmental Consequences	**Insignificant**	**Minor**	**Moderate**	**Major**	**Catastrophic**
Spatial extent – over what approximate area are environmental impacts likely to occur?	<10 m^2 e.g. less than 3m x 3m or 5m x 2m	<100 m^2 e.g. less than 10m x 10m	<1,000 m^2 e.g. less than 32m x 32m or 10m x 100m	<10,000 m^2 e.g. less than 100m x 100m or 10m x 1000m	>10,000 m^2 e.g. over 100m x 100m or 10m x 1000m
Reversibility – how possible is it that the environmental ***impacts*** can be reversed?	Reversible with minor intervention	Reversible with moderate intervention	Reversible with intensive effort	Reversible with intensive long-term effort	Effectively irreversible
Intensity / magnitude – how much change to the environment is likely to occur?					
Consider change to landscape features *e.g. stone polygons, rare or unusual rock formations or mineral assemblages, ice-free areas.*	Degradation or loss of < 1% of the area of local occurrences of a landscape feature	Degradation or loss of < 5% of the area of local occurrences of a landscape feature	Degradation or loss of <20% of the area of local occurrences of a landscape feature	Degradation or loss of <50% of the area of **local** occurrences of a landscape feature *or* Degradation or loss of up to 5% of the area **of all known occurrences** of a landscape feature (globally)	Greater than 50% of the area of **local** examples of a landscape feature *or* Degradation or loss greater than 5% of the area **of all known occurrences** of a landscape feature (globally)
Consider change to species of fauna and flora, including threatened species *e.g. moss beds, invertebrates.*	No observable change	Some individuals impacted. No population impact and no impact on threatened species	Loss of individuals. Minimal impact on population *or* Some impact on individuals of threatened species	Substantial impact on or loss of population. Potential loss of genetic diversity *or* Loss of individuals of threatened species	Local extinction of species. Loss of genetic diversity *or* Impact on one or more populations of threatened species
Consider change to environmental values of sites *e.g. biological, scientific, historic, aesthetic or wilderness value.*	No observable change	Some degradation of values	Substantial degradation or loss of values *or* Some degradation of values within nationally or internationally significant sites (ASPA, ASMA & Heritage managed areas)	Loss of values *or* Substantial degradation of a nationally or internationally significant site	Loss of values of a nationally or internationally significant site
Duration – over what period are the ***impacts*** likely to occur?	<1 month	<1 year	<5 years	<15 years	>15 Years

Figure 91 Environmental Consequence criteria descriptions

(iii) **Risk Rating**

The likelihood and consequence has been considered for each activity against the aspects of the environment it interacts with and the potential environmental impacts. The following risk ratings are applied for activities pre and post mitigation.

Likelihood	Consequence				
	Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
Almost Certain	Medium	Medium	High	Severe	Severe
Likely	Low	Medium	High	High	Severe
Possible	Low	Low	Medium	High	High
Unlikely	Low	Low	Medium	Medium	High
Will be remote	Low	Low	Low	Medium	Medium

Figure 102 Environmental Risk Rating Matrix

For the purposes of this assessment the following classification has been has been applied to this residual risk rating for the activities described in Chapter 5. These reflect the three levels of impact significance described in Article 8(1) of the Environmental protocol.

Risk Rating	Level of significance
Low	Less than minor or transitory
Medium	No more than minor or transitory
High	More than minor or transitory
Severe	

Figure 113 Risk Rating Level of significance

6.6 Traverse, Inland Station & MYIC Project: Environmental Aspects and Impacts Register

This Aspects and Impacts Register has referred to a number of documents and procedures, which are the responsibility of the AAD.

D22/28775 ***MYIC - Traverse - Inland Station*** **Environmental Aspects and Impacts Register** *The purpose of this register is to identify AAD activities/products/services that interact with the environment.*

