China Antarctica

Proposed Construction and Operation of a New Chinese Research Station Victoria Land, Antarctica

FINAL COMPREHENSIVE ENVIRONMENTAL EVALUATION

October 2021

Polar Research Institute of China

TongJi University

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CONTACT DETAILS

The compilation of the Final Comprehensive Environmental Evaluation (Final CEE) for the construction and operation of a new Chinese research station in Antarctica (the new station) is organized by Chinese Arctic and Antarctic Administration (CAA) and compiled by Polar Research Institute of China (PRIC) and Tongji University. Both CAA and PRIC are affiliated to the State Oceanic Administration (SOA).

CAA welcomes any comments and recommendations on the Final CEE.

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NON-TECHNICAL SUMMARY

1. Introduction

The CEP XXI in May 2018 discussed the second draft Comprehensive Environmental Evaluation (CEE) which was circulated by China in early 2018 for the proposed construction and operation of a new Chinese research station in the area of Victoria Land, Antarctica, and the report of the open-ended ICG led by the United States to review the draft CEE, and the two Information Papers (IP 23 and IP 25) submitted by China presenting further information in response to the comments raised by the ICG.

According to the discussions during the CEP XXI, Members welcomed China's initial responses to the comments raised by the ICG, and China's commitment to expanding the use of renewable energy and other measures to minimize the impact of the construction and operation of the proposed station, including moving the new station further away from the Adélie penguin colony. Several Members conducting scientific activities in Terra Nova Bay as well as the other areas of the Ross Sea region expressed their willingness to collaborate with China in science and logistics. A possible ASPA designation on Inexpressible Island was also initiated with respect to area protection and management. The CEP advised to the ATCM XXXXI in regard to the result of discussing the draft CEE:

1) **The draft CEE generally conformed to the requirements of Article 3 of Annex I to the Protocol on Environmental Protection to the Antarctic Treaty.**
2) **If China decided to proceed with the proposed activity, the final CEE could be strengthened through the inclusion of additional information and clarification on several aspects.**
3) **China was encouraged to consider the detailed comments provided by ICG participants as well as the summary of the main issues summarized in the ICG report, and issues raised by members during the discussion in the CEP XXI as summarized in the final report.**
4) **The information provided in the draft CEE supported the conclusion that the impacts of some activities within the project would have a more than minor or transitory impact, and that this level of EIA had been appropriate for this project.**

5) The draft CEE was well-written and logically organized, although some minor adjustments could strengthen the document even further.

The Final CEE has been prepared in accordance with Annex I of the Protocol on Environmental Protection to the Antarctic Treaty, and the domestic laws and procedures. It also referred to the Guidelines for Environmental Impact Assessment in Antarctica (Resolution 1, XXXIX ATCM, 2016). The Final CEE describes the following contents：

- Construction, operation, and maintenance of the new station
- Transportation process for cargos and personnel to the new station
- Analysis of potential environmental impact
- Prevention and mitigation measures to minimize environmental impact
- Gaps in knowledge and uncertainties

The site of the new station (74°55′S/163°42′E) was finally decided at the Inexpressible Island, Terra Nova Bay in the Ross Sea Region. Three initial candidate locations including the Inexpressible Island as shown in the Final CEE had been considered in the evaluation process based on the factors such as the convenience of scientific research and supporting logistic activities, and minimizing possible impact on the surrounding environment. When the Inexpressible Island was chosen as the premise of the new station, five alternative sites on the island were investigated and compared. The final decision on the site for building the new station was specifically kept further away from the Adélie penguin colony. Proposal for a Antarctic Specially Protected Area at Inexpressible Island had been discussed by China, Italy, and Republic of Korea and jointly submitted to ATCM 42 in 2019 as WP 47 and approved by ATCM 43 online in 2021.

The new station is a year-round station which will function as one of the key platforms of the Antarctic observatory network focusing on ocean, ice, and snow in the Ross Sea region. It will be valuable to compare the data obtained in the new station with those in the Zhongshan Station in the East Antarctica. China believes that understanding the change and variation of the climate, ice and ocean undergoing in Antarctica is a matter of priority for the Antarctic community. The main purpose of the new station is to provide a platform for regional multidisciplinary research focusing on the climate, cryosphere, and ocean system.

The main scientific programs based on the new station include the studies on atmospheric and atmosphere-ice-ocean interaction, glacial and ice shelf-ocean interaction, environment and ecosystem monitoring, space physics and the geological environment evaluation studies etc.

(1) Atmosphere-Ice-Ocean interaction studies

Build an atmosphere and atmosphere-ice-ocean observation system to conduct long-term continuous observation of changes in the atmosphere, sea ice and marine environment, and provide long-term, continuous observation data for climate change and atmosphere-ice-ocean interaction research.

- Establish an automatic weather observation station, combined with air sounding balloon measurements, to study the characteristics of descending wind around the station area and its inter-annual changes;
- Carry out sampling and observation of major greenhouse gases and aerosols, and grasp the basic chemical characteristics of the atmosphere and its seasonal and inter-annual changes;
- Deploy submersible targets to obtain basic data such as sea water temperature, salinity, velocity, and flow direction, and analyze sea ice, interglacial lakes and circulation and their change characteristics;
- Use aerial and satellite remote sensing to monitor long-term changes in sea ice distribution, and study the potential impact of downwind and climate change on the distribution and reserves of sea ice in Terra Nova Bay and surrounding sea areas.

(2) The environment and ecological process of the glacial lake（Terra Nova Bay）

Long-term continuous monitoring of the glacial lake of Terra Nova would be carried out to evaluate the key role of the glacial lake ecosystem in primary production and supporting the ecosystem of Terra Nova Bay.

- Use research boats and marine laboratory platforms to monitor the inter-annual changes in the ecological environment of the coastal waters, and grasp the response of biota to climate and environmental changes;
- Use sediment traps to obtain the seasonal and inter-annual variation characteristics of particulate matter flux, combined with satellite remote sensing water color data, to analyze the biological production process and its seasonal and inter-annual variation characteristics of the Terra Nova Bay area;

- Use the marine experimental platform to carry out environmental adaptability experiments of microalgae and other marine organisms to understand the environmental adaptability of marine plankton and dominant groups of fish;
- Use the temperature, salinity, chlorophyll, effective photosynthetic radiation (PAR) and other sensors carried by the latent standard (or online latent standard) to obtain long-term continuous observation data, and analyze the seasonal change of the primary yield of the ice lake and its regulation mechanism.

(3) Glacier/Ice Shelf-Ocean Interaction Research

- Carry out the monitoring of glaciers around the Inexpressible Island to study the potential impact of glacier melting and icebergs entering the sea on the marine environment and primary production.
- Use satellites to monitor the ice flow characteristics of the main glaciers around the Inexpressible Island, and evaluate the annual inflow of surrounding glaciers and their interannual changes;
- Use marine isotope tracing technology to monitor the glacier melting and freshwater input characteristics of Terra Nova Bay, and analyze the potential impact of freshwater input on the marine environment and biological communities;
- Deploy potential targets in the bottom water transport channel of Terra Nova Bay to obtain information on changes in bottom water temperature and salt, and grasp the melting of the Ross Sea ice shelf and its potential impact on bottom water characteristics;

(4) Study on the Number of Large Birds and Its Regulation Mechanism

The new station will carry out long-term monitoring of the Adélie penguin colony in the northern part of the Inexpressible Island, combining basic environmental data and coastal waters ecological data, revealing the interannual quantitative changes and regulation mechanisms, and assessing the potential of climate change for large Antarctic organisms Influence. Simultaneously monitoring and research of surrounding lichens and other terrestrial environment and biota would be carried out.

(5) Other observational researches

Establish a space physical observation system, carry out research on the middle and upper atmosphere-the middle layer and the thermosphere, understand atmospheric temperature changes, temperature changes from the troposphere to hundreds of kilometers, and the dynamics of neutral winds, and conduct research with the observation data from the Zhongshan Station in Antarctica Compare and obtain the evolution characteristics of polar space phenomena. The new station will also carry out research on near-Earth solar wind, magnetosphere and ionosphere, and geological structure.

The new station will set up professional marine laboratory and ocean observation system, and will be open to neighboring research stations of the United States, New Zealand, Italy, Germany, and Republic of Korea to jointly promote marine scientific research in the Ross Sea in the context of global change. The new station would also like to promote collaborative research in other disciplines.

2. Description of Proposed Activities

The Inexpressible Island is a rocky island located in Terra Nova Bay with the latitude of 74°51′00″-74°56′00″S and the longitude of 163°35′00″-163°45′20″E. The proposed site for the new station is located on a relatively flat ground in the southern part of the Inexpressible Island (74°55′S/163°42′E).

The Terra Nova Bay region is bordered by Cape Washington to the northeast and the Inexpressible Island to the southwest in the western Ross Sea region. The proposed site for the new station is about 29 km far from the Mario Zucchelli Station, and the distances from the site to Gondwana Station and Jang Bogo Station are about 37 and 38 km respectively.

The Final CEE considers the activities to be conducted in the following years: construction, operation, and dismantlement of the new station, installation, and use of temporary facilities during the construction, and transportation of supplies and personnel to the new station. The construction is expected to be finished in 2024/2025. The station is then scheduled to begin operation in 2024/2025.

The new station includes the central buildings, research facilities, and maintenance and operation facilities with a building area of 5250 m^2. The new station is planned to be used for around 25 years. It will accommodate up to 80 personnel in the summer and 30 personnel in the winter. The expected ratio of science to support personnel is 1:1 in summer and 1:2 in winter. The design for the new station is based on the experiences of many light-weight and modular

The design for the new station is based on the experiences of many light-weight and modular buildings that were combined in a variety of ways. The modularity allows for change by user according to the requirements, and is easier for construction and maintenance. The design incorporates energy efficiency measures by maximum use of natural lighting, the double outer walls, as well as five-time glazed windows, low energy products, and phase change materials. The stable aerodynamic structure of the central buildings will provide increased resistance against strong winds. Furthermore, the combination of elevated and slanting structures helps to minimize the amount of snow pile-up around the buildings.

The new station will innovatively establish a power generation system combined with solar, wind, hydrogen, micro-gas turbine and diesel hybrid. As a prerequisite, to ensure the safety and stability of power supply in the station area, a high-efficiency energy storage systems such as hydrogen fuel batteries, low-temperature-resistant lithium batteries, phase-change heat storage systems will be used to the greatest extent by intelligent integrated energy management systems according to the site condition of using renewable energy. Solar energy + wind energy + micro-gas turbines will be used as the main energy supply in summer, surplus solar and wind energy will be converted into hydrogen fuel cells for hydrogen storage for winter season, diesel generators are used as emergency backup; wind energy + diesel generators will be used as the main energy supply in winter, and surplus wind energy will be converted into hydrogen fuel cells for hydrogen storage and use, with a view to minimize diesel consumption and air pollutant emissions.

- The use of hybrid Solar-Wind-Diesel power supply system will significantly minimize the consumption of fossil fuels and reduce CO_2 emission as following:
- During 2026-2030, if the hybrid solar-wind-power system (100kW solar+100kW wind) successfully installed and operated, the renewable energy will be the main energy source for the whole station. The annually reduction of the emission by renewable energy system will be as follows: CO, 0.11 ton, NOx, 1.55 ton, SO_2, 0.10 ton, PM10, 0.14 ton, CO_2, 64.97 tons as shown in Tab 5-5.
- During 2031-2035, if the hybrid solar-wind-power system (150kW solar+200kW wind) successfully installed and operated, the renewable energy will be the main energy source for the whole station. The annually reduction of the emission by renewable energy

system will be as follows: CO, 0.20 ton, NOx, 2.87 tons, SO2, 0.19 ton, PM10, 0.25 ton, CO2, 119.91 tons as shown in Tab 5-6.

- After 2036, if the hybrid solar-wind-power system (150kW solar+300kW wind) successfully installed and operated, the renewable energy will be the main energy source for the whole station. The annually reduction of the emission by renewable energy system will be as follows: CO, 0.27 ton, NOx, 3.91 tons, SO2, 0.25 ton, PM10, 0.35 ton, CO2, 163.88 tons as shown in Tab 5-7.

A comprehensive advanced sewage treatment and solid waste disposal system will be installed and operated to prevent wastes and wastewater from affecting the surrounding environment. All wastes will be stored in accordance with the appropriate management plan, until safely treated or transported outside of the Antarctic Treaty Area. Furthermore, the wastewater will be recycled as much as possible by using the advanced gray water reclamation and recycle system.

