Rothera Modernisation - Phase 1 Initial Environmental Evaluation

BAS Antarctic Infrastructure Modernisation Programme

BAS Environment Office

September 2019

British Antarctic Survey

NATURAL ENVIRONMENT RESEARCH COUNCIL

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Introduction

This Initial Environmental Evaluation (IEE) has been prepared by the British Antarctic Survey (BAS) to assess the potential environmental impacts associated with the proposed Rothera Modernisation project. The proposed activities are part of the Natural Environment Research Council's (NERC) plans to modernise Rothera as the UK's gateway to Antarctica and to support the new polar research vessel, the Royal Research Ship Sir David Attenborough (SDA) currently being built and funded by the UK Government department Business, Energy and Industrial Strategy (BEIS).

The Rothera Modernisation Project will be realised over three phases. This IEE covers Phase 1, the scope of Phases 2 and 3 are yet to be defined and funded.

The scope of works under this phase includes the following activities:

- construction of the new Operations Building (involving extracting 15,258m^3 of rock fill) ;
- replacement of the site wide services;
- construction of an interim waste management facility; and
- demolition and decommissioning of Old Bransfield House, Fuchs, Vehicles Garage, Generator Shed, Bingham's, Carpenters workshop and the Miracle Span.

In order to facilitate the above scope of works, other support activities will have to take place, prior to and alongside the Phase 1 construction.

The scope of these works include:

- relocation of the Medium Frequency radar masts;
- replacement of the Bentham container; and
- repair of the aircraft hangar roof.

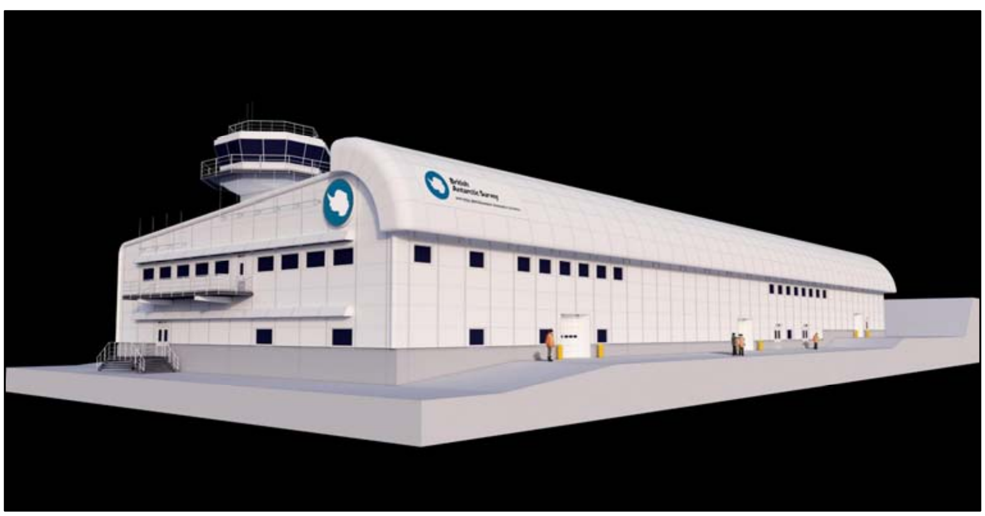

Fig 1. External view of proposed new Operations Building.

Scope of preferred option

The new Operations Building and site wide services will be designed for a peak station capacity of 136 people.

Architectural layout
The internal architectural layouts of the building have been developed in collaboration with BAS end users. Shared workspaces and a central store have been incorporated into the design to allow collaborative working, maximise station flexibility and to enable efficient stock control and cargo handling. Primary entrances on the North facade will benefit from natural snow scour and provide ease of access to the Operations Building from other key buildings namely Admirals House and New Bransfield House. Recreational and work spaces have been designed together within the building to enhance liveability on station.

Structural design
The Operations Building primary structure is a steel frame. This allows flexibility to reconfigure the internal layout of the building in the future if required. A precast concrete slab will be incorporated into the central store, waste management, vehicles garage and plant room areas to accommodate internal vehicle access and racking.

Mechanical and electrical services
Mechanical and electrical services strategies have been developed to be energy efficient and that consider future maintenance requirements and adaptation. Waste heat created by the electricity generation process will be recovered and fed into a district heating network. 140m^2 of photovoltaic panels are proposed to be installed to the northern façade of the building and four 225KvA generators are to be provided each with an output of 160kW. The specific mix of generator sizes are being considered in the current energy modelling exercise.

Fire strategy
The BAS Fire Strategy includes provision that building infrastructure in the Antarctic should be designed to meet or exceed the functional requirements of the UK building regulations to ensure that occupants are not exposed to an unacceptable level of risk and that sufficient measures are provided in the design to ensure life safety. Additionally, there is a BAS requirement to support operational continuity with a protect asset fire policy. The basis for the BAS Fire Strategy is guidance BS9999:2017

Acoustic strategy
An acoustic strategy has been developed which provides recommendations of suitable acoustic criteria to manage the airborne and impact noise transfer within the building as well as achieving appropriate room acoustics

The design life of the new Operations Building is intended to be 60 years with 25 years to the first major maintenance.

Alternatives

The findings of a condition survey in 2016 meant that the "Do Nothing" option is not viable in regard to the building and services infrastructure which were found to be operating beyond the design life or were in need of major repair. The 'do minimum' option was considered but discounted because the station would require a significant programme of repair and refurbishments to return the station infrastructure to an acceptable standard. During the options study both the one building and two building option were considered in detail.

The one building option had significant advantages over the two-building option as outlined below;
- 15% reduction in overall building footprint between one building and two building.
- The opportunity to complete in summer 2023 rather than summer 2024.
- The project will likely achieve MGO savings in the region of 20-25% (compared to a 2015 baseline).
- 33% reduction in labour costs and 15% reduction in material costs.

- 20% reduction in façade length to snow clear.
- No requirement to demolish existing Giants House accommodation building before construction could begin.
- Reduced maintenance activities associated with one-building in contrast to a two-building option.

Description of the Environment

Rothera Research Station has been used operationally on a continuous basis since 1975. The station was initially planned and constructed in phases, after which other infrastructure was added as operational requirements changed. The works proposed in this IEE are within the current operational footprint and previously developed areas of the site.

Levels of biodiversity at Rothera Point are not high compared to other equivalent areas in Antarctica. However, it does contain some examples of Antarctic fellfield environment, which is reasonably rare in the wider area. This is typically a dry, cold terrestrial habitat prone to rapid freezing and thawing, that experiences seasonal snow cover and long hours of daylight in summer and to which organisms have adapted in order to survive the extreme conditions. South polar skuas are the most abundant breeding birds at Rothera with occasional pairs of kelp gulls nesting and one Wilson's storm petrel nest has been found. Adélie Penguins are regular visitors but do not breed at Rothera. Although no seals breed at Rothera, Weddell and leopard seals are present all year round. Crabeater, elephant and fur seals are also present during the summer months. Minke, humpback and killer whales are seen in Ryder Bay each summer.

Antarctic Specially Protected Area (ASPA) 129 is located on the northern end of Rothera Point, which was designated to protect scientific values, and to serve as a control site, against which the effects of human impact associated with the adjacent Rothera Research Station could be monitored in an Antarctic fellfield ecosystem. No non-native plants or invertebrates are known to be present at Rothera Point or in the adjacent marine environment.

The key environmental receptors which are most likely to be impacted by the Rothera Modernisation project are as follows:

- Terrestrial flora – moss bank adjacent to the Miracle Span
- Terrestrial fauna – Nesting skuas on Rothera point
- Native terrestrial fauna and flora – which may be impacted by biosecurity incursions
- Local glaciology – the ice ramp
- Cultural heritage – artefacts identified within buildings due to be demolished

Description of Support Activities

Support activities to enable the delivery of the Rothera Modernisation Phase 1 works include:

- relocation of the MF radar
- replacement of the Bentham container
- repair of the hangar roof
- installation of CCTV
- shipping cargo and personnel
- provision accommodation & support services

Relocation of various BAS science assets will be required to accommodate the construction works. These tasks will be undertaken by the Rothera Facilities team. Additionally the Phase 1 project is also funding the repair of the hangar roof.

The anticipated volume of cargo required for the construction works and the demobilisation of construction plant and equipment, will require the use of a commercial charter vessel during the first, second and fourth season of construction. Construction personnel will be deployed to Rothera using existing BAS logistics. All personnel will be housed in either the existing permanent or temporary accommodation at Rothera.

Power generation for all construction activities will be provided independently to normal BAS operations. Other site services such as water, power and sewerage required for domestic use by construction staff will be provided by existing BAS services.

Impact Identification & Mitigation

A full assessment of the potential environmental impacts are included in this IEE. Most of the impacts can be managed within existing BAS procedures or with the addition of specific mitigation and monitoring.

The most significant potential impacts predicted for the construction activities, drilling and blasting and associated supporting activities are:

- Introduction of non-native species
- Dust deposition on the ice ramp
- Physical presence and disturbance impacting science and operations
- Terrestrial pollution from fuel spills
- Aesthetic changes to Rothera Station

The introduction of non-native species as a result of importing cargo or the deployment of personnel could have a significant impact in the longer term, but these impacts are less likely if standard operational procedures and enhanced mitigation measures are followed.

Impacts associated with the generation of dust could be significantly reduced with the implementation of robust mitigation measures which are managed throughout the construction period.

The likelihood of impacts occurring that are associated with the physical presence and physical disturbance created by the construction works is high. The mitigation measures which are already being developed to reduce these impacts will rely on the close working relationship between BAS and the contractor. Integrated and collaborative working be essential to avoid significant impacts.

The probability of impacts associated with fuel spills occurring will also be reduced if standard operating procedures are complied with during refuelling. In the unlikely event of a spill, oil spill contingency plans are in place and will be followed to minimise the severity of impacts.

The removal of rock to create an appropriate area in which to construct the new Operations Building combined with the size and extent of the new building will potentially alter the aesthetic value of

Rothera. Cut and fill studies have been undertaken and are ongoing to ensure that the minimum amount of rock is removed.

The most significant potential impacts predicted for the operation of the new building post construction are:

- Atmospheric emissions
- Physical presence and use of space
- Visual and aesthetic change

Once of the key design criteria is to reduce the fuel usage on station and ultimately reduce the impacts associated with atmospheric emissions, not only in Phase 1 but also in future phases of the Rothera Modernisation programme.

The size of the new building has been rationalised against the existing estate in order to provide infrastructure which minimises energy use and maintenance requirements.

The new building will be constructed within in the confines of the existing station footprint which is not considered pristine wilderness. However the wider context of near pristine Antarctic scenery of outstanding wilderness and aesthetic value surrounding Rothera should not be ignored.

Monitoring & Audit Requirements

A monitoring plan has been produced which defines the monitoring activities to be undertaken during the project. The monitoring tasks are split into three types of activities;

1. Short term monitoring of activities which could result in an immediate impact on the environment and can be modified during the construction programme to avoid adverse effects. This will include monitoring of the following activities:

    - Neutralisation of cement contaminated water
    - Wildlife displacement
    - Noise from drilling and blasting and construction activities
    - Vibration from drilling and blasting and construction activities
    - Airborne dust

2. Monitoring of environmental parameters which may reflect impacts that can only be measured in the long term (i.e. over several Antarctic seasons) and subsequently are unlikely to be modified beyond the original mitigation identified in the EIA. This will include monitoring of Skua breeding success on Rothera Point.

3. Standard BAS environmental management activities undertaken on a day to day basis by the construction partner and the data or findings reported to the BAS Environment Office.

Gaps in Knowledge and Uncertainties

- Further discussions will be undertaken with BAS Operations to finalise and agree the site laydown areas once the full site logistics of both the Rothera Wharf and the Rothera Modernisation are fully committed and developed prior to the start of the 2019-2020 season.
- The percentage reduction in MGO consumption is to be refined with further input into an energy savings workflow (ESW) model of the anticipated energy demand from the new operations building to undertaken at the next design stage.

- Ongoing studies to inform the actual amount of cut and fill required are being undertaken to finalise the volumes that will be needed to accommodate the new Operations Building.
- The future phases of the Rothera Modernisation project which are anticipated to be undertaken over the next 5-10 years are yet to be defined and funded. EIAs will be prepared as appropriate taking into account the cumulative effects of this proposed project, the Rothera Wharf and any other known future developments.

Conclusion

Having prepared this IEE along with rigorous mitigation measures to reduce the risk of the predicted impacts occurring, it is considered that the proposed activities will have no more than a minor or transitory impact.

Authors of the CEE

This CEE has been prepared by Clare Fothergill of the BAS Environment Office. The baseline section was written by Kevin A. Hughes with input from a number of expert contributors listed in the acknowledgements section. Construction specific mitigation measures, biosecurity procedures, spill response and waste management procedures were written in conjunction with Neil Goulding of BAM.

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1 INTRODUCTION

1.1 Background to AIMP

This Initial Environmental Evaluation (IEE) has been prepared by the British Antarctic Survey (BAS) to assess the potential environmental impacts associated with the proposed Rothera Modernisation project. The proposed activities are part of the Natural Environment Research Council's (NERC) plans to modernise Rothera as the UK's gateway to Antarctica and to support the new polar research vessel, the Royal Research Ship Sir David Attenborough (SDA) currently being built and funded by the UK Government department Business, Energy and Industrial Strategy (BEIS).

Over the next ten years the combined Antarctic Infrastructure Modernisation Programme (AIMP) represent the largest UK Government investment in polar science since the 1980s and will enable BAS to continue to deliver world leading science capability in the Polar Regions. Rothera Modernisation Phase 1 is the second AIMP project on site; the Rothera Wharf project having commenced in 2018 and due for completion in 2020. BAS have appointed the engineering consultancy Ramboll as the Technical Advisors for the project and BAM have been contracted as the Construction Partner, who in turn are partnered with design consultants Sweco UK.

1.2 Overview of proposed development

In 2017 a master planning exercise was completed for the whole of Rothera Station. The outcome of the study was captured in the *Rothera Modernisation Project Master Planning Report* produced by Ramboll. The report set out the potential future development strategy for Rothera Station which identified three different phases of works.

This EIA covers Phase 1 of the Rothera Masterplan. The scope of works includes the following activities:

- construction of the new Operations Building (involving extracting 15,258m^3 of rock fill) ;
- replacement of the site wide services;
- construction of an interim waste management facility; and
- demolition and decommissioning of Old Bransfield House, Fuchs, Vehicles Garage, Generator Shed, Binghams, Carpenters workshop and the Miracle Span.

Further works required to achieve the overall Rothera Masterplan project vision will be captured in future phases of the AIMP and once these are funded and designed will be presented in future EIA documents.

In order to facilitate the above scope of works, other support activities will have to take place, prior to and alongside the Phase 1 construction.

The scope of these works include:

- relocation of the Medium Frequency radar masts;
- replacement of the Bentham container; and
- repair of the aircraft hangar roof.

Refurbishment of Admirals House which was conducted in the 2017-2018 season was also included in Phase 1 works.

1.3 Purpose and scope of document

This IEE has been prepared in accordance with the requirements of Article 3 of Annex I to the Environmental Protocol to provide sufficient information on the Rothera Modernisation Phase 1 project, for an informed judgement to be made on the possible environmental impact of these activities on the Antarctic environment and whether or not they should proceed. The scope of this document covers the works associated with the Rothera Modernisation Phase 1 works only. Other development works which may be undertaken at Rothera in the future but have yet to be fully scoped, designed or funded are not included in this assessment. Such future initiatives have however been outlined in Chapter 14: Gaps in Knowledge and Uncertainties. The document has been split into the following chapters;

- Chapter 1 provides an **introduction** to the proposed project
- Chapter 2 provides the **approach to the environmental impact assessment**
- Chapter 3 describe the **proposed development** including the need, scope, location, alternatives considered and design plans.
- Chapter 4 outlines the **construction methodologies**
- Chapter 5 describes the **support activities** required to facilitate the project
- Chapter 6 outlines the **standard operational procedures** that will be followed
- Chapter 7 outlines the overall **construction programme and works schedules**
- Chapter 8 provides a **description of the current site and existing operations**
- Chapter 9 outlines the current **baseline environmental conditions**
- Chapter 10 presents the **assessment of the environmental impacts** and proposed **mitigation**
- Chapter 11 presents the proposed **monitoring and audit programme**
- Chapter 12 provides information on any known **gaps in knowledge or uncertainties**
- Chapter 13 sets out the **conclusions** of the assessment
- Chapter 14 provides contact details for the **authors** of the document
- Chapter 15 **acknowledges the contributors** to the document
- Chapter 16 provides the **references**
- Chapter 17 provides the **bibliography**
- Chapter 18 provides the **appendices**

A non-technical summary has been included at the beginning of the document to provide an overview of the IEE in a clear, concise and non-technical manner as well as outlining the conclusions achieved.

2 APPROACH TO ENVIRONMENTAL IMPACT ASSESSMENT

2.1 Statutory requirements

To ensure the protection of the Antarctic environment, the Antarctic Treaty nations adopted the Protocol on Environmental Protection to the Antarctic Treaty in 1991 (hereafter referred to as the Environmental Protocol). The UK enforces the provisions of the Environmental Protocol through the 'Antarctic Act 1994 and Antarctic Act 2013' and 'Antarctic Regulations 1995/490 (as amended).

Article 8 to the Environmental Protocol requires that any activities in the Antarctica Treaty area shall be subject to an assessment, in accordance with the procedures set out in Annex I to the Environmental Protocol, Environmental Impact Assessment (EIA).

One of the guiding principles is that an EIA be carried out before any activity is allowed to proceed. Activities should be planned and conducted on the basis of *'information sufficient to allow prior assessments of, and informed judgements about, their possible impacts on the Antarctic environment'* (Article 3, Environmental Protocol).

Annex I to the Environmental Protocol sets out the detailed requirements for EIA in Antarctica, and establishes a three-stage procedure based on different levels of predicted impact.

The assessment levels are:

- Preliminary Stage;
- Initial Environmental Evaluation (IEE); and
- Comprehensive Environmental Evaluation (CEE).

If an activity is determined as having less than *a minor or transitory* impact, the activity may proceed. An IEE must be prepared if it is determined that an activity will have an impact equal to or no more than *minor or transitory*. A CEE is for activities that are likely to have more than a *minor or transitory* impact on the Antarctic environment.

Following the EIA process as outlined in Annex I and in agreement with the UK Foreign and Commonwealth Office, BAS concluded that an IEE is the appropriate level of assessment for the Rothera Modernisation Phase 1 works.

It is acknowledged that EIA best practice is to take a holistic approach for multiple developments. However the AIMP spans a number of infrastructure development projects which are intended to be funded and constructed over a period of 7-10 years and for which design details are not yet available. The first of these was the Rothera Wharf Reconstruction and Coastal Stabilisation which commenced in 2018 and is still under construction at the time of writing. A CEE was produced and approved for that project. Cumulative impacts of the Rothera Wharf have been addressed where possible within this assessment. The activities in this assessment will also be assessed cumulatively in any future EIA submission for the overarching AIMP at Rothera.

This IEE is publicly available on the BAS website and Antarctic Treaty Secretariat EIA database.

2.2 EIA methodology

The approach taken when compiling this EIA followed the Environmental Impact Assessment Guidelines (ATS, 2016) prepared by the Committee for Environmental Protection (CEP). The guidelines provide advice and recommendations on appropriate document structure as well as methodologies for identifying and evaluating impacts. These suggestions have been followed wherever possible.

Other previously published CEEs and IEEs have been used as sources of information on the potential environmental impacts of activities within Antarctica, including how these have been assessed and how mitigation measures have been identified.

The scope and nature of the activities and a description of the principal characteristics of the Rothera Modernisation works have been provided in an attempt to define the project (Chapters 3-5). Design and construction details have been provided by the Construction Partner BAM and the Technical Advisor, Ramboll.

Baseline information on the current environmental state at Rothera has been included in order to evaluate the predicted impacts effectively. This information was largely sourced from scientific experts within BAS.

The environmental impact assessment process has followed a four step process involving:

- Identifying the **proposed activities** of the project;
- identifying the **environmental aspects** – i.e. the way in which any of the proposed activities interact with the environment such as atmospheric emissions, dust, noise, fuel spills, introduced non-native species etc.;
- identifying the **environmental impact** – i.e. the change in environmental value or resource as a result of the activity; and
- assessing the **significance of the identified impact**– i.e. considering the spatial extent, duration, probability of occurrence and severity of the potential impact on the environment with reference to the three levels of significance identified by Article 8(1) of the Protocol (i.e. less than, no more than or more than a minor or transitory impact.

A more detailed explanation of the methodology used is outlined in Chapter 10 - Assessment of the Environmental Impacts.

Chapter 10 presents the impacts that are identified and measures to mitigate or to prevent them from occurring. As suggested by the CEP's EIA guidelines, and successfully used in previous EIAs, a matrix format has been used to evaluate the significance of the identified impacts. Direct, indirect, cumulative and unavoidable impacts have been examined and are ranked according to their extent, duration, probability and significance. A risk rating has been applied to each impact before and after mitigation.

The impacts have been predicted on the basis of professional opinion and experience of individual BAS scientists and the BAS Environment Office. BAM have provided the terrestrial noise assessment.

A monitoring and audit plan has been developed to ensure that early warning of adverse effects can be identified quickly and modifications of activities can be made should they be necessary.

An overarching conclusion of the EIA process has been presented in Chapter 13.

2.3 BREEAM

The Building Research Establishment Environmental Assessment Method (BREEAM) is a method of assessing, rating, and certifying the sustainability of buildings and infrastructure projects.

Assessment is undertaken by third party certification of an asset's environmental, social and economic sustainability performance, using standards developed by the Building Research Establishment (BRE). BAS have worked with BRE to create appropriate criteria for all the new buildings associated with AIMP. The criteria include the following topics: management; energy; health & wellbeing; water; materials; waste; land use & ecology; pollution and innovation.

The aim of BREEAM rated projects is to achieve more sustainable infrastructure that enhance the well-being of the people who live and work in them and help to protect natural resources. "The main output from a certified BREEAM assessment is the rating. A certified rating reflects the performance achieved by a project and its stakeholders, as measured against the standard and its benchmarks." (BREEAM online)

The BREEAM ratings range as follows:

- Acceptable
- Pass
- Good
- Very Good
- Excellent
- Outstanding

A BREEAM pre-assessment has been completed for the new Rothera Operations Building. A target of 'Excellent' has been set and evidence is currently being collated to help achieve this.

2.4 Sustainability Plan

The BAS Sustainability Strategy for the AIMP has been developed to ensure that BAS infrastructure is designed, constructed and operated in accordance with best international sustainability practice.

The AIMP Sustainability Steering Group is responsible for setting sustainability targets and monitoring KPIs, maintaining the strategy through regular updates, and benchmarking progress to ensure the AIMP remains at the forefront of sustainable development.

An overarching strategy for all projects in the AIMP has been agreed and is included in Figure 2.1.

The Sustainability Strategy outlines 8 aims with associated objectives. Covering key sustainability themes, the Strategy has been developed through consideration of international best practice as well as the sustainability ambitions and requirements of the AIMP.

The AIMP includes projects that have committed to schemes with sustainability requirements such as CEEQUAL, BREEAM and the UK Government's Soft Landings Framework. As these schemes are largely evidence based, the Strategy has been developed to provide clear guidance for teams to demonstrate the sustainability of their projects. From an international perspective, the UN's Sustainable Development Goals (SDGs) are recognised as a transparent and global definition of sustainability and have been reflected in the formation of this Strategy.

A project specific Sustainability Management Plan is being developed for Rothera Modernisation. An update on the progress of activities against the plan will be provided annually.

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Figure 2-1 AIMP Sustainability Strategy aims and objectives

Aims		Objectives		
		A	**B**	**C**
1	**Create and maintain healthy working areas**	Maximise liveability, e.g. thermal comfort, air quality and natural daylight through best use of design standards	Consider the principles behind WELL design standard for all occupied buildings	Develop, maintain and monitor a good health and wellbeing programme
2	**Maintain an efficient and sustainable water and wastewater regime**	Ensure water conservation and recycling principles are incorporated into design proposals	Review wastewater (treatment) regime and consider alternative, more sustainable solutions	All operations will be planned to minimise water consumption
3	**Create an efficient, reliable and sustainable Antarctic energy network**	Minimise energy demand through best practice design	Minimise fossil fuel use through low-carbon / renewable energy design	Minimise energy-related carbon emissions across all AIMP projects
4	**Ensure resilient facilities through sustainable and appropriately innovative design**	Encourage innovation throughout the design and procurement process	Challenge designs by targeting ambitious CEEQUAL and BREEAM sustainability ratings	All work to adhere to BAS Resilience Strategy
5	**Develop and maintain inclusive, safe, resilient and sustainable BAS Antarctic communities**	Maximise inclusive, community-centric building design to encourage collaboration	Maintain and regularly monitor the performance of project infrastructure to ensure that it continues to meet the needs of the Antarctic community	Sustainability Strategy to be referenced within the AIMP H&S Policy
6	**Ensure responsible sourcing and efficient use of all resources through sustainable design and procurement**	Ensure sustainable sourcing of all materials and services throughout the supply chain, to be recorded within a Sustainable Procurement Statement for each project	Ensure waste minimisation through the integration of circular economy principles within the on-site community	Ensure sustainable use of materials and facilities throughout BAS, considering circular economy models for key resources
7	**Prioritise action to combat climate change and its impacts**	Establish whole life GHG emissions reduction targets for all projects, including the application of PAS 2080 (Carbon Management in Infrastructure)	Design and deliver facilities that are resilient and adaptable to the impacts of climate change	Establish low-carbon leadership at Board level and through project-specific Carbon Management Plans
8	**Interact sustainably with the Antarctic environment**	Project designs shall demonstrate that construction & operation of facilities will have no lasting negative impact on life below water, life on land, or the natural environment	Provide environmental and biosecurity training for all site operatives	Uphold the highest standard of biosecurity for all that enters or re-enters the Antarctic environment through project-specific Biosecurity Plans

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3 DESCRIPTION OF PROPOSED DEVELOPMENT

3.1 Purpose and need

The Rothera Modernisation project encompasses significant investment to modernise and restore the Rothera infrastructure so that it remains cost effective and safe. Many of the existing buildings have reached or are fast approaching the end of their economic life driving up maintenance costs and reducing organisational resilience. The objective is to reduce operating costs at Rothera, whilst maintaining the current level of Antarctic presence, through:

- Replacing aged buildings with modern, more flexible spaces to minimise future maintenance and operating costs and significantly improve the energy efficiency.
- Consolidate and rationalise the existing estate to provide infrastructure which minimises energy use and reduces the costs of snow clearance and maintenance of services.

The vision, critical success factors and project benefits are as follows:

The vision for Rothera is to provide a:

- centre of excellence for polar science for all UK scientists;
- outstanding operational delivery;
- integrated logistic hub that allows access to the rest of the continent;
- network-enabled station for multi-disciplinary science;
- station of choice for international collaboration;
- showcase for UK science and technology; and a
- test bed for cutting-edge innovation for extreme environments.

The critical success factors are to:

- provide sustainable infrastructure at Rothera to enable scientists to achieve excellence in science through safe and effective operations;
- provide infrastructure which will be fit for the new operational model of one research vessel and the transformation logistics supply management tool IBM Maximo;
- provide best value for money for the UK Government and maximise return on investment; and
- minimise the environmental impact of Rothera Research Station.

Project Benefits

- supports cohesive science delivery and operations;
- improves station resilience;
- improves flexibility of infrastructure for Rothera science delivery and operations
- reduces operational cost;
- reduces fuel consumption;
- reduces manual handling;
- reduces need for snow management; and
- improves staff welfare & quality of life

Rothera Station was established in 1976 and has evolved in a relatively piecemeal manner over the intervening years. It comprises of some twenty four principal buildings, which range in age from over 30 years to less than 10 years old. The nature and condition of the station's supporting infrastructure also varies significantly.

The Rothera Modernisation Masterplan, dated February 2018 concluded that a programme of works were required at Rothera to replace aged buildings with modern flexible working and living spaces, providing infrastructure that that reduces; energy consumption, operational cost and maintenance activities. New buildings for BAS Estates, Vehicles, Science and Operations, as well as new site wide services, were selected from the masterplan as the priorities in Phase 1. The decision was based on existing buildings and services on the station approaching the end or exceeding their acceptable design life.

The science and operations functions for Rothera Station are currently undertaken from a number of disparate buildings spread across the site. The majority of these buildings are life expired and do not provide the necessary functionality for what is required of them not only now but also for the future. The range of facilities and their uses include but are not restricted to:

- storage areas including: bio-security and unpacking areas, cargo handling, food storage (dry, fresh and frozen), bond store, general storage, personal stores;
- waste handling;
- a medical facility;
- station operations including: offices, control room, communications facility, stores and server room;
- laboratory and science research areas;
- trade workshops, including vehicle maintenance;
- power generation;
- potable water generation;
- field operations; and
- vehicle garaging;
- welfare facilities including: gymnasium, fitness studio, arts and craft room, music room and library/quiet area

Many of these functions are undertaken in buildings which were not specifically designed for their current use and, as a consequence, there are concerns in regard to compliance with statutory requirements, in particular in respect to meeting health, safety and environmental standards.

The project proposes to consolidate these functions into one new Operations Building which can meet the long term needs for Rothera Station and in doing so improve operational efficiency, reduce energy consumption, improve the working environment (including health and safety) and address environmental protection.

3.2 Location

Rothera Research Station is located on the south easterly shore of Adelaide Island on the Antarctic Peninsula Lat. 67°35'8"S, Long. 68°7'59"W. Adelaide Island is 140 km long, mountainous and heavily glaciated, with its highest peak at 2,565 metres.

The Station is mainly situated over an area of raised beaches which form a topographic "saddle" between Rothera Point, a large rock promontory to the East, and Reptile Ridge, a jagged outcrop of rock, to the West.

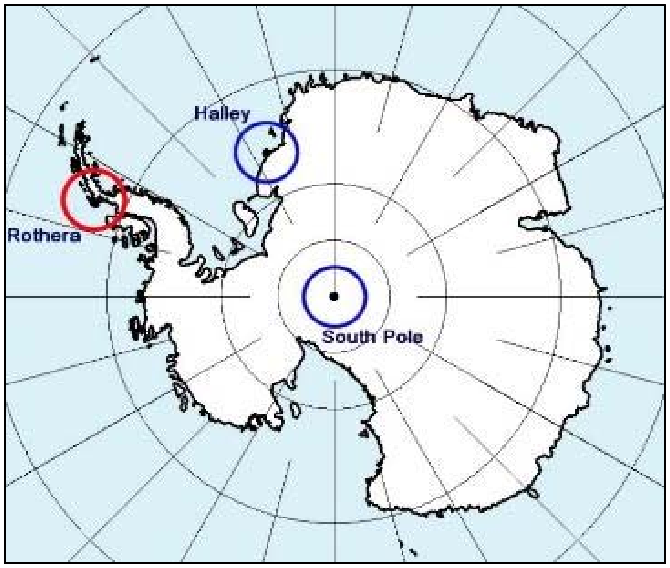

Figure 3-1 Location of Rothera in relation to the Antarctic continent

Figure 3-2 Aerial view of Rothera Research Station

Figure 3-3 Location of the proposed construction of the new Operations Building (within the green circle)

The proposed location of the new Operations Building is in the centre of the current operational site at Rothera, marked as the green circle on Figure 3-3. This is within the current footprint of the station marked as Zone 1. This location will constitute the main construction area and is hereafter referred to as the construction site.

3.3 Scope of preferred option

The Rothera Modernisation Project will be realised over three phases. Phase 1 includes the rationalisation of six buildings into a single Operations Building, as well as upgraded site wide services to improve energy efficiency and to reduce the maintenance burden. The buildings that will be removed as part of this rationalisation are Old Bransfield House, Fuchs House, Vehicles Garage, Generator Shed, Miracle Span, Bingham's and the Carpenter and Electrical Workshop.

To enable Rothera Modernisation Phase 1 to be undertaken, a number of smaller support projects will be necessary. These include the relocation of existing infrastructure including the waste management facility, scientific masts and containers as well as the relocation and upgrade of the site wide services.

This EIA document covers Phase 1 of the Rothera Modernisation only, the scope of Phases 2 and 3 are yet to be defined and funded, but may include a new accommodation building, marine facility, hangar and runway upgrades and further energy efficiency measures.

3.3.1 Operations Building

The proposed Operations Building will be located 30m from the New Bransfield House (NBH) walkway and 24m from Admirals House. The east-west orientation maximises the natural snow scour around the North, West and East Facades. The building will be fully on-grade to maximise the functionality of both science and operations activities providing direct access for pedestrians and vehicles between the building and station routes. To facilitate a fully on-grade building that fits to the terrain, a 1 metre step in the formation level is included. A building that is fully on-grade and orientated east to west, to maximise snow scour and functionality, will necessitate approximately 15,258m^3 of rock to be excavated with 11,114m^3 being returned as fill. A wind deflector has been designed to minimise snow accumulation on the Southern facade. See Figure 3-4.

The new Operations Building and site wide services will be designed for a peak station capacity of 136 people. The current average number of people on station is more than 100 during the summer season and approximately 20 during the winter season.

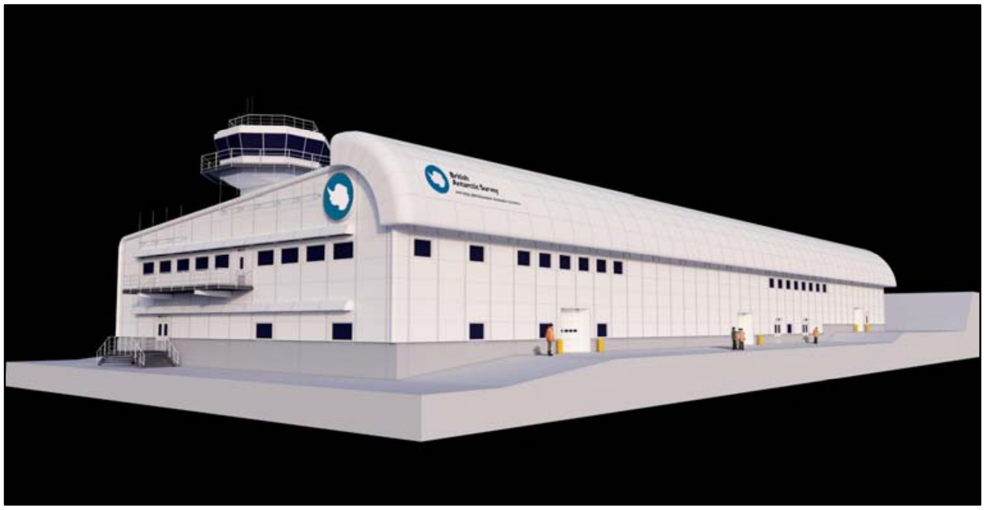

Figure 3-4 External view of proposed new Operations Building showing the wind deflector

3.3.2 Architectural layouts

The internal architectural layouts of the building have been developed in collaboration with BAS end users. Shared workspaces and a central store have been incorporated into the design to allow collaborative working, maximise station flexibility and to enable efficient stock control and cargo handling. Primary entrances on the North facade will benefit from natural snow scour and provide ease of access to the Operations Building from Admirals and NBH. Recreational and work spaces have been designed together within the building to enhance liveability on station.

3.3.3 Structural design

The Operations Building primary structure is a steel frame. This allows flexibility to reconfigure the internal layout of the building in the future if required. A precast concrete slab has been incorporated into the central store, waste management, vehicles garage and plant room areas to accommodate internal vehicle access and racking.

3.3.4 Mechanical and electrical services

Mechanical and electrical services strategies have been developed to be energy efficient and that consider future maintenance requirements and adaptation. Waste heat created by the electricity generation process will be recovered and fed into a district heating network that will be distributed into NBH. 140m^2 of photovoltaic panels are proposed to be installed to the northern façade of the building and four 225KvA generators are to be provided each with an output of 160kW. The specific mix of generator sizes are being considered in the current energy modelling exercise.

3.3.5 Fire strategy

The BAS Fire Strategy includes provision that building infrastructure in the Antarctic should be designed to meet or exceed the functional requirements of the UK building regulations to ensure that occupants are not exposed to an unacceptable level of risk and that sufficient measures are provided in the design to ensure life safety. Additionally, there is a BAS requirement to support operational continuity with a protect asset fire policy. The basis for the BAS Fire Strategy is guidance BS9999:2017

(2), and is focused on the following; Means of warning and escape; Internal fire spread (linings); Internal fire spread (structure); and external fire spread. The fire hazards arising at Rothera are different from a comparable facility in the UK. There is no national fire and rescue service and fires will need to be managed by a building management team trained as fire safety crews to re-enter the building. Major fires will need to be addressed predominantly by the building systems. Supplies, deliveries and maintenance will be restricted by seasonal weather conditions and the external environment necessitates provision of additional time to manage evacuation in the event of a fire.

The Fire Strategy was based on a resilience approach with a series of robust, independent safety measures at different stages of the hazard sequence; preventative safety measures; protective safety measures; and recovery safety measures. Preventative measures include a very early smoke detection apparatus, VESDA, visual and sound alarms and an individual paging alert system. The protective safety measures are to comprise of 60 minute internal wall compartmentalisation, fire shutters, fail safes with electromagnetic locking and hold open devices, emergency lighting and signage, and external wall compartmentalisation to prevent external spread of fire. The recovery safety measures consist of an automatic suppression system in accordance with BS8489 1:2016 (11), smoke clearance, and thermal imagery video cameras to plan re-entry to the building.

3.3.6 Acoustic strategy

An acoustic strategy has been developed which provides recommendations of suitable acoustic criteria to manage the airborne and impact noise transfer within the building as well as achieving appropriate room acoustics.

3.4 Predicted lifespan

The design life of the new Operations Building is intended to be 60 years with 25 years to the first major maintenance.

Building service plant items and materials are generally designed with a life expectancy below this, with a few exceptions such as pipework. For example combined heat and power (CHP) engines may need be replaced within 5 years. In order for a building to function over the 60 year timescales, plant and materials shall meet, as a minimum, the design life definitions given in the Chartered Institute Building Services Engineers (CIBSE) Appendix 12. A1 Guide M, a technical reference guide for designers and installers of building services, especially those focussed on low energy and environmentally sustainable buildings.

3.5 Design details – Operations Building

3.5.1 Building location

The 65% detailed design for the project was completed and signed off by the project board in June 2019. The proposed Operations Building is a 2-storey building located 30m to the south from the NBH walkway and 24m to the East from Admirals. The building location has been selected by balancing the following constraints:

- Vehicle access requirements to the building, turning circles and grounding of ISO containers. Proximity and gradient to Admirals and NBH.
- Suitable clearance to the existing buildings to enable on-going business as usual during construction.
- Suitable construction compound, including sufficient space for items such as the crane which need to be located 30m from Northern façade.
- Reducing the quantity of cut to meet programme/budget requirements to approximately 15,258m^3 of rock.
- Temporary diversion of existing services

3.5.1.1 Vehicle & Pedestrian Routes

The main vehicle and pedestrian routes have been included in the design to afford access to all sides of the new Operations Building. Access will enable BAS operatives to utilise the function of the building throughout the year independent of the prevailing weather conditions, thus supporting science for extended periods either side of the Austral Winter. The primary route for the traffic to the building is along the north face; the flat surface of the court yard being designed to enable vehicles with a trailer to be able to turn a full circle.

Beyond the primary north to south access route west of Admirals House, a secondary access route will be between the new operations building and Admirals. This route offers direct passage between NBH and the Wharf, and provides access to the south of the operations Building. The route around the East elevation is proposed for snow clearance vehicles. The site wide services gantry 6m above ground level that extends from the east side of the operations building does not restrict access for the snow clearing vehicles.

With considerable pedestrian and vehicle movement between Admirals House, New Bransfield House and the new Operations Building it is important to separate this traffic. A pedestrian route extending from NBH to the south of the station is separated from vehicle traffic. The route runs east to west, parallel with the courtyard, and then crosses the road taking a north-south course between Admirals and the foot of the gradient to the new operations building. The route then connects to the pedestrian route to the Bonner laboratory. For food and goods relief of NBH, the pedestrian access provides a suitable gradient and width for turning of the 4x4 'gator' vehicles. A staircase from NBH up to the courtyard provides direct and shortest possible routes for ease of access across station, particularly during winter.

The proposed gradients have been designed as follows:
• Non-trafficable slopes – maximum 1:3 gradient
• Pedestrian access routes – maximum gradient 1:12 (plus landing areas)
• Vehicular access routes – maximum gradient 1:10
• A 6m wide flat area is required adjacent to building facades as a minimum to provide sufficient access for snow clearance vehicles.

Further slope stability assessment work is being undertaken to finalise the design.

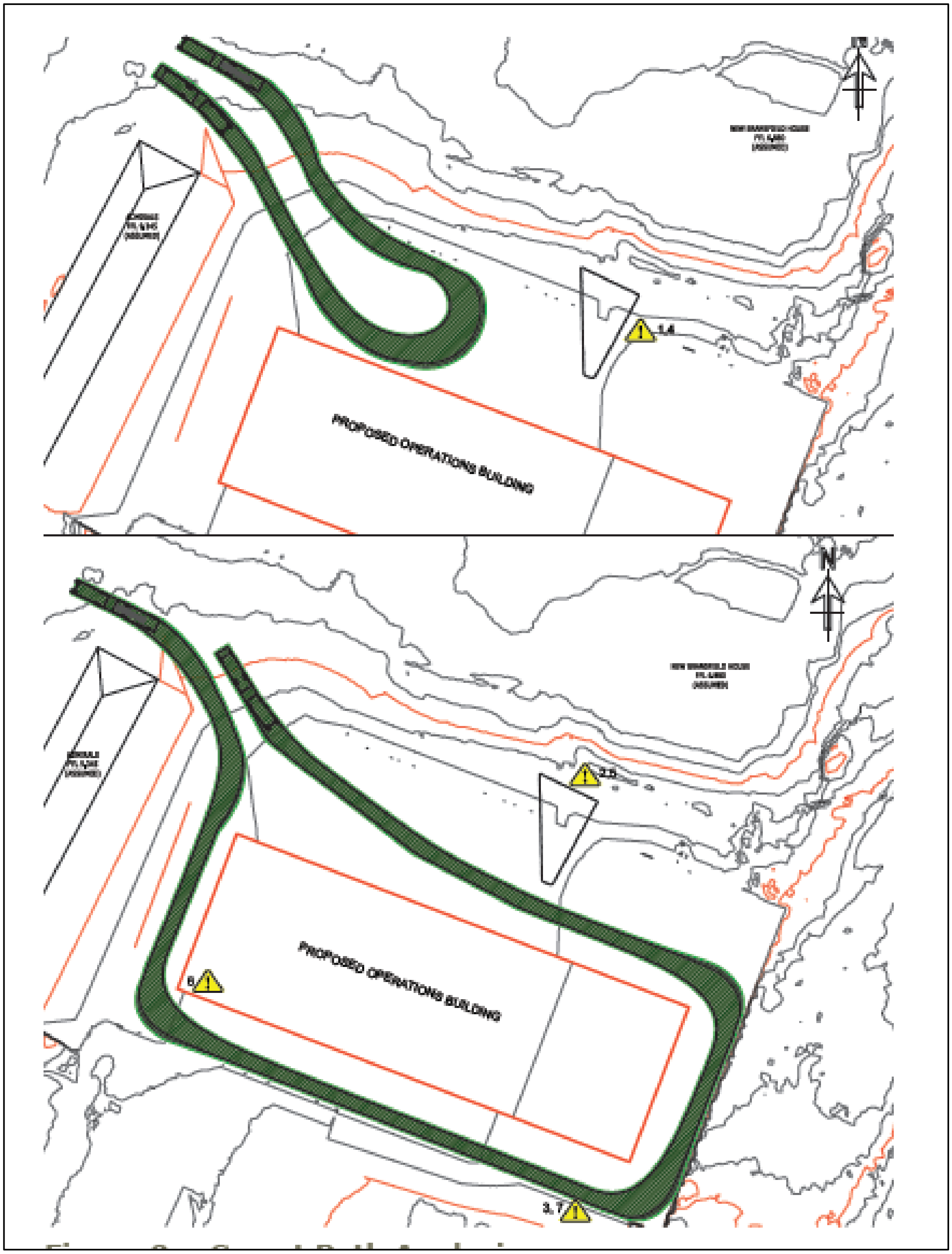

Figure 3-5 General vehicle access to new Operations building (top image) and access for snow clearing vehicles (bottom image)

3.5.1.2 Grading to Admirals

The formation level and finished floor level, as well as the proximity to the existing accommodation building Admirals, have been designed to reduce, as practicably as possible, the amount of cut and fill whilst maintaining appropriate external grading. The key parameters were as follows;

- 10m with no slope adjacent to the Western facade of the Operations building to provide route for vehicles and pedestrians.
- 6m with no slope adjacent to Admirals Eastern facade to assist with access for snow clearance vehicles
- 1:5 gradient for pedestrians between the Operations Building and Admirals. A gradient of 1:5 is designed to ensure ground stability for moving vehicles operating either side of the slope.

To include such parameters, the scientific operations building footprint would require 24m distance from Admirals as illustrated in Figure 3-6.

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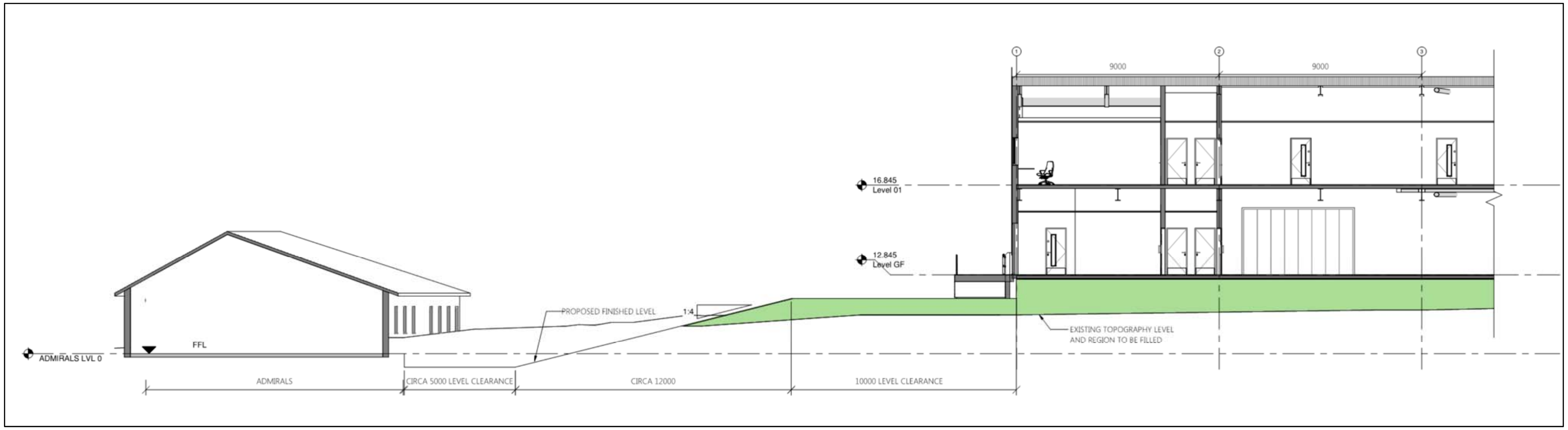

Figure 3-6 Cross section showing proximity of the new Operations Building in relation to Admirals House.

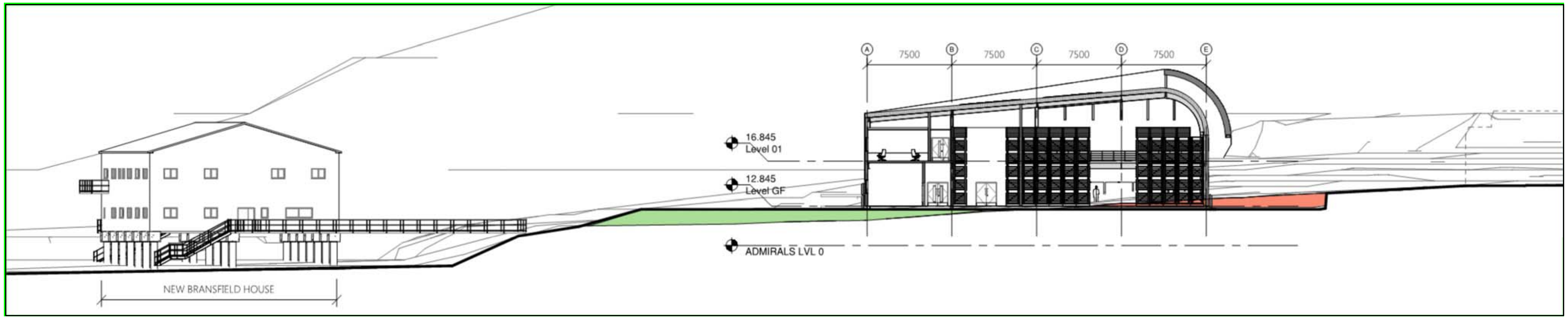

Figure 3-7 Cross section showing the proximity of the new Operations Building in relation to New Bransfield House.

Rock fill is required to level the 23m courtyard to the north of the new scientific operations building with a 1:10 slope for movement of vehicles up to the main access routes.

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3.5.2 Architectural Development

3.5.2.1 Access

The Operations Building will have two main personnel entrances. The first will be located on the North-West corner opposite Admirals and within a short walk from NBH. It will also be conveniently located for those travelling to and from the southern end of the station. A second personnel entrance will be located on the north elevation to allow direct access to/from NBH for all personnel accessing this end of the building. Additionally, this entrance will provide direct access in evenings and at weekends to the recreational facilities located on the first floor.

Large double access doors are proposed on the north elevation. These doors will allow direct vehicle access into the central store, waste management area and the vehicles garage and preparation area. The preparation area and the central store will also benefit from having access doors on the south elevation. Direct external access into the plant area from the south side of the building will also be provided.

3.5.2.2 Ground Floor Layout

The architectural layouts for both the ground and first floors have been developed in collaboration with BAS end users and adhere to a simple zonal concept as shown in Figure 3-8.

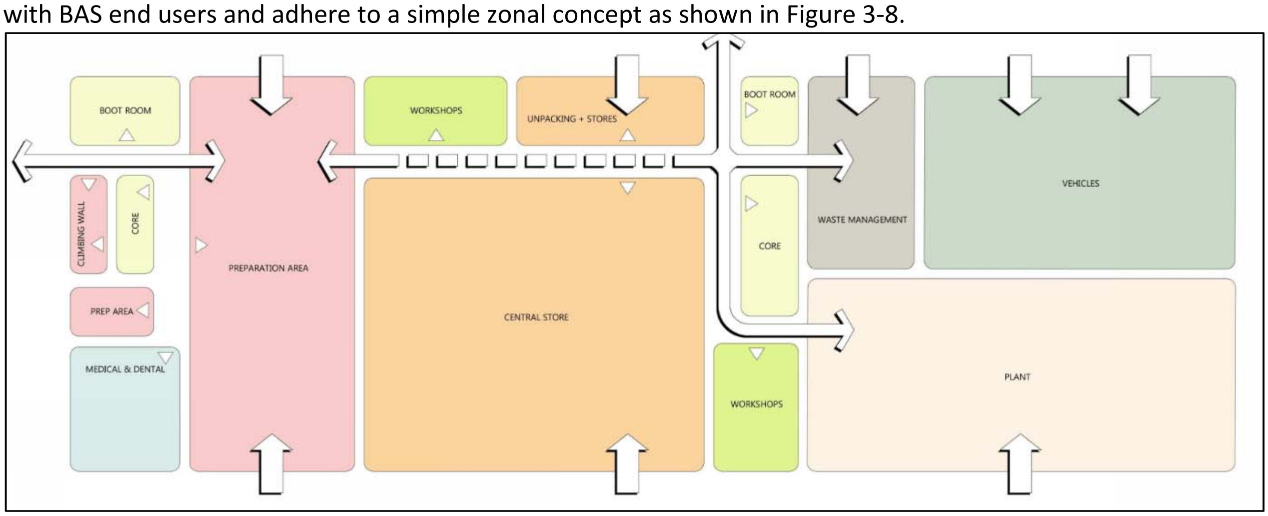

Figure 3-8 – Ground floor zonal layout

On the ground floor shared workspaces, such as the preparation area and workshops have been incorporated into the design to allow collaborative working and maximise station flexibility.

The approach to storage on station has been centralised to maximise capacity, and enable efficient stock control and cargo handling. The new central store is strategically located in the middle of the building providing ease of access from inside the building and from around the station. In addition, the location of the central store physically separates vehicles, waste management, estates and plant in the east of the building, from the noise-sensitive medical and dental unit, meteorological and field science and field operations in the west of the building.

Primary entrances to the ground floor are on the north and west façades where they will benefit from natural snow scour. Secondary doors on the south façade will allow flow through the building during busy periods, such as station relief and field deployment. Primary pedestrian entrances on the north and west façades, have been sited to enable ease of access to Admirals and NBH, and are supported by boot rooms.