16 records displayed

Serial	Location	Activity description	Condition	ASPECT *- choose ONE*	IMPACT(S) *- can choose multiple impacts*	Potential causes/sources of an impact happening *- brief dot points*	Inherent Likelihood	Inherent Consequence	Inherent RISK	Existing Reduction/Control Measures - against the Aspect. *e.g. Policy, procedures, outside controls or organisations, monitoring and reporting systems…*	Current Likelihood-2	Current Consequence-2	Current RISK2
1	Antarctica	Traverse from Staging Area to Little Dome C (LDC): - Transportation, storage and use of fuel	Normal	Energy use-Leak/spill of fuels	Degradation of wilderness values, Landscape change, Pollution of snow and ice	1. Incorrect use of machinery and equipment 2. Vehicle related incident 3. Tank puncture 4. ISO container dropped during crane operations 5. Drum puncture or spill 6. Machinery failure	Possible	Moderate	Medium	1. Jet A1 fuel drums are double chimed, stored and transported on traverse sleds for 2022-23 traversing activities only. 2. All 18 ISO fuel tanks have been designed and build specifically for Antarctic use, to engineer out known fuel spill sources and have been manufactured to relevant standards and are certified by Lloyds. No penetrator, pipework, valves or flanges at bottom of tanks. 3. Visual inspections conducted daily. 4. Training of personnel and application of best practice fuel management to reduce the likelihood of fuel spills caused by human error. 5. AAD Standard Operating Procedure Operations Manual. - Volume 1 : Station and Field Operating Procedures - Volume 2: Emergency Response 6. Crisis Management & Recovery Manual 7. Hazardous Chemicals Management Policy and procedures 8. AAD Incident Reporting system.	Unlikely	Moderate	Medium
2	Antarctica	Traverse from Staging Area to Little Dome C (LDC): - Transportation, storage and use of fuel	Normal	Energy use-Emission of gases	Pollution of the air, Depletion of non-renewable resources	1. Combustion of fuel and increase in emissions to the environment from exhaust	Almost certain	Insignificant	Medium	1. All machinery maintained and serviced prior to departure to ensure maximum efficiency throughout traverse. 2. Particulates and emissions dispersed over 1100 km of traverse. 3.Wind disperses particulates and minimises risk of emission concentrations.	Likely	Insignificant	Low
3	Antarctica	Traverse from Staging Area to Little Dome C (LDC): -Changes to topography	Normal	Physical disturbance-Landscape	Degradation of wilderness values, Landscape change	1. Berms created for existing infrastructure at staging location 2. Berms created for fuel depots along traverse route, and will be extended to accommodate extra vehicles and machinery associated with traverse 3. Compaction over traverse route	Almost certain	Minor	Medium	1. Change in snow surface will be short term in nature. The traverse route to LDC will be cleared by snow groomers each season. 2. Any surface impacts to ice sheet will be both minor and transitory. Snow surface will return to original condition within a few seasons due to snow accumulation processes. 3. Any berms will be allowed to naturally attenuate; flattening berms using machinery is considered more environmentally impactful than natural attenuation over multiple seasons of snow accumulation and ablation.	Possible	Insignificant	Low
4	Antarctica	Traverse from Staging Area to Little Dome C (LDC): -Noise and vibration	Normal	Physical disturbance-Noise emission	Noise pollution, Disturbance of fauna, Degradation of wilderness values	1. Increased noise and vibration from traverse vehicles, plant and equipment 2. Disturbance to transient fauna closest to Casey Station from traverse activities	Almost certain	Minor	Medium	1. Traverse will commence at Casey SLA and continue to inland station at LDC over continental ice sheet with no resident flora or fauna, and no field camps or stations until Concordia Station. Limited sensitive receptors (wildlife, field camps and stations) along the traverse route. 2. The AAD has extensive experience and established procedures and guidelines for working in and around wildlife. These are regularly reviewed and updated based on new information, research or investigations into past incidents. These will be applied should transient wildlife be encountered.	Almost certain	Insignificant	Medium
5	Antarctica	Traverse from Staging Area to Little Dome C (LDC): - Sewage and greywater	Normal	Waste Management-Sewage/greywater	Hazardous landfill/disposal, Pollution of snow and ice	1. Sewage and greywater impacts to the immediate environment through planned release (greywater) and/or accidental discharge or spill (sewage).	Likely	Minor	Medium	1. All traverse generated solid human waste, will be double-bagged and packed into empty sealed containers for return to Casey for treatment and/or incineration. 2. Grey water will be discharged in soft snow terrain in the surrounding areas of Traverse overnight locations. 3. AAD Standard Operating Procedure Operations Manual - Volume 1 : Station and Field Operating Procedures	Unlikely	Minor	Low
6	Antarctica	Traverse from Staging Area to Little Dome C (LDC): - General waste	Normal	Waste Management-Landfill	Landfill, Pollution of snow and ice	1. Waste and pollution impacts to the immediate environment through accidental release. 2. Waste materials being dispersed due to weather conditions.	Possible	Minor	Low	1. All traverse generated waste will be double-bagged and packed into empty sealed containers for return to Casey for treatment and/or incineration. 2. AAD Standard Operating Procedure Operations Manual - Volume 1 : Station and Field Operating Procedures 3. All traverse items will be secured/packed in a manner that prevents windblown debris.	Unlikely	Minor	Low
7	Antarctica	LDC Inland Station: - Establishment of drill site and inland station	Normal	Physical disturbance-Introductions	Biological change, Degradation of wilderness values	1. Introduction of non-native species translocated through movement of cargo, equipment, stores and personnel.	Possible	Minor	Low	1. The harsh conditions of the site (permanently negative surface temperatures) will reduce the risk of non-native species becoming established. 2. Biosecurity SOP D19/43754 includes procedures, staff training, emergency response and maintenance of buildings, external work areas and equipment. 3. It is mandatory for all AAP expeditioners to complete eLearning PDE101 Introduction to Environmental Management in Antarctic/sub-Antarctic and to attend an Environmental Management pre-departure session. Both presentations cover biosecurity. 4. Cargo, equipment and stores quarantined at AAD head office/CBC before being loaded in *RSV Nuyina* . 5. The CBC has an approved arrangement with the Australian Government to manage biosecurity risks on the Government's behalf. The AAD maintains an incident reporting system to monitor, respond and learn from biosecurity issues and threats, in a timely and effective manner. 6. AAD policies and procedures will be followed to ensure that all equipment is thoroughly cleaned of organic matter prior to arriving in Antarctica. 7. All equipment subject to inspection prior to commencement of traverse.	will be Remote	Minor	Low
8	Antarctica	LDC Inland Station: - Establishment of drill site and inland station	Normal	Energy use-Leak/spill of fuels	Degradation of wilderness values, Landscape change, Pollution of snow and ice	1. Fuel spill at inland station through accidential release/discharge to ice	Possible	Moderate	Medium	1. AAD Refuelling procedures and equipment including bunds and spill mats will be used when refuelling at both sites. If a spill occurs, all reasonable steps will be taken to contain the spill as quickly as possible and to minimise environmental damage. 2. AAD Standard Operating Procedure Operations Manual - Volume 2: Emergency Response 3. AAD incident reporting procedure.	Unlikely	Moderate	Medium
9	Antarctica	LDC Inland Station: - Establishment of drill site and inland station	Normal	Waste Management-Sewage/greywater	Pollution of snow and ice, Landscape change	1. Sewage and greywater impacts to the immediate environment through planned release (greywater) and/or accidental discharge or spill (sewage).	Likely	Minor	Medium	1. AAD Standard Operating Procedure Operations Manual - - Volume 1 : Station and Field Operating Procedures 2. At LDC all station waste, including solid human waste, will be double-bagged and packed into empty sealed containers for return to Casey for treatment and/or incineration. 3. At the inland station, grey water will be discharged below the snow surface and covered each season as part of the inland station winterisation. 4. All inland station materials secured and stored in a manner that prevents windblown debris.	Unlikely	Minor	Low

