DRAFT COMPREHENSIVE ENVIRONMENTAL EVALUATION (CEE)

Construction and Operation of
the Turkish Antarctic Research Station (TARS)
at Horseshoe Island, Antarctica

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ACRONYMS AND ABBREVIATIONS

AD	Antarctic Diesel
AHP	Analytical Hierarchy Method
AHU	Air Handling Unit
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASMA	Antarctic Specially Managed Area
ASPA	Antarctic Specially Protected Area
ASPeCt	Antarctic Sea Ice Processes and Climate
ATCM	Antarctic Treaty Consultative Meeting
ATS	Antarctic Treaty System
AWS	Automatic Weather Station
BAS	British Antarctic Survey
BDL	Below Detection Limit
BMS	Building Management System
CEE	Comprehensive Environmental Evaluation
CEP	Committee for Environmental Protection
CFD	Computational Fluid Dynamics
CHP	Combined Heat and Power (Co-Generation)
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COD	Chemical Oxygen Demand
COMNAP	Council of Managers of National Antarctic Program
dBA	A-Weighted Decibels
DDT	Dichlorodiphenyltrichloroethane
DM	Dry Matter
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
ERL	Effects Range / Low

ERM	Effects Range / Median
EU	European Union
$FeCl_3$	Ferric Chloride
GNSS	Global Navigation Satellite System
HCl	Hydrogen Chloride
HF	Hydrogen Fluoride
HSM	Historic Sites and Monuments in Antarctica
HVAC	Heating, Ventilation and Air-Conditioning
IBA	Birdlife International
ICC	International Code Council
IEC	International Electrotechnical Commission
IEE	Initial Environmental Evaluation
IMO	International Maritime Organization
ITU	Istanbul Technical University (Turkey)
MAM	Marmara Research Centre of TÜBİTAK
MARPOL	International Convention for the Prevention of Pollution from Ships
MoEU	Ministry of Environment and Urbanization
MoIT	Ministry of Industry and Technology
NFPA	National Fire Protection Association
NO	Nitrogen Oxide
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxides
NPI	Norwegian Polar Institute
NPSP	National Polar Science Program
O&M	Operation & Maintenance
OCP	Organochlorine Pesticide
ONHO	State Office of Navigation, Hydrography and Oceanography
PAH	Polycyclic Aromatic Compound
PCB	Polychlorinated Biphenyl
PM	Particulate Matter
PolReC	Polar Research Centre (ITU)
PRI	Polar Research Institute (TÜBİTAK MAM)
PROANTAR	Brazilian Antarctic Program

PV	Photovoltaic Panels
QGIS	Quantum Geographic Information System
R&D	Research and Development
RIB	Rigid Inflatable Boat
RIPEPAT	Regulation on the Implementation of the Protocol on Environmental Protection to the Antarctic Treaty
SBR	Sequencing Batch Reactor
SCAR	Scientific Committee on Antarctic Research
SO_2	Sulphur Dioxide
TAE	Turkish Antarctic Expedition
TARS	Turkish Antarctic Research Station
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbon
TR	Republic of Turkey
TSE	Turkish Standards Institute
TSS	Total Suspended Solids
TÜBİTAK	Scientific and Technological Research Council of Turkey
UAV	Unmanned Aerial Vehicle
UK	United Kingdom of Great Britain and Northern Ireland
UPS	Uninterruptible Power Supply
USA	United States of America
VFD	Variable Frequency Drive
WMP	Waste Management Plan
WHO	World Health Organization

0 NON-TECHNICAL SUMMARY

The Draft Comprehensive Environmental Evaluation (CEE) Report has been prepared regarding the construction and operation of the Turkish Antarctic Research Station (TARS) that is proposed to be established at Horseshoe Island in Antarctica. The environmental evaluation of its potential impacts on the environment forms the basis of this study. The determined site of TARS has been selected among different alternative sites resulting from a detailed multi-criteria evaluation. During all phases, high priority will be given to the protection of the environment with minimum probable impact. The main principles taken into account during design work were energy efficiency, reduction of waste generation, and fuel consumption using renewable energy sources of solar energy and wind power, along with maintaining safety and wellbeing of the scientific team. In the process of material selection, maximum durability throughout the lifecycle, and materials suitable for reuse, recycling and recovery are prioritized.

The construction will consist of mostly pre-fabricated modules to reduce the construction workload. The modular structure will also allow for the replacement of individual facilities when needed. TARS includes a main building, an energy center, a treatment center, fuel tanks, wind turbines, solar panels, 2 hangars, and an emergency shelter. During the establishment of the solar panels, factors such as, elimination of snow load, resistance to wind load, liquid discharge of snow and ice, and minimization of the risk of shadowing have been considered. Wind turbines are placed in accordance with the prevailing wind direction in the field. TARS will be elevated above the snow surface, and the facilities will minimize the requirement for snow management in all aspects of operation to reduce maintenance and minimize fuel consumption. The energy requirement will be supplied by renewable energy sources, followed by generators. TARS will be constructed in two stages over two consecutive Antarctic summers. The maximum number of construction personnel will be 130. It is planned that the necessary materials for accommodation, food, and beverages of the personnel will be brought to the project site from the mainland. During construction, personnel and materials will be transported to South America by international sea and air travel, where they will be transferred to Horseshoe Island with a vessel. Construction materials and vehicles will be transported to shore using barges. Direct on-site disposal of untreated wastewater will be absolutely prevented; and it will be treated by a package-type biological treatment unit coupled with a mechanical filter and a disinfection unit to achieve advanced treatment. These set of units will also be used under operation phase as the selected batch system is flexible and works efficiently under varying flowrates.

The station is designed for optimal use by 24 (max. 50) people. The operation of TARS is planned for ~25 years at its minimum. Following the seasonal operation for two consecutive Antarctic summers, TARS is planned to be operated year-round. The TARS team will consist of, but is not limited to, researchers, electricians, medical personnel, and other managerial personnel. It will also accommodate national and international researchers working in various fields. Apart from routine needs, the materials that will be required during the operation phase will be transported from the nearest mainland by sea or air travel taking into account the size, weight, and content of the material. The transportation of materials including potable water will reach to Lystad Bay by vessel to be further transferred to TARS by RIBs and barges. The lakes located on Horseshoe Island will be used as primary sources of domestic water apart from drinking. Water consumption will be diminished as the flushing water in toilets will be recovered from treated effluent. The package-type biological treatment system installed and operated during construction will still be in use at this stage with comparatively lower wastewater flowrates. The excess effluent will be discharged to the sea from the surface layer. Sorting at source will be accomplished for the recyclable waste and their volume will be reduced by a compactor. Food waste will be incinerated together with treatment sludge. Combustion slag/ash will be collected separately and will be removed from the continent along with other separated solid wastes. As such, hazardous wastes originating from the laboratories and/or other mechanical equipment will be collected and stored separately. They will similarly be removed from TARS by vessels.

The nearest human-made structure is Base Y which is approximately 4 km apart from the project site; however, they are located on different bays along the coastline. They are not in sight of one another due to the mountainous topography of the island in-between. One of the most important structures on the island is the Shoesmith Glacier, which extends widely in the east-west direction. Gaul Cove is located in the east, whereas the Lystad Bay is at the west. There are freshwater lakes between Lystad Bay and Gaul Cove. Flora and fauna are at minimum number and diversity on the island indicating the fact that it is not a vitality spot.

Potential environmental impacts caused by the construction and operation of TARS have been determined as air emissions, waste and wastewater, noise, fuel and oil leakage, and effects to flora and fauna. Mitigation measures will be applied to minimize the probable impacts. All vessels to be used for logistics will use Antarctic Diesel. Temporary generators and vehicles used during the construction phase will also be maintained to high standards for reduction of air emissions. Construction machinery will be selected based on their fuel efficiency and environmental performance. Proper equipment and logistics planning will enable efficient use of vehicles for all the activities. Staff will be trained on risk management, emergency planning, and on fire and leakage protection.

A monitoring program will be applied to put forth the probable effects of the running activity on the environment cradle-to-grave. Regular monitoring of the assigned mitigation measures will be followed during both construction and operation. Comprehensive information on the operation of the station will also be recorded for monitoring purposes.

Since the 1960s, young and keen scientists from Turkey have been active in scientific studies. The activities of Turkey in Antarctica have gained its own pace recently. Organizing expeditions to Antarctica regularly starting from 2017, Turkey has obeyed and will continue to obey to the current rules and procedures defined within Antarctic Treaty System (ATS).

The Republic of Turkey, a non-consultative party to the Antarctic Treaty since 1996, by intending to establish this research station, would like to take part in the polar studies and volunteers to share and add value to the gained knowledge with the other participating countries. Throughout the operation of TARS, Turkey will fully comply with the current Protocol on Environmental Protection to the Treaty & its Annexes.

Present Draft CEE Report prepared puts forth that running this station will pose an impact on the environment; however, the probable impacts will be minimized by implementing the proposed protection measures. Thus, the establishment of TARS is highly recommended as its advantages for the world, overcome its disadvantages.

1 INTRODUCTION

1.1 History of Turkish Antarctic Research

Turkish scientists' works in Antarctica within the framework of multilateral cooperation have started in the mid-1960s, and scientific research is continuing accordingly. There are three locations named after three Turkish scientists in Antarctica; Atok Karaali, Umran İnan and Serap Tilav who conducted their studies under international collaborations. Turkey became a Party to the Antarctic Treaty in 1996.

With the Polar Research Centre (PolReC) founded in 2015 under the umbrella of Istanbul Technical University (ITU), the first public unit in Turkey was established regarding polar sciences. Before PolReC, Turkish researchers took part in expeditions of other countries, such as France/Italy, Germany, Japan, Ukraine, the United Kingdom (UK), and the United States of America (USA), in order to conduct scientific studies. Upon the application of the Scientific and Technological Research Council of Turkey (TÜBİTAK) in 2016, Turkey has become an associate member of the Scientific Committee on Antarctic Research (SCAR). In 2017, the scientific studies of Turkey in Antarctica were taken under the auspices of the Presidency of the Republic of Turkey (TR) with the goal of sustainability. The first Turkish Antarctic Expedition (TAE-I) was conducted in the same year.

In 2017, with the support of 44 institutions and more than 100 scientists, a 5-year National Polar Science Program (NPSP 2018-2022) was put forth to identify the mission, vision, objectives and future research priorities of Turkey in polar studies. In the same year, Turkey became a party to the Protocol on Environmental Protection to the Antarctic Treaty and ratified all of its annexes. Turkey's application for becoming an observer member had been granted in 2018 at the Council of Managers of National Antarctic Program (COMNAP) meeting.

The second and the third TAEs were conducted in 2018 (TAE-II) and in 2019 (TAE-III) under the coordination of PolReC. In TAE-III (Figure 1-1), which included scientists from Bulgaria, Chile, Czechia, Germany, and New Zealand, a Temporary Scientific Research Camp of Turkey, had been deployed at Horseshoe Island located in Marguerite Bay on the west coast of the Antarctic Peninsula. This temporary camp, as shown in Figure 1-2, was made up of three modules to serve between 2018-2022 as its Initial Environmental Evaluation (IEE) had been approved by the Ministry of Environment and Urbanization (MoEU), and the Ministry of Industry and Technology (MoIT). During the expedition, an automatic weather station was established in the area giving way to continuous measuring, along with the initiation of topographic and bathymetric mapping in-and-around the island. The topography of the area was recorded via a LIDAR sensor installed on an unmanned aerial vehicle (UAV).

Figure 1-1. TAE-III Team with Crew of MV Betanzos

Figure 1-2. Turkish Antarctic Scientific Research Camp (2018-2022)

In December 2019, Polar Research Institute (PRI) was established within TÜBİTAK Marmara Research Centre (MAM). The Institute, as the national operator, aims to provide nation-wide support for the scientific studies together with research and development (R&D) activities regarding the polar regions, to maintain international collaboration in polar sciences, to accomplish multilateral polar expeditions, to plan and coordinate logistics to and at the polar regions, and to raise awareness at the national scale.

In 2020, the fourth Antarctic expedition (TAE-IV) was held under the coordination of TÜBİTAK MAM PRI with 24 participants from 16 local organizations and 2 researchers from Belarus and Bulgaria. During TAE-IV, 3 Global Navigation Satellite System (GNSS) stations were installed, bathymetric studies were conducted around Horseshoe Island, and 11 scientific projects were completed. Within the context of the four TAEs, 49 projects have successfully been carried out with over 50 international publications. TAE-V also has been planned to take place in 2021.

Under the coordination of MoEU, the Protocol on Environmental Protection to the Antarctic Treaty was adapted to the domestic legislation that entered into force in 2020 under the title of "Regulation on the Implementation of the Protocol on Environmental Protection to the Antarctic Treaty" (RIPEPAT).

1.2 Planned Scientific & Research Activities

The NPSP was prepared in order to ensure the sustainability of scientific activities on polar regions and declared under the coordination of the MoIT in 2017 with the contribution of researchers from numerous universities and governmental institutions, which had so far carried out various scientific projects on the polar regions.

The NPSP remains in implementation for five years between 2018-2022. In order to achieve the goals of the program, national and international workshops are being organized, Turkey's membership to international bodies and organizations are being ensured, polar research activities are facilitated, increasing qualified human resources are supported, funds of Antarctica projects and operation of the proposed research station is secured, public awareness is effectively raised, and multilateral cooperation among the Parties is also successfully strengthened, and will be followed up by the duration of the NPSP. As of today, most of the program objectives have been achieved.

The program prioritizes four scientific disciplines namely; physical sciences, geosciences, life sciences, social sciences and humanities. These are also in line with the working groups of the SCAR.

Physical sciences theme includes research topics, which are directly related to "global climate change" based on atmospheric and glaciological observations. The following topics are studied within the scope of physical sciences:

- Applied Physical Sciences and Innovative Technologies
- Atmosphere and Climate Research
- Modelling Studies
- Kinematics and other Monitoring Systems
- Sea Ice Processes
- Astronomy and Astrophysics

Antarctica holds information that could provide valuable insights on the history of the Earth. Geodynamic processes, geodesic research and geological studies are covered under the theme of Geosciences that include the following topics:

- Geodetic Studies
- Geomorphology
- Volcanology
- Magmatism and Geodynamics
- Marine/Lake Geology and Geophysics
- Glacial Studies
- Structural Geology
- Geodynamic Modelling
- Seismology

Despite the recent developments on energy, fisheries and biodiversity research on polar regions, there are knowledge gaps to be filled in terms of the marine living resources, and ecology in the Southern Ocean surrounding Antarctica. The unprecedented eco-geographical and climatological nature of Antarctica has enabled the adaptation and survival of the extreme organisms in the region, which have relatively low ecological tolerance compared to sub-tropical sea species. Research carried out in these areas are investigated under Life Sciences as prioritized below:

- Polar Biodiversity
- Biochemistry and Biochemical Cycles
- Biotechnology
- Ecology and Pollution Studies
- Medicine

In the scope of Social Sciences and Humanities, the following subjects are studied:

- Polar Law
- Education & Outreach
- International Polar Affairs
- Economics
- Polar Geopolitics
- Polar Tourism

Although Turkey has quite a number of qualified human resources who are scientifically interested in polar regions, the lack of infrastructure in these regions, and the limited duration of the expeditions restricted the realization of the activities in the field. Consequently, many projects of high scientific quality and novelty could not be carried out in the field or could only be conducted under limited conditions. In addition, long-term monitoring studies in the atmosphere, lithosphere, hydrosphere, and cryosphere in the polar regions require stationary equipment. In these monitoring studies, the presence of a research station in the region is of high importance to make the research sustainable by efforts like providing measurement data, supplying power to equipment, and performing routine maintenance/repair operations.

The next NPSP will be finalized and published in 2022 for the period of 2023-2027 after consulting the stakeholders. The next program, currently in draft status, will aim;

- to reveal the climatic conditions in the past in order to understand the climate change in the lithosphere, atmosphere, hydrosphere and cryosphere,
- to conduct studies on atmosphere, atmosphere-ocean interactions, sea ice and glacial processes, sea level rise, ocean currents, meteorology and on other related disciplines,
- to conduct research on climate and related systems and to develop future projections for effective climate policies,
- to conduct research based on long-term observations especially in disciplines such as seismology, geodesy, geology, and geography in order to make future projections through collecting past & present data,
- to conduct scientific researches based on measurements, observations and models of parameters such as waves, currents, tides, ocean energy, components, and physical properties of seawater, interactions of sea floor, atmosphere, and ocean & marine ecosystem in the Southern Ocean,
- to encourage studies that will provide a better understanding of the polar oceans, attributing priority to studies on marine resources, protection of such resources and maritime activities in the Southern Ocean,
- to determine the levels and sources of possible pollutants through long-term environmental and ecosystem observations in polar regions,
- to develop projects regarding scientific and technological innovations in the protection of polar regions based on continuous data collection,
- to explore space from the polar regions through astronomical observations and other up-to-date methods,
- to implement projects at polar regions utilizing remote sensing technology and by using satellites,
- to encourage studies on humanities in polar regions, with particular emphasis on physiology and psychology of the temporary inhabitants, isolated life and space studies, management and future of polar regions, polar law and history.

1.3 Purpose of the Turkish Antarctic Research Station (TARS)

Global climate change caused by significantly increasing carbon emissions affects the polar regions. The warming trend revealed by scientific studies in Antarctica causes the ecosystem to shift towards the relatively cooler Southern latitudes. In order to accurately observe trends in both biotic and abiotic components of the lithosphere, cryosphere, atmosphere and hydrosphere, the studies in the region should be long-term based.

Within the scope of the four TAEs, the regions to be explored in Antarctica have been reached by chartered ships; therefore, the scientific studies were conducted in regions where marine transportation was possible under favorable weather and sea conditions that only covered the summer season. In addition, the necessity to perform the projects within a limited time period affected the scientific quality of the studies conducted in the region. Access to the region was not possible in winter due to sea ice, and related observations could not be made during the breeding period of the polar species for the same reason. These led to problems in obtaining data needed in scientific studies on the Antarctic ecosystem, and caused disruptions in atmosphere and glacier projects requiring measurements with stationary equipment.

The long periods of darkness in Antarctica allow uninterrupted long-term space observations. In addition, sensitive detectors of space observation equipment are known to be capable of making more accurate measurements in cold polar conditions. In atmosphere and space observations that require precise measurements, equipment must be deployed steadily. Therefore, expeditions by vessels do not allow such measurements. However, a research station that can serve both in summer and winter seasons would allow long-term observations in different scientific disciplines, as well as to accomplish the objectives of NPSPs.

It is known that the number of observation stations providing scientific data to international measurement networks is quite limited on South of the Antarctic Circle, Horseshoe Island and its surroundings. The scientific research infrastructure to be established as part of the planned station will be integrated into international measurement networks, will widen the scope of these networks by providing data in meteorology, seismology, GNSS and atmospheric observation, and will help the formation of a better understanding of the world dynamics.

Turkey has high-resolution optical imaging capacity sun-synchronous orbital satellites named GÖKTÜRK I, II and RASAT. It will be possible to achieve data collection at higher frequencies for both current and future satellites, and these satellites can be used in remote sensing studies upon the establishment of the research station, which is planned to include a ground station for satellites in the far future.

Polar expeditions by marine vessels pose various disadvantages in terms of cost, safety, and the environment. The cost of vessels, used not only for meeting logistic needs but also for accommodation during the expeditions, is quite high compared to the amount spent for scientific research. With the establishment of the research station, vessel charter periods will be shortened and logistic costs will be reduced significantly allowing more budget to be allocated for research. In addition, due to the low number of vessels that can operate in the region, the availability of the vessels takes priority over scientific preferences in the expeditions lasting more than a month. This complicates the planning of the expedition and may reduce the efficacy of the scientific studies.

Marine vessels have impacts not only in terms of costs; but also in terms of environmental pollution. Every year, for transporting an expedition team of approximately 25 people by a vessel, a similar number of crew on-board is required. During the expeditions lasting about two months, the vessel, where people also accommodated, is deployed in the research area. In order to avoid icebergs and other navigational risks, the main engine of the vessel is always kept running. Considering both the need for accommodating more people in the region for a long-term and the high fuel consumption, resulting in high carbon emissions of vessels consequently, it is clear that the establishment of a research station in the region will significantly mitigate these impacts induced by vessels. It is predicted that the research station to be established will reduce the human footprint by decreasing the number of on-board crew and the vessel duration in the region in a cumulative manner.

The Temporary Scientific Research Camp established in Horseshoe Island during the TAE-III in 2019 has the capacity to accommodate up to 8 researchers overnight with minimum amenities. For this reason, other researchers were transported from the vessel to the work site daily by rigid inflatable boats (RIBs) and/or helicopters only when weather and sea conditions allowed. These operations causing an increase in carbon emissions reduce the working hours in the field and also pose a risk for the safety of researchers.

The temporary camp consisted of three modules with a 20’ container size. These modules, which are effectively used during the expeditions, serve as an office that can also be used as a dorm for 8 people, a warehouse containing field equipment and spare parts, and a kitchen for researchers to eat and rest, which can also be used as a laboratory in case needed. Bad weather conditions experienced during field studies of TAEs with approximately 25 researchers force them to stay in modules which concerns the researchers regarding their wellbeing and comfort. The motivation and psychological state of the researchers, who work in teams in such isolated regions, are of great importance in terms of work efficiency and safety. Establishment of a research station in Antarctica will provide scientists a more productive environment by offering the needed comfort and safety amenities.

Antarctic expeditions by chartered ships host limited scientific research infrastructure due to logistic reasons. This bound in infrastructure hinders the implementation of many projects found above the scientific thresholds in national project calls. Laboratories and other research facilities to be included in a research station will extend the duration of studies on polar sciences, and bring them to higher levels both in quality and quantity. Currently, samples collected during the expeditions are being transferred to laboratories in Turkey by providing sample-specific conditions without any pre-processing. By means of establishing the laboratories, the sizes of the required samples will be reduced with pre-processes. This will provide a financial advantage through a decrease in direct logistic costs.

Since all the research stations on the western coast of the Antarctic Peninsula are on the access route to Horseshoe Island, it will be possible to offer cost-effective solutions and to reduce carbon footprint in the region by means of joint logistic activities. Moreover, as in all research stations in Antarctica, the infrastructure to be established on Horseshoe Island will be at the service of not only Turkish scientists; but also for all requesting international partners.

Among the alternative sites (Section 3.2), Horseshoe Island has been determined as the region where different scientific disciplines intersect as a study area in Antarctica in the survey studies conducted with scientists. According to the scientific studies in the last decade, the average air and sea temperature increase due to the global climate change, a southward shift is estimated for the polar ecosystem (Péron et al., 2012; Hückstädt et al., 2020; Veytia et al., 2020). This indicates that southern latitudes will be one of the scientific hotspots in polar research in the future. Therefore, the selected region offers an advantage in this perspective. The presence of areas with high biodiversity, fjords, channels and Lagotellerie Island as an Antarctic Specially Protected Area (ASPA) in the surrounding area makes the region favorable for scientific research, while the limited biodiversity and population on the island makes it a suitable region to establish a station when environmental impacts are considered. In addition, the presence of the San Martín Base of Argentina, the Lt. Luis Carvajal Station of Chile, and the Rothera Station of the United Kingdom in the region, will provide opportunities for multilateral assistance, good opportunity for networking, and response in case of emergencies. These three research stations can be accessed from Horseshoe Island in an appropriate time by sea.

In terms of scientific collaboration, international researchers are hosted in Turkish expeditions. In the annual project calls for these expeditions, Turkish scientists have an intense demand for participation for conducting field research in Antarctica. In the absence of a research station, this demand will be met in a limited way. Therefore, it is of great importance for Turkey to gain this experience. With the research station to be established in the continent dedicated to peace and science, the gained knowledge will be shared to the service of humanity with special focus on global climate change.

1.4 Preparation and Submission of CEE

The Protocol on Environmental Protection to the Antarctic Treaty and all of its Annexes were ratified by Turkey in 2017. The RIPEPAT entered into force as the domestic legislation in 2020. The present Draft Comprehensive Environmental Evaluation (CEE) Report was prepared in accordance with the requirements specified in Article 8 and Annex I of the Protocol on Environmental Protection to the Antarctic Treaty, Guidelines for Environmental Impact Assessment (EIA) in Antarctica, as well as the related domestic Regulation on the Implementation of the Protocol on Environmental Protection to the Antarctic Treaty.

During the TAEs, Turkey has been conducting site research in order to perform long-term, high scientific quality and broader spectrum projects. Among the numerous examined sites in the West Antarctic Peninsula, Horseshoe Island and Marguerite Bay were the potential sites for the establishment of a scientific research station.

The Draft CEE Report is prepared by a group of experts from various disciplines (environmental sciences, civil engineering, architecture, geosciences, oceanography, maritime engineering, naval engineering, mechanical engineering) from prominent universities and governmental institutions of Turkey. The draft report is submitted to the MoEU for further evaluation within the context of the domestic legislation. After the review of the MoEU, the Draft CEE Report is submitted to the Committee for Environmental Protection (CEP) for review more than 120 days before Antarctic Treaty Consultative Meeting (ATCM) XLIII (2021). The Final CEE Report will be prepared after revising the document according to remarks and comments of parties, and will be presented at least 60 days prior to the start of the proposed activities.