3. Alternatives to Proposed Activities

Several alternatives including the no-action alternative, three alternative locations around Ross Sea region and five alternative sites on the Inexpressible Island and three schemes of station area planning and layout and site selection of main building had been compared. The selection of the proposed site not only considered its compatibility with construction and operation but also the research fields that China was planning to carry out. Considering a variety of logistical, engineering, scientific, environment and safety reasons, while minimizing the impact of the station on the environment, China decided that the best practical option was to construct and operate a new research station at the Inexpressible Island.

The Final CEE has fully considered the comments of the Committee and has significantly improved since 2018. After taking a full consideration of the suggestions of the Committee, it's believed that the proposed activities contained in the Final CEE would reduce the potential disturbance and impact to local fauna and flora and HSM14 to a minimum.

The new station is an independent year-round station for logistic and research activities on the Inexpressible Island in the Terra Nova Bay, Ross Sea region. It is expected to be an international platform for regional multidisciplinary research focusing on the chain reactions caused by the global changing climate and the National Antarctic Program will include studies on atmospheric and atmosphere-ice-ocean interaction, glacial and ice shelf-ocean interaction, environment and ecosystem monitoring, space physics and the geological environment evaluation studies, etc. The new station will also strength the potential logistics cooperation and collaboration with all the stations in the Terra Nova Bay and Ross Sea regions.

Under the premise of comprehensively considering construction capacity, convenience of operation, energy saving and safety, the design principle of combining concentration and decentralization is used to compare three alternative layouts and shape designs of the main building. Modules with similar functions will be centrally arranged to form an energy-saving layout and improve convenience. The layout of the new station separates the noisy area from the quiet area, provides convenient communication, reduces the impact of snow accumulation, keeps the main modules away from harmful substances, and ensures easy accessibility of transportation routes.

The overall planning and architectural design of the new station has been adjusted in accordance with the requirements of the Environmental Protection Protocol and the feedback content of the 2018 ATCM meeting to make it more suitable for the site environment of the planned construction area. Facing the special harsh environment conditions such as freezing cold, strong wind and radiation, as well as considering high sensitivity of environmental requirements in the Ross Sea area, the buildings adopt a centralized form, and the long axis is consistent with the dominant wind direction. The main building and the logistics center cleverly make use of the three-dimensional connection of the site height difference to reduce floor space and environmental disturbance. With the help of CFD simulation technology, combined with the surrounding terrain, the pressure distribution on the building surface is accurately calculated, the impact of strong winds and snow on the building would be reduced. The adjustment of the layout of station area would reduce the impact of construction and operation of the new station on local environment to a minimum.

Marine + land transportation is thought to be better than air + land transportation taking into account the cost, logistics convenience, and on-time performance under uneven weather conditions.

China's first domestically made icebreaker Xuelong 2 was delivered and commissioned to start her maiden voyage by participating the 36th Antarctic expedition from Shenzhen on Oct. 15, 2019. Xuelong and Xuelong 2 will greatly strengthen China's intercontinental transportation capacity to support the construction of the new station.

To keep the Antarctica baseline environment as clean as it is, considering the quantity of solid waste during the year-round operation and the difficulty of storage and transportation in Antarctica, the magnetization pyrolysis furnace has been selected for disposal of wastes in the new station after the comparison of three waste disposal approaches.

4. Initial Environmental Reference State of the Region

On the Inexpressible Island, where the new station will be located, there are several typical Antarctic species like Antarctic skuas and Adélie penguins. However, there are no colonies or habitats of any species close to the proposed site within 3.5 km.

According to the data from the automatic weather station Manuela (1988-2012), the wind speed in the proposed region is extremely high and variable. Strong westerly (the main direction is 265.3 degrees) wind can reach a maximum instantaneous speed of 43.5 m/s, the maximum daily average wind speed is 34.2 m/s, and there are more than 117 days with strong wind above 15 m/s in average annually. The annual average temperature and wind speed of the region are -18.5℃ and 12.0m/s, respectively. The extremely low temperature is -42.3℃ (September. 1st, 1992), while the highest temperature is 6.9℃.

The elevation of the island is relatively higher in the west than in the east. There is a north-southward mountain ridge on the west side, while ground and hilly land in the east. According to the geological, geomorphological and engineering survey in different areas on the Inexpressible Island, it can be seen that the surface material composition of the area is basically consistent：Most parts of the island are covered by moraine gravel, and the general thickness is within 1m with partial deepness; bedrock is dominated by monzonite and granite veins. The advantages of the proposed site in the southern part of the Inexpressible Island are obviously clear after comparing different sites. The proximity to the coastline and the low elevation makes it easier for construction and transportation. In comparison with the long and narrow area in the central concave valley, the characteristics of this site, like the flat terrain, square shape and bigger size is more conducive for the layout of the buildings. Both of them that the lithology of the ground exposed to bedrock is the same as that of other areas and high rock compressive degree are favorable for the foundation.

There are three lakes located in the middle part of the island. Lake 1 is about 546 meter in the perimeter, covering an area of about 21235 m2. Lake 2 is about 1127m in the perimeter, covering an area of about 49540 m2. Lake 3 is about 408 meter in the perimeter, covering an area of about 11566 m2. All the lakes are freshwater lakes.

To fully understand the distribution of lichens and mosses on the Inexpressible Island, an investigation was carried out during the 31st and 33rd CHINARE from December 26th, 2014 to January 4th, 2015 and February 3rd – 5th, 2017. A total of 8 lichens and 1 moss were recorded on the Inexpressible Island. The 8 lichens are Acarospora gwynnii, Bullia frigida, Candelariella flava, Lecanora expectans, Lecanora fuscobrunnea, Umbilicaria decussate, Xanthoria elegans and Xanthomendoza borealis. Only one moss is found as Bryum argenteum. The distribution and density of the moss and lichens found during the survey has been described in Chapter 4.

An average of ~24 450 breeding pairs of Adélie Penguin were present each season from 1981 – 2012 (Lyver et al. 2014). Approximately 60 breeding pairs of South Polar Skuas were present on the Inexpressible Island both within and near the vicinity of the IBA (ANT 178) in 1982 (Ainley et al. 1986), although the precise breeding area has not been defined (IBA, 2015).

Based on the on-site investigation from 2012 to 2017, Adélie Penguin (Pygoscelis adeliae), Antarctic Skua (Stercorarius maccormicki) and Weddell Seals (Leptonychotes weddellii) were observed on the Inexpressible Island. There are about 20000 pairs of breeding penguins in a small bay, along with the northern coast of the island. And the altitude of the nest is from no more than 1m to 33m. There is a separated small colony, including about 130 breeding pairs of Adélie Penguin, in the south of 600m away from the larger one. Around the rookery of the Penguin, about 60 breeding pairs of Antarctic Skua are distributed there. According to GPS data and on-site estimation, the penguin community covers an area of 0.5 square kilometers. In the northernmost part of penguin colony, there is a small lagoon, where small number of Weddell Seals appear occasionally. There are some seal bodies nearby, some has already been air-dried.

The penguin colony is located to the northern part of the Inexpressible Island while the proposed site is in the southern part of the Inexpressible Island. The discovered seal bodies are also located to the northern part of the Inexpressible Island. China has decided to move the planned station site to the southern part after a careful assessment of the possible impact and now the distance between the southern boundaries of the colony to the new station is more than 3.5 km.

Three flora species have been recorded on the Inexpressible Island: Iridaea cordata (Turner) Bory (as I.obovata Kützing), Phyllophora antarctica A. et E.S. Gepp and Plocamium cartilagineum Dixon since 1966. The macro-benthic vegetation is rather poor: only 9 Rhodophyceae (Erythrotrichia carnea, Clathromorphum lemoineanum,Gainia mollis, Iridaea cordata, Gymnogongrus antarcticus, Phyllophora antarctica, Plocamium cartilagineum, Ballia sertularioides, Phycodrys antarctica), 4 Fucophyceae (Lithoderma antarcticum , Petroderma maculiforme, Geminocarpus geminatus, Syringoderma sp) and 4 Chlorophyceae (Urospora penisulliformis, Monostroma hariotii, Prasiola crispa, and Lola irregularis) were found, which are widely distributed in Antarctic circumpolar and polar regions. The benthic associations were dominated by two macro-algal species (Iridaea cordata and Phyllophora antarctica) and by few animal taxa (mainly polychaetes, molluscs and peracarid crustaceans) in this area.

In shallow waters, gastropod fauna is represented by 31species, among which Neobuccinum eatoni, Onoba gelida, Powellisetia deserta, Philine cf. apertissima and Austrodoris kerguelenensis are the most abundant, while among bivalves (25 species) the most common species are Adamussium colbecki, Yoldia eightsi, Laternula elliptica and ``Montacuta'' nimrodiana. At present, most of the Antarctic mollusc species are known as having circumantarctic distribution and are considered eurybathic. The gastropods characterize the superficial algal belts dominated by the red algae Iridaea cordata and Phyllophora antarctica, bivalve distribution is wider. Adamumssium colbecki is the dominant species in the upper 100m, both on soft and hard bottoms, if the slope is suitable.

Sponges represent a major component of the Antarctic zoobenthos, remarkably contributing to the species richness of this continent. 49 demosponge species have been recorded in Terra Nova Bay,the most common species are Tedania charcoti, Axociella nidificata, Calyx arcuarius, Isodictya erinacea, I. cactoides, I. conulosa, Gellius rudis, Gellius spp., Myxilla elongata and Phorbas glaberrima. Most of the sponges were collected at 70-120 m depth.

Benthic associations of the shallow hard bottoms of Terra Nova Bay are characterized mainly by rhodophycean macro-algae dominating the first 30-35m depth, and by associated vagile invertebrates, mainly represented by polychaetes, molluscs and peracarid crustaceans.

5. Identification and Prediction of Environmental Impact, Assessment and Mitigation Measures of the Proposed Activities

A comprehensive environmental impact identification, prediction, and assessment of the new station's full life cycle period including the construction, operation and dismantling has been finished based on the data and experiences obtained from the survey and provided by references.

In addition, the environmental impact on air, snow, ice, ocean, and ecosystem in the period of construction and operation of the new station was estimated according to major factors including air pollutants, potential fuel and oil leakage, solid waste disposal, wastewater treatment and discharge, noise, man-made light, alien species introduction and ecosystem disturbance.

The main environmental impact of proposed activities includes:

- Atmospheric pollutants from fuel consumption
- Risks of fuel and oil spills from fuel transfer and refueling process as well as the leakage of fuel pipelines and tanks
- Discharge of hazardous and non-hazardous wastes such as construction waste, domestic waste, waste oil, chemical and food waste
- Wastewater from the construction and operation of the new station
- Noise from loading and unloading activities, equipment operations and other activities
- Disturbance to the local ecosystem of both marine and land bio-species (e.g., penguins, skuas and lichens)

Prevention and mitigation measures have been identified in the impact matrices to avoid or minimize these predicted impacts.

The new station will innovatively establish a power generation system combined with solar, wind, hydrogen, micro-gas turbine and diesel hybrid. As a prerequisite, to ensure the safety and stability of power supply in the station area, a high-efficiency energy storage systems such as hydrogen fuel batteries, low-temperature-resistant lithium batteries, phase-change heat storage systems will be used to the greatest extent by intelligent integrated energy management systems according to the site condition of using renewable energy with a view to minimize diesel consumption and air pollutant emissions. The new station will increase the use of renewable energy and maximize the use of indoor natural light and recycling waste heat to minimize the use of fossil fuels.

To prevent fuel spills, fuel tanks will be double-skinned and oil impermeable bund wall will be built around the fuel storage area. For prevention and clean-up of spills, appropriate equipment will be prepared in the new station in accordance with associated guidelines such as the guidelines of COMNAP (2003) and fuel manual by COMNAP (2008), etc. Intelligent Monitoring System based on internet technology (including automatic control operations, security monitoring, safety warning, remote data transmission and so on) will be applied to the fuel storage area.

Wastes will be managed according to the Waste Management Manual by COMNAP (2006). All wastes will be separated and securely stored until safely treated or transported outside of Antarctic region for disposal or recycling.

Wastewater will be treated using advanced treatment system. The treated water will be discharged up to the stringent level of wastewater standards e.g., BOD5 less than 4mg/ℓ and CODMn less than 6mg/ℓ according to Chinese Environmental Quality Standards for Surface Water (GB3838-2002) (Grade Ⅲ, normally for source water).

Noise will be kept at the level without disturbing the Antarctic skua or penguin colonies by appropriate use of construction equipment. The maximum noise level of the construction facilities will be no more than 85 dB, the noise will decrease to less than 35 dB within 200m from the boundary of the construction site.

Given that there is no area playing an important role as habitats or colonies of a certain species close to the proposed site within 3.5 km, the impact of the new station on the surrounding habitats or colonies of certain species, including the important bird areas on the Inexpressible Island (IBA,2015), will be minimized. During the construction and operation period, visitors without clear scientific research or monitoring purposes will be prohibited from getting close to the penguin colony.