Serial	Location	Activity description	Condition	ASPECT *- choose ONE*	IMPACT(S) *- can choose multiple impacts*	Potential causes/sources of an impact happening *- brief dot points*	Likelihood	Consequence	RISK	Existing Reduction/Control Measures - against the Aspect. *e.g. Policy, procedures, outside controls or organisations, monitoring and reporting systems…*	Likelihood-2	Consequence-2	RISK2
10	Antarctica	LDC Inland Station: - Establishment of drill site and inland station	Normal	Waste Management-Landfill	Landfill, Pollution of snow and ice	1. Waste and pollution impacts to the immediate environment through accidental release. 2. Waste materials being dispersed due to weather conditions.	Possible	Minor	Low	1. AAD Standard Operating Procedure Operations Manual - Volume 1 : Station and Field Operating Procedures 2. At LDC all station waste will be double-bagged and packed into empty sealed containers for return to Casey for treatment and/or incineration. 3. All inland station materials secured and stored in a manner that prevents windblown debris.	Unlikely	Minor	Low
11	Antarctica	LDC Inland Station: - Establishment of drill site and inland station	Normal	Physical disturbance-Human impact	Degradation of wilderness values	1. Establishment of temporary station in remote inland area and associated infrastructure and equipment	Almost certain	Minor	Medium	1. Inland station is temporary in nature and will be established over 5 seasons. On completion of the project, all buildings and infrastructure will be returned to Casey Station. 2. Number of people limited to 10-16 personnel on site each season. 3. Due to remote area, any surface impacts to ice sheet will be both minor and transitory. Snow surface will return on original condition within a few months due to snow accumulation processes. 4. Winterisation of the drilling camp will occur from 2023-24 to the end of the project, minimising disturbance to ice areas on an annual basis. 5. Traverse structures will return to Casey Station at the end of each drilling season.	Likely	Insignificant	Low
12	Antarctica	LDC Inland Station: - Establishment of drill site and inland station	Normal	Energy use-Emission of gases	Pollution of the air, Pollution of snow and ice	1. Use of non-renewable resources for station operation	Likely	Insignificant	Low	1. Inland station is temporary in nature and will be established over 5 seasons. On completion of the project, all buildings and infrastructure will be returned to Casey Station. 2. Number of people limited to 10-16 personnel on site each season. 3. Use of solar technologies for renewable energy sources and power generation is being explored as a supplement energy source.	Likely	Insignificant	Low
13	Antarctica	LDC Inland Station: - Establishment of temporary inland Ski Landing Area (SLA)	Normal	Physical disturbance-Landscape	Degradation of wilderness values	1. Annual disturbance to glacial ice at the SLA	Almost certain	Insignificant	Medium	1. All field aviation activities addressed under the Aviation IEE and associated Authorisation conditions. 2. Skiway landing area established in the first year using a Piston Bulley snow groomer. Subsequent years will require maintenance only. 3. Due to remote area, any surface impacts to ice sheet will be both minor and transitory. Snow surface will return on original condition within a few seasons due to snow accumulation processes.	Almost certain	Insignificant	Medium
14	Antarctica	LDC MYIC drilling	Normal	Hazardous Chemicals-Wastes	Degradation of wilderness values, Pollution of snow and ice	1. Use of drilling fluid, Estisol 140 (E-14), for operational activities, including introduction of drilling fluid into environment	Almost certain	Insignificant	Medium	1. At LDC a small amount of isopropanol will be required to clean the drill between runs (< 20L per season). Isopropanol is not environmentally hazardous and is 100% biodegradeable (https://echa.europa.eu/brief-profile/-/briefprofile/100.000.601). A small amount (ca. <60 L) of ethylene glycol may be introduced to the borehole, only in the case of an emergency, to unstick the drill. The ethylene glycol would remain in the hole. Ethylene glycol is readily biodegradeable according to OECD criteria (see e.g. https://www/echa.europa.eu/web/guest/registration-dossier/-/registered-dossier/15973/5/3/2). 2. Drilling fluid contained in the casing therefore presents minimal environmental risk. 3. Drilling fluid will remain for the duration of the project. On completion of the project, drilling fluid will be left in the hole to maintain scientific access to the ice sheet (without it the borehole will close). 4. The drilling fluid (ESTISOL 140) is a synthetic ester, specifically selected for its minimal environmental impact, it is not labelled as hazardous for the environment under the calculation procedure of the "General Classification guideline for preparations of the EU" (see e.g. Safety Data Sheet attached to IEE as Appendix 1).	Almost certain	Insignificant	Medium
15	Antarctica	LDC MYIC drilling	Normal	Hazardous Chemicals-Leak/spill	Degradation of wilderness values, Hazardous landfill/disposal, Pollution of snow and ice	1. Drilling fluid spill into ice 2. Contamination of the ice by leaving drilling fluid in casing 3. Contaminated melt water from ice chips and use of low temperature synthetic drilling fluid Estisol E-140	Possible	Insignificant	Low	1. Drilling fluid will be appropriately stored in sealed drums/tanks until use and managed to limit the possibilities of contamination to the environment. 2. Use of experienced and trained personnel in minimising drilling fluid loss, combined with knowledge of spill response procedures. 3. Drilling fluid will remain in the ice core casing for the duration of the project. Leaving the fluid in place allows the drill hole to remain viable to return to in the future for ice sheet measurements and monitoring of ice sheet processes. 4. Ice chips melted outside the drilling tent in a chip melting device. Meltwater with traces of E-140 disposed on site into the firn at a single fixed point. Trace quantities do not present an environmental risk in the ice sheet environment. 5. AAD incident reporting system.	Unlikely	Insignificant	Low
16	Antarctica	LDC MYIC drilling	Normal	Physical disturbance-Noise emission	Noise pollution	1. Noise pollution from drilling activities	Almost certain	Insignificant	Medium	1. There are no sensitive receptors (wildlife, stations or other field camps) in the proposed drilling site that would be impacted by noise from drilling activities. 2. Due to the remote location the impacts from noise are considered minimal. 3. Concordia Station is located ~35 km from the site and can be considered the biggest source of human impact in the area. 4. The European Beyond EPICA Oldest Ice Core (BE-OIC) inland station is 5.2 km to the north of the MYIC target drilling location and will be undertaking similar drilling activities. Both Concordia Station and BE-OIC activities are distanced enough as to not cause cumulative noise impacts.	Almost certain	Insignificant	Medium
									#N/A				#N/A
16 records displayed													

6.7 Environmental Monitoring and Management

Australia is strongly committed to the comprehensive protection of the Antarctic environment. The AAD is responsible for fulfilling that commitment, as well as mitigating and managing the environmental impacts of Australia's activities in the Southern Ocean and sub-Antarctic.

The AAD's Environmental Policy outlines a commitment to continual improvement in environmental performance and forms the foundation of the AAD's Environmental Management System (EMS). The EMS is a systematic framework for managing the AAD's interaction with the environment. The system considers the environmental; aspects, impacts, risks and opportunities associated with activities and strategic planning.

The overall objective of the EMS is to protect the unique environmental values of Antarctica and the Southern Ocean and, to ensure environmental monitoring and management are foremost in planning and operations within the organisation.

The objective of the environmental monitoring for the MYIC project will be to:

- Ensure ongoing compliance with the *Antarctic Treaty (Environment Protection) Act* 1980
- Ensure impacts are avoided or limited consistent with the environmental principles of the Madrid Protocol,
- Inform any changes needed to practices to comply with impact thresholds set by regulators,
- Ensure impacts are not in conflict with the broader community's expectations in relation to Antarctica's protection; and
- Inform the mitigation of any unforeseen but potentially significant impacts associated with operations and activities described in this IEE.

An environmental monitoring plan has been developed for the MYIC Project and is provided in Appendix 3.

Ongoing management of the main impacts and key environmental indicators identified in the IEE include but are not limited to:

- Fuel consumption and emissions
- Increase in noise and vibration
- Physical disturbance to the ice sheet, including the introduction of drilling fluid
- Waste, greywater and sewage management
- Biosecurity management and
- Incident reporting.

The AAD State of Environment database includes a range of indicators relevant to the MYIC project and station operations. These indicators are located in the Human Settlements Theme and includes indicators associated with fuel, electricity and water consumption; wastewater and solid waste management; and personnel numbers. This data will be updated annually at the end of the austral summer operations season.

6.7.1 Incident and Hazards Reporting

The AAD's environmental incident and hazard reporting system is a key component of the AAD's EMS and provides the capacity to monitor and track activities or incidents which either directly or indirectly have the potential (near misses and improvements) to impact the environment. This reporting system forms part of a monitoring framework that identifies, prioritises and responds to environmental impacts or risks in real-time. The integration of this reporting system into AAD quarterly and annual reporting provides analysis of incidents and trends to identify and monitor environmental impacts and response actions. AAD's environmental incident reporting system provides an evidence-based approach for the development and delivery of continual improvements to the AAD's EMS and Antarctic operations.

7 CONCLUSION

The Antarctic ice sheet contains the oldest ice on Earth—ice that holds unique records of changes in the Earth's climate system. The longest continuous ice core currently attained, EPICA Dome Concordia, reaches back to 800 thousand years (kyr) but it is almost certain that this can be extended to beyond a million years. The central objective of this project is to obtain a detailed and continuous record of climate and atmospheric composition, which extends through the period known as the mid-Pleistocene Transition (MPT). The MPT covers the interval from around 1.2 million years (Myr) to 800 thousand years (kyr) ago.

Planning and coordinating resources toward the recovery of such a record has been a major goal for the international ice-core science community for over a decade. In its White Paper on Oldest Ice [2020] the SCAR-endorsed International Partnerships in Ice Core Sciences (IPICS) calls on the community to prioritise recovery of "a replicated Antarctic ice core record extending at least 1.2 million and preferably 1.5 million years, into the past". The MYIC project forms the Australian Antarctic Program's response to this IPICS oldest ice challenge, and is a priority outcome of the Australian Antarctic Strategy and 20-year Action Plan and its 2022 update.

The Traverse, Inland Station and MYIC activities have been planned and designed to have minimum impact on the environment while enabling a successful Traverse and establishment of an Inland Station to gain scientific understanding, and increase capabilities to the Australian Antarctic Program. All procedures will conform to relevant AAD standards and operating procedures in environmental management, and will adhere to all conditions and permits issued under the ATEP Act.