1.5 National and International Legislations

Any Antarctic activity carried out by Turkey will be in accordance with the Protocol on Environmental Protection to the Antarctic Treaty. In addition, RIPEPAT, as the domestic regulation published by the MoEU regarding environmental protection Antarctica, involves the following enforcements:

- Any project planned in the Antarctic Treaty Area will be considered as an activity, and a preliminary evaluation is required by the MoEU after the impacts are estimated, the process may go on with an IEE or a CEE.
- The operational activities of the planned research station shall comply with the provisions of the RIPEPAT.
- The MoEU may suspend or cancel the activity if the activities violate the provisions of RIPEPAT.
- Key environmental indicators shall be appropriately monitored to assess and verify the impact of the activity subject to the Environmental Evaluation Report.

- If the monitoring studies reveals that the activity does not comply with the principles specified in the Environmental Evaluation Report, the negative effects shall be minimized.

Air, water and noise quality limits during the construction and operation of the research station were defined based on the related domestic regulations which are in compliance with the European Union (EU) acquis. Guidelines for Environmental Impact Assessment (EIA) in Antarctica (2016) document was considered during the preparation of Draft CEE Report. All maritime operations will fully comply with the provisions of International Convention for the Prevention of Pollution from Ships (MARPOL 73/78), Guidelines for Ships Operating in Arctic and Antarctic Ice-Covered Waters (2004) and International Code for Ships Operating in Polar Waters (IMO Polar Code, 2017). In addition to these, the recommendations in the following guidelines, manuals, handbooks, and other official documents were consulted during the draft CEE preparation:

- COMNAP-SCAR Antarctic Environmental Monitoring Handbook (2000)
- COMNAP's Framework and Guidelines for Emergency Response and Contingency Planning in Antarctica (2004)
- COMNAP Practical Guidelines for Developing and Designing Environmental Monitoring Programs in Antarctica (2005)
- COMNAP Best Practice for Energy Management - Guidance and Recommendations (2007a)
- COMNAP Waste Management in Antarctica (2007b)
- COMNAP Fuel Manual (2008)
- CEP Non-Native Species Manual (2019)
- COMNAP Symposium on Antarctic Station Modernization: Future-Proofing Infrastructure to Support Research and to Reduce Environmental Impact (2020)
- COMNAP COVID-19 Outbreak Prevention & Management Guidelines (2020)

1.6 Project Management

As the national polar operator, TÜBİTAK MAM PRI, will be responsible for the operation and maintenance (O&M) of the research station. The design and planning of TARS have been coordinated by a consortium led by PRI. The construction is planned to be completed in two consecutive Antarctic summers. Therefore, the research station is estimated to be fully operational in about two years after the Final CEE Report. The station is designed to operate year-round, however, it is planned to be operated in the summer period for the first two years of its lifetime. These first two years will be devoted to gain operational experience by running the research station as well as testing the infrastructure and equipment.

2 DESCRIPTION OF THE PROPOSED ACTIVITY

This Draft CEE Report comprises of the construction and operation of TARS, a station of scientific research & continuous monitoring. In the construction, O&M and dismantling stages of TARS, top priority will be given to the protection of the environment with minimum anthropogenic impact.

The potential environmental impacts of TARS have been taken into account at the design phase. The main principles of design are preservation of the environment, energy efficiency, and reduction in waste and fuel, along with maintaining safety and wellbeing of the personnel. All necessary health precautions will be taken as recommended by the World Health Organization (WHO), including vaccination of personnel against any existing (COVID-19) and/or probable pandemic situations. During both the construction and operation of TARS, similar to health precautions, safety measures will also be equally taken into consideration and applied.

Turkish Antarctic Research Station (TARS) at Horseshoe Island has been designed and will be implemented in accordance with the Antarctic Treaty System (ATS), Protocol on Environmental Protection to the Antarctic Treaty & its Annexes. TARS is designed to allow researchers to work from all scientific disciplines. It has been planned to have the main qualities as follows:

- Energy-Efficient
- Locally Compatible
- Economic
- Modular

2.1 Regional Overview

TARS, at latitude 67.829676° South and longitude 67.237757° West (coordinates: 67°49'46.83 "S 67°14'15.92" W), would be located in the Antarctic peninsula, within the Marguerite Bay, on the midwest coast of Horseshoe Island. The distance between the island and the nearest mainland, Tierra Del Fuego (archipelago in the south of South America separated from the mainland by the Magellan Strait), is approximately 1,500 km. It is about

20 km between Antarctica and Horseshoe island. In addition, there is a distance of approximately 35 km between the selected location and the San Martín Base of the Argentina Republic, approximately 70 km between the Republic of Chile's Carvajal Base, and approximately 50 km between the Rothera Station of the UK on Adelaide Island. To the north of Horseshoe Island is Pourquoi Pas Island, Bourgeois Fjords in the east, Camp Point Cape in the south, Lagotellerie Island, which is an important region for seabirds and also a protected area (ASPA-115) in the West at approximately 9 km distance (Figure 2-1).

Horseshoe Island was selected as the project site for the TARS resulting from multi-criteria evaluation. Site selection criteria and process is given in Section 3.2.

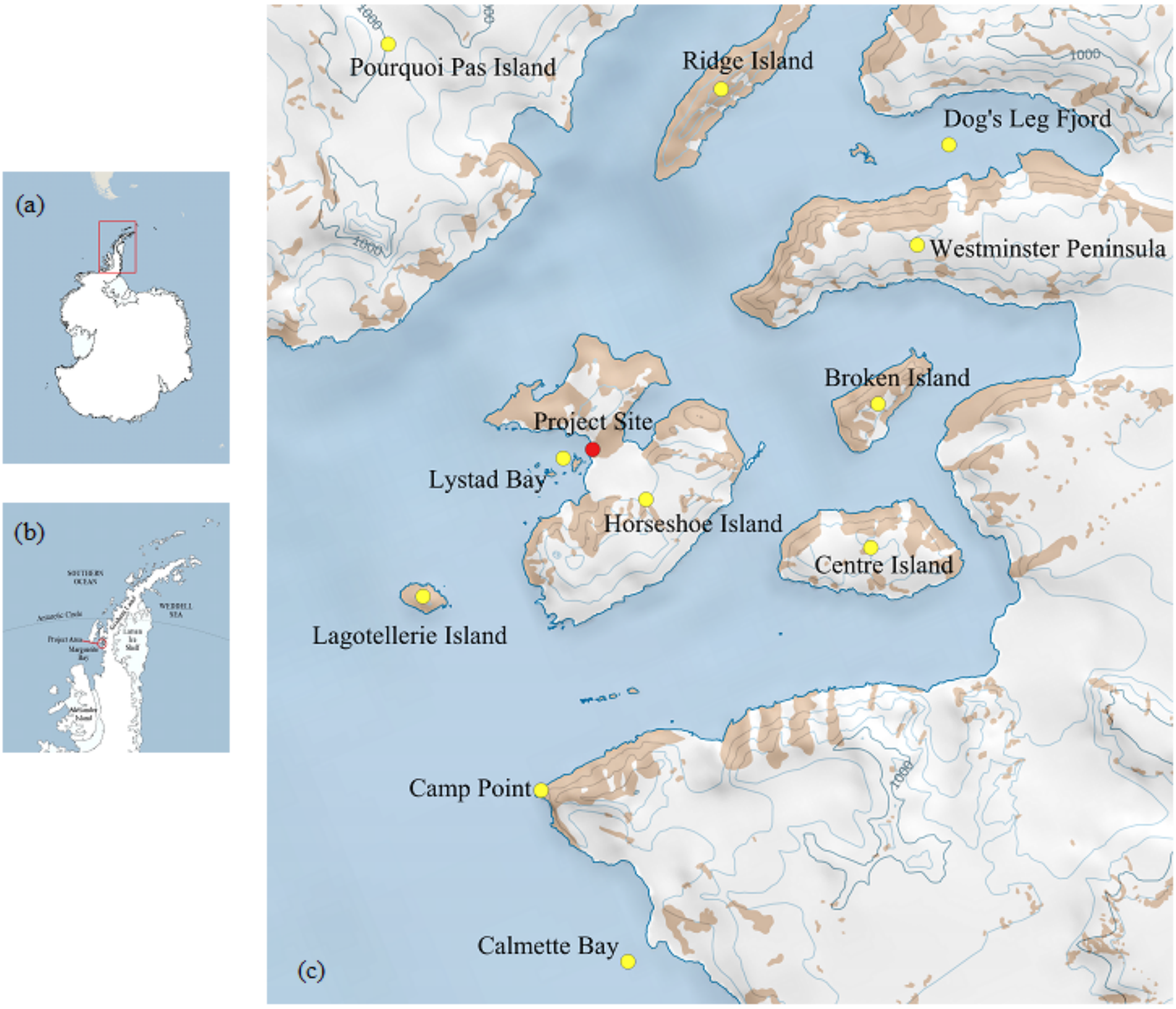

Figure 2-1. Regional overview of TARS, (a) red box shows Antarctic Peninsula, (b) red box represents the Marguerite Bay (c) red dot indicates the project site

2.2 General Specifications

The general characteristics of the planned TARS are listed as below:

- Design lifetime: Minimum 25 years
- Duration type: Year-round (full-year accommodation and monitoring capacity)
- The environmental impacts of the research station throughout all phases of its lifetime will be kept at minimum.
- The construction, operation and, when necessary, dismantling will be conducted in accordance to the requirements of the Protocol on Environmental Protection to the Antarctic Treaty.
- TARS is designed for maximum use by 50 people for work & accommodation.
- The total area of the main structures of TARS is ~4,000 m^2 (excluding solar panels, wind turbines, and fuel tanks).
- TARS is designed to allow room for upgrading of its capabilities to incorporate updated technological and environmental advances.
- The system design of TARS follows the principles of environmental protection, good health & safety, minimization of materials, and technologies of sustainable and efficient renewable energy.
- TARS will be staffed with mechanics, electricians, medical personnel, and other managerial team for year-round operation. It will also accommodate seasonal researchers in various fields such as, atmospheric sciences, geophysics, oceanography, biology, ecology, etc.
- The facilities will use renewable energy, such as wind and solar power for minimizing the use of fossil fuels. The remaining energy will be supplied by generators with a back-up generator for emergency needs.
- TARS will be equipped with instruments and laboratories to meet the scientific needs.
- The construction of TARS will consist of mostly pre-fabricated building modules made in Turkey to reduce the field workload of construction.
- TARS is designed for low maintenance & repair, and easy control & monitoring.
- The modular nature of TARS design will allow for the replacement of individual facilities without requiring the replacement of the station as a whole.

- TARS will be elevated above the snow surface, and the facilities will minimize the requirement for snow management in all aspects of the research station's operation in order to reduce maintenance and minimize fuel consumption.
- A comprehensive waste management program including minimizing of material usage, maximizing recycling & recovery will be incorporated. All wastewaters will be treated.

The details of specifications regarding TARS are provided in Section 2.4 dedicated for the construction period, and in Section 2.5 for the operation period. Closure and dismantling, presumably taking place circa 2050, is also briefly documented in Section 5.3.

2.3 Design of TARS

The main building is positioned where the land is most compatible with the topography. The living areas of the building have been designed in a way to make maximum use of the daylight of the region in summer months in terms of layout and interior space planning. During the winter period, one floor of the main building used for accommodation purposes may be closed for minimizing the energy consumption. COMNAP Symposium (2020) on Antarctic Station Modernization were fully considered at this stage. Lessons-learnt from the experiences of other countries provided guidance during the design phase. The general layout of the planned TARS is provided in Figure 2-2.

Engineering Design

Technical units are excluded from the main building and are planned as separate structures within the project site. This is a design decision taken in terms of improving both the functioning and security of the main building. Since only the air conditioning units are directly related to (and hence should be close to) the main building, they are partially planned as a mechanical area at the bottom floor. The emergency shelter unit is located within proximity of the landing site. Technical structures positioned in the general layout (Figure 2-2) are listed as follows; Main Building, Energy Centre, Treatment Centre, Fuel Tanks, Wind Turbines, Solar Panels, Hangar 1, Hangar 2, and Emergency Shelter. The main structures are given in Table 2-1.

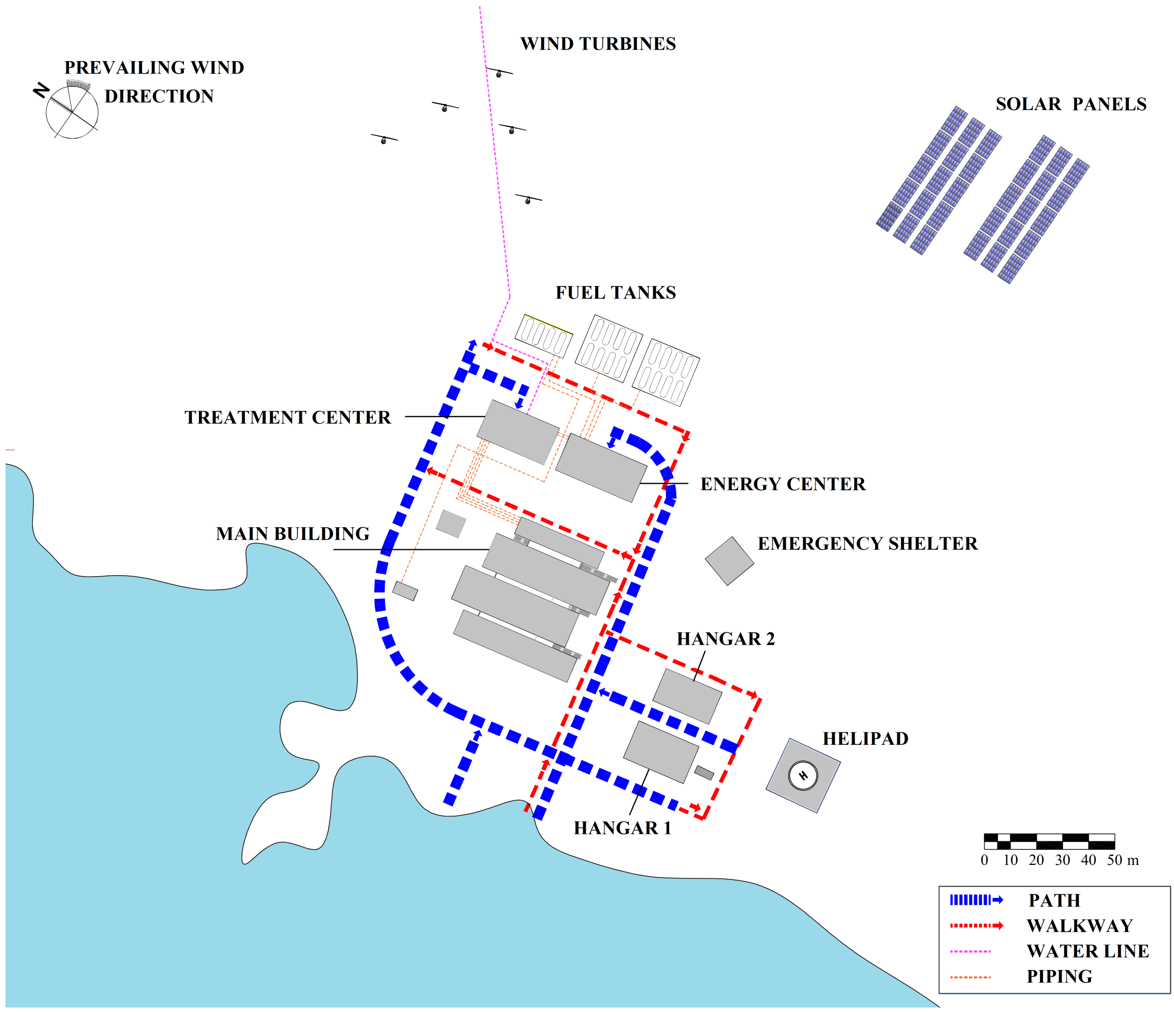

Figure 2-2. General layout of TARS

Table 2-1. Main structures and auxiliary units at TARS

Structures and Unit	Area (m^2)
Main Structures	
Main Building	2,000
Treatment Centre	500
Energy Centre	520
Emergency Shelter	180
Hangar 1	390
Hangar 2	320
Total	**3,910**
Auxiliary Units	
Fuel Tanks	1200
Solar Panels	1650
Helipad	466

In the project site, the landing site has been determined by considering the most suitable coastline for transportation of equipment, as well as the personnel. In general, the landing site covers a helipad for extraordinary air transport requirements, hangars to store the RIB and other kinds of equipment to be used in both research and maintenance, and a reserved maneuver area. The main building and the offices within, oversee this field for the personnel to follow the outdoor operation when required. In order to reach the closest Antarctic research stations and to conduct common research activities with Rothera, San Martín, and Carvajal, a RIB will be kept ready for take-off.

In the field, solar photovoltaic panels (PV) are located in areas where the sun can be used most efficiently. In the settlements of solar panels, factors such as, the elimination of snow load, resistance to wind load, liquid discharge of snow and ice melted by the installed resistances, minimization of the risk of shadowing have been considered. The prevailing wind direction is from the east-northeast of the project site. Thus, wind turbines are placed in accordance with the prevailing wind direction in the field. Vertical axis wind turbines will be placed on poles of 20 m at a platform with piles on the ground, as they are less dangerous to birds, perform better during strong winds, have less movable parts. Additionally, the generators of the wind turbines will be located on the ground.

Architectural Design

Antarctica's strong visual features represent large structural ice floes and their refractions. It is natural for buildings to be placed in this geography, which has already been defined in the strongest way by nature, to create harmony with its environment, and to establish a soft yet solid transition from the environmental structure to the building structure. Therefore, ice masses have been accepted as the starting point for the architectural concept design of the main building (Figure 2-3).

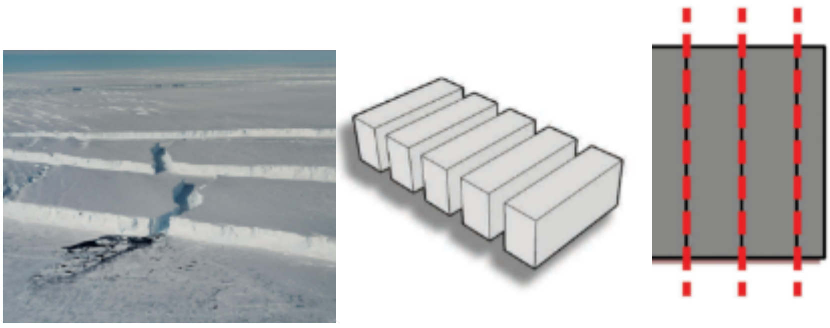

Figure 2-3. Architectural structure / mass fragmentation and separation

The modules of the main building have been designed with respect to ice fragmentation. With the slides designed as connection corridors between each module, transition (filter) areas are created that provide both connection bridges and insulation barriers. These filter areas prevent the interference of different functions in-between the modules and eliminate transitions such as noise, yet preserving the relation among modules and the integrity of the structure. Cold air passage can be prevented for energy saving via closing the block when not in use. Flexible modular design also allows for additional modules with the same design principles to be incorporated into the structure when necessary.

Function-based segregation of the design scheme is shown in Figure 2-4, where 3 zones stand out with respect to main requirements of TARS:

- Zone A: Working Area
- Zone B: Living Area
- Zone C: Sleeping Area

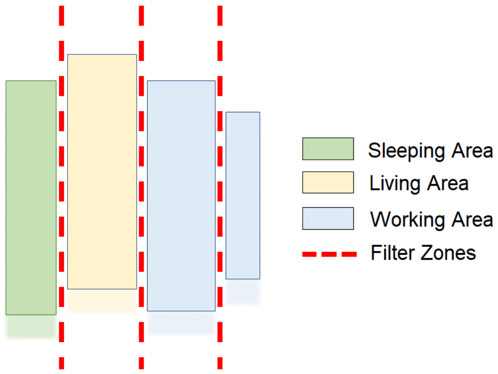

Figure 2-4. Main building design scheme

In the next stage, each module design had been developed regarding the local geographical features. According to local climate data, the structural mass is shaped in an aerodynamic form against possible strong winds. In addition, Computational Fluid Dynamics (CFD) analysis has been conducted for snow accumulation and winds. Thus, the structure has increased endurance to high wind loads with the carrier system with respect to relevant static calculations. In addition, the structure is raised on steel columns against snow accumulation and to provide minimum contact with land. In addition, the structure is insulated on all sides for saving energy. Thus, its environmental impact will be reduced.

As a result of the design, the structural features of TARS are as follows;

- Minimum connection to the ground with precast concrete foundations,

- Placement of steel columns on precast concrete foundations,
- Placement and attachment of steel beams that will carry the structure on the columns,
- Attachment of secondary beams on steel trusses that will carry the floor,
- Creating the main structure bearing the upper floor and roof,
- Installation of secondary beams for the upper floor cover,
- Attaching the roof steel and beams to the structure,
- Covering the front-line protective layer.

All steels and finish coating will be produced modularly in Turkey, allowing rapid assembly on site in Antarctica. The relatively short Antarctic summer construction period will thus be used efficiently.

It is planned to have a total of five laboratories at TARS including; chemistry, biology, geotechnical, pre-process, and cold laboratory. These laboratories are not designed for the final analysis of the collected samples, but to obtain initial findings and to perform pre-operations on samples, and thus, to facilitate logistic processes by reducing the amount of sample to be transported to Turkey.

Finally, the facade views of the main entrance of TARS along with its sky view are shown in Figure 2-5, Figure 2-6, and Figure 2-7 for visualization purposes. TARS main building sketches are given in Figure 2-8.

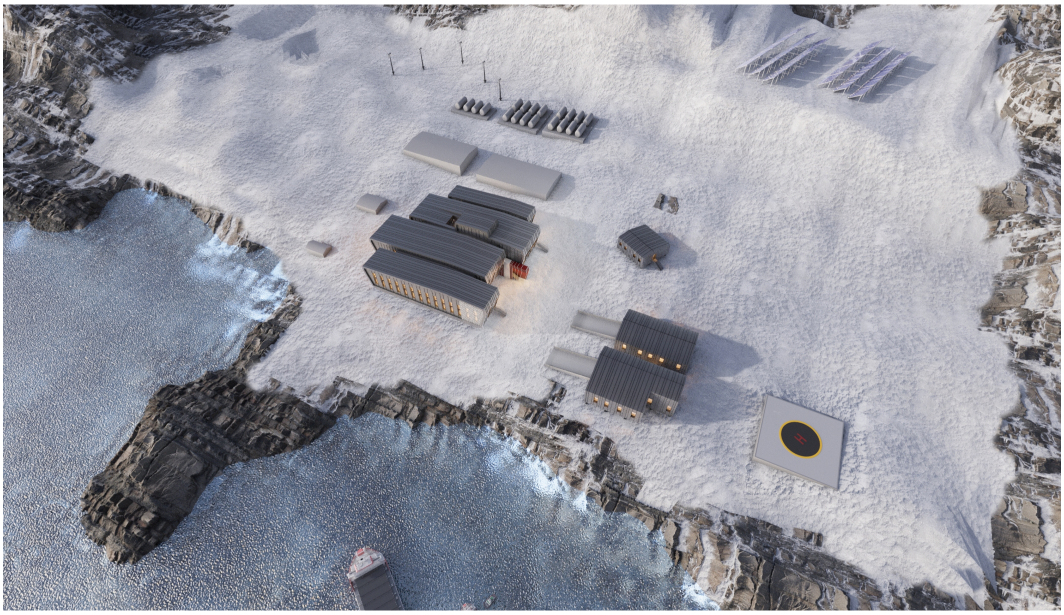

Figure 2-5. Main building top view

Figure 2-6. Main building west facade view

Figure 2-7. Main building north facade view

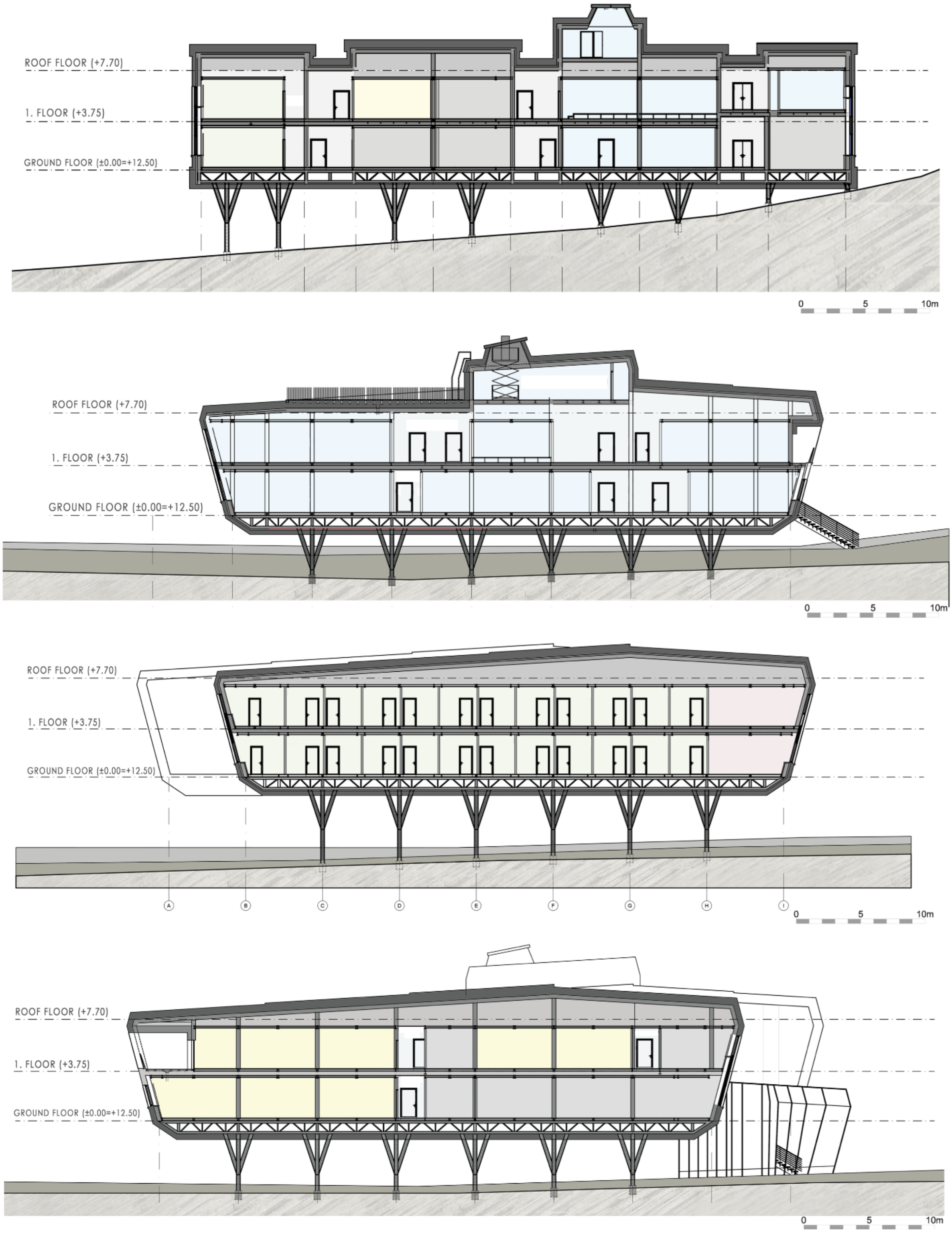

Figure 2-8. Detailed Main Building Sketches

Mechanical Design

In general, the criteria considered in making a choice between system alternatives are as follows:

- Initial investment, and O&M cost
- Ease of O&M and repair
- Architectural effects
- Flexibility and reliability
- Service life of the system
- Environmental impacts
- System performance
- Temperature and humidity
- Indoor air quality
- Noise level
- Energy consumption

Mechanical installation projects have been designed in accordance with nationally and internationally accepted standards given as follows:

- International Code Council (ICC) standards
- National Fire Protection Association (NFPA) standards
- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standards
- RIPEPAT (TR, 2020) standards

It has become important to use energy effectively, to minimize the emissions that adversely affect the global atmosphere, to alleviate the burden of energy costs on the facilities, and to protect the environment through minimum and efficient use of the energy resources. The following systems will be used in the project for achieving sustainability and energy efficiency:

- Solar and Wind Energy System
- Air Handling Unit (AHU) with Hygroscopic Heat Recovery
- Variable Flow and Pressure Systems
- Combined Heat and Power (CHP) System (Co-Generation System)
- Wastewater Treatment System

Indoor life quality has been optimized through air quality, thermal regime, acoustic and visual features, and minimization of noise in order to provide a comfortable physiological and psychological wellbeing for people.