Working areas, such as the field preparation area, waste management, central store and vehicles garage benefit for large double doors to allow access by either forklift or pallet truck, from the Northern forecourt, to reduce manual handling.

The medical and dental unit will be positioned in the south-west corner of the ground floor which offers convenient access via the main entrance and gives a sense of privacy.

3.5.2.3 First floor Layout

The first floor layout purposefully zones recreational areas in the east and office areas in the west. This provides a physical separation between work and recreation to enhance 'liveability' on station, as shown below in Figure 3-9.

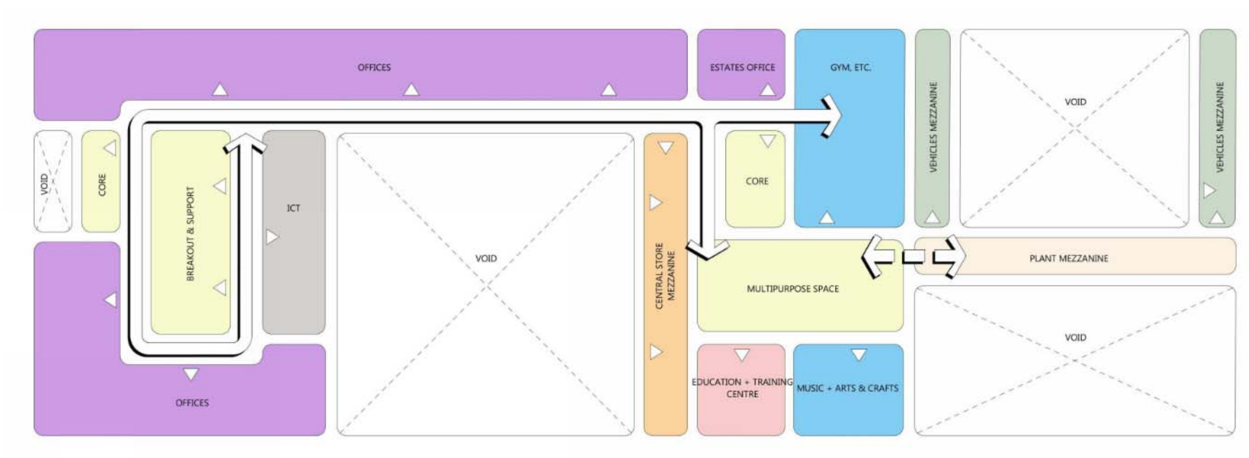

Figure 3-9 - First floor zonal layout

Offices have been positioned towards the western end of the building on the external walls with windows to benefit from natural daylight and views. Space in the middle of the building has been utilised for either storage, housing ICT equipment, or is lit from above by roof lights to provide a breakout space for informal meetings or just to enjoy a cup of tea. The breakout space also houses a display wall for various Rothera related heritage artefacts, and has access to the external science balcony with views over the runway towards the west. This working area of the building is accessed via the western stair case, which continues up to the Operations Tower.

The central store separates the office areas from the recreational areas to the east, which include a gym, locker room and sauna, as well as the arts & crafts and music rooms. These spaces are clustered around a multipurpose space lit from above by roof lights and can be accessed from the ground floor via the eastern staircase, further separating the work and recreation areas of the building. These spaces can also be accessed from the west by an internal first floor corridor.

Further to the east are the plant and vehicles mezzanines which provide additional space for plant and day storage of parts and consumables.

3.5.2.4 Operations Tower

The design of the Operations Tower has been developed by close collaboration between BAS Air Unit and ICT departments, and engineers at Sweco. The octagonal tower will have triple glazed windows on all sides to provide an almost 360° field of vision around the station and beyond. The window frames have been designed to incorporate the structural elements of the roof, while the balcony access door includes a triple glazed vision panel, both features are designed to minimise blind spots for operators within the tower. The height of the tower has been specifically designed to give lines of sight to the wharf and the runway to the north.

A balcony will surround the tower to allow safe access for maintenance and cleaning of windows, while a weatherproof hatch will give access to communications equipment on the roof via an internal 'loft' ladder.

The internal layout is centred on the buildings western staircase which comes up from the ground floor to the first floor, then narrows to come up into the tower. The tower is separated from the rest of the building by a door at first floor level. The radio operator console position has been prioritised on the western side for direct views of the runway, while the meteorological desk and balcony access door will be situated to the east. The floor area of the tower has been significantly reduced during the design process and rationalised to improve sightlines whilst maintaining the capability of accommodating the day-to-day functions of the tower and additional needs, such as staff training.

3.5.2.5 Central Store

To support changes to BAS's operating dynamic bought on by the arrival of the SDA, a central store controlled by IBM Maximo asset management system has been proposed for the modernisation project. This will allow BAS to benefit from better stock management, reducing waste and manual handling, while improving station resilience.

The Central Store has been designed over two storeys, with 4 storage compartments on each floor. See Figure 3-10. Compartments are separated by 60 minute fire rated partitions and 60 minute fire rated shutters. This divides the storage and its potential fire load, allowing a fog and mist fire suppression system to be designed, which can contain a fire within an individual compartment. In addition each compartment is continuously monitored by fire detection systems, to provide early warning to staff so that first aid firefighting measures can be taken to avoid a major fire developing. These changes have resulted in a reduction in storage capacity of 35%, which has been accepted on the grounds of the reduced fire risk and increased redundancy protecting business continuity on the station.

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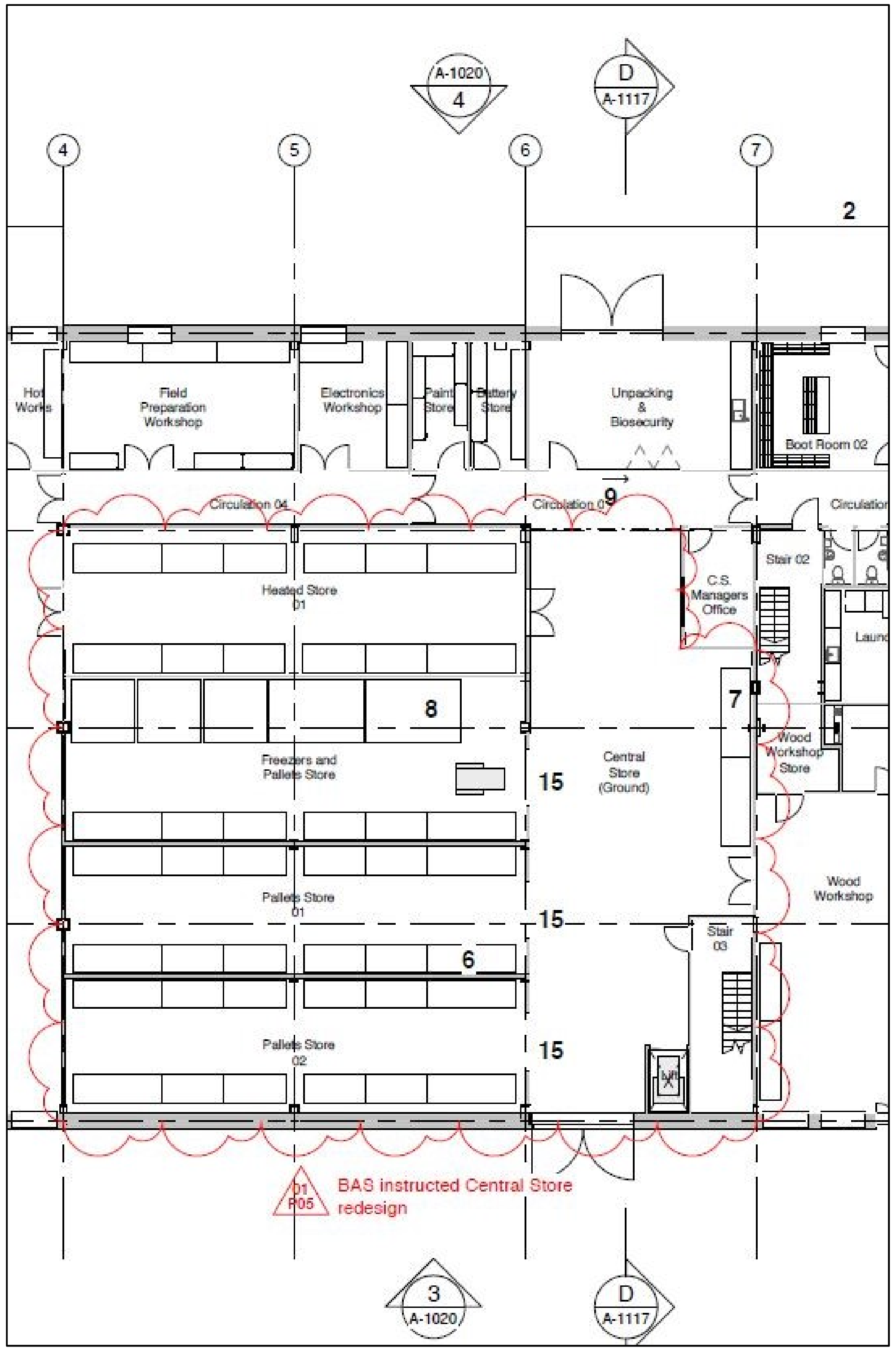

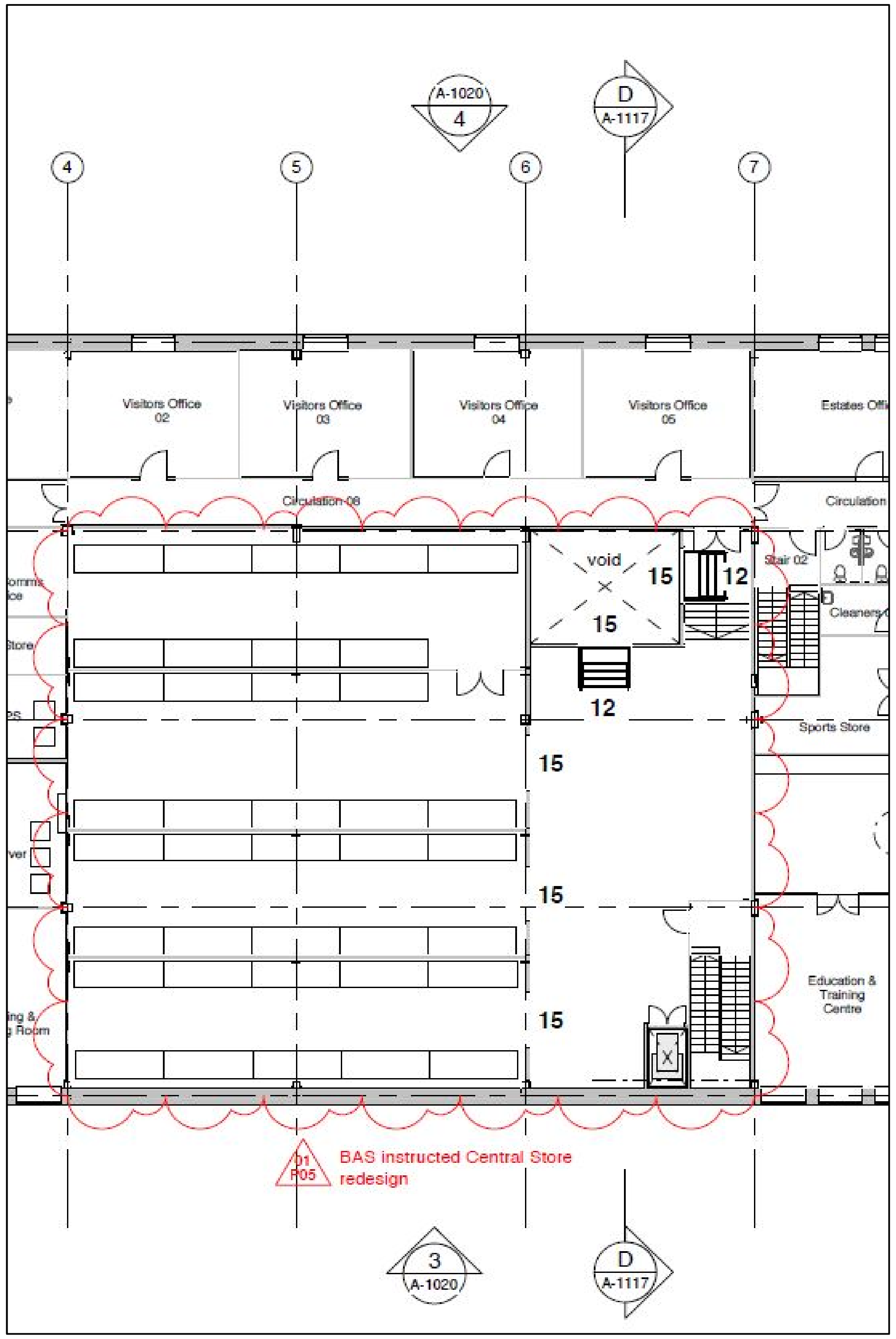

Figure 3-10 Central store ground and first floor layout, after WS4a redesign.

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The Central Store has been designed to be accessed internally from the west and east of the building by ground floor corridors, and externally from a cargo door to the north. During busy periods, such as station relief a second cargo door to the south can be opened to aid the movement of cargo to and from the wharf. Cargo entering through the northern door will pass through a biosecurity inspection area. Any cargo suspected of containing a biosecurity threat can be segregated from the rest of the store within an enclosed inspection area, where it can be washed or fumigated if required.

Following inspection, cargo will be moved by forklift into the ground floor of the Central Store, where it is either lifted onto the first floor via a fire protected lifting shaft or taken into the ground floor compartments to be stored in pallet racks or freezers. To maximise storage capacity the ground floor compartments have a ceiling height of 5m with racking height of 4.3m, which allows pallet racking up to three bays high, while still being within the working limits of the fog and mist fire suppression system.

Cargo lifted onto the first floor, will either be moved by electric pallet stacker onto pallet racking, or broken up and individual items stored on shelves for hand picking. A goods lift and dedicated stairwell allow personnel to access this part of the store to collect items requisitioned using IBM Maximo.

On both floors compartments will be frost protected, with one compartment on the ground floor heated to protect sensitive cargo such as dried food. Heat for this store will be recovered from the stations freezers in the adjacent compartment.

3.5.3 Mechanical, Electrical & power Services

The primary aim of the Mechanical Electrical and Power (MEP) services of the new Operations Building is to support building operations. Additional purposes include the reduction of the operational cost of supporting the energy demand of the station and hence reduce use of carbon fuels; providing MEP that is sustainable, incorporating simple engineering solutions with the resilience necessary for the logistical remoteness of the station; and also to provide services that are responsive to a building that is multi-functional, and with considerable variations in occupancy between seasons.

The core of the MEP services is the energy centre in the new operations building. The Energy Centre houses 4 x Combined Heat and Power (CHP) generators separated by fire rated compartments that provide the building with all its energy needs. The CHP recovers heat from the water jacket and exhaust stack which is used to meet the heating and hot water energy demands. Heated water not used by the building can be redistributed to other existing buildings including the 24-hour operation of NBH. The combination of generators have been sized to meet the electrical peak demand of the whole station. Resilience has been incorporated with a standby generator in the operations building and mobile generators for life support buildings across the station. New energy efficient boilers will be installed in each of the existing buildings to reduce fuel demand.

Temperature of rooms is maintained by radiant panels or radiators. Radiant panels allow for recirculation on electrical energy to reduce the demand for heated water. Rooms will have temperature sensors that enable the rooms to be heated to the specific functional requirement.

There will be a decentralised ventilation system that is responsive to the occupancy of each of the rooms. Air exchange will be configured to the change in occupancy and function of each of the spaces and rooms as per building regulations. The ventilation system will also be able to support the heat demand by re-distributing heat energy thus reducing the demand for hot water.

The Energy Centre will also accommodate the 2 x Reverse Osmosis (RO) plant that will distribute all the potable water needs for the station as well as water for the fire suppression system. The RO plant within NBH will be retained to provide resilience to the station's life support building.

The majority of services will be installed within the ceiling voids / roof space. The duck work and pipes will be transported to site with all ends sealed to prevent contamination and biosecurity issues.

3.5.4 Anticipated Energy Efficiencies

The Rothera Modernisation Sustainability Strategy and principle project benefit is to reduce the Station's energy consumption and assist in reducing its carbon footprint. The Modernisation Programme has set out a phased approach to deliver a 70% reduction in consumption of Marine Gas Oil (MGO) with Modernisation Phase 1 setting a target of between 20 - 25%. An Energy Simulation Work-flow (ESW) model has been developed by the Technical Advisor to support analysis of the base and peak energy loads of the remaining infrastructure on station and the new operations building to define the configuration of generators and MGO consumption. Supplier performance specifications will finally determine the generator size configuration and energy performance.

The Phase 1 scope to replace 6 operations buildings and replace the site wide services, was based on a priority to replace aging infrastructure, but also to maximise energy efficiency in the building infrastructure on station.

An energy model was generated inputting existing energy demand (based on austral summer and winter 2016/17) data to ascertain a baseline from which the energy model would discern the most suitable energy mix. A configuration of CHP generators was selected with heat recovery that could be used to supply heated water to the new Operations Building with any surplus heat being transferred to existing buildings.

Evaluation on the efficiency of the Distributed Heated Water (DHW) using the site wide network, in support of boiler capacity in existing buildings, determined that the greatest gain was to deliver heated water, 24 hours to the adjacent building, New Bransfield House. Optimisation of the distribution of heated water to Admirals and the Bonner Laboratory were omitted.

Given that the energy demand of the Operations Building will be predominantly electrical, the energy supply mix will include some renewables in the form of photovoltaic panels. Energy efficiency has been incorporated into the design of the heating system with radiant panels (electric) and radiators (heated water) systems to maximise heat recovery and power generation of the CHP generators. The ventilation system will also be used to regulate temperature thereby reducing the demand for new energy demand from the generators.

Improved zoning of the building functions will also reduce energy consumption. For example, areas that need to be maintained at above freezing temperatures such as the central store and vehicles garage are co-located whilst rooms and spaces that require more ambient temperatures are aggregated together. The seasonal variation in occupancy was considered in the design with offices and collaboration areas located in close proximity so areas of the building can be switched off and room temperatures lowered to reduce demand in the austral winter.

The location and orientation of building will be orientated east to west and a mono-pitch roof with wind deflector introduced to maximise the scour of snow by wind over the building and immediately adjacent to it. This intention is that this will reduce resources and vehicles required for snow management.

The external wall system of the building will comprise of SIP panels or a composite panel with insulation and thermal breakers, triple glazed windows and heat tracing around the seals of external doors to prevent transfer of cold air into the structure. The site wide services pipework will use a steel core surrounded by up to 200mm diameter widths of insulation to reduce the requirement for heat tracing and thus reduce energy demand.

3.6 Design details – Site Wide Services

The inclusion of the replacement of the site wide services within the scope of Phase 1 is fundamental to achieving the project objective of reducing fuel consumption and consequentially reduction of operational expenditure. The requirement to maintain an above ground network of site services provides advantages in significantly reduced earthworks placing services underground, ease of maintenance, but also flexibility for future infrastructure development. However, above ground services presents challenges in how the pipework and cables are protected from the extreme environmental conditions. Some of the drainage pipework between Giants House and the sewage treatment plant may be routed underground using a gravity fed pipe. A secondary pipe could be included to improve redundancy. A decision is to be made in the next design stage.

The renewal of the above ground services with far greater thermal efficient pipework means that fluid services such as fuel, potable water, and waste water can be distributed across site as they require significantly less heat tracing and hence energy demand to frost protect. Automatic distribution of services reduces the need for manual handling and minimises the potential for contamination from spills in moving fluids across station manually. The proposed pipework comprises a steel sheath surrounded by an insulation layer incorporating heat tracing and leak detection, and a PVU protective outer skin. The fluid systems leak detection system allows for fissures in the insulation layer to be identified immediately so that maintenance can be carried out on the specific weaker section before the service is disrupted. Meters will be also be installed to monitor the energy and service demand from buildings across the station.

The site wide service distribution will also include power supply from the CHP generators in the Operations Building and data cables. The proposed length of the new site wide service ring main, has been reduced from the current circuit by designing a more direct route between buildings and avoiding proximity to roadways/vehicle routes.

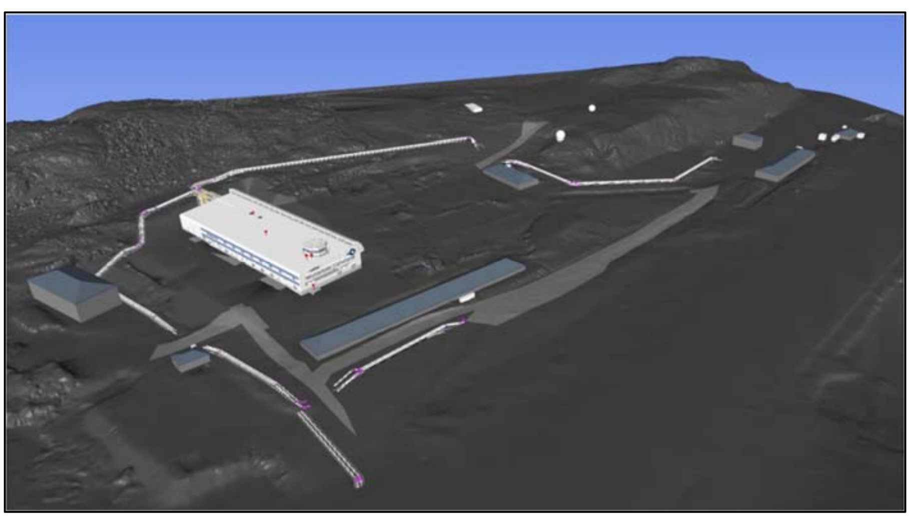


Figure 3-11 Proposed site wide services route (shown by white line)

Figure 3-12 Plan view of proposed site wide services

The site wide services ring main will comprise a precast concrete foundation anchored to the rock with a 2m tall steel support structure. The cable trays, trunking, electrical fibre optic cables, and pipework will be connected to the steel arms dissecting the upright steel support. There will be a steel support every 4 metres on the ring main to provide the support for the services.

3.7 Design details - Interim Waste Management Facility (IWMF)

The current waste management facility at Rothera is located within the proposed construction site for the new Operations Building. Hazardous and non-hazardous waste is currently segregated and stored in this facility.

During the first construction season it is proposed to demolish the building (known as the Miracle Span) and relocate the facility into an interim building. The Interim Waste Management Facility (IWMF) will be built north of the sewage treatment plant, adjacent to the fitters workshop prior to dismantling the Miracle Span to allow continuous operations and ensure resilience of the system.

The new Operations Building incorporates a waste handling facility which will replace the current segregation and storage of dry non-hazardous and dry hazardous waste. Wet waste e.g. food, and liquid hazardous waste will not be incorporated into the new facility. It is anticipated that a hazardous waste facility including a new incinerator will be built in Phase 2 of the Rothera Modernisation Project. The lifespan of the IWMF is anticipated to be up to 10 years.

The IWMF will be 25m long and 9m wide with a unique door sizing to accommodate the vehicles used on site. It will be a metal dome structured shed formed of steel arches covered with profiled steel sheeting. Recycled sheet piles will be laid horizontally on the ground to form the foundations. It is proposed that these sheet piles will be reused from the wharf project.

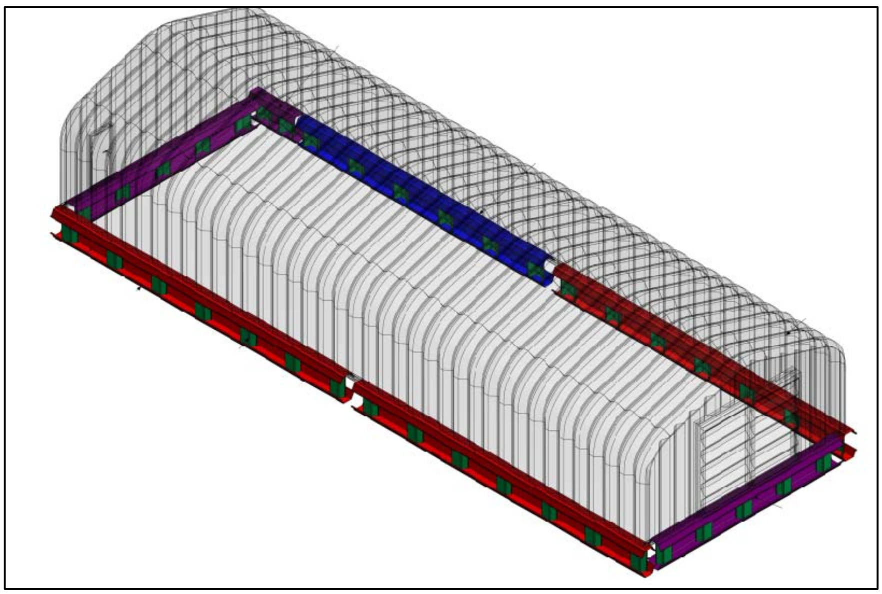


Figure 3-13 Schematic view of proposed new Interim Waste Management Facility

Internally the floor surface will be comprised of local rock aggregate, compacted and overlaid with 10mm fines. A dedicated 'hot zone' will be designated for the collection and temporary storage of liquid hazardous and non- hazardous waste. Within the 'hot zone', two steel containment pallets will be installed. Eight x 205l drums can be stored on each pallet which has a sump capacity of 590l each. It is proposed that a geotextile underlay will be installed underneath the pallets to create an additional bund should there be any leaks or spills within this area. See Figure 3-14.

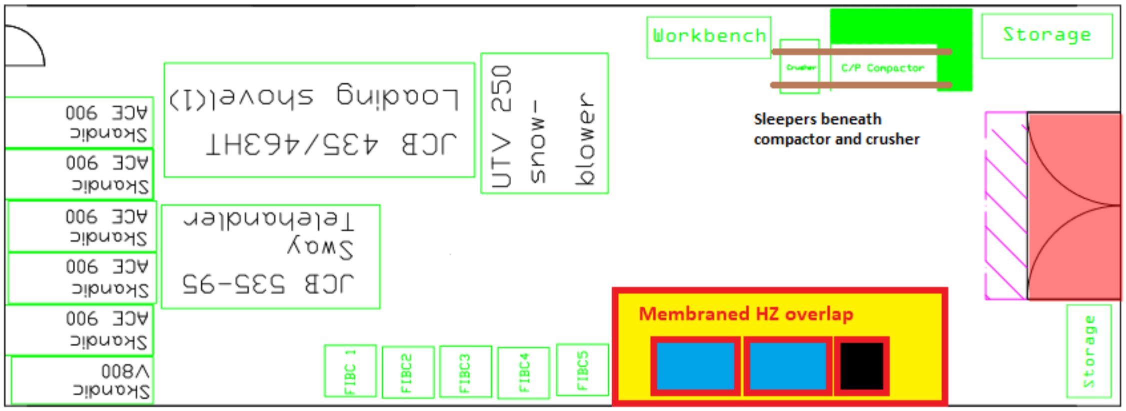


Figure 3-14 Proposed layout of IWMF

The IWMF will also be used as a storage area for skiddoos, a snow blower, tele handler and a loading shovel. All vehicles will use drip trays or plant nappies when stored plant in the IWMF.

3.8 Design details – Drilling & blasting

In order to provide the appropriate area of flat ground on which to construct the Operations Building, a cut and fill study was undertaken. This has been included in Appendix A: *Rothera Modernisation Drill & Blast Management Plan*. The location of the required cut and fill is within the existing station footprint, in the centre of the existing site between NBH and the garage workshop as shown in Figure 3-15 below and referred to as the construction site.

The depth of excavation required for the foundations of the new building have been assumed to be 1.9m deep below the finished floor level of the entire building footprint. The cut and fill study concluded that in total 15,258m^3 of rock cut will be required.

Of the total volume of cut, it is anticipated that approximately 11,200m^3 of 0-80mm rock fill will be required. During the production of this fill material it may be necessary to obtain additional rock material from existing stockpiles already sourced for the Rothera Wharf project.

Some of the 11,200m^3 of rock can be sourced by excavating material already on the surface of the construction site. However it is anticipated that, approximately 8,600m^3 of this rock will need to be blasted prior to excavation. After blasting, this material will then be loaded and hauled to a separate area on-station for processing and stockpiling, before being returned to the construction site to be used as fill material. Figure 3-15 shows the areas of cut and fill required. The areas of fill are coloured in dark green. All other colours denote different levels of cut which culminate in the south east corner of the site where the red to dark brown areas reflect the maximum amount of cut; up to approximately 8 metres.

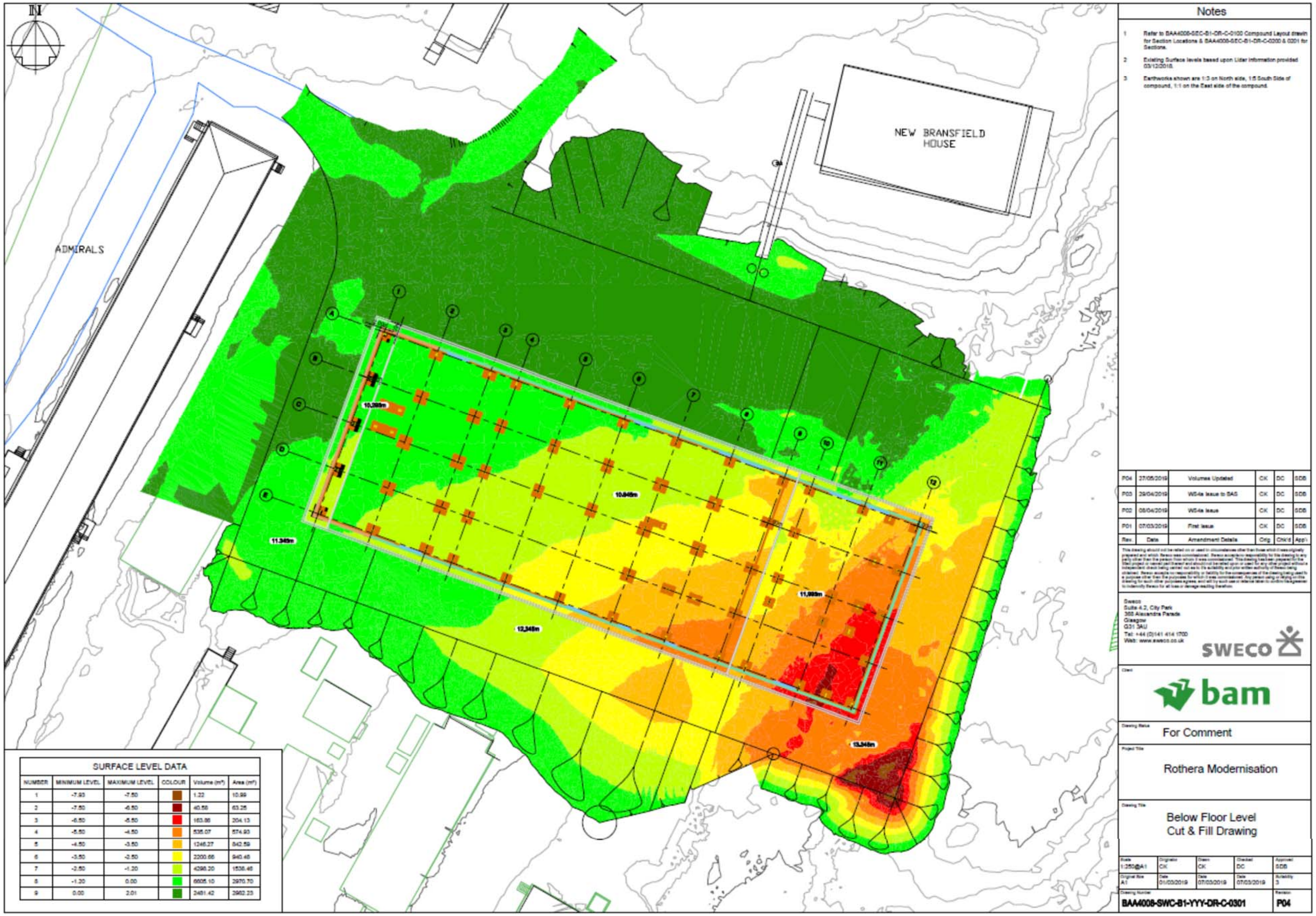
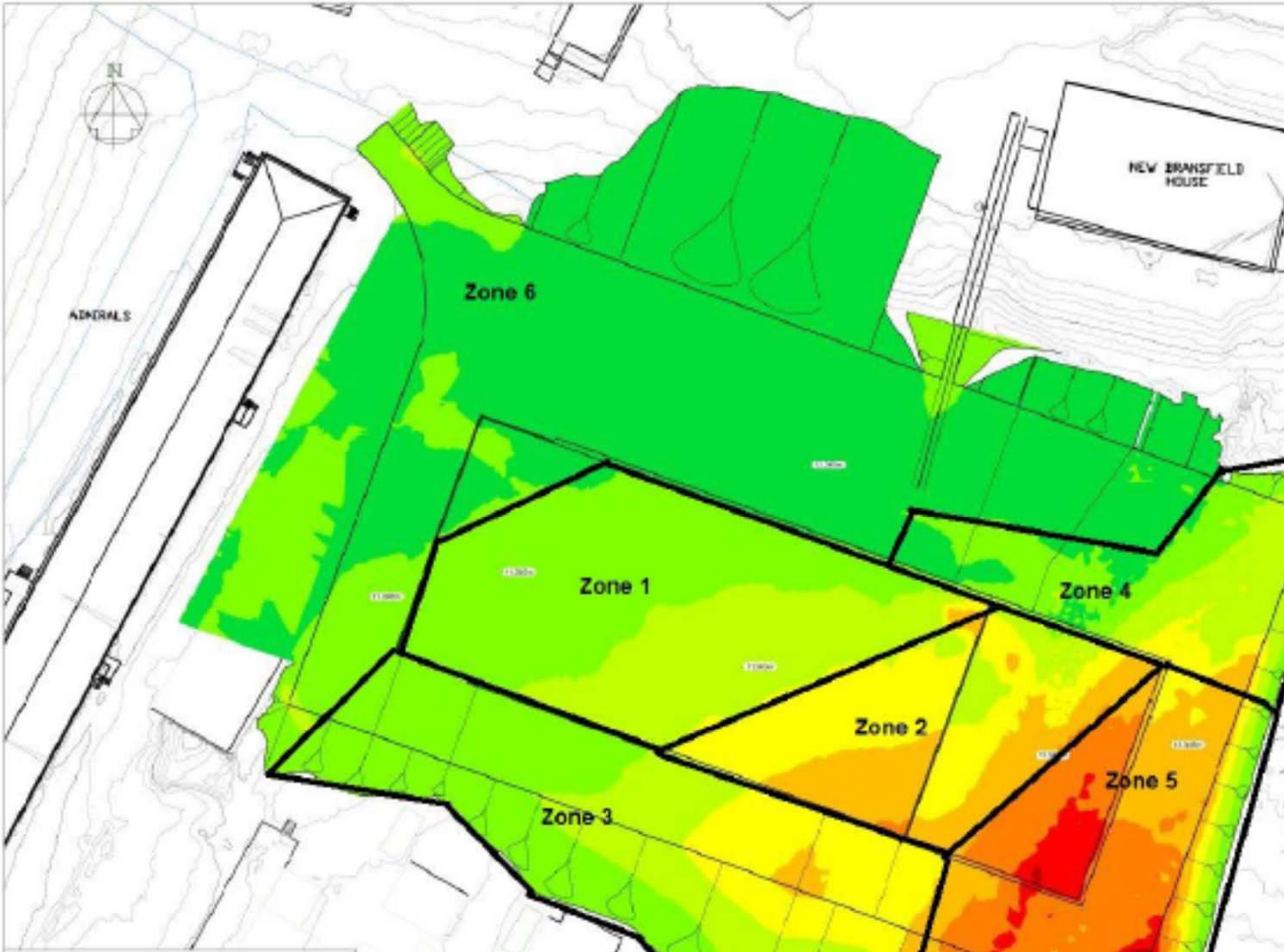


Figure 3-15 Below floor level cut & fill drawing



N
ADMIRALS
NEW BRANSFIELD HOUSE
Zone 6
Zone 1
Zone 4
Zone 2
Zone 5
Zone 3

Area	Materials		
	0-80mm	0-30mm	sand
	M^3	M^3	M^3
Building	4975		264
Perimeter	4764		
Hangar	1240		
Bridge	100		
Interim waste handling facility	135		
Total	11,214	0	264

The exact sequence of blasting will be determined by the Explosives Supervisor on-site once all of the loose overburden ha information affecting blasting has been considered. Figure 3-16 shows an indicative blasting sequence as follows:

- Starting in zone 1 the aim will be to develop a face in the shallow rock areas furthest away from buildings. This in maximum distances from sensitive structures.
- Development of the face will then continue into zone 2 with a thicker rock layer, but still at a distance from buildi
- Zones 3 and 4 will then be worked on, gradually moving towards the most sensitive areas. This approach will a existing areas of cut but away from the buildings.
- Finally zone 5 will be worked on to remove the thickest layer of rock.

As blasting progresses towards the buildings and other sensitive receptors, vibration levels will be monitored to determine peak particle velocity c compared to BS7385-2. In the event that compliance is not possible at the closest proximity the option is to allow exceedance with a potential for da reasonable to accept the risk of minor cosmetic damage to the site buildings which are due for demolition in season 4. Figure 3-19 to Figure 3-21 3D vi from the south west with new building included.

Figure 3-22 Proposed landscape once cut and fill has been completed

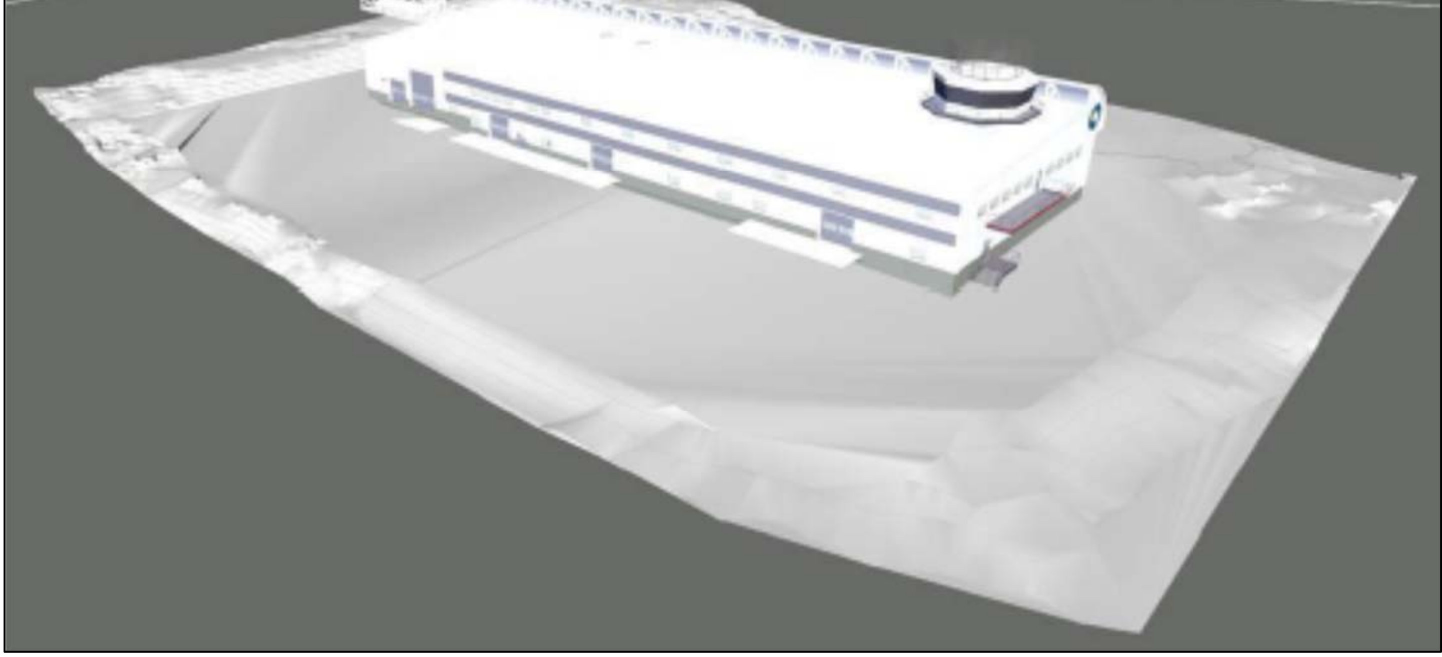


Figure 3-20 3D visualisation of cut required viewed from the North West with new Operations Building included

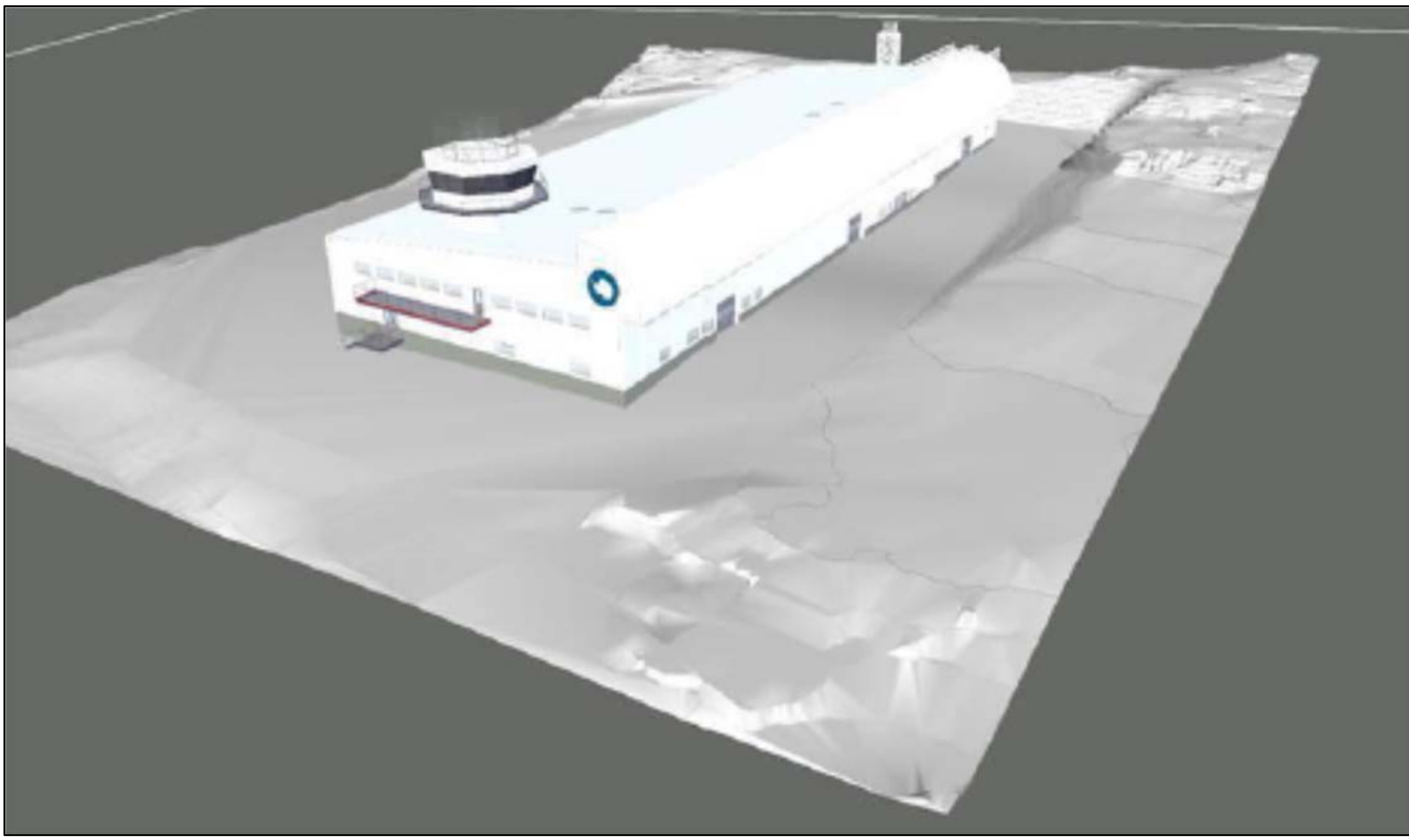


Figure 3-21 3D visualisation of the modernisation cut viewed from the south west with new building included.

Figure 3-22 Proposed landscape once cut and fill has been completed

3.9 Alternatives considered

Rothera Modernisation Phase 1 has been undertaken as a series of consecutive work stages aligned with the Royal Institute of British Architects (RIBA) Plan of Work 2013; a UK model for building design and construction processes. The stages are defined below.

Figure 3-23 RIBA Project Work Stages

Work Stage (WS)	RIBA Plan of Work 2013
WS 0 Strategic Project Definition	0 –Strategic Definition
WS 1 Project Feasibility	1 Preparation & Brief
WS 2 Assessment Study	2 Concept Design
WS 3a Developed Design	3 Developed Design
WS 3b Tender Preparation	
WS 3c Tender Invitation, Evaluation & Contract Awards	
WS 4 Technical Design	4 Technical Design
WS 5 Construction	5 Construction
WS 6 Completion & Handover	6 Handover & close out
WS 7 Defects Period	7 In-Use
WS 8 Financial close	8 Audit of costs

The design of Rothera Modernisation Phase 1 has evolved since Work Stage 1 in February 2018, when a long-list of options were reviewed, which included a "Do nothing", "Do minimum" or pursue either a "one building" or "two-building" option. At the time of writing the project is in WS4 Technical Design.

3.9.1 Do nothing option

3.9.1.1 Building infrastructure

A condition survey, completed in Spring 2016, identified that of the buildings and services/utilities only four (NBH, Bonner Laboratory, Admirals House and the sewage treatment plant (STP)) were rated as sound, exhibiting minor deterioration, (denoted as condition B in Figure 3-32) and not in need of replacement in the short term. The remainder required major repair or replacement (denoted as condition C in Figure 3-23) and four of the buildings, mainly built in the 1970's require urgent attention (denoted as condition D in Figure 3-23) and are being operated well beyond their design life. An explanation of the condition rating is included in Figure 3-24.

It is proposed that the buildings and site wide infrastructure highlighted in green in Figure 3-23 will be deconstructed and replaced as part of Rothera Modernisation Phase 1. Phase 1 will also include repairs to the roof of the Aircraft Hangar (highlighted orange), while additional infrastructure replacement is proposed to be included within future phases.

Facility	Year of Construction	Replace Date	Condition
New Bransfield House (messing & living)	2008	2033	B
Bonner Laboratories	2003	2028	B
Admirals House (principal living accommodation)	2001	2026	B
Sewage Treatment Plant	2000	2025	B
Power Generation Shed	1995	2020	C
Giants House (secondary accommodation)	1996	2016	C
Aircraft Hangar	1990	2015	C
Vehicles Garage & Workshops	1977	2014	C
Binghams (Technical Services)	1977	2012	D
Boat Shed & Office	1997	2012	C
Miracle Span (Waste Management facility)	1992	2012	D
Carpenter & Electrical Workshop	1976	2011	D
Services and Utilities	Various	2010	C
Fuchs House (Field Operations Building)	1979	2009	C
Old Bransfield House (Operations & welfare)	1977	2002	D

Figure 3-24 Summary of the building condition survey 2016

Figure 3-25 Building Condition Rating Explanation

Condition Score	Explanation
A	As new condition. Features one or more of the following: Typically built within the last 5 years, or may have undergone a major refurbishment within this period. Maintained / serviced to ensure refurbishment within this period. Maintained / serviced to ensure fabric and building services replicate conditions at installation No structural, building envelope, building services or statutory compliance issues apparent. No impacts upon operation of the building
B.	Sound, operationally safe and exhibiting only minor deterioration Typically features one or more of the following: Maintenance will have been carried out. Minor deterioration to internal/external finishes. Few structural, building envelope, building services or statutory compliance issues apparent. Likely to have minor impacts upon the operation of the building.
C	Operational, but major repair or replacement needed in the short to medium term (generally 3 years). Typically features one or more of the following: Requiring replacement of building elements or services or services elements in the short to medium term. Several structural, building envelope, building services or statutory compliance issues apparent, or one particularly significant issue apparent. Often including identified problems significant issue apparent. Often including identified problems with building envelope (windows / roof etc.), building services with building envelope (windows / roof etc.), building services (boilers, chillers etc.). Likely to have major impacts upon the operation of the building, but still allow it to be operable
D	Inoperable or serious risk of major failure or breakdown. Building is inoperable, or likely to become inoperable, due to statutory compliance issues or condition representing a health and safety compliance issues or condition representing a health and safety compliance issues or condition representing a health and safety risk or breach. May be structural, building envelope, or building services problems coupled with compliance issues. The conditions are expected to curtail operations within the building. Exclude very minor items which can be rectified easily.

Figure 3-26 and Figure 3-27 show the external condition of the aging infrastructure at Rothera.

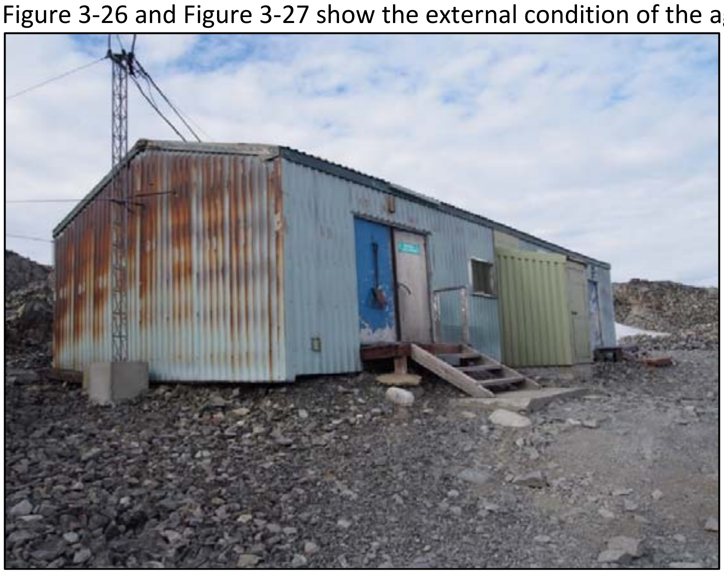


Figure 3-26 Carpenter & Electrical Workshop

Figure 3-27 Bingham's

New facilities for BAS Estates, Vehicles, Science and Operations, as well as new Site Wide Services, were selected from the masterplan as the priorities in Phase 1. This was decided based on existing buildings and services on the station approaching the end or exceeding their acceptable design life. The Masterplan concluded that all new building infrastructure should be orientated East – West, parallel to NBH (NBH) to maximise solar gain, built on-silts or utilising wind deflectors to reduce snow accumulation. As shown in Figure 3-28.

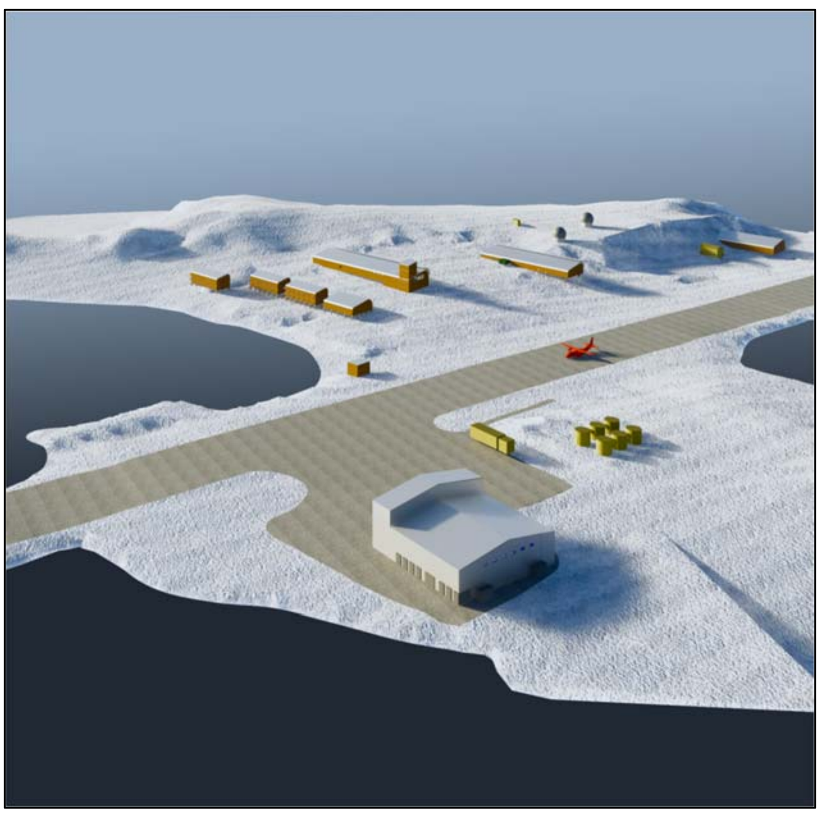


Figure 3-28 Visualisation of east-west orientation of new infrastructure

Site Wide Services

For the most part, the services at Rothera Station (electrical, water and sewage) run above ground. To protect these services, pipework and cables are contained within insulated timber enclosures. A typical example of an enclosure is shown in Figure 3-29.