The assessment of impacts included in Chapter 7 of this IEE has identified that the majority of impacts can and will be mitigated through methods and technologies already tested on AAD led ice core drilling activities and existing AAD procedures. These methods and deep-drilling technologies are also consistent with other international programs and application of best practise environmental management.

This IEE concludes that, provided the activity and the mitigations are undertaken in the manner described, this activity will have no more than a minor or transitory impact.

8 AUTHORS

This IEE was prepared by Dr Joel Pedro, Palaeoclimatologist for the Million Year Ice Core Project, Australian Antarctic Division (AAD) & Australian Antarctic Program Partnership (AAPP), Institute for Marine and Antarctic Studies (IMAS), University of Tasmania, Hobart, Tasmania. Additional support from Kirsten Leggett, Environmental Lead, Australian Antarctic Division (AAD), 203 Channel Highway, Kingston Tasmania, with technical input from the AAD science branch and subject matter experts across the AAD.

Mailing Address:
Australian Antarctic Division
GPO Box 858
Canberra City, ACT 2601
Australia

9 ACKNOWLEDGEMENTS

Expert contributions on MYIC traverse and field operations, and ice core drilling include the following AAD personnel; Dr Tas van Ommen, Tim Lyons and Dr Mark Curran.

Contributors to baseline environmental and impact assessment chapters include: Andy Sharman, Kirsten Leggett, Melissa Wrohan, Helen Achurch,

The authors Acknowledge assistance from Amanda Pepper in preparing the document.

10 ACRONYMS AND ABBREVIATIONS

AAD	Australian Antarctic Division
AAP	Australian Antarctic Program
AFFF	Aqueous Film-Forming Foam
ANARE	Australian National Antarctic Research Expedition
ASPA	Antarctic Specially Protected Area
ATEP	Antarctic Treaty (Environment Protection)
BE-OIC	Beyond EPICA Oldest Ice Core
CBC	Cargo and Biosecurity Centre
CCAMLR	Convention for the Conversation of Antarctic Marine Living Resources
CEMP	CCAMLR Ecosystem Monitoring Program
CMR	Crisis Management Response
DG	Dangerous Goods
EMS	Environmental Management System
GVM	Gross Vehicle Mass
GPS	Global Positioning System
IBC	Intermediate Bulk Container
IEE	Initial Environment Evaluation
IT	Information Technology
LDC	Little Dome C
MHE	Material Handling Equipment
OT&E	Operational Testing and Evaluation
SAB	Special Antarctic Blend
SOP	Standard Operating Procedure

11 REFERENCES

Berends, C. J., Köhler, P., Lourens, L. J., & van de Wal, R. S. W. On the cause of the mid-Pleistocene transition. Rev Geophys 59, e2020RG000727 (2021).

Fu, H-Z., & Ho, Y-S. Highly cited Antarctic articles using Science Citation Index Expanded: a bibliometric analysis, Scientometrics, 109:337–357 (2016).

IPICS white paper on oldest ice (2020). https://pastglobalchanges.org/sites/default/files/download/docs/working_groups/ipics/white-papers/ipics_oldaa_final.pdf, accessed February 2022.

Lilien, D. A., Steinhage, D., Taylor, D., Parrenin, F., Ritz, C., Mulvaney, R., Martín, C., Yan, J.-B., O'Neill, C., Frezzotti, M., Miller, H., Gogineni, P., Dahl-Jensen, D., and Eisen, O. Brief communication: New radar constraints support presence of ice older than 1.5 Myr at Little Dome C. The Cryosphere 15, 1881–1888 (2021).

Lisiecki, L. E. & Raymo, M. E. A Pliocene–Pleistocene stack of 57 globally distributed benthic $\delta^{18}O$ records. Paleoceanography 20, PA1003 (2005).

Parrenin, F., Cavitte, M. G. P., Blankenship, D. D., Chappellaz, J., Fischer, H., Gagliardini, O., Masson-Delmotte, V., Passalacqua, O., Ritz, C., Roberts, J., Siegert, M. J., Young, D. A. Is there 1.5-million-year-old ice near Dome C, Antarctica? The Cryosphere, 11, 2427-2437 (2017).

Petit, J. R. et al. Climate and atmospheric history of the past 420,000 years from the Vostok ice core, Antarctica. Nature 399, 429–-436 (1999).

Ruddiman, W. F., Raymo, M. E., Martinson, D. G., Clement, B. M., and Backman, J. Pleistocene evolution: Northern hemisphere ice sheets and North Atlantic Ocean, Paleoceanography 4, 353-412 (1989).

Sheldon, S., Popp, T., Hansen, S., & Steffensen, J. Promising new borehole liquids for ice-core drilling on the East Antarctic high plateau. *Annals of Glaciology, 55*(68), 260-270 (2014a). doi:10.3189/2014AoG68A043

Sheldon S.G., Hansen, S.B., Popp, T.J., Johnsen, S.J. The investigation and experience of using ESTISOL™ 240 and COASOL™ for ice-core drilling**.** *Annals of Glaciology*, 55, (68), 219-232, (2014b), https://doi.org/10.3189/2014AoG68A036

Steffen, W., Rockström, J., Richardson, K., Lenton, T.M., Folke, C., Liverman, D., Summerhayes, C. P., Barnosky, A. D., Cornell, S. E., Crucifix, M., Donges, J. F., Fetzer, I., Lade, S.J., Scheffer, M., Winkelmann, R. and Schellnhuber, H-.J. Trajectories of the Earth System in the Anthropocene, Proc. Natl. Acad. Sci. 115 (33), 8252-8259 (2018).

Talalay, P., Hu, Z., Xu, H., Yu, D., Han, L., Han, J., & Wang, L. Environmental considerations of low-temperature drilling fluids. *Annals of Glaciology, 55*(65), 31-40 (2014), doi:10.3189/2014AoG65A226.

Wolff, E., Fischer, H., Fundel, F. et al. Southern Ocean sea-ice extent, productivity and iron flux over the past eight glacial cycles. Nature 440, 491–496 (2006).

Yan, Y., Bender, M.L., Brook, E.J. et al. Two-million-year-old snapshots of atmospheric gases from Antarctic ice. Nature 574, 663–666 (2019).

Young, D. A., Roberts, J. L., Ritz, C., Frezzotti, M., Quartini, E., Cavitte, M. G. P., Tozer, C. R., Steinhage, D., Urbini, S., Corr, H. F. J., van Ommen, T. Blankenship, D. D. High-resolution boundary conditions of an old ice target near Dome C, Antarctica. The Cryosphere 11, 1897-1911 (2017).

12 APPENDIX 1 - SAFETY DATA SHEET ESTISOL-140

Esti Chem A/S (2019), ESTISOL 140 Safety Data Sheet (12.09.2019).

Safety data sheet
according to 1907/2006/EC, Article 31

Printing date 12.09.2019 *Revision: 12.09.2019*

SECTION 1: Identification of the substance/mixture and of the company/undertaking

· **1.1 Product identifier**

· **Trade name: ESTISOL 140**
· **1.2 Relevant identified uses of the substance or mixture and uses advised against**
No further relevant information available.
· **Application of the substance / the mixture** Solvents

· **1.3 Details of the supplier of the safety data sheet**
· **Manufacturer/Supplier:**
Esti Chem A/S
Erhvervsparken 16
DK - 4621 Gadstrup
Tel.: +45-56-65 33 72
Fax.:+45-56-65 33 75

· **Further information obtainable from:**
Product safety department
customerservice@estichem.com
· **1.4 Emergency telephone number:**
+45-56653372 - Office hours (Mo.-Fr. 8:00 - 16.00)
+45-40113372 - Outside office hours

SECTION 2: Hazards identification

· **2.1 Classification of the substance or mixture**
· **Classification according to Regulation (EC) No 1272/2008**
Skin Irrit. 2 H315 Causes skin irritation.