Outdoor Design Conditions

During TAE-III, a meteorological observation station was established in 2019 at Horseshoe Island. However, 1~2 seasons of climate data can be limited in weather-adaptive design. As stated in the 2017 ASHRAE Handbook - Fundamentals Chapter 14, the observation time to be used in the calculation of outdoor design criteria is 25 years in most cases (ASHREA, 2017). This time range allows for deriving design conditions from the longest possible observation period, and to capture land use or climate change trends over the past two decades covering the possibility of some missing data in-between. The actual number of years used in calculations for a particular station can be as short as 8 years, depending on the minimal amount of missing data.

The meteorological data of the UK Rothera Station, located approximately 50 km from Horseshoe Island, were collected over a period of 10 years. The lowest, highest and average temperatures are; -28.9 °C, 5.2 °C, and 3.9 °C, respectively, for the 10-year period of June 2010 to July 2019 (Rothera, 2020).

The data of the San Martín Meteorological Station, approximately 35 km bird flight from the island, has been published by the ASHRAE (2020) as shown in Annex I. Accordingly, the lowest temperature value recorded is -33.3 °C corresponding to a 4.4 °C lower value than the Rothera Station. As Rothera is farther north of the San Martín Base, slight temperature variations are expected. Considering the macro-climatic and the extreme conditions of Antarctica, both datasets were evaluated for the outdoor design criteria of TARS.

Each building is structured according to local geographical features. Main building has an aerodynamic form against strong winds, and is elevated for diminishing the accumulation of snow and minimizing the interaction with the environment. In addition, drains will be established at the roof of the main building at certain points where the tilt is relatively low.

In conclusion TARS is; ecological, energy efficient, economical, effective, useful, suitable for local natural and physical conditions, modular design to enable easy & quick to installation and removal. It is also important to state that TARS will be in alignment with the panoramic view through its adaptive architectural design.

2.4 Construction of the Research Station

All construction activities will be carried out in compliance with the ATS, Protocol on Environmental Protection to the Antarctic Treaty & its Annexes, and RIPEPAT. The building materials are selected with respect to environmental and safety parameters. In the process of material selection, the following parameters are prioritized:

- maximum durability throughout the lifecycle of TARS
- materials suitable for reuse, recycling, and recovery

No environmentally harmful substances will be utilized as specified in Annex III of the Protocol on Environmental Protection to the Antarctic Treaty. TARS has a light-weight construction that will facilitate relatively easy transport & construction.

2.4.1 Time Schedule and Duration

TARS will be constructed in two stages over two consecutive Antarctic summers as given in Table 2-2. The construction is planned to last 5 months maximum in the first year, and 4 months in the following year.

Table 2-2. Construction timetable of TARS

Construction Stages	Year 1												Year 2			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
Construction Works																
Mechanical Works																
Electrical Works																
Automation System																

2.4.2 Personnel

The minimum number of construction personnel and operators to reside at the project site is 85 corresponding to the start of construction, while the maximum number reaches to 130 people through the finalization of TARS. It is planned that the necessary materials for sheltering, food, and beverage of the personnel will be brought to the project site from mainland.

2.4.3 Transport and Logistics

TARS has been designed that all volumes will be manufactured in the factory as modular type, including fine-works and electro-mechanical installations. All tests of the finished modules will be completed in the factory. Completed modules will be stored in a form suitable for transportation, taking the necessary protection measures. Pre-manufacturing and modular production will provide advantages as ease of transportation, minimizing environmental effects, and keeping construction time short. 240 units of 20’ containers for construction materials, together with 180 standard size modules (2.44 m x 6.06 m) will be utilized for transport overall.

Personnel and materials will be transported to South America from Turkey by international sea and air travel, where they will be transferred to Horseshoe Island by vessel. Possible transportation routes to Horseshoe Island are summarized in Figure 2-9.

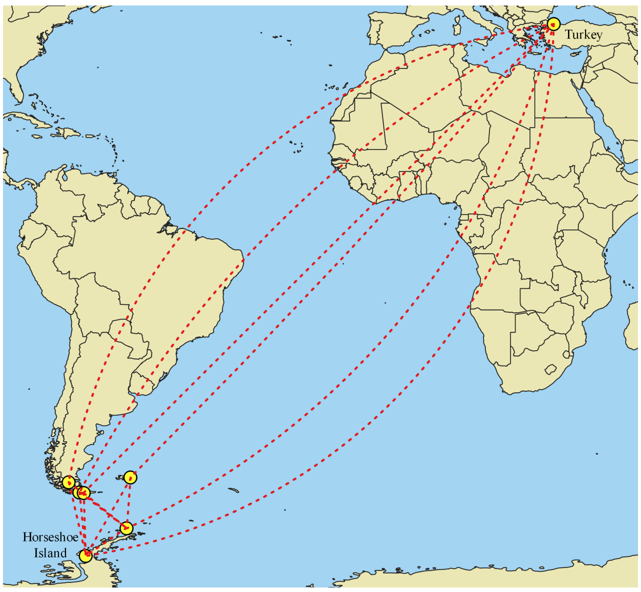

Figure 2-9. Possible transportation routes to Horseshoe Island

The west coast of Horseshoe Island is a natural port, regarded as an anchorage zone in global sea maps. The region provides suitable areas for all kinds of marine vessels to anchor due to its bathymetric and bottom structure, depending on suitable weather conditions. During TAE visits to the site, it was determined that high maneuverable vessels could safely anchor at a distance of up to 200 m to the coastline, within the framework of hydrographic measurements and local conditions at Lystad Bay. There exists a 20 m coastline on the shore that allows boats to dock, where a distance of 10 m from the coastal line is rocky. Therefore, the construction materials and vehicles will be transported from vessel to land via barges and RIBs.

In the first season, all materials and equipment will be loaded on the vessel, along with the parts planned to be built in the first year. Barges are planned to be used for transport from the vessel to the shore. First of all, machines and containers to be used for during construction will be unloaded at the field, and a construction camp will be established. This camp will be assembled to facilitate the construction activities, and it will be removed at the end. Until the construction camp is established, the workers will be accommodated on-board and will be disembarked daily. The already existing Turkish Scientific Research Camp modules (see Figure 1-2) will be integrated to the TARS construction camp. Simultaneously, generators to be used during construction, along with the systems, such as water tank(s), waste container(s) and wastewater storage tank(s), package-type wastewater treatment unit will be brought in order to make the construction site to be ready for the accommodation of workers.

In the first season of construction, all ground works; such as levelling and foundation works will be completed. Foundation works will be followed by steel construction, and the placement of the main building modules via cranes. Sections of the main building are planned to be completed, including the facade. Meanwhile, the foundation, infrastructure, and floor work of the mechanical-electrical technical parts (such as, generator, heating) will be installed.

In the second year, the site will be equipped with all the materials of the remaining products. When all construction works are completed, the existing construction camp will be dismantled and loaded on the vessel, along with the construction personnel, to be taken back to mainland. Utmost care will be given to environmental protection during this phase.

2.4.4 Energy Management

The energy management design has been based on COMNAP's Best Practices for Energy Management Guidance and Recommendations that highlights the importance of energy management on research stations, at the field and on vessels according to the energy management policy in Antarctica.

In each phase of construction, it is aimed to minimize materials to be used, cargoes to be transported, selected equipment, engineering processes, and waste disposal.

2.4.5 Fuel Consumption

During construction, Antarctic Diesel (AD), which is the common type of fuel used at all research stations in Antarctica, will be used in the generators to supply the necessary energy needs. The estimation of overall fuel consumption during the construction period is approximately 550 ton.

2.4.6 Water Management

At this stage, the manpower requirement will be between 85-130 people depending on the work schedule. Daily per capita water demand is considered as 100 L. Thus, maximum daily demand for domestic purposes is calculated as 13 m^3 for the construction period. The required water for domestic use will be transported by vessels.

2.4.7 Wastewater Management

The quantity of domestic wastewater is estimated to be approximately 80 % of the water used. Direct on-site disposal and/or storage of untreated wastewater to be further discharged outside the Continent will be absolutely prevented; and it will be treated by a package-type biological treatment unit coupled with a mechanical filter and a disinfection unit to achieve advanced treatment at this stage. This set of units will be installed and put into operation to be also used in the operation phase with a lower capacity. The selected batch system is flexible and works efficiently under varying flowrates. It will be used at its maximum capacity serving to 130 people during construction. The details of treatment system are given in Section 2.5.7. Trials of the wastewater treatment will be finalized within construction stage and treated effluent will be safely discharged to the sea from the sea surface. The treatment sludge arising from the system will be stored separately and upon the installation of the incinerator, it will be incinerated together with the food waste.

2.4.8 Waste Management

All solid wastes to be generated during the construction period will be sorted and collected separately for recycling and the volume will be reduced by compression. Food waste will be incinerated with the incinerator to be installed at this stage. Until incineration is initiated, food waste will be temporarily collected and stored in leak-proof storage units to be carried in leak-proof cargo containers via vessels to mainland for disposal out of Antarctica with respect to the domestic waste management legislation criteria.

2.4.9 Range of Impacts

The general range of impact produced during construction of TARS will cover almost all the facilities, wind turbines, solar panels. The project area of TARS is approximately 0.04 km^2. As it is a coastal station surrounded by hills, the spatial impacts will be limited to the constructed facilities. In order to limit the occupied area, the main building consists of two floors. Its elevated design will minimize the environmental impact on the original geographical features of the area. The temporal impact on the region caused by the construction of TARS is expected to last only 5 months (max.) of two consecutive Antarctic summer periods. These impacts are limited with the construction period.

2.5 Operation of the Research Station

The operation of TARS will be conducted in accordance with the requirements of the ATS, Protocol on Environmental Protection to the Antarctic Treaty & its Annexes, and RIPEPAT by PRI, as the designated national polar operator. The research station is designed for optimal use by 24 (max. 50) people for work & accommodation. The TARS team will consist of, but not limited to, researchers, electricians, medical personnel, and other managerial personnel for year-round operation. It will also seasonally accommodate national and/or international researchers working in various fields.

TARS will be operated with respect to the principles of environmental protection, wellbeing & safety, waste minimization, sustainable and renewable energy usage. The facilities will use renewable energy, such as wind and solar power for minimizing the use of fossil fuels. The remaining energy will be supplied by generators with a back-up generator for emergency needs. The elevated research station above the snow surface is aimed to minimize fuel consumption. Finally, the station design will allow for low maintenance & repair, and easy control & monitoring.

2.5.1 Time Schedule and Duration

The operation of TARS is planned to be ~25 years at its minimum. The duration type of the research station is year-round to provide full-year capability work, accommodation, and monitoring. On the other hand, the first 2 years of the operation phase is planned to take place during the Antarctic summer. Following the seasonal operation for 2 years, TARS is planned to be operated year-round.

2.5.2 Personnel and Accommodation

The occupational branch of the TARS ream, as given in Table 2-3, are the permanent researchers, technicians, and support staff whom will conduct the O&M of TARS. The minimum number of staff to reside at TARS is 12 during year-round, while the research station can accommodate maximum 50 people.

Table 2-3. Summer and year-round personnel at TARS

Occupation	Number of people during summer	Number of people during year-round
Station Chief	1	1
Researcher	15	5
Mechanical Technician	3	2
Electrical Technician	1	1
Medical Personnel	1	1
Supporting Staff	2	1
Cook	1	1
Total	24	12

2.5.3 Transport and Logistics

TARS is considered to be a relatively safe zone with its optimum proximity to Rothera Station of the UK with an airfield currently operating at the south of King George Island, San Martín Base of Argentina, and Carvajal Station of Chile. While TARS will be equipped with a helipad; the nearby research stations have the same opportunities as well. Logistics personnel and researchers will likewise arrive on Horseshoe Island by vessels departing from nearby ports, which also gives a way for multinational collaboration whenever possible.

The materials that will be needed during the operation of TARS will be transported by air or sea taking into account the size and content of the material. The transportation of materials will reach to Lystad Bay by vessel to be further transferred to TARS by RIB and barges. The project site is on the east coast of Lystad Bay at Horseshoe Island which nestles a 20-m coastline on the shore that allows boats to dock. A fuel line will be connected between the pumping station and the vessel that will supply the fuel, and the pumping station will transfer the fuel to the storage tanks following the recommendations in COMNAP Fuel Manual (2008).

During the operation phase, no land vehicles will be in use except a telehandler to handle boats and heavy loads. All other operations will be carried on foot at TARS.

2.5.4 Energy Management

The facilities within TARS will primarily utilize renewable energy, such as wind and solar power. The aim of relying on renewable energy sources is to minimize the use of fossil fuels and to maximize the sustainability of energy management of TARS. In order to assure the constant energy supply for year-round operation along with emergency needs, when necessary, there will be back-up generators installed. The design of the research station made way for the elevated facility to reduce snow management resulting in less fuel consumption.

As all national polar program operators of Antarctic facilities are required to prepare and adhere to Facility Contingency Plans, TARS will follow the contingency plan prepared specifically for the project site.

TARS' electrical design criteria has already been put forth during the design phase and it includes the following main items:

- Domestic and international standards and guidelines
- Power supply
- Energy requirement projections
- Energy distribution system
- Low voltage panels
- Lighting system
- Sockets installation
- Grounding installation
- Building management system (BMS)
- Closed circuit television system
- Fire detection and warning system
- Voice alarm and music broadcasting system
- Communication systems

All electrical equipment will comply with the following regulations, guidelines, and standards:

- Turkish Standards Institute (TSE)
- European Norms (EN)
- International Electrotechnical Commission (IEC)
- RIPEPAT
- ATS, Protocol on Environmental Protection to the Antarctic Treaty & its Annexes Environmental impact guidelines and policies

TARS' energy demand will be met by an eco-friendly hybrid system which is monitored remotely, and based on high energy efficiency. To the extent of which environmental and weather conditions may allow, renewable energy sources are the first preference of the automated hybrid system. This choice will diminish the use of fossil fuels to its possible lowest level. Sources of the hybrid system consist of wind turbines, solar panels, and generators. According to the projections, renewable energy sources encounter approximately 25% of the need for total energy. Solar energy accounts to 17% of total energy need, while wind power accounts to 8%. On the other hand, each generator is designed as to meet 100% of the total requirement for energy.

Solar energy will be utilized via solar panels that transform solar radiation into electricity. The panels shall provide the heating of the premises and the water for use of the personnel, along with the electricity of mechanical systems, such as fans and pumps. 750 PV panels with production capacity of 440 Wp, along with 5 H-Rotor wind turbines with production capacity of 20 kWp will be utilized at TARS.

Four generators with capacity of 400 kVA will be equipped to meet 100% of the power requirement of TARS. Two of the generators meet the primary power needs in rotation, while the third one stands by. The fourth will be a spare generator which may fill in if special situations arise, such as repairs or emergencies.

Total annual need for energy accounts for 1750 MWh/year. The essential circuits will be fed by uninterruptible power supply (UPS). The battery of UPS will approximately have a capacity of 30 minutes. Inner lightening fixtures has been chosen as LED due to their low energy consumption. Variable frequency drives (VSDs) will be used in the feeding of mechanical equipment. Special attention will be given to the energy efficiency of the procured equipment.

Heating, Ventilation and Air-Conditioning (HVAC System)

In the main building, the energy is required for heating of the fresh air to AHUs and water of the radiators. The supply of water necessary for heating equipment and coils of air conditioners will be obtained in two different ways; first, electricity obtained from renewable energy sources will be used in the warming of heating water. Secondly, when such sources are insufficient, waste heat coming from the CHP system will be directly used for the procurement of the heating water. The preference between these two choices will be regulated by an automated system considering the operation conditions which presents the advantage of utilizing a hybrid system at TARS. Thermal load belonging to the main building will be met by waste heat stemming from the CHP system. Given the loss of energy for heating of the exterior pipelines, along with the difficulties of operation regarding transfer by water, other buildings will be directly heated up by electricity.

In TARS, air-conditioning units, blast & exhaust fans, and heating water circulation pumps that pressurize and circulate air & water, will involve variable rotation (frequency converter controlled) that allows equipment to operate within adjustable loads for different flows, promoting a significant energy saving concept.

Ventilation system is divided into sectors based on their different purpose of use varying in time and location. Thus, in locations which are not operated during a given period, the ventilation system will be shut down.

In offices where fresh air flow is similar to that of the exhaust flow, and in 100% fresh air plants serving to odorless locations, rotating type heat recycling units will be used that allow to gain latent heat in a palpable manner. Additionally, air-conditioning energy demand will fall significantly during both winter and summer periods. Fresh air supply/exhaust (rotating type heat recycling) units will therefore be used to benefit from the waste heat of exhaust air.

Fire Protection Systems

Sprinkler system has been designed especially in the sleeping zone as high-risk area in the main building. The required fire water tank to be placed in the treatment center has a capacity of 150 m^3. Automatic fire detection will be installed in all closed areas of TARS. Manual call points will also be maintained throughout the research station. Alarm notification will be made with the emergency communication system in all open areas. Audio-visual warning devices will be placed in the connection corridors. Portable fire extinguishers suitable for specific needs will be placed ready for use in possible fire break out areas, such as electrical rooms, laboratories, etc. An extinguishing system will be installed for the hood in the kitchen area. The system will be automated through electrical and mechanical detection. The system can also be initiated manually with the activation button. The manual system will be placed on the fire evacuation route and will automatically activate the building fire alarm system.

COMNAP's Framework and Guidelines for Emergency Response and Contingency Planning in Antarctica (2004) will be adhered to during the preparation of emergency response and contingency planning manuals. In addition, fire-resistant zone walls have been planned, and emergency fire escape is provided with fire stairs. Fire-rated compartmentation will be furnished with fire resistance rating of 120 min for wall separating.

2.5.5 Fuel Consumption

AD will be used in the diesel generator for the remaining energy supply after the utilization of solar panels and wind turbines. The annual fuel consumption of the generator to be used during the operation period will be approximately 350 tons.

The fuel for the diesel generator will be stored in fuel tanks at TARS. The fuel tanks will be sufficient enough to accommodate more than 24 months of fuel for full capacity. The maximum amount of fuel to be stored for a such period of time corresponding to 20 fuel tanks with capacity of 40 tons each.

Fuel tanks will be installed above ground that has been made impermeable, with double wall and thermal insulation. In double-walled tanks, the sensors to be placed between the walls will detect fuel leakage, and in case of need for intervention, the relevant tank inlet & outlet valves will be closed automatically without disrupting the system integrity. The steel material of the tank and the welding method in its production will be made according to outdoor design conditions.

Vessels with high maneuverability can anchor in Lystad Bay through approaching up to 200 m distance to the coastline. Refueling will be maintained between the pumping station tanks and the vessel that will supply the fuel using the fuel line in compliance with the COMNAP Fuel Manual (2008) standards.

2.5.6 Water Management

Potable water will be transferred to TARS from mainland while lake water (liquid phase in Antarctic summer) will be used only for domestic purposes. The lakes located on Horseshoe Island will be used as primary sources of domestic water (Lake I & Lake II given in Section

4.3). In winter months when the lake freezes or for any other occasion where lake water cannot be utilized, it is planned to use snow and/or ice through melting. This alternative plan requires that snow/ice will be transported for melting. Snow/ice melting will be done through means of electrical resistances. Solar panels and wind turbines used to generate electricity can be directly used as the renewable energy sources for melting snow and/or ice. Depending on the daily water consumption, the capacity of the melting system is 60 kW. Water obtained will be transferred to the research station after filtration.

According to domestic standards, the daily water consumption design value is taken as 90 L/capita.day. However, it was accepted as 135 L/capita.day with 50% safety considering the conditions of Antarctica. It also includes the additional humidification capacity to prevent the adverse effects of dry air conditions in indoor environment.

The gross water consumption will be diminished as the flushing water in toilets will be recovered from treated wastewater. On the other hand, maximum water consumption value is taken higher just in case of any technical malfunctioning. Thus, the daily maximum water consumption for the research station to be operated with a maximum capacity of 50 people is calculated as 6.75 m^3 for the Antarctic summer period. In the treatment center, a raw water tank with a capacity of 20 m^3 will be installed to store the lake water or snow/ice to be used when necessary. Filtered water will be transferred to the water tank with a capacity of 10 m^3. As the number of people working year-round equals to 12 the daily water consumption equals to 1.62 m^3 in the winter period.

2.5.7 Wastewater Management

The package-type biological treatment system coupled with a mechanical filter and a disinfection unit that will be installed and put in use during construction stage will continue to work with a lower treatment capacity serving to maximum 50 people. The selected sequencing batch reactor (SBR) is flexible and works efficiently under varying flowrates. It $FeCl_3$ will be dosed at the stage of sedimentation to enable better sedimentation and to achieve less sludge. A mechanical filter will accompany the system for further filtration purposes prior to chlorination. As such, advanced treatment will be maintained. The final effluent will then be stored to be safely reused in toilet flushing. In cases where the treated water is insufficient, a piping line will be used from the domestic water line directly to the flushing water line.

The treatment system will be pre-engineered, and it will be directly installed at the treatment center of TARS. The piping and fixing of appurtenances will be completed at the construction stage ready to be in use in a short while. In the treatment of wastewater, a basket type screen will be installed initially. This type of screen is preferred in small package treatment systems in order to reduce investment cost and to gain space. A balancing tank of 5.5 m^3 will also be installed prior to transferring wastewater to the biological treatment unit for balancing the flowrate. Wastewater will be transferred to SBR via a submersible pump. The SBR tank will be made of carbon steel, and the required oxygen transfer to the system will be supplied by a blower (5 m^3/h). Oxygen will be supplied through a diffusor system of disc type with fine bubbles based at the bottom of the tank. Aeration, sedimentation and sludge stabilization processes will be handled within the same tank in alternative periods. The SBR treatment unit will be completely covered and only necessary manholes will be placed on it. Upon installation of the system at the predetermined area, inlet and outlet piping's and electrical works will be completed. It will be an automatically operating system.

2 m^3 stainless steel sludge tank will be installed near the balancing tank where excess sludge is stored. After the excess sludge is dewatered in the centrifuge or press filter, it will be combusted in the incinerator as cake (approximately 10 kg/day maximum) with approximately 25 % Dry Matter (DM). Upon the reuse and/or discharge of the treated water, sodium hypochlorite will be dosed to the effluent.

Part of the treated effluent will be recycled and reused in toilet flushing. The excess will be discharged to the sea from the surface layer. The receiving body where treated effluent will be discharged is considered as a sensitive area. Therefore, advanced treatment is regarded as the best method of treatment. The discharge limits for treatment effluents arising from wastewater treatment system in such a sensitive area will be taken as TN = 15 mg/L and TP = 2 mg/L. By adding $FeCl_3$ at the sedimentation stage in the SBR and by using a mechanical filter at the end of biological treatment, the treatment efficiency will increase. The projected COD will be less than 70 mg/L.