Figure 3-29: Typical Services' Enclosure

To prevent freezing, services are heated by uninsulated hot water heating pipes or electrical trace heating within the enclosures. These methods of heating are prone to failure and are known to lead to frequent freezing of the pipes resulting in unacceptable loss of supply.

During the condition survey in 2016, it was found that the age and condition of the timber enclosures means that they themselves have become a significant maintenance burden. The enclosures are difficult to make air tight and as a result lose a significant amount of heat whilst trying to maintain the necessary temperature to prevent freezing of services. In some areas the layout of the timber enclosures impede vehicle and pedestrian movements around the station and cause significant snow accumulations. Moreover, it was found that the design of the timber enclosures provide poor access for maintenance resulting in increased repair times and costs. The proposed redevelopment will enable the services distribution system to be rationalised and upgraded, which will improve the station's operational resilience, while reducing energy consumption and maintenance burden.

Figure 3-30 Typical service run enclosure

The findings of the 2016 condition survey mean that the "Do Nothing" option is not viable in regard to the building and services infrastructure which was found to be operating beyond its design life or in need of major repair.

3.9.2 Do minimum option

A "Do minimum" option would include a significant programme of repair and refurbishments projects designed to return the station infrastructure to an acceptable standard. Due to the number of buildings and services operating well beyond their design life, and the condition of other buildings (as outlined in Table 1), this approach would deliver only short term benefits at a high financial cost and requirement for substantial people resource. Furthermore, a programme of this type would leave BAS with a significant ongoing maintenance burden. As such this option is not viable.

3.9.3 Alternative Designs

3.9.3.1 One-building option

During the options study both the one building and two building option were considered in detail. The one building option had significant advantages over the two-building option as outlined below;

- 15% reduction in overall building footprint between one building and two building. The one building option would enable interdependent functions to operate within one enclosed space meaning that functions would not need to be replicated.
- The opportunity to complete in summer 2023 rather than summer 2024. A One building option would enable the Contractor to commence construction works in Season 1 with no requirement to deconstruct existing buildings with the exception of the waste handling facility, Miracle Span.
- With a 15% reduction in footprint and reduced requirement for site wide services to span two operations buildings, the project will likely achieve MGO savings in the region of 20-25% (compared to a 2015 baseline).
- 33% reduction in labour costs and 15% reduction in material costs. A reduced footprint to deliver the same gross internal area for operational functions would reduce the amount of materials and hence labour to complete construction works.
- 20% reduction in façade length to snow clear. (Currently considerable resource and fuel is expended in clearing snow from the faces of building infrastructure.)
- No requirement to demolish existing Giants House accommodation building before construction could begin.
- Reduced maintenance activities associated with one-building in contrast to a two-building option.

3.9.3.2 Two-building option

Given the clear advantages of a one-building approach outlined above, BAS developed a redundancy strategy to assess the level of business continuity offered by either the one or two building option. Within the strategy it was shown that, for each service that could be impacted by the one-building vs two-building decision, the two-building option would only provide greater redundancy if facilities, such as electrical and water production, were split between the two buildings. It was concluded that it was not feasible or proportionate to duplicate these facilities in each building and that dividing the facilities across the two buildings would be impractical for day to day operations.

In the event of a catastrophic scenario, such as a fire, one building would be less redundant than two buildings. However, it was concluded that the day to day benefits of one-building outweighed the benefits of designing for a catastrophic event with a very low likelihood.

Further substantiation for selecting a one-building approach was taken from the impact of construction on business-as-usual. To facilitate the two-building option, an accommodation building (Giants House), would have had to be deconstructed to clear the site for the construction works. This would have significantly reduced bed spaces on station for the foreseeable future, impacting both the delivery of science and making the construction works themselves unfeasible. In addition a two-building option would have extended construction over 5 seasons, further impacting the delivery of science and increasing construction costs. As such this option is unviable.

At the conclusion of Work Stage 2: Assessment Study, the preferred option was the construction of one-building based on the benefits it would deliver over the two-building option and the reduction of impact on the delivery of science. This option, as shown in Figure 3-4, was taken forward through Work Stage 3: Developed Design and Tender Preparation to the Work Stage 4: Detailed Design phase.

3.10 Overview of works

The Rothera Modernisation project is proposed to be completed over four Antarctic summer seasons commencing in November 2019 with completion anticipated to be in April 2023. A summary of the scope of works of the project consists of the following:

The Rothera Modernisation construction works are planned to take place during the austral summers of four consecutive Antarctic seasons as follows:

- Season 1 – 2019-2020
- Season 2 – 2020-2021
- Season 3 – 2021- 2022
- Season 4 – 2022 – 2023

Some site investigation works have previously been undertaken in the 2018 season however these were captured under a separate EIA submission and are not included in the scope of this document. A high level overview of the programme.

Season 1 – 2019-2020

The works in the first construction season consist of the following core activities:

- Decommissioning of the Miracle Span
- Construction of the Interim Waste Management Facility
- Diversion of site services including earthworks
- Excavation (mechanical & blasting)
- Installation of pre-cast concrete elements

Season 2 – 2020-2021

- Installation of site wide services
- Installation of precast slabs both ground floor and first floor
- Pre-assembly of roof elements
- Installing steel frame and building envelope

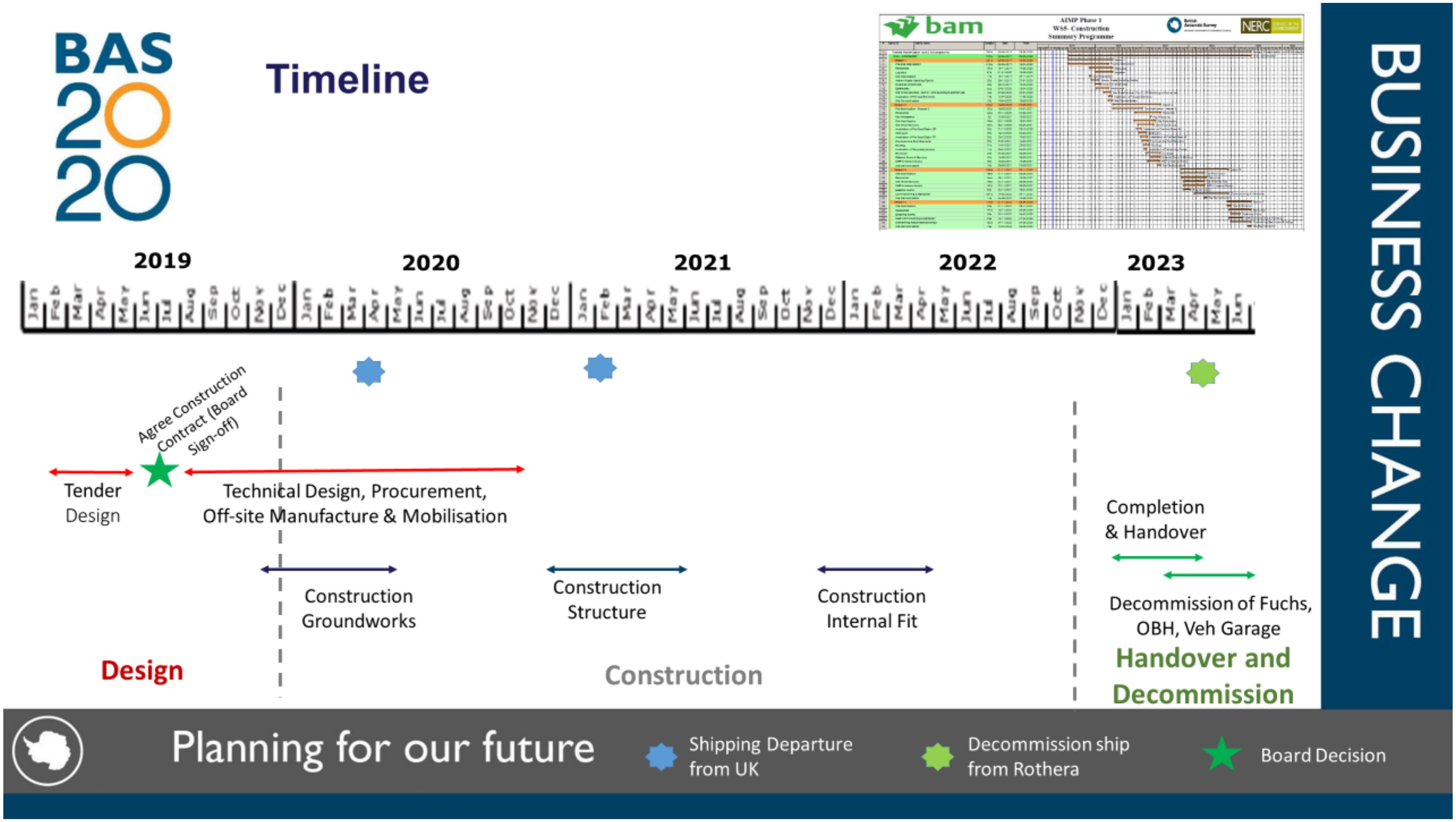
Season 3 – 2021- 2022

- MEP and Internal works to building
- External works
- Commissioning & Handover

Season 4 – 2022 – 2023

- Enabling works
- MEP commissioning & handover
- Dismantling redundant buildings

A construction programme and narrative are included in Chapter 6.


BAS 2020
Timeline
bam
BUSINESS CHANGE
2019
2020
2021
2022
2023
Agree Construction Contract (Board Sign-off)
Tender Design
Technical Design, Procurement, Off-site Manufacture & Mobilisation
Construction Groundworks
Construction Structure
Construction Internal Fit
Completion & Handover
Decommission of Fuchs, OBH, Veh Garage
Design
Construction
Handover and Decommission
Planning for our future
Shipping Departure from UK
Decommission ship from Rothera
Board Decision

3.11 Site set up and laydown

Figure 3-31 to

Figure 3-33 illustrate the main laydown areas that are proposed to be used for storage of equipment, plant, temporary facilities, and rock processing as well as identifying the main construction site. As the project develops the laydown requirements will vary, so each season the site laydown areas will change depending on the activities being under taken.

Discussions between the Rothera Wharf & Rothera Modernisation construction teams and relevant BAS departments have taken place in order to identify the most appropriate location for these areas and have taken into account key operational and science requirements including:

- Sufficient clearance to allow flight operations to proceed with minimal interruption.
- Sufficient clearance to existing buildings to limit additional snow accumulation.
- Access routes which minimise crossings with existing services and facilities.
- Minimal disruption to ongoing science programmes and research.
- Utilising the existing station footprint and avoiding encroaching on relatively un-impacted areas.

The following plan for Season 1 Laydown areas which includes proposed stockpiling and screening locations is currently under discussion with BAS Operations and is pending final approval.

3.11.1 Overburden Excavation

The Rothera Modernisation earthworks are planned to commence at the end of January 2020. The construction site in the centre of the station, will be cordoned off with fencing to create a safe working area followed by excavation of surface cobbles and overburden. There is an estimated 6700m^3 of overburden material sat on the granodiorite bedrock. The overburden will be processed as follows:

- An estimated 600m^3 of surface cobbles will be raked off and taken by 30t dumpers to the designated stockpile north of the aircraft hangar.
- The remaining overburden will be screened on the construction site to produce a 6N1 engineered fill and oversized rock.
- The 6N1, with a grading from 80mm down to fines (0mm), will be used as fill to provide a cohesive platform under the building.
- The oversize material, sized greater than 80mm, will be stockpiled on the West side of the runway adjacent to the boatshed using the same site for oversized rock from the Wharf excavations. An estimated 15% of the overburden material (c.1100m^3) will oversized. Oversized rock could be used for the stabilisation of the runway or wharf backfill based on design requirements.
- A contingency, and temporary, stockpile area for overburden 6N1 is provided for north of New Bransfield House which has capacity for 1100m3 of rock.

See

Figure 3-31 Site laydown at start of Season 1 February 2020 and

Figure 3-32 Site laydown midway through February 2020 Season 1.

3.11.2 Drill & Blasting

From late February 2020, the blasting and mechanical drill excavation works will commence. To provide room for this operation the screener will be moved from the central construction site, to the East side of the runway adjacent to Admirals. The excavation, drill and blast operation is planned to last for just over a month with 26 blasts. The material from each blast will be removed by an excavator and loaded onto 30t dumpers. Once screened the engineered fill will be used to:

- Prepare the vehicle access roads,
- The site wide services access tracks,
- The container storage area south of the hangar
- Completion of the building platform.

The excess quarried material will be stored along the east side of the runway outside the runway exclusion zone where the Wharf project material was stockpiled for the 2018/19 Season. By the end of March the stockpile will increase to an estimated 8200m^3, below the stockpile capacity for 10,000m^3.

Oversized material will equate to 20% of the rock output which will be stockpiled between the area on the point (south of Giants House towards the memorials) which has capacity for 1800m^3 and the west side of the runway. The west side stockpile will be capable of holding up to 3000m^3.

Before the end of the 2020 season the runway 6N1 stockpile will be reduced to accommodate:

- 2,700m^3 for creating the building platform within the construction site area,

- 1,300m^3 fill for the mat to support the 300tonne crane
- 1,700m^3 to cover the building up to the underside of the building slab after installation of the concrete inclusions.

At the end of the season it is anticipated that there will be the following stockpiles:

- West side of runway, located north of the hangar a stockpile comprising of cobbles 600m^3 spread up to 500mm thick
- West side of the runway located adjacent to the temporary boat shed comprising of oversize material will be a stockpile up to 3000m^3
- East side of the runway (located to the south of station towards the memorials) comprising of oversize material will be stockpile up to 1800m^3 but an estimated likely amount of 1000m^3.
- East side of runway 6N1 stockpile, an estimated 2700m^3
- East side of runway located north of New Bransfield House, it is anticipated that all stockpiles will be removed by the end of the season
- Construction site stockpiles will be diminished by the end of the seasons and all fill will have been placed and compacted. No stockpiles at the end of the season.

See

Figure 3-33 Site laydown March 2020 Season 1.

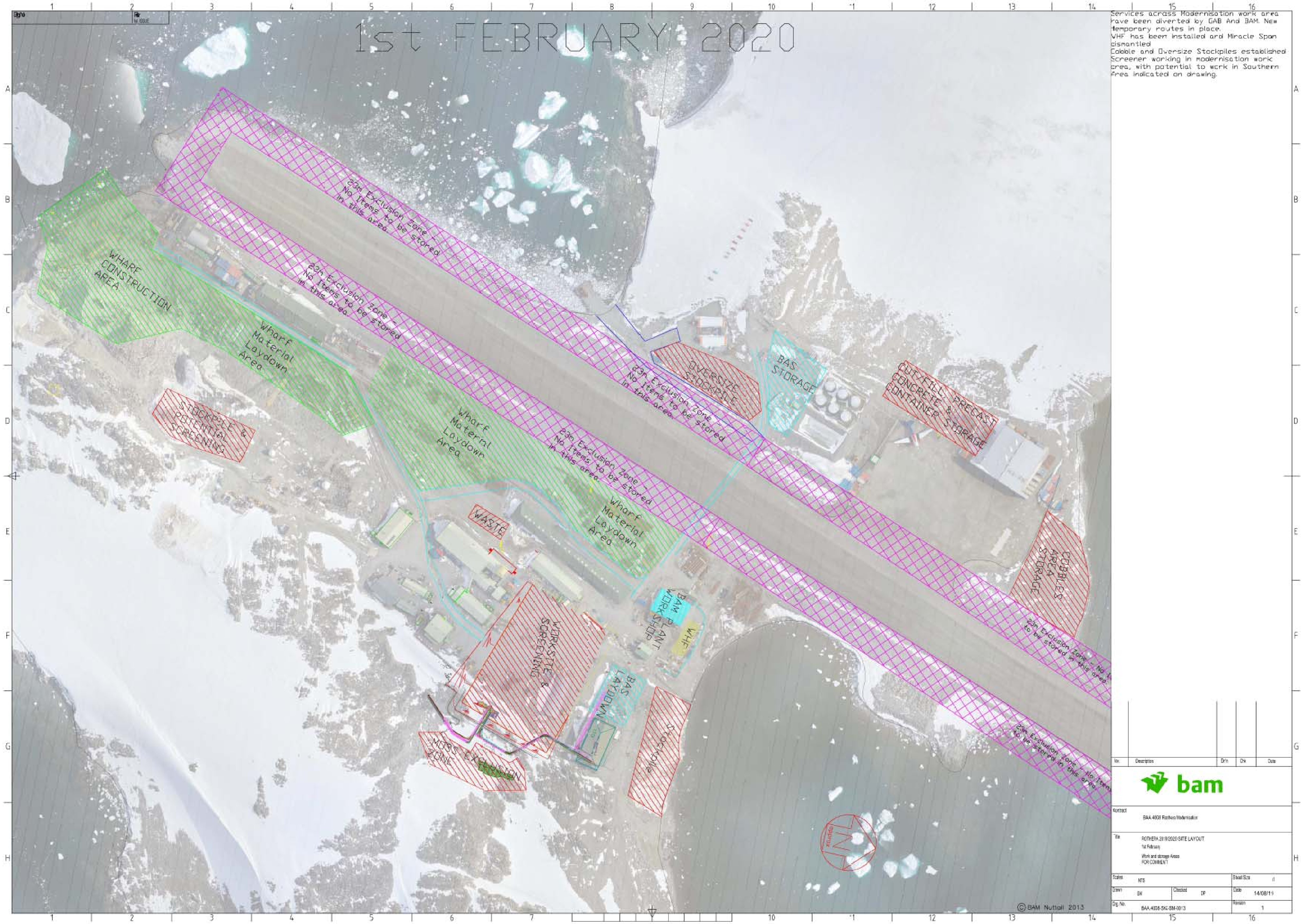
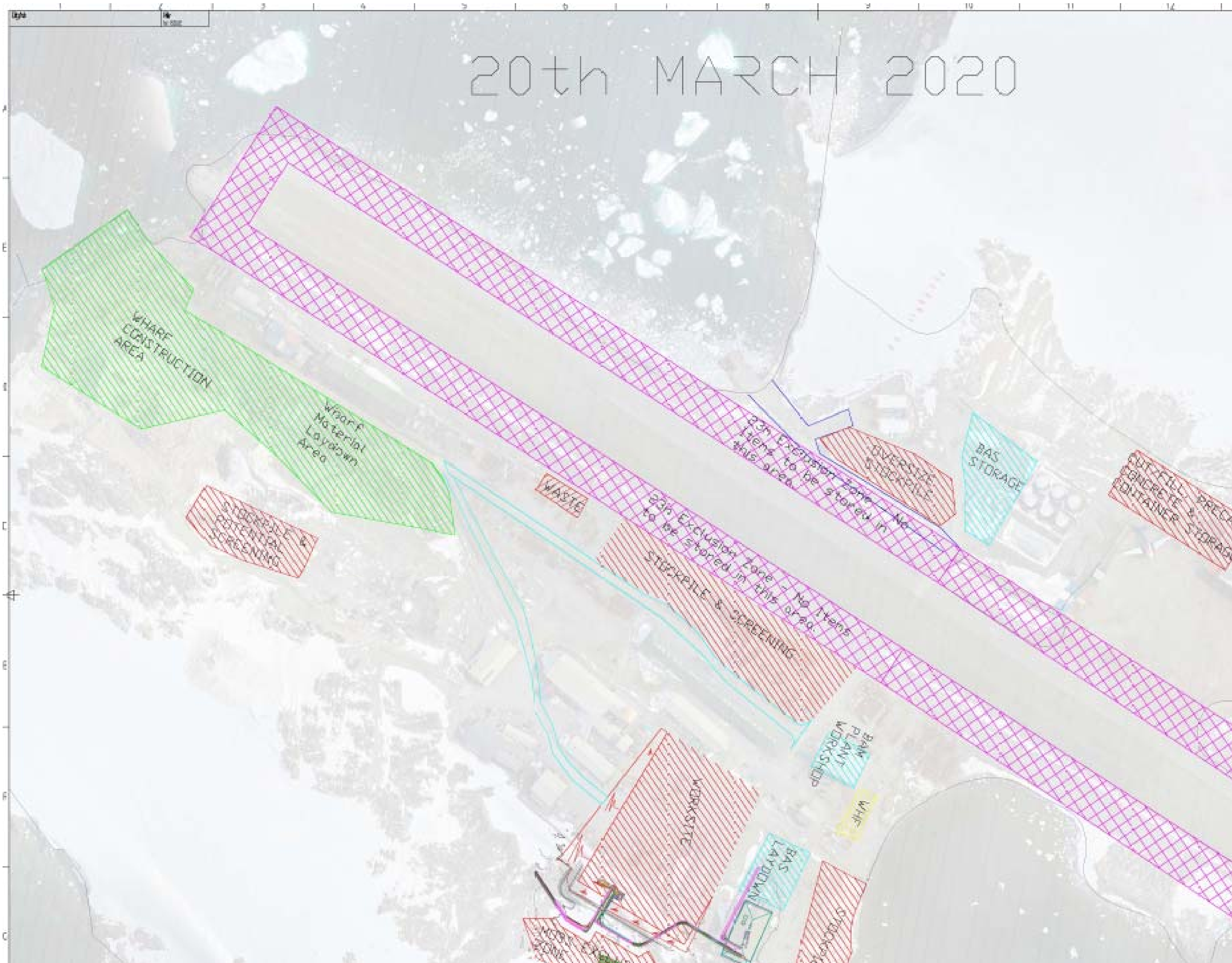


Figure 3-31 Site laydown at start of Season 1 February 2020


20th FEBRUARY 2020
23m Exclusion Zone - No Items to be stored in this area.
23m Exclusion Zone - No Items to be stored in this area.
23m Exclusion Zone - No Items to be stored in this area.
23m Exclusion Zone - No Items to be stored in this area.
WHARF CONSTRUCTION AREA
Wharf Material Laydown Area
Wharf Material Laydown Area
STOCKPILE & POTENTIAL SCREENING
OVERSIZE STOCKPILE
BAS STORAGE
CUT/FILL, PRECAST CONCRETE & CONTAINER STORAGE
WASTE
STOCKPILE & SCREENING
WORKSITE
BAM PLANT WORKSHOP
WHF
BAS LAYDOWN
STOCKPILE
A
B
C
D
E
F
G
1
2
3
4
5
6
7
8
9
10
11
12


20th MARCH 2020
WHARF CONSTRUCTION AREA
Wharf Material Laydown Area
STOCKPILE & POTENTIAL SCREENING
WASTE
23m Exclusion Zone - No Items to be stored in this area.
23m Exclusion Zone - No Items to be stored in this area.
STOCKPILE & SCREENING
OVERSIZE STOCKPILE
BAS STORAGE
BAM PLANT WORKSHOP
WHF
WORKSITE
BAS LAYDOWN

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3.12 Anticipated waste

All construction waste will be managed onsite by the construction team. Domestic waste will be incorporated into the standard BAS waste management system. See Section 6.2 Operational Procedures: Waste Management, for further detail and Appendix B: *Rothera Modernisation Site Waste Management Plan (SWMP).*

The SWMP defines the selected waste management measures of prevention, reuse, recycling and recovery and, at the end of the project. This allows a comparison to be made between forecast and actual waste quantities. Generation of waste material will be minimised at every stage of the project (design, procurement and construction), and reduction strategies will be implemented and detailed in the SWMP.

Estimates of the quantities of waste produced will be carried out monthly. These estimates will be used to inform the construction team of their waste reduction performance. The anticipated tonnage and volumes for waste from the Rothera Modernisation excavation, construction and demolition activities are listed below. Further information is provided in Appendix B:

Figure 3-34 Excavation Waste

Type of Waste	EWC Code	Estimated Quantity Tonnes/(m^3)					Waste Management Action in Detail
		Total	Re-Use	Recycle	Recover	Dispose	
Inert Soil and Stone	17 05 04	72,150 (6,900)	72,150 (6,900)				Material to be re-distributed on site at Rothera

Figure 3-35 Construction Waste

Type of Waste	EWC Code	Estimated Quantity kg/(m^3)					Waste Management Action in Detail
		Total	Re-Use	Recycle	Recover	Dispose	
Steel	17 04 05	4,000 (0.51)		4,000 (0.51)			
Concrete / Grout	17 01 01	1,150 (0.5)	1,150 (0.5)				Waste grout to be crushed and used
Cementitious Wash Water		10,000 (10)				10,000 (10)	Solids removed, remaining liquid
Alkaline Batteries	20 01 33	14 (0.005)				14 (0.005)	
Clothing / Textiles	20 01 10	50 (2.0)				50 (2.0)	
Cardboard	20 01 01	2,600 (20)		2,600 (20)			
Paper	20 01 01	150 (2.0)		150 (2.0)			
Timber	17 02 01	2,500 (5.0)	1,000 (2.0)	1,500 (3.0)			
Plastic	20 01 39	6,000 (6)		3,600 (3.6)	1,500 (1.5)	900 (0.9)	

Oil	13 02 07	5000 (5)				5000 (5)	
Oil Filters	16 01 07	50 (0.1)				50 (0.1)	
Oil Contaminated Rags	15 02 02	50 (0.2)				50 (0.2)	
Aerosols	16 05 04 16 05 05	64 (0.3)		32 (0.15)		32 (0.15)	
Glass	17 02 02	100 (0.02)					Stored in 205 litre steel drum

Figure 3-36 Demolition Waste

	Concrete	Wood	Steel	Insulation	Plaster Board	Calcium Silicate Board	Cement Particle Board	Aqua Elite Board	Acoustic Insulation
	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)
Fuchs House	44.08	70.47	0.10	173.81					
Old Bransfield House	95.11	347.83	3.60	656.78		5.62		22.66	2.27
Ops Tower	20.00	18.11	2.57	25.83	9.12	0.10			
Generator Shed	75.38	22.06	2.00	47.43			7.538		
Tractor Garage	107.28	22.84	5.60	28.02	3.79				
Miracle Span	84.86		0.80						
Chippy Shed / Binghams	2.29	20.28		39.55					
Totals	**429**	**501.59**	**14.67**	**971.42**	**19.18**	**6.44**	**8.76**	**22.66**	**2.27**

Figure 3-37 Demolition Waste from Removal of Services.

*It is anticipated that there may be asbestos waste generated when Old Bransfield House is demolished. Preliminary surveys indicate the risk is low however it could be in the region of up to a tonne of waste if found. Expert contractors will be on site to safely remove and package for disposal outside of the Treaty area.

	Metals				**Plastics**							**Wood**
	Copper	**Steel**	**Al.**	**Galv. Steel**	**PVC**	**HDPE**	**ABS**	**PP**	**PE**	**Armaflex**	**Insudite**	**Ply**
	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)
Electrical	1.29	0.67			3.79							
Fuel		1.09										
Heating					0.18							
Potable Water						0.6						
Sea Water					1.29		0.51	0.28	22.29			
Waste Water					1.36		0.36			9.23		
Fire Systems	0.03		0.01								0.14	
Data	0.001								0.008			
Ducting						2.59						
Wooden Box Trunking												38.95
Cable trays				0.34								
Totals	**1.32**	**1.76**	**0.01**	**0.34**	**6.62**	**3.19**	**0.87**	**0.28**	**22.30**	**9.23**	**0.14**	**38.95**

3.13 Personnel

Construction personnel will be on site at Rothera from November to April/May in all four construction seasons. Equipment and materials will be demobilised from Rothera by the end of austral summer in 2023 by ship.

It is anticipated that the maximum numbers of construction personnel on site at any one time each season will be as follows:

- Season 1 2019-2020 Maximum number on site at any one time 27 Pax
- Season 2 2020-2021 Maximum number on site at any one time 45 Pax
- Season 3 2021-2022 Maximum number on site at any one time 52 Pax
- Season 4 2022-2023 Maximum number on site at any one time 30 Pax

Table 3-10 below provides a breakdown of the total number of personnel on station during each season. Not all of the personnel listed below will be on station at the same time however.

Figure 3-38 Numbers of personnel on station

	Season			
Job Title	Season 1	Season 2	Season 3	Season 4
Senior Agent	1	1	1	1
Sub-Agent	1	1	1	1
Site Engineer	1	1	1	1
General Foreman	1	0	0	1
Section Foreman	0	1	1	0
Drill Rig Operator	2	0	0	0
Plant Operator	6	5	4	5
Dumper Driver	2	2	0	0
Banksman/Slinger	3	5	2	3
Dozer D6T	0	1	0	0
Scaffolders	0	2	0	0
Steel Erector	0	7	0	0
Cladding & Interiors	0	10	0	0
Door Fitters	0	4	0	0
Logistics Team	3	4	4	3
CEO	11	9	7	10
MEP Manager	1	2	1	0
Mechanical Eng.	1	8	10	0
Electrician	1	8	10	1
Carpenter	0	0	10	0
Asbestos contractor				4
Maximum number of staff on site during the season **(not necessarily concurrently)**	34	71	52	30

3.14 Plans for decommission proposed development

At the end of the new Operations Building lifetime there is an obligation to remove the structure whilst mitigating the effect of the surrounding environment. It is envisioned the following will be taken into consideration:

- Reuse the majority of the equipment and furniture in the building either on station or returned to the UK.
- Deconstruct rather than demolish the building.
- Planning in advance of the deconstruction to demonstrate opportunities of reuse or recycling.
- Materials which could be reused on site include:
  - concrete foundations and perimeter wall;
  - thermosal products;
  - steel stairs and walkways;
  - secondary steel supports;
  - glass partitions;
  - prefabricated units;
  - solar panels;

The following general sequence for deconstruction may be used:

- Disconnect existing services and set up temporary low voltage lighting and heating.
- Remove all FFE and hazardous materials
- Take down the walls and partitions.
- Remove prefabricated units including the sauna and MEP equipment
- Create a large internal space on the two floors mitigating noise and dust issues to the surrounding environment
- Remove the external attachment including the solar panel, balcony and louvres.
- Deconstruct the roof and wall cladding placing the units in containers for processing in the UK
- Remove the secondary steel and then reverse engineer the steel frame removal. All members placed in containers for reuse/recycling in the UK.
- All concrete flooring and ground level units de-bonded and packed for crushing on site or in the UK.
- The foundations will be distressed from the ground anchors and processed along with the other concrete products.
- The anchors will be surveyed and then cut off 1m below ground level.
- The ground profile under the building plot will be landscaped to blend in with the surrounding environment using materials natural to Rothera.

4 CONSTRUCTION METHODOLOGIES

4.1 Operations Building

The proposed scientific operations building will be a 90 by 30 metre two-storey (14m high) steel framed structure on a 2.2m grid with an anchored concrete bearing pad foundation. The floor system comprises a ground bearing concrete slab to tolerate lateral movement on the ground floor, and a suspended precast concrete slab on the first floor. The external wall system is formed of either a pre-constructed Structural Insulated Panels (SIPs) or composite panel.

The construction works discussed in the subsequent paragraphs are divided between 3 construction seasons with groundworks in Season 1; erection of the steel frame columns and beams, roof and external wall system complete in Season 2; and the internal fit-out in Season 3.

Season 1

4.1.1.1 Earthworks

Steel Frame construction methodologies begin with the construction of its foundation and thus, preparation of a working platform. The ground must be level for construction but also adjusted to a height that allows for safe operation of vehicles using the building and for appropriate access in its near environs. The loose materials will be removed with excavators until solid rock or the formation level is reached. A combination of mechanical breaking and blasting of rock will be conducted on consecutive days over a 26-day period between February and March 2020 to excavate rock to the required formation level. Materials for reuse will be screened and re-laid on the West side of the work area where infill is required to reach the required formation level in preparation to install the ground anchors and concrete foundations. Remaining quarried rock excavated to level the working area will be stockpiled on station.

Following the installation of the concrete foundations the area will be backfilled to the Ground Floor Finished Floor Level (FFL).

Construction Activities;

- Excavate the loose rocks / pebbles from the footprint of the building.
- Drill blast holes on east side of working platform to complete blasting of fissured rock.
- Transport the materials to and from the stockpile areas
- Screen and crush the materials, if required
- Maintain the stockpile areas
- Backfill the west side of new building
- Backfill and compact around the concrete foundations

Plant;

- 3 No. Excavators
- 2 No. Articulated Dump Trucks
- 1 No. Wheel loader / Bulldozer

Personnel;

No. Plant Operators

- 3 No. Banksman

Materials;

- Quarried Rock: 15,258m3 of rock to be excavated.

- Sand: 100m^3 washed marine dredged sand supplied in sealed one ton bags.
- Backfill: 11,114m^3 will be used to fill the working platform of the operations building.

4.1.1.2 Ground Anchors

The concrete foundations will be connected with ground anchors to the underlying rock. To install the ground anchors holes will be drilled at the centre of the concrete foundations. After drilling the ground anchor will be installed and grouted to the required level.

Construction Activities;

- Set up drill rig and drill holes to the required depth
- Install prefabricated ground anchors
- Apply grout to the required level around the ground anchor

Plant;

- Drill Rig D7
- Telehandler
- Tractor with water bowser
- Grout pump

Personnel;

- 1 No. Driller
- 1 No. Banksman

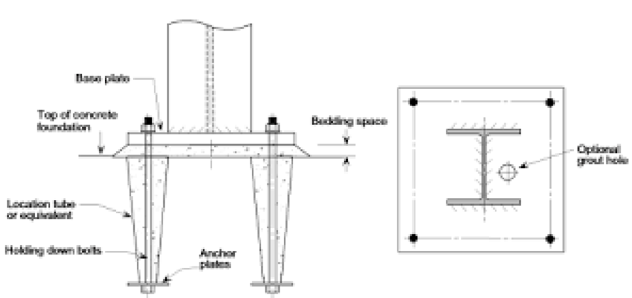
Materials;

- Steel Anchor: 62
- Grout: 20m^3 Conbextra GP non-shrink grout

4.1.1.3 Foundations & retaining walls

The foundations will be installed with a crane positioned on a working platform set at a suitable level under the Ground Floor Finished Floor Level (FFL). The pockets for each foundation and the retaining wall will be excavated to the required level followed by installation of a geotextile layer then 100mm layer of compacted 30mm graded fill. An additional nominal layer of sharp sand will be spread under the foundation to provide greater connectivity to the underlying ground bearing fill materials.

Each foundation will be positioned using coordinated positioning along with a line & level backup. This dual system will check the alignment and distance between each foundation. The foundations are the most important part of the building structure as they create the position and support for all the above structure.



A similar method will be used for the installation of the retaining wall on Grid Line 9 of the operations building and the perimeter wall. After installation the surrounding void will be back filled with 80mm graded fill. An overburden layer of fill will protect the foundation and holding down bolts during the austral winter period. Only part of the protective perimeter wall will be installed in the first season, with the remainder constructed at the start of season 2 ahead of the floor and steel frame erection.

Main Plant;

- 35t Excavator
- 8t Excavator
- 30t CAT Dumper
- 75t Rough Terrain Mobile crane
- Telehandler JCB 535-140 (when required)
- Articulated Dump Truck 28t CAT 730
- Plate Compactor Robotic 1400kg/ m2
- Roller Compactor Bomag/ CAT 120/ CB7
- Container Handler Cat V900 or similar (Type TBC)
- Agricultural Tractor 4x4 200hp New Holland T6090
- Flatbed trailer
- Survey equipment
- Small tools

Personnel;

- machine operators
- 2 Banksmen / Slingers
- 2 General operatives

Materials;

- 1300m^3 of 80mm graded locally won fill (6N) (6F2) to be used under the building to bring levels back up to formation.
- Approximately 1000m^3 of 30mm graded locally excavated fill.
- Sharp sand - 100m^3. This will be sourced from a marine environment, washed and stored in sealed bags in accordance with the biosecurity regulations and the BAM biosecurity management plan.
- 71 x precast concrete foundation blocks, 51 have holes to accommodate connections to the ground anchors.
- Precast retaining wall units: The retaining wall will be formed of 4 parts, each weighing approximately 11 tonnes.

Season 2

4.1.1.4 Preliminary works for steel erection

The steelwork, floor system and external envelope will be installed in the second season to ensure the building is weather/water tight before the austral winter season commences in May 2021. Before erection occurs the following enabling works need to be undertaken.

- Initial seasonal site setup and snow clearance
- Remove any the overburden to required level and any frost effected fill and then re-compact
- Setup the pedestrian walkways, haulage routes and site boundary.
- Create the exclusion and restriction zones

All fill materials will be compacted in accordance with the earthworks specification (95%) and crane platform temporary works requirements.

Main Plant;

- 35t Excavator
- 8t Excavator
- 30t CAT Dumper
- Telehandler JCB 535-140 (when required)
- Articulated Dump Truck 28t CAT 730
- Plate Compactor Robotic 1400kg/ m2
- Roller Compactor Bomag/ CAT 120/ CB7
- Container Handler Cat V900 or similar (Type TBC)
- Agricultural Tractor 4x4 200hp New Holland T6090
- Flatbed trailer
- Survey equipment

Personnel;

- machine operators
- 2 Banksmen / Slingers
- 2 General operatives
- 1 Electrician (BAS Support Staff)

Materials;

- Fencing
- Site compound containers
- Electrical connections.

4.1.1.5 Ground Bearing Concrete Flooring

Once the perimeter wall has been established in each sector (Grid line 12-9, 9-4, 4-1) the ground bearing slabs will be installed. The general sequence for installation will be:

- Placement and compaction of general fill to within 600mm of the FFL
- Where required, placement of a geotextile to contain the 100mm layer of compacted fines and sand 30mm down.
- A layer of Damp Proof Membrane (DPM) will be placed on top of the fill. A non-compressible insulation placed on top of the DPM. A further layer of DPM will be placed on top of the insulation
- The floor slab placed and checked for line and level.
- Adjacent units laid along the grid lines, set up relative to the future primary steel column locations. A set of four floor panels will cover the space between each grid line.
- Installation of steel vehicle pit
- Recheck integrity and then tighten the mechanical joints.
- Repeat across the width and length of the building ahead of the steelwork erection.

Main Plant;

- Crawler Crane 55m Boom 300t Liebherr LR1300 with fly jib
- 75t Rough Terrain Mobile crane
- Container Handler Cat V900 or similar (Type TBC)
- MEWP Scissorlift >44ft. Electrical
- Scaffold access platforms
- Agricultural Tractor 4x4 200hp New Holland T6090
- Flatbed trailer

- Crawler Excavator 8t Caterpillar CAT308E
- Articulated Dump Truck 28t CAT 730
- Grout Mixing Plant 410
- Survey equipment

Personnel;

- 3 crane operators
- 3 plant operators
- 2 Banksmen / Slingers
- 2 General operatives
- 2 Steel erectors

Materials;

- Precast concrete components: 3,100 Tonnes
- Geotextile: 1700m^2
- 1200 Gauge DPM: 7,000m^2
- Tape to seal 1200 Gauge DPM: 2,000m
- Grout / infill material: 20m^3
- Connection materials
- Sharp Sand: 20m^3
- 150mm Kingspan Green Guard GG700 insulation (Non compressible insulation): 3,300m^2
- 100mm Kingspan Green Guard GG700 insulation:300m^2
- 1 x Steel vehicles pit (dimensions 0.8 x 7.5 x 1.4m).
- Expansion Joint Compressible Filler Board 300mm wide Non compressible insulation.
- Cemtop GP self-levelling floor surfacing system: 100m3

4.1.1.6 Primary Steelwork Frame

All operations for the cranage will be undertaken from the North side of the structure. The 30m wide expanse of level ground, with a one metre step, is ideal for the two 300t crawler cranes & 75t mobile cranes. Each crane will be setup with suitable boom and fly jib to lift the required loads on the far side of the building. The cranes will sit near the centre of the building. Crane 1 will predominately work from East to the centre (Grid Line 12-4) and crane 2 from the Centre to the West (Grid Line 4-1). The Crane Appointed Person (AP) will ensure they are set up safely. All primary steelwork along with specific secondary steel will be installed up to the mechanical level. The connections will be protected with intumescent paint before the concrete flooring or other materials are installed.

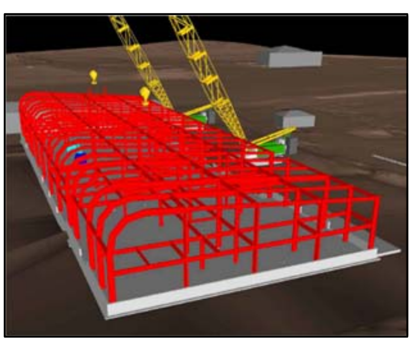


Figure 4-1 Internal frame structure

Main Plant;

- Crawler Crane 55m Boom 300t Liebherr LR1300 with fly jib
- Container Handler Cat V900 or similar (Type TBC)
- MEWPS Cherry pickers
- Agricultural Tractor 4x4 200hp New Holland T6090
- Flatbed trailer
- Grout Mixing Plant 410
- Compressor 950cfm Atlas Copco!
- Survey equipment

Personnel;

- 3 crane operators
- 3 plant operators
- 2 Banksmen / Slingers
- 2 General operatives
- 2 Steel erectors

Materials;

- UB steel components: 400 Tonnes
- Grout: 20m^3
- Connection materials (Lindapter type AAF high slip resistance clamp. Bolt and plate): 1700 no.
- M20 bolts, grade 8.8, galvanised. 100mm long: 260 no.

4.1.1.7 Steelwork Roof

Once a stable steel frame structure has been established and plumbed in on each of the three sectors (GL12-9, 9-4, 4-1), the first floor suspended slabs and stair units will be positioned and installed

The stairs will be installed before the upper floors. This will provide safe access to personnel working on the concrete floor leading edge. The general sequence for installation of the concrete stairs:

- Position the 1st set of steps in relation to the support steel frame and ground floor concrete slab.
- Install the intermediate landing and tie together
- Lay second set of steps to the first floor.
- Install the upper floor landing and tie together
- Install temporary handrails and landing protective matt (lip at top of steps).

The general sequence for installation of the first floor suspended floor slabs:

- Lay slab adjacent to primary support beam and column. Personnel working from MEWPs
- Tie to the column and beam. Personnel working from MEWPs and the completed fixed floor with temporary edge support.
- A set of four slabs are laid between primary steel members.
- Recheck slabs for integrity and alignment with each other.
- Mechanical joints tightened.
- Repeat across the building. 90 slabs in total.

Main Plant;

- Crawler Crane 55m Boom 300t Liebherr LR1300 with fly jib
- 75t Rough Terrain Mobile crane

- Container Handler Cat V900 or similar (Type TBC)
- MEWP Scissorlift >44ft. Electrical
- Scaffold access platforms
- Agricultural Tractor 4x4 200hp New Holland T6090
- Flatbed trailer
- Crawler Excavator 8t Caterpillar CAT308E
- Articulated Dump Truck 28t CAT 730
- Grout Mixing Plant 410
- Survey equipment
- Small tools

Personnel;

- 3 crane operators
- 3 plant operators
- 2 Banksmen / Slingers
- 2 General operatives
- 2 Steel erectors

Materials;

- Precast concrete components: 1,100 Tonnes
- Grout / infill material: 20m3
- Connection materials
- Cemtop GP self-levelling floor surfacing system: 100m3
- 150mm diameter twin wall flexible ducting (black) 300 m
- 100mm diameter twin wall flexible ducting (black) 30m

4.1.1.8 Steelwork Roof

Once the concrete inclusions have been installed the cranage will concentrate on the secondary steel for the building envelope. The 300t cranes will lift each beam into position under the guidance of the team working from two MEWPS to fix them into position. As each sector of the building (GL12-8, GL8-4, GL4-1) is finished the cladding system will be installed by a separate specialist team.

The steel roof structure will be erected on the ground in a designated area adjacent to NBH. The 30m long roof will be constructed in two sections with the roof under the wind deflector built separately to the remainder. The steel frames will be built on a flat prepared level crane platform. A frame template will sit of the ground ready to receive the roof components. The roof primary, secondary, purlins and miscellaneous steel will be placed and tightened. Using slung loads from the tele-handler and excavator cranage. Where applicable this will include two vertical stub columns (each grid line) required to tie into the roof beams.

Main Plant;

- Crawler Crane 55m Boom 300t Liebherr LR1300 with fly jib
- 75t Rough Terrain Mobile crane
- Container Handler Cat V900 or similar (Type TBC)
- Telehandler JCB 535-140
- Crawler Excavator 35t Caterpillar CAT336D
- MEWP Scissorlift >44ft. Electrical
- Scaffold access platforms
- Compressor 950cfm Atlas Copco!

- Agricultural Tractor 4x4 200hp New Holland T6090
- Flatbed trailer
- Survey equipment
- Small tools

Personnel;

- 3 crane operators
- 3 plant operators
- 2 Banksmen / Slingers
- 2 General operatives
- 2 Steel erectors

Materials;

- UB steel components: 400 Tonnes
- Grout: 20m^3
- Connection materials (Lindapter type AAF high slip resistance clamp. Bolt and plate): 1700 no.
- M20 bolts, grade 8.8, galvanised. 100mm long: 260 no.

4.1.1.9 Installation of building envelope

Build-up of the elements

The wall elements will be either a prefabricated Structural Insulated Panels (SIP) or composite panel to the full height of the building. The width of the elements will generally range from 2.2 - 2.5m. The windows, louvres, protrusions and provisions will be installed in the factory. After installation of the wall and roof elements, the metal cladding is to be installed on top of the SIPs. The installation of the wall elements of the building envelope is divided into two sections for the two LR1300 crawler cranes, which are located at the North side of the building.

The panels are to be numbered for ease of installation on site. Containers with elements will be placed on site by trailers containing the required numbers in order of installation per day to minimize obstructions on site.

Installation of the wall elements

The installation of the wall elements of the building envelope is divided in two sections for the two LR1300 crawler cranes which are located at the North side of the building.

Sequence of works will be as follow:

	Orientation	Grid line	Crane
1	North	12 to 9	Crane 1 (LR1300)
2	East	All	Crane 1 (LR1300)
3	South	12 – 9	Crane 1 (LR1300)
4	North	9 – 1	Crane 2 (LR1300)
5	West	All	Crane 2 (LR1300)
6	South	9 – 1	Crane 2 (LR1300)

The north side of the building will be erected first to protect the internal structure from the prevailing wind. This will also reduce the impact of the wind when installing the South side elements.

- Installation of brackets for the connection of the wall elements onto the steelwork.
- All work at height will be from MWEPs or proprietary scaffold towers.

- Wall elements will be rolled out of the container on skids. The lifting attachments are to be connected to lifting points installed inside the wall elements.
- Wall elements are to be lifted into the correct position and connected to brackets number 1 – 3 as per the table.
- After checking the alignment, the element will be adjusted to ensure correct alignment
- Once wall elements 1 – 3 are installed, the same sequence of work will be performed for wall elements 4 - 6 using crane 2.
- After approval of the alignment of the building elements, the capping is to be installed.
- Installation of outstanding works:
    - Installation of cantilever steel of science balcony
    - Flashing at connection: bottom of the façade and the concrete plinth.
    - If required additional MEP apertures through the façade
    - Installation of MEP services through the apertures of the wall elements.

Main Plant:

- Crawler Crane 55m Boom 300t Liebherr LR1300 with fly jib
- Container Handler Cat V900 or similar
- MEWPS Cherry pickers
- Agricultural Tractor 4x4 200hp New Holland T6090
- Flatbed trailer
- Survey equipment
- Vacuum lift for wall elements
- Small Tools

Personnel;

- 2 No. Plant operator
- 2 No. Banksman
- 1 No. Slinger / signaller
- 1 No. Supervisor building envelope
- 8 No. Building Envelope installers (2 teams)

Materials:

- Lifting accessories
- SIP wall elements: 12mm OSB board, PIR insulation, 12mm OSB board. Vapour barrier is to be applied on inner and outer site of the SIP Panel.
    - Wall Panels North Side (Type A & B together): 642.15 m²
    - Wall Panels South Side (Type E & F together): 602.37 m²
    - Wall Panels East Side (TYPE i): 207.42 m²
    - Wall Panels West Side (Type J): 207.42 m²
- Flashing, capping, mechanical joints

Installation of roof panels

The roof elements consists of curved and straight roof elements which are both: 2.2m wide.
In the factory, 2 no 1.1m wide SIPs have been connected together. The external cladding, sky lights and provisions for the wind deflector have also been incorporated during assembly in the factory. The roof elements will be installed using the 2 no. LR1300 crawler cranes as shown below.

Sequence of works will be as below.

	Orientation	Grid line	Crane
1	South Element E	Curved sections radius: 3.4m including thermal breaking for wind deflector. Grid line: 12 – 9.	Crane 1 (LR1300)
2	South Element E	Curved sections radius 3.4m including thermal breaking for wind deflector. Grid line: 9 – 1.	Crane 2 (LR1300)
3	North Element B	Curved sections radius: 0.6m. Grid line: 12 – 9.	Crane 1 (LR1300)
4	North Element B	Curved sections radius: 0.6m. Grid line: 9 – 1.	Crane 2 (LR1300)
5	Gridline: Element C	Straight elements gridline 12 – 9	Crane 1 (LR1300)
6	Gridline: Element D	Straight elements gridline: 12 – 9	Crane 1 (LR1300)
7	Gridline: Element C	Straight elements gridline 9 - 1	Crane 1 (LR1300)
8	Gridline: Element D	Straight elements gridline: 9 – 1.	Crane 2 (LR1300)

Installation of the curved elements

The curved panels (panels E) will be installed; first due to the profile complexity and the vertical fin will include anchor hooks for the fall arrest system. This will create a safe working platform for personnel on the roof.

Installation of outstanding works:

- Louvres located at the West façade
- Installation of balcony
- PV Panel brackets on North façade
- If required additional MEP protrusions through the façade

Installation of the straight roof element

Approval of final alignment primary & secondary steelwork gridline: 9 – 12. Installation of brackets for the connection of the roof elements onto the steelwork. After lifting the elements into correct position and connected to the brackets number: 5 - 8 as per table is to be installed, alignment is to be checked. Each element installed for number 5 of the table has a fall protection eye incorporated in the panels to allow for safe access for the installers on the roof. Access onto the roof can be granted by a temporary scaffolding staircase which is located on the east side of the building on the outer perimeter of the building and by the precast concrete staircase located at the West side at the communications tower.

After installation of panels: D, the panels: C will be installed. As permanent fall protection has been installed in the stubs/fins of the wind deflector which are the panels: E, the temporary fall protection eyes do not need to be included in these SIP panels. The element will tightened/ loosened to ensure correct alignment in line with the ITP. Mechanical joints to be installed every vertical connection to ensure weatherproofing using a MEWP.

The same sequence of work will be performed for gridlines 9 – 1 using crane 2. The similar activity to be completed for the shaft of the communications tower. After final approval of the alignment: elements of table of the building elements the capping and flashing is to be installed. Installation of cladding can be simultaneously once the SIP panel installation is progressing.

Installation of external doors

The external doors can be divided in two categories: personnel & industrial. There are fourteen external doors with four single and four double personnel doors along with seven industrial doors sized 3.0 x 3.5m and one at 5.0 x 5.0m.

The external doors can be divided in two types of doors:
Personnel external doors

- 2 No. Single insulated inward swinging doors
- 2 No. Double insulated outward swinging doors

Industrial external doors

- 7 No. doors dimensions: 3.0 x 3.5m
- 1 No. doors dimensions: 5.0 x 5.0m

Sequence of installation:

- Install the door frame by the bolted connection to the secondary steelworks.
- Lift door into the correct position by forklift/telehandler
- Connect the hinges on the doors onto the door frames top to bottom
- Install the hydraulic actuators
- Install the heat tracing and dual power supply battery to enable the automatic opening and closing of the doors
- Prior to handover remove all protective films and damage preventive packaging

Personnel;

- 1 No. Plant operator
- 2 No. Installation Engineers
- 1 No. Slinger / signaller

Plant:

- 1 No. Telehandler
- 1 No. Forklift
- 1 No. scissorlift

After the wall elements and doors have been have been installed the following elements are to be installed:

- Canopies
- PV panel brackets for installation of the PV Panels
- BAS Logo West façade
- Installation of VHF Aerial antennas East/West and North façade.

4.1.1.10 Installation of external steel structures

Control tower fabrication and installation.
The fabrication of the control tower will take place in the area next to the NBH. The structure primary and secondary steel will be constructed along with the steps, structural floor elements, cladding and roof. Once completed, the walkway, roof handrail and internal finishing along with the primary MEP will be completed. The general sequence for prefabrication and installation will be:

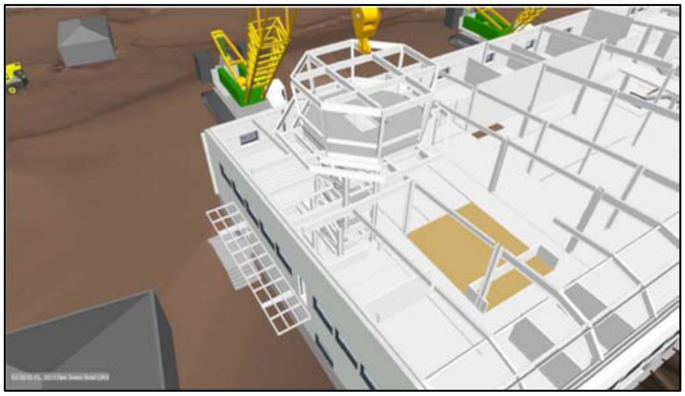


Figure 4-2Installation of the control tower.