6. Environmental Management and Environmental Impact Monitoring Plan

PRIC will make Environmental Management Plan before the construction work. The Environmental Management Plan will cover the protection measures for penguins and skuas, refueling and fuels transportation, waste collection and disposal, sewage treatment and gray water recycling, equipment, field operation and the tackling of emergencies, etc. It will guarantee the safety and orderly progress of various activities, and consequently prevent the occurrence of environmental accidents and minimize environmental impact.

PRIC will also make station environment monitoring plan to define the actual impacts on the surrounding environment. The monitoring activities would be divided into two categories. One is to monitor the potential environmental impact, to discover as early as possible the disadvantageous impact and take actions immediately to reduce or eliminate such impact. Another is to monitor and record the relevant station operation information to verify the CEE and determine whether the impact conforms to those estimated.

7. Gaps in Knowledge and Uncertainties

Knowledge limitations and uncertainties have been fully considered in this Final CEE which include the unpredictability of environmental conditions such as global climate change and regional weather variation, the changes in future activities of the new station, the application of upgraded energy technology, the change of scientific activities, and small adjustments to the construction mode etc. These may lead to the delay of the construction and the slight changes in the scientific research and logistic support in the future.

8. Conclusion

（1）The new station is an independent perennial station for logistics and research activities on the Inexpressible Island in Terra Nova Bay, Ross Sea area. It will become an international platform for international multidisciplinary research, focusing on ocean and global climate change research, including research on atmosphere and atmosphere-ice-ocean interaction, glacier and ice shelf-ocean interaction, environmental and ecosystem monitoring, space physics and geological environment assessment research, etc. The new station will also strengthen potential logistical cooperation and coordination with all stations in the Terra Nova Bay and Ross Sea region.

（2）This Final CEE has fully considered the opinions put forward by the CEP, and is further adjusted and optimized based on the draft CEE submitted to the ATCM in May 2018 and is deemed to further enhance safety and reduce the impact on the local environment. To further increase the protection of the penguin colony in the northern part of the Inexpressible Island, China, Italy, and Republic of Korea jointly proposed a new ASPA on the Inexpressible Island in 2019, and was approved by the ATCM43 online in 2021.

（3） In order to protect the Antarctic environment and minimize the impact of human activities, the new station will follow the principle of “environmental protection first” during the entire process of construction and operation. Each step, including the selection of materials, equipment and engineering process, daily operation and the disposal of waste, will comply with the provisions of the Protocol and minimize adverse environmental impacts. In the construction and operation of the new station, it will attach great importance on environmental protection, energy saving and emission reduction. Hydrogen fuel batteries and renewable energy and advanced environmental technology will be used as much as possible to minimize the impact of construction and operation on the local environment.

（4）Environmental management plans, environmental monitoring plans, pollution prevention and emergency plans will be made and implemented. Scientific management and supervision over the entire process of construction and operation of the station will be realized to minimize the impact on the Antarctic environment.

（5）This Final CEE concludes that the proposed activities are likely to have more than minor or transitory impact on the Antarctic environment, but the continuous, scientifical and standardized operation of the new station will make important contributions to global scientific research. The scientific value is believed to outweigh the “more than minor or transitory” impact on the Antarctic environment, and thus, it fully proves the feasibility of the proposed activity.

1. Introduction

1.1 Main conclusion and updates of the Final CEE after the ATCM XXXXI

1.1.1 Main conclusion of the draft CEE submitted in 2018

During the ATCM XXXI and CEP XXI held in May 2018, CEP advice to the ATCM on the draft CEE prepared by China for the proposed construction and operation of a new Chinese research station in Victoria Land, Antarctica as follows:

The Committee discussed in detail the draft Comprehensive Environmental Evaluation (CEE) prepared by China for 'Proposed Construction and Operation of a New Chinese Research Station, Victoria Land, Antarctica' (WP 13). The Committee also discussed the report of the open-ended ICG led by the United States to review the draft CEE (WP 28), and the two Information Papers (IP 23 and IP 25) submitted by China in an initial response to the ICG comments. The Committee further discussed additional information provided by China in response to issues raised by members during the discussion in the CEP XXI.

According to the discussions during the CEP XXI, Members welcomed China's initial responses to the comments raised by the ICG, and China's commitment to expanding the use of renewable energy and other measures to minimize the impact of the construction and operation of the proposed station, including moving the new station further away from the Adélie penguin colony. Several Members conducting scientific activities in Terra Nova Bay as well as the other areas of the Ross Sea region expressed their willingness to collaborate with China in science and logistics. A possible ASPA designation on Inexpressible Island was also initiated with respect to area protection and management. The CEP advised to the ATCM XXXXI in regard to the result of discussing the draft CEE:

1) The draft CEE generally conformed to the requirements of Article 3 of Annex I to the Protocol on Environmental Protection to the Antarctic Treaty.

2) If China decided to proceed with the proposed activity, the final CEE could be strengthened through the inclusion of additional information and clarification on several aspects.

3) China was encouraged to consider the detailed comments provided by ICG

participants as well as the summary of the main issues summarized in the ICG report, and issues raised by members during the discussion in the CEP XXI as summarized in the final report.

4) The information provided in the draft CEE supported the conclusion that the impacts of some activities within the project would have a more than minor or transitory impact, and that this level of EIA had been appropriate for this project.

5) The draft CEE was well-written and logically organized, although some minor adjustments could strengthen the document even further.

1.1.2 Main updates in this Final CEE based on the draft CEE submitted in 2018

Since 2018, China has organized two expeditions for detail investigation of the proposed site and draw full attention to the suggestions raised by the Committee in 2018, the main updates in the Final CEE are as follows:

- Actively organized and carried out the visit to the McMurdo Station, Scott Base, Jang Bogo Station and Zucchelli Station, engaging in the discussions about the national planned scientific program of USA, New Zealand, Republic of Korea, and Italy, arranging potential logistics cooperation and scientific collaboration with all the countries in the Terra Nova Bay and Ross Sea regions.
- Fully investigated around the Inexpressible Island and supplement the description of the initial environmental reference state, with a focus on the geology of the region, the soil, freshwater, and near-shore marine communities, and the distribution and abundance of the fauna and flora communities especially the colony in the northern part of the Inexpressible Island (Inexpressible Island Antarctic special reserve area).
- Fully considering the cumulative impacts associated with the activities of multiple national programmes, China, Italy and Republic of Korea jointly submitted a proposal for a ASPA designation at the Inexpressible Island and Seaview Bay, Ross Sea in 2019 and the proposal was approved in 2021.
- Taking advantage of the better geological conditions in the southern part of the Inexpressible Island, the construction area of the new station will be distributed in a semi-centralized manner. Such facilities cover an area to achieve more intensive land use,

and limit it to less than 0.10 square kilometers to minimize the interference to the local environment; the main building is moved up from a shallow 15m above sea level to a hill ridge with an altitude 28m, avoiding future iceberg invasion. At present, the main building is in an exposed area of bedrock, with more solid geological conditions (the characteristic value of the maximum natural foundation bearing capacity is 300-3000kpa): the basic conditions are more stable, which is conducive to resisting strong winds and avoiding unevenness settlement. The ocean laboratory located in the east wing of the main building is closer to the sea, and combined with the in-situ comprehensive observation system carried by the experimental platform, it fully supports the all-weather observation and monitoring business facing the ocean.

- The new station will innovatively establish a power generation system combined with solar, wind, hydrogen, micro-gas turbine and diesel hybrid. As a prerequisite, to ensure the safety and stability of power supply in the station area, a high-efficiency energy storage systems such as hydrogen fuel batteries, low-temperature-resistant lithium batteries, phase-change heat storage systems will be used to the greatest extent by intelligent integrated energy management systems according to the site condition of using renewable energy with a view to minimize diesel consumption and air pollutant emissions. The new station will increase the use of renewable energy and maximize the use of indoor natural light and recycling waste heat to minimize the use of fossil fuels.
- According to the specific wind speed environment of the proposed site, the details of wind power generation were carefully analyzed. Since 2018, new energy microgrid test systems including wind and solar systems have been tested at the Taishan summer camp in Antarctica with similar latitudes and lower minimum temperatures; wind turbines, photovoltaics and other renewable energy power generation accounted for an average of more than 75% in one monthly power generation cycle, from January 25, 2020 to February 24, 2020, and diesel power generation only accounted for 25%, which greatly reduced the diesel usage in the Antarctic summer and was also accumulated a wealth of experience for the future renewable energy system of the new station, the wind resources of the Inexpressible Island are better than that of the Taishan summer camp, and the potential for emission reduction is greater.

- Based on the committee's recommendations, a more detailed environmental monitoring program was revised. The purpose of monitoring is to assess and analyze the impact of the construction, operation, and scientific activities of the new scientific research station on the surrounding environment.
- Other mitigation measures related to non-native species, fuel management and waste separation and management have also been optimized in the new CEE.
- Temporary facilities will be dismantled after finishing the construction of the new station and the wastes will be transported back to China for disposal and the site would be restored to its original status.

The Final CEE has been prepared in accordance with Annex I of the Protocol on Environmental Protection to the Antarctic Treaty, and the domestic laws and procedures. It also referred to the Guidelines for Environmental Impact Assessment in Antarctica (Resolution 1, XXXIX ATCM, 2016). The Final CEE describes the following contents：

- Construction, operation, and maintenance of the new station
- Transportation process for cargos and personnel to the new station
- Analysis of potential environmental impact
- Prevention and mitigation measures to minimize environmental impact
- Gaps in knowledge and uncertainties

1.2 Purpose of building a new station in Victoria Land

As an independent station that will operate year-round, the new station will develop an Antarctic observatory network with the Chinese Great Wall Station, Zhongshan Station, Taishan Summer Camp and Kunlun Station and if possible, with stations of other countries, especially in the Terra Nova Bay region.

The site of the new station (74°55′S/163°42′E) was finally decided at the Inexpressible Island, Terra Nova Bay in the Ross Sea Region. Three initial candidate locations including the Inexpressible Island as shown in the Final CEE had been considered in the evaluation process based on the factors such as the convenience of scientific research and supporting logistic activities, and minimizing possible impact on the surrounding environment. When the Inexpressible Island was chosen as the premise of the new station, five alternative sites on the island were investigated and compared. The final decision on the site for building the new station was specifically kept further away from the Adélie penguin colony. Proposal for a Antarctic Specially Protected Area at Inexpressible Island had been discussed by China, Italy, and Republic of Korea and jointly submitted to ATCM 42 in 2019 as WP 47 and approved by ATCM 43 online in 2021.

The new station is a year-round station which will function as one of the key platforms of the Antarctic observatory network focusing on ocean, ice, and snow in the Ross Sea region. It will be valuable to compare the data obtained in the new station with those in the Zhongshan Station in the East Antarctica. China believes that understanding the change and variation of the climate, ice and ocean undergoing in Antarctica is a matter of priority for the Antarctic community. The main purpose of the new station is to provide a platform for regional multidisciplinary research focusing on the climate, cryosphere, and ocean system.

We are exploring the possible future cooperation with the Korean and New Zealand colleagues. MOUs on polar cooperation between China and other countries like Russia, USA, Norway, and Germany have been signed. China has fully expressed the desire to develop more cooperation with other countries and hope that countries in this region would promote scientific cooperation and the share of research platform by means of further communication and coordination.

China believes that understanding climate change impacts on Antarctica are a matter of critical importance for the world and for the continent itself. The main purpose of the new station is to provide an international platform for regional multidisciplinary research focusing on the chain reactions caused by the changing climate.

Although isolated from other continents, Antarctica is connected to the rest of world through oceanic and atmospheric circulations. Antarctica and the surrounding Southern Ocean are key drivers of Earth's oceanic and atmospheric systems.

A critically important feature is that about 90% of Earth's ice (around 25.2 million gigatons) is found in the Antarctic, and 70% of all available fresh water is locked up in the Antarctic ice sheet - if melted, it would raise sea level by nearly 60 meters. Equally important, the Southern Ocean extends over about 38 million km2 and encompasses about 20% of the world's ocean waters. It connects the three main ocean basins (Atlantic, Pacific, and Indian) and creates a global circulation system that is largely driven by the eastward-flowing Antarctic Circumpolar Current - the world's largest current. The current generates an overturning circulation that transports vast amounts of heat and takes up a significant amount of carbon dioxide from the atmosphere. Atmospheric pressure, humidity, air temperatures and wind patterns for our entire planet are interconnected and greatly influenced by processes in the Southern Ocean.