2.5.8 Waste Management

High efforts will be made to minimize waste generation. The total solid waste that may arise from TARS during the first 2 years of seasonal operation will be around 24 kg/day; whereas, this value will be 12 kg/day during year-round stay at TARS. Sorting will be accomplished for the recyclable waste and their volume will be reduced by compression under possible circumstances. A suitable compactor will be used for this purpose. Food waste (approximately 50% of total waste) will be incinerated in the incinerator installed at the construction stage. Combustion slag/ash will be collected separately and will be removed from the continent by vessels along with other separated solid wastes. As such, hazardous wastes originating from the laboratories and/or other mechanical equipment will be collected and stored separately. They will similarly be removed from TARS by vessels.

A double-chamber incinerator to minimize air emissions will be installed at the treatment center with its own fire protection system. Emissions that might arise will be reduced by integrating a wet scrubber to the incinerator. The food waste and dewatered residual sludge cake arising from wastewater treatment will be directly sent to this unit for combustion.

2.5.9 Operation Manual and Training

Environmental Management Plans (EMPs) covering fire protection, emergency, contingency, and oil spills will be available during the operational phase of TARS. The following items will be included in an operation guideline both for effective management, O&M, and repair:

- Safety guidelines for fuel handling and contingency plan for oil spills,
- Guidelines for environmental protection including energy and waste management,
- Guidelines and checklists regarding all major facilities, vehicles, and equipment, including their periodic maintenance and repair,
- Contact list of responsible technical staff for management and maintenance,
- List of standard specifications of spare parts.

2.5.10 Range of Impacts

The temporal impact on the region will be caused by the operation of TARS is expected to last minimum 25 years. The general range of impacts of TARS will cover all of its facilities, including wind turbines and solar panels. Site-specific impact area extends from the seashore up to the far edge of the solar panels. Therefore, the spatial impacts will only be limited to the facilities of TARS (Figure 2-10). The local range of impact (~1 km radius of the project site) covers the freshwater lakes from which the domestic water of TARS will be supplied, along with the south-western islets. As given in Section 4.6, breeding and nesting of fauna were not observed in the past four TAE surveys and the literature reviews.

5 km radius represents the mid-regional extent of TARS is almost identical to the boundaries of the entire island, encompassing the historic site Base Y in the neighboring bay. Skua Lake that has been studied by scientists since the 1990s bearing rich diatom diversity lies within this extent. Based on the suitable location of the project site, it can be stated that any sort of impacts arising from the operation of TARS is limited, and is not expected to cause significant effect on its environment.

10 km radius represents the regional extent of TARS and mainly covers the sea. The Lagotellerie Island that has been designated as a protected area (ASPA-115) due to its relatively diverse flora and fauna, is the largest island within this radius. It is considered that the probable impact will not be affecting the local species.

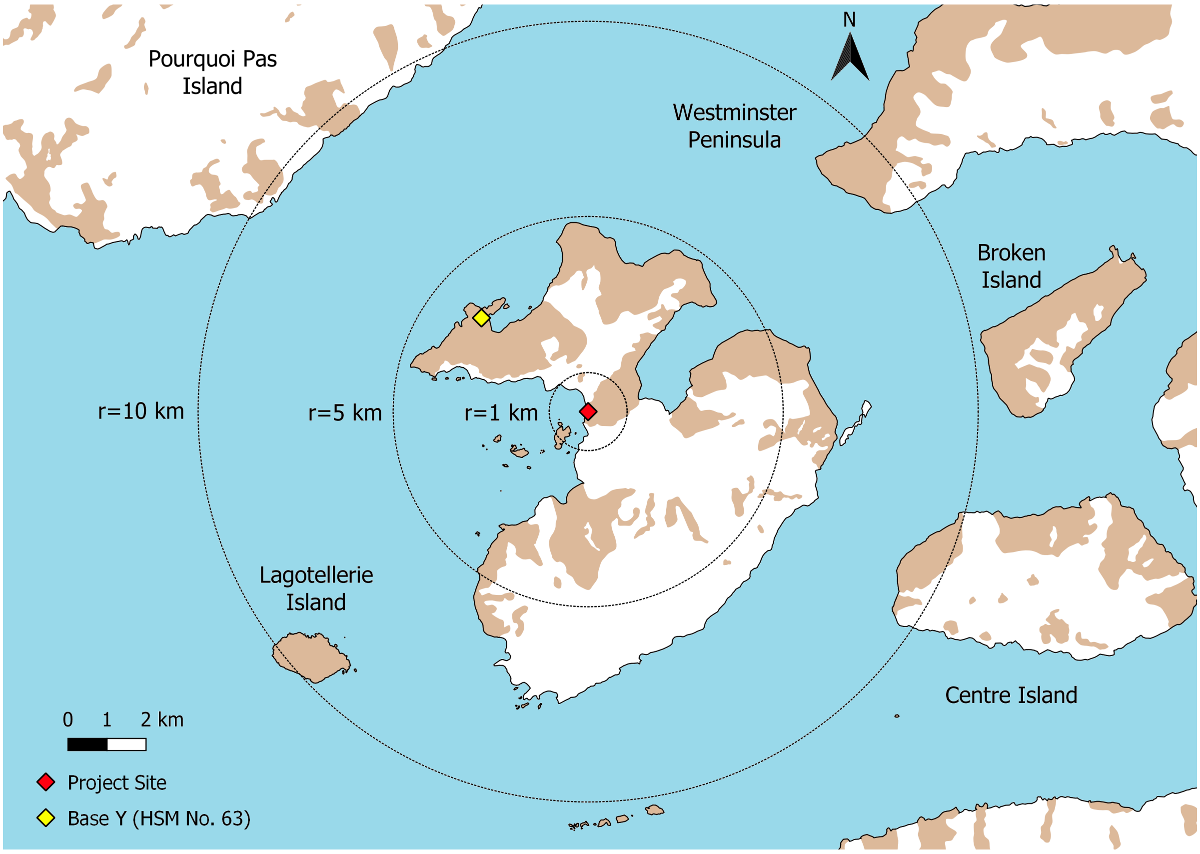

Figure 2-10. Range of impacts of TARS

3 ALTERNATIVES TO THE PROPOSED ACTIVITY

3.1 No-Action Alternative

No direct, indirect or cumulative negative environmental impact will be observed in the region if TARS is not established and operated in Horseshoe Island as evaluated within the scope of this report. Although it is foreseen that there will be no negative environmental impact if the proposed activities are not accomplished, a cumulatively increasing environmental impact occurs during annual expeditions to the region for scientific purposes. When the advantages and disadvantages regarding the realization of the planned activity are examined, it is thought that conducting this activity will have less environmental impact in the region in the long-term compared to short-term expeditions. The expected scientific value would be reduced in case of not establishing TARS.

3.2 Location Alternatives

While TAE-I was planned in 2017, 35 possible locations were determined for the research station to be established. In the determination process; the views of Turkish scientists who had continental experience were taken and logistic evaluations were made following the literature review. After the survey of the sites, 17 of the 35 possible locations were found favorable due to logistics, topography, sea ice, environmental and climatic conditions, and distance from other research stations as given in Figure 3-1. 4 alternatives among 17 alternatives were determined in the workshop, which was held with a wide participation after the 2017 TAE-I. These 4 points were re-visited in 2018, topographic and bathymetric maps were produced, logistic routes, and sea ice properties were recorded, soil structure, architectural perspective, earth-marine-physical-life sciences, and environmental and climatic conditions were examined in TAE-II. Finally, a site selection study was conducted with the Analytical Hierarchy Method (AHP), a method that is frequently used in decision-making processes is used for sorting decision alternatives based on multiple criteria (Annex II).

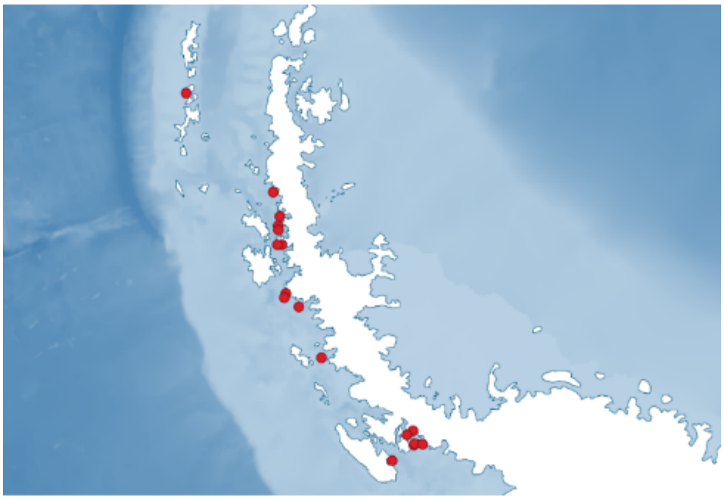

Figure 3-1. Alternative sites

The determined criteria and sub-criteria were presented to the opinion of expert stakeholders and comparison evaluations were taken. Consistency analysis of the criteria and relative pairwise comparisons were made (Yavaşoğlu, et. al., 2019), . As a result of the evaluation, the weighted average of the 4 alternative sites was calculated (Table 3-1).

Table 3-1. AHP weighted average values for alternative sites (1 to 5)

Alternative Sites	Main Criteria			
	Spatial Conditions	Accessibility	Legislative Conditions	Overall Score
Horseshoe Island	4.20	3.80	3.61	3.78
Hovgaard Island	3.71	2.82	3.35	3.22
Nansen Island	3.07	2.96	3.52	3.24
Portal Point	2.62	2.26	2.68	2.52

The 4 options determined in the evaluation carried out with the participation of stakeholders based on the criteria that are listed under the headings of geology, topography, bathymetry, climate, logistics, sea ice, legal status, flora and fauna interaction, association with protected areas, accessibility and spatial planning were used. In addition, solar radiation assessment was also conducted for the areas determined in Horseshoe Island to enable the use of solar energy. In-situ observations revealed that the areas determined in the island based on the prevailing wind, surrounding topography, and in terms of glacier and snow accumulation were more advantageous than other areas of concern.

In conclusion, the proposed site at Horseshoe Island has been decided as the most suitable site among the options for establishing a long-term research station.

3.3 Design Alternatives

Potential environmental impacts have been taken into account from the very start of the design work. In the structural solution; resistance to wind, minimum energy loss with compact design, maximum use of daylight, use of thermal insulation in parallel to climate data, the energy requirement has been considered. The design alternatives are:

- Linear form,
- "T-shape" form,
- Compact modular form.

The modular form provides high building safety due to its compact design with comparatively less occupation of land. Its aerodynamic structure against the wind is to be based on its angular form on the facade surface. The elevated structure prevents the accumulation of snow and eliminates the snow load. Modular form, structure and layout well fit to the topography of the area. The building has been designed as two floors, reducing the surface area and eliminating the need for insulation between the floors by preventing heat loss. Maximum use of daylight has been considered in planning. Based on these advantages, "compact modular form" has been determined as the most suitable option for the main building. Durable, low maintenance, sound and heat-insulated facade & interiors, and hygienic interior flooring among the other material properties of the building.

Solar panels may also be installed on the roof and/or on the sides of the main building as an alternative option. Disadvantages of this option are; increasing the static loads of the main building, possibility of breaking the panels in high winds, and high maintenance and repairmen will be relatively difficult. Moreover, due to limited surface area of the roof expected renewable energy will be less compared to installation on the ground. Therefore, this option will not be preferred for TARS.

3.4 Wind Turbines Alternatives

Since "H-rotor" vertical-axis wind turbines operate at a lower speed than conventional horizontal-axis turbines, they generate lower noise. They contain fewer mechanical parts than conventional ones, therefore, they have a less chance of mechanical failure, and less maintenance requirement. For the same reasons, the environmental impacts, along with their managerial aspects, are relatively low. Characteristics such as the vacuum effect and/or tail effect are quite low compared to conventional horizontal wind turbines due to their low speed. Thus, “H-rotor” vertical-axis wind turbines are considered to be a much eco-friendly type for TARS.

4 ENVIRONMENTAL REFERENCE STATE

4.1 Location

Horseshoe Island has been selected as project site. The location is between volcanic mountains and peaks, with topography of a gentle slope, and a natural harbor feature. From the volcanic peaks of the island, the Searle Mountain in the north has a height of 537 m, and the Breaker Mountain of 879 m as given in the satellite image of Figure 4-1. Although the sea bathymetry is quite variable, hydrographic measurements indicated that the project site could be reached via vessels as close as ~200 m. Landing and access to the project site is provided through Lystad Bay located on the west coast of the island. The project site is accessed after the gentle slope from the coastline at approximately 40 m distance. The view of project site is provided in Figure 4-2.

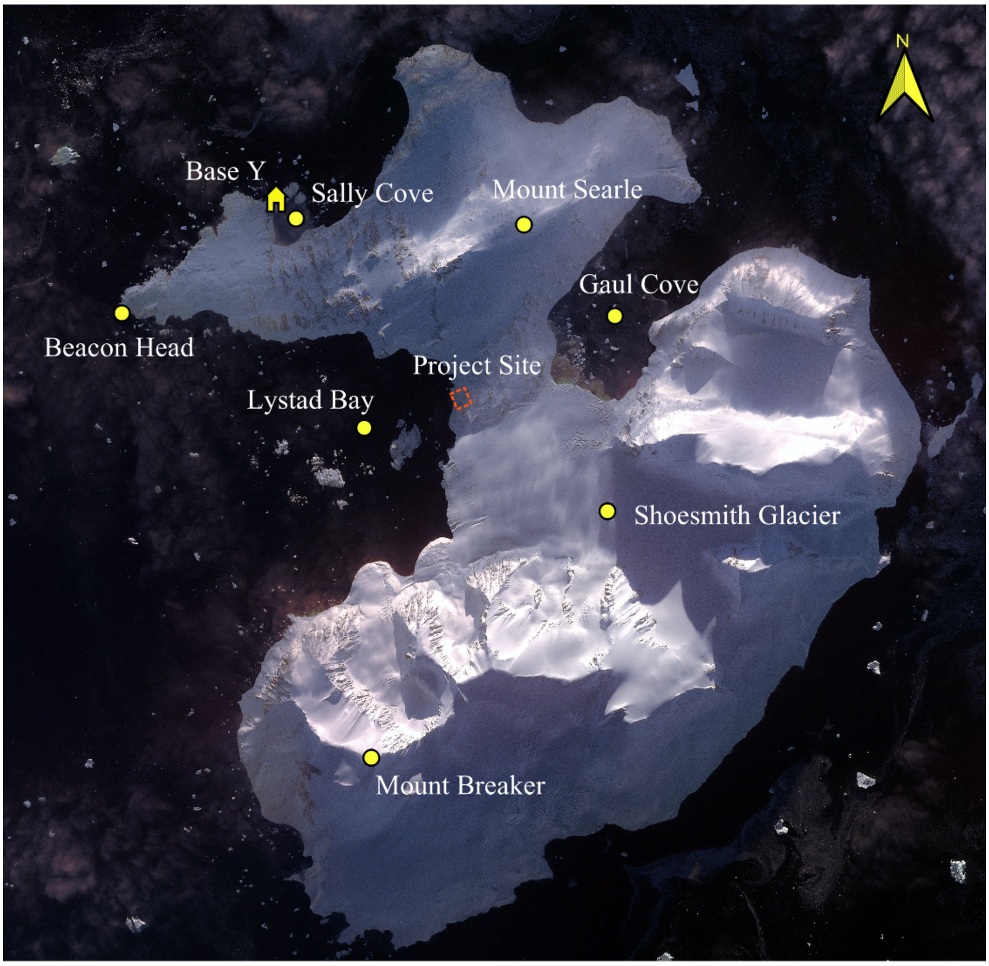

Figure 4-1. Overview of Horseshoe Island from GÖKTÜRK-2 satellite image

Figure 4-2. View of the project site

The island hosts “Base Y”, as a historic site (HSM No. 63) of the UK that has been used in the 1960s for scientific research. Project site and Base Y are approximately 4 km apart; however, they are located on different bays along the coastline. They are not in sight of one another due to the mountainous topography of the island in-between.

One of the most important structures on the island is the Shoesmith Glacier, which extends widely in the east-west direction and has an area of approximately 6.5 km^2. Gaul Cove is located in the middle east of the island and Lystad Bay is located at the west. Lystad Bay entrance to the project site is easy to access, its topography is mild with a rocky structure. Gaul Cove, on the other hand, has a steep slope and the gravel structure is not suitable for building a research station. The structure connecting Gaul Cove and Lystad Bay forms an isthmus that separates the northern and southern topography of Horseshoe island. Within this structure, there are freshwater lakes at approximately 100 m altitude between Lystad Bay and Gaul Cove as can be seen in Figure 4-3.

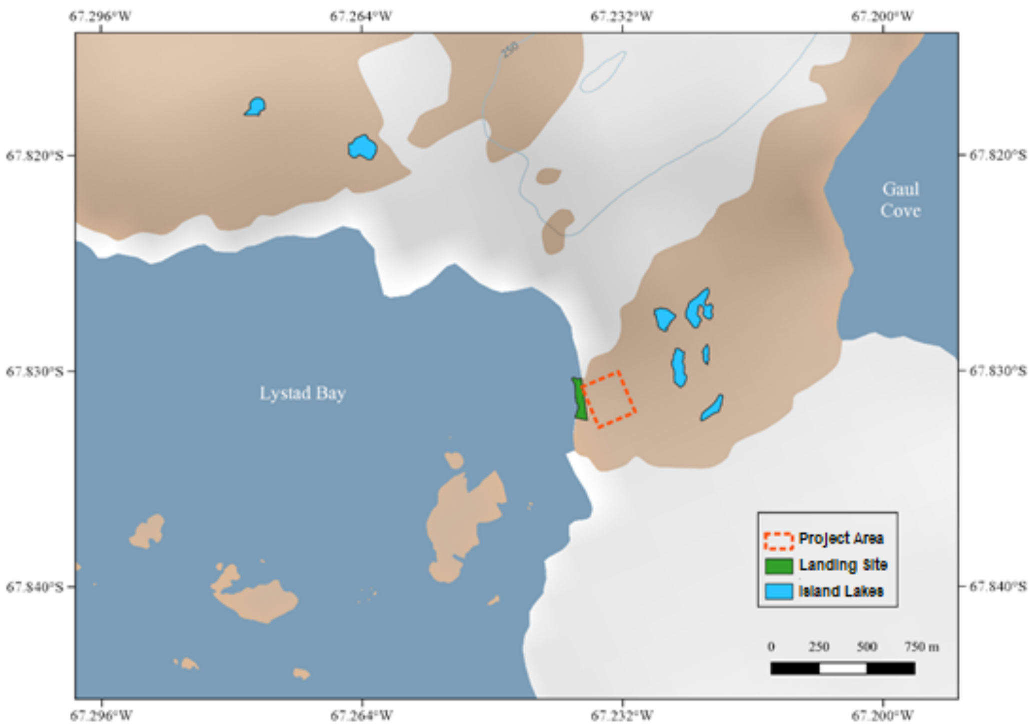

Figure 4-3. Landing site, lakes and project site overview at Horseshoe Island

4.2 Topography, Geology and Geomorphology

The project site has been analyzed geologically, geophysically and topographically in detail. The contour map of the project site is given in Figure 4-4. When the contour lines are examined, it is seen that the slope is low in terms of topography at project site. The south-western part of the island has mild slope. This slope provides the transportation of liquids (water, fuel, etc.) from the tank(s) to the main building by gravity. The coastal line has been studied by bathymetric measurements, and it is observed that the sea bottom is suitable for navigation.

The island has a complex geology. The glacier-free regions are mainly composed of plutonic rocks consisting of granite and gabbro, banded gneiss and granitic gneiss belonging to the metamorphic complex. Besides, there are sediments and moraines formed as a result of glacial movements on the island. The north of the island consists of rocks of more diverse origin, while the mountains in the south are ponderous granites.

The observations at the field during TAE visits revealed that the rocky structure is covered mostly by medium-coarse gravel-sized material at the landing site. It has been observed that the bedrock is outcropped throughout the island, and there are large blocks on the ground surface. Similarly, the smallest grain materials encountered are in the size of gravel at the project site. This type of rock and gravel with coarse-medium grain diameter is a suitable foundation soil in terms of both bearing capacity and settlement. It is anticipated that the structural loads of buildings can be safely transferred to the ground.

The general stratigraphy of the island is listed by Matthews (1983) as; volcanic semi-depth rocks (dykes), Andean plutonic rocks (gabbro, granite, diorite, granodiorite rocks), Antarctic Peninsula volcanic group rocks (tuff, agglomerate, andesitic lavas, volcanogenic sediments), Antarctic Peninsula Metamorphic complex (banded gneiss, granitic gneiss). In addition to metamorphic and volcanic rocks, there are typical glacial deposits, lateral and moraines formed due to glacial movements and melting.

On Horseshoe Island, the area from the landing site of Lystad Bay to Gaul Cove was investigated in the west-east direction. The entrance is a coastal erosion plain with a less inclined surface formed by the waves. These surfaces are generally covered with gravel and sand. On the surface of this part of the island, different sizes of pebbles eroded from the surrounding rocks were observed. There are dark grey colored gabbro-diorite rocks in the vicinity of the project site along the coastline. Behind these rocks, beige-pink granite rocks were seen.

Foliated granites, as metamorphic rocks formed under high temperature and pressure, were observed extensively at the area headed towards Gaul Cove from the lakes. Among the foliated granites, where foliation is very clear, grey-banded foliated granites composed of feldispat and quartzose bands are situated on the southwest of Gaul Cove. These rocks are the part of Antarctic Peninsula Metamorphic complex. The rocks contain feldispat and quartzose dominantly (Figure 4-5).

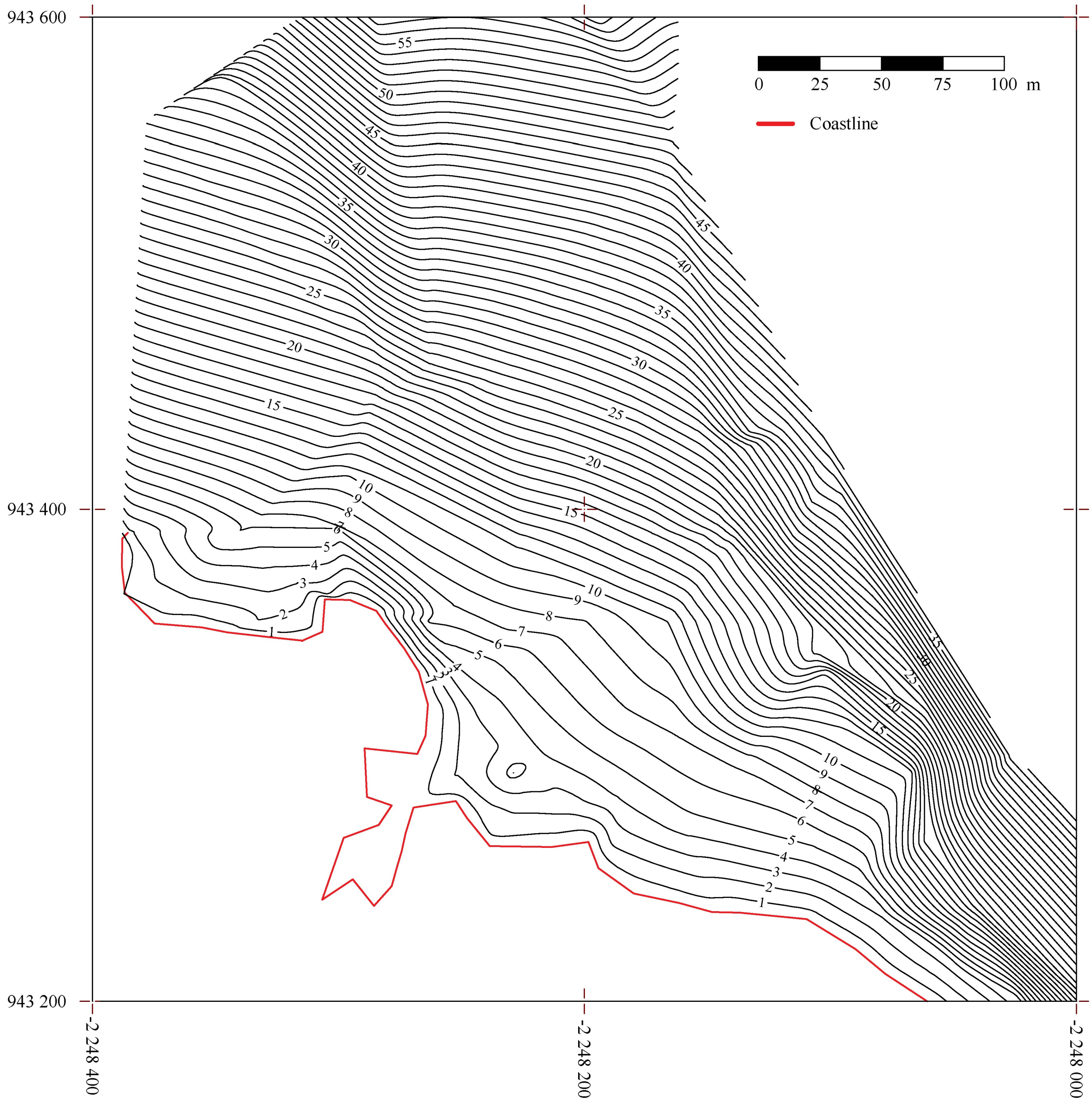

Figure 4-4. Contour map of the project site

Figure 4-5. Granitic gneiss rocks observed on Horseshoe island (TAE-II)

Sediments belonging to the glaciers melting era were widely observed at the west of Gaul Cove. Pebbles and blocks with a range of sizes are scattered around. At this area, lateral moraines are available on the slopes. Moraines are different sized mostly edged glacier sediments, which are pulled off and carried from the valley plains and slopes (Figure 4-6).