A steel template will sit off the ground ready to receive the control tower components. The steel primary frame will be placed on the template using the 75tonne crane and MEWP's. The roof primary, secondary, purlins and miscellaneous steel will be placed and tightened. Using slung loads from the tele-handler and excavator cranage.

Where applicable this will include two vertical stub columns (each grid line) required to tie into the roof beams. Once connected all the steel members will be painted at the joints. The top of the four columns will be used to lift the whole frame into position on the roof. Personnel working in MEWPS and the first floor access platforms will tie the prefabricated roof into the existing structure. The steel work in the gaps between the installed sections will be lifted into position using the 300t cranes.

Main Plant;

- Crawler Crane 55m Boom 300t Liebherr LR1300
- 75t Rough Terrain Mobile crane
- Container Handler Cat V900 or similar (Type TBC)
- MEWP Scissorlift >44ft. Electrical
- Scaffold access platforms
- Agricultural Tractor 4x4 200hp New Holland T6090
- Flatbed trailer
- Grout Mixing Plant 410
- Survey equipment
- Small tools

Personnel;

- 2 crane operators
- 3 plant operators
- 2 Banksmen / Slingers
- 2 General operatives
- 2 Steel erectors

Materials;

- UB steel components: 400T
- Connection materials
- Intumescent paint

Miscellaneous Works

Miscellaneous construction activities for the building structure include the first floor balcony which will be installed near the end of season 2 as carnage becomes available. The structure components will be prefabricated in the area adjacent to NBH. The complete structure, including handrails, flooring and architectural features will be offered up to the protruding steel beams. Once bolted together the connections will be painted and protected. Personnel will work off MEWP's.

Main Plant;

- 75t Rough Terrain Mobile crane
- MEWP Scissorlift >44ft. Electrical
- Scaffold access platforms
- Agricultural Tractor 4x4 200hp New Holland T6090
- Flatbed trailer
- Small tools

Personnel;

- 1 crane operators
- 2 plant operators
- 1 Banksmen / Slingers
- 2 General operatives
- 2 Steel erectors

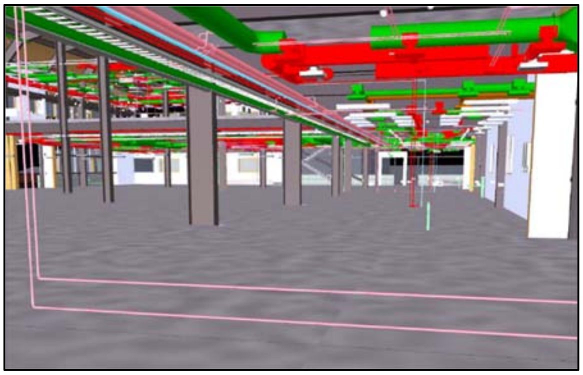
Materials;

- UB steel components
- Metalwork components
- Connection materials
- Intumescent paint

4.1.1.11 Mechanical and Electrical Power Works

The Mechanical Electrical and Power (MEP) Works and internal finishes within the new operations building will commence from mid-2020-2021 Austral Summer Season, with completion by May 2022. The Contractor BAM Nuttall Ltd, and Sub-contractor, G.A Barnies Group will commence the internal fit-out once the roof over the plant room is complete.

The majority of services will be installed within voids above the ceilings. The main items of plant such as the boilers, CHPs, Fuel tanks, oil tanks, hot water cylinders, reverse osmosis (RO) plant pressurisation units, water booster sets and fire pumps will be skid mounted and installed within the Operations Building plant room. Other plant items such as pumps, expansion vessels and heating coils will be installed throughout the building as detailed on the installation drawings. The cold water storage tanks will be supplied in sections and assembled on site. These items of plant will be unloaded and lifted into the building by the use of the site tele-handler and moved into their required positions by the use of skates and plant movers. All plant will be installed in accordance with the relevant manufacturer's installation details.



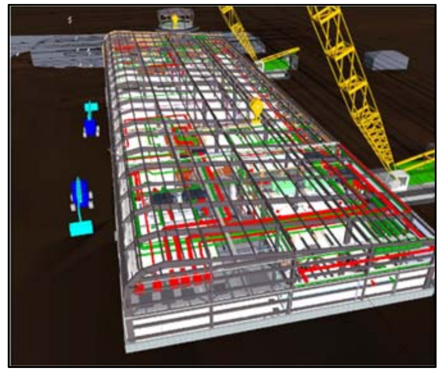


Figure 4-3 First fix MEP within the building before walls installed.

The stores for M&E equipment will arrive on a commercial vessel in January 2021 and will be stored until required for internal fit-out. Containers will not be heated, including storage over the Austral Winter. The new operations Building will be maintained at 5^{o}C from the beginning of season 3 onwards. This will be achieved with a temporary heating system until the plant room is fully commissioned at the end of the season.

A temporary lighting system will be installed during season 2 with three loops to mitigate against power outages. The lighting and other temporary power to the building during construction will be supplied through a site distribution board fed back to the BAS generator shed. Site mobile generators will only be used for backup if there is a power blackout.

Grout is to be mixed in a bunded and hoarded enclosure. Dust levels are to be monitored at sensitive receptors. Dust suppression will be carried out if required using water spray. Washout activities to be undertaken in a fully bunded area using the minimum possible quantity of water. Wash waters to be neutralised before discharge to ground or the sea. Dust from construction activities within the New Operations Building will need to be controlled to ensure the health of operatives. Water spray will be used to supress dust and regular sweep outs will be carried out to remove dust build up.

If noxious fumes are identified as a potential by product during the construction process, this will be carried out in well ventilated areas or forced ventilation will be used.

Waste from construction works will be segregated in bulk bags within the new Operations Building. Full bulk bags will then be transferred to the waste storage containers.

MEP Mechanical

Mechanical – The ductwork for mechanical systems including the drainage, low temperature hot water (LTHW) and water pipes will predominately comprise galvanised sheet metal and transported to site with all ends sealed to prevent contamination and bio security issues. They will be installed within service risers in the ceiling voids or roof space.

The soil stacks will be made from push fit PVC-U and waste pipes in MuPVC with solvent weld fittings. The soil vent pipes (SVPs) will include access points, bosses and branches to connect appliance wastes. They will terminate in ceiling and roof voids with air admittance valves.

MEP Electrical and Data

The main LV switchboard will be provided in modules in the UK. Prior to shipment the main switchboard shall undergo Factory Acceptance Testing (FAT), witnessed by BAM and BAS.

The power & lighting sub circuit cabling will be installed within galvanised steel conduit throughout the Operations Building. These galvanised conduits shall be installed from the main steel trunking containment within the ceiling voids to the final outlet positions within partitions and surface on walls.

The structured cabling within the building shall be installed on cable baskets. PVC Conduit will be installed to protect the cabling from the baskets to the outlets within walls / partitions. We plan to use the following structured cabling systems.

- Cat 6a Cables,
- Fibre Optic Cables,
- VHF antenna cables,

Internal walls

Internal walls will be prefabricated as much as is practically feasible ahead of shipment and installed on station. Many of the provisions and openings will be installed during fabrication to include for MEP containment, penetrations and internal doors and windows.

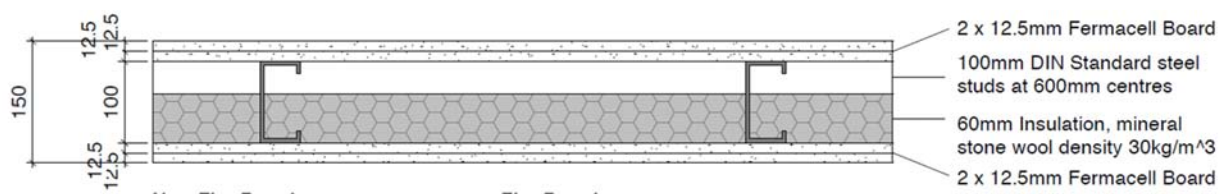


Figure 4-4 Proposed wall structure WT03.

Flooring Surfacing

To prevent inconsistencies in the finished flooring a thin grout layer is applied. The screed layer will ensure a level floor for the end user. An epoxy flooring comprising primer, adhesive and coating will be applied in storage and plant areas. The epoxy has the purposes of removing inconsistencies within the prefabricated floor panels as well as to provide a clean working surface.

The primer coat is applied to the exposed concrete in the UK precast factory. The adhesive and top coat are applied later in the construction process. For the application of the material itself, the building does not have to be heated. The proposed product (Hardener FH super) can be applied at relatively low ambient temperatures down to 3°C.

Energy Mix Marine Gas Oil (MGO) Fuel System and Photovoltaic (PV) Panels

The MGO fuel pipelines shall be installed within the plant rooms of the Operations building. A two pipe system will be installed between the buildings oil storage tanks and the boilers / CHPs. These pipelines shall be installed with threaded pipework with all valves, fittings and solenoids. Pipe work will be cut to size and threads cut on site using powered threading machine. The flues from the 2 no. boilers and the 4 no. CHPs shall connect into their respective flue headers before crossing the plant rooms and exiting through the end wall. The flues will then rise on the external face of the building and terminate at High Level.

The proposed PV panels will be mounted on the North Elevation of the Building on the manufacturers proprietary mounting rails attached to the cladding façade.

Building Management Systems (BMS)

The BMS will form a network across the complete site. The BMS Control Circuit cabling shall be installed on baskets and within conduits throughout the Building. This system monitors the following components;

- Room Air Temperatures,
- LTHW Flow temperatures
- LTHW Return Temperatures,
- DHCWS Temperatures,
- Air volumes / pressures,
- Pump pressures / volumes / flow rated,
- Energy metering,
- MGO Metering,
- LTHW Metering,

Ceilings

Various suspended ceilings boards are to be installed. Initially, all the ceiling hangers are installed. Ceiling hangers are cut on site to the correct length for the ceiling. After the hangers are installed, the ceiling grid including wall angles can be installed. The cross tees are kept in place using the ceiling hangers and wall angles fixed against the wall edges.

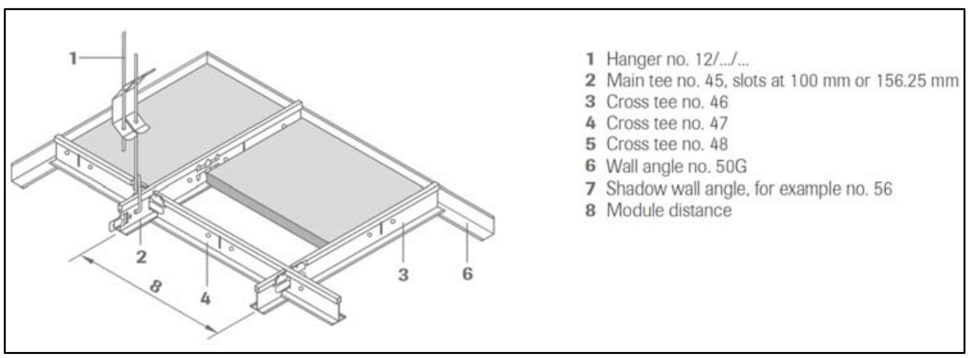


Figure 4-5 Square edge suspended ceiling detail

Service Tie-Ins to Existing Buildings

After the site wide services have been installed, these will be connected to several of the existing buildings (NBH, Admirals, Giants and Bonner lab). The plant rooms will be modified to accompany the new CHP system. With the exception of Giants House (accommodation), new plate heat exchangers will replace boilers. The potable water supply and waste water will be connected to the new services. This is also applicable for the power supply, data supply and fire alarm.

4.2 Container storage location

In April 2020, at the end of 2019-2020 season, sixty, 40ft containers and 4000 tonnes (approx. 600 segments) of concrete, will be transported to Rothera Research Station on a charter vessel. These containers will to be stored on station during the winter season. Two locations were considered for the storage area for these containers. The initial location was alongside the runway, however this option was discounted on safety grounds for the operation of the runway and due to anticipate snow build up during the winter.

The alternative location now proposed is south of the hangar, adjacent to the apron. The advantage of this location is that this it does not interfere with flights. The area has also been partially disturbed previously during the construction of the runway, see Figure 4-6.

Figure 4-6 Container and precast concrete storage area south of the hanger

The area required to store the containers is approx. 80 x 31m and will need to be prepared before it can be used. This will require the removal of all loose material in the vicinity; re-route an existing draining channel and backfilling and compacting the area.

- Removal of all loose materials
- Re-route drainage channel
- Backfill and compact area

4.2.1 Removal of loose material

The area will need to be cleared of any containers which are currently stored there. Then excavations can begin to remove the loose rock up to a depth of 500mm. The loose rock will be loaded onto Articulated Dump Trucks (ADTs) and transported to the stockpile area. The primary stockpile area is situated along the east side of the runway. See

Figure 3-31 Site laydown at start of Season 1 February 2020.

The depth that will be excavated will be 500mm below the surface level of the apron. The total quantity of rock that will be removed is approx. 1,200m^3, however this estimation assumes that the top surface level is flat which is already known to be undulating.

4.2.2 Drainage

Currently the area is also used as drainage for the apron. With the materials (grading 30-80mm) used to backfill the area this can still be used for drainage of the site. Alternatively a channel can be created along the outside perimeter of the area or drainage pipes can be included during the backfill.

4.2.3 Backfill and compaction

The last activity will be to backfill the area with 0-80mm material. The material with grading 0-80mm will be used as base layer up to a thickness of 400mm. The top layer will consist of 0-30mm and will be approx. 100mm thick. The materials will be transported from the stockpile areas to the container storage area by ADTs. An excavator or wheeled loader will load the ADTs. After transporting, the ADT will tip the material in the required area. A wheeled loader or bulldozer will level the materials. The materials will be laid in layers of 200mm and compacted with a roller. After the area has been prepared plate bearing tests will be carried out to verify the compaction and to determine if it meets the design criteria.

4.2.4 Protection of existing fuel pipe

The storage area is in close proximity to the existing fuel farm and fuel pipe supplying the apron. In order to protect the fuel pipe a bund will be created to ensure vehicles cannot be driven into the pipe. This will be done by installing a "rock wall" between the fuel pipe and the storage area.

The installation will be completed by an excavator at a safe distance from the fuel pipe. The safe distance is 2m and this is the distance between the fuel pipe and the maximum reach of the excavator.

On the apron side of the fuel pipe, a bund cannot be constructed as this would interfere with the aircraft operations. A demarcated access route to the container storage area will be enforced to ensure that vehicles cannot get into close proximity to the fuel line.

Figure 4-7 Location of proposed bund to protect fuel line

4.2.5 Surface protection of runway crossing

The heavy plant (ADT's and tractor + trailers) will require daily access to the containers and will be crossing the runway regularly. This will increase the possibility of damage to the surface of the runway. In order to keep the surface in good condition a daily check will be conducted by BAS Estates. When required the surface will be repaired by levelling and rolling the surface. If a larger repair such as an infilling pot holes is required, BAM will provide the required plant, vibrating roller, and materials to compact the surface. The materials to repair the runway will be taken from the existing stockpiles that are managed by BAM.

4.3 Interim Waste Management Facility (IWMF)

The Miracle Span is the only significant structure to be removed from the site during the Season 1 construction period. Before the structure is removed, it is planned for a new interim waste management facility to be erected to ensure waste handling facilities can operate continuously. The IWMF will be setup prior to dismantling the Miracle Span to allow continuous operation of waste management on station. The new facility will be located to the north of the temporary plant workshop, see Figure 4-8.

The IWMF superstructure was procured and delivered to Rothera in November 2018. It is 25m long and 9m wide with a unique door sizing to accommodate the BAS vehicle and opening. A trench will be dug to accommodate recycled sheet piles from the Wharf used as foundation to support the superstructure. The foundations and structure have been designed to withstand the environmental conditions at Rothera. The superstructure will be erected by the site team within a week.

The working surface of the internal floor will be overlaid with compacted 10mm fines. See section 3.7 for the internal layout details. The facility will be connected to the mains electrical supply via the STP.

Once all the waste management equipment has been transferred to the new structure, the old Miracle Span will be deconstructed using the following the sequence.

- Internal materials removed and a safe working area exclusion zone setup.
- Utility connections including the electrical supply from Fuchs disconnected.
- Superstructure and floor will be cleaned to remove environmental hazards
- All waste will be placed in suitable containers and skips as the works progress.
- The end walls will be removed. They do not affect the integrity of the remaining arch.
- An excavator will reduce the height of the canopy and fold in the side elements.
- The steelwork will be flattened along the crown of the superstructure to remove tension in the structure.
- The superstructure steelwork will be cut from the base using a steel saw, sheers or similar
- The concrete base and upstand walls will be covered in fill to form the working platform for the new Operations Building.

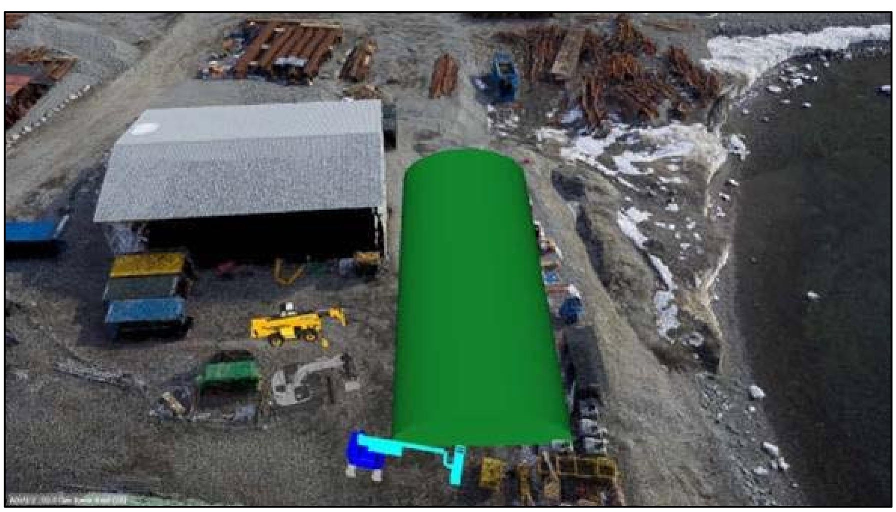


Figure 4-8 Proposed location of the IWHF north of the Temporary Plant Workshop

As part of the relocation of the Miracle Span and associated waste management services, the station incinerator will also need to be moved and a power supply installed. An existing concrete plinth NE of

New Bransfield House will be extended slightly to accommodate the 20’ container which houses the incinerator. This is likely to require, roughly 2m^2 of concrete. A new power supply will be installed from New Bransfield House and the length of the cable from the rear of the building to the new site will be laid in plastic ducting. This is approximately 25m.

Figure 4-9 Proposed temporary location for incinerator.

4.4 Drilling & blasting

The specific methodologies to be followed during the drilling and blasting activities are set out in detail in Appendix A: *Rothera Modernisation Drilling and Blasting Management Plan*.

Approximately 8,300m^3 of rock extraction will be undertaken using drilling and blasting with explosives. This will involve the drilling of vertical, or near vertical holes, in the range of 64mm to 76mm diameter, with a tracked hydraulic drill rig. These holes will be drilled in rows parallel and adjacent to an open face, or in a pattern to develop an open face. These holes will then be charged with explosives and stemmed with angular aggregates. After blasting, this material will then be loaded and hauled to a separate area on-station for processing and stockpiling, before being returned to the modernisation location to be used as fill material. It is anticipated that 11,200m^3 of 0-80mm rock fill will be required of which 4,300m3 will be filled between gridlines 1-4 of the operations building.

It is anticipated that the majority of blasting will be undertaken during the 2019-2020 austral summer, with approximately 20 – 30 individual blasts. There will be 26 consecutive days of blasting within a 30 day window between 13 February and 13 March 2020 as per the Contractor's Construction Programme 'BAA4008-ZZ-ROT-PR-8002-AIMP Operations Building WS4b-8 detailed' dated 24th July 2019). The duration of each blast will typically be less than 0.5 seconds. Drilling will continue during working hours on most of the working days during the drilling and blasting period. The fill material between gridlines 1-4 will be laid over a 15 day period between 24th February and 15th March 2020.

There is no requirement for blasting outside of the first season with excavation works completed by April 2020.

This drilling and blasting process will be strictly controlled following BAM Ritchies blasting procedures and following the requirements of the UK Quarries Regulations 1999. The Quarries Regulations 1999 provide the strictest requirements currently in place and also ensure compliance with BS5607:1998 Code of practice for the safe use of explosives in the construction industry. In addition the use of explosives will comply with British Antarctic Survey Code of Practice: Explosives, 3rd edition, 2007.

The anticipated quantities of explosives which will be required to undertake the works are shown in table 3-6.

Figure 4-10 Anticipated quantities of explosives

Explosives	Total quantity
Senatel Powerfrag packaged emulsion explosive	4000 kg
Pentex Primers	1400 pcs
Exel MS in-hole non-electric detonators	2800 pcs
Exel Connectadet non-electric surface detonators	1400 pcs
Cordex detonating cord (not on the surface)	800 m
Dunarit Boosters	200 boxes

4.4.1.1 Explosive storage

Due to the large explosives requirement for the blasting operations it will not be possible to store the project explosives at the current BAS station storage location and instead these explosives will be stored on the ski way as per the arrangements for the Rothera Wharf project.

The ski way depot will hold approximately 170 boxes of Senatel powerfrag and 200 small boxes of Dunarit boosters. The depot will be laid on the snow surface - due to low snow accumulation levels at the ski way and potential manual handling/depot footprint issues with raising the depot onto empty drums. Access will only be by the Shotfirer or appointed persons assisting during explosives transfers. The storage area is approximately half way along the ski way and 60m outside the local travel area to ensure restricted access to authorised personnel only. The location will allow Twin Otters to taxi to the store, minimizing double handling.

In addition to the ski way storage, it is possible to store up to a maximum of 1000kg at the Rothera station using both the existing BAS storage magazines and two BAM magazines installed in 2018 for the Rothera Wharf Project. The 1000kg will be split between two locations a minimum of 24m apart as per the Explosives Regulations 2014: Safety Provisions. For further details see Appendix A.

No new works are required at any of these storage locations. A bund constructed of sand in bulk bags has been installed up to 1.0m thick, and 2.0m high. See Figure 4-11. No explosives stacked in the magazine will be greater than 1.4m high to ensure that the bund overtops the explosives by 0.6m. The bund shall be separated from the magazine by 0.6m to 1.0m and extend laterally 1.0m beyond the end of the magazine on any side facing buildings or the other magazine. The bund must cover the sides facing the other magazine and the closest buildings.

Figure 4-11 BAM on station explosives magazine

4.4.1.2 Environmental Aspects

There are a number of potential environmental aspects that blasting at Rothera may have on local receptors. These include:

- removal of ground currently occupied by structures, science or communications equipment;
- permanent ground displacement in the immediate vicinity of the blasting that may affect the integrity of a structure or its foundations;
- rock projection from the blast site, or displacement from adjacent faces may affect anything within this region;
- ground vibrations from the blasting affecting structures, fauna or science adjacent to the blast area;

- sound pressure waves in the water from transmission from blasting on adjacent land may cause disturbance to marine fauna;
- air-overpressure (noise) affecting fauna in the vicinity;
- dust;
- fumes; and
- residual contamination from explosives residue

These aspects and proposed mitigation measures for potential impacts are discussed in Section 10.5

4.4.1.3 Load Haul and rock Processing

Once blasted, rock will be loaded by hydraulic excavator into articulated dump trucks and taken the proposed rock processing area on the west side of the runway for screening. The screened rock will then be stockpiled and later returned to the construction site for use as fill. Where there is a shortfall in the quantity of rock required for producing fill, additional rock will be taken from existing stocks sourced for the Rothera Wharf project.

4.4.1.4 Screening

The primary location for screening and stockpiling is immediately east of the runway in Zone 1 of the station as noise and heavy movement of traffic are kept away from BAS operations. The area has been used by the Rothera Wharf for its stockpiling of quarried rock which will be removed for backfilling the new wharf A' frames from mid-February 2020. Until 01 March 2020, an interim screening and stockpiling location is required for screening of approximately 7,000m^3 of rock and stockpiling of circa 1000m^3 (between 13 February and 01 March 2020 -2 weeks duration). The interim location will remain on the east side of the runway in Zone 1 either utilising made ground close to the point or immediately north of New Bransfield House (NBH). Oversized rock greater than 80mm in size (approx. 400m3) will be stockpiled temporally with the existing Rothera Wharf quarried rock on the west side of the runway adjacent to the temporary boatshed. The oversized rock will be used for stabilisation work to the runway or for backfilling the new Rothera Wharf.

Levelling of the screening area will be undertaken using surface overburden material from the modernization area.

See Figure 3-19 for the site layout showing the screening locations.

4.4.1.5 Production of backfill material from blasted rock

Production feed will come from as-blasted rock from the modernisation cut, augmented by additional rock from the Rothera Wharf project if required. All feed material will be screened to separate 0-80mm material from 80mm+ oversize using a mobile or fixed grizzly screen. This simple screening process does not impart any shape to the product. Product is then loaded to stock, or direct to the project. Oversize material will be stockpiled for use elsewhere. No crushing operations are planned. The rate of processing of backfill material has been based on 300m^3 per day.

Figure 4-12 Mobile screening unit already at Rothera

4.4.1.6 Loading Rock at the face

Blasted rock will be loaded using a hydraulic excavator into an articulated dump truck. The excavators working at the face will create a rock platform and rock trap between the rock-pile and the platform to prevent the rock being worked collapsing on the excavator or dump trucks. This platform is constructed with material from the rock-pile compacted by the excavator tracking back and forward. As the rock-pile continues to be worked, the platform is extended as the excavator works along the rock-pile starting at one end, removing the platform from the worked out area in a progressive sequence. The slopes of the platform must not be undercut, but follow the natural angle of repose of the material. The height of the platform shall be such that it enables the excavator to load safely into the rear of the dump trucks or mobile crusher being loaded. The area where dump trucks are loaded will become a restricted loading zone. This loading zone is defined by the manoeuvring zone of the excavator or loading shovel and the manoeuvring zone of the trucks being loaded. Within this restricted zone only the excavator and dump trucks being loaded may enter.

Access to the restricted zone for other vehicles will be controlled by the supervisor or designated banksman and will only be permitted when loading has been stopped and the equipment is in its safe position and will not recommence until the other vehicles have left the area and permission is given by the supervisor. Other vehicles will wait as directed by the supervisor and in an area separate to waiting dump trucks.

4.4.1.7 Tipping

The areas where dump trucks tip their load to feed the processing plant, or in stocking areas, will be restricted areas in a similar way to the loading area described above. Dump trucks coming from the face to areas where other personnel are present will be controlled by a designated banksman who will control when the truck can off-load.

As far as possible the production of dust will be avoided, but the process of, loading, transporting and screening rock will produce dust. Measures to minimise the dust becoming airborne and a hazard to personnel and the environment have been included in the proposed mitigation measures in Section 10.5.

4.4.1.8 Personnel

The following team of people will be deployed to Rothera to undertake the drilling and blasting works:

- 1 Explosives Supervisor
- 1 Shotfirer
- 1 Assistant Shotfirer
- 1 Driller
- 1 Excavator operator
- 1 Loading shovel/screener operator
- 1 or more dump truck operators
- Additional assistance will be required at the time of blasting as Blast controller and Sentries
- Assistance will be required for the transportation of explosives, stemming and blast mats

4.4.1.9 Equipment & Vehicles

The following equipment will be used for drilling and blasting. Additional ancillary equipment may be required or be shared with construction activities. E.g. water and fuel bowsers, maintenance equipment, tractors tailors and aircraft.

Item	No.	Comment
Drill Rig Atlas Copco D7	1	All to be sourced from the Rothera Wharf Project
Excavator 35-50t	1	
Wheel Loader CAT966	1	
Articulated dump truck (ADT)	1	

4.5 Site wide services

4.5.1 Temporary Diversion of Services

To construct the new operations building several utilities will need to be temporarily diverted, including potable water, power, fire alarm, and data cables that supply New Bransfield House and are fed from the Generator shed and Old Bransfield House (OBH). Additionally, the power supplies to the Aircraft Hangar, Sewage Treatment Plant, and an earthing cable that runs from the generator shed to NBH, will also have to be diverted.

The proposed temporary diversion of the electrical cables, potable water and fire alarm services will run from the existing Generator Shed underground, north of the Vehicle Garage to Fuchs. At this point the diversion will connect services, with the exception of the potable water, outside OBH in the existing services trunking. The potable water will run above ground in a timber trunking and will join with the same service from OBH. When all the services are together they will run along to the east of Fuchs towards the STP. From there the newly diverted services will turn towards New Bransfield House. The sequence of temporary works will be as follows:

- Creating provision underneath the existing bridges / road crossings
- Install timber trunking along Fuchs towards New Bransfield House
- Excavate trench from Generator Shed to Fuchs
- Install new cabling and piping for the temporary diversion
- Disconnect existing services from the applicable building
- Connect the new laid cabling and piping to the existing building
- Commission and handover the services

Plant;

- 14T Excavator
- Telehandler (when required)

Personnel;

- No. Mechanics / Electricians
- 2 No. Carpenters
- 1 No. Plant Operator (BAS?)

Materials;

- Electrical cable
- Potable water pipe
- Fibre optic cable
- Data Cable
- Duct Heating

4.5.2 New Side Wide Services

Season 2

The new Operations Building will be connected to the existing buildings and fuel farm via the site wide services. The routing is predominately at the edge of the station. The piping and cabling for the site wides services will be supported on a steel structure. First the precast concrete foundations and steel structure will be installed. Afterwards the piping will be installed and tested. On top of the steel support structure a cable tray will installed. In the cable tray all the electrical and fibre optic cables are installed.

Construction Activities

- Level the ground surface for installation of the precast concrete foundations
- Install the precast concrete foundations
- Erect the steel support structure
- Install and test the prefabricated piping
- Install the cable trays or trunking
- Pull the electrical and fibre optic cables

Plant

- Excavator
- Telehandler

Personnel;

- 1 No. Plant operator
- 1 No. Banksman
- 1 No. Slinger / signaller
- No. Mechanics / Electricians

Materials;

- Precast concrete foundations
- Steel support structure
- Pipe, including insulation, for fuel, waste water, potable water and CHP
- Electrical cables
- Fibre optic cables
- Cable tray or trunking

Season 3

Services tie-in to Existing Buildings

After the site wide services have been installed, these will be connected to several of the existing buildings (NBH, Admirals, Giants and Bonner lab). In all the plant rooms, except Giants, new plate heat exchangers will replace existing boilers. The potable water supply and waste water will be connected to the new services. This is also applicable for the power supply, data supply and fire alarm.

Construction Activities

- Remove boilers from the existing plant rooms in NBH, Admirals and Bonner Lab
- Install new plate heat exchangers in the above mentioned plant rooms
- Connect the plate heat exchangers and boilers to existing pipe work
- Connect the potable water to the existing pipe work
- Connect the waste water to the existing pipe work
- Connect the electrical cables to the existing distribution boards
- Connect the fibre optic and fire alarm cables to the exiting panels

Plant

- Telehandler

Personnel;

- 1 No. Plant operator
- 1 No. Banksman
- 1 No. Slinger / signaller
- No. Mechanics / Electricians

Materials;

- Boilers
- Plate Heat Exchangers

4.6 Demolition & decommissioning of existing buildings

After the commissioning of the new Operations Building, deconstruction of the following existing assets at Rothera will be undertaken

There are 38 listed structures and buildings forming Rothera Station. The table below lists the effected structures and how they fit into the AIMP plans.

No	Building	Action	New Facility	Deconstruct Method
16	Fuchs House	Replaced	New Operations Building	3
17	Old Bransfield House	Replaced	New Operations Building	3
18	Communications Tower	Replaced	New Operations Building	3
20	Boiler Room & RO Plant	Replaced	New Operations Building	3
21	Tech Services Office (ISO)	Replaced	New Operations Building	1
22	Fuel Tank	Replaced	New Operations Building	1
23	Sauna	Replaced	New Operations Building	1
24	Lubricating Oil Store (ISO)	Replaced	New Operations Building	1
25	Field Prep Area & Vehicle Garage	Replaced	New Operations Building	3
26	Carpenter & Electrical Workshop	Replaced	New Operations Building	3
27	Timber Store (ISO)	Replaced	New Operations Building	1
28	Electrical Store (ISO)	Replaced	New Operations Building	1
29	Battery Charge Unit (ISO)	Replaced	New Operations Building	1
30	Power Generation	Replaced	New Operations Building	3
31	Binghamns Technical Services Store	Replaced	New Operations Building	3
32	Paint Store (ISO)	Replaced	New Operations Building	1
35	Miracle Span	Replaced	Waste Handling Facility (Temp) and New Operations Building	2
37	Stores (ISO)	Replaced	New Operations Building	1
38	Incinerator	Moved	N/A	1

Listed Structures and Buildings at Rothera Station 2017

Methods of Building Deconstruction

The methods for deconstruction of the site structures fall into two main categories. They are:

1 ISO or similar containers

2 Buildings

Category 1 - ISO or similar containers

The units covered by the category 1 method for deconstruction are:

- Tech Services Office (ISO)
- Fuel Tank
- Sauna
- Lubricating Oil Store (ISO)
- Timber Store (ISO)
- Electrical Store (ISO)
- Battery Charge Unit (ISO)
- Paint Store (ISO)
- Stores (ISO)

Most of the above units have been classified as ISO containers on the reference drawing. Some ISOs have been significantly modified and have their own characteristics, whilst some are structures of a similar size and will be removed using the same process outlined below.

Before any deconstruction, works begin all materials and Furniture, Fixtures and Equipment (FFE) will be removed by BAS. It is assumed that all hazardous materials including liquids from generators, electrical or mechanical systems reservoirs and unsealable containers will have been removed before BAM commence operations.

BAM will undertake a condition survey and verify the incoming services are isolated and disconnected. These services may include external power, communication cables, and other utility connections. Once isolated BAM will make the container safe for transportation. Once the debris has been cleared, each container will be cleaned to mitigate dust & fibres escaping into the local environment.

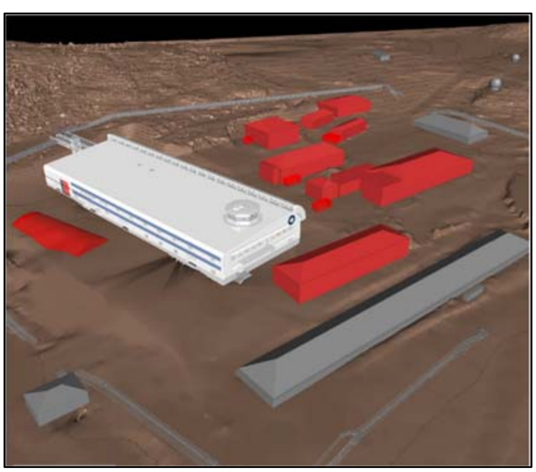
For practical purposes, some containers will be shipped back to the UK without the internal elements being removed. They will still be checked for contaminants and all safety & environmental precautions will be taken to ensure an environmental or safety incident does not occur. Before any container leaves Rothera a safety check will be completed and signed off. Once back in the UK all the containers will be transported to the BAS facility in Cambridge for reuse on their future research project.

All of the fuel tanks to be removed including those located adjacent to the Generator Shed, Vehicles Garage and OBH, will be drained of fuel, which will be filtered and reused. The tanks will be vented to ensure that no flammable gasses are present. The tanks will then be cold cut into manageable pieces and stored in containers before being returned to the UK for disposal. Any sludge or residue in the tanks will be stored in 205 litre drums as hazardous waste.

Category 3 Buildings

The units covered by the category 3 method for deconstruction of buildings are:

- Fuchs House
- Old Bransfield House (2 storey)
- Communications Tower (3 storey)
- Boiler Room & RO Plant
- Field Prep Area & Vehicle Garage
- Carpenter & Electrical Workshop
- Power Generation (double height space)



- Technical Services Store (Binghams)

Figure 4-13 Schematic of the buildings to be removed (in red)

The buildings proposed to be decommissioned vary in use, form, size and composition. Together they currently comprise of the main work buildings supporting the science and operations at Rothera Station. The order of demolition will be dependent on the appropriate sequence for moving personnel and equipment into the new Operations Building and the disconnections from the existing service network.

The following is the proposed sequence of deconstruction of all the buildings. Some steps may not be required in all the buildings.

1	BAS to remove all internal materials, standalone equipment & furniture and move to the new buildings or arrange for disposal.
2	Disconnect and physically separate all services to the facility.
3	Check for all services which may pass though or go under/over the structure to other live facilities. These will need to be identified and then protected or diverted.
4	Set up temporary power supplies for construction equipment, independent of the existing system to the building. The supply could be from portable generators or from the new main site supply within the New Operations Building using transformers to support the 110v tools.
5	All waste liquids and hazardous materials and asbestos , not required by BAS, to be separated and stored according to the COSHH and Control of Asbestos Regulations 2012 requirements prior to removal to the UK for disposal
6	BAS to remove all fixings for reuse in the new building or BAM to remove if designated as waste or for transportation to the UK.
7	All materials to be packaged inside the building and taken directly to the required new location with suitable protection to prevent potential air or surface contamination.
8	Remove false ceilings and other fixtures in order to expose the internal service ducts and cables.
9	Remove the main cabling and duct networks.
10	Remove the internal walls, flooring and the remaining fixings.
11	Expose the internal connections for the wall and roof panels
12	Remove all non-structural items including cladding for the roof, walls and any remaining inclusions.
13	Where practical all waste materials are to be separated and stacked into wood, metal, plastics etc. for packing into designated containers in preparation for transportation to the UK.
14	Set up external access platforms for the roof.
15	Where required set up internal propping to support the roof joists and wall sections on each floor
16	Clean the inside of the building to mitigate airborne and ground pollution.
17	Deconstruct the roof panels and stack/pack for transportation to the UK.
18	Repeat the deconstruction method for the wall panels.
19	Where required, remove stairs, other access structures, floor panels and beams as each floor is deconstructed.
20	Once the ground floor has been removed, take apart the steel/wood structure supported on the foundations.
21	The principal for the foundations is to leave all embedments below the new ground level in place. They will be recorded and surveyed for future reference. Concrete and other materials above ground level will need to be removed. Concrete will generally be broken up using a remote saw and breaker. All rebar and steelwork will be cut off flush with the foundation block to prevent trip hazards.
22	All waste materials not suitable for reuse at Rothera or the other Antarctic bases will be stacked, packed, or placed in containers for shipping back to the UK. At present, there is an estimated 3000m3 of waste materials requiring removal from site.
23	The ground under the old buildings will be dressed with local rock to remove trip hazards and provide a platform for the future buildings, service yards and access routes.

Unless noted otherwise on the construction programme, the above buildings will be removed once their functions have been transferred into the new Operations Building. Some structures maybe partially cleared ahead of the planned deconstruction period. Specific Activity Plans will be created for each structure prior to the season in which they are to be deconstructed. Some structures will have specific variations to the above method to ensure continuous safe operation of the station.

5 SUPPORT ACTIVTIES

5.1 Relocation of MF radar masts

In order for the Rothera Modernisation construction site to be established, existing infrastructure on station will need to be relocated or decommissioned. This includes 9 medium frequency radar masts currently grouped in two locations at Rothera. The first group comprises five masts shown by the green dots adjacent to the Miracle Span and NBH on Figure 5-1. It is intended that these masts will be fully decommissioned and the steel towers removed and recycled/reused off site.

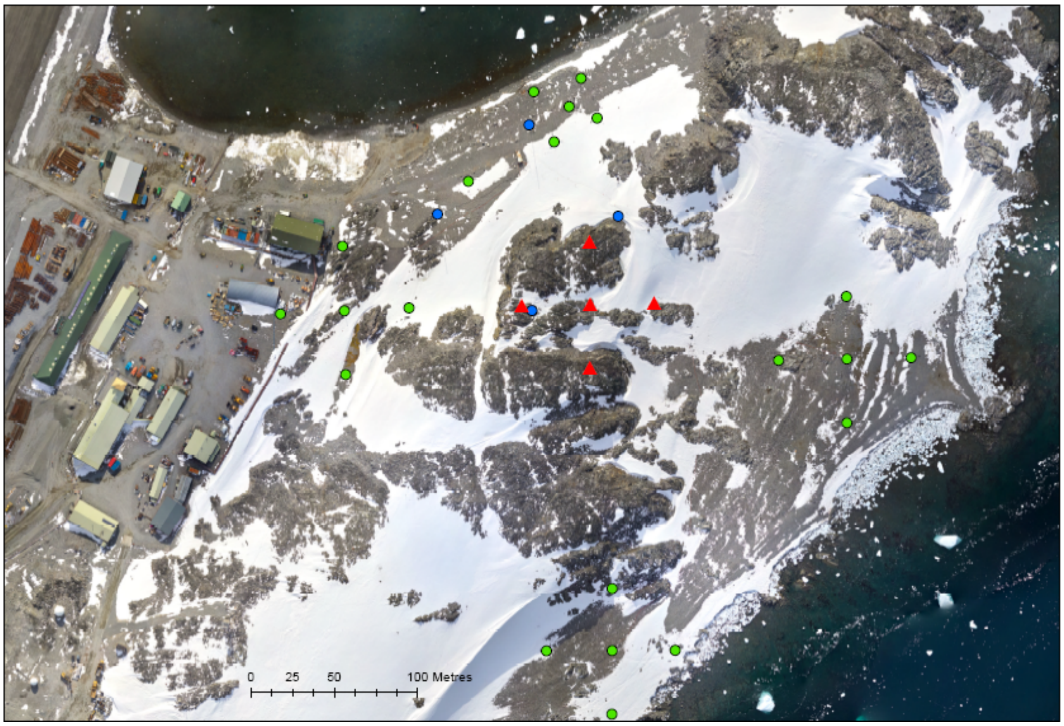


Figure 5-1 Existing and proposed radar mast locations

The second group is comprised of four masts and is shown by the four blue dots on Figure 5-1. It is intended that the steel sections of these masts shall be reused to construct a new group of masts, the location of which is shown by the red triangles on Figure 5-1. The new masts will have a fifth structure which will comprise of a telescopic mast.

A number of the masts which are proposed to be decommissioned are currently mounted on concrete plinths. It is the intention that each of these plinths will remain insitu. The plinths may be reused in the future by other science equipment. Each plinth consists of approximately $4m^3$ of concrete.

For the new masts a mixture of concrete plinths and gabion rock basket will be used as the foundations for each structure. Please refer to Figure 5-2, Figure 5-3 and Figure 5-4. Each gabion basket consisting of a metal frame, approximately 1m x 0.5m x 0.5m in size will be filled with rock. The rock will be sourced locally either from existing rock stockpiles or from the material removed from the construction site.

It is anticipated that at least two of the new masts (the central and eastern ones) will require the installation of concrete foundations. The size of the foundations will be approximately 1m x 1m x 1m.

Each of the new masts will require support from steel wire guy lines anchored into either the gabion baskets, concrete foundations or bolted directly into the rock. Where gabion baskets are used, (in addition to the basket used as the foundation for the mast), up to four other baskets will be installed for the guy lines. Approximately 50m of guy lines will be installed in total, each fitted with bird deflectors to minimise the risk of bird strikes.

Figure 5-2 Concrete foundation

Figure 5-3 Concrete anchor for guy lines

Figure 5-4 Mast erected on gabion basket with gabion basket anchor points for guy lines

The height of the new masts will be;

- Northern mast 4.1m
- Southern mast 3.0m
- Eastern mast 16.1m
- Western mast 1.5m
- Central mast 7.5m

The new masts will be lower in height than the existing ones and none will exceed the height of the current tallest masts on the point.

Once the masts have been constructed, the radar antenna will be installed which consists of a 4mm steel wire strung between the five masts. The wire runs from the centre mast to each of the four out rigger masts. In total, 38.2 metres of wire is required to complete this sequence and the sequence is repeated four times. In addition two coaxial cable feeds will also run from the radar hut to the central mast. These are fed in rigid coil, plastic communications pipe for protection. (This is similar to existing antenna on east beach).

Other construction materials required will include, cement, sand, timber and strengthened steel reinforced bar, mast sections, steel wire, anchor bolts. The movement of these materials, alongside the required steel tower sections will mean that there will be regular foot traffic to the proposed work site for at least a couple of weeks.

The sequence of the works will be as follows:

- Create concrete foundations/gabion baskets
- Decommission old masts
- Construct new mast array
- Install radar antenna

It is anticipated that the works will commence in December 2019, however this will be subject to weather conditions, local temperatures and snow cover. Due to the anticipated local conditions it is expected that the works will not be complete until mid-March 2020. Approximately eight staff will be involved in the construction works including a building surveyor, electronics engineer, x2 AME engineers, x2 RAF mast engineers, x2 builders. The works will be overseen by the Rothera Facilites Engineer.

The proposed location of the new mast is in the vicinity of previously used skua nest sites. Please refer to Chapter 9.1.3. Mitigation measures to minimise the disturbance and potential impact on nesting skuas has been included in Section 10.4.3.7.

5.2 Bentham container works

The Bentham container is a shipping container which has been adapted as a distribution hub for various communication systems and scientific equipment on Rothera Point.

A new container is due to be installed to replace the current Bentham container in order to facilitate the new operations tower in the new Operations Building. It is being built in the UK and shipped to Rothera on the JCR. The new container will lay directly adjacent to the existing container.

The intent is to utilise the existing concrete corner pads shown in Figure 5-5. If this is possible no further concrete will need to be used. If the existing structure is deemed unsuitable however, two concrete plinths will be constructed adjacent to the existing installation roughly $1m^2$ to rest the corners of the container on. The area will require a small amount of groundwork prior to the foundations being built. This is likely to require a small amount of rock to be moved to level the area. The rock will be re-distributed in the local area.

The internal fittings of the container most of which are associated with IT equipment will be transferred into the new container. Following the swap over of services, the existing Bentham container will be disassembled and shipped out of Rothera as scrap metal.

The new container is due to arrive at Rothera in January 2020 but final installation will not be complete until January 2021. The old container is due to be removed in the 2020-2021 season.

Figure 5-5 Aerial view of current Bentham Container

5.3 CCTV Installation on runway

Two CCTV cameras are due to be installed in between the refuelling hut and the temporary boatshed. The cameras will be mounted on a pole and will be pointed NE and SE to capture the runway in areas where rock stockpiling is obscuring the view. The cameras will transmit to a screen in the operations tower.

The pole will be roughly 4m high and secured to a gabion basket using locally sourced rock. The gabion basket dimensions will be 1m x 0.5m x 0.5m. The pole and cameras will be removed once the stockpiles have been removed.

5.4 Repair of aircraft hangar roof

The current aircraft hangar roof is due for repair to prevent the ingress of water. The proposed works involves the permanent removal of all roof insulation and the repair of the roof both internally and externally using epoxy roof seal and patches.

The current insulation is soft fibre glass wrapped in plastic and covers the entire roof of the hangar. In total this is an area of approximately 30m x 30m. The insulation is roughly 50mm thick with an estimated volume of $45m^3$. This will be removed and exported for appropriate disposal.

Once the insulation is removed the roof will remained unlagged and repairs will be made from the outside and inside of the roof. The repairs will be made with sealing kits that have previously been used at Rothera. The works are proposed to be carried out during the 2019-2021 season. Future replacement of the roof is likely to be within the scope of Phase 2 or 3 of the project.

5.5 Shipping & air freight

Shipment	Date	Activity
Shipment 1 Rothera Wharf Commercial Vessel	November 2018	Equipment to mobilise the site surveys and 1st construction season – completed.
Personnel mobilisation 1	October 2019	Mobilise personnel by air for commencement of the construction season.
Shipment 2 FIRS to FI & BAS JCR	December 2019	Equipment is to be mobilized ahead of the full construction season to allow site preparation and commence earthworks. Part of this early mobilisation will be to transport a large quantity of explosives. It is proposed to mobilize these resources through the BAS assets.
Shipment 3 Commercial Vessel	March 2020	Mobilize civil, steel and envelopes materials via charter from Europe. The vessel will also demobilize the wharf project and return cargo back to a selected port in Europe.
Personnel demobilisation 1	May 2020	Personnel to return home
Personnel mobilisation 2	November 2020	Mobilise personnel by air for start of second construction season.
Shipment 4 Commercial Vessel	December 2020	Mobilise architectural and MEP materials via charter ship from Europe
Personnel demobilisation 2	May 2021	Personnel to return home
Personnel mobilisation 3	October 2021	Mobilise personnel by air for start of third season
Personnel mobilisation	October 2022	Mobilise personnel by air for start of fourth season
Personnel demobilisation	May 2023	Personnel to return home
Shipment 5 Commercial Vessel	May 2023	Final demobilisation of materials and equipment

5.5.1 Cargo

Transport of all construction equipment and plant (including permanent materials, temporary works, equipment and consumables) from the supply hubs in the UK and Europe to the project site at Rothera will be undertaken by a charter ship. This will be an F-class type vessel adhering to ice Class 1A which is equivalent to Polar Code 6. The vessel will depart from an EU port and sail directly to Rothera Station to unload the cargo. Where relevant, optimizations with other partnership projects will be investigated. It is anticipated that a charter ship will visit Rothera during the first season 2019/2020, the second season 2020/2021 and the final season 2022/2023.

Prior to and during loading, biosecurity measures outlined in the Appendix C: *Rothera Modernisation Biosecurity Plan* will be undertaken and inspected by the BAM Environmental Manager. Visits to suppliers will be carried out to ensure that premises used for manufacture, storage and packing address biosecurity issues. Biosecurity inspections and fumigation will be carried out at Kilsyth and Teesport, where materials are consolidated into containers. All cargo will inspected before loading onto the charter vessel at Teesport.

The BAS Environment Office will also undertake an environmental audit at this time. Upon arrival at Rothera, all cargo and mechanical plant will be re-inspected either on board the vessel or at a holding location at the wharf. All inspections will be recorded and any incursions reported to BAS Environment Office.

5.5.2 Personnel

Personnel will be transported to Rothera either by sea or by air. Personnel will fly from the UK to South Atlantic gateways using established scheduled flights. The majority of personnel will then fly to Rothera on the BAS Dash 7 aircraft. In some instances, personnel may be transported by BAS ships to or from Rothera. Specific personnel numbers are included in the relevant project descriptions earlier in this document. All cargo and personnel will adhere to the BAS biosecurity procedures and the requirements set out in Appendix C: *Rothera Modernisation Biosecurity Plan*.

5.6 Accommodation

All personnel will be housed in either the existing permanent accommodation at Rothera (Admirals or Giants) or within Viking's House, the temporary accommodation units installed in the 2017-2018 season specifically to provide extra accommodation for the construction staff.

5.7 Energy use

Power generation for all construction activities will be provided independently to normal BAS operations. Domestic power for lighting, heating, and other domestic requirements will be provided through the existing systems. Currently the main power to the station is provided by two online diesel generators with a third on standby and a fourth being serviced. There are also some auxiliary units. Currently the station operates on the cusp of needing the third generator. Additional electrical load from construction works is likely to result in the third generator being used on a more regular basis rather than just for back up. Two portable generators are available on site for emergency power or additional power demand

5.8 Water

BAS will provide all domestic and construction water required for the project. Where ever possible, sea water will be used for construction activities, e.g. dust suppression, casting concrete.

6 OPERATIONAL PROCEDURES

6.1 Fuel management & spill response

6.1.1 Fuel use

It has been estimated that the Rothera Modernisation construction works will use 816m^3 of marine gas oil as detailed in the following register for the plant and equipment anticipated to be used on the project.