Cooling and sinking processes in the Southern Ocean and circulation of sea waters throughout the global deep ocean exert a powerful control over the Earth's climate. The Southern Ocean also plays a very important role in the global carbon cycle and removing carbon dioxide from the atmosphere through chemical and biological processes. The Southern Ocean supports the abundant marine ecosystem. These important functions have a critical relationship with sea ice. Changes in the integrated polar ocean-ice system will have far-reaching impacts.

The western part of the Antarctic Peninsula is warming up two to three times the global average, and it is one of the fastest warming areas on the planet. During this period, 3 of the 12 ice shelves in the peninsula have been significantly reduced, and 4 have collapsed, with a total loss of about 18% of the floating ice. However, in the eastern part of Antarctica, due to the impact of the ozone hole, there observe much less impact of global warming, and the rate of warming is lower than the global average (Figure 1-1). Regional differences in response to climate warming and changes highlight the complexity of the current processes affecting the earth’s environment.

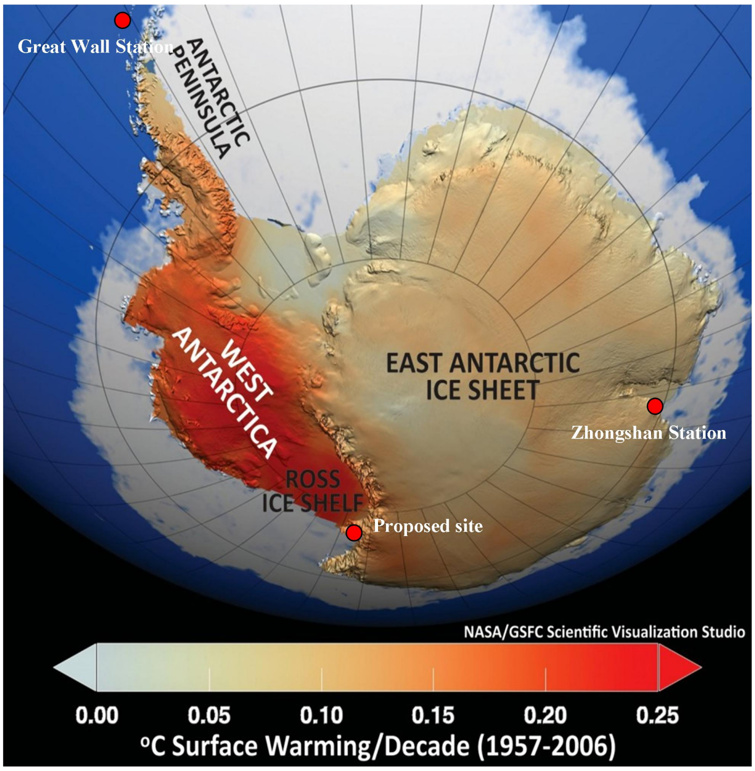

Figure 1- 1 Surface Warming of West Antarctica (Cited from http://www.sciblogs.co.nz)

To further understand the Antarctic environmental characteristics and variations under the influence of global climate change, China is implementing a special project to clarify the changes in the polar environment, especially the polar ocean environment. China is going to strengthen the investigations and researches on changes in the Southern Ocean (characteristics, ice shelf-ocean interaction and atmosphere-ice-ocean interaction) and response to climate and marine ecosystem. Until now, most of Chinese Southern Ocean investigation activities are mainly limited in: (1) Prydz Bay（Zhongshan Station as a base）, where the warming is less obvious and the physical, chemical, and biological oceanography, ice shelf-ocean interaction, sea ice variation are studied, (2) Waters near Antarctic Peninsula (Great Wall Station as a base), a region of quick warming, where ocean environment and marine ecosystem are investigated, and (3) Part of waters during the cruise to Great Wall Station or Zhongshan Station (Figure 1-2).

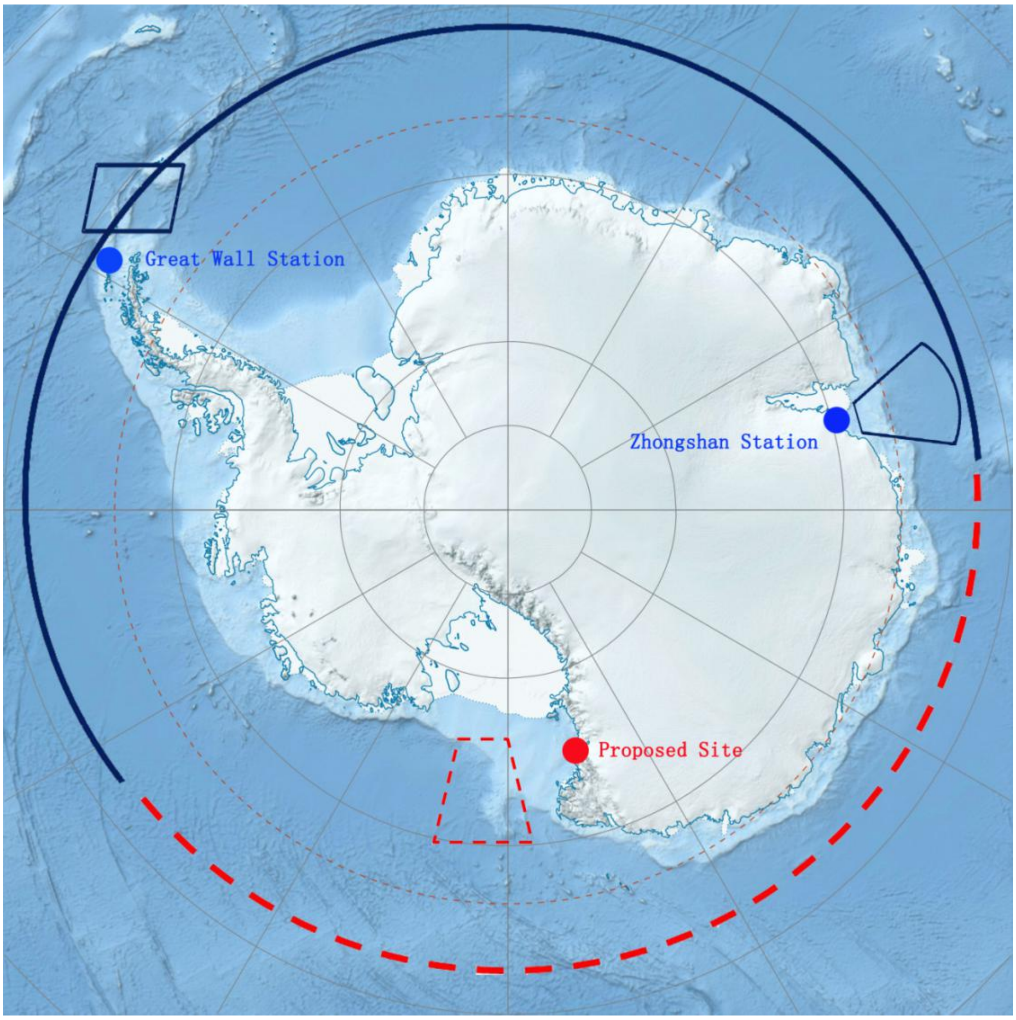

Figure 1- 2 Conventional investigation areas of Chinese annually expedition in Southern Ocean

As the highest latitude ocean in the southern hemisphere, the Ross Sea is the most active area in the Antarctic Circle. It has the largest ice shelf in Antarctica, the Ross Ice Shelf (approximately 182,000 square miles), and the longest ice tongue, the Drygalski ice tongue. Before the ice shelf was formed under the action of ocean currents and wind, it was once a large ice lake. Ice shelves and interglacial lakes are of great significance to water flow, air-ice-sea interactions, and ecosystems.

The interaction between the Antarctic ice sheet/ice shelf and the ocean is the main process that affects the ice sheet material balance and promotes the ice sheet instability mechanism. The Ross Ice Shelf and the Nansen Ice Shelf around the new Chinese research station are used to study the Antarctic ice sheet / Ideal place for interaction between ice shelf and ocean. The degree of melting of the bottom of the two, the reason and its contribution to the material balance of the supported ice sheet, the complex ice bottom environment and process in the grounding area and its influence on the instability of the ice sheet, the geometric characteristics of the sea cavity under the ice shelf and its dominant the characteristics of ice-sea interaction, the entry channel of warm circumpolar deep water and its material and energy exchange process are the frontiers and hotspots of current research on global climate and sea level changes. Therefore, relying on China's new research station to carry out long-term observations and monitoring of satellite, aviation, ground, and underwater ice sheet/ice shelf-ocean interactions will help to improve the understanding of the above-mentioned key features and processes, and further contribute to the evaluation and it provides an important basis for predicting global climate and sea level changes.

Terra Nova Bay is the bottom ring of the global thermohaline circulation-the main generating place of the bottom water of Antarctica. The formation of Antarctic bottom water is an important engine that drives the operation of the thermohaline circulation system, and then plays an important role in the global climate system through the heat exchange between the ocean and the atmosphere.

Terra Nova Bay has one of the most typical nearshore interglacial lakes in Antarctica. The nearshore interglacial lakes are the main ice producing areas in Antarctica and are called Antarctic "ice factories"; the salt precipitation process during ice production leads to Antarctica the predecessor of the bottom water-the formation of high-density shelf water, the water mass mixes with the circumpolar deep water and then sinks to the bottom of the Antarctic Sea area, and finally forms the bottom water of the Antarctica. The nearshore interglacial lake is mainly produced by the gravity flow produced by the nearshore wind field in Antarctica, especially the violent radiation cooling of the ice sheet-the downward wind drives the offshore sea ice movement. Declining wind is the most prominent feature of atmospheric circulation in high latitudes in the southern hemisphere, the most stable in winter, and the longest duration. Terra Nova Bay is one of the strongest downwind regions in Antarctica. Winter wind speeds frequently reach storm levels. Meteorological conditions are very bad, so few countries have established research stations in this area, but here is a key place to study the origin of Antarctic bottom water and its regulation mechanism. Accurate understanding and understanding of the ice-sea-atmosphere coupling process of the interglacial lakes of Terra Nova Bay is essential for grasping the generation law of Antarctic bottom water and the operation law of the global ocean circulation system, and improving the cognition and prediction ability of global climate change.

The Ross Sea is one of the most productive areas in Antarctica (water blooms were observed in the Ross Sea in spring, see Figure 1-3). Although its food web is relatively stable, its oceanography, biogeochemistry, and sea ice coverage have undergone tremendous changes, and this change is likely to continue in the future. In contrast to the Amundsen-Bellingshausen area, the coverage and persistence of the Ross Sea ice has been increasing, which has led to a reduction in the open water duration of its biome. The model predicts that as the ozone hole recovers, the ice sheet will begin to decrease. In the next century, ocean currents on the continental shelf may change, and it is expected that the intensification of ocean currents will lead to changes in deep ocean currents. Such changes in ice and circulation will lead to changes in the distribution and composition of plankton, but it is currently difficult to predict the nature of these changes. Unlike other Southern Ocean regions, the continental shelf is very narrow. Antarctic krill is the most important herbivore. The herbivores on the wide continental shelf of the Ross Sea are mainly crystal krill and whitebait, which are the main prey of higher nutritional levels. At present, the Ross Sea is one of the most species-rich areas in the Southern Ocean, and it is also a “hot spot” for biodiversity because of its wide variety of habitats. Although the Ross Sea is one of the most in-depth researched areas in the entire Southern Ocean, the impact of climate change on the oceanography and ecology of the Ross Sea is still full of uncertainty.

The nearshore interglacial lakes have a long time of receiving sunlight in spring and summer, and become the high value area of Antarctic biological productivity. Under the dual effects of physical and biological absorption of carbon dioxide, the interglacial lake has become an important carbon sink area in the polar regions, and the active deep convection activities here can move the carbon dioxide absorbed by the surface layer to the deep layer, and with the formation of the bottom water of Antarctica Buried at the bottom of the ocean. Therefore, conducting carbon flux research in the Gulf of Terra Nova is also of great significance for understanding the carbon sink function and climate effects of the polar regions.