Figure 4-6. Sediments consisting of different sizes of pebbles seen behind the coastal etching plain (TAE-II)

As given in Figure 4-7, the geological map of Horseshoe Island was prepared on which lithological, tectonic and structural features were adapted from Matthews (1983) and Yıldırım (2020). Beach deposits and foliated granitic gneiss forms the majority of the project site.

Çiner et. al (2019) collected samples from erratic pink granite boulders at an altitude of ~80 m above sea level yielded ages that range between 12.9 ± 1.1 ka and 9.4 ± 0.8 ka at Horseshoe Island. As in other studies on Antarctic erratics, it has been reported as the youngest erratic age (9.4 ± 0.8 ka) underlining the true age of deglaciation, which confirms a rapid thinning of the Marguerite Trough Ice Stream at the onset of Holocene.

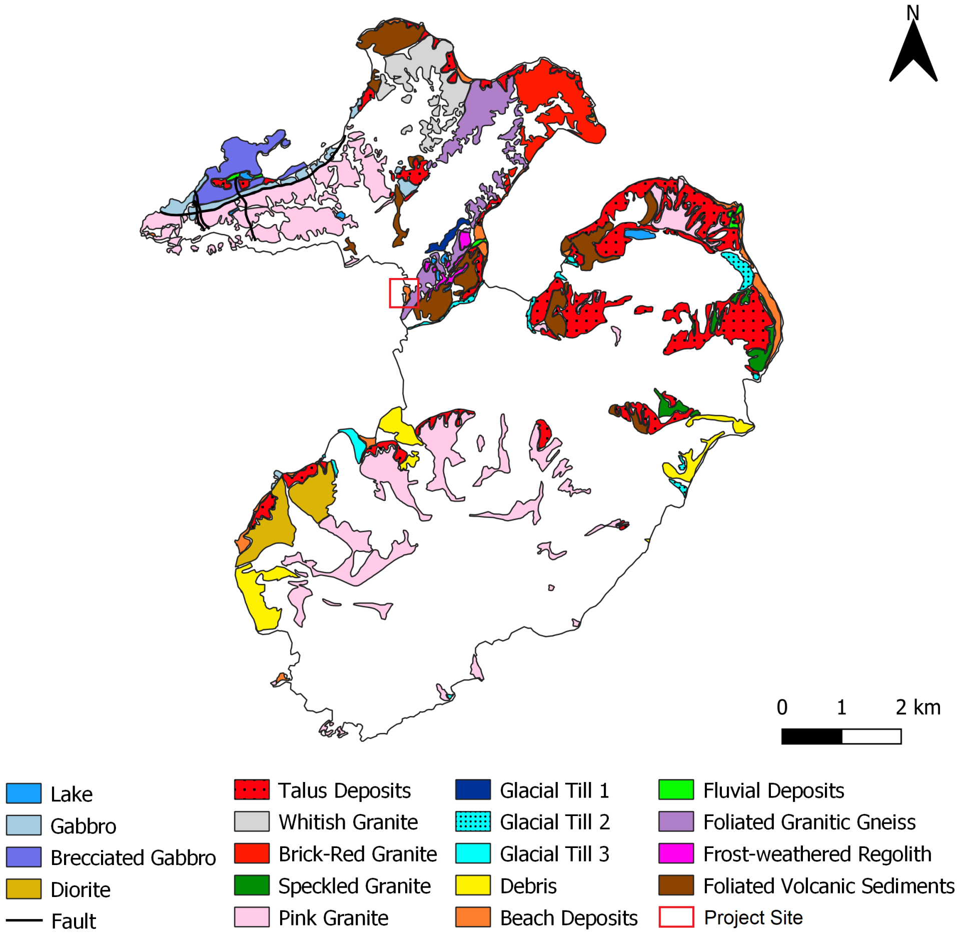

Figure 4-7. Geological map of Horseshoe Island adapted from Matthews (1983) and Yıldırım (2020)

4.3 Sea and Land Characteristics

The bathymetry map of the Marguerite Bay surrounding Horseshoe Island, as given in Figure 4-8, has been prepared by using multi-beam eco-sounder within a period of 2 years during TAE-III and TAE-IV visits. National State Office of Navigation, Hydrography and Oceanography (ONHO) conducted this survey.

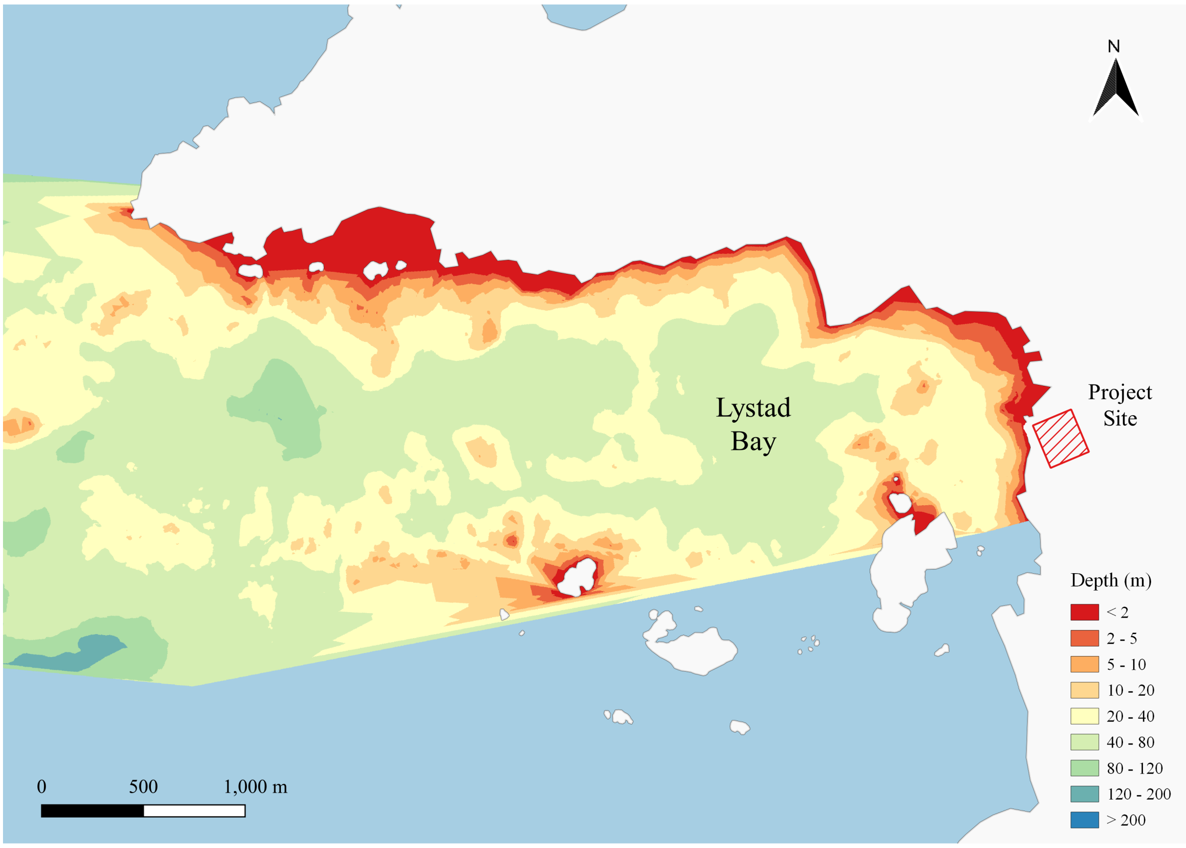

Figure 4-8. The bathymetry of the sea in Lystad Bay

The important lakes to TARS, namely Lake 1 and Lake 2, along with Lake 3, are shown on Figure 4-9. The Late Quaternary environmental changes in Marguerite Bay have been studied by Hodgson et al. (2013). The study provides the water chemistry of Lake 1 and Lake 2 as given in Table 4-1. As can be seen from Table 4-1, both lakes show freshwater quality pointing out the fact that they can be used for domestic water supply at TARS. They stated that light penetrates down to the bottom of the Lake 1 (depth of 3.2 m) resulting in rich benthic and epilithic mats of cyanobacteria, and zooplankton community. Moss patches were observed towards the edges of the lake.

The water chemistry of Lake 1 indicated a typical polar freshwater oligotrophic lake. The water column consists of a warmer surface layer done to 1.6 m followed by stable cooling through the lower layers (January 2003). The water column is otherwise considered to be well-mixed, and there is no oxygen depletion with depth. The ~110 cm sediment core revealed three lithological units; glaciolacustrine green-grey silt with clay and sand below, a transition zone in the middle, and laminated microbial mats at top (Hodgson et al., 2013).

Figure 4-9. Lake 1, 2, and 3 on Horseshoe Island

Table 4-1. Water chemistry of lakes at Horseshoe Island (Hodgson et. al., 2013)

Parameters	Units	Polar Freshwater	
		Lake 1	Lake 2
Temperature	°C	3.7	5.6
Oxygen saturation	%	96.2	122
Conductivity	µS/cm	131.2	166.8
Anions			
Cl	mg/l	28	41.4
SO_4-S	mg/l	13.1	20.1
Cations *(including Si)*			
Al	mg/l	<0.002	<0.002
Fe	mg/l	0.016	0.003
Mg	mg/l	2	3.03
Ca	mg/l	1.43	2.08
K	mg/l	0,72	0.894
Na	mg/l	14.6	21.8
Si	mg/l	0.054	0.054
Nutrients			
NO_3-N	mg/l	<0.100	<0.100
NH_4-N	mg/l	0.036	0.015
PO_4-P	mg/l	<0.005	<0.005
Total N, TOC & DOC			
DOC	mg/l	1.06	0.91
TN	mg/l	0.14	0.07
TOC	mg/l	1.10	0.78

Water samples were collected from specific points regarding the lakes within and the island shores in TAE-IV (Table 4-2). The detailed sampling locations in TAE surveys covering the sea and lake samplings have been given on the same map of Horseshoe Island in Figure 4-10.

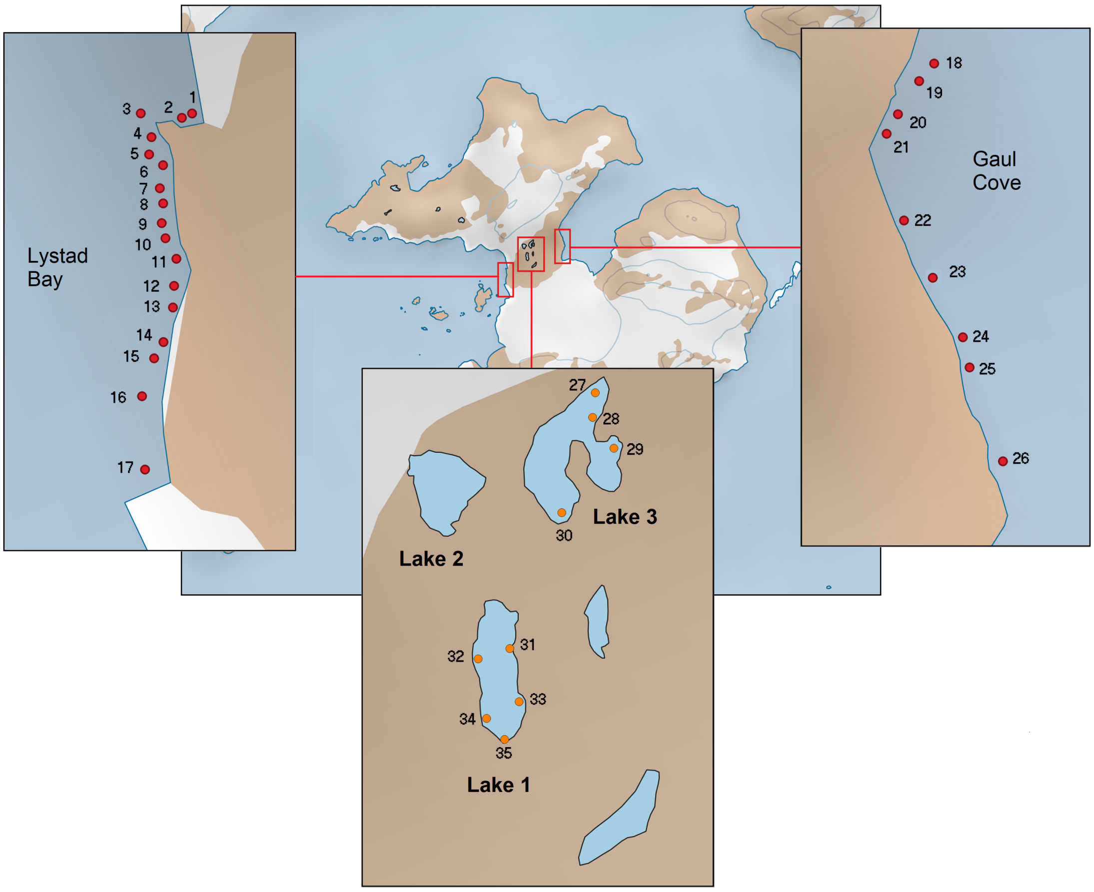

Figure 4-10. Water sampling locations map of Horseshoe Island

Table 4-2. Physicochemical evaluation of sampling locations at Horseshoe Island

Location	Sampling Point	pH	Temperature (°C)	Conductivity (µS/cm)	Dissolved Oxygen (mg/L)
Lystad Bay	1	8.43	2.6	49,000	10.8
	2	8.57	2.1	41,000	10.3
	3	8.42	2.2	54,000	10.3
	4	8.40	2.2	53,000	10.2
	5	8.41	2.2	53,000	11.0
	6	8.40	2.2	53,000	10.9
	7	8.39	2.4	53,000	9.6
	8	8.39	2.2	53,000	9.7
	9	8.38	2.3	53,000	9.7
	10	8.39	2.1	52,000	10.0
	11	8.39	2.2	53,000	10.1
	12	8.39	2.1	53,000	10.4
	13	8.39	2.0	52,000	10.4
	14	8.38	2.1	53,000	10.0
	15	8.37	2.1	53,000	10.2
	16	8.38	1.9	53,000	10.4
	17	8.30	1.8	54,000	10.6
Gaul Cove	18	8.33	2.1	51,000	10.4
	19	8.31	2.7	50,000	10.3
	20	8.29	2.8	50,000	10.3
	21	8.21	3.8	49,000	11.5
	22	8.36	1.6	51,000	11.6
	23	8.30	1.5	52,000	11.8
	24	8.36	1.2	29,000	12.5
	25	8.18	1.4	49,000	11.3
	26	8.33	1.5	52,000	11.2
Lake 3	27	8.40	0.8	154	12.0
	28	8.12	1.1	122	11.8
	29	8.06	2.5	121	13.4
	30	7.87	1.1	120	12.1
Lake 1	31	8.60	3.4	112	12.0
	32	8.41	3.2	112	12.0
	33	8.22	3.2	116	12.1
	34	8.00	2.8	108	12.7
	35	8.57	3.6	113	12.0

Soil samples and bottom sediments from lakes and coastal waters of Horseshoe Island were collected during the TAEs as shown on Figure 4-11. In order to obtain a baseline data before the construction and operation of TARS, the collected samples were analyzed for Polycyclic Aromatic Compounds (PAHs), Polychlorinated Biphenyls (PCBs), Organochlorine Pesticides (OCPs), and 14 metals.

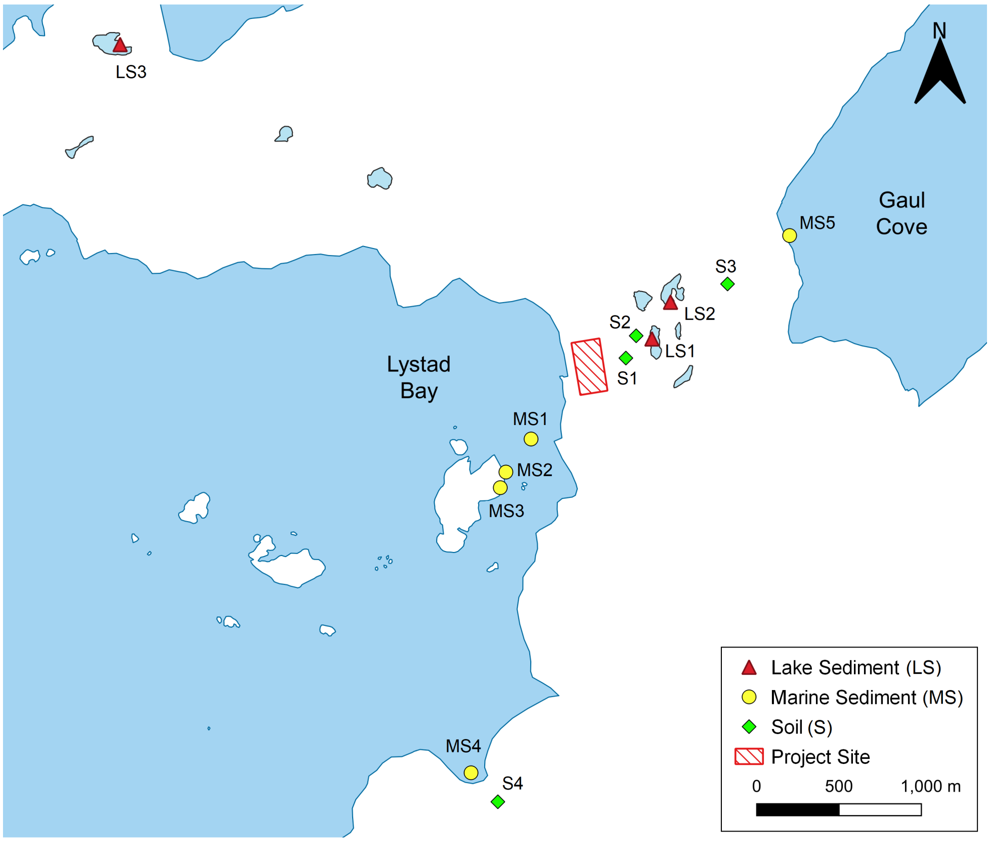

Figure 4-11. Sampling locations map of Horseshoe Island

The collected samples were analyzed for 16 PAH compounds, and the concentrations are shown in Table 4-3. The total PAH levels varied between the range of 24-39 µg/kg for lake sediments, 7.7-29.2 µg/kg for marine sediments, and 13-19 µg/kg for soil. Phenanthrene, anthracene and fluorantene were the dominant compounds for all analyzed samples. Benzo(a)anthracene and dibenzo(a,h)anthracene compounds were only detected in Lake 1 samples, which showed the highest total PAH concentrations. The quantified levels were well below than the effects range / low (ERL) and effects range / median (ERM) values (Long & MacDonald, 1998), which are frequently used in sediment quality guidelines (Buchman, et. al., 2008).

Table 4-3. PAH levels in soil and sediment samples at Horseshoe Island (µg/kg dry weight)

Compound	LS1	LS2	LS3	S1	S2	S3	S4	MS1	MS2	MS3	MS4	MS5
Naphthalene	3.5	3.0	4.1	2.6	1.2	0.84	1.1	0.25	1.3	bdl	bdl	bdl
Acenaphthylene	0.15	0.045	bdl	0.071	0.14	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Acenaphthene	0.077	0.079	0.069	0.073	bdl	bdl	0.062	bdl	bdl	bdl	0.041	bdl
Fluorene	0.69	0.27	0.18	0.12	0.13	bdl	0.15	bdl	0.18	bdl	bdl	bdl
Phenanthrene	14	12	9.7	4.5	5.7	9.5	8.2	3.5	10.0	4.8	6.8	4.0
Anthracene	0.67	0.072	0.073	0.11	0.14	0.14	0.097	0.11	0.12	bdl	0.12	0.051
Fluoranthene	7.5	8.3	4.7	2.0	2.1	4.3	4.6	1.6	3.1	3.1	13.9	2.3
Pyrene	7.9	9.3	5.0	3.9	3.3	3.9	3.7	2.0	2.7	3.2	8.1	2.8
Benzo(a)anthracene	0.33	0.055	0.10	0.071	0.090	0.057	0.065	0.043	0.051	0.042	0.043	0.059
Chrysene	0.34	0.033	0.041	bdl	bdl	0.035	bdl	0.096	0.089	bdl	bdl	0.032
Benzo(b)fluoranthene	1.6	0.11	0.092	0.088	0.064	0.077	bdl	0.070	0.086	bdl	0.077	0.10
Benzo(k)fluoranthene	0.519	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Benzo(a)pyrene	0.77	0.030	0.099	bdl	0.029	bdl	bdl	bdl	bdl	bdl	0.054	0.069
Indeno(1,2,3,c-d)pyrene	0.29	0.039	0.050	0.048	0.023	0.025	0.032	0.025	0.027	bdl	0.021	0.026
Dibenzo(a,h)anthracene	0.049	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Benzo(g,h,i)perylene	0.30	0.041	0.048	0.053	0.024	0.022	bdl	0.022	bdl	bdl	0.025	0.028
Total PAH	39	33	24	14	13	19	18	7.7	18	11.1	29.2	9.5

*bdl: Below detection limit

Seven indicator PCB compounds were analyzed in the samples and the results are given in Table 4-4. The total PCB levels ranged between 0.011-0.045 µg/kg for lake sediments, below detection limits to 0.017 µg/kg for marine sediments, and 0.0026-0.012 µg/kg for soil samples. Similar to PAHs, the highest concentrations were measured in lake samples, where marine sediments contained the lowest levels for PCBs. No PCB compounds were detected in two marine sediment samples (MS1 and MS5).

Table 4-4. PCB levels in soil and sediment samples at Horseshoe Island (µg/kg dry weight).

Compound	LS1	LS2	LS3	S1	S2	S3	S4	MS1	MS2	MS3	MS4	MS5
PCB 28/31	0.0078	0.0043	0.0035	bdl	bdl	0.0033	0.0063	bdl	0.012	bdl	0.0039	bdl
PCB 52	0.0044	0.0028	0.0041	0.0026	bdl	0.0027	0.0036	bdl	bdl	bdl	0.0031	bdl
PCB 101	bdl	bdl	0.0035	bdl	bdl	bdl	bdl	bdl	bdl	bdl	0.0017	bdl
PCB 118	0.0058	bdl	0.0073	bdl	bdl	bdl	0.0022	bdl	bdl	0.0067	0.0039	bdl
PCB 138	0.0078	0.0035	0.0051	bdl	0.0031	bdl	bdl	bdl	0.0046	bdl	bdl	bdl
PCB 153	0.010	bdl	0.0061	bdl	0.0041	bdl	bdl	bdl	bdl	0.0046	bdl	bdl
PCB 180	0.0090	bdl	0.0032	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Total PCBs	0.045	0.011	0.033	0.0026	0.0073	0.0061	0.012	bdl	0.017	0.011	0.013	bdl

*bdl: Below detection limit

11 Organochlorine Pesticides (OCPs) were analyzed in the collected samples (Table 4-5). Only DDT derivatives and HCH isomers were detected, and the quantified concentrations were in trace levels.

Table 4-5. OCP levels in soil and sediment samples at Horseshoe Island (µg/kg dry weight)

Compound	LS1	LS2	LS3	S1	S2	S3	S4	MS1	MS2	MS3	MS4	MS5
Aldrin	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
p,p'-DDD	0.010	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
p,p'-DDE	0.014	0.011	0.024	0.008	bdl	0.010	0.007	0.005	0.009	bdl	0.007	0.004
p,p'-DDT	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Dieldrin	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Endrin	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
α-HCH	0.011	bdl	0.0031	bdl	0.0051	bdl	0.0034	bdl	0.0048	bdl	0.0047	bdl
β-HCH	bdl	bdl	bdl	bdl	bdl	0.0036	bdl	0.005	0.016	bdl	bdl	bdl
δ-HCH	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
γ-HCH	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl
Heptachlor	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl

*bdl: Below detection limit

The samples were analyzed for 14 metal elements and the levels are given in Table 4-6. The levels were in the same order of magnitude for soils and sediments. In general, the determined metal levels were below average shale concentrations and Effects Range / Low (ERL) values specified in the quality guidelines (Turekian & Wdepohl, 1961. The highest aluminum and copper levels were measured in lake sediments, while marine sediment samples contained the highest values for cadmium and copper. For the other metals, the maximum concentrations were measured in the soil samples (especially S3). Mercury was not detected in any of the samples.

Table 4-6. Metal levels in soil and sediment samples (µg/g dry weight).

Metal	LS1	LS2	LS3	S1	S2	S3	S4	MS1	MS2	MS3	MS4	MS5
Al	69455	62509	61851	63350	42822	59493	63094	56944	48270	49871	40604	40512
As	4.7	3.8	4.7	3.6	2.7	6.1	3.0	6.1	4.9	2.2	2.3	2.8
Cd	0.18	0.14	0.09	0.33	0.12	0.27	0.11	0.86	0.51	0.11	0.02	0.02
Co	11	12	9.2	11	9.2	14.9	10	5.8	6.4	11	2.8	2.6
Cr	43	41	30	38	31	49	26	18	20	26	7.3	9.0
Cu	19	17	28	16	16	24	21	21	17	13	11	7.9
Fe	39567	36674	36190	37741	31816	46329	41149	21966	25388	38366	12622	13459
Li	16	18	12	18	15	25	18	7.3	6.0	8.5	8.1	6.3
Mn	601	642	607	658	545	824	896	507	471	669	203	278
Ni	12	13	10	12	10	19	14	7.3	8.5	11	3.3	3.5
Pb	20	18	20	25	24	21	22	11	11	15	15	13
V	103	97	95	96	77	109	80	64	71	121	23	24
Zn	90	103	79	95	84	139	88	71	79	72	50	51
Hg	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl

*bdl: Below detection limit

In addition, total organic carbon (TOC) content of the samples were analyzed in CHN analyzer. TOC content changed between 4.3-5.9 % for lake sediments, 5.0-6.6 % for marine sediments, and 6.0-7.7 % for soil samples.