Figure 6-1 Plant & Equipment Register

Fleet No.	**Equipment**	**Useage Code**	**Season 1 (m3)**	**Season 2 (m3)**	**Season 3 (m3)**	**Season 4 (m3)**	**Total (m3)**	**Fuel (ltr/hr)**
AC10101	Mobile RT Crane 75t Terex RT1075 Quadstar	3	3	4	2	8	**17**	11.70
AC15101	Crawler Crane 300t Liebherr LR1300	3	4	37	0	0	**40**	37.09
AC15102	Crawler Crane 300t Liebherr LR1300	3	4	37	0	0	**40**	37.09
AC16002	Telehandler 4t JCB 540-140	3	2	9	5	4	**20**	6.17
	Telehandler Attachment: Manriding Basket	5	0	0	0	0	**0**	0.00
AC17001	MEWP 227kg Genie Z60-34	3	1	2	3	1	**7**	2.98
AC17002	MEWP 227kg Genie Z60-34	3	0	2	3	1	**6**	2.98
AC17003	MEWP 300kg Genie Z45/25 XC	3	0	2	3	1	**6**	2.98
	HD Trailer 44t	5	0	0	0	0	**0**	0.00
	Flatbed Trailer 20ft.	3	0	0	0	0	**0**	0.00
	Flatbed Trailer 20ft.	3	0	0	0	0	**0**	0.00
	HD Trailer 40t	5	0	0	0	0	**0**	0.00
AC25006	Fuel Bowser 3000L Tolsma AGM TW01	3	0	0	0	0	**1**	0.23
AC25007	Water Bowser 8200L	3	0	0	0	0	**0**	0.23
AC26001	Agricultural Tractor 4x4 165hp New Holland T6090	3	5	9	5	6	**25**	11.89
AC26002	Agricultural Tractor 4x4 165hp New Holland T6090	3	2	9	0	6	**17**	11.89
AC29001	Gator 14kW John Deere TH6x4 Diesel	3	0	0	0	0	**1**	0.55
AC29002	Gator 14kW John Deere TH6x4 Diesel	3	0	0	0	0	**1**	0.55
AC43102	Mobile Double Screen 30-80mm Sandvik QE341	1	0	0	0	0	**0**	5.94
AC50001	Crawler Dozer 86kW CAT D5N	3	0	5	1	3	**9**	10.11
AC51001	Wheel Loader JCB 456ZX	3	0	11	0	7	**18**	23.79
AC53002	Crawler Excavator 49t Doosan DX490	3	14	14	0	18	**45**	32.52

AC53003	Crawler Excavator 8t Caterpillar CAT308E	3	2	7	1	1	**11**	5.57
AC53101	Crawler Excavator 35t Caterpillar CAT336D	3	17	15	9	11	**53**	17.30
AC53102	Crawler Excavator 35t Caterpillar CAT336D	1	9	0	0	0	**9**	17.30
	Plate Compactor	3	3	1	0	2	**7**	6.54
AC56103	Articulated Dump Truck 28t CAT 730 - 1	3	14	11	3	8	**36**	24.42
AC56104	Articulated Dump Truck 28t CAT 730 - 2	3	14	9	0	0	**23**	24.42
AC61001	Water Pump 4" Isuzu C100 Hydry	3	0	0	0	0	**0**	0.38
	Water Pump - Suction Hose 8 lengths @ 6m 75mm	5	0	0	0	0	**0**	0.00
	Water Pump - Lay Flat Delivery 400m, 2 (or 4) x 100, 4x 50m 75mm	5	0	0	0	0	**0**	0.00
AC65001	Compressor 936@12cfm_bar Atlas Copco XAHS-447	2	0	0	0	0	**0**	0.90
AC65002	Compressor 773@10.3cfm_bar Atlas Copco XATS-377	3	0	6	14	0	**20**	11.51
AC70001	Generator 173kVA	3	0	9	9	1	**18**	13.73
AC70002	Generator 173kVA	3	0	0	0	0	**0**	13.73
AC70005	Generator 5.5kVA ARCGEN 6DV	3	0	3	5	3	**11**	3.43
AC70006	Generator 5.5kVA ARCGEN 6DV	3	0	3	0	0	**3**	3.43
	Snijder Workshop inc Generator	3	6	9	0	6	**21**	13.73
AC71001	Diesel Lighting Units, Kubota 3.7kW SMC TL90K LED	3	0	0	0	0	**0**	0.30
AC71002	Diesel Lighting Units, Kubota 3.7kW SMC TL90K LED	3	0	0	0	0	**0**	0.30
AC71003	Diesel Lighting Units, Kubota 3.7kW SMC TL90K LED	3	0	0	0	0	**0**	0.30
AC71004	Diesel Lighting Units, Kubota 3.7kW SMC TL90K LED	3	0	0	0	0	**0**	0.30
AC71005	Diesel Lighting Units, Kubota 3.7kW SMC TL90K LED	3	0	0	0	0	**0**	0.30
AC71006	Diesel Lighting Units, Kubota 3.7kW SMC TL90K LED	3	0	0	0	0	**0**	0.30
AC71007	Diesel Lighting Units, Kubota 3.7kW SMC TL90K LED	3	0	0	0	0	**0**	0.30
AC72002	Diesel Welder 500A ARCGEN 500CC/CV2	3	0	1	0	1	**2**	2.33
AC72003	Diesel Welder 300A ARCGEN WM300AVC	3	0	1	0	1	**2**	2.33
AC86001	Drill Rig Cassegrande C6xp	1	4	0	0	0	**4**	11.29
AC86002	Drill Rig Atlas Copco ROC D7	1	7	0	0	0	**7**	19.97

	Satellite Office 20x10ft.	3	1	2	0	2	**5**	2.00
	Drying Room 24x8ft.	3	3	14	5	4	**26**	4.00
	Container, PPE storage 20ft.	3	0	0	0	0	**0**	0.00
	Container, Rigging storage 20ft.	3	0	0	0	0	**0**	0.00
	Container, Rigging storage 20ft.	3	0	0	0	0	**0**	0.00
	Container, Small Tools storage 20ft.	3	1	2	3	2	**7**	2.00
	Container, Small tools storage 10ft.	3	1	2	3	2	**7**	2.00
	Lined heated storage container 20ft.	3	3	14	5	4	**26**	4.00
	COSHH Container 20ft.	3	1	2	0	2	**5**	2.00
	Waste Oil Tank, nos 6 1m3	3	0	0	0	0	**0**	0.00
	Ablution Unit 32x8ft.	3	1	2	0	2	**5**	2.00
	Explosive Storage Container 20ft.	1	0	0	0	0	**0**	0.00
AC91001	Fuel Tank 3000L Tolsma AGM TW01	3	0	0	0	0	**0**	0.00
AC93001	Diesel Heaters 5.5kW SIP Fireball 215XD	3	0	0	0	0	**1**	0.45
AC93002	Diesel Heaters 5.5kW SIP Fireball 215XD	3	0	0	0	0	**1**	0.45
AC93004	High Pressure Wash Hot 1450PSI Electric 110V TW100	3	0	0	0	0	**0**	0.14
AC93005	High Pressure Wash Hot 1450PSI Electric 110V TW100	3	0	0	0	0	**0**	0.14
AIMP	Spider Crane (Mainly for internal works)	3	0	0	0	0	**0**	0.00
AIMP	Container reach stacker for 40ft containers	3	3	6	0	2	**11**	10.22
AIMP	Floor Saw for 600mm Rad blades	1	0	0	0	0	**0**	2.00
AIMP	Heavy duty Winch (mainly for SWS)	3	0	0	0	0	**1**	2.00
AIMP	1-2m3 Grout Pan (Anchors, floors)	3	0	0	1	0	**1**	2.00
AIMP	Scissor Lift	3	4	5	2	1	**12**	2.98
AIMP	small tools	3	4	11	13	2	**30**	10.00
AIMP	Fencing 400m Police Barrier	5	0	0	0	0	**0**	0.00
AIMP	Flatbed Trailer 40ft.	3	0	0	0	0	**0**	0.00
AIMP	Flatbed Trailer 40ft.	3	0	0	0	0	**0**	0.00
AIMP	Commissioning process 4 generators	4	0	0	13	0	**13**	20.59
AIMP	Commissioning electrical components within the building	4	0	0	13	0	**13**	20.59
AIMP	Commissioning the electrical system in the new building	4	0	0	13	0	**13**	20.59
AIMP	Commissioning the lighting system in the new building	4	0	0	13	0	**13**	20.59

AIMP	Commissioning the utility system in the new building	4	0	0	13	3	**16**	20.59
AIMP	Dual running of the exisitng and new generators	4	0	0	18	3	**21**	20.59
Total			**135**	**279**	**177**	**119**	**710**	
				March 2019 Summary figures			710	
				Variance factor 15%			106	
				Rounded up (Gross)			**816**	

6.1.2 Fuel Storage

All fuel will be stored by BAS in their fuel farm except for fuel for construction generators which will be stored in a 2,250 litre bunded tank adjacent to the generators.

Numerous items of mechanical plant will be used as detailed in the plant list and the site set up plan. Items of plant and the generator tanks will be refuelled using a towable 5,000 litre bunded steel bowser. This will be towed by a tractor or similar item of plant. Oil spill equipment will be located adjacent to the fuel tank and will accompany the fuel bowser at all times. All mechanical plant will carry spill kits as stipulated in Figure 6-5.

6.1.3 Refuelling

Refuelling of plant and equipment will be carried out using a towable 5,000 litre bunded steel diesel bowser pulled by a tractor or similar item of plant. The procedure for carrying out this operation is detailed below in Figure 6-2 and Figure 6-3. Only trained personnel will undertake these procedures.

6.1.4 Emergency Spill Contingency Plan

The plan detailed in Figure 6-4 describes the procedures that will be used by personnel involved in construction activities in the event of a spill when working at Rothera. All spills are to be reported to the Rothera Station Leader and to the BAS Environment Office.

For Tier 1 spills it will be the joint responsibility of the Site Environmental Engineer and General Foreman to manage the spill response. The Project Manager will still retain the overall responsibility for incident management. In the event of a spill greater than Tier 1 which is generally >205 litres the BAS Station Leader will co-ordinate the spill response.

All operatives will be briefed on this Emergency Spill Contingency Plan by the Works Supervisor prior to works commencing. All spills are to be reported to the station leader and the BAS Environment Office at the time of occurrence

All plant will be inspected daily paying particular attention to possible leaks and condition of hydraulic oil hoses. These checks will be recorded on the 'Daily Plant Check Sheets' and in the 'Daily Activity Plan Compliance Record'. All refuelling will be carried out in line with the Rothera refuelling procedures as outlined above.

Filling the Towable Bowser

1. **Before Filling the Bowser**

- Ensure that spill kits are available and within easy reach of the refuelling location.
- Ensure that a suitable fire extinguisher (CO_2, dry powder or foam) is available and within easy reach of the refuelling location
- Make sure the item to be refuelled is as close to the refuelling point as possible but allows access to the bowser hoses.
- Switch off all item of plant in the vicinity and remove the keys.
- Ensure no other sources of ignition are present.

2. **Filling the Bowser**

- Bowser are to be refilled from the branch connector from the circulation loop on the generator shed (metered).
- Put on PVC gloves
- Undo the diesel cap from the item of plant
- Take an absorbent pad from the spill kit and use a drip tray to catch any drips from the fuel hose.
- Connect pipe work from generator shed bowser fill point to the bowser.
- Open the inlet tap on the bowser and open the man hole cover lid- this is to aid venting-failure to do so will over pressurise the tank.
- Close valve M9A
- Open the valve M17A on the metered branch connector
- The bowser will have no latch on the supply hose so that the lever must be manually depressed in order to deliver fuel.
- Both the bowser and day tanks have vents to atmosphere. Do not overfill. This will also help prevent spillage when on uneven ground
- When using the Bowser ensure the man hole cover lid is open to aid venting, failure to do so will implode the tank
- Filling of fuel tanks must be attended at all times, under no circumstances must tanks be left to 'fill themselves'.

3. **After Filling the Bowser**

- When the bowser is full close the valves in the reverse sequence
- Place the diesel delivery hose back into the generator shed, ensuring any drips are collected by the absorbent pad and drip tray.
- Place fuel cap back on the bowser.
- Place any diesel contaminated PPE or spill kit material in the oil contaminated waste drum.

Figure 6-2 Procedure for filling the towable bowser

Refuelling Plant from the Towable Bowser.

1. **Before Refuelling**

- Ensure that spill kits are available and within easy reach of the refuelling location.
- Ensure that a suitable fire extinguisher (CO2, dry powder or foam) is available and within easy reach of the refuelling location
- Make sure the bowser is as close to the item to be refuelled as possible but allows access to the bowser hoses.
- Switch off item of plant to be refuelled and remove the keys.
- Ensure no other sources of ignition are present.

2. **Refuelling**

- Put on PVC gloves
- Unlock the bowser
- Undo the diesel cap from the item of plant
- Take an absorbent pad from the spill kit and use a drip tray to catch any drips from the fuel hose.
- Place the fuel hose into the diesel refilling point on the item of plant.
- Start the diesel delivery pump.
- The bowser will have no latch on the supply hose so that the lever must be manually depressed in order to deliver fuel.
- Never leave refuelling unattended
- Do not fill the diesel tank to the brim; allow a little room to prevent spillage on uneven ground

3. **After Refuelling**

- Place the diesel delivery hose back into the compartment within the tank, ensuring any drips are collected by the absorbent pad or plant nappy.
- Relock the tank
- Place fuel cap back on the item of plant refuelled.
- Place any diesel contaminated PPE or spill kit material in the oil contaminated waste drum

Figure 6-3 Procedure for refuelling plant from the towable bowser

Emergency Spill Contingency Plan	
Fuel and chemical spills within BAS are classified as follows:	
Tier 1	Small spills which can be dealt with immediately by one or two people. Generally <205l on land.
Tier 2	Medium spills that require the Rothera Station Leader to co-ordinate the response. Will need as a minimum a dedicated response team or potentially the full resources of the station and assistance from BAS Cambridge.
Tier 3	Large spills which exceed the resources of the station and BAS Cambridge and require outside assistance
<u>In the event of a fuel, oil or chemical spill the following procedure should be followed</u>	
1	Stop work immediately
2	If spillage is flammable, extinguish all possible ignition sources.
3	Identify the source of the pollution and prevent further leakage. • Plug leaking drums • Right upturned containers • Switch off machinery with leaking hydraulic hoses
4	Quickly assess the spill. Determine: • The risk of fire or harm to human health • Time and location of spill • Type of spilt material and quantity (All spills on water are considered to be tier 2 or above)

<u>For Tier 1 Spills</u>	**<u>For Tier 2 or 3 Spills</u>**
Put on suitable PPE, including waterproof gloves	Immediately inform the Station Leader who will take responsibility for co-ordinating the spill response.
Prevent further spread of spill using absorbent socks.	Put on suitable PPE, including waterproof gloves
Attention to be taken to prevent oil from entering the sea, watercourses or drainage systems.	Follow the Station Leader's instructions.
Inform the Station Leader	
Recover spilt material using absorbent pads or skimmers.	
Dispose of waste fuel, contaminated spill kit materials and PPE in 205ltr drums. The Station Leader will identify the correct drums for disposal.	

<u>For All Spills</u>
All personnel who may have come into contact with the spill are to receive a medical check up
All construction personnel are to assist the Station Leader in preparing a detailed spill report to be submitted to the BAS Accident, Incident, Near Miss & Environmental (AINME) database.

Figure 6-4 Emergency Spill Contingency Response Plan

6.1.5 Emergency Spill Response Equipment

The following emergency spill response kits will be available on station in the event of a spill stored in 2 x static bins adjacent to the 2,250 litre fuel tank situated to the north-east of the old boat shed as shown in the site layout drawings,

Figure 3-31.

The spill kit will be contained in a 120 litre, yellow polyethylene static chest suitable for spills up to 205 litres containing:

- 60 No. 50cm x 40cm 'Superior' oil-only pad
- 4 No. 7.5cm x 1.2m 'Superior' Sock Oil
- 8 No. 38cm x 23cm oil absorbent pillow

- 10 No. 30cm black cable tie
- 10 No. 46cm x 90cm 200 gauge blue plastic disposal bag
- 1 No. Spill Kit instruction sheet
- 5 Pairs Goggles
- 5 Pairs PVC Gloves

All items of plant over 20 tonnes will carry a spill kit containing:

- 25 No. 50cm x 40cm 'Superior' oil-only pad
- 4 No. 7.5cm x 1.2m 'Superior' Sock Oil
- 5 No. 30cm black cable tie
- 5 No. 46cm x 90cm 200 gauge blue plastic disposal bag
- 1 No. Spill Kit instruction sheet
- 2 Pairs Goggles
- 2 Pairs PVC Gloves

The spill kit will be contained in a vinyl holdall.

All other mechanical plant will carry a spill kit containing:

- 18 No. 50cm x 40cm 'Superior' oil-only pad
- 24 No. 7.5cm x 1.2m Superior Sock Oil
- 3 No. 30cm black cable tie
- 3 No. 46cm x 90cm 200 gauge blue plastic disposal bag
- 1 No. Spill Kit instruction sheet
- 1 Pair Goggles
- 1 Pair PVC Gloves

The spill kit will be contained in a vinyl holdall.

Spare oil spill materials will be kept in the stores to replenish the kits if used.
These will consist of:

- 500 No. 50cm x 40cm 'Superior' oil-only pad
- 50 No. 7.5cm x 1.2m Superior Sock Oil
- 100 No. 38cm x 23cm oil Absorbent pillow
- 100 No. 30cm black cable tie
- 100 No. 46cm x 90cm 200 gauge blue plastic disposal bag

Figure 6-5 Emergency spill equipment

6.2 Waste management

The contractor will be responsible for managing all construction waste on site at Rothera. Hazardous waste which will mostly be waste oil will be stored in oil drums inside a bunded shipping container

During season 1, non-hazardous waste will be stored in the current waste storage containers used for the wharf construction, which are situated between Admirals House and the runway. During season 2, these waste storage containers will be moved to the wharf, where construction works will have been completed. Hazardous waste (which is mostly used engine oil) is stored on bunds within the workshop.

Metal waste will be stored in shipping containers. All other inert waste will be stored in shipping containers. All waste will be segregated and stored in weather proof containers and will be checked daily to ensure it is secure from wildlife and weather.

During season 1, non-hazardous waste will be stored in the current waste storage containers used for the wharf construction, which are situated between Admirals House and the runway. During season 2, these waste storage containers will be moved to the wharf, where construction works will have been completed. Hazardous waste (which is mostly used engine oil) will be stored on bunds within the fitters workshop.

All construction waste will be removed from the Antarctic Treaty area and returned to the UK for appropriate disposal in accordance with the Protocol on Environmental Protection to the Antarctic Treaty. The waste hierarchy will be applied. See Appendix B: Rothera Modernisation Site Waste Management Plan.

Before unused materials are defined as waste they will be offered to the Station Leader and the Facilities Manager for re-use at Rothera.

The contractor's chartered demobilisation vessel will remove construction waste from Rothera. Consignments will be packed and labelled in accordance with international shipping regulations. Waste will be disposed of in the UK by licenced waste contractors meeting the requirements of the Waste (England and Wales) (Amendment) Regulations, 2014, the Duty of Care Regulations, 1991, and the Hazardous Waste Regulations, 2005.

Some waste may be consigned to BAS vessels for return to the UK. In such circumstances all waste will be packaged and consigned in accordance with BAS's standard waste management procedures set out in the BAS Waste Management Handbook.

A list of the predicted waste types, quantities and disposal options is provided in the draft SWMP included in Appendix B. The Environmental Engineer will be responsible for onsite management of construction waste and ensuring appropriate final disposal. A target for a 75% diversion rate from landfill for construction waste generated on this project has been set.

All domestic waste generated during the construction period will be dealt with by BAS as per the Rothera waste management procedures. All staff will comply with the waste segregation requirements as directed by the Rothera Station Leader.

6.3 Biosecurity

The Rothera Modernisation project will involve an increased input of personnel cargo, equipment and plant to Rothera. This intensification of activity has the potential to increase the risk of non-native species introductions into the local environment.

It is essential that all necessary precautions are taken to prevent the introduction of non-native species to Rothera from other locations. A specific Biosecurity Plan (see Appendix C) for the construction works at Rothera has been prepared, detailing the guidance and measures that will be taken along the material supply chain as well as for personnel working at Rothera. It has been developed with reference to the BAS Biosecurity Handbook (2016) and the CEP Non Native Species Manual (2016). All personnel will be briefed on the biosecurity plan and will need to read, and understand this prior to deployment.

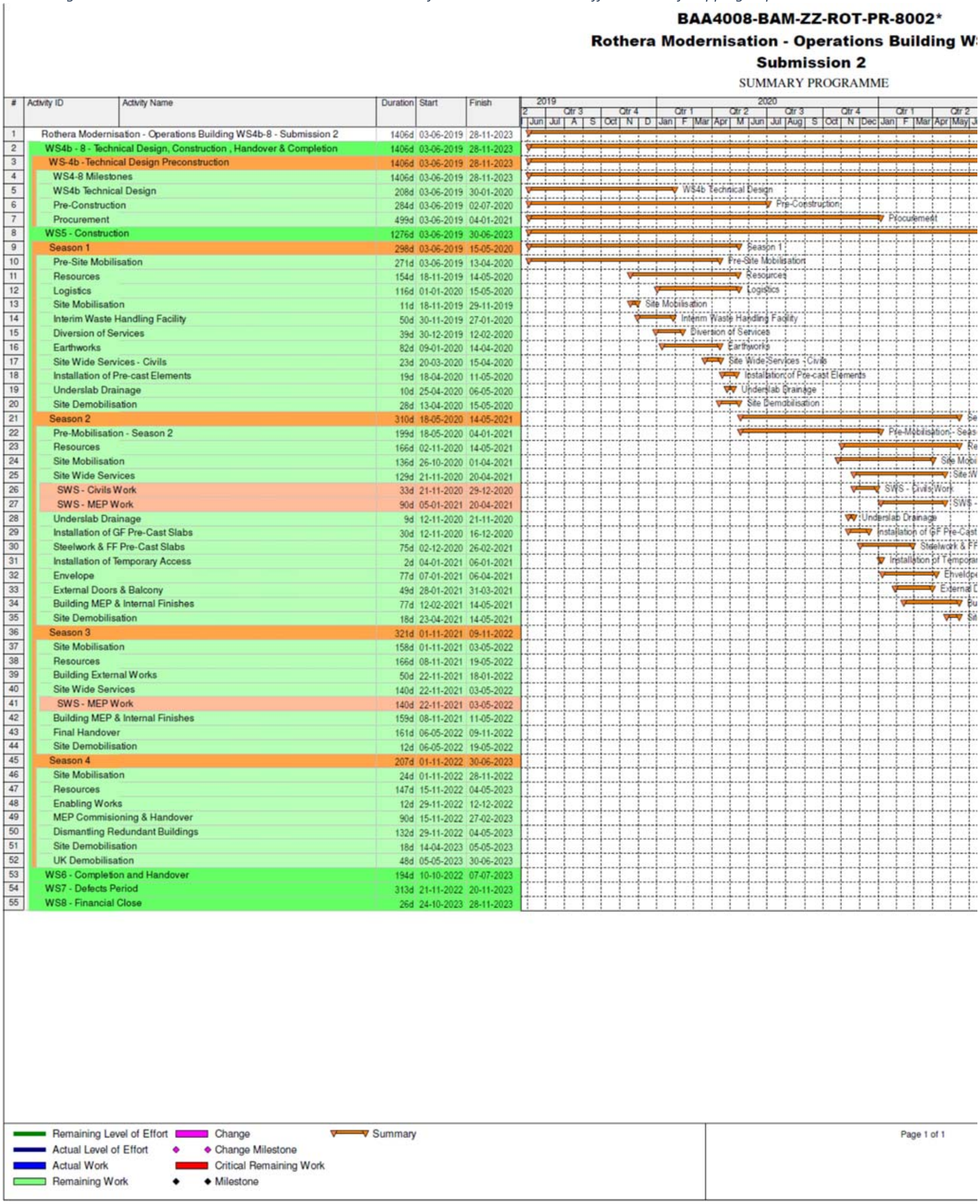
The measures include actions that require pre-departure checks on personal items and cargo, and pre and post disembarkation of cargo and personnel on arrival at Rothera. See Appendix C*: Rothera Modernisation Biosecurity Plan* for the full breakdown of the measures committed to. Evidence of the measures undertaken will be provided in the form of completed checklists. BAM will provide signed evidence that these checks have been completed appropriately. BAS will also audit the procedures during the project. Any biosecurity incursions will be reported immediately to the BAS Environment Office.

7 CONSTRUCTION PROGRAMME

The Rothera Modernisation construction works are planned to take place during the austral summers of four consecutive Antarctic seasons as follows:

- Season 1 – 2019-2020
- Season 2 – 2020-2021
- Season 3 – 2021- 2022
- Season 4 – 2022 – 2023

Construction work in Season 1 is anticipated to begin in mid-November 2019, whilst the Rothera Wharf construction is continuing. This will allow there to be some shared utilisation of resources and a more efficient use of shipping requirements.



BAA4008-BAM-ZZ-ROT-PR-8002*

Rothera Modernisation - Operations Building W

Submission 2

SUMMARY PROGRAMME

#	Activity ID	Activity Name	Duration	Start	Finish
1		Rothera Modernisation - Operations Building WS4b-8 - Submission 2	1406d	03-06-2019	28-11-2023
2		WS4b - 8 - Technical Design, Construction , Handover & Completion	1406d	03-06-2019	28-11-2023
3		WS-4b - Technical Design Preconstruction	1406d	03-06-2019	28-11-2023
4		WS4-8 Milestones	1406d	03-06-2019	28-11-2023
5		WS4b Technical Design	208d	03-06-2019	30-01-2020
6		Pre-Construction	284d	03-06-2019	02-07-2020
7		Procurement	499d	03-06-2019	04-01-2021
8		WS5 - Construction	1276d	03-06-2019	30-06-2023
9		Season 1	298d	03-06-2019	15-05-2020
10		Pre-Site Mobilisation	271d	03-06-2019	13-04-2020
11		Resources	154d	18-11-2019	14-05-2020
12		Logistics	116d	01-01-2020	15-05-2020
13		Site Mobilisation	11d	18-11-2019	29-11-2019
14		Interim Waste Handling Facility	50d	30-11-2019	27-01-2020
15		Diversion of Services	39d	30-12-2019	12-02-2020
16		Earthworks	82d	09-01-2020	14-04-2020
17		Site Wide Services - Civils	23d	20-03-2020	15-04-2020
18		Installation of Pre-cast Elements	19d	18-04-2020	11-05-2020
19		Underslab Drainage	10d	25-04-2020	06-05-2020
20		Site Demobilisation	28d	13-04-2020	15-05-2020
21		Season 2	310d	18-05-2020	14-05-2021
22		Pre-Mobilisation - Season 2	199d	18-05-2020	04-01-2021
23		Resources	166d	02-11-2020	14-05-2021
24		Site Mobilisation	136d	26-10-2020	01-04-2021
25		Site Wide Services	129d	21-11-2020	20-04-2021
26		SWS - Civils Work	33d	21-11-2020	29-12-2020
27		SWS - MEP Work	90d	05-01-2021	20-04-2021
28		Underslab Drainage	9d	12-11-2020	21-11-2020
29		Installation of GF Pre-Cast Slabs	30d	12-11-2020	16-12-2020
30		Steelwork & FF Pre-Cast Slabs	75d	02-12-2020	26-02-2021
31		Installation of Temporary Access	2d	04-01-2021	06-01-2021
32		Envelope	77d	07-01-2021	06-04-2021
33		External Doors & Balcony	49d	28-01-2021	31-03-2021
34		Building MEP & Internal Finishes	77d	12-02-2021	14-05-2021
35		Site Demobilisation	18d	23-04-2021	14-05-2021
36		Season 3	321d	01-11-2021	09-11-2022
37		Site Mobilisation	158d	01-11-2021	03-05-2022
38		Resources	166d	08-11-2021	19-05-2022
39		Building External Works	50d	22-11-2021	18-01-2022
40		Site Wide Services	140d	22-11-2021	03-05-2022
41		SWS - MEP Work	140d	22-11-2021	03-05-2022
42		Building MEP & Internal Finishes	159d	08-11-2021	11-05-2022
43		Final Handover	161d	06-05-2022	09-11-2022
44		Site Demobilisation	12d	06-05-2022	19-05-2022
45		Season 4	207d	01-11-2022	30-06-2023
46		Site Mobilisation	24d	01-11-2022	28-11-2022
47		Resources	147d	15-11-2022	04-05-2023
48		Enabling Works	12d	29-11-2022	12-12-2022
49		MEP Commisioning & Handover	90d	15-11-2022	27-02-2023
50		Dismantling Redundant Buildings	132d	29-11-2022	04-05-2023
51		Site Demobilisation	18d	14-04-2023	05-05-2023
52		UK Demobilisation	48d	05-05-2023	30-06-2023
53		WS6 - Completion and Handover	194d	10-10-2022	07-07-2023
54		WS7 - Defects Period	313d	21-11-2022	20-11-2023
55		WS8 - Financial Close	26d	24-10-2023	28-11-2023

Remaining Level of Effort | Change | Summary
Actual Level of Effort | Change Milestone
Actual Work | Critical Remaining Work
Remaining Work | Milestone

Page 1 of 1

Figure 7-1 provides an overview of the construction programme.

BAA4008-BAM-ZZ-ROT-PR-8002*

Rothera Modernisation - Operations Building WS4b-8 - Submission 2

SUMMARY PROGRAMME

British Antarctic Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

NERC SCIENCE OF THE ENVIRONMENT

#	Activity ID	Activity Name	Duration	Start	Finish
1		Rothera Modernisation - Operations Building WS4b-8 - Submission 2	1406d	03-06-2019	28-11-2023
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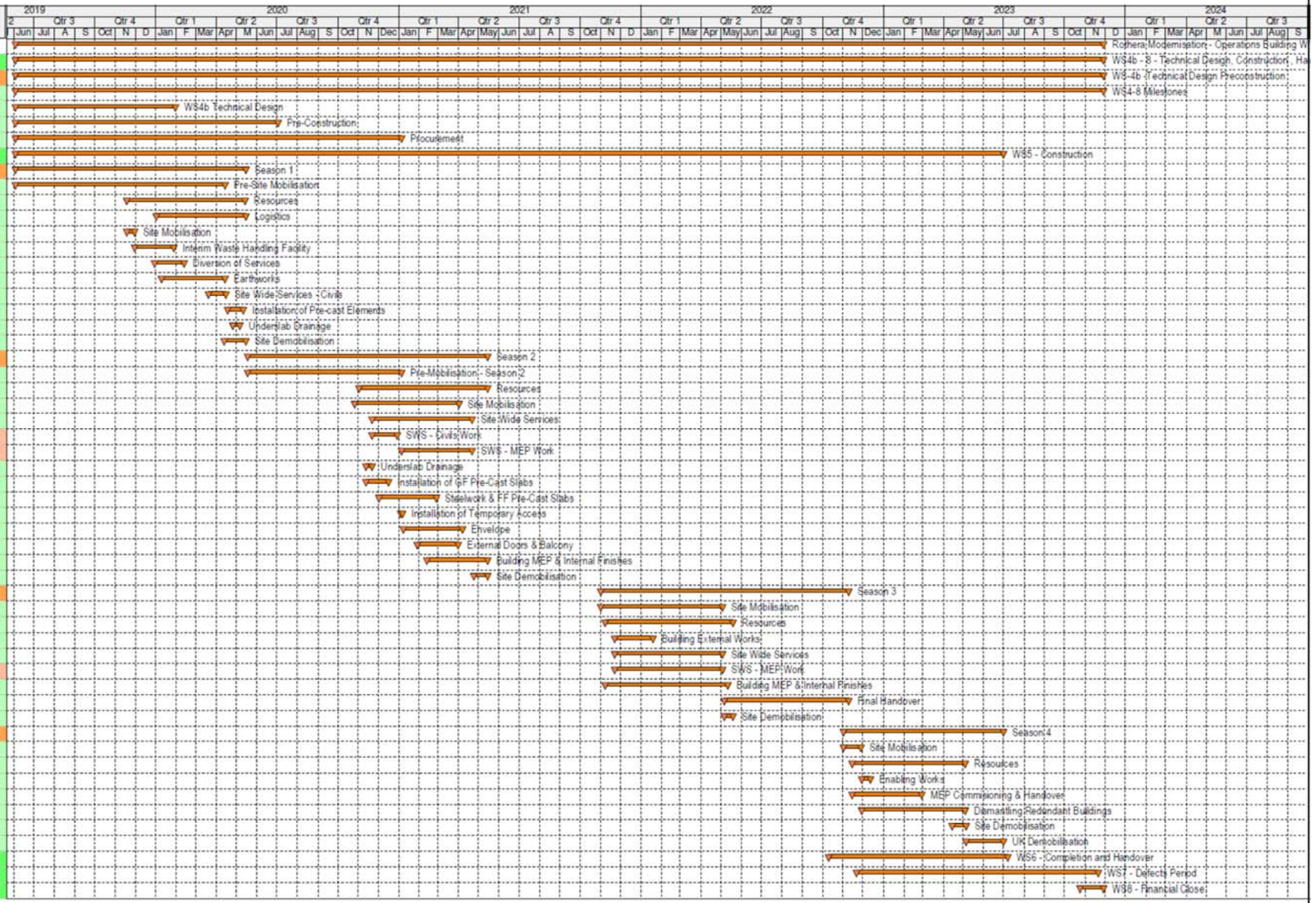

Remaining Level of Effort
Actual Level of Effort
Actual Work
Remaining Work
Change
◆ Change Milestone
Critical Remaining Work
◆ Milestone
Summary

Page 1 of 1

Date	Revision	Checked	Approved
24-07-2019	TASK ORDER SUBMISSION 2 - SUMMARY	CM	

Figure 7-1 Overview of Construction Programme

**Zoom to 200% to view detail*

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8 DESCRIPTION OF SITE

8.1 Location

Built on a rock promontory at the southern tip of the Wormald Ice Piedmont, Rothera Research Station is situated on Adelaide Island to the west of the Antarctic Peninsula Lat. 67°35'8"S, Long. 68°7'59"W.

8.2 History of site

Rothera Research Station has been used operationally, on a continuous basis since 25 Oct 1975. The station was initially planned and constructed in phases, after which other infrastructure was added as operational requirements changed (see Figure 8-1 and 8-2). The eastern side of Rothera Point is largely free of buildings; however, several antennae have been erected (see Figure 9.3).

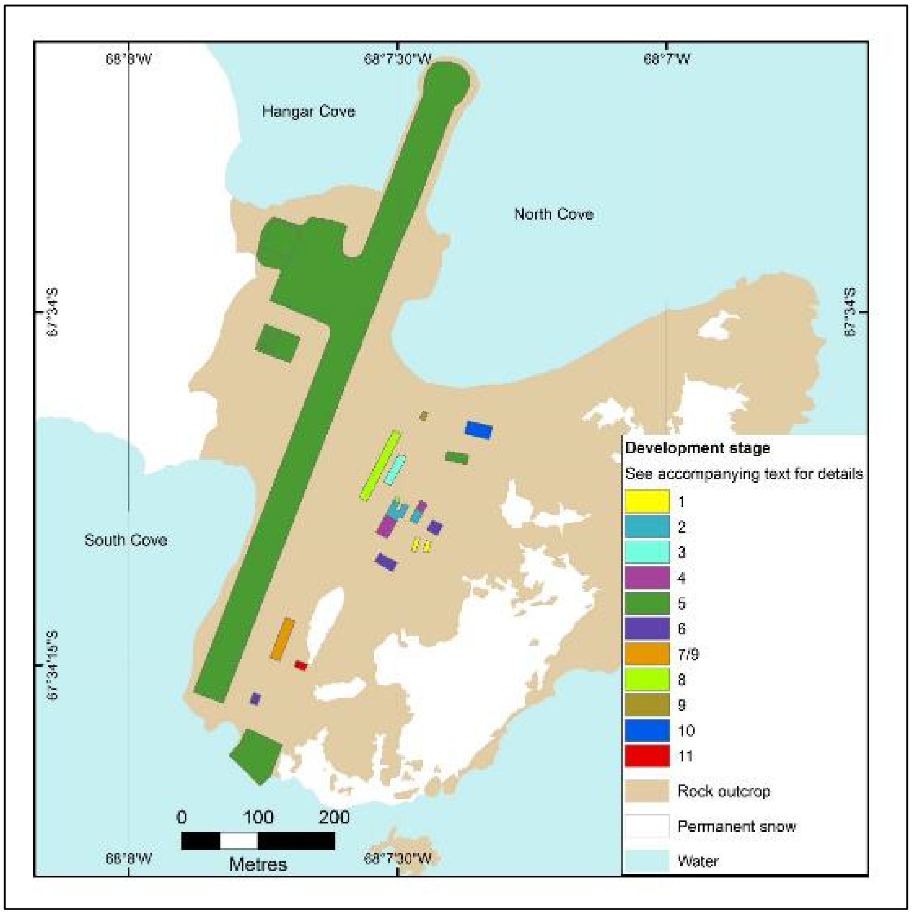

Figure 8-1 Rothera Research Station buildings on Rothera Point, Adelaide Island.

Chronology of station facility construction on Rothera Point is outlined below and relates to the colour-coded map of station buildings in Figure 8-2 Chronology of Construction on Rothera Point.

Figure 8-2 Chronology of Construction on Rothera Point

Order	Phase or infrastructure	Notes
1	Phase I	A small accommodation hut was erected on 1 Feb 1976.
2	Phase II	Phase II was built in 1976/77, which included the main accommodation block, power house and tractor shed. An old storage shed from Adelaide (Station T) was erected close to Phase I and known as the Bingham building after Surgeon Commander EW Bingham, Leader of BAS 1945-47.
3	Phase III	Phase III was erected 1978/79 and included scientific offices and a travel store and cold room. In 2001 the travel store was named Fuchs House after Sir Vivian Fuchs, Director of BAS 1958-73. Further building work has been undertaken when required.
4	Phase IV	Phase IV, begun Nov 1985 and completed in the 1986/87 season was an extension to Phase II. In 2001 it was named Bransfield House (after BAS ship RRS *Bransfield*).
5	Runway and aircraft infrastructure	A wharf and gravel runway (with bulk fuel tanks and aircraft hangar) became operational in the 1991/92 season. Substantial rock blasting occurred, including the removal of 'Flagstaff Hill'. The wharf was named Biscoe Wharf after the BAS ship RRS *John Biscoe*. A new storage hut, called the Miracle Span, now used primarily for waste management activities, was also constructed in 1991/92.
6	Boat shed, accommodation and generator shed	Under the next phase of development, a boatshed was completed in 1994/95, a transit accommodation block in 1996/97 (named Giants House in 2001 after the Rothera sledge dog team "Giants"), and a new generator shed.
7	Bonner Laboratory	The Bonner Laboratory became operational in 1997, housing biological research facilities when Signy (Station H), was reduced to summer only operations. It was named after W N Bonner, biologist 1953-86 and Deputy Director of BAS 1986-88.
8	Accommodation and air operations control tower	A new accommodation building was erected during the 1999/00 and 2000/01 seasons. It was named Admirals House after the Rothera dog team **"**Admirals". Also in 1999/00 an air operations control tower was added to the north end of Bransfield House.
9	Replacement Bonner Lab and sewage treatment facility	The Bonner Laboratory was destroyed by fire on 29 Sep 2001 but rebuilt in the 2002/03 season, when a sewage treatment plant was also erected.
10	NBH	A new living block, including canteen, library and recreational facilities, was completed in 2007/08 and named New Bransfield House. The original Bransfield House then became known as 'Old Bransfield House'.
11	Dirck Gerritsz Laboratory	The Dirck Gerritsz Laboratory was opened on Sunday 27 Jan 2013 by Leo le Duc on behalf of the Ministry of Education, Culture and Science of the Netherlands. The laboratory is a collaboration between the British Antarctic Survey and the Netherlands Organisation for Scientific Research (NWO) and hosts four research projects.
12	Rothera Wharf	The redevelopment of Rothera Wharf commenced in the 2018 -2019 season and is due to be complete by the end of April 2021.

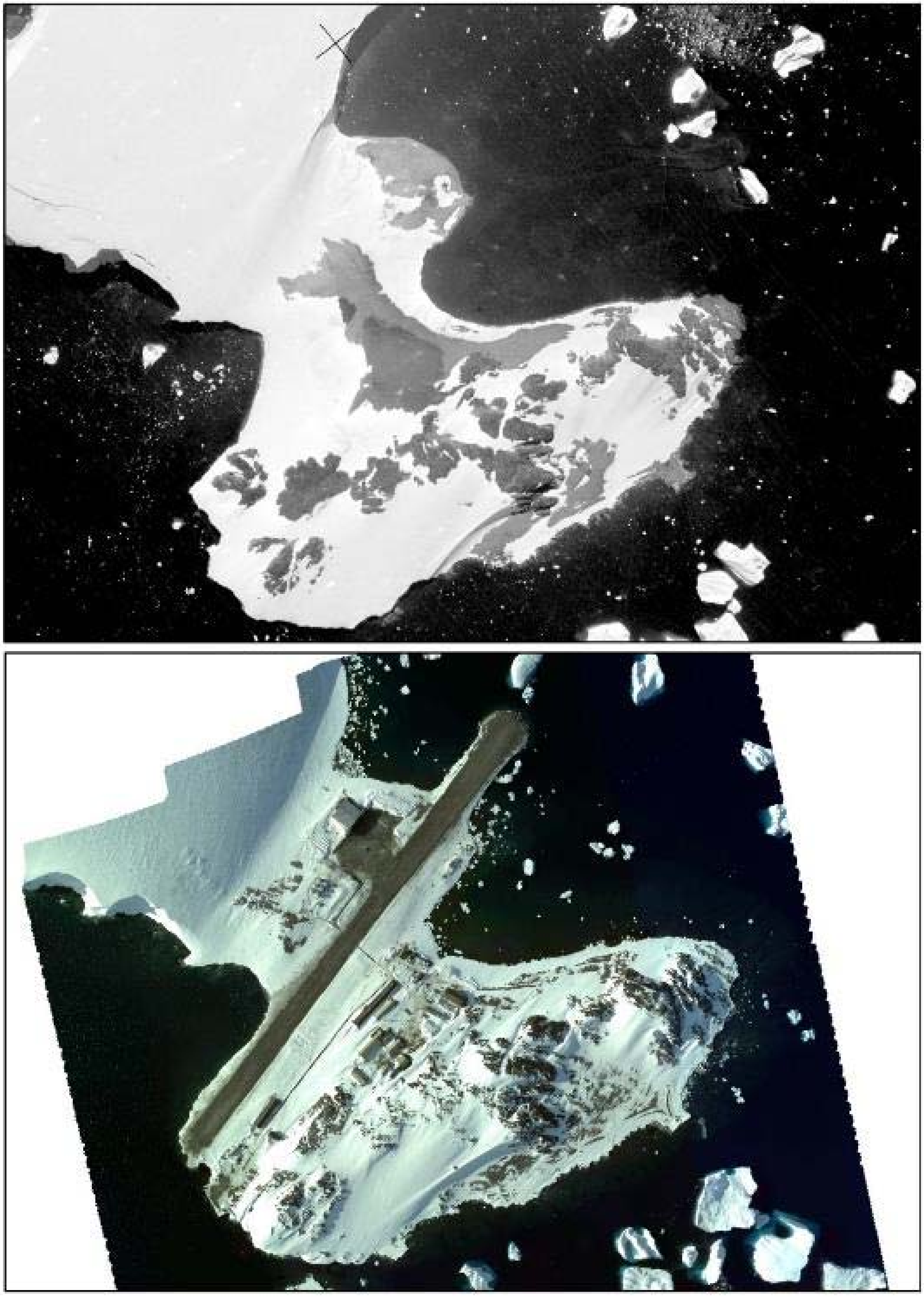

Figure 8-3 Aerial photographs of Rothera Point

The photos shown in *Figure 8-3* taken in 1957 (top) and 2013 (bottom) show the extent of human modification of the landscape in the intervening 57 years.

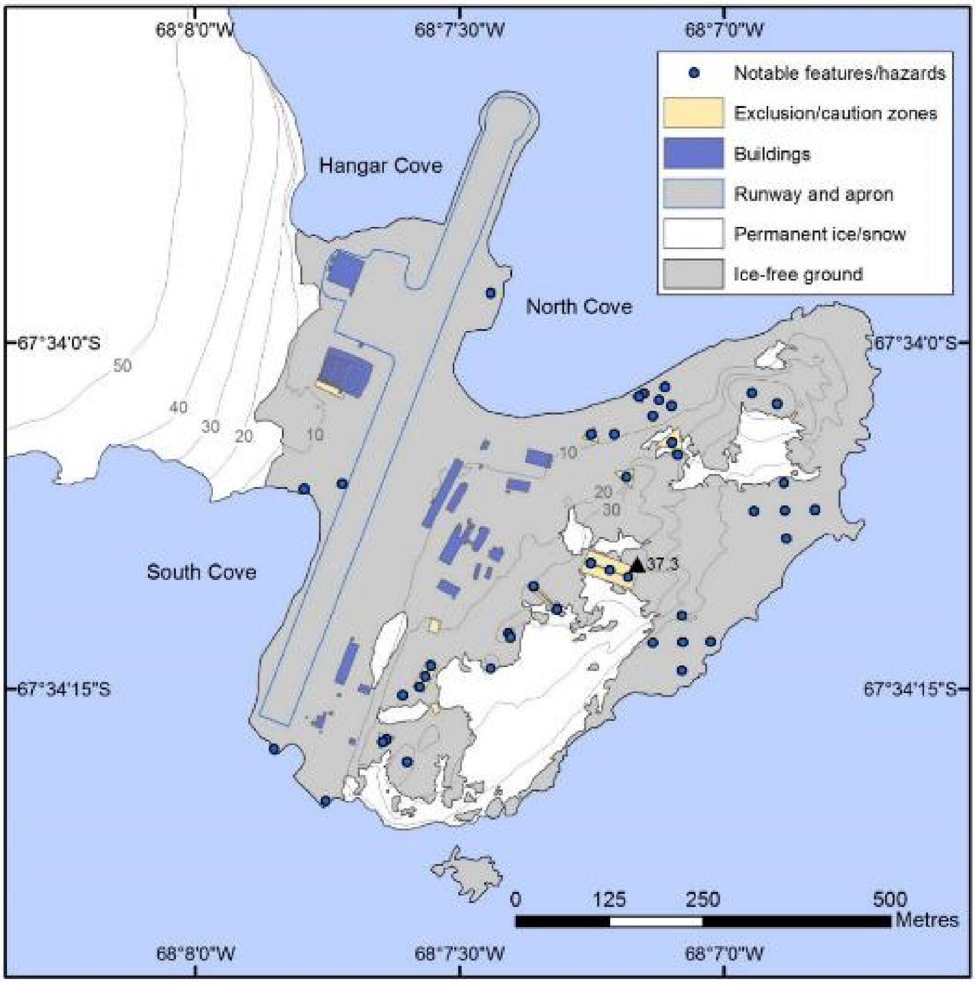

Figure 8-4 Buildings and other minor infrastructure (aerials, masts, radars, cairns, etc.) located on Rothera Point 2016.

8.3 Current Use of Site

8.3.1 Domestic

Rothera Station can currently support a maximum of 168 bed spaces (which includes the 32 beds in the temporary accommodation installed for the construction teams) during the austral summer which comprises both science and operational support personnel.

During the 2017-2018 season the maximum number of people on station reached 160 people with an average of 120 people on station at any one time. During the austral winter there are usually 20 people on station.

8.3.2 Science

Rothera supports a wide range of BAS, UK University and international collaborative science programmes including the Dirck Gerritsz laboratory that is staffed by scientists from the Netherlands polar research programme.

The scientific research conducted at Rothera spans a wide range of disciplines, including space weather, terrestrial biology, marine biology, oceanography, meteorology, atmospheric chemistry and ozone monitoring. The research at Rothera is led by three main BAS teams:

- Atmosphere, Ice and Climate (AIC)
- Space Weather and Atmosphere (SWA);and
- Biodiversity, Evolution and Adaptation (BEA)

8.3.2.1 Atmosphere, Ice and Climate

Meteorological data have been collected at Rothera since 1976, providing 41 years of continuous climatological data. These continuous data sets have provided the backbone of the important climate statistics from the Antarctic Peninsula, over the last four decades. Weather balloons are launched at over 400 locations around the world, at the same time each day. These data points are used in real-time by weather forecasters to get a global snapshot of the atmosphere. Climate scientists are also interested in the long-term records of temperatures at different heights in the atmosphere. At Rothera weather balloons are launched five times a week. There are only 18 launch sites in Antarctica so each site is crucial.

It is surprisingly hard to accurately measure precipitation quantities, particularly in windy and snowy conditions. At Rothera there is an array of precipitation sensors which, working side-by-side, gives us an idea of how much precipitation Rothera receives, and which sensors work best in which conditions.

There is a tide gauge installed at the wharf, which is calibrated once a week by conducting a tide dipping. This tide gauge forms part of the Global Sea Level Observing System.

It is vital that scientists continue to monitor the levels of ozone in the atmosphere so that they can understand the current state of the Antarctic ozone hole. At Rothera this is achieved using a SAOZ instrument (Systeme Automatique d'Observation Zenithal). SAOZ measures scattered sunlight in a way which allows scientists to determine how much ozone the light has passed through.

8.3.2.2 Space Weather and Atmosphere

Physical scientists use medium frequency radar and meteor radar to study wind and temperature in the upper atmosphere above Antarctica, and a low-power magnetometer at Rothera – one of a chain of instruments that BAS has installed across Antarctica – records variations in the Earth's magnetic field.

8.3.2.3 Bonner laboratory & Biodiversity, Evolution and Adaptation

The Bonner Laboratory supports station focused science projects predominantly in the areas of marine biology, oceanography and terrestrial biology. The BEA team aims to understand how past, present and future environmental change has and will affect polar biodiversity both on land and in the ocean, and how life adapts to extreme polar conditions. Their research outcomes will provide deep insight into the impact of environmental change on the natural world, make a strong contribution to future conservation measures, and generate new and innovative areas of research that have potential societal benefits.

The team has two research groups: Biodiversity and Adaptations. The Biodiversity group focuses its investigations on mapping species distributions, how they relate to current and past environments and how this information can be used to predict future distributions under environmental change. The Adaptations group investigates adaptations to extreme polar conditions, from the molecular level through physiology to ecology and, using experimental approaches, how these may affect species abilities to adapt under future change scenarios. Both groups work together towards the same aim: to develop a holistic picture of future patterns of biodiversity in a changing world.

The RaTS (Rothera Biological & Oceanographic Times Series) programme has been running at Rothera since 1997 and comprises an integrated suite of oceanographic and biochemistry data (e.g. temperature, salinity, macronutrients, chlorophyll) collected at a key site of rapid climate warming and high inter-annual variability on the Antarctic Peninsula. Changes in the ocean/climate system can occur over decades, and these changes are best detected using continuous, long-term monitoring programmes. The Rothera Time Series (RaTS) is one of the most important long-term monitoring programmes in Southern Ocean science, partly because it features winter-time measurements that are difficult to obtain.

As part of the NWO (Netherlands Organisation for Scientific Research) Netherlands Polar Program the Dirk Gerritsz Laboratory was opened at Rothera in 2013. It consists of four containerized laboratories and is the only Dutch funded laboratory in Antarctica. Researchers primarily come from Dutch universities or NWO research institutes and research focuses on climate change, glaciology, marine ecology and oceanography.

8.3.3 Air Operations

To support science and logistics in Antarctica, BAS operate a fleet of five aircraft, specially adapted for flying in extreme Antarctic climate. The BAS aircraft consist of four De Havilland Canada Twin Otters and one De Havilland Canada Dash-7 equipped with modifications to allow them to carry out airborne science surveys. Between them they undertake a wide variety of transport and science missions.

Due to the 900 m gravel runway at Rothera the Dash-7 is able to undertake regular shuttle-flights to and from South Atlantic gateways and is able to carry fuel and provisions to the deep field site at Sky Blu which supports a blue ice runway. The Twin Otter aircraft whilst carry much smaller payloads are more versatile, being able to land on wheels or skis and regularly transport scientists to remote deep field study sites within Antarctica.

8.3.4 Vehicle Operations

Vehicles at Rothera play a key role in moving people and equipment around the station. Maintenance of vehicles is undertaken by a team of vehicle mechanics and plant operators. The day-to-day coordination of vehicle use is arranged between the Facilities Engineer and the station management team. The following vehicles comprise the current fleet at Rothera:

- X15 Skidoos (Alpine 3) (including those deployed at Sky Blu, Fossil Bluff and with field parties)
- X10 Skidoos (Skandic V800)
- X10 Skidoos (ACE 600)
- X3 Tractors
- X10 Trailers
- X5 Loaders (forklift/bucket capability)
- X1 Snocat
- X1 Dozer
- X1 Crane (Nodwell 110c)
- X2 Tanker (for runway dust suppression)
- X6 Gators
- X1 ATV
- X1 Container Handler (SWL 20t)
- X1 Pick-up truck (fire response)
- X1 Digger 860 SX
- X1 JCB JS 130 (excavator)
- X2 Multi terrain loader/blower
- X3 Pedestrian snowblower
- X3 Attachment snowblower
- X1 Concrete Mixer
- X1 Access platform

8.3.5 Boating Operations

Boating operations are a vital part of science and operations activities at Rothera. There are currently five boats within the Rothera fleet. These are:

- Stella - 5.5m Humber Destroyer RIB (Console)
- Erebus - 6.0 m Humber Destroyer RIB (Console)
- Nimrod - 6.0 m Humber Destroyer RIB (Console)
- Terra Nova - 4.8m Humber Defender (Tiller)
- Sea Rover - 6.4m Sea Rover HDPE (Console)

Sea Rover and Terra Nova are primarily used as science platforms, in particular for the deployment of CTDs. The three Humber Destroyers are used for diving and SAR cover for air operations as required.