· **2.2 Label elements**
· **Labelling according to Regulation (EC) No 1272/2008**
The product is classified and labelled according to the CLP regulation.
· **Hazard pictograms**

GHS07

· **Signal word** Warning
· **Hazard statements**
H315 Causes skin irritation.
· **Precautionary statements**
P264 Wash thoroughly after handling.
P280 Wear protective gloves.
P302+P352 IF ON SKIN: Wash with plenty of water.
P321 Specific treatment (see on this label).
P332+P313 If skin irritation occurs: Get medical advice/attention.
P362+P364 Take off contaminated clothing and wash it before reuse.
· **2.3 Other hazards**
· **Results of PBT and vPvB assessment**
· **PBT:** Not applicable.
· **vPvB:** Not applicable.

SECTION 3: Composition/information on ingredients

· **3.2 Chemical characterisation: Mixtures**
· **Description:** Mixture of substances listed below with non hazardous additions.

(Contd. on page 2)

Safety data sheet
according to 1907/2006/EC, Article 31

Printing date 12.09.2019 Revision: 12.09.2019

Trade name: ESTISOL 140

(Contd. of page 1)

· **Dangerous components:**

CAS: 103-09-3 EINECS: 203-079-1 Reg.nr.: 01-2119483620-40-XXXX	2-ethylhexyl acetate	Skin Irrit. 2, H315	> 50%

· **Additional information:** For the wording of the listed hazard phrases refer to section 16.

SECTION 4: First aid measures

· **4.1 Description of first aid measures**
· **General information:** No special measures required.
· **After inhalation:** Supply fresh air; consult doctor in case of complaints.
· **After skin contact:** Immediately wash with water and soap and rinse thoroughly.
· **After eye contact:** Rinse opened eye for several minutes under running water.
· **After swallowing:** If symptoms persist consult doctor.
· **4.2 Most important symptoms and effects, both acute and delayed** No further relevant information available.
· **4.3 Indication of any immediate medical attention and special treatment needed**
No further relevant information available.

SECTION 5: Firefighting measures

· **5.1 Extinguishing media**
· **Suitable extinguishing agents:**
CO2, powder or water spray. Fight larger fires with water spray or alcohol resistant foam.
· **5.2 Special hazards arising from the substance or mixture** No further relevant information available.
· **5.3 Advice for firefighters**
· **Protective equipment:** Wear self-contained respiratory protective device.

SECTION 6: Accidental release measures

· **6.1 Personal precautions, protective equipment and emergency procedures** Wear protective clothing.
· **6.2 Environmental precautions:** Do not allow to enter sewers/ surface or ground water.
· **6.3 Methods and material for containment and cleaning up:**
Absorb with liquid-binding material (sand, diatomite, acid binders, universal binders, sawdust).
· **6.4 Reference to other sections** No dangerous substances are released.

SECTION 7: Handling and storage

· **7.1 Precautions for safe handling** No special measures required.
· **Information about fire - and explosion protection:** No special measures required.

· **7.2 Conditions for safe storage, including any incompatibilities**
· **Storage:**
· **Requirements to be met by storerooms and receptacles:** Provide solvent resistant, sealed floor.
· **Information about storage in one common storage facility:** Store away from foodstuffs.
· **Further information about storage conditions:** None.
· **Recommended storage temperature:** -10-40 °C
· **7.3 Specific end use(s)** No further relevant information available.

SECTION 8: Exposure controls/personal protection

· **Additional information about design of technical facilities:** No further data; see item 7.

(Contd. on page 3)

Safety data sheet
according to 1907/2006/EC, Article 31

Printing date 12.09.2019 Revision: 12.09.2019

Trade name: ESTISOL 140

(Contd. of page 2)

· **8.1 Control parameters**
· **Ingredients with limit values that require monitoring at the workplace:**
The product does not contain any relevant quantities of materials with critical values that have to be monitored at the workplace.
· **DNELs**
Workers - Hazard via inhalation route, local / systemic:
- long term exposure 71.8 mg /m³
- acute/short term exposure 143.6 mg/m³

Workers - Hazard via dermal route:
- long term exposure 55.11 mg/kg bw / day
· **Additional information:** The lists valid during the making were used as basis.

· **8.2 Exposure controls**
· **Personal protective equipment:**
· **General protective and hygienic measures:**
The usual precautionary measures are to be adhered to when handling chemicals.
· **Respiratory protection:** Not required.
· **Protection of hands:**
Only use chemical-protective gloves with CE-labelling of category III.
To minimise the wetness in the glove due to perspiration changing of gloves during a shift is required.
For the protection against chemicals in areas with heightened risk of injury (mechanical hazard) no recommendation for a suitable glove material can be given.
The glove material has to be impermeable and resistant to the product/ the substance/ the preparation.
Selection of the glove material on consideration of the penetration times, rates of diffusion and the degradation
· **Material of gloves** Nitrile rubber, NBR

· **Penetration time of glove material**
For the mixture of chemicals mentioned below the penetration time has to be at least > 120 minutes (Permeation according to EN 374 Part 3: Level 1).
The determined penetration times according to EN 374 part III are not performed under practical conditions. Therefore a maximum wearing time, which corresponds to 50% of the penetration time, is recommended.
Value for the permeation: Level ≤ 1
The exact break trough time has to be found out by the manufacturer of the protective gloves and has to be observed.
· **Eye protection:** Safety glasses

SECTION 9: Physical and chemical properties

· **9.1 Information on basic physical and chemical properties**	
· **General Information**	
· **Appearance:**	
Form:	Fluid
Colour:	Clear
· **Odour:**	Fruit-like
· **Odour threshold:**	0.2 ppm
· **Change in condition**	
Melting point/freezing point:	-93 °C
Initial boiling point and boiling range:	199 °C
· **Pour point**	Undetermined.
· **Flash point:**	75 °C
· **Ignition temperature:**	270 °C
· **Explosive properties:**	Product does not present an explosion hazard.

(Contd. on page 4)

Safety data sheet
according to 1907/2006/EC, Article 31

Printing date 12.09.2019 Revision: 12.09.2019

Trade name: ESTISOL 140

(Contd. of page 3)

· **Explosion limits:**	
Lower:	1.1 Vol %
Upper:	7.5 Vol %
· **Density at 20 °C:**	0.865 g/cm³
· **Solubility in / Miscibility with water:**	Not miscible
· **9.2 Other information**	No further relevant information available.

SECTION 10: Stability and reactivity

· **10.1 Reactivity** No further relevant information available.
· **10.2 Chemical stability**
· **Thermal decomposition / conditions to be avoided:** No decomposition if used according to specifications.
· **10.3 Possibility of hazardous reactions** No dangerous reactions known.
· **10.4 Conditions to avoid** No further relevant information available.
· **10.5 Incompatible materials:** No further relevant information available.
· **10.6 Hazardous decomposition products:** No dangerous decomposition products known.

SECTION 11: Toxicological information

· **11.1 Information on toxicological effects**
· **Acute toxicity** Based on available data, the classification criteria are not met.