4.4 Glaciology and Sea Ice

In the study conducted by Yıldırım (2020), the geomorphologic evaluation of Horseshoe Island analyzed the type and distributional variances with regards to glacial & peri-glacial landforms. The island mainly consists of 3 geomorphological sections of which the northern and southern sectors are still under the influence of glaciers. A non-erosive ice cap covering the northern sector does not show typical glacial features. On the contrary, the southern sector is shaped by sediment-covered and tide-water glaciers, namely, the Shoesmith Glacier.

Marguerite Bay is surrounded by Adelaide Island on the north & west, by Loubet Coast and Fallieres Coast on the east, by the Wordie Ice Shelf and Alexander I Island on the south. The northern and north-eastern parts of the bay contain a complicated system of fjords which produce a lot of icebergs. The tidal currents carry ice in and out of the bay. Gaul Cove located in north-eastern part of Horseshoe Island is usually blocked by icebergs and sea ice. Lystad Bay is usually clear of icebergs and sea ice during the summer season. Entrance of the Marguerite Bay lay on the southern extremity of Adelaide Island and northern extremity of Alexander I Island. Vessels sailing from the northern parts of the peninsula pass through the Adelaide and Avian islands.

Sea ice, being an important factor in decision-making on maritime operations and logistics, is one of the prominent indicators of climate. Sea ice has been monitored using satellites for more than 40 years (Figure 4-12). Daily sea ice data starting from 1970's and available ASPeCt (Antarctic Sea Ice Processes & Climate) in-situ data have been collected and examined. Increasing global temperature and changing climate affect sea ice coverage to a dramatic decrease. Coverage and thickness are two main properties of sea ice regarding logistics. According to available data, sea ice formation in the Marguerite Bay starts in the first half of June (Kern et al., 2016). It reaches up to 10/10 coverage, 60 to 70 cm thickness with 20 cm of snow cover in the winter. Sea ice starts to melt in late October each year. In the second half of December, sea ice thickness decreases to 10 cm with 5/10 coverage. In the first half of January, sea ice in the northern parts of Marguerite Bay mostly disappears. Variation in the sea ice coverage throughout the year is thoroughly considered during the design, construction, and operation of TARS.

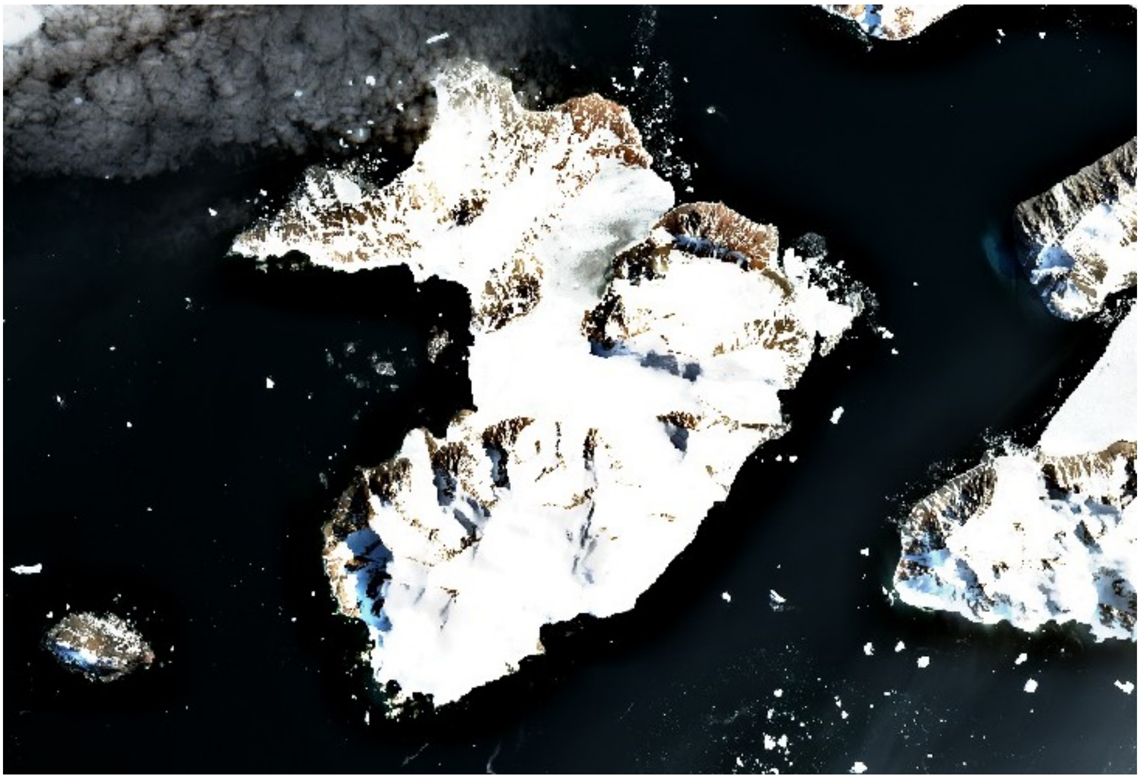

Figure 4-12. Satellite image of Sentinel 2 - L2A as of January 9th, 2021 (Sentinel, 2021)

4.5 Climatic Conditions

Global database regarding the climatic design conditions of the world, which also covers the continent, can easily be accessible at ASHRAE (2020). In TAE-III, an automatic weather station (AWS) was established in 2019 at Horseshoe Island, where recent short-term climatic data has been obtained. The available long-term meteorological data belonging to San Martín Base of Argentina, and Rothera Station of the UK and has been utilized within the scope of the Draft CEE Report. It is seen that simultaneous recordings belonging to year 2019-2020 comply with the data of the AWS, therefore, both Argentina and the UK data is considered to represent the project site.

Based on the meteorological data of the San Martín Base of Argentina for 1990-2014, the lowest and highest temperatures measured were recorded as -30.5 and 8.9 °C, respectively, with an average annual temperature of -4.6 °C. The annual average wind speed during this period was reported as 4.6 m/s, while the monthly average wind speed changed between 4.1 and 5.2 m/s.

According to the meteorological data obtained from the UK Rothera station for the long-terms of 1976-2021, it was observed that the monthly mean temperatures were ranging from -20.5 to 2.7 °C. Within this period, the lowest temperature was measured as -39.5 °C in August 1980, while the highest value was recorded as 8.7 °C in January 2003. The monthly mean wind speeds varied between 2.4 and 12.3 m/s for the same period of time, where the average speed was calculated as 6.2 m/s, and the highest value was recorded as 46.2 m/s in August 2008.

For a better overview on the meteorological data of the last decade, air temperature covering the period extending from June 2010 to July 2020 is provided in Figure 4-13. The minimum value is -28.9 °C as observed in July 2019 while the maximum is 5.2 °C as in February 2020. The daily mean for temperature is -3.9 °C for the decade. Similarly, Figure 4-14 provides the daily means of wind speeds during the same period. The minimum value is 0 m/s with no wind observed in various times around the year, the maximum value is 24.3 m/s, whereas the 10-year average of the daily means corresponds to ~6.4 m/s. The wind direction graph has been plotted on Figure 4-15 which shows that the prevailing wind direction is in the north-northeast direction. The short-term findings of the AWS provides that the wind direction for the project site is east-northeast.

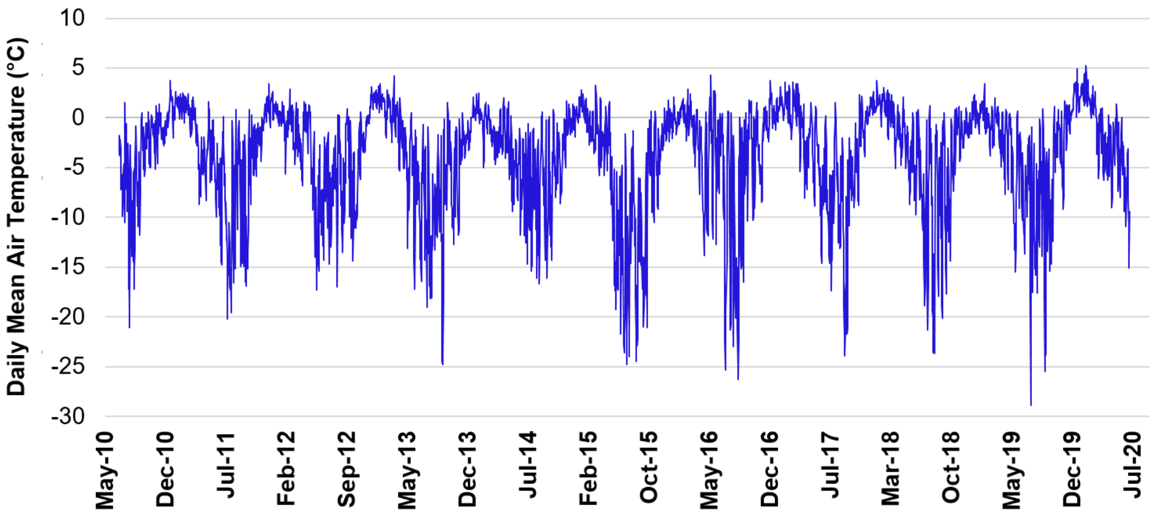

Figure 4-13. Daily mean of air temperatures for 2010-2020 (Rothera, 2020)

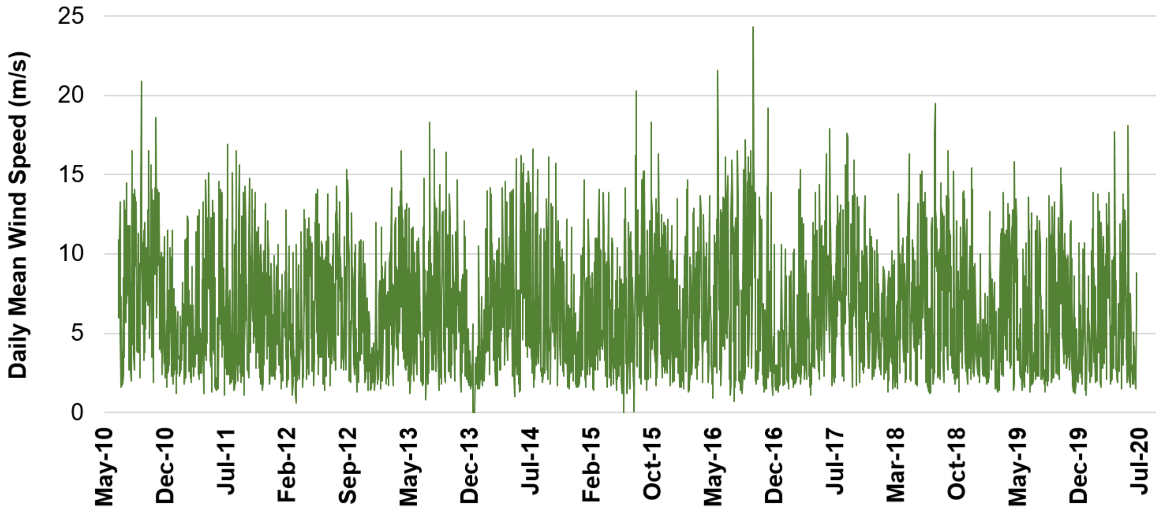

Figure 4-14. Daily mean of wind speed for 2010-2020 (Rothera, 2020)

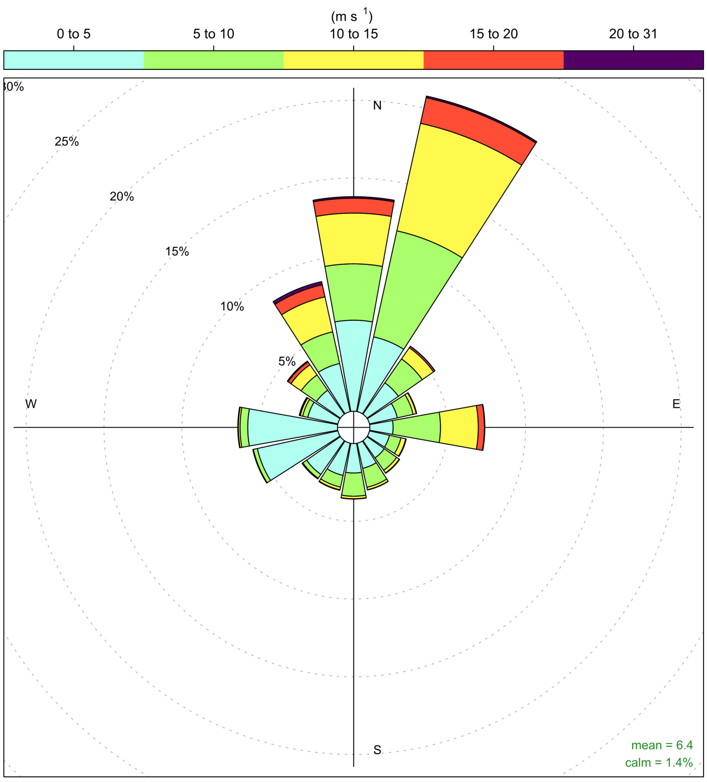

Figure 4-15. Wind direction for 2010-2020 (Rothera, 2020)

Finally, using the satellite data, the maximum snow accumulation is given in Figure 4-16 within 2018-2019, whereas this maximum value is estimated as 180 cm at the project site.

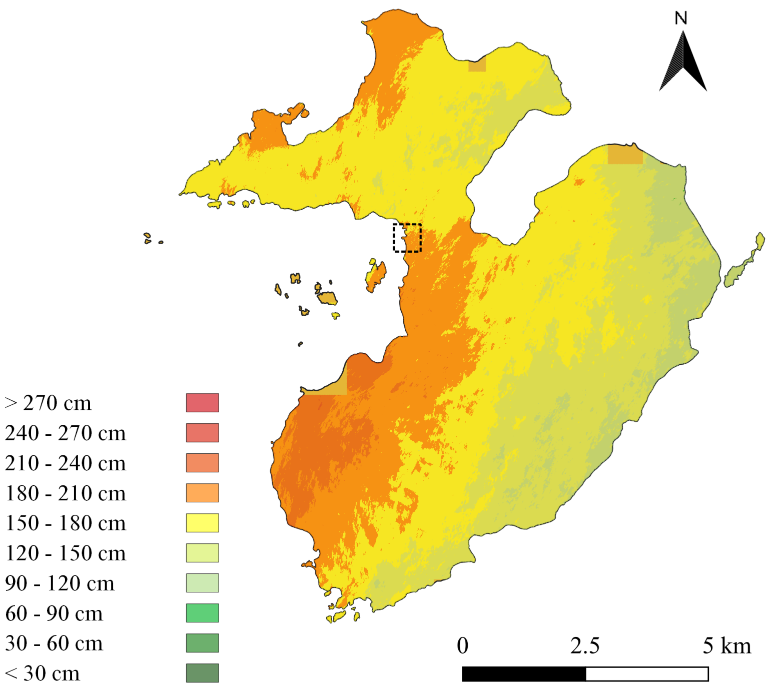

Figure 4-16. Maximum snow accumulation in Horseshoe Island in 2018-2019

4.6 Flora and Fauna

During the previous TAE surveys, limited flora and fauna was observed at the project site, as the island is not a vitality spot. This is one of the supporting arguments for choosing the site location. Nevertheless, the habitat of all local organisms will be taken into account, location of species and dates significant to local habitat will be recorded.

4.6.1 Flora

Species of moss, lichen and other vascular plants were not observed at the project site during TAEs. On the other hand, various lichen and moss species have been observed on the rocks with increasing altitude in the north-east direction. The presence of vascular plants could not be detected at any point on the island. Lichens observed during TAE surveys is given in Figure 4-17 as an example.

Figure 4-17. Lichens observed in Horseshoe Island during TAE surveys

Moss and lichen have been recorded in the British Antarctic Survey database (BAS, 2020) as provided in Annex III. Especially during the TAE-III visit (2019), Horseshoe Island was extensively surveyed for the two terrestrial plant species reported for Antarctica, *Colobanthus quitensis* (Kunth) Bartl. and *Deschampsia* Antarctica Desv (BAS, 2020). However, neither of these plant species were observed.

Casanovas et al. (2013) studied the patterns of moss and lichen species diversity on the Antarctic Peninsula where data from the existing databases and additional published recordings had also been used. They reported the species richness for lichen and moss for Horseshoe Island, including 17 and 12 species, respectively.

Marine species have been investigated by Mystikou et. al. (2014) regarding the diversity of seaweed species of the south-western Antarctic Peninsula. Combining data from surveys completed in 1973–1975 and a 6-week intensive diving-based field study in 2010–2011, they presented a baseline seaweed species checklist for the Marguerite Bay region. This checklist included the following taxa for Horseshoe Island: *Lithoderma Antarcticum* Skottsberg (Phaeophyceae), *Mesophyllum* sp. Me. Lemoine (Rhodophyta), *Phyllophora Antarctica* A.Gepp and E.S. Gepp (Rhodophyta), *Plocamium hookeri* Harvey in J.D. Hooker and Harvey (Rhodophyta), *Porphyra* sp. C. Agardh (Rhodophyta) and *Sarcodia* sp. J. Agardh (Rhodophyta).

The Antarctic Treaty's Visitor Site Guideline of Horseshoe Island (No. 24) describes it as a small rocky island in Bourgeois Fjord at Marguerite Bay, where 29 species of lichen and 15 species of moss have been reported (Visitor Site Guideline, 2020).

Two Turkish scientists have recently published initial findings of their studies. Özçimen et. al. (2020) studied the isolation and identification of certain microorganism species collected from the Skua Lake, while Cura (2020) detected diatom species from 3 different lakes (including Lake 1 & 3). She defined diatoms as silica-shelled eukaryotic aquatic phytoplankton's that are one of the most important organisms due to their roles in various biogeochemical processes in the carbon cycle. In this study, Antarctic lakes were examined for diatom species diversity by using both microscopic and molecular methods. Lake water and sediment samples from 14 lakes that were located in the two Antarctic islands, including Horseshoe Island, were used for the identification of diatom species. The last sampling expedition was realized in 2020 where sediments and water samples of the lakes were collected. Horseshoe Island samples put forth that the lakes were bearing the lowest diatom abundance and variety (Cura, 2020). A total of 96 taxa belonging to 23 genera and 73 species were recorded from King George and Horseshoe Islands. The most common diatom genera were Planothidium, Achnanthidium, Nitzschia, Fragilaria, and Pinnularia. *Achnanthidium dolomiticum, Nitzschia homburgiensis, Planothidium lanceolatum, Craticula pseudocitrus, Fragilaria capucina,* and *Pinnularia brebissonii*. The identified species were pennate diatoms. The sizes of diatoms ranged between 3-50 μm in length and between 3-40 μm in width. Lake sediment samples showed more diatom species compared to the lake water samples, as a result of accumulation of settled diatom shells. The diatom frequency was quite low in water samples (Cura, 2020).

Early studies on Horseshoe Island date back to the beginning of 1990s. Hansson & Hannelore (1992) have completed a diatom community response study on shallow Antarctic lakes including 2 lakes from Horseshoe Island with separate drainage areas, and had no connection with each other. Sampling was undertaken during the Swedish Antarctic Expedition in 1989. Lakes were visited between the February 15- March 15 when they were ice-free. The 2 lakes on Horseshoe Island, had only 9 and 11 diatom taxa, which was significantly fewer than the other 25 Antarctic lakes investigated with the scope of the study (Hansson & Hannelore, 1992).

Wasel (1990) studied the diatom-stratigraphy in the sediments of Skua Lake. During the Swedish Antarctic expedition (1988/89), several lakes were cored and sampled for reconstruction of polar depositional environments. The vegetation found around the lake consisted of only a few crustose lichens. In one of the longest cores sampled, diatom assemblages were analyzed at approximately every 6 cm. The lowermost part shows a presence of marine diatoms, both neritic, and sea ice species. The start of limnic conditions in the sediment core (20-0 cm) is marked by a peak in the frequencies of *Gomphonema angustatum*, *Rabenhorst*, *Cocconeis japonica*, *A. Cleve*, and *Fragilaria virescens* Ralfs.

4.6.2 Fauna

The Antarctic Treaty's Visitor Site Guideline of Horseshoe Island (No. 24) states that the occasionally confirmed breeders are brown skua and kelp gull (Visitor Site Guideline, 2020). In the TAEs conducted during February-May period, nearly 100 Adélie penguins (*Pygoscelis adeliae*) were seen as scattered in different parts of Horseshoe Island (Figure 4-18). Penguins were not observed at the project site in any of the TAEs. Breeding locations for birds or seals were not seen at the project site. On the island, seabirds are confined to brown skua (*Stercorarius Antarcticus*), Antarctic tern (*Sterna vittata*), and Antarctic imperial shag (*Phalacrocorax bransfieldensis*). A few shags were also detected on the coast.

Figure 4-18. Adélie penguins on Beacon Head at Horseshoe Island

Weddell (*Leptonychotes weddellii*), crabeater (*Lobodon carcinophaga*), and Antarctic fur seals (*Arctocephalus gazella*) were observed on the western coast of Horseshoe Island. On the east coast of the island (Gaul Cove), leopard seals (*Hydrurga leptonyx*) were rarely seen.

On March 1989, a herd of arctic terns were recorded moving north close to Horseshoe Island on what was considered as a migration route by Gudmundsson et. al. (1991). Milius (2000) studied the birds of Rothera on Adelaide Island. According to the study, a group of 4 arctic terns *Sterna paradisaea* were seen on March 1998; identified by the whiteness of the breast and belly, and the broad white trailing edge to the secondaries.

One of the scientific observation activities of TARS is to develop the map of local bird routes, and continue periodic tracking. It should be noted that all flora and fauna in and around the project site will be periodically observed, surveyed, and recorded upon the operation of TARS.

4.7 Previous Human Activities

The project site or its close proximity have never been used as a research station in the past. Turkish scientists were surveying to the area for the past 4 years within the context of TAEs (2017-2020). The Temporary Scientific Research Camp was established in 2019. Other possible human-induced activities in the region might be touristic visits and/or Antarctic camping activities. Some camping residues were found and recorded in TAE-I which seemed to remain from a campground of the 1980s.

4.8 Special Areas

The UK's Base Y is designated as a Historic Site and Monument (HSM No. 63). It is located on a small peninsula at the north-western end of Horseshoe Island overlooking Sally Cove. It is noteworthy as a relatively unaltered and well equipped British scientific base of the late 1950s. It was occupied continuously from March 1955 to August 1960, and re-opened for a 4-month period in 1969 (Visitor Site Guideline, 2020). This base that is under protection by ATS is open to island visitors as a museum as of today. It is ~4 km away from TARS in its northwest direction. It is important to indicate that the project site is not visible to Base Y even under optimum weather conditions due to distance and elevated topography.

The Lagotellerie Island has been designated as a protected area (ASPA-115) because of its relatively diverse flora and fauna. The island, which approximately 9 km away from TARS, is of importance especially due to its local bird species. It has been designated as an Important Bird Area by Birdlife International (IBA, 2020) as it supports around 270 breeding pairs of Antarctic shags and 81 pairs of south polar skuas. However, no current data exists indicating that the project site is located under the migration route of the birds. One of the scientific observation activities of the planned research station is to develop the map of local bird routes.

The Avian Island, located in the south of Adelaide Island, is in the west-northwest direction from Horseshoe Island at 70 km distance. As stated in the related management plan pertaining to ASPA-117, Avian Island is the southern limit of breeding range of birds, namely, southern giant petrels (*Macronectes giganteus*), blue-eyed cormorants (*Phalacrocorax atriceps*), the kelp gull (*Larus dominicanus*), brown skuas (*Catharacta loennbergi*). Therefore, the presence of a migration route for these bird species directly passing over Horseshoe Island is of low probability.

5 PREDICTION OF IMPACTS, EVALUATION AND MITIGATING MEASURES OF THE PLANNED ACTIVITIES

The environmental impacts of TARS including direct, indirect and cumulative impacts have been evaluated in this Draft CEE Report for covering the construction and the operation phases. Protocol on Environmental Protection to the Antarctic Treaty & its Annexes, RIPEPAT, and domestic legislation on the control of air quality, noise level, water and wastewater treatment, and solid waste management will be taken into consideration at TARS. Mitigating measures were accordingly given under sections below.

5.1 Construction Phase

5.1.1 Air Quality

As the majority of the manufacturing and fabrication will be completed in Turkey, available for modular-type transfer, construction time will be minimized, and in turn the emission release to the atmosphere will be limited. Main air emission of TARS will arise from; marine transportation, generator used for camp and facilities, construction equipment and vehicles. Fossil fuels will generate usual combustion by-products; such as, CO, NO_x, SO_2, CO_2, and PM10 (Particulate Matter). The impact of such emissions is expected to be low. However, emissions are cumulative and may contribute to local and regional atmospheric pollution. The predicted air emissions generated through all construction activities are given in Table 5-1 with details provided in Annex IV.

Table 5-1. Overall predicted emissions generated during construction (tons)

Source	CO	NO_x	SO_2	PM10	CO_2
Marine transportation	0.40	5.86	0.37	0.51	245.60
Generator used for camp and facilities	0.38	5.57	0.35	0.49	233.32
Equipment and vehicles	0.18	2.58	0.16	0.23	108.06
Total	0.97	14.01	0.89	1.22	586.98

Emissions during shipping will be dispersed and are expected to pose minor impacts on air quality. Emissions are cumulative and may contribute to regional and global atmospheric pollution.