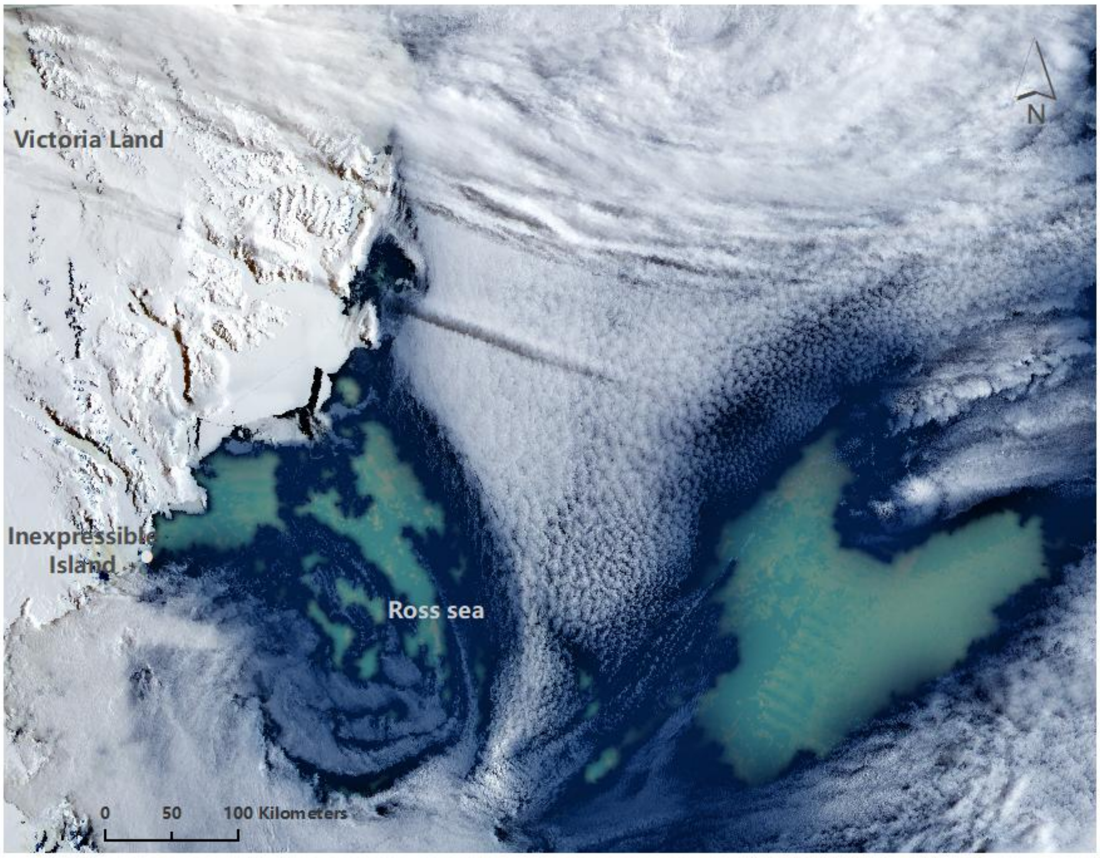

Figure 1- 3 A phytoplankton bloom was viewed in the Ross Sea on January 22, 2011

(Data source : Medium Resolution Spectral Imager (MERSI) on China's FY-3A satellite)

The Ross Sea is an ideal place for oceanography and air-ice-ocean interaction research, and the station is a platform for long-term environmental monitoring, which is important for understanding characteristics of the variation. To build a new station in the region of the Ross Sea, China will have the capacity to monitor and research the typical waters in the Southern Ocean, the sub-Antarctic waters with fast warming, the east Antarctic waters with relatively low warming and Antarctic waters with severe ice shelf-ocean and air-ice-ocean interaction, which can help us understand the characteristics and variations of the Southern Ocean.

The proposal of construction of a new station and the related scientific plans are the major contents of the 12th, 13th, and 14th Five-Year China's Polar Research Plans. By implementation of these plans, China hopes to deepen the study on the Southern Ocean, develop her role in addressing climate changes, and contribute to better environmental protection, promotion of sustainable development and further enhancement of the scientific knowledge of the public.

China would also like to discuss the issue of coordination of scientific and logistical activities with countries that establish stations in the Terra Nova Bay area and the western Ross Sea region, including coordinating the stations, research vessels and air transportation of personnel. During December 2014 to January 2015, China had successfully transported 25 foreign researchers from Italy, Korea, Japan, and New Zealand in this area by R/V Xuelong and has shifted more than 8 tons supply materials for New Zealand to several locations in the western Ross Sea including Adare Cape as shown in Figure 1-4 and Figure 1-5.

Figure 1- 4 2015 XUELONG International Workshop on Antarctic Science (January 8th,2015)

Figure 1- 5 China transporting 48 oil tanks to Adare Cape by KA 32 (January 7th,2015)

1.3 History of Chinese Antarctic activities

China has accomplished world-renowned achievements in conducting Antarctic activities over past four decades, which scaled up from scratch to booming. China actively participates, defend, and contribute to international Antarctic governance mechanism. As an Antarctic Consultative Party, China has been firmly safeguarding the principles of the Antarctic Treaty by protecting Antarctic environment, facilitating peaceful use of Antarctica, advocating scientific studies, and promoting international cooperation, to contribute to the growth of human knowledge, the progress of social civilization and sustainable development.

In November 1984, China sent its first Antarctic expedition to West Antarctica and the expeditioners landed on the King George Island in December of the same year. A ceremony for the foundation of the Great Wall Station (62°12′59″S, 58°57′52″W Figure1-6) was held. In February 1985, the Great Wall Station was successfully built up and some expeditioners overwinter there in the same year. In November 1988, China dispatched an expedition to East Antarctica to build the second Chinese Antarctic Base, the Zhongshan Station in the Miller Peninsula in February 1989 (69°22′24″S, 76°22′40″E Figure1-6). In January 2009, China dispatched an expedition to inland Dome A area and established the third Chinese Antarctica Base, the Kunlun Station (80°25′01″S, 77°06′58″E Figure1-6) there. In February 2014, China established the Taishan Summer Camp as a relay point for the inland expedition (73°51′50″S, 76°58′29″E Figure 1-6). Up to the present, China has successfully organized 37 Antarctic scientific expeditions and sent more than 5000 expeditioners in total to the Antarctic for scientific studies and logistic support, gradually forming a supporting system of "Two ship and Three stations and One camp", that is, R/V Xuelong (Figure 1-7) and R/V Xuelong 2(Figure 1-8) provides logistic support to the Great Wall Station (Figure 1-9), Zhongshan Station (Figure 1-10), Kunlun Station (Figure 1-11) and Taishan Summer Camp (Figure 1-12).

China is currently developing Antarctic observation and monitoring network on the stations and camp which are supposed to satisfy the demand of logistic support to Antarctic expeditions. All the bases have become not only the ideal sites for the scientists to carry out studies in Antarctica but also the platforms for China’s opening to the outside world to cooperate with other countries.

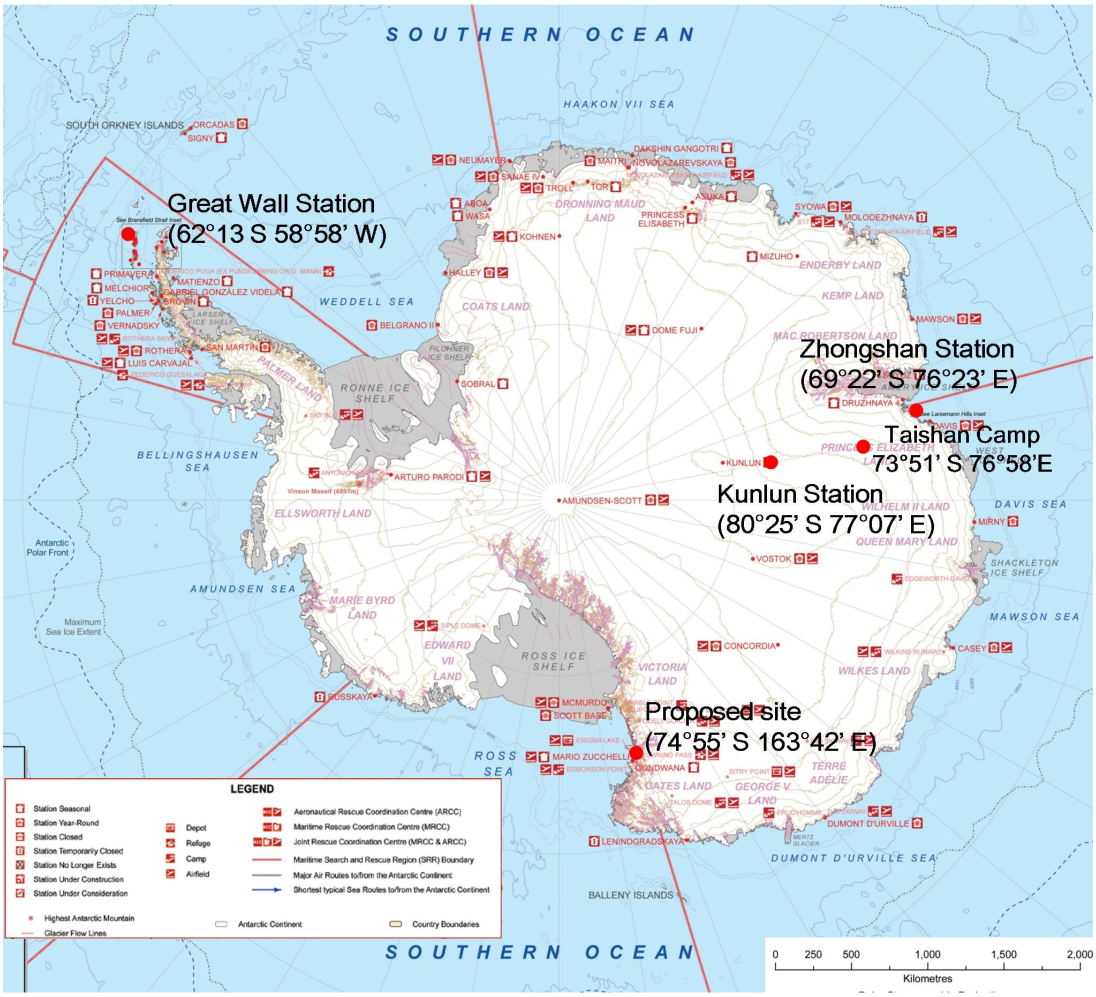

Figure 1- 6 Distribution of the Chinese Antarctica Research Stations (Base Map: COMNAP 2009)

Figure 1- 7 R/V Xuelong in the Southern Ocean

Figure 1- 8 R/V Xuelong 2 in the Southern Ocean

Figure 1- 9 Chinese Great Wall Station located in West Antarctic

Figure 1- 10 Chinese Zhongshan Station located in East Antarctic

Figure 1- 11 Chinese Kunlun Station located in the inland of Antarctica

Figure 1- 12 Taishan Summer Camp located in the inland of Antarctica

Over the last 35 years, the Chinese scientists have carried out multiple disciplinary observations and surveys in glaciology, oceanography, atmospheric science, biology, geology, and mapping, etc. They have collected a great number of precious samples, data, and information from multi-years of arduous field surveys under harsh conditions. In terms of geological studies, a deepened understanding of the crust evolution in East Antarctica has been scored through the studies on the pan-African tectonic structure. At the same time, with arduous efforts in the past years, the CHINARE has collected more than 11,400 pieces of meteorite samples and has laid a foundation for further studies on the movement of celestial bodies. The ecological studies took Antarctic krill as an important indicator and combined it with environmental and climatic changes. The glaciology studies have initially accomplished the detection on the basic observation profiles in the area from the Zhongshan Station to Kunlun Station in the 9th and 10th Five-Year Plan Periods, which have laid a foundation for China's studies on inland ice sheets and the construction of a new station in Dome A, Antarctica. Base on this, the study on the interaction between Amery ice shelf and ocean has been carried out and promoted a broader combination between glaciology and the international frontier sciences. In the solar-terrestrial studies, a cooperative project between China and Japan for medium and long-term observation was implemented and a number of important phenomena such as afternoon aurora was discovered and proved. The project further promoted the construction of the Arctic observation station which is mutually conjugated with the Zhongshan Station by taking the observation in the Zhongshan Station as a basis, thus promote the joint observation of the solar-terrestrial space from the South to North Poles. In the studies on recent modern environmental evolution in the Antarctic, the geochemical index elements integrated study was proposed to study the evolution of important biological populations on the scale of thousand years. In addition, much progress has been made in climate studies, landform mapping, earthquake observation and physical oceanography survey of the Southern Ocean. These scientific studies have enriched the knowledge of the ice and snow world of the Antarctic and contributed to the conservation of the global ecological environment and the common prosperity of the human society.

Since 1984, China has already signed cooperation agreements with some countries (as shown in Figure 1-13). To implement those agreements, China send scientists to join other countries on-site investigation, work out cooperation research program, and promote personnel and information exchange. The longstanding cooperation is conducive to improve scientific research level, share data and information, realize cost effective, and protect the environment. China will continuously commit to strengthen the bilateral and multilateral cooperation for the following.