· **LD/LC50 values relevant for classification:**		
Oral	LD50	3000 mg/kg (rat)

· **Primary irritant effect:**
· **Skin corrosion/irritation**
Causes skin irritation.
· **Serious eye damage/irritation** Based on available data, the classification criteria are not met.
· **Respiratory or skin sensitisation** Based on available data, the classification criteria are not met.
· **Acute effects (acute toxicity, irritation and corrosivity)**
Dermal (rabbit): OECD 404 (Acute Dermal Irritation / Corrosion Category 2 (Irritant)
· **CMR effects (carcinogenity, mutagenicity and toxicity for reproduction)**
· **Germ cell mutagenicity** Based on available data, the classification criteria are not met.
· **Carcinogenicity** Based on available data, the classification criteria are not met.
· **Reproductive toxicity** Based on available data, the classification criteria are not met.
· **STOT-single exposure** Based on available data, the classification criteria are not met.
· **STOT-repeated exposure** Based on available data, the classification criteria are not met.
· **Aspiration hazard** Based on available data, the classification criteria are not met.

SECTION 12: Ecological information

· **12.1 Toxicity**
· **Aquatic toxicity:** No further relevant information available.
· **12.2 Persistence and degradability** No further relevant information available.
· **12.3 Bioaccumulative potential** No further relevant information available.
· **12.4 Mobility in soil** No further relevant information available.
· **Additional ecological information:**
· **General notes:**
Water hazard class 1 (German Regulation) (Self-assessment): slightly hazardous for water
Do not allow undiluted product or large quantities of it to reach ground water, water course or sewage system.
· **12.5 Results of PBT and vPvB assessment**
· **PBT:** Not applicable.

(Contd. on page 5)

Safety data sheet
according to 1907/2006/EC, Article 31

Printing date 12.09.2019 Revision: 12.09.2019

Trade name: ESTISOL 140

(Contd. of page 4)

· ***vPvB:*** *Not applicable.*
· ***12.6 Other adverse effects*** *No further relevant information available.*

SECTION 13: Disposal considerations

· ***13.1 Waste treatment methods***
· ***Recommendation***
Must not be disposed together with household garbage. Do not allow product to reach sewage system.

· ***Uncleaned packaging:***
· ***Recommendation:*** *Disposal must be made according to official regulations.*

SECTION 14: Transport information

· ***14.1 UN-Number***	
· ***ADR, ADN, IMDG, IATA***	*Void*
· ***14.2 UN proper shipping name***	
· ***ADR, ADN, IMDG, IATA***	*Void*
· ***14.3 Transport hazard class(es)***	
· ***ADR, ADN, IMDG, IATA***	
· ***Class***	*Void*
· ***14.4 Packing group***	
· ***ADR, IMDG, IATA***	*Void*
· ***14.5 Environmental hazards:***	
· ***Marine pollutant:***	*No*
· ***14.6 Special precautions for user***	*Not applicable.*
· ***14.7 Transport in bulk according to Annex II of Marpol and the IBC Code***	*Not applicable.*
· ***UN "Model Regulation":***	*Void*

SECTION 15: Regulatory information

· ***15.1 Safety, health and environmental regulations/legislation specific for the substance or mixture***
· ***REGULATION (EC) No 1907/2006 ANNEX XVII*** *Conditions of restriction: 3*
· ***15.2 Chemical safety assessment:*** *A Chemical Safety Assessment has not been carried out.*

SECTION 16: Other information

This information is based on our present knowledge. However, this shall not constitute a guarantee for any specific product features and shall not establish a legally valid contractual relationship.

· ***Relevant phrases***
H315 Causes skin irritation.

· ***Department issuing SDS:*** *product safety department*
· ***Abbreviations and acronyms:***
ADR: Accord européen sur le transport des marchandises dangereuses par Route (European Agreement concerning the International Carriage of Dangerous Goods by Road)
IMDG: International Maritime Code for Dangerous Goods
IATA: International Air Transport Association
GHS: Globally Harmonised System of Classification and Labelling of Chemicals
EINECS: European Inventory of Existing Commercial Chemical Substances
ELINCS: European List of Notified Chemical Substances
CAS: Chemical Abstracts Service (division of the American Chemical Society)

(Contd. on page 6)

Safety data sheet
according to 1907/2006/EC, Article 31

Printing date 12.09.2019 *Revision: 12.09.2019*

Trade name: ESTISOL 140

(Contd. of page 5)

DNEL: Derived No-Effect Level (REACH)
LC50: Lethal concentration, 50 percent
LD50: Lethal dose, 50 percent
PBT: Persistent, Bioaccumulative and Toxic
vPvB: very Persistent and very Bioaccumulative
Skin Irrit. 2: Skin corrosion/irritation – Category 2

13 APPENDIX 2 - SUMMARY OF STANDARD OPERATING PROCEDURES

AAD Standard Operating Policy and Procedures
Standard Operating Procedure Operations Manual - Volume 1: Station and Field Operating Procedures - Volume 2: Emergency Response - Volume 9: Traverse Operations (currently under development)
Crisis Management and Recovery Manual
Hazardous Chemicals Management Policy and Procedures
Cargo and Biosecurity Standard Operating Procedures
AAD station and field waste management guide 2020–2024

14 APPENDIX 3 - MYIC, TRAVERSE AND INLAND STATION MONITORING PLAN

Australian Government

Department of Climate Change, Energy, the Environment and Water

Australian Antarctic Division

AUSTRALIAN ANTARCTIC PROGRAM

Million Year Ice Core, Traverse and Inland Station Environmental Monitoring Plan 2022-2028

Project Name and/or EPBC Number	Project 4632 **Million Year Ice Core, Traverse and Inland Station**
Project Location	Casey Station Traverse Staging Area to Little Dome C
Principal Contractor details	Australian Antarctic Division, Department of Agriculture, Water and the Environment 203 Channel Highway, Kingston Tasmania 7050 PH: 03 6232 3610
ABN/ACN	ABN: 34 190 894 983
Authorisation Number or Approved Action (EPBC)	TBA
Date of preparation	17 August 2022

Responsible Officer: Environmental Lead AAD eFile ref: D22/40785	**Authorising Officer:** Environmental Manager	**Authorisation Date: TBA** **Review Date:** August 2023
Issue	**Date**	**Status**
0.1 – 0.8	18/08/2022	Drafts – for internal Review

Contents

1 Introduction

A key objective of the Australian Antarctic Program (AAP) is to protect the unique environmental values of Antarctica and the Southern Ocean and to ensure that environmental monitoring and management are foremost in planning and operations within the organisation. The Australian Antarctic Division's (AAD) Environmental Policy outlines a commitment to continual improvement in environmental performance, and forms the foundation of the AAD's Environmental Management System (EMS) in compliance with the international standard ISO 14001. Environmental monitoring and reporting are key components of the EMS, serving to verify predicted environmental impacts of project activities, assess the efficacy of mitigation actions, and trigger management responses if thresholds are exceeded.

The AAD's environmental monitoring activities form part of an integrated monitoring system that collects, records and reports on performance data collected from a wide range of applications, networks and programs. Environmental monitoring activities undertaken by the AAD include data collection in relation to the main risks and key environmental indicators identified in the AAD Environmental Aspects and Impacts Register.