Mitigating Measures

All vessels to be used for logistics of TARS will use AD as a highly refined fuel. Temporary generators and vehicles used during the construction phase will also be periodically maintained to reduce air emissions. Construction machinery will be selected based on their fuel efficiency and environmental performance. None of them will be left idle to reduce emissions, and operators will be trained on this fact. Proper equipment and logistics planning will enable efficient use of vehicles for all construction activities. Catalytic converters will be fitted, where practical. The construction camp will be highly insulated to minimize energy loss.

5.1.2 Wastes

The construction activities are expected to generate mostly non-hazardous solid waste, such as, packaging materials, metal, and plastics. Some hazardous wastes, including adhesives and waste oil, will also be generated. The amount of annual waste oil is estimated to be 1.3 m^3. The maximum daily amount of domestic solid waste are estimated to be 0.13 tons. As modular design is preferred, the expected amount of construction waste will be highly reduced compared to the conventional construction methods.

Waste materials may be blown by wind, covered by snow or scavenged by birds, if not stored properly. Inappropriately handled waste may have some negative effects on the fauna.

Mitigating Measures

All wastes, will be cautiously sorted, packaged, labelled at source, secured and removed from Antarctica. It will be reused, recycled and/or disposed of safely by licensed contractors.

The site will be kept tidy to ensure that materials are not intentionally become buried in the snow. Waste materials will not be left outdoors or be in contact with the local fauna. Thus, any probable negative impacts will be highly reduced.

Waste hierarchy will be followed to minimize effects regarding waste; such as, minimization (modular type design), reduction of packaging waste, sorting at source, and storing in appropriate containers. One member of the staff will be responsible for waste management during construction who will also be responsible for routine inspections to avoid spreading of any waste in and around the construction area. Prohibited products will not be shipped to Antarctica as listed in the Protocol on Environmental Protection to the Antarctic Treaty Annex III.

5.1.3 Wastewater

The maximum daily amount of wastewater that may originate during construction phase will be around 10 m^3 (100 L/capita.day x 0.80 x 130 capita). However, wastewater will actually be expected to be less than this value due to energy and resource-conscious life standards prevailing in Antarctica.

Mitigating Measures

Direct on-site disposal of untreated wastewater will be absolutely prevented; and it will be treated in a package-type wastewater treatment system with sufficient capacity.

5.1.4 Noise

Noise will be generated during the transportation of cargoes from vessel to project site, machinery and equipment operations and from other similar activities. During the construction of TARS, the loudest activity will be during the excavation for the foundation works on the ground. Therefore, minimum excavation works are planned for the foundations of the supporting branches of the building. Construction activities will result in noise pollution especially around the main building site.

Birds and sea mammals might be affected by noise. However, there are no colonies of skua, seal and penguins on Horseshoe Island. Thus, significant noise effect is not expected on rarely found fauna nearby the project site during the temporary construction phase.

Along with noise, vibration is an equally important parameter that may disturb the living bodies at site. Vibration may arise from the construction site.

Mitigating Measures

As mentioned previously, majority of the pre-manufacturing in modular-type design will reduce noise levels at site. The domestic regulation on evaluation and management of noise (TR, 2010a) states the limit values for noise at construction sites as given in Table 5-2. These limits will be met up to maximum extend during construction by not operating many construction machineries simultaneously, when possible. The compliance with the limit values for noise levels will be taken under control by periodical recordings. In case the upper limits are exceeded, noise generating activity will be reduced/stopped.

Table 5-2. Limit values for noise levels arising from construction sites (TR, 2010a)

Activity	L_{day} (dBA)
Building	70
Paths	75
Other Sources	70

Vehicles will be periodically serviced to minimize noise output and vibration levels. Necessary controls and maintenance of mechanical equipment and tools, especially greasing/lubricating, will be made on a regular basis to prevent possible malfunctions and unusual noises.

5.1.5 Flora and Fauna

Flora and fauna were at minimum coverage, in number and diversity as seen during the previous field studies. Moss species and other vascular plants were not observed at the project site; however, some species were scattered on the rocks with increasing altitude in the north-east direction. No penguins were encountered in the project site. Therefore, the construction work may not affect the surrounding ecosystem significantly.

Significant disturbance to penguins is not expected during shipping operations. Minor disturbance may create a stress on birds and mammals especially during the unloading activity. Another possibility may arise by the movement of the vehicles and construction machinery under operation. Unintentional introduction of non-native species, in particular microorganisms, due to the transportation activities may also be encountered.

Mitigating Measures

All staff will be given guidance on minimizing disturbance to flora and fauna. The contractor will make sure that all necessary measures will be taken to prevent the introduction of non-native species. For example, all equipment is thoroughly cleaned before shipment from mainland, new working outfit & gear will be provided for all construction personnel, outfit and boots will also be disinfected with proper solutions before each landing. Landing and unloading location has been selected to have minimum impact on flora and fauna.

Noise limits will be reduced up to maximum extend during construction by not operating many construction machineries simultaneously. The compliance with the limit values for noise levels will be taken under control by periodical recordings. In case the upper limits are exceeded, noise generating activity will be reduced/stopped.

All necessary health precautions will be taken as recommended by the WHO, including vaccination of personnel against any existing (COVID-19) and/or probable pandemic situations.

5.1.6 Fuel and Oil Spills

Fuels, lubricating and hydraulic oils will be used during the transport and construction stages. The type of fuel to be used during construction is AD. Fuel storage tanks at approximately 30-ton capacity will be located at the construction site. Containers (20 L) will be used during storage and transportation of smaller quantities of fuel. Fuel and oil spills may occur during maintenance and fueling of the vehicles and generators by leakage. The maximum risk is the loss of the fuel container. Vessels offshore could lead to a large fuel spill by accident; however, such a risk is quite low.

Probable spills may have an effect on flora and may also lead to contaminate the surface layer. Fuel spills will contribute to the cumulative effects with time.

Mitigating Measures

Standard procedures of the COMNAP Fuel Manual (2008) will be followed for handling and use of fuels in any kind of activities. These procedures will involve prevention of fuel spills by using the correct equipment at the correct place; such as suitable sorbent mats at the fuel transfer locations. Staff training for minimizing any probable leakages during handling and transfer of fuels will be given in case of oil spills. Oil spill kits on-board will be kept ready for use in case of marine accidents.

An individual Oil Spill Contingency Plan for TARS, based on COMNAP guidelines, and domestic measures given in RIPEPAT, will be prepared for transport, construction and operation. In case of any discrepancy updating of the procedures will be accomplished. All spills will be reported to the Construction Manager, fuel handling and spill response implementations will be self-audited, and will also be recorded for monitoring purposes. In case of an emergency situation, the provisions of the Protocol on Environmental Protection to the Antarctic Treaty will be followed, and the ATS Secretariat will be informed.

Indirect Impacts

The plan will be in accordance with the guidelines for oil spill planning developed by COMNAP. Impacts on the environment will occur in the event of a major oil spill or a large fire. As stringent measures will be taken to avoid such events, the possible risk will be minimized. Therefore, the indirect impacts will be highly reduced.

5.2 Operation Phase

Environmental Management Plans (EMPs) specifically prepared for TARS, covering fire protection, emergency, contingency, and oil spills will be available during the operational phase of TARS.

5.2.1 Air Quality

During the operation of TARS, atmospheric emissions will basically arise from resupply vessel, generators, vehicles, and incinerator. They will include the parameters of CO, NO_x, SO_2, CO_2 and PM10.

The resupply vessel will visit TARS twice a year to bring cargo and passengers to the research station, to remove any sort of stored waste, and collect returning cargo and passengers.

To minimize the use of fossil fuels during operation, TARS has been designed with a low energy requirement focusing on the use of renewable energy wherever possible. There will be a continuous process during the operation to reduce its energy requirement through the application of conservation measures. For example, CHP system will provide electrical power and heat demand of TARS.

A double-chamber incinerator will be used to incinerate food waste and sewage sludge. The operating temperature in the primary chamber will be 1000 °C, whereas the secondary chamber will be kept at 1100 °C to retain the exhaust gases in at least 2 seconds. The quantities of waste which will be incinerated are maximum 10 kg/day dewatered sludge cake and 25 kg/day food waste. The total sum of 35 kg/day will lead to emissions that are of low significance.

Annual emissions during year-round operation of TARS are estimated as given in Table 5-3. Since seasonal operation is planned in the first 2 years, the values will be much lower during this period.

Table 5-3. Predicted annual emissions from consumption during year-round operation (tons)

Source	CO	NO_x	SO_2	PM10	CO_2
Marine transportation (resupply ship)	0.162	2.346	0.149	0.205	98.240
Generator	0.347	5.043	0.320	0.440	211.216
Vehicle	0.002	0.035	0.002	0.003	1.474
Total	0.511	7.424	0.471	0.648	310.930

All emissions from the described activities affect air quality. The overall impacts are expected to be low, however, the emissions are distributed over longer time spans.

The predicted impacts may affect the species through the contamination of surface layer. Emissions during shipping will be dispersed and are expected to pose minor impacts on air quality. Emissions are cumulative and may contribute to regional and global atmospheric pollution.

Mitigating Measures

Environmental considerations will be taken into account during all operational activities. For example, the resupply vessel will use AD and comply with the provisions of MARPOL Annex VI on air emissions. The main engine of the vessel will be stopped and the generator will be used during anchoring to limit fuel consumption. The stay of the resupply vessel will be kept at minimum.

Only two vehicles will be in use during the operation phase. In order to reduce the emissions, the vehicles will be selected considering low emissions and the use of catalytic converters will be preferred. TARS will maintain generators to the highest standard. Operations will be planned carefully to ensure the most effective use of vehicles, particularly during unloading. Their periodical maintenance will be provided in compliance with manufacturer standards.

TARS has been designed to minimize snow management by its aerodynamic shape, size, orientation and coating. The main building will be located within the close vicinity of other units. This will minimize the dependence on vehicles, and allow staff to walk. Power consumption will be monitored. Interior design will maximize the use of daylight. Energy saving controls will be applied in the facilities, including the kitchen and the laundry. For example, one floor of the main building allocated for accommodation purpose will be completely closed during winter period. Similarly, laboratories that will not be in use for a certain time, will be heated to frost-free temperatures. All the equipment and machinery in the station will be selected from highest energy-saving class.

Emissions from the incinerator will be reduced by integrating a wet scrubber system. Flue gas emission limit values given in the domestic Incineration of Wastes Regulation (TR, 2010b) will be complied with during its operation (Table 5-4).

Table 5-4. Flue gas emission limit values (TR, 2010b)

Parameter	Daily average values
Total dust	10 mg/m^3
Gaseous and vaporous organic substances, expressed as TOC	10 mg/m^3
Hydrogen Chloride (HCl)	10 mg/m^3
Hydrogen Fluoride (HF)	1 mg/m^3
Sulphur Dioxide (SO_2)	50 mg/m^3
Nitrogen Monoxide (NO) and Nitrogen Dioxide (NO_2), expressed as nitrogen dioxide	400 mg/m^3

The limits stated in the domestic regulation in compliance with EU on management of air quality (TR, 2009) will also be adhered to during operation of TARS. The limits for emissions are given in Table 5-5.

Table 5-5. Limit values for emission parameters (TR, 2009)

Pollutant	Average period	Limit value
SO_2	Hourly	350 µg/m^3
	Daily	125 µg/m^3
	Yearly	20 µg/m^3
NO_2	Hourly	200 µg/m^3
	Yearly	40 µg/m^3
NO_X	Yearly	30 µg/m^3
PM(10)	Daily	50 µg/m^3
	Yearly	40 µg/m^3
CO	8-hourly	10 mg/m^3

Oil spills that may result in air emissions will be carefully recorded and the clean-up procedures will be implemented in time based on the Oil Spill Contingency Plan. In case of an emergency situation, the provisions of the Protocol on Environmental Protection to the Antarctic Treaty will be followed, and the ATS Secretariat will be informed.

All emissions from the combustion of fuels in connection with the described activities at TARS affect air quality. The overall impacts are low; however, the emissions are distributed over larger areas, and time spans are longer.

5.2.2 Wastes

TARS has been designed taking into account the concepts of sustainable development, efficient energy consumption, and effective waste disposal, with a minimum lifetime of 25 years. A Waste Management Plan (WMP) will be prepared that will comply with all the requirements of Annex III of the Protocol on Environmental Protection to the Antarctic Treaty. The plan will comprise of waste hierarchy steps including prevention, reduction, source separation, reuse, recycling, and final disposal of waste away from the continent, and training of staff. One member of the staff will be responsible for waste management during operation who will also be responsible for routine inspections.

During the operation of TARS, both non-hazardous and hazardous solid waste will eventually be generated. The most appropriate products would be selected to limit the amount of hazardous wastes. In buildings the wastes will be collected in designated areas. One of the rooms in the main building will be allocated for waste storage including different types of bins labeled. The waste storage areas will be cleaned and inspected regularly. Successively, the bins will be emptied in larger transport boxes which will be removed when a resupply vessel is organized.

Mitigating Measures

None of the solid wastes will be disposed of into the environment. The amount of hazardous waste (e.g., originating from the laboratories) will be kept to an absolute minimum. Hazardous liquid waste will be collected in separate containers and stored in a waste storage room in specially designated containers until removal from Antarctica.

A waste compactor will be used to compact the recycling waste which will be hauled away by the resupply vessel on its return. Food waste is planned to be transferred to the incinerator for combustion along with the dewatered sludge cake. Special care will be given to the storage of food waste as any food items left outside may be scavenged by birds. The incinerator has an operating temperature of 1000°C in the primary chamber, and 1100°C in the secondary chamber. The second chamber is designed to retain the exhaust gases in at least 2 seconds. Combustion slag/ash will be collected separately and will be removed from the continent by vessels along with other wastes.

5.2.3 Wastewater

Almost 80 % of the domestic water used will be generated as wastewater. Based on 135 L of daily water consumption per capita during the operation phase of TARS, wastewater per person per day will be approximately 100 L. Pollution of wastewater will be minimized by using limited quantities of eco-friendly (biodegradable and low Phosphorus) detergents and cleaning agents. Treated effluent will be recycled and reused in toilet flushing. Therefore, water consumption will be highly reduced.

Mitigating Measures

The excess treated effluent will be discharged to the sea from the surface layer. In this way, the ice masses that can pile up towards the shore will not be able to damage the pipe. The wastewater discharge point has been chosen as being far from other buildings and as the shortest distance between the treatment center and the sea.

The discharge limits of advanced treatment effluents arising from wastewater treatment systems are TN = 15 mg/L and TP = 2 mg/L. The projected COD will be less than 70 mg/L. These stringent levels will thereby minimize the impact on marine environment. The biological sludge will be transferred to the incinerator for further combustion after dewatering.

5.2.4 Noise

The use of generators and mechanical equipment may also exert noise; however, significant noise levels will not be expected as these units will be installed in closed areas. Therefore, limited disturbance to the birds may be of concern. The operation of vehicles and resupply vessel will also generate noise, but their impact will be in limited scale and temporary. The vertical-axis wind turbines are also expected to significantly generate lower noise levels (36 dBA) compared to equivalent horizontal-axis turbines. The impact of noise will logarithmically decrease by distance.

Along with noise, vibration is an equally important disturbance parameter that may disturb the living bodies at site. Vibration may arise from all mechanical equipment including the generator.

Mitigating Measures

Noise absorbing materials will be installed in the energy center. All staff will be given guidance on minimizing disturbance to fauna. The domestic environmental standards in compliance with the EU regulations will be considered as strict criteria of ecosystem and human health protection, and well qualified for application to the Antarctic environment (TR, 2010a). Recording of the annual noise level measurements for at least one year, will be used for generating the noise distribution map of TARS. In case of exceeding the limit values, the noise sources will be detected and required measures will be implemented.

In order to reduce the effect of vibration, isolators will be installed on the mechanical equipment, and noise cassettes will be used for the generators. A muffler will be used in order to decrease the noise arising from exhaust of generator.

5.2.5 Flora and Fauna

Previous TAE surveys put forth the reality that the project site and its vicinity lack a rich flora and fauna. In that respect, the site bears advantages regarding the disturbance of any habitat. The operation of TARS will have limited effect on the biotic environment. As expected, disturbance may occur during the shipping operations especially on marine life. As far as it is known, there exists no breeding areas for sea mammals at the selected unloading location. There is a minor risk of the accidental introduction of non-native biota, in particular microorganisms, because of the transportation of humans and materials.

Mitigating Measures

The provisions in the Annex II of the Protocol on Environmental Protection to the Antarctic Treaty, and Non-Native Species Manual (2019) manual will be strictly complied. Staff will be given guidance on minimizing disturbance to all the living bodies. In order to prevent the introduction of non-native species, TARS management will ensure that all equipment is cleaned before shipment, and all provision supplies are controlled and packed with care. Landing and unloading location has been deliberately selected to pose minimum impact on wildlife. Probable future scientific visits to nearby sensitive areas by TARS staff will be limited during breeding seasons, and all staff will be given guidance on minimizing disturbance to flora and fauna.

Noise limits will be reduced up to maximum extend during operation. The compliance with the limit values for noise levels will be taken under control by periodical recordings. In case the upper limits are exceeded, noise generating activity will be reduced.

All necessary health precautions will be taken as recommended by the WHO, including vaccination of personnel against any existing (COVID-19) and/or probable pandemic situations.

5.2.6 Fuel and Oil Spills

Fuels, lubricating and hydraulic oils will be used during the operation TARS. The type of fuel to be used during operation is AD, and it will be pumped to fuel tanks from the resupply vessel. The fuel piping network within TARS will be fully automatic. Containers (20 L) will be used during storage and transportation of smaller quantities of fuel.

Fuel and oil spills may occur during maintenance and fueling of generators and vehicles. The highest risk may arise from any discrepancy that might occur at the fuel tank. Any sort of damage to the resupply vessel could lead to a large fuel spill. However, the occurrence rate of this circumstance is quite low. Therefore, no significant environmental impact is likely to take place.

Probable spills may have an effect on flora and may also lead to contaminate the surface layer. Fuel spills will contribute to the cumulative effects with time.

Mitigating Measures

Standard procedures will be developed for the transport, handling, transfer and use of fuels. These procedures will include fuel spill prevention, use of correct equipment (such as sorbent mats), minimizing handling and transfer of fuels, double-walled containment with leakage detection system in-between, and staff training. The fuel tanks will be placed on an impermeable surface. The design of fuel tanks allows for minimizing adverse effects on the environment, such as snow build up on valves and fittings, and from accidents caused during operational activities. Minimization of spills during fueling will be managed by using suitable sorbent mats at the fueling points, spill containment, and clean-up equipment.

An individual Oil Spill Contingency Plan for TARS, based on COMNAP guidelines, and domestic measures given in RIPEPAT, will be prepared for transport, construction and operation. All spills will be reported to the Station Chief, fuel handling and spill response implementations will be self-audited, and will also be recorded for monitoring purposes. In case of any discrepancy updating of the procedures will be accomplished.

Standard procedures of the COMNAP Fuel Manual (2008) will be followed for handling and use of fuels in any kind of activities. These procedures will involve prevention of fuel spills by using the correct equipment at the correct place; such as suitable sorbent mats at the fuel transfer locations. Staff training for minimizing any probable leakages during handling and transfer of fuels will be given in case of oil spills.

Indirect Impacts

The plan will be in accordance with the guidelines for oil spill planning developed by COMNAP. Impacts on the environment will occur in the event of a major oil spill or a large fire. As stringent measures will be taken to avoid such events, the possible risk will be minimized. Therefore, the indirect impacts will be highly reduced.

5.3 Closure Phase (Dismantling)

Dismantling of the research station will be realized according to the ATS, and the updated versions of the Protocol on Environmental Protection to the Antarctic Treaty & its Annexes, and Antarctic Clean-up Manual of the time. It is important to conduct environmental monitoring after dismantling at the area in order to measure any of the probable impacts following closure phase.

After TARS is out of service, approximately 40 staff will be able to dismantle in 2.5 months. The dismantling steps will be as follows:

- Dispatching necessary staff and equipment for dismantling process to the island,
- Removal of mobile units and inner equipment and furniture,
- Cutting off electrical and mechanical connections,
- Removal of modules and steel load bearing system in a successive manner starting from the top floor,
- Levelling off the ground when reached to the ground floor,
- Transportation of the dismantled modules and other units to barges using crane and transporters of sufficient capacity,
- Transferring them to vessel via barges.

Modular system offers fast and practical solutions either at the installation or dismantling stage. After having stripped of related connections, dismantling process may be accomplished by cranes in a systematic manner. Considering that working season is short in the island, the practicality of modular system presents fast dismantling procedure.

5.4 Cumulative Impacts

A cumulative impact is the combined impact of past, present, and possible future activities. These impacts can be cumulative over time and space. Emissions due to construction and operation of TARS are detailed in Section 5.1.1 and Section 5.2.1. These emissions are cumulative and contribute to local, mid-regional, and regional levels of pollution. Combined effects are limited to the relatively short times and usually occur when more than one activity is conducted at the same time during the operation of TARS.

Cumulative impacts will mainly arise from emissions to air and discharge of excess effluent to the sea. Emissions generated by fuel consumption will impact air quality directly, which may in turn, affect water, snow, and ice in the long run. Emissions may cumulatively affect the overall air quality. However, these emissions will disperse rapidly with the wind effects. Thus, cumulative impacts may be regarded as insignificant.

The effluent arising from the treatment of wastewater may cause some marine risks which may impact the sea flora and fauna if a proper treatment cannot be achieved. However, the risk will highly be eliminated as the amount of effluent will be comparatively low since part of it will be recycled and utilized for toilet flushing. Additionally, high level of wastewater treatment will be accomplished. Thus, cumulative impacts on marine environment will be limited.

5.5 Impact Matrix

Environmental impacts of the construction and operation activities of TARS are given in Table 5-6 and Table 5-7, respectively. The resulting environmental impact of each activity is identified. The probability, extent, duration, and significance of these impacts are ranked with respect to the criteria below:

Probability: Unlikely / Low / Medium / High /Certain

Extent:

- Site specific (near the construction site)
- Local (around 1 km Radius from the project site)
- Mid-Regional (around 5 km Radius from the project site, accepted as Horseshoe Island boundaries)
- Regional (around 10 km Radius from the project site)
- Continental (Antarctic Continent)
- Global (Worldwide)

Duration:

- Very Short (-days)
- Short (weeks-months)
- Medium (years)
- Long (decades)
- Overlong (centuries)

Significance:

- Very low (almost no impact)
- Low (very little)
- Medium (average)
- High (significant)
- Extremely high (serious)

Table 5-6. Impact matrix for construction

Activity	Output	Predicted impact	Probability	Extent	Duration	Significance	Mitigation measures
Shipping and landing	Atmospheric emissions	-Cumulative impacts on air quality	High	Regional	Long	Low	-Strictly follow up of IMO regulations -Use of AD as a highly refined fuel
		-Contamination of surface layer and ecosystems	Low	Regional	Long	Very low	
	Fuel spills and hazardous wastes generation	- Marine pollution	Medium	Site Specific	Short	Medium	-Utmost care given during re-fueling -Keeping of oil spill kits on-board ready for use in case of any local oil spills
	Non-hazardous wastes and wastewater generation	-Marine pollution	Low	Site specific	Short	Very low	-Handling of wastes and wastewater in accordance to the MARPOL requirements -All vehicles, equipment, outfit, boots, and gear to be cleaned before shipment
		-Introduction of non-native species	Low	Site specific	Short	Very low	
Construction of the research station	Topographic change	-Land disturbance during foundation work	Medium	Site specific	Very short	Very low	-Application of foundation techniques without piles or anchors -Minimum connection to ground with precast concrete foundations, -Minimization of impact by limiting site footprint area
		-Land disturbance during land levelling	Low	Site specific	Short	Low	
	Path construction	-Land disturbance during land levelling	Medium	Local	Short	Medium	-Limiting number of facilities and vehicles within the site -Most operations carried on foot between closely located units -Minimization of damage by considering topographical features
		-Disturbance to panoramic view and aesthetic natural values	Medium	Local	Long	Low	
	Mobility of equipment	-Disturbance to ground surface	High	Site specific	Short	Medium	-Limiting transfer paths of equipment
	Atmospheric emissions	-Contamination of ground surface	High	Mid-Regional	Short	Low	-On-site assembling -Selection of construction machinery based on fuel efficiency and environmental performance -Limiting operation of equipment and machineries -Use of high-quality insulating materials -Periodical maintenance of generators and vehicles -Avoiding idling of vehicles
	Fuel and oil spills	-Contamination of snow, soil and rocky surface	Low	Site specific	Long	Medium	-Establishment of Oil Spill Contingency Plan -Utmost care and attention during re-fueling -Keeping of oil sorbents ready for use to prevent spreading of a spill
	Generation of non-hazardous wastes & wastewater	-Contamination of snow, soil and rocky surface	Low	Site specific	Short	Low	-Sorting, collection, and removal of waste from the continent -Application of modular-type system to limit the generation of construction waste -Use of clean outfit, boots, and gear -Periodic inspections at project site
		-Introduction of non-native species	Low	Local	Short	Low	

Activity	Output	Predicted impact	Probability	Extent	Duration	Significance	Mitigation measures
	Generation of noise	-Loss of biodiversity	Unlikely	Local	Medium	Very low	-Periodic use of equipment -Application of low noise and low vibration techniques -Avoiding idling of vehicles -Establishment of a monitoring plan considering for birds and mammals around the island
	Construction equipment & workers	-Disturbance to soil	Medium	Local	Short	Medium	-Using clean construction equipment -Use of clean outfit, boots and gear
		-Introduction of non-native species	Medium	Local	Short	Medium	

Table 5-7. Impact matrix for operation

Activity	Output	Predicted impact	Probability	Extent	Duration	Significance	Mitigation measures
Operation of the research station	Atmospheric emissions	-Contamination of ice, snow and soil	Low	Local	Long	Low	-Use of renewable energy -Reduction of energy consumption using waste heat from the CHP system -Use of high efficiency devices and appliances
	Generation of wastes & wastewater	-Contamination of ice, snow, soil and rocky surface	Low	Local	Long	Low	-Following waste management hierarchy including sorting at source -Periodic inspections at project site -Incineration of food waste and treatment sludge -Limiting use of hazardous materials -Minimization of wastewater by recycling and reuse -Application of stringent water quality standards for treated effluent
		-Potential impact of wastewater	Medium	Local	Medium	Medium	
	Fuel and oil spills	-Contamination of ice, snow, soil and rocky surface	Medium	Site specific	Long	Medium	-Keeping of oil sorbents and clean-up equipment ready for use -Training of the staff on spill prevention and clean-up procedure -Periodic auditing
		-Fuel leakage during fuel transfer	Medium	Local	Medium	Medium	
	Operation of wind turbines	-Disturbance to ecosystem by noise	Low	Local	Long	Low	-Installation of vertical-axis wind turbines to reduce noise & vibration, and minimize bird strike
		-Disturbance to birds' wellbeing	Medium	Local	Long	Low	
		-Bird strike	Low	Site specific	Long	Very low	
Research activities	Observation of flora and fauna	-Disturbance to habitat and breeding activities	Medium	Mid-Regional	Long	Medium	-Limiting access to habitat -Limiting activities apart from scientific studies -Prevention of disturbance by conducting preliminary evaluation of sampling
		-Disturbance caused by sampling	Medium	Local	Medium	Medium	
	Visitors	-Expansion of range by visitors	Medium	Mid-Regional	Long	Medium	-Compliance with the General Guidelines for Visitors to the Antarctic (Resolution X) -Limiting access to any breeding site -Establishment of visiting plan and conduct visitor training -Use of clean outfit, boots and gear
		-Disturbance to breeding birds	Medium	Mid-Regional	Short	Medium	
		-Damage to vegetation	Medium	Mid-Regional	Medium	Medium	
		-Introduction of non-native species	Low	Mid-Regional	Medium	Low	
Operation of vehicles	Atmospheric emissions	-Cumulative impacts on ground surface	Unlikely	Mid-Regional	Long	Very low	-Using limited number of vehicles -Use of energy efficient vehicles
Refueling of vehicles	Fuel spills	-Accumulation of contaminants on ice and snow	Medium	Site specific	Long	Medium	-Re-fueling only in designated areas -Utmost care during re-fueling -Keeping of oil sorbents ready for use -Establishment of Oil Spill Contingency Plan
		-Loss of scientific value	Unlikely	Site specific	Long	Low	

6 ENVIRONMENTAL MONITORING

A monitoring program will be developed in accordance with the Practical Guidelines for Developing and Designing Monitoring Programs in Antarctica (COMNAP, 2005). Monitoring program will be applied with the start-up of TARS to put forth the probable effects of the running activity on the environment. Regular monitoring of the assigned mitigation measures referred in the impact matrices (Table 5-6 and Table 5-7) will be followed during operation. The environmental quality changes and quality control regarding human activities are listed as two separate issues given below.