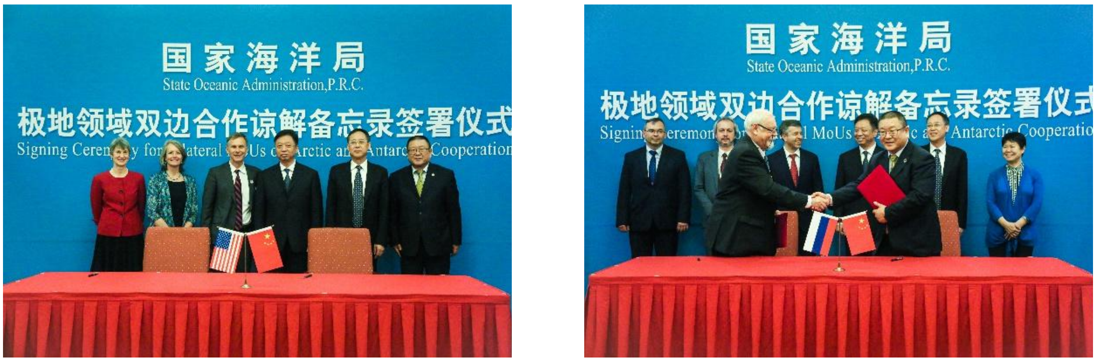

Figure 1- 13 Signing ceremony for bilateral MOUs on the Arctic and Antarctic cooperation with six countries during the ATCM 40 in Beijing (May,26th 2017)

To promote the international humanitarian spirit, RV Xuelong and the fixed-wing aircraft "Xueying 601" participated in several S&R operations in Antarctica. Xuelong and the Australian vessel Aurora Australis succeeded in rescuing the Russian vessel Akademik Shokalskiy in 2013-2014 through their full cooperation. Xue Long participated in 2016 in rescuing the stranding Aurora Australis in the Mawson Station. Additionally, Xueying 601 participated in rescuing a pilot in the Davis Station in 2015-2016.

1.4 Scientific programs supported by the new station

Antarctica, surrounded by the Southern Ocean, is vital for understanding the global climate change. Its vast ice-covered regions are like a global thermostat that regulates the Earth's climate system. However, its different areas are behaving differently. For example, the ice sheet in East Antarctica appears close to balance, but that in West Antarctica is thinning rapidly. To understand how Antarctica impacts and responses to the global climate change, we need to consider it and to put it into the whole Earth system. In Antarctica, China has built Great Wall, Zhongshan and Kunlun stations on the Southern tip of Antarctica peninsula, in East Antarctica and at Dome A inland Antarctica, respectively. Systematic observations about climate change have been carried out based on these stations. Additional observations based on the new station, where is in the Ross Sea region, will much improve our ability to study Antarctica. In addition, besides in Polar Regions, China is also making efforts for understanding the climate change in subtropical and tropical regions. For example, a multi-national ongoing program, NPOCE (the Northwestern Pacific Ocean Circulation and Climate Experiment), leading by China is designed to observe, simulate, and understand the dynamics of the Northwestern Pacific Ocean circulation and its role in low-frequency modulations of regional and global climate. Based on the new station and relied on the Xuelong and Xuelong 2, we will carry out comprehensive surveys from Rose Sea to Southern Pacific Ocean. Combining these surveys with the NPOCE program will provide us an opportunity to put Antarctica into the whole Earth system to consider its role in global climate change.

The Ross Sea is one of the most active sectors of the Southern Ocean and Antarctic Research. China is planning to build a new station in the Ross Sea region and is keen to avoid duplication and contribute to the scientific activities undertaken by the other countries based in the region (New Zealand, Italy, USA, German, Korea).

The new station will function as one of the key platforms of the Antarctic observatory network focusing on ocean, ice, and snow in the Ross Sea region. It will be valuable to compare the data obtained in the proposed Chinese Station with those in the Zhongshan Station in the East Antarctica. China believes that understanding the change and variation of the climate, ice and ocean undergoing in Antarctica is a matter of priority for the Antarctic community. The main purpose of the new station is to provide a platform for regional multidisciplinary research focusing on the climate, cryosphere, and ocean system.

The main scientific programs based on the new station include the studies on atmospheric and atmosphere-ice-ocean interaction, glacial and ice shelf-ocean interaction, environment and ecosystem monitoring, space physics and the geological environment evaluation studies etc.

（1）Atmosphere-Ice-Ocean interaction studies

Build an atmosphere and atmosphere-ice-ocean observation system to conduct long-term continuous observation of changes in the atmosphere, sea ice and marine environment, and provide long-term, continuous observation data for climate change and atmosphere-ice-ocean interaction research.

- Establish an automatic weather observation station, combined with air sounding balloon measurements, to study the characteristics of the descending wind around the station area and its inter-annual changes;
- Carry out sampling and observation of major greenhouse gases and aerosols, and grasp the basic chemical characteristics of the atmosphere and its seasonal and inter-annual changes;
- Deploy submersible targets to obtain basic data such as sea water temperature, salinity, velocity, and flow direction, and analyze sea ice, interglacial lakes and circulation and their change characteristics;
- Use aerial and satellite remote sensing to monitor long-term changes in sea ice distribution, and study the potential impact of downwind and climate change on the distribution and reserves of sea ice in Terra Nova Bay and surrounding sea areas.

（2）The environment and ecological process of the glacial lake（Terra Nova Bay）

Long-term continuous monitoring of the glacial lake of Terra Nova was carried out to evaluate the key role of the glacial lake ecosystem in primary production and supporting the ecosystem of Terra Nova Bay.

- Use research boats and marine laboratory platforms to monitor the inter-annual changes in the ecological environment of the coastal waters, and grasp the response of biota to climate and environmental changes;
- Use sediment traps to obtain the seasonal and inter-annual variation characteristics of particulate matter flux, combined with satellite remote sensing water color data, to analyze the biological production process and its seasonal and inter-annual variation characteristics of the Terra Nova Bay area;
- Use the marine experimental platform to carry out environmental adaptability experiments of microalgae and other marine organisms to understand the environmental adaptability of marine plankton and dominant groups of fish;
- Use the temperature, salinity, chlorophyll, effective photosynthetic radiation (PAR) and other sensors carried by the latent standard (or online latent standard) to obtain long-term continuous observation data, and analyze the seasonal change of the primary yield of the ice lake and its regulation mechanism.

（3）Glacier/Ice Shelf-Ocean Interaction Research

- Carry out the monitoring of glaciers around the Inexpressible Island to study the potential impact of glacier melting and icebergs entering the sea on the marine environment and primary production.
- Use satellites to monitor the ice flow characteristics of the main glaciers around the Inexpressible Island, and evaluate the annual inflow of surrounding glaciers and their

interannual changes;

- Use marine isotope tracing technology to monitor the glacier melting and freshwater input characteristics of Terra Nova Bay, and analyze the potential impact of freshwater input on the marine environment and biological communities;
- Deploy potential targets in the bottom water transport channel of Terra Nova Bay to obtain information on changes in bottom water temperature and salt, and grasp the melting of the Ross Sea ice shelf and its potential impact on bottom water characteristics;

（4）Study on the Number of Large Birds and Its Regulation Mechanism

The proposed research station will carry out long-term monitoring of the Adélie penguin colony in the northern part of the Inexpressible Island, combining basic environmental data and coastal waters ecological data, revealing the interannual quantitative changes and regulation mechanisms, and assessing the potential of climate change for large Antarctic organisms Influence. Simultaneously carry out monitoring and research of surrounding lichens and other terrestrial environment and biota.

（5）Other observational research

Establish a space physical observation system, carry out research on the middle and upper atmosphere-the middle layer and the thermosphere, understand atmospheric temperature changes, temperature changes from the troposphere to hundreds of kilometers, and the dynamics of neutral winds, and conduct research with the observation data from the Zhongshan Station in Antarctica Compare and obtain the evolution characteristics of polar space phenomena. The new station will also carry out research on near-Earth solar wind, magnetosphere and ionosphere, and geological structure.

The new station will set up professional marine laboratory and ocean observation system and open to other stations. The new station is expected to promote the multinational and multidisciplinary research collaborations in Northern Victoria. Currently, the United States, New Zealand, Italy, Germany, and Korea have run their research stations in the Ross Sea. China will share the observing and monitoring data with other stations. The scientists who are interested in the Antarctic research are also welcome to utilize the research platform of the station. China believes that the relevant study by Chinese scientists could be complementary to the existing activities or enhance the science that is currently being undertaken in the area to advance those research projects. Table 1-1 contains the detailed description of the main research fields based on the new station, in which the major research work expected to be carried out and how they are complementary to those already undertaken or planned by the existing stations have been clearly defined.

Table 1- 1 A list of main research fields of new Chinese station on the Victoria Land, Antarctica

Subject	Content	Equipment	Region	Significance	How to connect with studies of other stations
Physical Oceanography	Observation of polynya	The research vessel, moorings, etc.	Terra Nova Bay	The Terra Nova Bay Polynya keeps open in winter and produces denser shelf water that is an important source of the Antarctic Bottom Water. Additionally, the polynya has essential influences on the local ocean-atmosphere exchange and the marine ecosystem in this region.	Most previous research of polynya was based on remote sensing data and *in situ* observations in summer. As a supplement, moorings will be deployed in the polynya by Chinese expeditions to collect hydrographic data in winter to deepen the understanding of processes in polynya and their contributions to modification of shelf water.
	Interaction between glacier tongue and ocean	The research vessel, CTD/LADCP, turbulence profiler, etc.	Drygalski Glacier Tongue and its surrounding sea waters	Although the Drygalski Glacier Tongue has been monitored and studied for decades, the interaction between the glacier tongue and its surrounding sea waters are still limited.	Measurements will be conducted in the ocean area surrounding the Drygalski Glacier Tongue. These data, as a supplement of remote sensing data, will be used to analyze the stability of the ice tongue and interactions between the ice tongue and the surrounding ocean, sea ice and icebergs.

Subject	Content	Equipment	Region	Significance	How to connect with studies of other stations
	Observation in the outflow region of Ross Sea	The research vessel, CTD/LADCP, moorings, etc.	The northwest shelf region, including the Terra Nova Bay, Drygalski Basin, Nordenskjold Basin, Crary Bank and Mawson Bank.	The major circulation in the Ross Sea is a clockwise gyre, the Ross Gyre. The ocean area near the new Chinese Station is the outflow region of the Ross Sea. The surface current in the region of Terra Nova Bay is prevalent northward (Commodari and Pierini, 1999; Flocco *et al*., 2003). However, the circulation patterns in the deeper layer and remote region are more complex. Studying the circulation in this region will help further understanding of the contributions of the Antarctic Bottom Water formed in the Ross Sea.	A comprehensive observation and study have been conducted on the shelf slope exchange in the Ross Sea recently (Gordon *et al*., 2009). The oceanographic survey on the shelf is still limited.
	Monitoring of Sea ice	GPS, ice radar, ice driller, ice drifter, Ice	Northwest Ross Sea, with a focus on the region	Variations of Antarctic Sea ice show a great regional deference. Local monitoring of sea ice not only serves for the study of local	Measurement of sea ice is a basic research work of all coastal Antarctic stations. More observations will help the sea ice research more productive. Cooperation is

Subject	Content	Equipment	Region	Significance	How to connect with studies of other stations
		Mass Balance Buoy, up looking sonar, etc.	near the new station and polynya.	atmosphere-ice-ocean interactions but also establishes the research base for the whole Antarctic Sea ice. More *in situ* observations, especially the measurements of ice thickness, are necessary to validate remote sensing sea ice productions.	welcome.
Glaciology	Monitoring of ice shelf change and flow velocity	Remote sensing, GPR (ice sounding), GPS, middle-depth ice-coring drill (100 to 1,000 meters), hot-water ice drill, AWS, etc.	Ross ice shelf	Ross ice shelf is one of biggest two ice shelves in Antarctica. Its change will influence significantly not only to the Southern Ocean currents and marine ecosystem but also to the stability of the western Antarctic ice sheet.	The area of the Ross ice shelf is huge, we hope that we can supply more data for the research of the ice shelf.

Subject	Content	Equipment	Region	Significance	How to connect with studies of other stations
	Monitoring the rapid ice streams of western Antarctic ice sheet	Remote sensing, GPR, GPS, surveying and mapping, surface mass balance measurement, ice drill and borehole probe, AWS, etc.	Land ice feed regions of Ross Ice Shelf	There are many rapid ice streams feeding Ross ice shelf in the western Antarctic ice sheet. Their flow characteristics and dynamics are basic to understanding the ice sheet change.	We hope that we can supply more data for the research of the ice shelf.
	Ice core study with high resolution	Ice coring drill, GPR, AWS, snow stratigraphy observation and sampling equipment, ice core measurement and analysis	Inland regions (specific drilling sites to be determined)	High snow accumulation in West Antarctica is beneficial to obtain high-resolution records of climatic environment change from ice core study.	Ice core study is one of the Antarctic research hotspots. An ice core from different regions can provide records with various time-scales and resolution. Scientists from other stations are welcome to join this project.