The Australian Antarctic Division (AAD) has prepared this monitoring plan to accompany the submission of the Initial Environmental Evaluation (IEE) for the Million Year Ice Core (MYIC) project's field operations commencing November 2022 and extending over the following 6 Antarctic summer field seasons to 2028. The project incorporates Traverse, the establishment of a temporary Inland Station and undertaking ice core drilling activities at Little Dome C.

1.1 Purpose and objectives

The purpose of this environmental monitoring plan is to outline the key environmental monitoring requirements identified through the environmental impact assessment process for the **Million Year Ice Core, Traverse and Inland Station**. It details the monitoring activities, methods, timing, data management, reporting and review requirements, and identifies the roles and responsibilities of project personnel to ensure that environmental outcomes are met.

The objectives of the monitoring plan are to:

- Ensure ongoing compliance with the *Antarctic Treaty (Environment Protection) Act* 1980
- Ensure impacts are avoided or limited, and are consistent with the environmental principles of the Madrid Protocol
- Evaluate the IEE's conclusion that the impacts of Traverse, establishment of an inland station and MYIC drilling activities are likely to remain minor and transitory
- Inform any changes required to practices or methodologies to comply with any impact thresholds described in the IEE
- Ensure that environmental impacts are not in conflict with the community's expectations in relation to Antarctica's protection, and

- That any unforeseen and potentially significant impacts associated with Traverse, the establishment of an inland station and MYIC drilling activities, as described in this IEE, are captured and utilised for the future management of similar activities within AAD.

A full breakdown of the environmental impact assessment and mitigation measures to reduce those impacts is provided in the Million Year Ice Core, Traverse and Inland Station IEE.

2 Project description

To deliver the MYIC Project, the AAD proposes drilling a ca. 2800 m deep ice core in the Little Dome C (LDC) region at 122.52059°E, 75.34132°S, in the Little Dome C region ca. 35 km SW of Concordia Station and 1100 km inland of Casey Station. This IEE describes the potential environmental impacts associated with the three major components of the activity:

i. Inland Traverse between Casey Station and LDC required to support project logistics.

ii. Installation of the MYIC Drilling Camp ('Inland Station') at LDC and occupation of the camp, from early December to early February only, for the duration of the project.

iii. Ice core drilling using the AAD deep drill system.

Inland Traverse and logistics support overview

The AAD's Traverse will depart the Casey Station Traverse staging area early in the austral summer for the MYIC drilling site, returning to Casey Station late in the season. At the completion of LDC field operations each season, the Inland Station will be winterised and the Traverse will depart the Little Dome C site. Traverse departure from LDC is expected in late January to February throughout the campaign, with the exact timing subject to environmental and logistical considerations, predominantly extreme negative temperature. Aviation assets will also support Traverse and the Inland station with a ski landing area to be established at the Inland Station and potentially an ancillary ski landing area along the Traverse route. All aviation activities for this project are addressed under the AAD's IEE for Aviation (2020-2024).

MYIC Inland Station overview

The MYIC drilling camp 'Inland Station' will be installed around the MYIC borehole coordinates at 122.52059°E, 75.34132°S. The site is 35 km SW of the permanent French-Italian station of Concordia (East Antarctica), on the remote East Antarctic ice sheet. It is not a sensitive environmental site and no vegetation or wildlife is present. The Inland Station is expected to be occupied by up to 26 personnel from November to February of each austral summer field season for the duration of the project. This includes 10 personnel on Traverse for some of the time and 16 personnel at the Inland Station. A maximum of 60 – 70 working days in the field is foreseen each season. The Inland Station will not be occupied outside the summer field season.

The Inland Station will consist of the necessary shelter and facilities to support the ice core drilling and ice core processing, along with the supporting shelter, kitchen and mess, workshops, amenities, power generation for the camp and an excavated ice core storage area. The Inland Station structures will remain on site for the duration of the project, with the exception of vehicles and mobile structures that will return with Traverse back to Casey Station at the end of each Field season.

The Inland Station structures are designed for minimal impact, with insulated vans mounted on sleds and removable Weatherhaven tents. All structures will be removed and the camp returned to initial conditions, with the exception of the proposed retention of the bore casing and fluid filled borehole and potential retention of an ice core archive in a firn cave on site at the completion of the project.

MYIC ice drilling overview

The MYIC deep drilling activity is planned from the 2022/23 to 2027/28 austral field seasons. The expected final drill depth is ca. 2800 m. Drill camp set up and pilot drilling is planned in 2022/23, followed by target depths of 400 m in 2023/2024, 1000 m in 2024/2025, 2000 m in 2025/26 and 2800 m in 2026/27. The 2027/28 field season is scheduled as a contingency ice drilling season, for sampling of basal material and for completion of borehole measurements and closure of the drilling camp.

Closure of the drilling camp is scheduled for 2027/28. With the exception of the proposed retention of the borehole casing, fluid-filled borehole and ice core archive, all other camp equipment and infrastructure will be removed from the site and trenches filled.

3 Monitoring plan scope

The MYIC, Traverse and Inland Station Monitoring Plan has been developed and is based on the risk and impacts identified through the IEE development process and covers all activities from the Casey Ski Landing Area (SLA), the Traverse to Little Dome C, ice core drilling activities, and the establishment of a temporary inland station. This plan identifies the key areas for environmental monitoring of the main impacts and environmental indicators identified in the IEE.

These include:

- Fuel consumption and emissions
- Noise and vibration and potential impacts to transient wildlife
- Physical disturbance to the ice sheet, including the introduction of drilling fluid
- Waste and greywater management
- Biosecurity management.

Any additional monitoring required as part of the activity's Notice of Determination and Authorisation conditions will be incorporated into the abovementioned environmental indicators.

The AAD Science Branch subject matter experts will review data collected under this Plan, as required. An annual review of data and evaluation of management measures will be undertaken with key stakeholders from Operations and Safety Branch, Science Branch, and Antarctic and Environmental Regulation (AER) to identify ongoing and additional monitoring, management and mitigation requirements.

Monitoring data collected under this Plan will be made publicly available via the Australian Antarctic Data Centre (AADC) and within one year of its collection.

4 Monitoring Approach

4.1 Roles and Responsibilities

The following personnel are responsible for implementing the **Million Year Ice Core, Traverse and Inland Station** *Monitoring Plan*:

- **All personnel (including subcontractors)** – responsible for reporting any environmental compliance issues to the MYIC Project Manager in Kingston, or the MYIC Science Lead.
- **MYIC Project Manager/Science Lead** – responsible for the coordination of any incident responses and logging of environmental inspection information. Responsible for ensuring that the delegated personnel are executing the required monitoring activities and reporting according to the requirements in this environmental monitoring plan.
- **MYIC Field Team** – responsible for implementing management measures and rectifying any compliance issues related to these activities.

4.2 Environmental Awareness and Training

All people involved with the **Million Year Ice Core, Traverse and Inland Station** will receive training to ensure full understanding of responsibilities when implementing the environmental monitoring plan. The training is in addition to the mandatory training and awareness presentations and are tailored to the role of the individual and their level of involvement in implementing the monitoring plan.

Specific training completed by project personnel include:

- Pre-departure briefings covering the IEE/EIA and authorisation/Works authority, and
- Training relevant to the collection of data including the deployment and use of any monitoring equipment required.