8.3.6 Fuel Storage

8.3.6.1 Marine Gas Oil (MGO)

Rothera has provision for the bulk storage of 716,200 litres of Marine Gas Oil (MGO) which is approximately 12.5 months' supply. All the long term storage tanks are made from steel and are either bunded or double skinned.

In 2019 four temporary single skinned tank tainers were sent to Rothera to help provide contingency storage of fuel during the construction of the Rothera Wharf. Each tank holds 24m^3 of MGO fuel. These tanks are currently located adjacent to the fuel farm and are contained in a temporary bund.

Figure 8-5 Bulk MGO storage at Rothera

Location	Capacity of tanks (litres)	Contingency Containment
Fuel Farm	3 x 230,000ltrs (Total = 690,000)	Bund can contain >100% of tanks capacity
Adjacent to fuel farm	4 x 2,300 =9,200 ltrs	Single skinned tanks held in a bund
Generator shed	2 x 5,500ltrs (Total = 11,000)	Self bunded tanks and concrete bund
Boiler House (OBH)	6,400	Doubled skinned tank
Garage	1,800	Doubled skinned tank
Giants	2,000	Concrete bund
Bonner Laboratory	5,500	Self bunded tank
NBH	12,000	Self bunded tank
Admirals House	5,000	Doubled skinned tank

Supply to the fuel farm is through a combination of steel and flexible hosed pipes. The flexible hoses are laid out during ship's relief and connected to the above ground steel pipes. Avery-Hardall dry-break valves or fueling guns are fitted to all refueling hoses to eliminate any spillage. All refuelling follows set operational procedures which the Rothera Facilities Engineer maintains.

The bulk tanks feed the Generator shed, Old Bransfield House and the garage. These tanks are filled on a daily basis. Bulk fuel is delivered to the generator shed through two plastic coated steel pipes (100 mm) buried underground. The fuel is circulated and heat traced to prevent it from waxing. Each tank is fitted with control valves and a re-circulating pump is situated in an enclosed housing to the south east of the fuel farm. Other MGO tanks are filled using a 12,000 litre mobile bowser towed by either the Bull dozer or JCB 456.

This operation will change once the new site wide services infrastructure is built. See Section 3.6

8.3.6.2 Aviation Fuel

The following table illustrates the quantity of aviation fuel (AVTUR) stored at Rothera and at depots out in the field during normal operations Aircraft are refuelled using the fuel dispenser pump on the apron as and when required. At deep field locations aircraft are refuelled using drummed AVTUR. The amount of fuel depoted in the field varies widely from year to year dependant on the requirement of scientific field project. The following table gives an approximation of AVTUR stored at Rothera and in the field:

Figure 8-6 AVTUR Storage at Rothera

Location	Quantity
Bulk fuel AVTUR at Rothera (litres)	3 x 230,000 ltrs (Total = 690,000)
No. of drums at Rothera (205 litre capacity each)	400-800
No. of drums at Fossil Bluff (205 litre capacity each)	10-50
No. of drums at Sky-blu (205 litre capacity each)	500-800
No. of drums stored in field depots	Varies seasonally

8.3.6.3 Other Fuels

Other equipment and plant at Rothera are operated with petrol and kerosene. The quantities stored at Rothera are listed below.

Figure 8-7 Other fuel storage at Rothera

Fuel Type	Quantity
Petrol –205 litre drums	**80 drums** (min. 40 required for winter & further 40 required for summer prior to ship relief)
Kerosene – 205 litre drums	**15 drums**(to allow for winter trips, early season and contingency)

8.3.7 Power Generation

Electrical power at Rothera is provided by 4 x Volvo TAD 752GE diesel engines, producing 144kW, coupled to AC generators housed in the generator shed. 24 hour continuous power is provided by having two on line at any time but with an automated means of changing over from one set to another. There are two mobile generator sets Volvo TAD 752GE which can be plugged into NBH or the Bonner laboratory. There is an auxiliary power container behind the hangar housing Cummins generators for emergency purposes to power the hangar. Power usage is minimized wherever possible and any equipment to be installed at Rothera that requires electrical power must be approved through the planning process prior to installation.

Rothera requires on average 700 m^3 of MGO per year to maintain serviceability.

- 66% is required of power production
- 29% is used for heating
- 3% used by vehicles
- 2% is used for incineration

Most of the heating is supplied in conventional heating systems, oil boilers in larger building and electric heaters in small buildings. The larger building are also equipped with air handling units. Rothera uses on average 180kw to 200kw of power and any one time.

Rothera has several energy efficient measures in place:

- Heating controls and temperatures are closely monitored to improve efficiency
- Power is monitored and reduced where practicable.
- Energy efficient lighting
- Greater use of natural lighting
- Building Management System (BMS)

See Section 3.5.3 for the proposed changes to the system once the Phase 1 works have been completed.

8.3.8 Water Generation

Fresh water is produced at Rothera by reverse osmosis (RO), converting salt water to fresh water through a process of desalination. The RO plant is online 24 hours a day and can produce up to 14m^3 per day. Water is readily available unless there is a mechanical failure. Efficient use of water use is encouraged to minimize fuel use.

Potable water is initially stored in the reverse osmosis room which has 3 tanks with a total volume of 28 m^3. It is then pumped to smaller satellite tanks situated in other buildings. A melt tank is also available for emergency use. All personnel are reminded to keep water usage to a minimum, particularly in summer when there are more people on Station.

Water figures fluctuate between the summer and winter usage. Salt water is used in 3 buildings for flushing toilets.

- Average use of potable water Mar-Sep 70 m^3 per month (21 x personnel).
- Average use of potable water Oct-Dec: 200m^3 per month (Station average 70-90 personnel).
- Average use of salt water use Mar-Sep 30 m^3 per month (21 x personnel).
- Average use of salt water Oct-Dec: 90m^3 per month (Station average 70-90 personnel).

Two RO plants will operate in the new Operations Building.

8.3.9 Rothera Wharf

The Rothera Wharf construction team (approximately 50 staff), travelled to Rothera in advance of the arrival of the charter vessel at the end of December 2018. All plant, equipment and materials were offloaded by early January 19.

Since then the team has built a temporary jetty and boat shed in South Cove to allow science diving operations to continue safely throughout the season, away from the construction works. They have erected a plant fitter's workshop, which is used to maintain plant and do minor steel fabrication works.

The team have carried out 12 blasts (using around 16 tonnes of explosives) and extracted 26,000 tonnes of rock fill. The largest rocks (> 300kg) have been set aside for use as primary armour in the coastal stabilisation works. 30-80mm graded rock fill has been stockpiled and will be or has been used to back fill the new wharf as needed. The remaining material (< 30mm) has been screened again and will be used as fines for repairing the runway surfacing.

The dismantling of the existing Biscoe Wharf began as soon as the charter vessel carrying plant and equipment for the project left Rothera. This was a complex operation that required close supervision and assessment by the Project Team to ensure there was no risk of uncontrolled collapse. The dismantling process included digging out the existing fill, which was then processed and added to the appropriate stockpiles for potential reuse. The condition of the existing wharf steelwork was assessed at this stage and it was determined that the rate of corrosion was such that cathodic protection will not be required on the new wharf. Two assembly jigs were erected and have been used to assemble the rear frames (the internal structure of the new wharf). Six of these rear frames have been completed and installed in their final positions. Installation includes drilling and grouting tension anchors and grouting an underwater pad to resist compressive forces.

At the end of the season, the west wall of the wharf, and the north western corner section had been installed. In addition the temporary ice shields on the six frames have also been installed. This has enabled the partially constructed wharf to be backfilled thus making it safe to be left over winter.

All the above has been done safely and with full consideration of the impact on the environment and ongoing station operations.

9 DESCRIPTION OF ENVIRONMENT

Reference is made in this section to Rothera Point. This is the area of land to the east of the Wormald Ice Piedmont shown in Figure 9-1, which is largely ice free and within which the Rothera Research station is situated. Rothera Point is located within Antarctic Conservation Biogeographic Region (ACBR) No. 3 Northwest Antarctic Peninsula. Recent estimates suggest that ice-free ground may comprise as little as 0.18% of Antarctica (Burton-Johnson et al., 2016). Of the c. 25,000 km2 of ice-free ground, only a small proportion is located close to the coast where climatic conditions are suitable for the development of substantial vegetation communities and where wildlife colonies and haul out sites are found (Fretwell et al., 2011). However, coastal sites are also often favoured as sites for logistic facilities by national operators and as visitation sites used by the tourism industry (Pertierra et al., 2017).

9.1 Ecology

Levels of biodiversity at Rothera Point are not high compared to other equivalent areas. For example the nearby islands in Ryder Bay have much higher levels of biodiversity. However, Rothera Point does contain some examples of Antarctic fellfield environments, which are reasonably rare in the wider area (Convey and Smith, 1997). In contrast the near shore marine environment is considerably more species diverse and the subject of most biological research in the area (Barnes, 2007).

9.1.1 Terrestrial Flora

Rothera Point contains no large areas of green vegetation, with substantial continuous moss and liverwort patches limited to a single area of c. 100 m2 adjacent to a transient melt stream in a gully 100 m east of the Miracle Span marked as Area A in Figure 9-1. Confirming this, analysis of remote sensing imagery (using Normalised Difference Vegetative Index (NDVI) methodology) revealed that areas of significant green vegetation are spatially limited (Hughes et al., 2016). Areas of high NDVI value on East Beach relate to algae and cyanobacteria in ephemeral pools fed seasonally by melting snow and ice (Figure 9-1, area B).

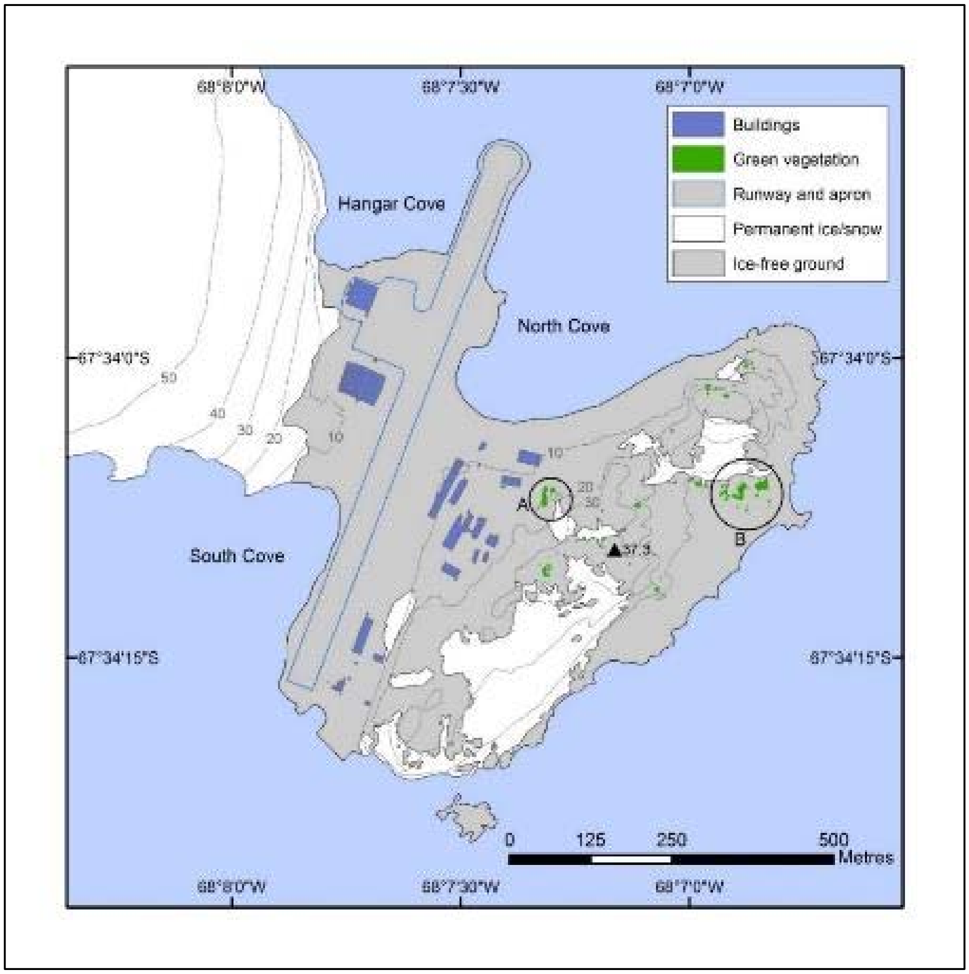

Figure 9-1 Areas of green vegetation detected on Rothera Point using NDVI methodology.

Circled areas A and B denote the location of particularly rich areas of moss/liverwort and algal vegetation, respectively. The vegetation labelled A in Figure 9-1 is close to the area where building activity is proposed.

Cryptogams (mosses, liverworts, lichens, algae)

The limited terrestrial biological interest within the Rothera Point is confined to the rock bluffs where there is a locally abundant growth of lichens. There are no particularly special or rare terrestrial flora in the locality of Rothera Point (Antarctic Treaty Secretariat, 2017). The vegetation is representative of the southern "maritime" Antarctic fellfield ecosystem and is dominated by the fruticose lichens *Usnea antarctica, Usnea sphacelala*, and *Pseudephebe minuscula*, and the foliose lichen *Umbilicaria decussata* (Øvstedal and Smith 2001; Cannone et al., 2018). Lichen vegetation is reasonably well developed and diverse, dominated by crustose and foliose species, and is typical of the southern maritime Antarctic, as previously described. Bryophytes are generally sparse (mainly *Andreaea spp*). Bryophytes are limited to two main habitats, these being around the relatively small areas of soil and sorted ground, and in rock crevice and epilithic habitats (Ochyra et al., 2008). In the former habitat, although sparse on the higher ice free area, there are some well-developed stands of Andreaea spp. especially below the western and south-western edges of the Antarctic Specially Protected Area (ASPA 129) (see Section 10.9 Protected Areas), and *Sanioni*a sp. especially below the eastern and south-eastern edges. These are intermixed with a small amount of what appears to be *Bryum sp*. and possibly also *Ceratodon* and *Cephaloziella*. Examples of crevice and epilithic species include *Bartramia* (some with sporophytes) and *Schistidium/Grimmia.*

The vegetation composition does appear to have remained constant since the mid-1990s. The total area of moss cushions or carpets, while remaining small, may have expanded slightly, including habitats along the spine of Rothera Point, and in the sandy/silty areas of East Beach (P. Convey, pers comm.) (See Figure 9-1, point B).

Vascular plants

A single very small population of Antarctic pearlwort (*Colobanthus quitensis*) has been observed below the northern cliff of the Point (Figure 9-2 and 9-3). A small population of Antarctic pearlwort (*Colobanthus quitensis*) may continue to persist in a small gully at the base of crags under the Point's north-west cliffs. Sixteen separate plants or clumps of varying sizes were noted previously, at least two of which included mature and open seedheads; however, these plants are vulnerable to long-term burial by snow and their persistence is uncertain. A single plant of Antarctic hairgrass (*Deschampsia antarctica*) was located in a small depression at the northern edge of the summit plateau of the Point (figure 9-4 and 9-5). This plant also possessed a single mature seedhead. However, its on-going persistence at the site is in doubt.


Figure 9-2. Small population of Antarctic Pearlwort C. quitensis*. Figure 9-3 Plant with previous year's seed heads*


Figure 9-4 Location of Antarctic Hairgrass Deschampsia antarctica. Figure 9-5 Inflorescence

9.1.2 Terrestrial Fauna

The terrestrial invertebrate fauna is impoverished and consists only of a few species of mites and springtails, of which *Halozetes belgicae* and *Cryptopygus antarcticus* are the most common. Nematodes and rotifers have also been recorded in freshwater pools. There are no special or rare terrestrial fauna on Rothera Point (Convey and Smith, 1997).

9.1.3 Avifauna

Common Breeding Species at Rothera

For a comprehensive review of birdlife at Rothera Point, including reference to relevant literature, see Milius, 2000. Of the bird species observed in the vicinity of Rothera Point, only some are known to breed locally: snow petrel (*Pagodroma nivea*), Wilson's storm petrel (*Oceanites oceanicus*), imperial/Antarctic shag or cormorant (*Phalocrocorax [atriceps] bransfieldensis*), south polar skua (*Catharacta maccormicki*), and kelp/Dominican gull (*Larus dominicanus*) and Antarctic tern (*Sterna vittatta*). On Rothera Point itself, south polar skuas are the most abundant breeding birds with occasional pairs of kelp gulls nesting and one Wilson's storm petrel nest has been found (Phillips et al., 2019).

Snow Petrel (*Pagodroma nivea)*

Snow petrels may breed in small numbers and are recorded throughout the year around Rothera Point, though less often in early and mid-summer. It is possible that they breed on some of the rock outcrops in the Rothera area.

Wilson's storm petrel (*Oceanites oceanicus*)

This species may breed in small numbers on Rothera Point, probably <15 pairs, although it also breeds on many (maybe all) of the other local islands in Ryder Bay, e.g. Lagoon Island. Birds return in late November or early December and although records are few, their departure is likely to be during April.

Antarctic shag (*Phalacrocorax [atriceps] bransfieldensis*)

Up to 74 pairs of the Antarctic shag breed on Killingbeck Island (1.6 km east of Rothera Point) and the small rock just north of the island. Up to 251 pairs breed on Mucklescarf Island, close to Lagoon Island, although the exact numbers may vary considerably between years. A further colony located on Skart Island (Mikkelsen Islands) was discovered in Jan 2018 and contained 80 pairs (Phillips et al., 2019). Antarctic shags can be seen at all times of the year, although their presence in winter is likely to be dependent on sea-ice conditions. Between late March and late June 1996, large flocks containing 300–400 adult and juvenile birds were seen with over 1000 recorded on 22 June, indicating that more than just the local breeding population was present.

South polar skua (*Stercorarius maccormicki*)

South polar skuas breed at Rothera Point and the population has been monitored annually since the 1988/89 season. The location of recorded nest sites are shown in **Error! Reference source not found.**) (UK Polar Data Centre, Rothera Point and Anchorage Skua data, 2017). Nest sites are often reused but may be inactive for a number of consecutive years. Rock removal undertaken during the 2018/19 season means the most southerly nesting site may no longer remain viable. Long-term data indicated that the population size at Rothera Point varied considerably between years, increasing overall by 1.9% per annum from 11 breeding pairs in 1975/76 to 24 breeding pairs in 2017/18 (see Figure 9-7) Additionally, up to almost 1000 birds breed on many of the other islands in Ryder Bay (Lagoon, Leonie, Killingbeck, Donnelly and Anchorage) (See Figure 9-7; Phillips, 2019) and at least one incubating pair has been observed on Reptile Ridge. The spring return to Rothera usually falls between 15 and 25 October with departure in late April/early May, with the latest birds likely to be migrants from farther south. At Rothera Point, large numbers of non-breeding skuas (up to 200) congregate in communal areas, often near shallow melt pools, particularly beside the melt pools on East Beach and at either end of the runway.

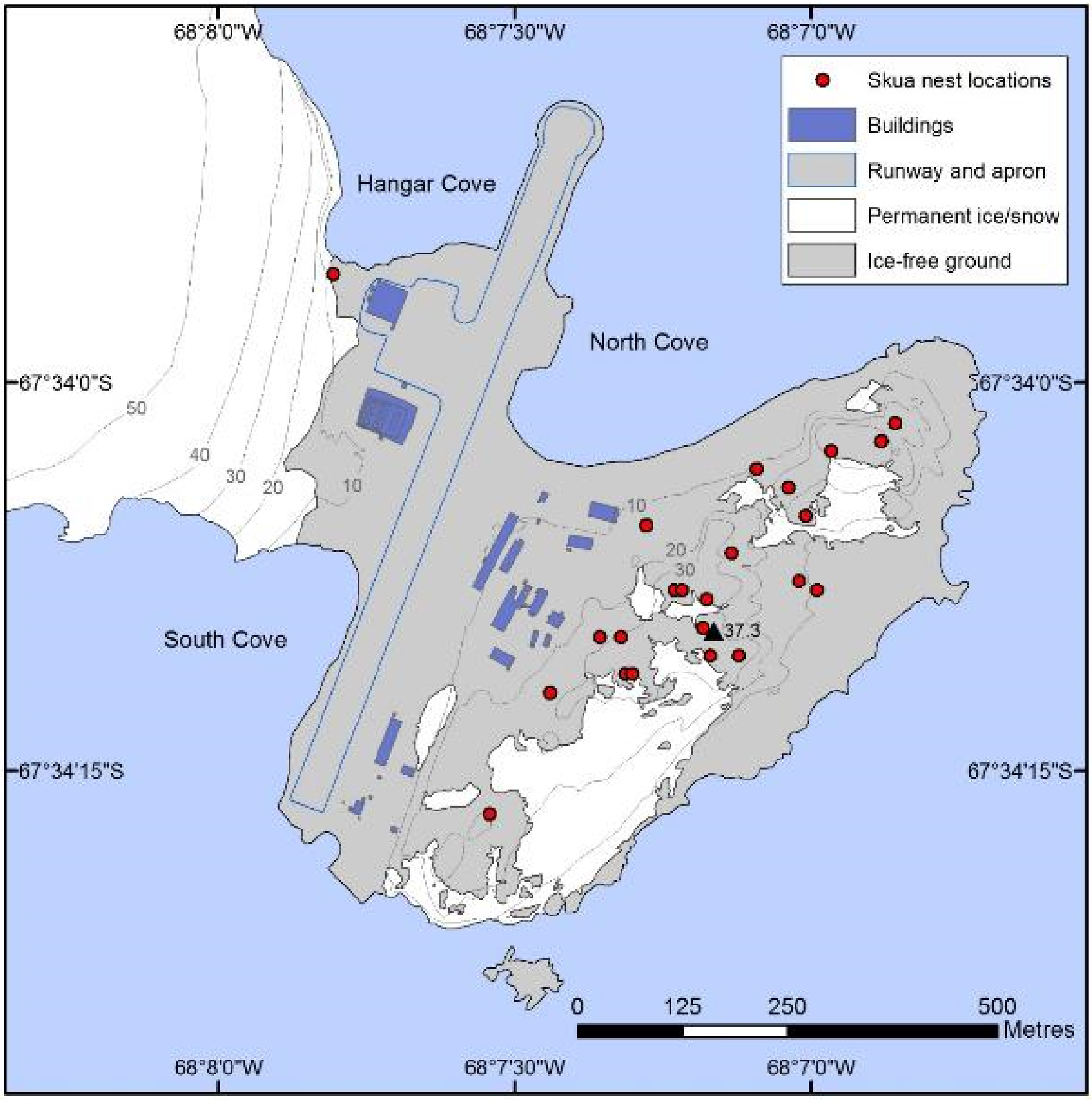

Figure 9-6 Distribution of skua nesting sites on Rothera Point, Adelaide Island between 2005 and 2016.

Note, the red circles mark the general areas in which nests are located as the precise location may vary by a few metres year on year.

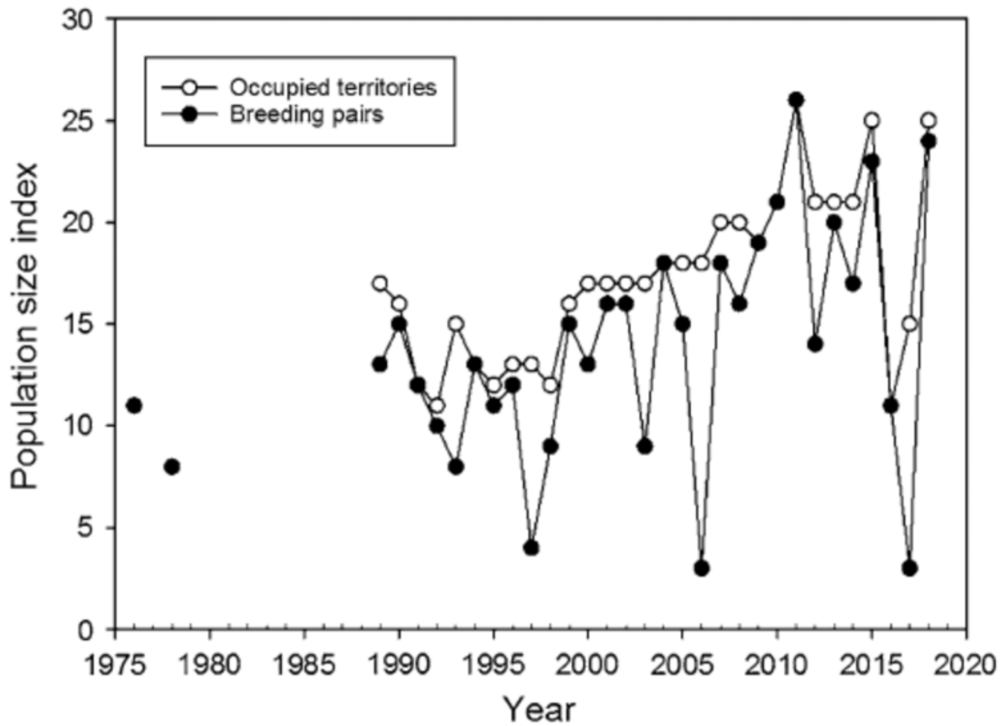

Figure 9-7 Changes in population sizes of south polar skuas at Rothera Point, Ryder Bay (Antarctic Peninsula) from 1976 to 2018. Years refer to the time of chick fledging (i.e. 1976 represents the 1975/76 austral summer)

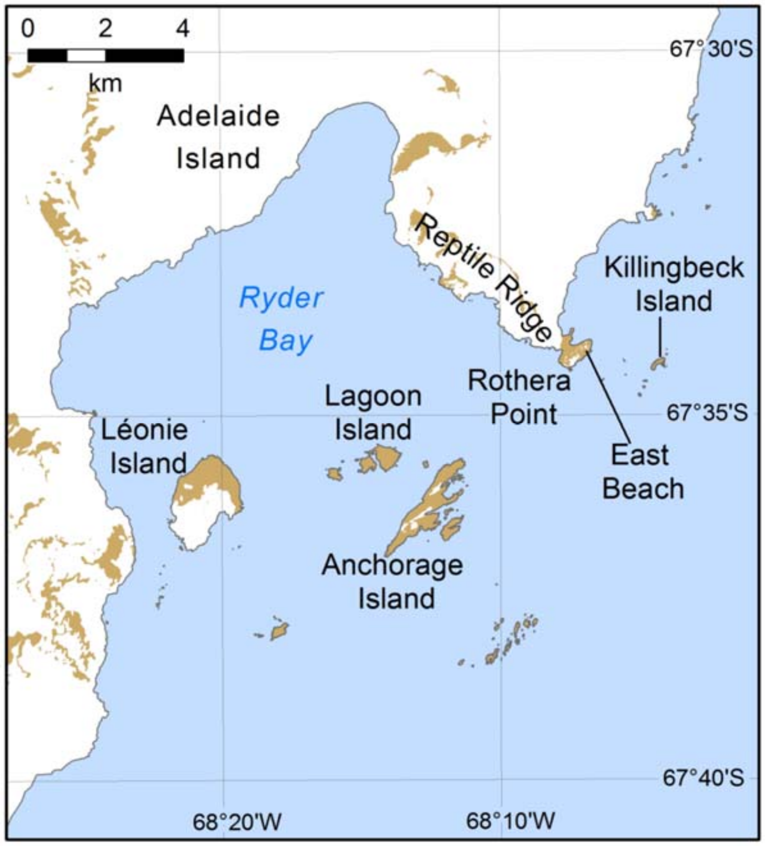

Figure 9-8 Location map of Ryder Bay and surrounding area

Kelp gull (*Larus dominicanus*)

The Rothera Point breeding population varies from c. zero to four pairs. This species also breeds on the other local islands (Killingbeck, Lagoon, Anchorage and in larger numbers on Leonie). In winter, kelp gulls are one of the most regularly recorded species at Rothera.

Antarctic tern (*Sterna vittata*)

Breeds locally, on Killingbeck Island, Reptile Ridge (c. 100 pairs) and on Lagoon Island and possibly Anchorage Island. About 60 terns, some of which were on nests, were noted on Rothera Point in February 1962 and a nesting colony of 100+ birds was reported at Rothera Point on 16 January 1969. However, the colony disappeared after the establishment of the station in 1976. Birds are seen commonly around Rothera Point between late September/early October and March and far more rarely in winter.

Common Non-breeding Species at Rothera

Emperor penguin (*Aptenodytes forsteri*)

Emperor penguins are rare, although almost annual, visitors, with seldom more than single birds seen although a group of 19 was recorded on 7 November 1977. Nearly all records fall between August and November.

Adélie penguin (*Pygoscelis adeliae*)

Seen almost daily during the summer months (late October to March) and less frequently, but still regularly, throughout the remainder of the year. In summer, counts vary greatly with up to 120 birds observed on East Beach on a single day. Winter occurrence is probably largely dependent on sea ice coverage; available records suggest that they become quite scarce when the sea ice is at its most extensive. During February and March, many of the birds present come ashore to moult. From late February to April, a small number of first-year birds are regularly recorded, although during the winter almost all birds are adults. Fragments of bone and egg shell in soil provide evidence of ancient penguin (mid to late Holocene), probably Adélie penguin, colonies on Rothera Point (Emslie and McDaniel, 2002).

Chinstrap penguin (*Pygoscelis antarctica*)

Rare summer visitors with records usually involving single birds between January and March.

9.1.4 Marine mammals

Seals

No seals use Rothera Point as a breeding site. Weddell seals (*Leptonychotes weddelli*) are the most obvious mammal and are present all year round in the area around Rothera Point (See Figure 9-9) (BAS, 2017). In late September, pups are born out on the sea ice. Crabeater seals (*Lobodon carcinophagus*) and elephant seals (*Mirounga leonina*) are also present, and fur seals (*Arctocephalus gazelle*) arrive in varying numbers at the end of each summer. Increasing numbers of both elephant and fur seals have been experienced in the last few seasons at Rothera and whilst no scientific surveys have been undertaken to establish the actual numbers of individuals, operational tasks have been impacted by the presence of seals on roadways and the runway. The leopard seal (*Hydrurga leptonyx*) is present all year round and, in 2003, an attack resulted in the death of a marine biologist at Rothera Point (Muir et al., 2006).

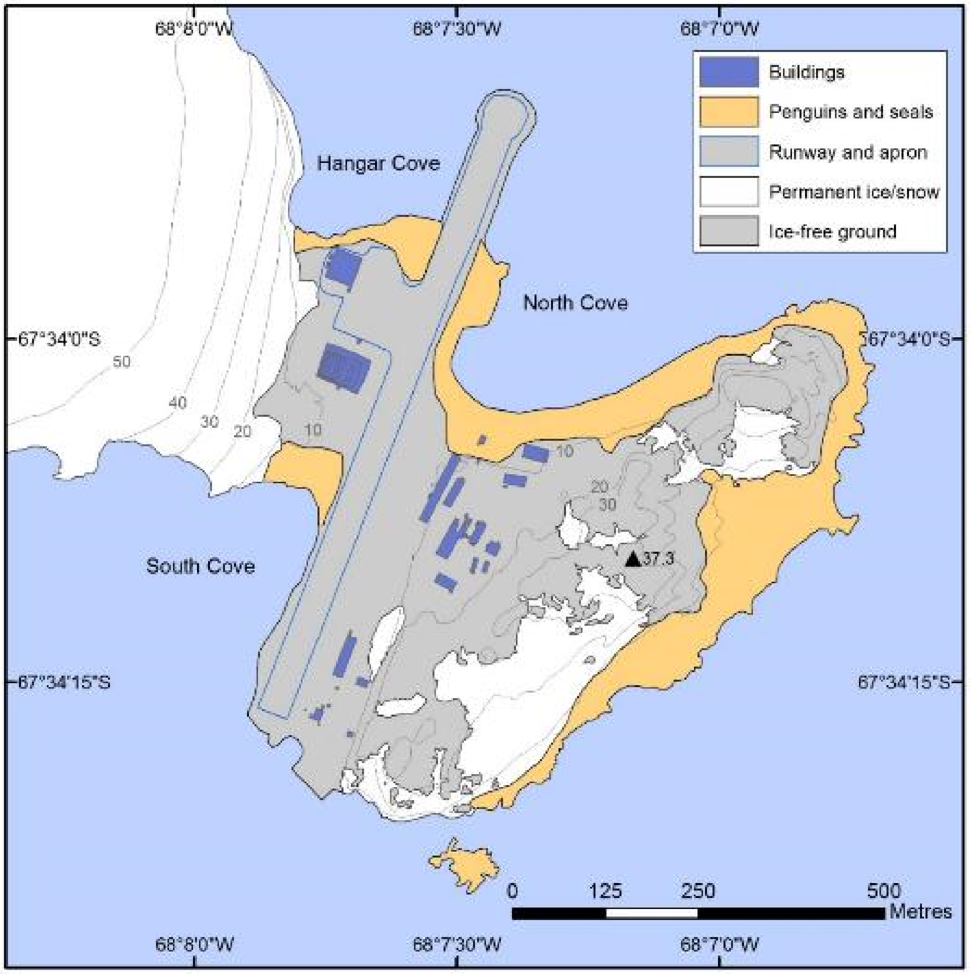

Figure 9-9 Low lying area of Rothera Point where low densities of seals & penguins may be found commonly

Whales

Minke whales (*Balaenoptera bonaerensis*) and humpback whales (*Megaptera novaeangliae*) are seen in Ryder Bay each summer. During some years minke whales can be observed frequently and may be year-round residents, including within the ice pack if present. There is little evidence for substantial blue or fin whale activity in Marguerite Bay (Sirovic and Hildebrand, 2011). Killer whales (*Orcinus orca*) inhabit the larger Marguerite Bay area and are usually seen from the station several times each summer. Humpback whales are seasonal residents, migrating between tropical breeding and calving grounds to feed along the Western Antarctic Peninsula in austral summer and autumn months. There are areas within Marguerite Bay with high krill predator occurrence rates including the area around Rothera Point and the northern extent of Marguerite Bay near the south eastern end of Adelaide Island (Friedlaender et al., 2011).

9.1.5 Non-native species

No non-native plants or invertebrates are known from Rothera Point or the adjacent marine environment. However, there was a report, dating from the mid-1990s, of the non-native collembolan (springtail) *Hypogastrura viatica* at Leonie Island, Marguerite Bay (Hughes et al., 2015). This is the most southerly record of the presence of a non-native species in the natural environment on the Antarctic Peninsula (see **Error! Reference source not found.**).

As one of the most biologically rich terrestrial sites in the vicinity of Rothera Point, Leonie Island has been a focus of biological research visits for over two decades. Rothera Point acts as a logistics hub for aircraft operations across large areas of the Antarctic Peninsula and continental Antarctica. Should a non-native species be present at the station, there may be potential for this species to be inadvertently spread to other distant Antarctic locations via aircraft and also ship movements. A monitoring project was initiated in Jan 2015 to establish the presence and distribution of *Hypogastrura viatica* (non-native springtails) on the islands in Marguerite Bay and on Rothera Point (See Figure 9-11**Error! Reference source not found.**) (Hughes et al., 2017). Taxonomic expertise was provided by Dr. Penelope Greenslade of the University of Ballarat, Australia. No evidence for the presence of *Hypogastrura viatica* or any other non-native invertebrate was found in the c. 36,796 specimens collected. From these data we cannot categorically state that *H. viatica* is absent from the area, but given the number and distribution of samples collected, it is likely that it is present in only very low numbers and it is possible that it has become locally extinct.

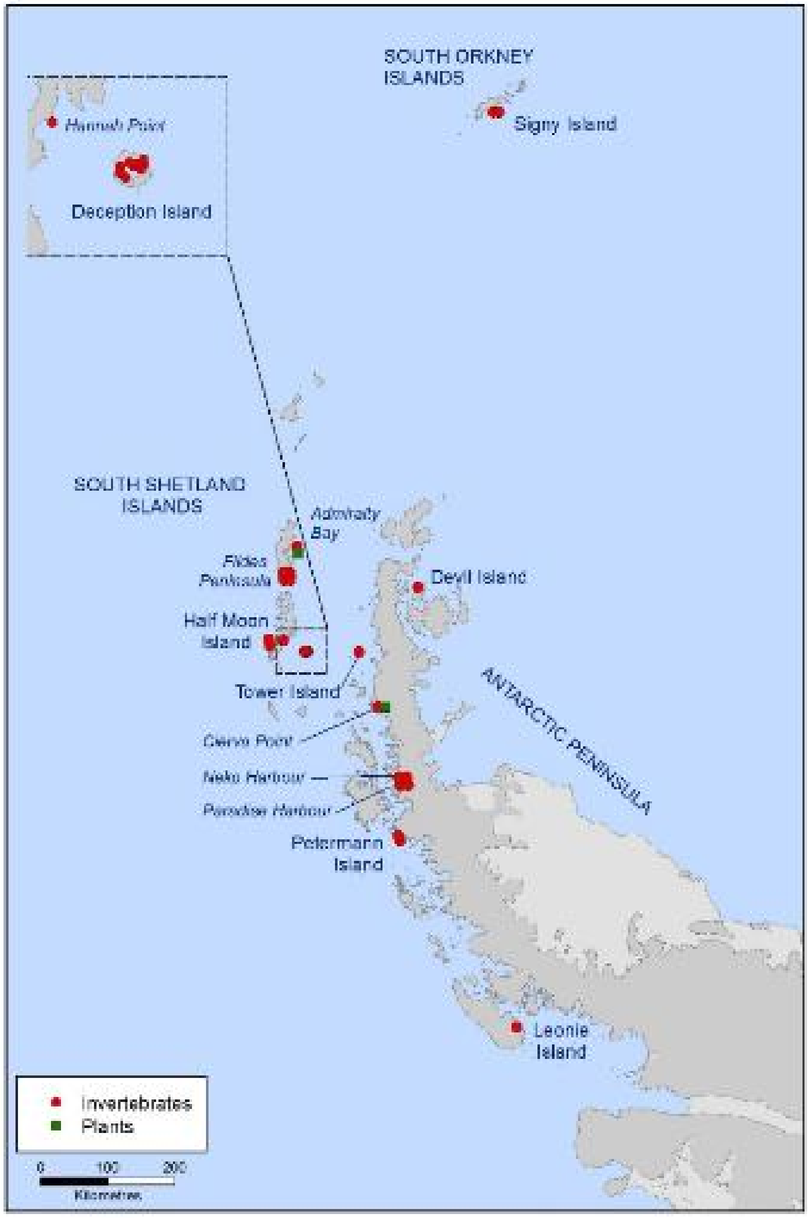

Figure 9-10 Map of the Antarctic Peninsula region showing the distribution of known non-native species

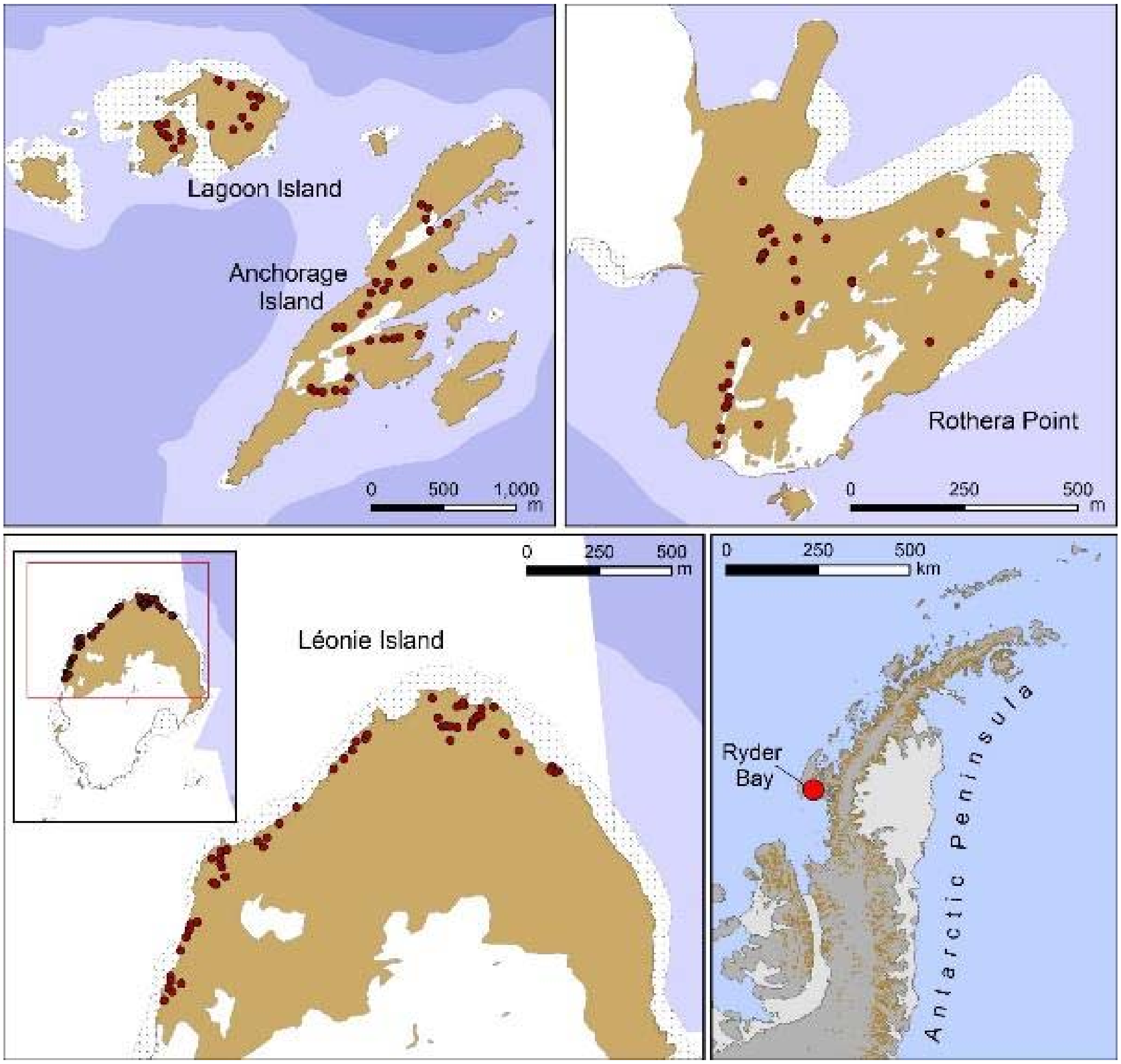

Figure 9-11 Monitoring location for the non-native springtail Hypogastrura viatica *in the vicinity of Rothera Point and islands of Marguerite Bay.*

9.2 Physical Characteristics

9.2.1 Meteorological Conditions

The climate is cold and dry and represents a transition from that typical of the more oceanically-influenced 'maritime' Antarctic to the north and the more extreme climate of 'continental' Antarctica to the south. A programme of surface synoptic meteorological measurements commenced at Rothera Research Station in 1977 (Turner et al., 2004). Mean monthly air temperatures range between c. -10.5 and + 1.4 oC (See Figure 9-12**Error! Reference source not found.**), with the prevailing wind from the north-north-east and averaging at 12.1 m s-1 (See Figure 9-13).

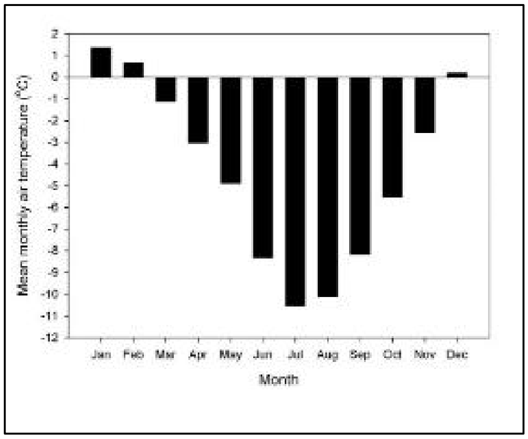

Figure 9-12 Mean monthly air temperature at Rothera Point, Adelaide Island (1977-2015)

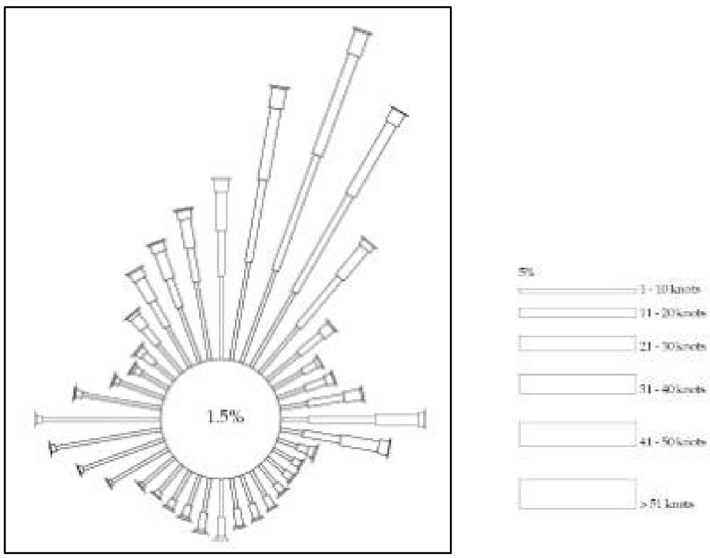

Figure 9-13 Wind rose for Rothera Point, Adelaide Island

9.2.2 Air Quality

No air quality data exist for Rothera Point; however, significant volumes of hydrocarbons are combusted in the vicinity of the station to power station generators and the engines of vehicles, ships, small boats and aircraft. Monitoring of heavy metals in lichens on Rothera Point undertaken between 1976 and 1989 showed pollution close to the station, particularly those areas affected by diesel generators and within c. 200 m to the northwest, north and northeast of the station, corresponding with the prevailing wind directions (Bonner et al., 1989). Beyond this area the concentrations progressively declined with increasing distance from the station. Nevertheless, the frequently high to moderate wind speeds in the area may rapidly disperse any pollutants, so minimising any impacts beyond the immediate vicinity of the pollution sources.

9.2.3 Tides and Waves

The tides at Rothera are diurnal (i.e. one high tide and one low tide each day). On some neap tides the difference between high and low water can be very small.

Figure 9-14 Tide Table

Astronomical tides for Rothera Point are given on Admiralty chart 3462 as follows (CD: chart datum):

State of the Tide	Abbrev.	Level
Mean High High Water	MHHW	+1.3 m CD
Mean Low Low Water	MLLW	+0.4 m CD
Mean Sea Level (taken as the mean of MHHW & MLLW)	MSL	+0.85 m CD

9.2.4 Geomorphology

Rothera Point is a small peninsula situated on the southeast of Adelaide Island (Bonner et al., 1989). It is a low rocky headland of about 0.4 km2 comprising a north-east to south-west trending, with a dissecting ridge rising to 39 m altitude. There is an area of raised beach composed of rounded boulders on the south-eastern side and similar but more extensive terrain (though composed of smaller stones and pebbles) on the north-west side. The latter forms an isthmus between North and South Cove and connects Rothera Point itself to Adelaide Island. The isthmus was extensively altered and widened during the construction of the gravel runway in the early 1990s. The sloping ice-ramp with a gradient of about 1:5 leads from the isthmus to the Wormald Ice Piedmont.

The rocks of Rothera Point have been subject to extensive frost shatter although some areas have been made smooth by the action of ice that has since retreated. A large ice-dammed melt pool that used to exist where Rothera Station now stands had disappeared by the early 1970s; its former shore lines were distinguished by more than 20 narrow terraces, but these are now largely indistinguishable due to station construction activities (Shears, 1995). Several poor quality raised beach terraces are present on East Beach, representing previous higher sea level episodes, and the process of isostatic rebound is thought to be on-going in the area. Raised beaches are also evident on the neighbouring Anchorage and Leonie islands and occur at 6, 18 and 23 m. Other areas of ice-free topography are widespread elsewhere in Laubeuf Fjord and northern Marguerite Bay, but few possess extensive level ground.

During the 2018/19 season rock was removed from the rock cliffs north-east of Biscoe Wharf to provide material for construction of the replacement wharf.

9.2.5 Soils

Soil is restricted to small pockets of glacial till and sand intermixed with relictual penguin guano in depressions and amongst the rocks (ATS, 2017). Deeper deposits have permafrost and occur as scattered small circles and polygons of sorted material. There are no extensive areas of patterned ground and periglacial features are poorly represented. There are frequent accumulations of decaying limpet (*Nacella concinna*) shells deposited by gulls (*Lars dominicanus*), forming patches of calcareous ‘soil’. The disappearance of snow and ice patches during the past 30 years has revealed deposits of organic mud, feathers and bones derived from an ancient Adelie penguin rookery (Emslie and

McDaniel, 2002). Otherwise, there are no accumulations of organic matter, except for a very shallow layer of decaying moss peat beneath patches of moss.

9.2.6 Surface Water

No large areas of freshwater exists on Rothera Point, with the exception of a c. 50 metre long transient pool located at the west fringe of the large area of permanent ice to the south of Rothera Point. Seasonal meltwater from the permanent ice feeds into this water body, which consequently fluctuates in level. During winter, and sometimes extending into the summer months, the surface of the water is not visible due to ice and snow cover. The pool was partially infilled during the 2018/19 season. Transient streams may form at other locations around the Point, with flow rate depending upon the season and level of melt of the associated snow and ice bodies. The large relatively flat area of ground at East Beach may contain transient pools that may support algal and cyanobacterial communities. The flat area to the west of the Hangar may contain small transient meltwater pools.

9.2.7 Geology

The stratified rocks of central Adelaide Island are probably of Late Jurassic age, based on similarities to rocks from elsewhere on the west coast of the Antarctic Peninsula (Riley et al., 2012). The lithological unit that is directly relevant to Rothera Point and the surrounding area is the 'Adelaide Island intrusive suite' which is a series of isolated and composite granitoid plutons. A large part of the exposed geology on Adelaide Island consists of these plutonic rocks. Many of the plutons on Adelaide Island are heterogeneous and are characterised by concentrations of well-rounded xenoliths, which are typically more mafic than the host rock. The plutons can be seen to intrude the volcano-sedimentary sequences at several localities, including Reptile Ridge which lies at the top of the Rothera ice ramp.

The geology around Rothera Point is dominated by granodiorite, with minor amounts of quartz diorite and diorite. The geology of Rothera Point is interpreted to be consistent with the rest of the Adelaide Island intrusive suite and is therefore thought to be approximately 48 Ma (Eocene age). The mineralogy of the Rothera Point granodiorite consists of plagioclase, quartz, amphibole, biotite and variable amounts of chlorite and epidote, which has formed along cracks and joints in the rock, as a result of hydrothermal alteration. Malachite (copper) mineralisation is also a characteristic of the granodiorites of the Wright Peninsula and Rothera Point.

Close to the Memorial on Rothera Point, the primary lithology is granodiorite, although it is frequently characterised by abundant rounded mafic patches within the granodiorite host (Figure 9-15). The mafic 'blebs' are gabbroic in composition and are distinct to the xenolith-hosted granodiorite. The formation of this feature would have meant that the mafic blebs (gabbro) were relatively hot and less viscous compared to the 'colder' and more viscous granodiorite magma, therefore the gabbro would have 'frozen' when intruded into the granodiorite magma. This process where the gabbro and granodiorite magmas remain as distinct, recognizable rock types rather than becoming completely mixed is called 'magma-mingling'. With magma mingling there are some chemical interactions between the two magmas by slow and complex diffusional processes, but thermal equilibrium is reached long before chemical equilibrium, so the effects on the granodiorite composition are relatively minor.

Figure 9-15 Magma mingling on Rothera Point.

A ground investigation report has been produced based on the findings of a Site Investigation undertaken at Rothera in 2018-2019. This report has been included in Appendix D: *Rothera Ground Investigation Report.*

9.2.8 Glaciology

Access from Adelaide Island to Rothera Point is via an ice ramp forming the southern limit of the Wormald Ice Piedmont (**Error! Reference source not found.**See Figure 9-16).

Figure 9-16 The ice ramp that connects Rothera Point to the Wormald Ice Piedmont.

The surface elevation of the ramp rises from 10 to 110 m asl, over a horizontal distance of around 600 m. Following the establishment of the scientific station in 1975, the ramp saw considerable year-round vehicle traffic, largely in support of aircraft operations from a skiway on the piedmont. This traffic increased steadily over the years. In early 1990, construction of a gravel runway between the station and ramp began and by 1992 all aircraft operations had been transferred to this runway. Subsequent traffic on the ramp has been light. A survey programme was initiated in February 1989 to monitor the ice ramp's mass balance and to detect any changes (Smith et al., 1998). The uppermost part of the ramp shows no clear decline in mass balance; however, lower sections of the ramp surface have lowered, in common with other sites on the Antarctic Peninsula (**Error! Reference source not found.**See Figure 9-17). The deposition of dust on the ramp originating from the runway may also be contributing to surface lowering, and mitigation measures are employed to reduce dust dispersal from the runway. Studies suggest that the ramp has been subject to episodes of advance and retreat over longer timescales.