Subject	Content	Equipment	Region	Significance	How to connect with studies of other stations
		equipment, etc.			
	Glacier monitoring	GPS, GPR, surveying and mapping, mass balance and velocity measurement, optical spectrum instrument, etc.	（Reeves, Larsen, David）Glaciers near the station, such as Reeves Glacier, Larsen Glacier, and David Glacier	Monitoring of different glaciers can provide the basis for understanding response mechanism of different glaciers to climate change in Antarctica.	Glacier change is strongly controlled by local topography so that there is a big difference between different places and glacier types as well.
Marine ecology	Zooplankton ecology	R.V. *Xuelong*	Terra Nova Bay	This research will focus on the impact of Ross Sea polynya on zooplankton community structure and trophic strategies of dominant species. We will compare the result with polynya in Prydz Bay to better understand the response of ecosystems in	Scientists from Italy, America, and some other countries had conducted systematically research on distribution and abundance of dominant zooplankton taxa like copepods and krill. These valuable data would help us do further research from the scope of trophodynamics to better understand the response of

Subject	Content	Equipment	Region	Significance	How to connect with studies of other stations
				different sectors of the Southern Ocean to environmental change.	zooplankton to the Southern Ocean ecosystem.
	Marine food-web analysis	R.V. *Xuelong*	Terra Nova Bay	Sea ice extent increased in the Ross Sea these years, contrary to that near the Antarctic Peninsula region. Increasing of sea ice extent and the existence of polynya would have a bottom-up effect on marine ecosystem through plankton to the whole food web. The research will help us better understand the mass and energy transport in the Ross Sea polynya.	Scientists from Italy and some other countries had conducted systematical work on water masses, primary production, plankton community and benthic community of Ross Sea polynya during the Italian oceanographic cruises in the Ross Sea from 1980's. These works provided us a great deal of valuable data. Our research will focus on the potential impact of sea ice and polynya variations on the food web in the Ross Sea in the future.
	Benthic Ecology	R.V. *Xuelong* GPS; Box sampler/Multi cores; In situ mass filtration system；ocean observatory	Terra Nova Bay Western Ross Sea	(1)Focus on the response of the benthos communities after ice-shelf collapse events, and how the benthic ecosystem evolves. Benthic community in the sea around Antarctica is very thrifty. Ice-shelf collapse events	(1)Ice-shelf collapse events happened in the Antarctic Larsen area, after that, the benthos community have been studied. We hope that we could get more data from other similar events, so that we can understand the benthos how to respond to globe warming.

Subject	Content	Equipment	Region	Significance	How to connect with studies of other stations
		network		would scrape the seabed and expose more sea area uncovered by ice, leading positive or negative effecting on benthic ecosystem. (2)This research aims to conduct eDNA metabarcoding, along with ROV and traditional survey method to investigate fish/benthos diversity and abundance. We intend to establish an alternative fish/benthos diversity survey approach suitable for Antarctic ocean, investigate species composition and diversity patterns of fish/benthos, and infer fish/benthos abundance from aqueous eDNA，thereby we can elucidate numbers and spatial distribution patterns of fishes/benthos, and reveal the	(2) No study to-date has utilized metagenomic shotgun sequencing of eDNA to investigate Antarctic marine macrofaunal community composition, but only one research near Anvers and Brabant Islands, West Antarctic Peninsula (including stations located at Palmer Station vicinity). (3)Setting an ocean observatory network near the new station, as the Polar Remote Interactive Marine Observatory located about 3 miles to the south of Palmer Station, aims at obtaining long-term data from Ross Sea comparing to other data from Antarctic Peninsula

Subject	Content	Equipment	Region	Significance	How to connect with studies of other stations
				ways that species composition and abundance distribution of fishes/benthos response to the changes of ecological environment including climate change and glacier collapse. We hope to draw a baseline for biodiversity conservation and management of ecosystem for vicinity region of Inexpressible Island, and provide fundamental data for studies regarding the mechanism of response and feedback of Antarctic ecosystem to environmental changes. (3) The ocean observatory network is a cabled observatory to be located near the new station and provide year-round biological and related environmental data, aiming to long-term monitoring the	

Subject	Content	Equipment	Region	Significance	How to connect with studies of other stations
				ecosystem dynamics, fish/benthos behavior and climate changes.	
Terrestrial ecosystem and Zoology	Studies on the Antarctic lichen, moss, and birds (Population dynamics, adaptation mechanism)	RS; GPS; Voice analysis system; Temperature logger; Camera trap	Inexpressible Island and the nearby area	The study of lichen distribution on the island will better understand the terrestrial ecosystem and the relationship between global climate change. The birds of Antarctica, and particularly the penguins, are important in the Antarctic marine food web and ecosystem. The study on the penguin population of the inexpressible island will better understand the population dynamics and its relationship with marine ecosystem nearby.	Current research activities on Antarctic birds including: (1) to study the migration flyway, colony distribution, habitat selection of some penguins and seabirds. Examine the contaminant accumulation and transfer in the food web of Antarctica; (2) to study the impact of climate change on polar wildlife by combining the data of population dynamics, habitat change, and climate change, investigate adaptation strategies of birds on the polar environment. Based on the new station, we can observe the population year-round, to clarify the influence of environmental variation and human activities on the penguin population. Other stations, such as Italian station, New Zealand are welcome to participate in this project.

Subject	Content	Equipment	Region	Significance	How to connect with studies of other stations
Polar Atmospheric and space physics	Auroral physics/ Polar ionospheric physics/ polar upper atmospheric physics/ solar wind-magnetosphere-ionosphere coupling	Auroral all-sky imager system, instruments for Ionospheric TEC and scintillation, Lidar, Fluxgate magnetometer, Induction Magnetometer	Station area	The new station is in the polar cap area (the magnetic poles are open to space), and the time difference of the magnetic field of Zhongshan Station is 10 hours to monitor the evolution process of solar wind energy and particles injected into the earth space, revealing the solar wind-magnetosphere-polar ionization Layer coupling law.	The U.S. McMurdo Station monitors aurora, magnetic field variation, ionospheric absorption and convection, mesospheric kinetic temperature and so on. New Zealand's Scott Base located about 1.8 miles (three kilometers) from the U.S. McMurdo Station, is engaged in the research activities of the magnetosphere. These stations are about 320 km from the Inexpressible Island, just a good distance in cooperation to conduct triangle aurora observation, to extend the field of view of aurora observation, and to monitor space plasma wave propagation, etc. Italian Zucchelli Station (74.70° S 164.11° E) has a digital sonde, an imaging radiometer and permanent observatories for Geomagnetism, and we might have some cooperation in observation of ionospheric and magnetic field. Space physics processes have different scales both in temporal and special.

Subject	Content	Equipment	Region	Significance	How to connect with studies of other stations
					Therefore, one-point observation has many limitations on monitoring a space physics phenomenon and we normally need to use observations from as many as possible sites. Obviously, combining the observations at out new station with that at other stations nearby, we can provide many advantages in space physics study.
Geology	(1) Accretionary orogenesis of the Pacific margin of Gondwana. (2) Crustal and lithospheric structures the Pacific margin of Gondwana. (3) Comparative study of accretion-type and collision-type ultrahigh-pressure metamorphism.	Broadband seismograph	Northern Victoria Land with an area of 400 × 500 km^2	The research program will reveal the structural style of Paleozoic Pacific margin of Gondwana and mechanism of subduction and exhumation of oceanic-type ultrahigh-pressure metamorphic rocks, and provide information for the tectonic model of the oceanic subduction zone.	With the support of Italian and German stations, basic geological investigations on (1) regional geology, Paleozoic metamorphic and igneous rocks, and (3) Mesozoic volcanic and strata have been done in Northern Victoria Land. On that basis, we will focus on the accretionary orogenesis of Paleozoic continental margin through combined observations of geology and geophysics and study on some special rocks (e.g., high- and ultrahigh-pressure metamorphic rocks).

1.5 The related work and results during 2018-2021

1.5.1 The main results of 2018-2019

In 2018-2019, from January 3 to January 20, 2019, a field team composed of 20 scientists and logistics support personnel carried out work in the area of the proposed site of the new station, and obtained a batch of important result about new station plans and designs and a batch of valuable scientific data supporting the management plan of special protected areas.

(1) Obtaining the depth of bedrock: For the first time in Antarctica, the method of high-density electrical sounding was used to physically probe the foundation of the proposed site. A total of 10 sets of 90-meter-long profiles and 2 sets of 180-meter-long profiles were completed on site. The total length of the completed section is 1,260 meters.

(2) Obtaining the physical parameters of the core: 3 exploration holes were completed in this survey, and the final hole depths were 8.0 meters, 11.3 meters, and 10.9 meters, and the total footage was 30.2 meters. The longest core is about 1.2 meters.

(3) Completion of environmental protection supporting projects for temporary facilities: the installation of external drainage pipes for the sewage treatment system of the temporary facilities, the installation of water inlet pipes for the seawater desalination system, and the lifting and installation of the wind turbine for testing have been completed.

(4) Completion of the route exploration from Ross Sea New Station to the Special Reserve: A tracked all-terrain vehicle + walking method was used to complete the route of 6.1km, including 3.7km on snow and 2.4km on mountain, and 301 GPS points were determined. Set up 10 sign poles, after the route is simply trimmed, a single crossing is expected to take 0.5 hours.

(5) Completion of route exploration from the new station to the junction of Republic of Korea Inland Team: The tracked all-terrain vehicle method is used to complete the route from the new station to the junction of the Republic of Korea Inland Team, the distance is about 14km, and the GPS point 337 is determined. It took 0.7 hours for each crossing.

(6) Completion of the route exploration from the new station to the runway built by the Italian Station: A tracked all-terrain vehicle + walking method is used to complete the route about 38.6km, determine 223 GPS points, and take about 3 hours in a single crossing.

1.5.2 the main results of 2019-2020

In 2019-2020, from January 1 to February 26, 2020, an on-site team composed of 21 scientists and logistics support personnel carried out work in the area of the proposed site of the new station, and obtained a batch of important result about new station plans and designs and a batch of valuable scientific data supporting the management plan of special protected areas.

(1) Complete the temporary helipad: learn from the experience of the Korean station and the Italian station apron, use the existing idle materials to realize the recycling of resources, choose a relatively safe location to build the temporary helipad, and improve the helicopter's safety of landing on the site, further guarantees the safety of scientists and logistics personnel.
2) Complete the optimization and adjustment of the layout of temporary facilities: rearrange the positions of machinery, water, and electricity, living supplies, sanitary cabins, and aviation oil tanks, and open the main descending wind channel. After 2 blizzards, it effectively solved the temporary problem of snow blockage in the facility area, provides a valuable reference for the future optimization design of the layout of the main buildings in the new station.
(3) Acquire water depth data of the terminal area: complete the nearshore water depth measurement and underwater image data acquisition of the planned terminal area to provide basic data for future terminal construction.
(4) Obtain bedrock depth and lithological parameters: The survey method combining drilling and exploration pits is adopted, and 12 drilling holes are completed, with a total footage of 93 linear meters. The drilling range covers the future facilities of the new station: the main building, logistics center, new energy sites and expansion plots, bedrock was found in 7 holes in the planned area of main building area; 4 exploration pits were completed, with a total footage of 7.1 linear meters, and a total of 100.1 linear meters of survey footage was completed.
(5) Complete the installation of the renewable energy test system: completed the wind power generation system commissioning and trial operation verification, completed the installation of the solar power generation wind resistance structure, and verified the wind energy and solar system stability and safety under continuous wind of 30m/s.

1.6 Preparation and submission of the Final CEE

The Final CEE is prepared by CAA based in Beijing, and PRIC located in Shanghai, with support and input from Tongji University focusing on environmental impact assessment, and the institutions for station design, technical support institutions and scientists.
The Final CEE has been approved by China’s Ministry of Foreign Affairs and SOA.

1.7 Laws, standards, and guidelines

During the preparation of the Final CEE, full reference has been given to many international laws such as those of the Antarctic Treaty System, the Convention on Biological Diversity, the Kyoto Protocol on Climate Change, the Protocol of the International Convention for the Prevention of Marine Pollution from Ships (MARPOL 73/78) and the Convention on the Dumping of Wastes at Sea as well as China's relevant laws and regulations. The guidelines and documents for environmental impact assessment developed by the COMNAP and SCAR have been followed in the course.

1.7.1 International laws, standards, and guidelines

The Antarctic Treaty System, which includes Antarctic Treaty itself and the related measures, resolutions, and decisions adopted by ATCM, and the Convention for the Conservation of Antarctic Seals (CCAS 1972), the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR 1980) and the Environmental Protocol.