5 Related Monitoring, Reporting, and Supporting Studies

5.1 Incident management and reporting

The AAD's environmental incident and hazard reporting system is a key component of the AAD's EMS. The system provides the capacity to monitor and track activities or incidents which either directly or indirectly have the potential (near misses and improvements) to impact the environment. This reporting system forms part of a monitoring framework that identifies, prioritises and responds to environmental impacts or risks in real-time. The integration of this reporting system into AAD quarterly and annual reporting allows for the analysis of incidents and trends to identify and monitor environmental impacts and response actions. AAD's environmental incident reporting system provides an evidence-based approach for the development and delivery of continual improvements to the AAD's EMS and Antarctic operations.

5.2 Other monitoring and reporting

The AAD State of Environment database includes a range of indicators relevant to the MYIC project and station operations. These indicators are located in the Human Settlements Theme and includes indicators associated with fuel, electricity and water consumption; wastewater and solid waste

management; and personnel numbers. This data will be updated annually at the end of the austral summer operations season.

6 Implementation

6.1 Duration

The monitoring period covered by this plan is summarised below:

Year (austral season)	2022/23	2023/24	22024/25	2025/26	2026/27	2027/28
Traverse (T)	T1	T2 and T3	T4	T5	T6	TBA
LDC field activities	Inland Station start set up Pilot drilling Ice core processing and RTA Prep LDC ski-landing area for aviation	Install Inland Station Drilling up to ca. 400 m Ice core processing and RTA	Drilling to ca. 1200 m Ice core processing and RTA	Drilling to ca. 2000 m Ice core processing and RTA	Drilling to ca. 2800 m (bed) Ice core processing and RTA	Contingency season Completion of drilling Sampling of basal material Removal of Inland Station Science on bore hole
Days at LDC	60 – 70	60 – 70	60 – 70	60 – 70	60 – 70	TBA

7 Monitoring - Pollution

7.1 Impact summary

The potential predicted impacts from the **Million Year Ice Core, Traverse and Inland Station** include:

1. Pollution of the environment caused by
    a. inadvertent release of fuel, caused by tank puncture, fuel drum spill or rupture,
    b. accidental release/spill of drilling fluid or other hazardous chemical
2. Pollution and emission to the environment from diesel and engine exhaust
3. Pollution of the environment caused by intentional discharge of liquid human waste and grey water from Traverse and Inland Station activities
4. Pollution of the environment and degradation of wilderness values caused by
    a. Release of meltwater containing drilling fluid, and
    b. Drilling fluid presence in casing.

7.2 Monitoring plan 2022-2027

Objectives				
P-O-1	Monitor accidental release of contaminants from MYIC, Traverse and Inland Station activities e.g. fuel, hazardous chemicals			
P-O-2	Monitor compliance of Traverse vehicles, fuel storage, and equipment compliance maintenance schedules			
P-O-3	Monitor release of human liquid waste and greywater			
P-O-4	Monitor the use of drilling fluid in drilling operations			
Indicator		**Trigger**	**Management Response/s**	
P-I-1	Pollution events – fuel or contaminant loss/spill	Release of fuel or contaminant	• Investigate cause • Repair failure point • Review and update procedures, storage/transportation methods. • Implement required changes to procedure/process.	
P-I-2	Equipment servicing, maintenance and replacement schedule compliance	Servicing, maintenance and replacement intervals exceeded.	• Investigate cause • Review and update equipment maintenance and procurement processes.	
P-1-3	Discharge events – liquid human waste and greywater	Release of human liquid waste and greywater	• Document discharge location and upper limit on quantity.	
P-1-4	Volume of drilling fluid in the environment as a result of operations	N/A	N/A	
Method		**Location and Frequency**		
		Traverse (T1-T6)	**MYIC site and Inland Station**	**Casey SLA**
P-M-1	Fuel loss monitoring and fuel spills logged and tallied	Event	Event	Event
P-M-2	Plant/equipment operating hours and fuel consumption logged by Lead Diesel Mechanic.	Monthly	Monthly	Monthly
P-M-3	Liquid human waste and greywater discharge to firn pits accounted for (estimated upper limit).	Event	Event	N/A
P-M-4	Logged quantities of drilling fluid used	N/A	Weekly	N/A
Reporting				**Frequency**
P-R-1	Incident Report			Event
P-R-2	Plant/equipment records			Monthly
P-R-3 P-R-4	MYIC, Traverse and Inland Station IEE report of activities			Annually

8 Monitoring - Wildlife

8.1 Impact summary

The potential predicted impacts from the **Million Year Ice Core, Traverse and Inland Station** include:

1. Wildlife disturbance in Traverse areas closest to Casey Station where transient fauna may be encountered.

8.2 Monitoring plan 2022-2027

<table>
<tr><td colspan="5">Objectives</td></tr>
<tr><td>W-O-1</td><td colspan="4">Assess the number of detected wildlife behaviour changes in response to Traverse activities</td></tr>
<tr><td colspan="2">Indicator</td><td>Trigger</td><td colspan="2">Management Response/s</td></tr>
<tr><td>W-I-1</td><td>Wildlife behavioural changes</td><td>Wildlife visibly panicked or distressed</td><td colspan="2">• Reduce speed, alter course and/or temporarily ceasing activity</td></tr>
<tr><td colspan="2" rowspan="2">Method</td><td colspan="3">Location and Frequency</td></tr>
<tr><td>Traverse (T1-T6)</td><td>MYIC site and Inland Station</td><td>Casey SLA</td></tr>
<tr><td>W-M-1</td><td>Documentation of wildlife behaviour observations</td><td>Event</td><td>N/A</td><td>Event</td></tr>
<tr><td colspan="4">Reporting</td><td>Frequency</td></tr>
<tr><td>W-R-1</td><td colspan="3">Incident report</td><td>Event</td></tr>
</table>

9 Monitoring - Wilderness Value

9.1 Impact summary

The potential predicted impacts from the **Million Year Ice Core, Traverse and Inland Station** include:

1. Introduction of non-native species into the Antarctic environment through the movement of cargo, equipment, stores and personnel
2. Degradation of wilderness values through establishment of temporary station and Ski Landing Area, and through increased noise and vibration from vehicles, plant and equipment, and drilling activities.

The monitoring of impacts to wilderness values from increased noise and vibration, and the presence of a temporary station are not considered necessary due to the remote location and absence of sensitive receptors.

9.2 Monitoring plan 2022-2027

<table>
<tr><th colspan="5">Objectives</th></tr>
<tr><td>WV-O-1</td><td colspan="4">Ensure high levels of biosecurity are maintained for all Traverse activities</td></tr>
<tr><th colspan="2">Indicator</th><th>Trigger</th><th colspan="2">Management Response/s</th></tr>
<tr><td>WV-I-1</td><td>Non-native species or pathogen</td><td>Non-native species or pathogen detected</td><td colspan="2">Remove biosecurity risk and submit incident report.</td></tr>
<tr><th colspan="2" rowspan="2">Method</th><th colspan="3">Location and Frequency</th></tr>
<tr><th>Traverse (T1-T6)</th><th>MYIC site and Inland Station</th><th>Casey SLA</th></tr>
<tr><td>WV-M-1</td><td>Ex-HBA AAD Cargo Biosecurity procedures including inspections and incident reporting.</td><td>Event</td><td>Event</td><td>Event</td></tr>
<tr><th colspan="4">Reporting</th><th>Frequency</th></tr>
<tr><td>WV-R-1</td><td colspan="3">Incident reports</td><td>Event</td></tr>
</table>

10 Monitoring plan review

Review of the environmental monitoring plan will be undertaken:

- following significant environmental incidents
- when there is a need to improve performance in an area of environmental impact, identified through incident and annual reporting.