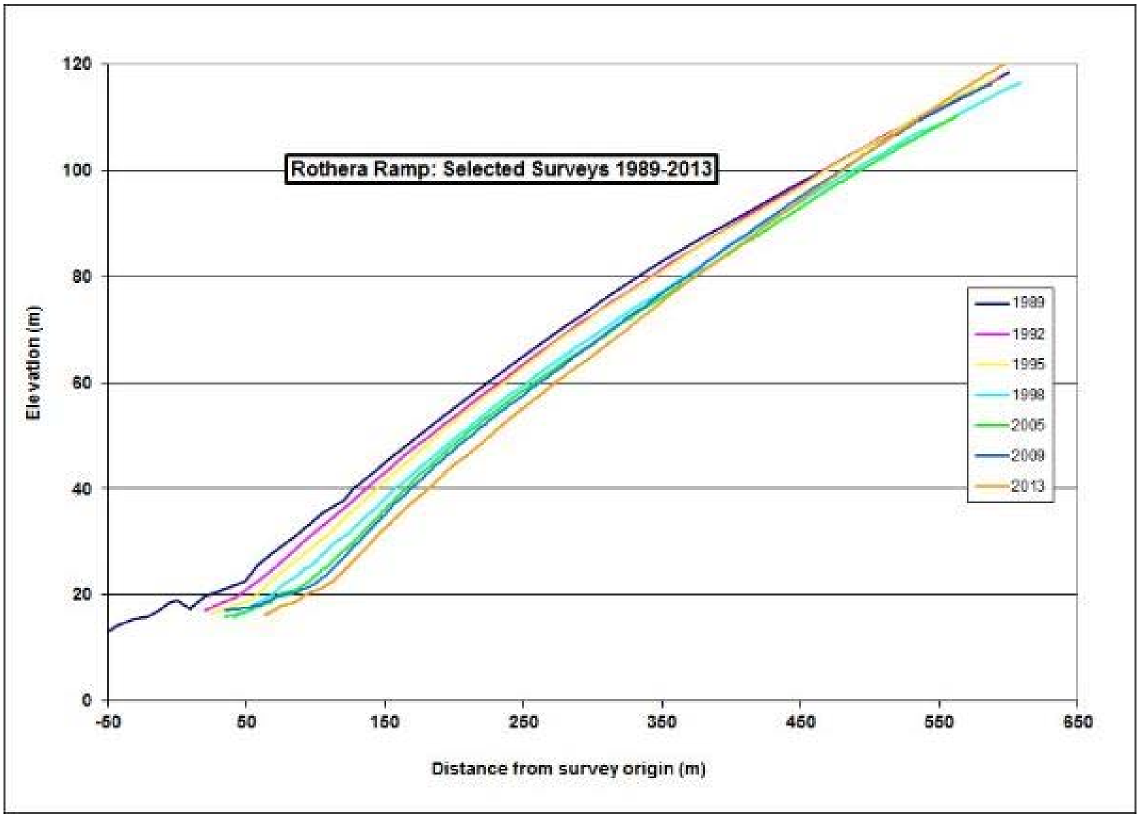

Figure 9-17 Elevation of the Rothera ice ramp between 1989 and 2013.

Several other areas of permanent ice exist on Rothera Point, notably to the south where ice cliffs have formed above the sea (to the east of the wharf) but also crossing the southern boundary of Antarctic Specially Protected Area No. 129 shown on Figure 9-18.

9.2.9 Permafrost

In February 2009 a new 30 m permafrost borehole was installed close to the British Antarctic Survey Station at Rothera Point, Adelaide Island (67.57195°S 68.12068°W) (Guglielmin et al., 2014). The borehole is situated at 31 m asl on a granodiorite knob with scattered lichen cover. Snow persistence is variable both spatially and temporally with snow free days per year ranging from 13 to more than 300, and maximum snow depths varying between 0.03 and 1.42 m. This variability is the main cause of high variability in ground surface temperatures, that ranged between − 3.7 and − 1.5 °C. The net effect of the snow cover is a cooling of the surface. The active layer thickness ranged between 0.76 and 1.40 m. Active layer thickness temporal variability was greater than reported at other sites at similar latitude in the Northern Hemisphere, or those with similar mean annual air temperature to the Maritime Antarctica, because vegetation and a soil organic horizon are absent at the study site. No change in temperatures during the year was observed at about 16 m depth, where the mean annual temperature was − 3 °C. Permafrost thickness was calculated to range between 112 and 157 m, depending on the heat flow values adopted. The presence of sub-sea permafrost cannot be excluded considering the depth of the shelf around Rothera Point and its glacial history.

9.2.10 Flood Risk

Tsunami risk is difficult to predict or mitigate against; however, the region lies within the influence of tectonic events around the Scotia Arc and may be subject to tsunami incidents at some points in the future. Nevertheless, the location of Rothera Point within Marguerite Bay on the east side of Adelaide Island, with the Antarctic Peninsula on the other side of Laubeuf Fjord, may afford some protection against the most severe impact of a tsunami with a more distant source.

Sea level rise is not expected to be sufficient over the anticipated lifespan of the wharf to present a significant threat and will be largely compensated for by on-going isostatic rebound in the region. Some local flood risk may be presented by the drainage of the freshwater pool located to the south of Rothera Point, should any alterations be made to the local topography during possible future construction work.

9.2.11 Noise & vibration

Rothera Point is already an area subject to substantial levels of noise originating from aircraft using the gravel runway, large vehicles for cargo transfer, construction purposes and snow movement, and occasional use of sirens to signal aircraft landings or a station emergency. Many of the marine mammals hauled out around the station and the non-breeding skuas that congregate, particularly at the north end of the runway, appear to be habituated to these noises and show little or no observable sign of disturbance. Adélie penguins that may congregate on East Beach are subject to less noise originating from the station and runway. A noise assessment has been undertaken and included in Appendix H.

9.3 Protected Areas

The primary reason for the designation of ASPA No. 129 Rothera Point, Adelaide Island (Lat. 68o07'S, Long. 67o34'W), as an Antarctic Specially Protected Area (ASPA) is to protect scientific values, and primarily that the Area would serve as a control area. The intention was that the effects of human impact associated with the adjacent Rothera Research Station (UK) could be monitored in an Antarctic fellfield ecosystem (**Error! Reference source not found.**see Figure 9-18) (ATS, 2017). Rothera Point was originally designated in Recommendation XIII-8 (1985, SSSI No. 9) after a proposal by the United Kingdom. The area itself has little intrinsic nature conservation value.

The ASPA is unique in Antarctica as it is the only protected area currently designated solely for its value in the monitoring of human impact. The objective is to use the ASPA as a control area that has been relatively unaffected by direct human impact, in assessing the impact of activities undertaken at Rothera Research Station on the Antarctic environment. Monitoring studies undertaken by the British Antarctic Survey (BAS) began at Rothera Point in 1976. On-going environmental monitoring activities within the Area and Rothera Point include: (i) assessment of heavy metal concentrations in lichens; (ii) measurement of hydrocarbon and metal concentrations in gravel and soils and (iii) survey of the breeding bird populations.

Entry into the ASPA is strictly prohibited unless in accordance with a permit issued by an appropriate national authority (e.g. the FCO Polar Regions Department).

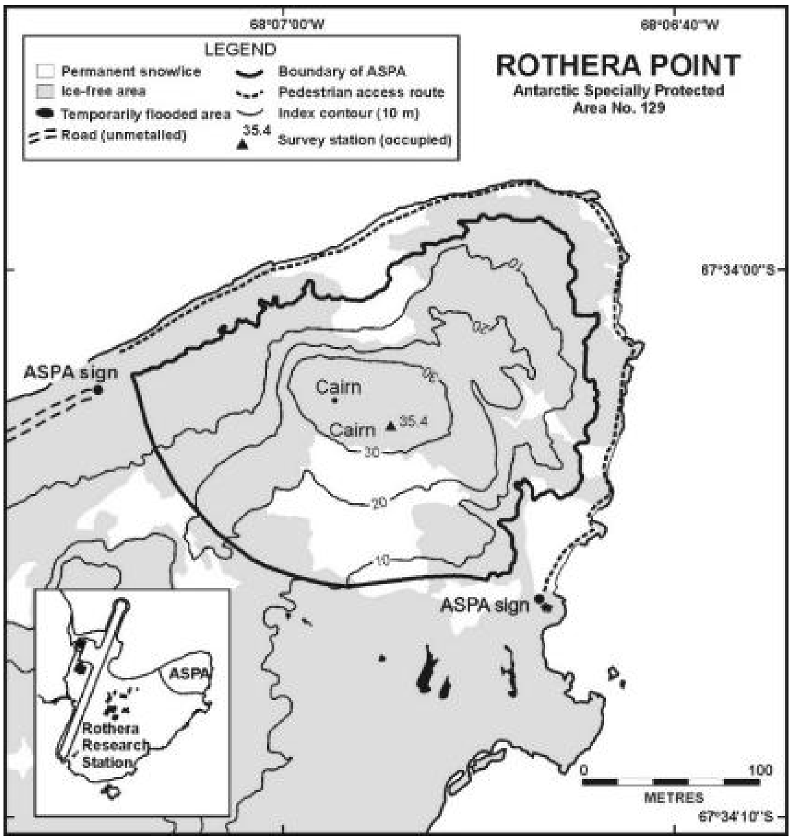

Figure 9-18 Map of ASPA No. 129 Rothera Point, Adelaide Island

In May 2019 a draft management plan for a new protected area 'Léonie Islands and south-east Adelaide Island, Antarctic Peninsula' was submitted to the Committee for Environmental Protection's Subsidiary Group on Management Plans prior to likely endorsement at the Antarctic Treaty Consultative Meeting in 2020. The primary reason for the designation of the six sites located on the Léonie Islands, Ryder Bay, and south-east Adelaide Island, Antarctic Peninsula (67° 36' S; 068° 14 W), as an ASPA is to protect a combination of outstanding scientific, environmental, wilderness and aesthetic values and, in particular, relating to the avifauna and terrestrial biological communities within the Area (see Figure 9-19).

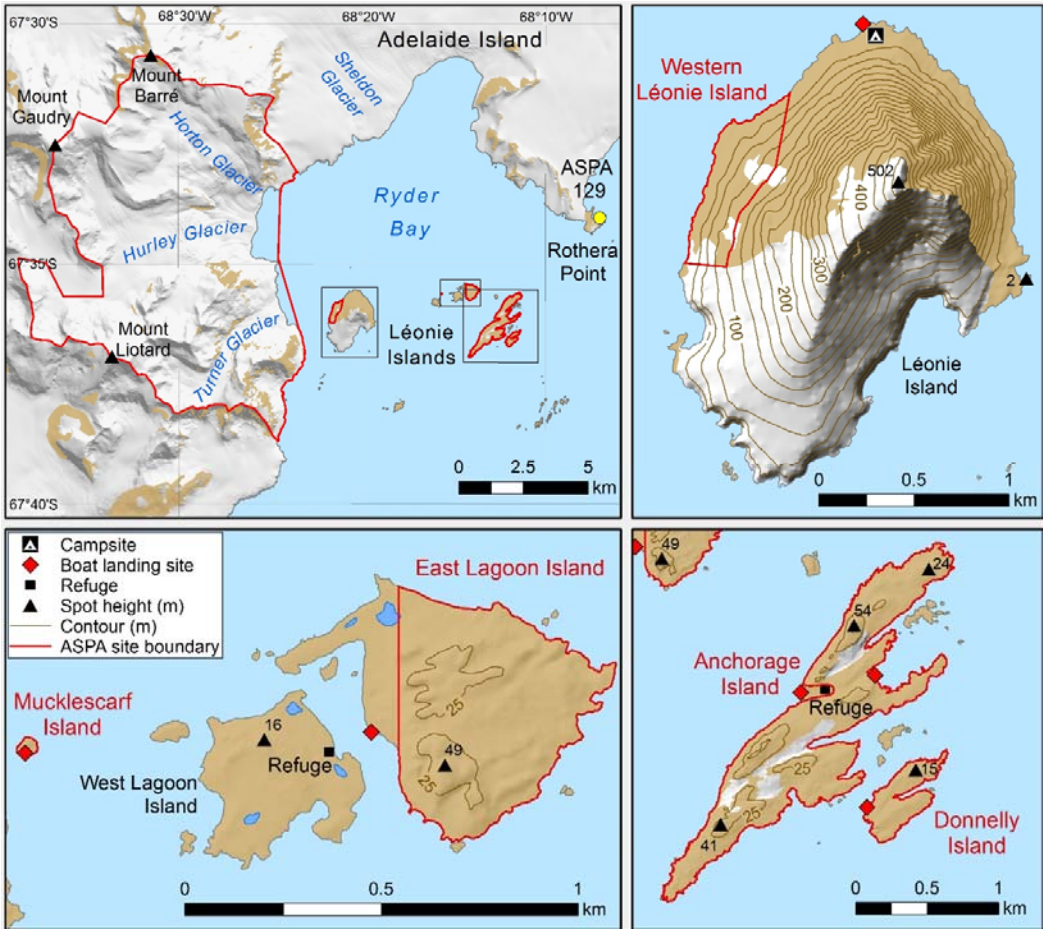

Figure 9-19 Map of the multi-site ASPA within the Léonie Islands, Ryder Bay, Antarctic Peninsula: Anchorage Island; Donnelly Island; East Lagoon Island; western Léonie Island; Mucklescarf Island and south-east Adelaide Island.

9.4 Cultural Heritage

BAS has operated from Rothera since 1975, see Section 9.2. Whilst there are no formally designated Historic Sites and Monuments (HSMs) at Rothera, that station does have a rich cultural heritage which has developed over the years. Heritage is important to BAS and the wider UK Antarctic community so potential impacts to heritage are considered in this IEE.

A heritage survey was undertaken at Rothera in December 2016 by Ieuan Hopkins, BAS Archives Manager and Rachel Clarke, BAS Head of Environment, to identify objects with potential heritage significance.

The purpose of the survey was to;

- identify those items of heritage value which will require ongoing management and/or extraction prior to the Rothera re-development;
- to ensure that those items of heritage value put at risk by the station and wharf redevelopment are appropriately protected;
- to elicit the views of station personnel, as stakeholders, with regards heritage in general, and the heritage value of items at Rothera; and
- to enable these views to be factored into the redevelopment process and assessments of heritage value.

The review was undertaken using the Heritage Selection Process, written in conjunction with the United Kingdom Antarctic Heritage Trust (UKAHT). This process aims to provide a systematic and consistent methodology for the identification of those objects (defined as either an artefact, building or site) with heritage value. Heritage is here defined as all inherited resources which people value for reasons beyond mere utility. (Historic England, 2008) This definition includes the widest range of physical 'things'. It also encompasses the range of emotional and intellectual values attached to them, (Hopkins, 2017).

The survey identified a number of objects with potentially broad heritage significance (i.e. significance to stakeholders other than station personnel, including former BAS staff, historians/heritage professionals and the general public). Numerous items were also found to have significance to those personnel living on the station, but not necessarily more broadly.

The views of staff on station with regards to the importance of heritage were also collected. A staff discussion on the subject of heritage was held, and involved a large proportion of the staff at Rothera. The importance of a sense of continuity and connection with the past was an aspect of heritage that was repeatedly voiced, as was a sense of trusteeship and respect for the heritage created and left by previous staff.

A copy of the survey results has been included in Appendix E: *Rothera Heritage Survey Results*. Instructions on how each artefact should be handled have been included in the results.

Six key heritage artefacts were identified in the survey namely, Bingham's House, Rothera ceiling, dog genealogies, dog pen doors, Rothera span diagram, and trace and harness hooks. The Heritage Selection Process form for each of these artefacts has been included in Appendix F: *Rothera Heritage Selection Process Forms*. Specific details on what constitutes the artefact is included and detail on exactly how the item should be conserved or otherwise.

9.5 Wilderness & Aesthetic Value

Whilst there is not an internationally agreed definition of aesthetic value in Antarctica, it is generally characterised by the lack of visible evidence of human activity including permanent infrastructure. In addition the wilderness value of a location in Antarctica is often related to a feeling of remoteness (Tin and Summerson, 2013).

Rothera Research Station has been the main BAS research and operational hub within Antarctica for more than 40 years concentrating its infrastructure development largely within the confines of the 0.4 km2 area of Rothera Point. This concentration of activity within a small area means that there has not been an on-going expansion of the station footprint (as observed at other Antarctic stations), not least because space for construction is limited.

A result of this constraint is that evidence of human presence is visible from most areas of Rothera Point; however, the great majority of infrastructure has been construction on the northwest side of the central rocky north-east to south-west trending ridge that dissects Rothera Point. Consequently, it is possible to experience a genuine wilderness experience when on East Beach and on the northern fringes of Antarctic Specially Protected Area No. 129. Indeed, it is common for station personnel wanting to get away from busy station life to go for a 'walk round the Point', which involves walking around the northern fringes of the ASPA to East Beach and then up to the memorial cross before returning to station. With most of the infrastructure confined to the Point itself, views in almost every direction away from the Point show near pristine Antarctic scenery of outstanding wilderness and aesthetic value (Figure 9-20). The proposed works are well within what is considered to be the existing footprint of the station and within the most disturbed area of Rothera Point. The height of the new Operations Building is 28.41m a.s.l. The current equivalent building (OBH) is 23.98m a.s.l. (The actual height of the new tower will be 28.41m - 12.84 (formation height) = 15.57m structural height. The existing tower is 23.98 - 13.082 (Ground height) = 10.89m structural height.

When all the works are complete six of the existing buildings on site will be demolished. The visual impact of Rothera station will alter once the project is complete.

Figure 9-20 View from Rothera Point across Marguerite Bay to Leonie Island, and the Princess Royal Range beyond

9.6 Climate Change Projections

Rothera Point has been subject to human activity for over 40 years and in that time some parts have been dramatically modified from their original state, while others remain relatively free of impacts. Coupled with this, climate variability has resulted in changes in marine, terrestrial and ice characteristics around Rothera Point with consequent impacts upon local marine and terrestrial ecosystems. On-going development of BAS' logistical capacity at Rothera will likely result in further modifications of the environment, with impacts likely to be minimised if constrained to areas of existing human activity and impact.

Climate change impacts may be more difficult or impossible to mitigate, which may have substantial impacts on elements of the logistical capacity at the station. With the current scientific data available it is impossible to accurately predict the impacts of climate change on environments in the vicinity of Rothera Research Station. However, should climate warming occur then impacts upon the Rothera Research Station and Rothera Point may include:

- melting and steepening of the ice ramp that joins Rothera Point to the rest of Adelaide Island;

- increase in ice-free ground on Rothera Point, associated with the melting and shrinking of areas of permanent ice;
- changes in bird population numbers linked to climate change effects on food sources and weather conditions during the breeding season;
- seasonal changes in water availability for terrestrial communities leading to alterations in community structure and species distribution across Rothera Point;
- changes in permafrost depth;
- further changes in the intensity of iceberg scour of marine environments around Rothera Point, linked to changes in sea ice conditions that are, in turn, associated with changes in winds over the Peninsula;
- changes in the presence of sea ice-dependant species around Rothera, as sea-ice become less reliable; and
- increased likelihood of establishment of any non-native species introduced to Rothera Point.

9.7 Future Environmental Reference State

The proposed Rothera modernisation works are within the current footprint of Rothera Research Station and are largely on previously disturbed ground. On completion of all construction activities it is not anticipated that the future state of the environment will differ greatly from the existing condition, as result of the works. The main impacts will be experienced during the construction period which are likely to be temporary. A full impact assessment of the activities is presented in Chapter 11 Impact Identification and Mitigation.

9.8 Summary

The key environmental receptors which are most likely to be impacted by the Rothera Modernisation project are as follows:

- Terrestrial flora – moss bank adjacent to the Miracle Span
- Terrestrial fauna – Nesting skuas on Rothera point
- Native terrestrial fauna and flora – which may be impacted by biosecurity incursions
- Local glaciology – the ice ramp
- Cultural heritage – artefacts identified within buildings due to be demolished

10 ASSESSMENT OF THE ENVIRONMENTAL IMPACTS

10.1 Methodology

This chapter identifies the actual or potential impacts that could or will occur as a result of the proposed project activities.

The environmental impact assessment process has followed a four step process involving:

- Identifying the **proposed activities** of the project;
- identifying the **environmental aspects** – i.e. the way in which any of the proposed activities interact with the environment such as atmospheric emissions, dust, noise, fuel spills, introduced non-native species etc.;
- identifying the **environmental impact** – i.e. the change in environmental value or resource as a result of the activity; and
- assessing the **significance of the identified impact** – i.e. considering the spatial extent, duration, probability of occurrence and severity of the potential impact on the environment with reference to the three levels of significance identified by Article 8(1) of the Protocol (i.e. less than, no more than or more than a minor or transitory impact.

10.2 Proposed Activities

The nature and scale of the proposed activities associated with the Rothera Modernisation project have been described in Chapter 3 – Chapter 7 of this document. These activities have been summarised and divided into the following categories and are further subdivided in Figure 10-1 for the purposes of impact assessment:

- Construction activities for the Operations Building;
- Excavation by drilling & blasting;
- Support activities including
    - relocation of the MF radar
    - replacement of the Bentham container
    - repair of the hangar roof
    - installation of CCTV
    - shipping cargo and personnel
    - provision accommodation & support services
- Post construction operation of the building

10.3 Environmental Aspects

"An environmental aspect may involve an output or addition to the environment (e.g. 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.) or a removal from the environment (e.g. use of lake water, collection of moss samples, removal of rocks)." (ATCM, EIA Guidelines, 2016)

The environmental aspects associated with the activities listed in Section 10.2 have been summarised in Table 10.1 below. The overview of environmental aspects suggest atmospheric emissions (from the burning of fossil fuels) along with noise and dust emissions will occur as a result of the general construction activities and the excavation, drilling and blasting of rock. The reliance on machinery also presents the risk of fuel spills for some of these activities. Due to nature of the project and as a result of the ongoing Rothera Wharf construction project, it has been identified that the construction activities will take up physical space and stretch the current footprint of the operational site which has the potential to cause physical disturbance on land and to flora and fauna. The potential to introduce non-native species as a result of input of cargo and personnel to Rothera is also identified.

Figure 10-1 Environmental Aspects

No.	ACTIVITIES	ENVIRONMENTAL ASPECTS											
		Atmospheric emissions (burning fossil fuels)	**Noise emissions**	**Dust emissions**	**Waste**	**Light (external)**	**Physical presence and use of space**	**Physical/ mechanical disturbance on land**	**Fuel or hazardous substance release**	**Non-native species introduction**	**Disturbance to native flora/fauna**	**Visual**	**Heritage**
Construction activities													
1.	Site set up & presence of construction personnel				✓		✓				✓		
2.	Vehicle, plant & equipment operation	✓	✓	✓		✓		✓	✓		✓		
3.	Fuel management & refuelling								✓				
4.	Earthworks		✓	✓			✓	✓	✓			✓	
5.	Foundations & concrete flooring	✓		✓			✓	✓					
6.	Erection of steelworks	✓	✓				✓					✓	
7.	Installation of cladding & roof panels				✓		✓					✓	
8.	MEP works	✓	✓	✓	✓		✓	✓	✓				
9.	Demolition & relocation of waste management facility	✓	✓	✓	✓		✓	✓	✓		✓	✓	
10.	Preparation of ground & storage of shipping containers (plant & equipment)	✓	✓	✓			✓	✓	✓		✓	✓	
11.	Relocation & upgrade of site wide services		✓	✓	✓		✓	✓			✓	✓	
12.	Demolition of building assets		✓	✓	✓		✓	✓	✓		✓	✓	✓
Excavation by drilling & blasting													
13.	Site set up for duration of drilling & blasting						✓				✓		
14.	Blasting & excavation of material	✓	✓	✓			✓	✓	✓		✓		
15.	Loading, transporting & tipping of rock fill	✓	✓	✓			✓	✓			✓		
16.	Stockpiling & screening rock	✓	✓	✓	✓		✓	✓			✓	✓	
Support activities													
17.	Relocation of MF Radar Mast			✓	✓		✓	✓	✓		✓	✓	
18.	Replacement of Bentham container				✓		✓	✓					
19.	Repair of hangar roof				✓		✓						
20.	Installation of CCTV cameras											✓	
21.	Shipping cargo to Rothera	✓								✓			
22.	Transport of personnel to Rothera (flights & shipping)	✓								✓			
22.	Provision of accommodation & support services (e.g. power, food, water) for personnel	✓			✓				✓				
Post construction/ operation of new building													
24.	Day to day operation of building	✓			✓	✓	✓		✓	✓		✓	

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10.4 Identification of Environmental Impacts and Mitigation Measures

This section identifies the potential environmental impacts of the project. The impacts are considered to be any changes in environmental value or resource that will or may occur as a result of the identified outputs/aspects, from the proposed activities. The worst case impacts have been considered here and the actual or potential impacts are summarised in Table 10.6 impact Matrix.

The impacts have been divided as per the four core activities of the project listed in Section 10.2 and below.

- Construction activities for the Operations Building;
- Excavation by drilling & blasting;
- Support activities; and
- Post construction operation of the building

To avoid repetition where the same impact has been predicted to occur across a number of activities, the environmental impact and mitigation measures have been presented together.

Each impact has been identified as either direct, indirect, cumulative or unavoidable defined as follows:

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

- **An indirect impact** is a change in environmental value or resource that results from interactions between the environment and other impacts - direct or indirect (e.g. alteration in seagull population due to a decrease in limpet population which in turn was caused by an oil spill) (ATCM, EIA Guidelines, 2016).

- A **cumulative impact** is the combined impact of past, present, and reasonably foreseeable activities. These activities may occur over time and space and can be additive or interactive/synergistic. (e.g. decrease of limpet population due to the combined effect of oil discharges by base and ship operations).

- An **unavoidable impact** is an impact for which no further mitigation is possible. For example it may be possible to reduce the area from which the proposed new infrastructure will be visible, but it is unavoidable that the infrastructure will be visible over some area.

Where possible mitigation and or monitoring activities have been suggested after each impact. A full monitoring plan is included in Appendix G*: Rothera Modernisation Monitoring Plan*.

10.4.1 Impacts of construction activities

10.4.1.1 Atmospheric pollution (Direct/Cumulative)

There will be a minor but cumulative contribution to global atmospheric pollution as a result of emissions associated with the following activities:

Associated Activities:

- Vehicle, plant & equipment operation
- Foundations & concrete flooring
- Erection of steelworks
- MEP works
- Demolition & relocation of waste management facility
- Preparation of ground for storage of shipping containers

Mitigation:

- Most efficient logistics planned
- Generators & plant will be selected which balance efficiency & reduced emissions.
- Regular inspection and maintenance will be carried out to ensure all vehicles, plant and generators operate efficiently.
- All drivers will be instructed to turn off engines during periods of waiting for 5 minutes or more.
- No mitigation has been provided for the emissions associated with the production of the concrete foundations, steel works or other construction materials.

10.4.1.2 Noise pollution (Direct/Cumulative)

Noise produced as a result of construction activities has the potential to disturb local wildlife potentially resulting in avoidance or stress behaviour and nest abandonment.

Associated Activities:

- Vehicle, plant & equipment operation
- Earthworks
- Erection of steelworks
- MEP works
- Demolition & relocation of waste management facility
- Preparation of ground for storage of shipping containers
- Relocation & upgrade of site wide services
- Demolition of building assets

A terrestrial noise assessment for the equipment and activities proposed to be used during the construction period has been carried out by Neil Goulding, BAM Environmental Manager. The full assessment including the detailed mitigation is included in Appendix H. The following mitigation measures are a summary of the conclusions made in the terrestrial noise assessment and standard construction mitigation measures as agreed with the construction partner:

Mitigation

- Plant items will be positioned to ensure exhaust outlets point away from sensitive receptors therefore reducing noise received by them.

- Regular maintenance of all plant and vehicles to ensure it is working efficiently and generating as little noise as possible.
- A minimum speed limit of 10mph will be enforced.
- A soft start procedure (gradually increasing noise over a period of time) will be implemented for all noisy equipment and consideration given to the impact on wildlife. Animals on land (except nesting birds) will be given the opportunity to move away from the noise source before it reaches its highest levels.

Monitoring

- The long term monitoring of nesting skuas at Rothera will continue by BAS scientists throughout the season and will help to identify the longer term impact of these activities on nesting success.
- Monitoring of noise will take place at four locations on site near the construction site and to ensure that noise levels do not exceed the levels which could cause an onset of Temporary Threshold Shift (TTS) in seals and birds as established in the terrestrial noise assessment. TTS is a temporary reduction of hearing capability caused by intensive noise or by prolonged exposure to noise and is considered an auditory/physiological injury. If the noise levels are exceeded then works in that area will cease until additional mitigation measures can be implemented.

10.4.1.3 Dust pollution resulting in smothering of flora (Direct/Cumulative)

The day to day movement of vehicles and general construction activities will produce dust which during dry weather will become air borne. This has the potential to damage soil organisms and vegetation through direct contact.

Associated Activities:

- Vehicle, plant & equipment operation
- Earthworks
- Laying foundations and concrete flooring
- Erection of steelworks
- MEP works
- Demolition & relocation of waste management facility
- Preparation of ground for storage of shipping containers
- Relocation & upgrade of site wide services
- Demolition of building assets

Mitigation

- Plant will be selected that is designed to reduce excessive dust production.
- Good maintenance of all plant and equipment to ensure it is working to optimum capacity.
- Vehicles transporting rock fill material will be fitted with dust sheets.
- Low speed limit of 10mph will be maintained and enforced on site.
- Areas of excavated rock material and transport roads will be periodically sprayed with pumped seawater to reduce dust levels.
- Grouting & cement equipment to be washed out in a fully bunded area using the minimum possible quantity of water.
- Wash waters to be neutralised before discharge to ground or the sea.

Monitoring

- Dust monitors will be continually monitoring dust levels throughout the construction period to ensure that dust levels do not exceed the agreed levels set out in Appendix G Monitoring Plan. If the dust limits are exceeded, works will cease until additional mitigation measures can be implemented.

10.4.1.4 Increased quantities of waste (Direct)

The construction project will generate significant quantities of waste increasing the volume of waste that will need to be sent to landfill and other appropriate disposal. There is also an increased risk of waste being released into the local environment if suitable waste management procedures are not followed.

Associated Activities:

- Clear out of buildings prior to demolition
- Site set up & presence of construction personnel
- Installation of cladding & roof panels
- MEP works
- Demolition & relocation of waste management facility
- Relocation & upgrade of site wide services
- Demolition of building assets

Mitigation:

- The Rothera Move Manager will be present on site and advise which of the building's contents are either waste, materials to be retained, or heritage which will be managed
- The SWMP (Appendix B) will be followed for all construction waste and the BAS Waste Management Handbook for all domestic waste.
- Pre-deployment training on waste management
- Daily checks will ensure waste is contained to avoid wind blow
- Dedicated area for storing and segregating waste.
- All construction waste will be returned to the UK and disposed of by licensed contractors.
- Packaging will be minimised where possible prior to consigning cargo south.
- BAM commitment to achieving 75% diversion of waste from landfill for construction waste.

Monitoring:

- Disposal routes of waste will be recorded as and when waste is returned to the UK. The overall waste statistics will be collated at the end of the project.

10.4.1.5 Light pollution (Direct)

The use of artificial light in low light or during the hours of darkness could attract birds and lead to bird strikes, injury or fatalities.

Associated Activities:

- Vehicle plant and equipment operation

Mitigation:

- Minimise use of lighting rigs during low light or darkness
- Rigs to be angled towards the ground, not horizontal.
- Lights switched off immediately if more than 5 strikes in one period of works.
- Lights to be turned off when not in use.
- Rothera Station Leader and BAS Environment Office to be informed should there be any bird strikes
- Continued use of lighting rigs will only be allowed after consultation with the BAS Environment Office

Monitoring:

- Construction staff will be vigilant throughout the use of the lighting rigs for any interactions with birds and follow the agreed mitigation above.
- Any bird strikes will be recorded on the BAS AINME database.

10.4.1.6 Physical presence and use of space on site (Direct)

There is potential for science activities to be disrupted or reduced and for science equipment to be damaged as a result of the all of the construction activities.

Additionally the presence of the construction project has the potential to disrupt day to day station operations impacting the running of the station and morale of staff.

Associated Activities:

- All of the new Operations Building construction activities

Mitigation:

- A Construction Impacts Management Plan is being finalised which identifies sensitive science equipment that could be impacted by the construction activity. Dialogue has been ongoing to the relevant owners of equipment to ensure there is minimum impact.
- A Rothera Station Integration Plan was prepared for the wharf project and is being developed to include the Modernisation project.
- Pre-deployment training sessions to be held with BAM & BAS staff.
- There will be an increase in the number of station staff to be employed including chefs, station support and field GAs during the construction period.
- Project Integration Manager has been employed to ensure station operations are not adversely impacted by the construction project.

Monitoring:

- Station management will continuously monitor the operational and science requirements throughout the construction programme.
- Weekly meetings will occur between the construction team and station management.

10.4.1.7 Physical disturbance on land (Direct & Cumulative)

There is the potential for significant deterioration of road ways and the runway due to increased volume of heavy plant.

Associated Activities:

- Vehicle plant and equipment operation
- Earthworks
- Foundations & concrete flooring
- MEP works
- Demolition & relocation of waste management facility
- Preparation of ground for storage of shipping containers
- Relocation & upgrade of site wide services
- Demolition of building assets

Mitigation:

- Daily checks on all routes used by construction vehicles.
- Road & runway maintenance included in construction programme.

Monitoring:

- Weekly meetings will occur between the construction team and station management in order for issues such as maintenance schedules on the road ways and runway to be reviewed.

10.4.1.8 Fuel or hazardous substance release (Direct, indirect & cumulative)

There is potential for pollution to the local environment (marine and terrestrial) through the use of fuels and hazardous substances during construction and demolition activities. This could result in mortality to flora and fauna and secondary contamination if animals or birds ingest any contaminated material. Hazardous waste will be generated if absorbents are used as a result of a spill.

There is an increased risk of a collision between the fuel pipe (which leads from the fuel farm to the apron) and vehicles, in the vicinity of the temporary container storage area. Currently the pipe is unprotected but the area is inaccessible to vehicles. The project requires vehicles to enter the area not only to undertake minor excavation works but also to move containers into and out on a daily basis.

Associated Activities:

- Vehicle plant and equipment operation
- Fuel management & refuelling
- Earthworks
- Demolition & relocation of waste management facility
- Preparation of ground for storage of shipping containers
- Relocation & upgrade of site wide services
- Demolition of building assets

Mitigation:

- Refuelling will be carried out as per the procedures set out in Section 6.1.3 by trained personnel in line with station refuelling procedures.
- Spill kits in all vehicles and key locations on site as set out in Section 6.1.5.
- Plant nappies to be used for all plant.

- All construction staff to receive spill response training.
- Construction spill response plans to be followed for tier 1 as per Section 6.1.4.
- Obstruction bund to be created between the container storage area and the fuel pipe from the fuel farm to minimise risk of vehicle incidents.
- Clear demarcation of vehicle routes in the vicinity of the fuel pipe.
- Rothera OSCP to be followed for tier 2 or 3.
- Method statement for demolition of buildings and removal of fuel tanks to be followed to minimise risk of spills.
- All spills reported to Rothera Station Leader & BAS Environment Office.

10.4.1.9 Disturbance to native flora & fauna

Construction activities have the potential to cause disturbance, injury or fatality to local seals and birds resulting in avoidance/stress behaviour and nest abandonment.

Associated Activities:

- Site set up and presence of construction personnel
- Vehicle, plant and equipment operation
- Demolition & relocation of waste management facility
- Preparation of ground for storage of shipping containers
- Relocation & upgrade of site wide services
- Demolition of building assets

Mitigation:

- All construction staff to receive pre-deployment and on-station briefings regarding wildlife viewing and working close to wildlife.
- Only trained personnel will be involved in the displacement of seals which by their presence are stopping or delaying the progress of works. Training will be provided onsite by an appropriately trained member of BAS staff.
- A small area of moss has been identified close to (but outside of) the construction site which is out of bounds for all construction staff and vehicles. This will be communicated in onsite toolbox talks and will be clearly demarcated as a no-go zone for all but essential maintenance personnel. See Figure 10.2.
- All access routes for plant and vehicles will be clearly demarcated.
- All vehicles will be inspected and wheels checked for the presence of seals and penguins before engines are started.

Monitoring:

- Long term skua monitoring to continue throughout construction programme by BAS staff.
- Seal displacements will be recorded as per the monitoring plan in Appendix G.

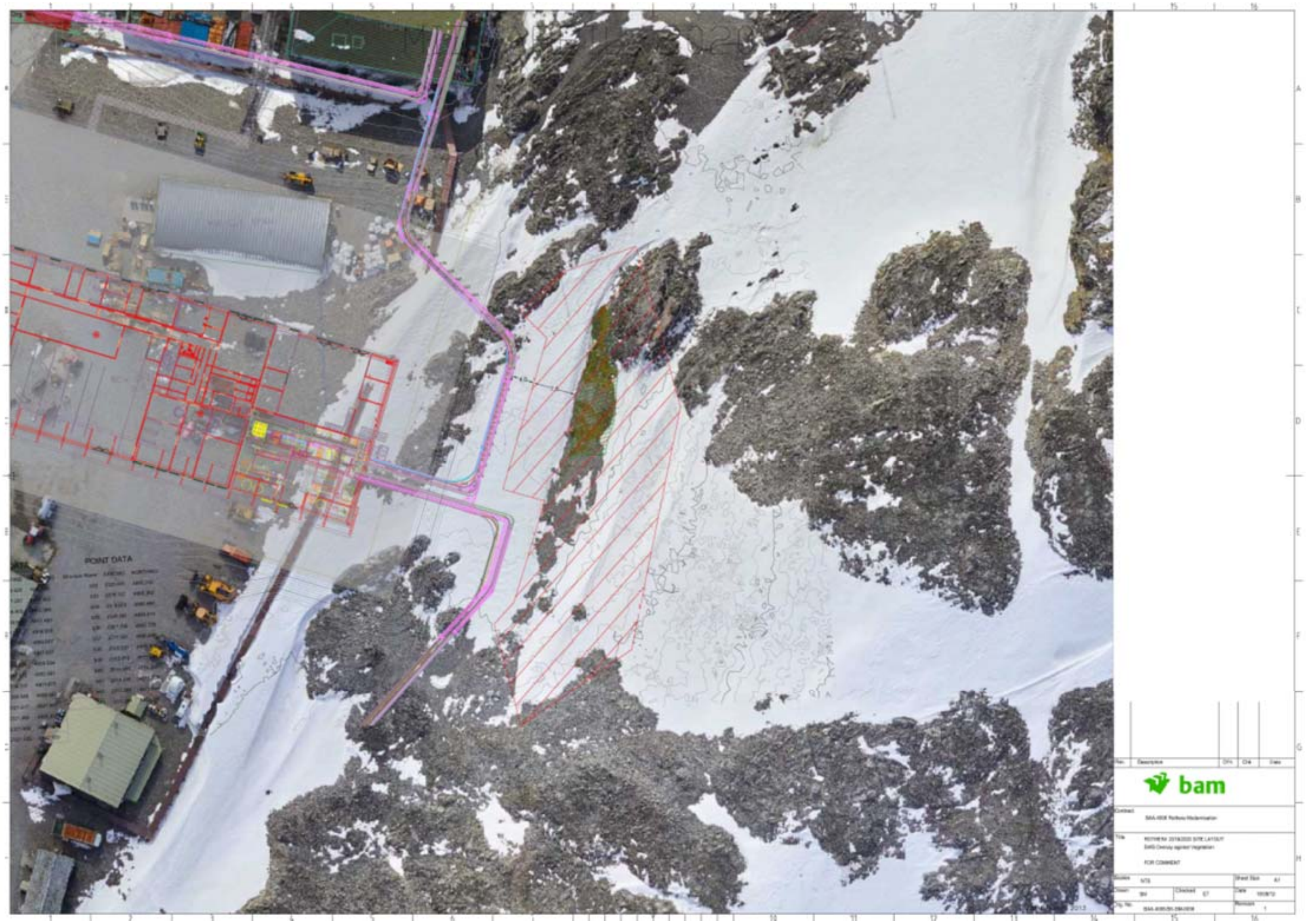

Figure 10-2 Moss Bank 'no-go' zone demarcated by red hashed area

10.4.1.10 Visual impacts (Direct)

The construction activities associated with the new Operations Building are anticipated to have a visual impact in the short term with the presence of significant construction plant and equipment over a four year period. (The longer term visual impact once the building has been completed has been considered in Section 10.4.4).

Associated Activities:

- Earthworks
- Erection of steelworks
- Installation of cladding and roof panels
- Demolition & relocation of waste management facility
- Preparation of ground for storage of shipping containers
- Relocation & upgrade of site wide services
- Demolition of building assets

Mitigation:

- Construction activities will be confined to agreed areas on site. Any changes to the locations used by the construction team, plant or equipment will be discussed and agreed with the Rothera Station management team and where appropriate the BAS Environment Office. If necessary permission with the FCO will also be sought.

10.4.1.11 Heritage impacts (Direct)

There is the potential for heritage artefacts to be damaged or lost during the demolition of buildings.

Associated Activities:

- Demolition of building assets

Mitigation:

- A heritage survey has been undertaken to identify items that have heritage value within the buildings at Rothera. The results of the survey and the instructions of how they should be treated are included in Appendix E and Appendix F.
- The Rothera Move Manager has been given responsibility for ensuring that the heritage instructions are completed.
- An area within the new Operations Building has been designated for the display of key heritage items.
- The Construction Impacts document acknowledges the heritage artefacts that need to be retained within each building.

Monitoring:

- The Rothera Move Manager will confirm when all heritage artefacts have been relocated or returned to the UK.
- BAS Head of Archives and Head of Environment Office will undertake a heritage review on completion of the new Operations Building and once all demolition has been completed.

10.4.2 Impacts of excavation by drilling & blasting

10.4.2.1 Atmospheric pollution (Direct/Cumulative)

There will be a minor but cumulative contribution to global atmospheric pollution as a result of emissions associated with the following activities:

Associated Activities:

- Blasting and excavation of rock material
- Loading, transporting and tipping of rock
- Stockpiling and screening rock

Mitigation:

- Generators & plant will be selected which balance efficiency & reduced emissions.
- Regular inspection and maintenance will be carried out to ensure all vehicles, plant and generators operate efficiently.
- All drivers will be instructed to turn off engines during periods of waiting for 5 minutes or more.

10.4.2.2 Noise pollution/Air over pressure (Direct/Cumulative)

Noise produced as a result of excavation activities has the potential to disturb local wildlife potentially resulting in avoidance or stress behaviour, nest abandonment or hearing damage.

When an explosive is detonated, transient airborne pressure waves are generated. As these pressure waves pass a given position, the pressure of the air rises very rapidly to a value above the ambient pressure, then falls more slowly to a value below atmospheric pressure, before returning to the ambient value after a series of oscillations. The maximum pressure reached is the peak air overpressure.

These pressure waves are comprised of energy over a wide frequency range, with frequencies above 20 Hz audible to the human ear as sound, whilst those below 20 Hz are in the form of concussion. The sound and concussion together is known as air overpressure and is usually measured in decibels (dB) with no frequency filtering applied.

In a blast, these airborne pressure waves are produced from five main sources:

- Rock displacement from the face.
- Ground induced airborne vibration.
- Release of gases through natural fissures.
- Release of gases through stemming.
- Insufficiently confined explosive charges.

Although it is possible to make predictions of the attenuation of air-overpressure, it is considered unrealistic to do so due to the affect that meteorological factors and surface topography have on the transmission of this energy. UK guidance contained within mineral planning guidance MPG 9:1992 and MPG 14:1995, Minerals Technical Advice Note 1 (Welsh Government, 2004) and the UK Department of Environment Transport & the Regions (DETR) report: *The environmental effects of production blasting from surface mineral workings* (1998) recommend that air-overpressure should be controlled at source rather than setting a specific limit. These control measures are discussed below in the mitigation section.

Terrestrial fauna identified in close proximity to the blasting location are nesting Skuas as shown in Chapter 9, Figure 9-6. This plan shows the location of nest sites to the east of the blast site which have been occupied over the past several seasons. Nest sites are often reused but may be inactive for a number of consecutive years. It should be assumed therefore that any nest site identified on Figure 9-6 could become active in the future. Consultation with the BAS Seabird Ecologist suggests that it is unlikely that the skuas will be adversely affected by the blasting air-overpressure.

Associated Activities:

- Blasting and excavation of rock material
- Loading, transporting and tipping of rock
- Stockpiling and screening rock

Mitigation:

- Blasting will be undertaken at approximately 100m from the closest shoreline, therefore the marine environment will be unaffected by these blasting works.
- Prior to blasting the Shotfirer will check the blast site to ensure that it is clear of any birds.
- Plant will be positioned away from sensitive receptors e.g. nesting sites.
- Blast mats will be used to suppress noise and dust during blasting.
- Acoustic screening will be utilised where noise levels are likely to exceed agreed limits.
- The following Blast Design Control Measures included in Appendix A: *Rothera Modernisation Drilling and Blasting Management Plan*, will be followed to reduce air-overpressure at source.
    - Consider reducing the maximum instantaneous charge fired in any one delay period.
    - Record geological conditions during drilling to ensure that weak areas are decked in the hole with aggregates to avoid energy escape.
    - Correct confinement of explosives through use of correct burden and stemming.
    - Utilise laser surveying of open faces and shot-holes to allow correct explosive placement and to avoid low burdens that allow energy to escape to the atmosphere. Ensure quality stemming is used in the top of the holes to prevent energy release through the hole collar.
    - Use in-hole initiation systems.
    - Avoiding un-confined explosives, including detonating cord, by using non-electric surface initiation systems.
    - Avoid blasting when weather conditions may lead to increased propagation of air overpressure to the sensitive receptors; such as downwind conditions from the blasting site to the receptor(s) and when there is low cloud or an atmospheric temperature inversion.
    - Controlling the direction of firing shots to help limit sound travelling in unfavourable directions.
    - No secondary blasting of boulders.
    - Careful selection of the location of the quarried rock source in conjunction with BAS management to minimise the impact through distance and orientation in respect to sensitive receptors.

Monitoring:

- The BAS long term monitoring programme for skuas will continue throughout the construction period, which will record any impacts on breeding activity at Rothera.
- Noise monitors will continuously record noise levels throughout the drilling and blasting activities as per the details in the monitoring plan in Appendix H.

10.4.2.3 Dust pollution resulting in smothering of flora (Direct/Cumulative)

The process of blasting, drilling, fragmenting, loading, transporting and screening rock will produce dust which has the potential to damage soil organisms and vegetation through direct contact.

Another potential impact is that dust deposition on the ice ramp could result in increased melt during summer months resulting in compromised operational delivery.

Associated Activities:

- Blasting and excavation of rock material
- Loading, transporting and tipping of rock
- Stockpiling and screening rock

Mitigation:

- The activities which create dust, in particular screening of rock, will be located on the eastern side of the runway, which within the constraints of the site is as far from the ramp as is possible.
- The drill rig will be fitted with dust suppression equipment. This will normally consist of a dust hood at the foot of the mast, which makes a seal with the ground, a dust ring, which seals around the drill string, and a dust collection system which extracts the dust directly away from the hole and places it onto the ground. Although the dust is still susceptible to being picked up by wind, the effects are significantly reduced.
- Careful blast design will prevent excessive ejection of material into the air; however, in dry conditions, some dust cannot be avoided. The direction of firing may reduce the pick-up of dust into the air by using natural topography to create shelter.
- After the blast has been fired and before any screening takes place the rock pile area will be watered with seawater using a tractor and bowser.
- The haul roads will be sprayed with the seawater, should the need arise.
- All routes used by the vehicles and plant will be well maintained and have compacted surfaces.
- Grading screens will be fitted with seawater spray bars and dust skirts and all conveyors will be covered.
- The screening plant will only be operated within its design capacity to reduce excessive dust production.
- All plant and equipment will be maintained on a regular basis.
- Limitation of material drop heights during stockpiling, processing and loading operations will help to minimise dust.
- Vehicle speeds limits on site will be set low (max 10 mph) and enforced.
- Double handling will, as far as practical, be minimised to reduce the overall number of tipping actions.
- During high winds, operations will be temporarily suspended. As with blasting, during excessively dry, windy conditions, especially where the wind direction will blow dust towards sensitive receptors, it may be necessary to suspend other operations if it is not possible to control dust by

other means. This will be reviewed on a daily basis by the Site Manager. In conjunction with the Rothera Station Leader before charging commences.

Monitoring

- Dust monitors will be continually monitoring dust levels throughout the construction period to ensure that dust levels do not exceed the agreed levels set out in Appendix G Monitoring Plan. If the dust limits are exceeded, works will cease until additional mitigation measures can be implemented.

10.4.2.4 Increased quantities of waste (Direct)

Once screening of the blasted rock has occurred, there is the potential for quantities of waste rock material to be generated which are not required as part of the construction of the Operations Building. This would be result in stock piles of low grade materials on station.

Associated Activities:

- Stockpiling and screening of rock

Mitigation:

- Wherever possible quarried rock will be reused on station for other infrastructure projects such as the regrading of the runway, coastal stabilisation works or other Rothera Station local building projects.
- Once Phase 1 is complete in Season 22/23 it is anticipated that the remaining volume of rock (left over) is 2700m3. All other rock will be used for backfill of the construction site, earthworks for the site wide services. That does not include any fill needed for the runway stabilisation.

Monitoring:

- Any materials left over from the project will be discussed with the Construction team, Rothera Station Management and Rothera Facilities to ensure that waste rock material is fully utilised elsewhere.

10.4.2.5 Physical presence and use of space on site (Direct and cumulative)

There is potential for science activities to be disrupted or reduced and for science equipment to be damaged as a result of the drilling and blasting activities.

Additionally the need to evacuate buildings during blasting has the potential to disrupt day to day station operations impacting the running of the station and morale of staff.

Whilst the proposed stockpiling and screening areas are all within the current footprint of the operational area of Rothera Station, they are not normally used for operational or construction purposes. The locations shown on

Figure 3-31,

Figure 3-32 and

Figure 3-33 are generally covered by snow or ice until late into the season. The potential cumulative impact of using these areas is that there will be no contingency areas for operational purposes. In addition having two construction teams on site and delivering business as usual science and operations all within the first season, could lead to conflict of use, resulting in compromised safety and environmental procedures.

Associated Activities:

- Site set up for duration of drilling and blasting
- Blasting and excavation of rock material
- Loading, transporting and tipping of rock
- Stockpiling and screening rock

Mitigation:

- Project Integration Manager has been employed to ensure station operations are not adversely impacted by the construction project.
- Evacuation plans will be agreed with station management to ensure appropriate safe evacuation occurs with minimal disturbance to day to day activities on site.
- A Construction Impacts Management Plan is being finalised which identifies sensitive science equipment that could be impacted by the construction activity. Dialogue has been ongoing to the relevant owners of equipment to ensure there is minimum impact.
- A Rothera Station Integration Plan will be produced.

- Pre-deployment training sessions to be held with BAM & BAS staff.
- Construction activities will be confined to agreed areas on site. Any changes to the locations used by the construction team, plant or equipment will be discussed and agreed with the Rothera Station management team and where appropriate the BAS Environment Office. If necessary permission with the FCO will also be sought.

Monitoring:

- Station management will continuously monitor the operational and science requirements throughout the construction programme.
- Weekly meetings will occur between the construction team and station management.

10.4.2.6 Physical disturbance on land (Direct & Cumulative)

There is the potential for rock throw to occur during blasting which could damage buildings or injure nearby wildlife.

Ground displacement could also occur as a result of the blasting impacting sensitive receptors.

The long term impact of the drilling and blasting works is that the local topography will be permanently altered to accommodation the new Operations Building.

Associated Activities:

- Blasting and excavation of rock material
- Stockpiling and screening rock

Mitigation:

- Rock throw will be strictly controlled through the blast design process as per the Drilling and Blasting Management Plan in Appendix A.
- Rock throw will be contained within the immediate area of the construction site.
- Prior to blasting the Shotfirer will check the blast site to ensure that it is clear of any wildlife and birds.
- During operations, blasting vibration levels will be monitored using blasting seismographs to measure levels of peak particle velocity and air-overpressure at selected site sensitive locations. This monitoring will be both to ensure compliance with site threshold limits and to further increase the number and distribution of results, to allow continuous improvement of vibration prediction models and increasing confidence in predictions.
- Sensitive receptors have been identified in Appendix A Drilling and blasting Management plan and appropriate requirements arranged to minimise any potential impacts with particular regard to ground displacement as a result of vibration.
- Cut and fill studies have been undertaken to ensure that only the minimum amount of rock necessary is removed.

Monitoring:

- The BAS long term monitoring programme for skuas will continue throughout the construction period which will record any impact on breeding activity at Rothera.
- Vibration monitoring will occur throughout the duration of the project as outlined in Appendix G: *Rothera Modernisation Monitoring Plan*.