Environmental changes

- Sampling of air, water, soil, lichen, and snow in the local environment of TARS for analysis,
- Changes in meteorological conditions including snow accumulation.

Quality Control at TARS regarding human activities

- Performance of wastewater treatment system,
- Investigation of bacteria in the effluent (treated wastewater) prior to discharge,
- Sorting, storage, and recycling of solid waste,
- Performance of incinerator,
- Noise levels emitted from equipment,
- Condition of fuel tanks.

Monitoring plans are developed to investigate any potential impacts of the activity; thus, any adverse effects that might be revealed will be put forth in time allowing modification of the activity to remove or reduce the impact.

During the operation of TARS, measurements and data recordings both on air quality, and environmental changes will be kept and stored for monitoring and evaluation purposes. Examples to such data are; fuel consumption data, oil spills, population, waste generation, water consumption, waste disposal routes, wastewater discharge to the sea etc. As a result of the assessments made, recommended mitigation measures will be reviewed, updated, and implemented.

Table 6-1 refers to the monitoring plan of Environmental Changes, and Table 6-2 states the monitoring parameters and frequency of sampling regarding quality assurance of TARS.

Table 6-1. Monitoring plan of environmental changes

Component	Parameter	Sampling/Observation	Frequency
Ecology	Flora and fauna	Invasive species, any changes observed	Once a year
Coastal Seawater Quality	TSS, DO, Electrical Conductivity, pH, Temperature	Sampling from 3 points near the effluent discharge	Twice a year
Snow	TSS, pH	Near main building Near wind turbines	Twice a year
Soil	TPH	4 points at oil storage sites 4 points at waste oil storage sites	Once a year
Air Quality	SO_2, NO_2, NO_X, PM10, CO, NOx	Main building site	Twice a year
Noise	Noise level	Noise level from different areas at site	Twice a year

Table 6-2. Monitoring parameters and frequency of sampling regarding quality assurance of TARS

Component	Parameter	Sampling/Observation	Frequency
Wastewater	TSS, COD, TN, TP, Total Coliform	Effluent prior to discharge	Twice a year
Wastewater Treatment Center	Operation	Operation Inspection Book	Once a day
Incinerator	Total dust, gaseous and vaporous organic substances, HCl, HF, SO_2, NO, NO_2	Flue gas	Once at every use
Incinerator	Operation	Operation Inspection Book	Once at every use
Fuel Tanks	Tanks	Oil Leaks	Once a day

7 GAPS IN KNOWLEDGE AND UNCERTAINITIES

Gaps in knowledge and uncertainties identified in the preparation of the Draft CEE Report on the construction and operation of TARS are listed below:

- Continuation of a worldwide force major situation like COVID-19, infectious diseases, may retard the proposed activities either during construction or operation.
- Some changes in the project management and methodology of the construction of the research station may occur based on necessities and environmental conditions.
- Uncertainties caused by extreme weather, and/or sea-ice conditions still remain.
- Additional or supplementary environmental evaluations will be needed based on the technological advances that will take place within the 25 years of operation period. Under such circumstances, necessary changes like installations and operations may be considered.
- The accuracy of technical and logistical estimations will always pose uncertainty when sudden environmental conditions are considered. This task is usually is confronted within the environmental evaluation report of any proposed activity.

8 CONCLUSION

The Draft CEE Report basically refers to the construction and operation of TARS, a station of continuous research & monitoring, with the aim to contribute to the valuable studies in the scientific arena of disciplines in cooperation with other national polar programs in Antarctica. The service life of TARS is expected to be around 25 years, where the first 2 years of its operation will be in Antarctic summers, followed by year-round operation for the next years.

The project site is a coastal region surrounded by high hills at Horseshoe Island in the Antarctic Peninsula. An environmentally challenging design of TARS is based on sustainable technology and high energy efficiency with the incorporation of renewable energy (solar & wind), thereby limiting the use of fossil fuels for transportation and field work. Safety, wellbeing, functionality and cost are among the other equally significant design factors.

The potential environmental impacts of TARS have been taken into account at the design phase regarding fuel, waste and wastewater management. In the construction and operation stages, top priority will be given to the protection of the environment with minimum anthropogenic impact. The research station is designed to have low maintenance costs. The construction materials are selected for minimum maintenance requirement during operation. TARS will be elevated above the snow surface with its units requiring minimal snow management in all aspects of the research station’s operation resulting in fuel and maintenance reductions.

While the maximum number of personnel during the construction stage will be 130; TARS will encompass 12 people during year-round operation with a maximum of ~50 people in the summer season. Waste and wastewater management will be of utmost importance and care will be given to their effective management. During the construction stage, waste will be stored and carried outside the continent, while wastewater will be treated within a package-type treatment unit that will also be used in the operation phase. During operation, minimization of water consumption will be achieved through recycling and reuse of treated effluent in the flushing of toilets. The excess effluent will be discharged to the sea. The strict discharge standards are foreseen for the effluent. Wastes arising from the research station will initially be sorted for recycling and be compacted. Food waste and sludge arising from wastewater treatment center will be incinerated, and resulting combustion ash will be stored and disposed outside Antarctica.

The Draft CEE Report has identified and evaluated the potential impacts that may be generated during construction and operation of TARS. Corresponding matrices were prepared for better understanding the potential impacts. The activities outlined in the matrices indicate the results of this Draft CEE Report upon their implementation in time will lead to minimum disturbance of the environment. Solutions developed against the disturbance of the environment mainly focus on staff training, monitoring and the Environmental Management EMPs covering fire protection, emergency, contingency, and oil spills.

To conclude, Turkey, accelerating its Antarctic activities since 2017, has implemented the provisions of The Protocol on Environmental Protection to the Antarctic Treaty, painstakingly. Disadvantages of the proposed activity of TARS will be minimized by applying the related mitigation measures. As this Draft CEE Report states, advantages of establishing TARS overcome its disadvantages. Turkey's keen scientists are willing to add value to Antarctic science.

9 PREPARERS AND CONTRIBUTORS

The Draft CEE for the proposed Turkish Antarctic Research Station (TARS) at Horseshoe Island, Antarctica, was prepared by the Ministry of Environment and Urbanization (MoEU), the Scientific and Technological Research Council of Turkey (TÜBİTAK) Marmara Research Center (MAM) Polar Research Institute (PRI), and Istanbul Technical University (ITU) within the framework of the Turkish National Polar Science Program (2018-2022).

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12 ANNEXES

ANNEX I. **ASHRAE Meteorological Data**

ANNEX II. **TARS Site Selection**

ANNEX III. **Horseshoe Island Flora and Fauna**

ANNEX IV. **TARS Air Emission Calculations**

ANNEX I. ASHRAE Meteorological Data

San Martín Base ASHRAE Handbook Data (ASHRAE, 2020)

2009 ASHRAE Handbook - Fundamentals (SI)

BASE SAN MARTIN, Antarctica WMO#: 890660

Lat: 68.12S Long: 67.13W Elev: 4 StdP: 101.28 Time Zone: -4.00 (XXX) Period: 83-06 WBAN: 99999

Annual Heating and Humidification Design Conditions

Coldest Month	Heating DB		Humidification DP/MCDB and HR						Coldest month WS/MCDB				MCWS/PCWD to 99.6% DB	
	99.6%	99%	99.6%			99%			0.4%		1%			
			DP	HR	MCDB	DP	HR	MCDB	WS	MCDB	WS	MCDB	MCWS	PCWD
8	-30.5	-27.4	-35.1	0.1	-29.5	-31.8	0.2	-26.9	35.1	-8.8	30.7	-6.7	0.9	320

Annual Cooling, Dehumidification, and Enthalpy Design Conditions

Hottest Month	Hottest Month DB Range	Cooling DB/MCWB						Evaporation WB/MCDB						MCWS/PCWD to 0.4% DB	
		0.4%		1%		2%		0.4%		1%		2%			
		DB	MCWB	DB	MCWB	DB	MCWB	WB	MCDB	WB	MCDB	WB	MCDB	MCWS	PCWD
1	3.6	6.5	2.8	5.6	2.1	4.9	1.6	3.3	5.8	2.6	4.9	2.1	4.2	6.0	0

Dehumidification DP/MCDB and HR									Enthalpy/MCDB						Hours 8 to 4 & 12.8/20.6
0.4%			1%			2%			0.4%		1%		2%		
DP	HR	MCDB	DP	HR	MCDB	DP	HR	MCDB	Enth	MCDB	Enth	MCDB	Enth	MCDB	
1.2	4.1	2.9	0.6	3.9	2.4	0.1	3.8	2.1	15.7	6.0	14.4	5.1	13.4	4.4	0

Extreme Annual Design Conditions

Extreme Annual WS			Extreme Max WB	Extreme Annual DB				n-Year Return Period Values of Extreme DB							
				Mean		Standard deviation		n=5 years		n=10 years		n=20 years		n=50 years	
1%	2.5%	5%		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
30.9	23.3	19.0	7.5	-33.3	9.3	4.4	1.6	-36.5	10.5	-39.1	11.5	-41.5	12.4	-44.7	13.6

Monthly Climatic Design Conditions

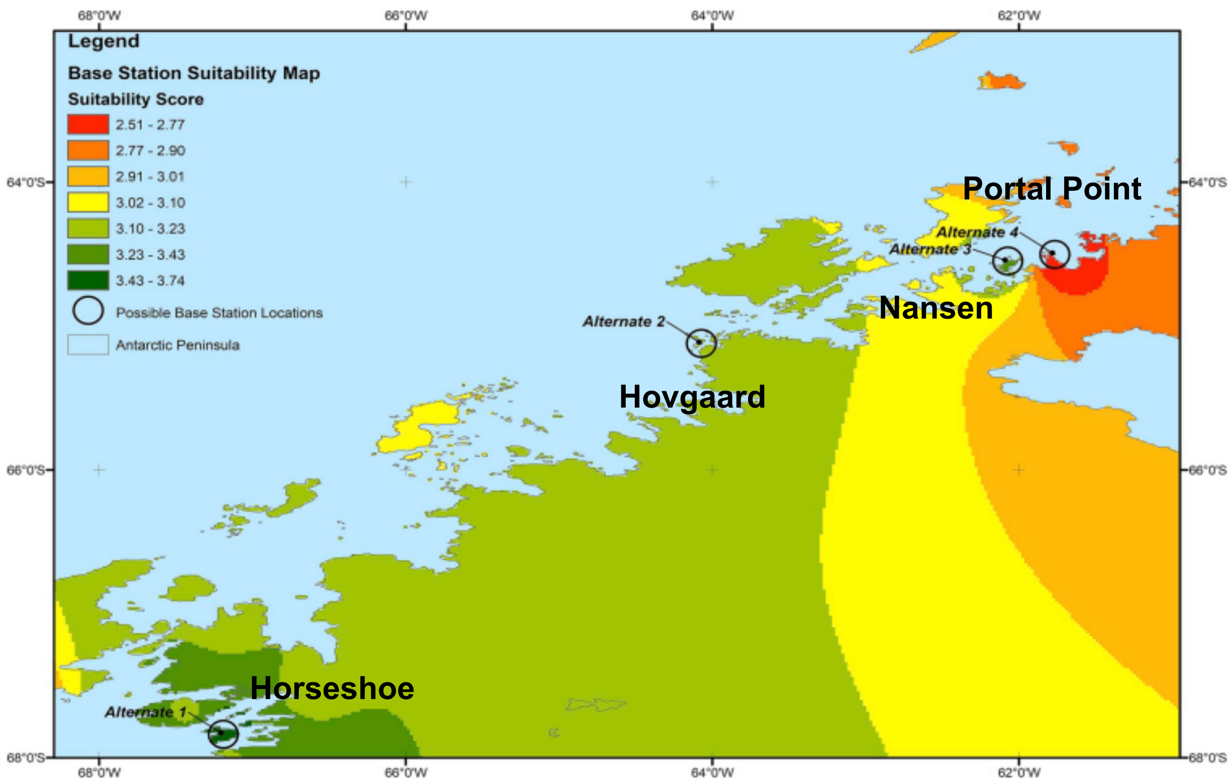
			Annual	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Temperatures, Degree-Days and Degree-Hours	Tavg		-5.0	1.9	1.0	-1.4	-3.5	-5.6	-10.2	-12.3	-12.5	-9.7	-5.8	-2.2	0.5
	Sd			1.75	1.94	2.81	3.39	4.90	6.73	7.97	7.81	6.98	5.40	3.26	2.10
	HDD10.0		5485	251	253	353	404	485	604	692	697	592	491	367	295
	HDD18.3		8527	509	487	611	654	743	854	951	956	842	749	617	553
	CDD10.0		0	0	0	0	0	0	0	0	0	0	0	0	0
	CDD18.3		0	0	0	0	0	0	0	0	0	0	0	0	0
	CDH23.3		0	0	0	0	0	0	0	0	0	0	0	0	0
	CDH26.7		0	0	0	0	0	0	0	0	0	0	0	0	0
Monthly Design Dry Bulb and Mean Coincident Wet Bulb Temperatures	0.4%	DB		8.2	7.0	6.6	5.7	6.3	4.6	4.1	3.4	4.8	5.6	5.9	7.6
		MCWB		4.1	3.1	3.4	2.4	3.1	1.5	0.8	0.5	1.4	2.3	2.2	3.8
	2%	DB		6.3	5.6	4.7	3.5	4.0	1.9	2.4	1.8	3.5	4.2	4.4	5.8
		MCWB		2.5	2.0	1.6	1.0	1.6	0.0	0.1	0.0	0.7	1.3	1.2	2.3
	5%	DB		5.4	4.7	3.4	2.1	2.4	0.0	0.2	0.1	2.1	3.0	3.2	4.8
		MCWB		1.8	1.5	0.7	0.1	0.2	-0.8	-1.2	-1.2	-0.1	0.5	0.5	1.5
	10%	DB		4.6	3.8	2.2	1.0	0.7	-1.2	-1.9	-1.7	0.1	1.6	2.1	3.8
		MCWB		1.3	0.9	0.0	-0.5	-0.6	-2.1	-2.9	-2.6	-1.2	-0.2	-0.1	0.8
Monthly Design Wet Bulb and Mean Coincident Dry Bulb Temperatures	0.4%	WB		4.3	3.4	3.8	2.8	3.6	2.4	1.6	1.5	2.0	3.0	2.9	4.1
		MCDB		7.8	6.2	6.3	5.1	6.0	4.6	3.9	2.7	4.4	5.2	5.4	7.1
	2%	WB		3.1	2.5	1.9	1.3	2.0	0.5	0.4	0.1	1.1	1.7	1.7	2.8
		MCDB		5.6	4.7	4.0	3.0	4.2	1.6	2.2	1.7	3.3	3.8	3.8	5.1
	5%	WB		2.3	1.9	1.0	0.4	0.6	-0.6	-0.8	-0.7	0.1	0.9	0.8	2.0
		MCDB		4.5	4.1	2.8	1.8	2.1	0.4	0.8	0.6	2.2	2.8	2.7	4.1
	10%	WB		1.8	1.4	0.3	-0.3	-0.4	-1.6	-2.4	-1.9	-0.8	0.0	0.1	1.2
		MCDB		3.8	3.2	1.7	0.9	1.0	-0.8	-1.4	-0.9	0.7	1.8	1.8	3.1
Mean Daily Temperature Range		MDBR		3.6	3.3	3.8	4.0	4.6	6.0	7.0	8.4	7.5	6.5	5.0	3.8
	5% DB	MCDBR		5.0	4.5	5.2	4.9	6.4	6.7	7.7	8.9	7.5	7.0	5.8	5.3
		MCWBR		3.3	2.9	3.5	3.5	4.6	5.2	6.2	6.5	5.3	5.1	4.1	3.3
	5% WB	MCDBR		4.5	4.1	4.8	4.6	5.8	6.0	7.5	7.2	6.8	6.6	5.6	4.9
		MCWBR		3.2	2.8	3.4	3.5	4.6	5.2	6.4	6.2	5.4	5.3	4.3	3.3
Clear Sky Solar Irradiance	taub			0.263	0.257	0.243	0.226	0.133	N/A	0.125	0.209	0.221	0.233	0.252	0.259
	taud			2.257	2.304	2.402	2.550	2.215	N/A	2.224	2.554	2.422	2.356	2.250	2.268
	Ebn,noon			989	936	844	642	269	N/A	259	658	864	963	998	1011
	Edh,noon			123	105	78	45	24	N/A	22	44	75	99	123	125

Source: [ASHRAE climatic design conditions 2009/2013/2017 (ashrae-meteo.info)]

ANNEX II. TARS Site Selection

Selected Criteria for Analytical Hierarchy Method (AHP) Process

#	Criterion
1	**Spatial Conditions**
2	Bathymetry
3	Topography
4	*Aspect*
5	*Slope*
6	*Height*
7	Currents
8	Capacity of Land
9	Temperature
10	Wind Speed
11	**Accessibility**
12	Logistics
13	Sea Ice
14	Grounding Line
15	Megadunes
16	Snow Accumulation
17	Closeness to Ports
18	Closeness to Airports
19	Closeness to Other Research Stations
20	Closeness to ERA (Emergency Response Area)
21	**Legislative Conditions**
22	ASPA (Antarctic Specially Protected Area)
23	ASMA (Antarctic Specially Managed Area)
24	MPA (Marine Protected Area)
25	HSM (Historic Sites and Monuments in Antarctica)



Alternative Sites (Yavaşoğlu, et. al., 2019)

ANNEX III. Horseshoe Island Flora and Fauna

Moss and Lichen Species

Type	Name
Lichen	*Acarospora convoluta Darb.*
Lichen	*Acarospora macrocyclos Vain.*
Lichen	*Pseudephebe pubescens (L.) Choisy*
Moss	*Ceratodon purpureus (Hedw.) Brid.*
Moss	*Bartramia patens Brid.*
Moss	*Bryum argenteum Hedw.*
Moss	*Bryum pseudotriquetrum (Hedw.) Gaertn.*
Lichen	*Buellia cladocarpiza M. Lamb*
Lichen	*Buellia subpedicellata (Hue) Darb.*
Lichen	*Caloplaca isidioclada Zahlbr.*
Lichen	*Candelariella vitellina (Hoffm.) Mull. Arg.*
Lichen	*Catillaria corymbosa (Hue) M. Lamb*
Lichen	*Lecidea atrobrunnea (Ram.) Schaer.*
Moss	*Coscinodon reflexidens Mull. Hal.*
Lichen	*Haematomma erythromma (Nyl.) Zahlbr.*
Lichen	*Huea coralligera (Hue) Dodge & Baker*
Lichen	*Lecania brialmontii (Vain.) Zahlbr.*
Lichen	*Lecanora atrobrunnea*
Lichen	*Lecanora physciella (Darb.) Hertel*
Lichen	*Physcia caesia (Hoffm.) Furnr.*
Lichen	*Physcia caesia (Hoffm.) Furnr.*
Lichen	*Leptogium puberulum Hue*
Lichen	*Physcia caesia (Hoffm.) Furnr.*
Moss	*Pohlia nutans (Hedw.) Lindb.*
Lichen	*Pseudephebe minuscula (Nyl. ex Arnold) Brodo & Hawksw.*
Lichen	*Psoroma cinnamomeum Malme*
Lichen	*Rhizocarpon disporum (Hepp) Mull. Arg.*
Lichen	*Rhizoplaca aspidophora (Vain.) Redon*
Lichen	*Rhizoplaca melanophthalma (Ram.) Leuck. & Poelt*
Moss	*Sanionia uncinata (Hedw.) Loesk.*
Moss	*Schistidium antarctici (Card.) L. Savic. & Smirn.*
Moss	*Willia austroleucophaea (Besch.) Broth.*
Lichen	*Polycauliona candelaria (L.) Th. Fr.*
Lichen	*Xanthoria elegans (Link.) Th. Fr.*
Moss	*Syntrichia magellanica (Mont.) R.H. Zander*
Lichen	*Umbilicaria decussata (Vill.) Zahlbr.*
Lichen	*Usnea sphacelata R. Br.*
Lichen	*Usnea subantarctica F.J. Walker*
Lichen	*Sphaerophorus polycladus Mull. Arg.*
Moss	*Coscinodon reflexidens Mull. Hal.*
Lichen	*Placopsis pycnotheca Lamb*
Moss	*Syntrichia magellanica (Mont.) R.H. Zander*
Moss	*Syntrichia sarconeurum Ochyra & R.H. Zander*
Moss	*Bryum pallescens Schleich. ex Schwaegr.*
Moss	*Bryum argenteum var. argenteum Hedw.*

Source: http://apex.nerc-bas.ac.uk/f?p=148:1

ANNEX IV. TARS Air Emission Calculations

Predicted emissions during construction

Source	Total Fuel		Type of emission	Emission factor (g/kg)	Total Emissions (ton)
	Volume (m^3)	Weight (ton)			
Marine transportation	500	400	CO	1.01	0.40
			NO_x	14.66	5.86
			SO_2	0.93	0.37
			PM10	1.28	0.51
			CO_2	614.00	245.60
Generator used for camp and facilities	475	380	CO	1.01	0.38
			NO_x	14.66	5.57
			SO_2	0.93	0.35
			PM10	1.28	0.49
			CO_2	614.00	233.32
Equipment and vehicles	220	176	CO	1.01	0.18
			NO_x	14.66	2.58
			SO_2	0.93	0.16
			PM10	1.28	0.23
			CO_2	614.00	108.06

Predicted annual emissions generated during operation

Source	Total Fuel		Type of emission	Emission factor (g/kg)	Total Emissions (ton)
	Volume (m^3)	Weight (ton)			
Marine transportation (resupply vessel)	200	160	CO	1.01	0.162
			NO_x	14.66	2.346
			SO_2	0.93	0.149
			PM10	1.28	0.205
			CO_2	614.00	98.240
Generator	430	344	CO	1.01	0.347
			NO_x	14.66	5.043
			SO_2	0.93	0.320
			PM10	1.28	0.440
			CO_2	614.00	211.216
Vehicle	3	2.4	CO	1.01	0.002
			NO_x	14.66	0.035
			SO_2	0.93	0.002
			PM10	1.28	0.003
			CO_2	614.00	1.474