- Additional monitoring of the closest sensitive receptors will be undertaken and once confidence is gained that the vibration limits will not be exceeded at these receptors, monitoring will continue at varied distances to obtain data for prediction models.
- A survey cairn in the ASPA is considered to be at low risk from the effects of vibration due to the distance from the blast site. However due to its heritage importance, BAS staff permitted to enter the ASPA will monitor the cairn before, during and after the blasting.

10.4.2.7 Fuel or hazardous substance release (Direct, indirect & cumulative)

There is potential for pollution to the local environment (marine and terrestrial) through the use of fuels and hazardous substances. This could result in mortality to flora and fauna and secondary contamination if animals or birds ingest any contaminated material. Hazardous waste will be generated if absorbents are used as a result of a spill.

Possible risk of asbestos being present in buildings to be demolished (although preliminary surveys indicate risk is low there is a possibility of up 1 tonne which will need expert extraction).

Ingredients contained within the explosives are toxic to humans and the environment. Under normal use and following the strict blasting procedures the risks are mitigated.

Associated Activities:

- Blasting and excavation of rock material

Mitigation:

- Refuelling will be carried out as per the procedures set out in Section 6.1.3 by trained personnel in line with station refuelling procedures.
- Spill kits in all vehicles and key locations on site as set out in Section 6.1.5.
- Plant nappies to be used for all plant.
- All construction staff to receive spill response training.
- Construction spill response plans to be followed for tier 1 as per Section 6.1.4.
- Rothera OSCP to be followed for tier 2 or 3.
- All spills reported to Rothera Station Leader & BAS Environment Office.
- Expert contractors will be on site to deal with any unexpected asbestos in a safe and compliant manner and to package and consign any waste to an appropriate disposal point outside of the Antarctic Treaty area.
- The drilling and blasting management plans will be followed at all times.

10.4.2.8 Disturbance to native flora & fauna

Drilling and blasting activities have the potential to cause disturbance, injury or fatality to local seals and birds resulting in avoidance/stress behaviour and nest abandonment.

Associated Activities:

- Site set up for duration of drilling and blasting
- Blasting and excavation of rock material
- Loading, transporting and tipping of rock
- Stockpiling and screening rock

Mitigation:

- All construction staff to receive pre-deployment and on-station briefings regarding wildlife viewing and working close to wildlife.
- Only trained personnel will be involved in the displacement of seals which by their presence are stopping or delaying the progress of works. Training will be provided onsite by an appropriately trained member of BAS staff.
- A small area of moss has been identified close to (but outside of) the construction site which is out of bounds for all construction staff and vehicles. This will be communicated in onsite toolbox talks and will be clearly demarcated as a no-go zone for all but essential maintenance personnel. See Figure 10.2.
- All access routes for plant and vehicles will be clearly demarcated.
- All vehicles will be inspected and wheels checked for the presence of seals and penguins before engines are started.

Monitoring:

- Long term skua monitoring to continue throughout construction programme by BAS staff.
- Seal displacements will be recorded as per the monitoring plan in Appendix G.

10.4.2.9 Visual impacts (Direct)

The cut and fill process associated with drilling and blasting activities will alter the aesthetics of Rothera Station both in the short term and longer term through the removal of approximately 15,258 m^3 of rock. In order to accommodate the new Operations Building a suitable area of flat ground is required which due to the topography at Rothera will need both the removal and infilling of rock.

Associated Activities:

- Blasting and excavation of rock material
- Stockpiling and screening rock

Mitigation:

- The proposed site for the construction of the new building was considered during the design stage. Whilst there will inevitably be some visual impact of the groundworks the site is within the current footprint and operational area of Rothera Station and is comprised of disturbed ground overlain with large cobbles. Under normal operational conditions the site is in constant use by vehicles and pedestrians.
- The cut and fill study discussed in Section 3.8 was undertaken to ensure that the minimum amount of ground disturbance is undertaken.

10.4.3 Impacts of support activities

10.4.3.1 Atmospheric pollution (Direct/Cumulative)

There will be a minor but cumulative contribution to global atmospheric pollution as a result of emissions associated with the following activities:

Associated Activities:

- Shipping cargo to Rothera
- Transport of personnel to Rothera
- Provision of accommodation, power, & domestic services

Mitigation:

- Due to the limited number of available beds on station only staff essential to the construction of the Operations Building will be sent to Rothera.
- Economic and operational constraints on shipping cargo will also be employed and a rationalisation of what plant and equipment will be needed is currently being undertaken.
- All staff on station will be briefed on using energy efficiently whilst on station including 3 minute showers, minimising water usage and switching of power and lights when not needed.

Monitoring:

- Data will be collected and the increased contribution to atmospheric pollution form the deployment of personnel and cargo and any associated ship charter will be accounted for in the overall BAS carbon accounts.

10.4.3.2 Increased quantities of waste (Direct)

The support activities will generate significant quantities of waste increasing the volume of waste that will need to be sent to landfill and other appropriate disposal. There is also an increased risk of waste being released into the local environment if suitable waste management procedures are not followed.

Increased production of sewages and grey water will lead to a great volume of waste discharged into the marine environment which could result in pollution and potentially disease in the marine flora and fauna and could impact future science.

Associated Activities:

- Relocation of MF Radar
- Replacement of Bentham container
- Repair of hangar roof
- Provision of accommodation, power, & domestic services

Mitigation:

- Old mast sections for the MF radar will be reused where possible in the new mast. All other steel tower sections will be removed form Rothera for recycling as scrap metal.
- The Bentham container will be removed form Rothera for recycling as scrap metal. All internal fittings will be reused in the new container.
- Insulation is due to be removed from the hangar roof and will be sent for appropriate disposal. It is not intended to replace the insulation.

- All toilets and washing facilities are connected to the foul drainage system. Human waste undergoes maceration and then primary filtration (removal of sewage sludge which is then incinerated) before discharge to sea as per the requirements of the Environmental Protocol.

Monitoring:

- Monitoring of the sewage outfall will continue this season by BAS scientists.
- All quantities and final disposal routes for BAS generated waste will be captured in the annual waste statistics.

10.4.3.3 Physical presence and use of space on site (Direct and cumulative)

All of the supporting activities require space on station which is currently at a premium alongside the construction of the Rothera Wharf.

The largest space requirement is the need to store 200, 40 foot shipping containers. This is proposed to be in the location south of the hangar. This is an area of station that has been disturbed in previous years but has not been actively used in recent years prior to the Rothera Wharf construction. The requirement to prepare this area by excavating and grading it prior to storing containers and the day to day access required throughout all four construction seasons will increase the maintenance requirements on the roadways, runway and apron.

Additional temporary accommodation was provided at the start of the Rothera Wharf construction. No further accommodation will be provided and all construction staff will be housed in existing infrastructure.

Associated Activities:

- Relocation of MF Radar
- Replacement of Bentham container
- Shipping cargo to Rothera
- Transport of personnel to Rothera
- Provision of accommodation, power, & domestic services

Mitigation:

- The MF Radar is being moved to accommodate the construction site for the Operations Building. Nine masts will be removed and replaced by five new ones thereby making more efficient use of space on station.
- The Bentham container will be a like for like replacement in terms of space required. Whilst the services are being moved into the new container, both containers will remain on site for two seasons. In the longer term the old container will be removed from station for disposal.
- Daily checks on all routes used by construction vehicles will be undertaken.
- Road & runway maintenance will be included in the construction programme.

Monitoring:

- Weekly meetings will occur between the construction team and station management in order for issues such as maintenance schedules on the road ways and runway to be reviewed.

10.4.3.4 Physical disturbance on land (Direct & Cumulative)

The creation of a number of concrete pads and plinths will be required to support the foundations for the MF Radar mast and the Bentham container. In some instances guy lines will be bolted directly into the local rock.

Associated Activities:

- Relocation of MF Radar
- Replacement of Bentham container

Mitigation:

- Where possible gabion baskets will be used instead of concrete. This will be dependent on the height and weight of the masts.

10.4.3.5 Fuel or hazardous substance release (Direct, indirect & cumulative)

There is potential for pollution to the local environment (marine and terrestrial) through the use of fuels and hazardous substances. There is the potential for damage to soil, organisms and vegetation as a result of the use of high alkaline cementitious liquids and cement dust.

This could result in mortality to flora and fauna and secondary contamination if animals or birds ingest any contaminated material. Hazardous waste will be generated if absorbents are used as a result of a spill.

Associated Activities:

- Relocation of waste management facility (incinerator concrete pad)
- Relocation of MF Radar
- Provision of accommodation, power, & domestic services

Mitigation:

- Concrete batching will be located away from sensitive environmental receptors.
- Refuelling procedures for mobile and static plant and equipment to be followed.
- Rothera OSCP to be followed in event of a spill

10.4.3.6 Non-native species introduction (Indirect)

Non-native species may be imported unintentionally to Rothera and the local vicinity in association with equipment and general cargo. Introduced species may become established in ice-free areas with negative impacts upon local ecosystem structure and function, endemic species and associated scientific research.

Associated Activities:

- Shipping cargo to Rothera
- Transport of personnel to Rothera

Mitigation:

- All personnel being deployed to Rothera will receive a pre-deployment briefing from a member of the BAS Environment Office, which will cover biosecurity, waste management, oil spill response and wildlife interactions.

- All activities will be undertaken in accordance with the Rothera Modernisation Biosecurity Plan included in Appendix C and the BAS Biosecurity Handbook (compiled with reference to the CEP's Non Native Species Manual).
- A trained manager will inspect all plant, equipment, materials and personal belongings prior to loading onto the vessel and on disembarkation/offloading at Rothera.
- The following requirements will be placed in all plant and equipment to be shipped to Rothera:
    - All re-usable containers will be thoroughly cleaned and lined with plastic sheeting.
    - No polystyrene or organic packaging material, including hay straw or wood shavings, will be used.
    - All wood packaging and wood products will be new and comply with ISPM 15[1].
    - No corrugated cardboard packaging material will be used.
    - Openings in structural members will be sealed.
    - Containers will be cleaned and fumigated.
- All equipment and materials required for the proposed activity will be thoroughly cleaned before dispatch to Antarctica.
- Should soil, seeds or propagules be imported unintentionally, they must be carefully collected and removed. Rodents and insects must be exterminated immediately. Disposal may include incineration at Rothera or removal from Antarctica.
- The Rothera Station Leader and the BAS Environment Office must be informed immediately if a biosecurity incident occurs.

10.4.3.7 Disturbance to native flora & fauna (Direct)

Support activities have the potential to cause disturbance, injury or fatality to local seals and birds resulting in avoidance/stress behaviour and nest abandonment.

Associated Activities:

- Relocation of MF Radar

Mitigation:

- The proposed location for the new MF Radar mast is in close proximity to previously used skua nesting sites. Skuas are known to reuse nests year on year even if they have failed to rear chicks' previously. In order to minimise the disturbance to any nesting skuas the works would ideally be carried out in early December or late February. The first activity is to pour and set the concrete foundations. The setting of the concrete is highly dependent on the ambient temperature and if these are too low the concrete will not set. Whilst every effort will be made to undertake the works in early December the conditions will be assessed at the time when on site. The BAS Facilities Manager will liaise directly with the Environment Office when the works are ready to commence. An assessment on the potential disturbance to any nests that are inhabited at the time will be undertaken in conjunction with Richard Philips, BAS Seabird Ecologist. Mitigation will be agreed at the time and may require a delay in works if nests are occupied.
- The guy lines and antenna of the new masts will be fitted with reflective tags in order to deter bird collisions.
- A small area of moss has been identified close to the masts proposed to be deconstructed. Walking or driving on the moss bank is prohibited. Access to the area adjacent to the moss,

[1] ISPM 15 is an International Phytosanitary Measure that directly addresses the need to treat wood materials of a thickness greater than 6mm. Its main purpose is to prevent the international transport and spread of disease and insects that could negatively affect plants or ecosystems.

will be restricted to essential personnel involved in the removal of the mast structure and the sensitivity of the location will be communicated in onsite toolbox talks. See Figure 10.2.

Monitoring:

- Skua monitoring will continue throughout the relocation of the MF radar and up to date information on nest activity will be used to inform the mitigation methods.
- BAS Facilities team will demarcate the no-go zone around the moss bank and ensure it is communicated to relevant personnel on station. Photos of the moss bank will be taken at monthly intervals during the construction activities to monitor any impact.

10.4.3.8 Visual impacts (Direct)

A change in the visual impact and local aesthetic values may be impacted by the following support activities.

Associated Activities:

- Relocation of MF Radar
- Installation of CCTV

Mitigation:

- There is the potential for the visual impact of the MF radar to be reduced as a result of replacing nine masts with five. Whilst the mast will be moved to higher ground that the current location none of the individual towers will exceed the highest science asset currently on the point.
- One pole of roughly 4m high will secured to a gabion basket using locally sourced rock. The gabion basket dimensions will be 1m x 0.5m x 0.5m. The pole and cameras will be removed once the stockpiles have been removed. In the context of the construction activities which will be undertaken whilst the CCTV is in place it is unlikely that this will create a negative visual impact.

10.4.4 Impacts of the new Operations Building post construction

10.4.4.1 Atmospheric pollution (Direct/Cumulative)

There will be a minor contribution to global atmospheric pollution as a result of the new Operations Building.

Mitigation:

- A key design criteria of the new Operations Building is to reduce the fuel usage. The project will likely to achieve MGO savings in the region of 20-25% (compared to a 2015 baseline).

Monitoring:

- Meters will be installed to monitor the energy and service demand from buildings across the station.
- Data will be collated and presented as part of the BAS carbon accounts on an annual basis once the building is in operation.

10.4.4.2 Waste (Direct)

The new Operations Building will generate waste in a similar manner to that which is currently produced on station. However, the new operating model of the *RRS Sir David Attenborough* focusses on the containerisation of cargo which will provide an opportunity to reduce packaging that was previously necessary to protect break bulk cargo.

In addition cargo will be stored in a central store rather in a number of different locations on station. This also provides an opportunity for greater bulk buying of items between departments.

Mitigation:

- Design of the new Operations Building is reliant on containerisation of cargo providing an opportunity to reduce packaging.
- New central stores will promote bulk purchasing which can aid in the reduction of packaging.
- The new waste management facility within the new Operations Building will provide a cleaner more efficient area to manage dry recyclable and dry hazardous waste.

Monitoring:

- Maximo system to replace current inventory software. The intent is to have better stock control, which in turn will reduce the amount of perishable goods that are wasted or inadvertently over ordered.

10.4.4.3 Physical presence and use of space

The new Operations Building will be 30m (width) x 90m (length) x 16m (height) (28m above sea level at the highest point of the Operations Tower) requiring 2,700m^2 of floor space. It will be the largest single building on station.

Mitigation:

- The building has been designed to consolidate and rationalise the existing estate to provide infrastructure which minimises energy use and reduces the costs of snow clearance and maintenance of services.

- On completion the project will have replaced aged buildings with modern, more flexible spaces to minimise future maintenance and operating costs and significantly improve the energy efficiency.

10.4.4.4 Fuel or hazardous substance release (Direct, indirect & cumulative)

The risk of fuel and hazardous substance release will be reduced by the redesign of the site wide services and use of the fluid leak detection system.

Mitigation:

- Automatic distribution of services reduces the need for manual handling and minimises the potential for contamination from spills in moving fluids across station manually.
- The proposed pipework comprises a steel sheath surrounded by an insulation layer incorporating heat tracing and leak detection, and a PVU protective outer skin. The fluid leak detection system allows for fissures in the insulation layer to be identified immediately so that maintenance can be carried out on the specific weaker section before the service is disrupted.

Monitoring:

- Meters will be also be installed to monitor the energy and service demand from buildings across the station.

10.4.4.5 Visual (Direct)

The aesthetic values at Rothera will alter with the construction of the new Operations Building.

Mitigation:

- Being built within the confines of the existing station which is not considered pristine wilderness, it is unlikely that the visual impact will change significantly from its current status.

10.5 Evaluation of the Environmental Impacts

10.5.1 Methodology

In section 10.3 the potential environmental impacts associated with the Rothera Modernisation project have been identified. This section evaluates those impacts in order to identify both the significance and risk of the impact occurring.

In order to evaluate the overall significance, each potential impact has been assessed against the following criteria:

- extent of impact – area or volume where changes are likely to be detectable;
- duration of impact - time period during which changes are likely to occur;
- probability of the impact occurring; and
- severity of the impact if it were to occur - a measure of the amount of change on the environment which also considers the resilience of the environment and its ability to recover from the impact.

Each criteria for each impact is given a score from 1 – 5 to identify whether it is considered 'very low', 'low', 'medium', 'high' or 'very high'. Figure 10.3 provides an explanation and definition of the scale used.

Figure 10-3 Evaluation of impact significance

Impact Criteria	**Definition of Scoring Values**				
	Very Low (VL) 1	**Low (L) 2**	**Medium (M) 3**	**High (H) 4**	**Very High (VH) 5**
Extent of Impact	Site specific: Confined to the construction site, specific asset or laydown areas	Local: Confined to Rothera Point and local marine environment	Regional: Northwest Antarctic Peninsula (Biogeographic region)	Continental: Antarctica and Southern Ocean south of 60°S	Global: Earth and atmosphere
Duration of Impact	Minutes to days	Weeks to months	Several seasons to several years	Decades	Centuries to millennia
Probability of Impact	Very unlikely to occur under any circumstance	Unlikely to occur under normal operations & following standard BAS procedures	Possible if standard BAS or project specific procedures are not followed.	Probable. Likely to occur during the project.	Unavoidable. Certain to occur
Significance/Severity of Impact	No direct impact on the environment and local ecosystems. Recovery is definite.	Impacts may occur but are less than minor or transitory. Reversible in the short term.	Changes to the environment and local ecosystem are minor or transitory. Recovery is likely.	Changes to environment and local ecosystem are greater than minor or transitory. Recovery is slow and uncertain.	Major changes to the environment and local ecosystem which are irreversible, certain to occur and unavoidable. Recovery unlikely.

10.5.2 Risk Scoring

Once the significance criteria have been scored for each impact, this is then used to calculate the overall risk score by using the following calculation:

Risk Score = Extent x duration x probability x severity

By multiplying the value of the each criteria it produces a risk score between 1 and 625. This is repeated after the mitigation measures have been implemented to allow for a comparison and to demonstrate whether the mitigation measures have resulted in a reduction of the risk score. The higher the number the greater the environmental risk of the impact. The risk score values have been split into categories of impact and colour coded for ease of identification. As presented in the table below, they are aligned to the three levels of impact significance identified in Article 8(1) of the Environmental Protocol.

Figure 10-4 Risk Score & Description

Description	Risk Score	Ref Article 8(1) of the Environmental Protocol
Impact acceptable and will be managed through normal operating procedures and outlined mitigation measures	1-60	Less than minor or transitory
Impact needs active management through mitigation measures and monitoring	61 -120	No more than minor or transitory
Impact significant. If no practical mitigation measures are possible then BAS senior management must decide whether to accept the risk.	121 – 625	More than minor or transitory

10.5.3 Risk Response

Aligned with the risk score, a risk response has been identified for each impact. Three different overarching responses are identified:

- Avoid – apply mitigation so that the impact does not occur
- Reduce – apply mitigation to reduce the risk of the impact occurring
- Accept – acceptance of the risk of the impact occurring with no further mitigation

Where 'avoid' or 'reduce' have been assigned to an impact, the response should involve applying the normal operating procedures and mitigation measures in order to eliminate or reduce the risk. The risk score is then recalculated. Where there are no practical mitigation measures for an impact the response can only be 'accept'. Therefore, if the activity is undertaken, the resulting impact must be accepted.

10.6 Impact Matrix

10.6.1 Construction Activity Impacts																	
No.	Activities	Environmental Aspect	Potential Impact(s)	Type of Impact (Direct, indirect, cumulative, or unavoidable)	Extent	Duration	Probability	Significance/Severity	Risk Score (pre-mitigation)	Risk Response	Preventative or mitigating measures	Extent	Duration	Probability	Significance/Severity	Risk Score (post mitigation)	Ref Article 8 of the Environmental Protocol
1.	• Vehicle, plant & equipment operation • Foundations & concrete flooring • Erection of steelworks • MEP works • Demolition & relocation of waste management facility • Preparation of ground for storage of shipping containers	Atmospheric emissions	Minor but cumulative contribution to regional and global atmospheric pollution. Heavy metal and particulate fallout	Direct/ Cumulative	1	3	5	2	30	Reduce	• Generators & plant will be selected which balance efficiency & reduced emissions. • Regular inspection and maintenance will be carried out to ensure all vehicles, plant and generators operate efficiently. • All drivers will be instructed to turn off engines during periods of waiting for 5 minutes or more. • (No on-site mitigation has been provided for the emissions associated with the production of the concrete foundations, steel works or other construction materials. However the Rothera Sustainability Plan will encourage the selection of materials with a lower embedded carbon)	1	3	4	2	24	Less than minor or transitory
2.	• Vehicle, plant & equipment operation • Earthworks • Erection of steelworks • MEP works • Demolition & relocation of waste management facility • Preparation of ground for storage of shipping containers • Relocation & upgrade of site wide services • Demolition of building assets	Noise emissions	Disturbance to local seals and birds resulting in avoidance behaviour, nest abandonment.	Direct/ Cumulative	2	3	3	3	54	Reduce	• Regular maintenance of all equipment to ensure it is working efficiently. • 10mph speed limit maintained and enforced on site. • Plant items will be positioned to ensure exhaust outlets point away from sensitive receptors. • Regular maintenance of all plant and vehicles to ensure it is working efficiently and generating as little noise as possible. • A soft start procedure will be implemented for all noisy equipment and consideration given to the impact on wildlife.	2	3	3	2	36	Less than minor or transitory
3.	• Vehicle, plant & equipment operation • Earthworks, Laying foundations and concrete flooring, MEP works • Demolition of waste management facility • Preparation of ground for shipping containers • Site wide services	Dust emissions	Dust deposition on ice ramp resulting in increased melt. Smothering of local flora.	Direct & cumulative	2	3	4	3	72	Reduce	• Control of dust from plant by spraying roadways, and areas being prepared for laydown with seawater. • Use of dust suppression skirts on screening plant • Grouting & cement equipment to be washed out in a fully bunded area using the minimum possible quantity of water. • Wash waters to be neutralised before discharge to ground or the sea.	2	3	3	3	54	Less than minor or transitory

10.6.1 Construction Activity Impacts

No.	Activities	Environmental Aspect	Potential Impact(s)	Type of Impact (Direct, indirect, cumulative, or unavoidable)	Extent	Duration	Probability	Significance/Severity	Risk Score (pre-mitigation)	Risk Response	Preventative or mitigating
	• Demolition of building assets										
4.	• Site set up & presence of construction personnel • Installation of cladding & roof panels • MEP works • Demolition & relocation of waste management facility • Relocation & upgrade of site wide services • Demolition of building assets	Waste	Increased waste sent to landfill. Pollution of local environment.	Direct	2	3	3	3	54	Reduce	• The SWMP (Appendix construction waste Management Handboo • Dedicated area for sto • All construction waste and disposed of by lice • Packaging will be minir consigning cargo south • BAM commitment to waste from landfill for • Pre-deployment traini • Daily checks will ensur wind blow
5.	• Vehicle plant and equipment operation	External light emissions	Disorientation of birds causes strikes resulting in injury or mortality	Direct	1	3	4	3	36	Reduce	• Minimise use of lightir darkness • Rigs to be angled towa horizontal. • Lights to be turned off • Lights switched off i strikes in one period o • SL and BAS Environn should there be any bi • Continued use of light after consultation with
											• Sensitive science equi approached to ensure

10.6.1 Construction Activity Impacts											
No.	Activities	Environmental Aspect	Potential Impact(s)	Type of Impact (Direct, indirect, cumulative, or unavoidable)	Extent	Duration	Probability	Significance/Severity	Risk Score (pre-mitigation)	Risk Response	Preventative or mitigating
	• Demolition & relocation of waste management facility • Preparation of ground for storage of shipping containers • Site wide services • Demolition of building assets										
8.	• Vehicle plant and equipment operation • Fuel management & refuelling • Earthworks • Demolition & relocation of waste management facility • Preparation of ground for storage of shipping containers. • Relocation & upgrade of site wide services. • Demolition of building assets.	Fuel or hazardous substance release	Pollution to local environment. Mortality to flora & fauna. Secondary contamination to birds if ingested. Hazardous waste associated with spill materials.	Direct, indirect & cumulative	2	3	4	3	72	Reduce	• Refuelling carried out with station refuelling • Spill kits in all vehicles • Plant nappies to be us • All construction staff t training. • Construction spill resp for tier 1 • Rothera OSCP to be fo • Obstruction bund to b container storage area fuel farm to minimise • Clear demarcation of v of the fuel pipe. • All spills reported to R Environment Office.
	• Site set up and presence of construction personnel • Vehicle, plant and equipment operation										• All construction staff and on-station briefin and working close to w • Only trained personn displacement of seals.

10.6.1 Construction Activity Impacts

No.	Activities	Environmental Aspect	Potential Impact(s)	Type of Impact (Direct, indirect, cumulative, or unavoidable)	Extent	Duration	Probability	Significance/Severity	Risk Score (pre-mitigation)	Risk Response	Preventative or mitigating
10.	• Earthworks • Erection of steelworks • Installation of cladding and roof panels • Demolition & relocation of waste management facility • Preparation of ground for storage of shipping containers • Demolition of building assets	Visual	Visual change to the built and natural landscape altering aesthetic value of Rothera.	Direct/ cumulative	2	3	4	3	72	Accept	• Construction activities areas on site. Any cha by the construction te be discussed and agre management team an Environment Office an
11.	• Demolition of building assets	Heritage	Loss or damage to heritage artefacts	Direct	1	4	3	3	36	Reduce	• Heritage survey under value. • Rothera Move Manag that the heritage instr • Heritage display area c • The CIMP document need to be retained w • Heritage review to complete.

10.6.2 Excavation, drilling & blasting Impacts

No.	Activities	Environmental Aspect	Potential Impact(s)	Type of Impact (Direct, indirect, cumulative, or unavoidable)	Extent	Duration	Probability	Significance/Severity	Risk Score (pre-mitigation)	Risk Response	Preventative or mitigating
1.	• Blasting and excavation of rock material • Loading, transporting and tipping of rock • Stockpiling and screening rock	Atmospheric emissions	Minor but cumulative contribution to regional and global atmospheric pollution. Heavy metal and particulate fallout	Direct/ Cumulative	1	3	5	2	30	REDUCE	• Generators & plant wi efficiency & reduced e • Regular inspection and out to ensure all vehic operate efficiently. • All drivers will be instr during periods of wait
2.	• Blasting and excavation of rock material • Loading, transporting and tipping of rock • Stockpiling and screening rock	Noise emissions	Disturbance to local wildlife potentially resulting in avoidance or stress behaviour, nest abandonment or hearing damage.	Direct/ Cumulative	2	3	3	3	54	Reduce	• Prior to blasting the Sh site to ensure that it is • Plant will be positione receptors e.g. nesting • Blast mats will be used during blasting. • Acoustic screening wil levels are likely to exce • Blasting will be undert from the closest shore environment will be u works
3.	• Blasting and excavation of rock material • Loading, transporting and tipping of rock • Stockpiling and screening rock	Dust emissions	Smothering of flora. Dust deposition on the ramp resulting in increased melt during summer.	Direct/ Cumulative	2	3	4	4	96	Reduce	• Keep activities which c sensitive receptors and wherever possible. • Use of dust suppressic • Careful blast design to material into the air. • Blast mats to be used blast. • Suspend blasting on ex when blowing in the d receptors.

5.	• Site set up for duration of drilling and blasting • Blasting and excavation of rock material • Loading, transporting and tipping of rock • Stockpiling and screening rock	Physical presence & use of space	Disruption to station operations and science.	Direct, indirect & cumulative	2	3	5	3	90	Reduce	• Evacuation plans to er evacuation occurs witl to day activities. • A CIMP produced iden equipment. . • A Rothera Station Inte produced. • Pre-deployment traini BAM & BAS staff. • Construction activities areas on site. Any cha Ops, the Environment
6.	• Blasting and excavation of rock material • Stockpiling and screening rock	Physical disturbance on land	Rock throw during blasting could damage buildings or injure nearby wildlife. Ground displacement could impact sensitive receptors.	Direct	1	2	4	3	24	Reduce	• Rock throw strictly cor process as per the Dril Management Plan. • Prior to blasting the Sh site to ensure that it is birds. • Sensitive receptors ide Blasting Management • Cut & fill study undert minimum amount of r
7.	• Blasting and excavation of rock material	Fuel or hazardous substance release	Pollution to local environment. Mortality to flora & fauna. Secondary contamination to birds if ingested. Exposure of humans and wildlife to toxic materials contained in explosives.	Direct, indirect & cumulative	2	3	4	3	72	Reduce	• Refuelling will be carri set out in Section 6.1.3 with station refuelling • Spill kits in all vehicles set out in Section 6.1.5 • Plant nappies to be us • All construction staf training. • Construction spill resp tier 1 as per Section 6. • Rothera OSCP to be fo • All spills reported to R Environment Office. • The drilling and blastin followed at all times. S risk of exposure to exp

8.	• Site set up for duration blasting and excavation of rock material • Loading, transporting and tipping of rock • Stockpiling and screening rock	Disturbance to flora & fauna	Disturbance, injury or fatality to local seals and birds resulting in in avoidance or stress behaviour, nest abandonment or hearing damage.	Direct	2	3	4	3	48	Reduce	• All construction staff and on-station briefin and working close to v • Only trained personn displacement of seals. • Prior to blasting the S site to ensure that it birds. • All vehicles will be ins for the presence of engines are started.
9	• Blasting and excavation of rock material • Stockpiling and screening rock	Visual	Visual change to the built and natural landscape altering aesthetic value of Rothera.	Direct/ cumulative	2	4	5	3	120	Accept	• Construction activities areas on site. • The cut and fill study u the minimum amount undertaken.

10.6.3 Support Activity Impacts

No.	Activities	Environmental Aspect	Potential Impact(s)	Type of Impact (Direct, indirect, cumulative, or unavoidable)	Extent	Duration	Probability	Significance/Severity	Risk Score (pre-mitigation)	Risk Response	Preventative or mitigating
1.	• Shipping cargo to Rothera • Transport of personnel to Rothera • Provision of accommodation, power, & domestic services	Atmospheric emissions	Minor but cumulative contribution to regional and global atmospheric pollution. Heavy metal and particulate fallout	Direct/ Cumulative	3	2	5	2	60	Accept	• Only staff essential Operations Building w • Rationalisation of plar station to be undertak • All staff will be briefed on station.
2.	• Relocation of MF Radar	Dust	Potential damage to flora & fauna due to high alkaline cementitious dust or liquids.	Direct	1	2	2	3	12	Accept	• Concrete batching w sensitive environment • Cement not to be mixe
3.	• Relocation of MF Radar • Replacement of Bentham container • Repair of hangar roof • Provision of accommodation, power, & domestic services	Waste	Increased waste sent to landfill. Pollution of local environment.	Direct	2	3	3	3	54	Reduce	• Planned re-use of ma other steel to be sent • The Bentham contai metal. All internal fitt • Appropriate package provided. • All toilets and washin the foul drainage syst STP.
4	• Relocation of MF Radar • Replacement of Bentham container	Physical presence & use of space	Disruption to station operations and science.	Direct, indirect & cumulative	1	2	4	3	24	Reduce	• 9 MF masts to be rem ones - more efficient u • Old Bentham contai station for disposal.
5.	• Relocation of MF Radar • Replacement of Bentham container	Physical disturbance on land	Concrete pads and plinths, created on ice free ground impacting local geology.	Direct	1	4	4	2	32	Reduce	• Where possible gabio of concrete.

7.	• Shipping cargo to Rothera • Transport of personnel to Rothera	Non-native species introduction	Non-native species introduced & established altering local ecosystem. Increased risk to endemic species. Impact on future science.	Indirect	2	4	4	4	128	Reduce	• All staff to atten deployment traini • All personnel Biosecurity Plan. • All cargo to be consignment and • Personal items of checked before de
8.	• Relocation of MF Radar	Disturbance to native flora & fauna	Disturbance, injury or fatality to local seals and birds resulting in in avoidance or stress behaviour, nest abandonment or hearing damage	Direct	1	2	4	4	32	Reduce	• Onsite assessmen time impact on an programme know at the time and m nests are occupied • Guy lines and ante fitted with reflect collisions
9.	• Relocation of MF Radar • Installation of CCTV	Visual	Visual change to the built and natural landscape altering aesthetic value of Rothera.	Direct/ cumulative	1	3	2	2	12	Accept	• 9 MF masts to be new ones. • New masts will no asset currently on • Small pole appro cameras.

10.6.4 Impacts of the new Operations Building post construction										
Activities	Environmental Aspect	Potential Impact(s)	Type of Impact (Direct, indirect, cumulative, or unavoidable)	Extent	Duration	Probability	Significance/Severity	Risk Score (pre-mitigation)	Risk Response	Preventative or mitigating measu
Operational impacts of the new building	Atmospheric emissions	Minor but cumulative contribution to regional and global atmospheric pollution. Heavy metal and particulate fallout	Direct/ Cumulative	2	4	5	3	120	Reduce	• A key design criteria is to on station.
Operational impacts of the new building	Waste	Increased waste sent to landfill. Pollution of local environment.	Direct	2	4	3	2	48	Reduce	• Design reliant on contain providing an opportunity • New central stores will pr purchasing which can aid packaging. • The new waste managem provide a cleaner, more e manage dry recyclable ar waste.
Operational impacts of the new building	External light emissions	Disorientation of birds causes strikes resulting in injury or mortality	Direct	1	4	3	3	36	Reduce	• Standard BAS procedure are briefed on) of ensuri switched off when not ir used during winter. • All bird strikes reported c
Operational impacts of the new building	Physical presence & use of space	The new building will be the largest and tallest single building on station.	Direct	1	4	4	4	64	Accept	• The building has been de and rationalise the exist infrastructure which min reduces the costs of maintenance of services. • On completion the proje aged buildings with m

Operational impacts of the new building	Visual	Visual change to the built landscape altering aesthetic value of Rothera.	Direct/ cumulative	2	4	5	3	120	Accept	• Being built within the co station which is not wilderness, it is unlikely will change significantly f

10.7 Cumulative Impacts

Cumulative impacts are the combined impacts of past, present and reasonably foreseeable activities which may occur over time and space and be interactive (ATS, 2016). When considered in this wider context of other actions, an activity may result in a potentially significant impact that may occur over a longer period of time, at a particular location and in conjunction with other events.

Rothera Point has been used operationally since 1975 and has been developed and expanded ever since. The proposed works will not increase the overall footprint of the current station, however in conjunction with the Rothera Wharf construction project, will require the use of a large proportion of the accessible areas on station during construction periods. To ensure the impact on day to day operations of the station is minimised, the demand on space and laydown areas will need to be managed effectively. The implementation of the Rothera Station Integration Plan will be essential if the planned operational and science delivery is to continue unaffected.

The combined activities of the Rothera Modernisation and the Rothera Wharf projects which have been identified as having a potentially cumulative impact are listed below:

- Introduction of non-native species
- Dust deposition on the ice ramp
- Terrestrial and marine pollution from fuel spills
- Physical presence and disturbance impacting science and operations
- Removal of rock resulting in a change in the aesthetics of Rothera Point

A full description of the impacts and proposed mitigation for each of these activities within the context of this project are included earlier in this chapter.

11 MONITORING & AUDIT REQUIREMENTS

11.1 Monitoring

Article 5 of Annex I to the Environmental Protocol explicitly requires appropriate monitoring of key environmental indicators to be put in place to assess and verify the predicted impacts following completion of a CEE. It states that monitoring needs to "*be designed to provide regular and verifiable records of the impacts of the activity*" (Article 5(2)) and to *"provide information useful for minimising or mitigating impacts, and, where appropriate, information on the need for suspension, cancellation or modification of the activity"* (Annex I, Article 5, (2) (b) Environmental Protocol, 1991). Provision should also be made for regular and effective monitoring to be in place to facilitate early detection of possible unforeseen effects of activities (Article 3 (2) (e) Environmental Protocol, 1991).

Within Appendix G: *Rothera Modernisation Monitoring Plan* a monitoring plan has been included outlining the monitoring activities to be undertaken during the project.

The main impacts identified in this assessment for which there are key environmental indicators include the contamination of the terrestrial environment, habitat loss, noise, vibration, dust and wildlife displacement.

The monitoring tasks are split into three types of activities;

4. Short term monitoring of activities which could result in an immediate impact on the environment and can be modified during the construction programme to avoid adverse effects. This will include monitoring of the following activities:

   - Neutralisation of cement contaminated water
   - Wildlife displacement
   - Noise from drilling and blasting and construction activities
   - Vibration from drilling and blasting and construction activities
   - Airborne dust

5. Monitoring of environmental parameters which may reflect impacts that can only be measured in the long term (i.e. over several Antarctic seasons) and subsequently are unlikely to be modified beyond the original mitigation identified in the EIA. This will include monitoring of Skua breeding success on Rothera Point

Any changes to activities proposed as a result of the monitoring data, will be made by the Construction Manager in conjunction with the BAS Environment Office. All monitoring data will be communicated to the BAS Environment Office and be available on request for auditing purposes.

6. Environmental management activities – these will be undertaken by the construction partner as indicated in the Figure 11-1 below and the data or findings reported to the BAS Environment Office.

Figure 11-1 Environmental Management Activities

Environmental Management Activity	Location in EIA	Reporting Output
Waste Management: segregation, packaging, storage and disposal of waste as per the SWMP and BAS WMH	Appendix B	▪ Waste Transfer Notes ▪ Waste Data
Biosecurity: Implementation of the Rothera Biosecurity Plan at all stages of cargo and personnel movement	Appendix C	▪ Biosecurity Checklists ▪ Biosecurity breaches reported
Fuel Management: daily refuelling as per refuelling procedure.	BAM refuelling procedure – Section 6.1	▪ Training records of staff ▪ Fuel spills reported ▪ Fuel consumption for carbon accounting
Oil Spill response: BAM staff will respond to all Tier 1 spills and follow the direction of Rothera Station Leader for all Tier 2 and Tier 3 spills. BAM will provide appropriate spill response equipment.	BAM Oil Spill Contingency – Section 6.1.4 BAM Spill Response Equipment – Section 6.1.5	▪ Fuel spills reported ▪ Spill kits used and disposed of appropriately

In addition BAS will continue to monitor waste statistics, fuel use for construction activities, and fuel use for carbon accounting e.g. flights, ships etc. which will be reported annually to the FCO as the UK's competent authority.

11.2 Audit Programme

An audit programme will be undertaken during the construction works by the BAS Environment Office to ensure that the actions and mitigation measures committed to in this document are being adhered to.

The audits will also be conducted against the ISO14001:2015 standard to which BAS is registered. A minimum of two onsite audits will be undertaken during the construction programme and a further EIA review which will include a site visit to Rothera will be undertaken on completion of the works.

12 GAPS IN KNOWLEDGE & UNCERTAINTIES

12.1 Rothera Modernisation Phase 1

12.1.1 Site setup locations and logistics

The locations of material and plant laydown and storage areas available have been identified indicatively on the Site Layout Drawing

Figure 3-31,

Figure 3-32 and

Figure 3-33. Further discussions will be undertaken with BAS Operations to finalise and agree these locations once the full site logistics of both the Rothera Wharf and the Rothera Modernisation are fully committed and developed prior to the start of the 2019-2020 season.

12.1.2 Resource quantities

The volume of cut and fill required will be dependent on the useable yield of excavated material. The volumes provided in this IEE are based on worst case estimations derived from information provided by the Site Investigation and the experience that the contractor has from working with similar rock properties. Slope stability analysis is currently being undertaken and once this has been completed the cut and fill requirements will be finalised.

Anticipated volumes of water and fuel presented in this document are based on estimations on the current design detail.

12.1.3 Energy Efficiency

The percentage reduction in MGO consumption project benefit is to be refined with further collaboration with CHP suppliers on the performance specification and energy performance curves for specific generator sizes. The MGO consumption target is based on an assessment of the MGO demand from a 2015 baseline and input into an energy savings workflow (ESW) model of the anticipated energy demand from the new operations building at WS4a (65%) detailed design.

12.1.4 Plant & Equipment

The large plant items listed are unlikely to change, however, it is anticipated there may be minor changes in the types of smaller plant such as tractors, trailers, generators and compressors.

12.2 Future Phases of Rothera Modernisation

Phase 1 of the Rothera Modernisation project will enable the station to be ready for a new operating dynamic with the commission of RSS Sir David Attenborough. The infrastructure will be designed to fully utilise the containerisation of cargo using the new asset management system, IBM Maximo.

Longer-term, the infrastructure will help drive the future phases of the project towards achieving greater energy efficiency, reduce whole life costs associated with operations and realise logistical efficiencies. These benefits will be realised with completion of Phase 1 and will be further developed over time as Phases 2, and 3 progress toward completion.

The infrastructure enablers include the following features:

- installation of heat recovery generators;
- installation of Solar Photovoltaic based renewable energy arrangements;
- improved zoning of building functions that will reduce energy consumption;
- a Central Store that reduces manual handling and enables more efficient supply; and
- location and orientation of building that reduces resource required for snow management.

Phase 2

At the current stage of planning Phase 2 is anticipated to include:

- construction of a new aircraft hangar;
- construction of a new marine facility;
- new building to replace Giants House;
- improved access to route to East Beach; and
- proof of concept for renewable energy (wind).

Phase 3

At the current stage of planning Phase 3 is anticipated to include:

- a new building to replace the Bonner Laboratory;
- a new building to replace New Bransfield House;
- a new building to replace Admirals House;
- a new sewage treatment plant;
- improved communications infrastructure; and
- renewable energy installations.

The funding and full scope of these future phases has not yet been confirmed and will be considered in future environmental impact assessments.

13 CONCLUSIONS

The Rothera Modernisation Phase 1 construction project, is an essential project for BAS to be able to modernise and restore the Rothera infrastructure so that it remains cost effective, and safe whilst minimising energy use and reducing the costs of snow clearance and maintenance of services.

The project has been designed to take account of BAS sustainability aspirations which will be evidenced through the BREEAM assessment. The proposed plans largely avoid areas of ecological sensitivity and will predominantly occur in previously disturbed and developed locations at Rothera.

A full assessment of the potential environmental impacts are included in this IEE within Chapter 10. Most of the impacts can be managed within existing BAS procedures or with the addition of specific mitigation and monitoring.

The most significant potential impacts predicted for the construction activities, drilling and blasting and associated supporting activities are:

- Introduction of non-native species
- Dust deposition on the ice ramp
- Physical presence and disturbance impacting science and operations
- Terrestrial pollution from fuel spills
- Aesthetic changes to Rothera Station

The introduction of non-native species as a result of importing cargo or the deployment of personnel could have a significant impact in the longer term, but these impacts are less likely if standard operational procedures and enhanced mitigation measures are followed.

Impacts associated with the generation of dust could be significantly reduced with the implementation of robust mitigation measures which are managed throughout the construction period.

The likelihood of impacts occurring that are associated with the physical presence and physical disturbance created by the construction works is high. The mitigation measures which are already being developed to reduce these impacts will rely on the close working relationship between BAS and the contractor. Integrated and collaborative working be essential to avoid significant impacts.

The probability of impacts associated with fuel spills occurring will also be reduced if standard operating procedures are complied with during refuelling. In the unlikely event of a spill, oil spill contingency plans are in place and will be followed to minimise the severity of impacts.

The removal of rock to create an appropriate area in which to construct the new Operations Building combined with the size and extent of the new building will potentially alter the aesthetic value of Rothera. Cut and fill studies have been undertaken to ensure that the minimum amount of rock is removed.

The most significant potential impacts predicted for the operation of the new building post construction are:

- Atmospheric emissions
- Physical presence and use of space
- Visual and aesthetic change

Once of the key design criteria is to reduce the fuel usage on station and ultimately reduce the impacts associated with atmospheric emissions, not only in Phase 1 but also in future phases of the Rothera Modernisation programme.

The size of the new building has been rationalised against the existing estate in order to provide infrastructure which minimises energy use and maintenance requirements.

The new building will be constructed within in the confines of the existing station footprint which is not considered pristine wilderness. However the wider context of near pristine Antarctic scenery of outstanding wilderness and aesthetic value surrounding Rothera should not be ignored.

Having prepared this IEE along with rigorous mitigation measures to reduce the risk of the predicted impacts occurring, it is considered that the proposed activities will have no more than a minor or transitory impact.

14 AUTHORS

This CEE has been prepared by Clare Fothergill of the BAS Environment Office. The baseline section was written by Kevin A. Hughes with input from a number of expert contributors listed below in the acknowledgements section. Construction specific mitigation measures, biosecurity procedures, spill response and waste management procedures were written in conjunction with Neil Goulding of BAM.

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15 ACKNOWLEDGEMENTS

Expert contributors to the Baseline Section include the following BAS personnel; Steve Colwell, Peter Convey, Rosey Grant, Laura Gerrish, Ieuan Hopkins, Louise Ireland, Anna Malaos, Teal Riley, Helen Peat, Richard Phillips, Andrew Smith and Iain Staniland. Detail on facilities management at Rothera was provided by Tim Jackson and Ben Clarke.

Detail on the design elements of the project have been provided by The BAS Project Management Team, Dave Brand and Joe Stebbing as well as BAM personnel David Phethean, Nick Geurts, Eric Tromper and Maurice Siemensma. Jan Cordon of BAM has provided detail on the excavation, drill and blast procedures.

This IEE has been reviewed internally at BAS by Rachel Clarke Head of Environment, Dave Brand Project Manager for the Rothera Modernisation, David Seaton Programme Manager for AIMP and Rebecca Grady Project Manager for Ramboll.

16 REFERENCES

- Antarctic Treaty Secretariat, (2017), Management Plan for Antarctic Specially Protected Area No. 129 Rothera Point, Adelaide Island. Available at: http://www.ats.aq/devPH/apa/ep_protected.aspx?lang=e

- Bonner, W.N., Lewis-Smith, R.I. and Walton, D.W.H. (1989), Final Comprehensive Evaluation for the proposed construction of an airstrip at Rothera Point, Antarctica. NERC, Swindon.

- Burton-Johnson, A., Black, M., Fretwell, P. and Kaluza-Gilbert, J. (2016), An automated methodology for differentiating rock from snow, clouds and sea in Antarctica from Landsat 8 imagery: A new rock outcrop map and area estimation for the entire Antarctic continent. *The Cryosphere*, 10. 1665-1677.

- Cannone, N., Convey, P., Malfasi, F. (2018) Antarctic Specially Protected Areas (ASPA): a case study at Rothera Point providing tools and perspectives for the implementation of the ASPA network in the Antarctic Peninsula. *Biodiversity and Conservation* 27: 2641-2660.

- Convey, P. & Smith, R.I.L. (1997) The terrestrial arthropod fauna and its habitats in northern Marguerite Bay and Alexander Island, maritime Antarctic. Antarct. Sci. 9, 12-26.

- Convey, P., Bindschadler, R., Di Prisco, G., Fahrbach, E., Gutt, J., Hodgson, D.A., Mayewski, P.A., Summerhayes, C.P., Turner, J. (2009), Review. Antarctic climate change and the environment. Antarctic Science, 21. 541-563.

- Emslie, S.D., McDaniel, J. (2002), Adelie penguin diet and climate change during the middle to late Holocene in northern Marguerite Bay, Antarctic Peninsula. Polar Biology 25, 222-229.

- Friedlaender, A.S., Johnston, D.W., Fraser, W.R., Burns, J., Halpin, P.N., Costa, D.P. (2011). Ecological niche modeling of sympatric krill predators around Marguerite Bay, Western Antarctic Peninsula. Deep Sea Research II 58: 1729–1740.

- Fretwell, P.T., Convey, P., Fleming, A.H., Peat, H. J., Hughes, K.A. (2011), Detecting and mapping vegetation distribution on the Antarctic Peninsula from remote sensing data. *Polar Biology*, 34. 273-281.

- Guglielmin, M, Worland, RM, Baio, F. (2014) Permafrost and snow monitoring at Rothera Point (Adelaide Island, Maritime Antarctica): Implications for rock weathering in cryotic conditions. Geomorphology 225: 47–56.

- Historic England, (2008), Conservation Principles, Policy and Guidance'. Historic England, London.

- Hopkins, I. (2017), Rothera Visit – Heritage Survey Review, Unpublished Internal BAS Report.

- Hughes, K. A., Greenslade, P., and Convey, P. (2017), The fate of the non-native collembolon, *Hypogastrura viatica*, at the southern end of its introduced range in Antarctica. Polar Biology 40: 2127-2131.

- Hughes, K. A., Ireland, L., Convey, P., Fleming, A.H. (2016), Assessing the effectiveness of specially protected areas for conservation of Antarctica's botanical diversity. Conservation Biology, 30. 113-120.

- Hughes, K. A., Pertierra, L.R., Molina-Montenegro, M. A., Convey, P. (2015), Biological invasions in terrestrial Antarctica: what is the current status and can we respond? Biodiversity and Conservation, 24. 1031-1055.

- Milius, N. (2000), The birds of Rothera, Adelaide Island, Antarctic Peninsula. Marine Ornithology 28: 63-67.

- Muir, S.F., Barnes, D.K.A., Reid, K. (2006), Interactions between humans and leopard seals. Antarctic Science, 18. 61-74.

- Øvstedal, D.O. and Smith, R.I.L. (2001), Lichens of Antarctica and South Georgia. A Guide to their Identification and Ecology. Cambridge University Press, Cambridge, 411 pp.

- Ochyra, R., Bednarek-Ochyra, H. and Smith, R. I. L. (2008), The Moss Flora of Antarctica. Cambridge University Press, Cambridge. pp 704.

- Pertierra, Luis R., Hughes, Kevin A., Vega, Greta C., Olalla-Tárraga, Miguel Á. (2017), High Resolution Spatial Mapping of Human Footprint across Antarctica and Its Implications for the Strategic Conservation of Avifauna. *PLOS ONE*, 12. e0168280. doi:10.1371/journal.pone.0168280

- Phillips, R.A., Silk, J.R.D., Massey, A. and Hughes, K.A. (2019). Surveys reveal increasing and globally important populations of south polar skuas and Antarctic shags in Ryder Bay. Polar Biology 42: 423–432

- Riley. T. R., Flowerdew, M. J. and Whitehouse, M. J. (2012), Chrono- and lithostratigraphy of a Mesozoic–Tertiary fore- to intra-arc basin: Adelaide Island, Antarctic Peninsula. Geological Magazine 149: 768-782.

- Shears, J. R. (1995), Initial Environmental Evaluation – expansion of Rothera Research Station, Rothera Point, Adelaide Island, Antarctica. British Antarctic Survey, Cambridge, 80 pp.

- Širović, A., and Hildebrand J. A. (2011), Using passive acoustics to model blue whale habitat off the Western Antarctic Peninsula. Deep-Sea Research Part II 58:1719-1728.

- Širović, A., Hildebrand, J.A, Wiggins, S.M., McDonald, M.A., Moore, S. E., Thiele, D. (2004), Seasonality of blue and fin whale calls and the influence of sea ice in the Western Antarctic Peninsula. Deep-Sea Research II 51:2327–2344.

- Smith, A.M., Vaughan, D.G., Doake, C.S.M., Johnson, A.C.. (1998), Surface lowering of the ice ramp at Rothera Point, Antarctic Peninsula, in response to regional climate change. Annals of Glaciology, 27. 113-118.

- Tin T., and Summerson R. (2013), Growing human footprint, diminishing wilderness in Antarctica. International Journal of Wilderness 19 (3): 10–13, 36.

- Turner, J., Colwell, S. R., Marshall, G. J., Lachlan-Cope, T. A., Carleton, A. M., Jones, P. D., Lagun, V., Reid, P. A., Iagovkina, S. (2004), The SCAR READER Project: toward a high-quality database of mean Antarctic meteorological observations. Journal of Climate, 17. 2890-2898.

17 BIBLIOGRAPHY

- Antarctic Treaty Secretariat, (2016), Guidelines for Environmental Impact Assessment in Antarctica, [Online] Available at: http://www.ats.aq/e/ep_eia.htm [Accessed 01.04.2019].
- Committee for Environmental Protection, (2016), Non-native Species Manual, Secretariat of the Antarctic Treaty, Buenos Aires.
- Fothergill, C., (2018). Rothera Wharf Reconstruction & Coastal Stabilisation Final Comprehensive Environmental Evaluation, BAS.

18 APPENDICES

18.1 Appendix A: Rothera Modernisation Drilling and Blasting Management Plan

18.2 Appendix B: Rothera Modernisation Site Waste Management Plan

18.3 Appendix C: Rothera Modernisation Biosecurity Plan

18.4 Appendix D: Rothera Site Ground Investigation Report

18.5 Appendix E: Rothera Heritage Survey Results

18.6 Appendix F: Rothera Heritage Selection Process Forms

18.7 Appendix G: Rothera Modernisation Monitoring Plan

18.8 Appendix H: Noise Assessment