China acceded to the Antarctic Treaty in 1983 and obtained the consultative party status in 1985. China ratified the Environmental Protocol in 1994. The Environmental Protocol set out environmental principles, procedures, and obligations for the comprehensive protection of the Antarctic environment and its dependent and associated ecosystems. Compilation and submission of this Final CEE is an important step taken by China to implement her obligations under the Protocol. The Final CEE has been prepared in accordance with Annex I of the Protocol on Environmental Protection to the Antarctic Treaty (1998). It also referred to the Guidelines for Environmental Impact Assessment in Antarctica (Resolution 1, XXXIX ATCM, 2016).

The international conventions such as the Convention on Biological Diversity (1993),the Kyoto Protocol on Climate Change (2005), the Protocol of the International Convention for the Prevention of Marine Pollution from Ships(MARPOL 73/78) and the Convention on the Dumping of Wastes at Sea(1975), to which China has become a contracting party, have established the requirements for environmental protection and sustainable development in different aspects and have become important bases for the development of the Final CEE for the construction and operation of the new station.

The COMNAP and the SCAR are the two international organizations involved in the Antarctic affairs. They have developed relevant guidelines and documents regarding the activities in Antarctica. The Final CEE has made reference mainly to the Guidelines for Oil Spill Contingency Planning (COMNAP, 1992), the Environmental Monitoring Manual in Antarctica (COMNAP, 2000) , The Technical Standards for Environmental Monitoring in Antarctica (COMNAP, 2000), the Practical Guidelines for the Development and Design of Environmental Monitoring Programs (COMNAP, 2005b) and the Guidelines for EIA in Antarctica (Resolution 1, XXXIX ATCM, 2016) ,Fuel Manual in Antarctica(COMNAP/ATCM, 2008), Non-native Species in Antarctica (ATCM/CEP, 2017) etc.

1.7.2 Chinese laws, standards, and guidelines

The construction and operation of the new station will strictly abide by relevant domestic environmental laws, standards as well as technical guidelines for Environmental Impact Assessment, as listed below:

1. Legal Instruments

PRC Law on Environmental Protection, 1 January 2015

PRC Law on Solid Waste Prevention and Control, 30 October 1995

PRC Law on Water Pollution Prevention and Control, 15 May 1996

PRC Law on Environmental Noise Prevention and Control, 29 October 1996

PRC Law on Energy Saving, 1 November 1997

PRC Law on Marine Environmental Protection, 25 December 1999

Regulations Concerning the Management of Hazardous Wastes Transfer Bills, 31 May 1999

Implementation Rules of PRC Law on Water Pollution Prevention and Control, 20 March 2000

PRC Law on Atmospheric Pollution Prevention and Control, 29 April 2000

Policies on Urban Sewage Treatment and Pollution Prevention and Control Technologies, 13 July，2000

PRC Law on Environmental Impact Assessment, 28 October 2002

PRC Law on Renewable Energy, 28 February 2005

National Scheme for Emergent Environmental Incidents, 24 January 2006

Regulations Concerning Environmental Monitoring Management, 25 July 2007

2. Environmental Standards

PRC Standards on Surface Water Environmental Quality, GB3838-2002)；

http://kjs.mee.gov.cn/hjbhbz/bzwb/shjbh/shjzlbz/200206/W020061027509896672057.pdf

3. Environmental Assessment Guidelines

Technical Guidelines for Environmental Impact Assessment—General Principles HJ/T2.1-2016).

（http://kjs.mep.gov.cn/hjbhbz/bzwb/other/pjjsdz/201612/W020161214348664955109.pdf）

Technical guidelines for environmental impact assessment—Atmospheric environment (HJ/T2.2-2018).

(http://www.mee.gov.cn/ywgz/fgbz/bz/bzwb/other/pjjsdz/201808/W020180814672740551977.pdf)

Technical guidelines for environmental impact assessment surface water environment.(HJ 2.3-2018)

Technical Guidelines for Environmental Impact Assessment—Acoustic Environment (HJ/T2.4-2009).

(http://kjs.mep.gov.cn/hjbhbz/bzwb/other/pjjsdz/201001/W020111114405983168993.pdf)

Technical Guidelines for Environmental Impact Assessment—Ecological Impact (HJ19-2011).

(http://kjs.mep.gov.cn/hjbhbz/bzwb/other/pjjsdz/201104/W020130206494860363682.pdf)

1.8 Project management system

Under the direct leadership of SOA, and with the support from the Ministry of Foreign Affairs, the National Development and Reform Commission, the Ministry of Science and Technology and National Natural Science Foundation, CAA takes responsibility for coordinating the design and construction of the new station.

The designing institution of the new station has broadly analyzed the architectural history in Antarctica, compared and studied various modes of buildings, conducted on-site investigations, learned lessons and experiences of buildings in Antarctica and absorbed comments and recommendations from specialists in architecture, scientific research, logistics, and management. The systematic design of the station gives priorities to the environmental protection, safety, energy saving. The economization as the important basis for assessing and guiding all the conceptual decision-making requires adopting technologies with sustainability and high energy efficiency and minimization of environmental impact. The construction of the new station is expected to be finished in 2024/2025 austral summer season and then it will enter into trial operation. PRIC is responsible for the management and maintenance of the new station and CAA is responsible for coordination and implementation of the follow-up scientific research, logistic support, environmental management and overseeing the project.

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- Dr. Zhang Yi, senior engineer, Architectural design and Research Institute of Tsinghua University CO.LTD
- Mr. Wang Zhongjun, Construction experts, Shanghai Zhenhua Heavy Industry (Group) Co., Ltd.

2. Description of Proposed Activity

2.1 Scope

The Final CEE is developed in accordance with Annex I of the Environmental Protocol and the references had been made to the Guidelines for EIA in Antarctica (Resolution 1, XXXIX ATCM, 2016).

2.2 Location

The Terra Nova Bay region is bordered by Cape Washington to the northeast and Inexpressible Island to the southwest in the western Ross Sea of East Antarctica. Italy's Mario Zucchelli Station is in the Northern Foothills in the west. The station mainly operates as a summer station, where qualified research on oceanography, geology, ecology etc. is conducted. Cape Möbius lies approximately 7 km northeast of the Mario Zucchelli Station, and Germany's Gondwana Station is situated at the southern end of the cape. The station is a base for research in geology and geophysics only during the alternate summer. The Korean Jang Bogo Station is located on the flat ground of a small bay1.2 km to the northeast of the Gondwana Station. The distances from the proposed site to the Mario Zucchelli Station is about 29 km, to the Gondwana Station is 37 km and to the Jang Bogo Station is 38 km as shown in Figure 2-1.

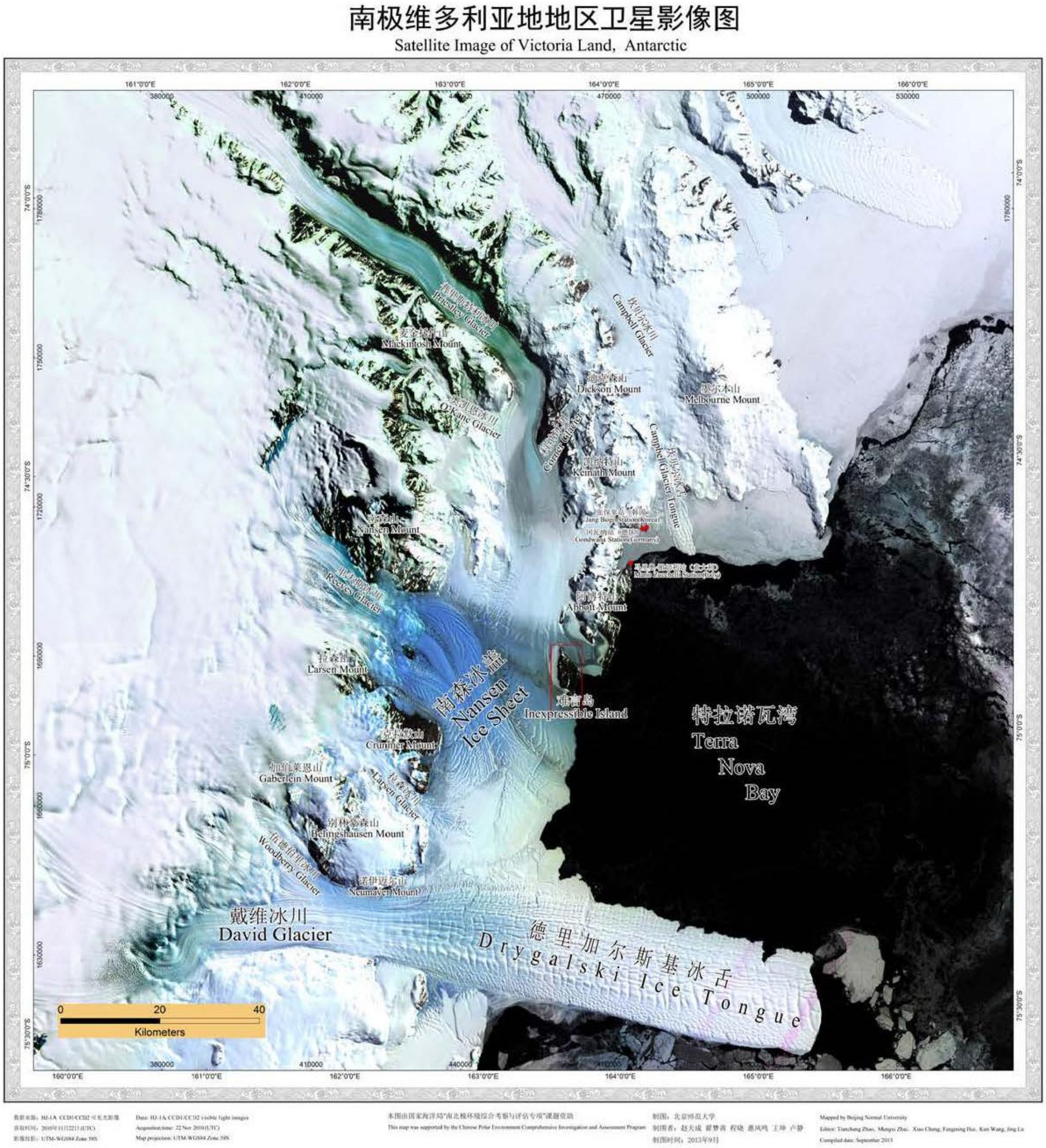


Figure 2- 1 Location of the proposed site
(Base image: HJ-1A Micro-sat （CHINA），2010.11.22)

The proposed site for the new station is located on the flat ground of the southern part of the Inexpressible Island as shown in Figure 2-2. The Inexpressible Island is a rocky island located in Terra Nova Bay at 74° 54'S, 163° 43'E.

Figure 2- 2 Overview of the proposed site on the Inexpressible Island

Mt. Larsen (1562m), Mt. Gerlache (980m) and Mt. Crummer (895m) stand NW-SE direction in the southwest rear of the proposed site, over which the 16 km wide Reeves Glacier is developed in parallel, which stretches from northwest to southeast and flows to the sea. The Larsen glacier lies 30 km away in the southwest direction from the proposed site and is parallel to the Reeves Glacier, which stretches from northwest to southeast and flows to the sea. The David glacier lies 45km away from the proposed site in the south, which stretches from west to east and flows to the sea as shown in Figure 2-1.

The shortest distance between the proposed site and the habitat is more than 3.5 kilometers and is separated by multiple ridges. The habitats of Antarctic Skuas and Adélie penguins located on the northern coast of the Inexpressible Island will not be directly disturbed by the construction and operation of the new station.

Several Weddell Seals were observed on the north end of the Inexpressible Island but no colony was found, and hence, they will not be directly disturbed by the construction and operation of the new station.

2.3 Site selection

The selected site of the new station must have outstanding significance for research and involve scientific issues closely related to human survival environment and other important scientific resources. The site must be accessible and able for logistic supports and human survival.

On consideration of the potential environmental impact and convenience of station construction and operation, several comparable criteria including biological sensitivity, fresh water availability, landing possibility, logistics convenience, site elevation, land flatness and snow accumulation risk were established.

Through the comprehensive consideration of the above-mentioned factors, the Inexpressible Island in Terra Nova Bay region is considered as the most suitable location for the new station while the southern part of the Inexpressible Island is the relatively suitable site for the main buildings of the station.

2.4 Principal characteristics of proposed activities

The activities covered by this Final CEE are:

- Construction, operation, maintenance and dismantle of the new station
- The transportation process for cargoes and personnel to the new station
- Analysis of the potential environmental impact
- Prevention and mitigation of the environmental impact
- Environmental Management and Environmental Impact Monitoring Plan

2.4.1 General specification of the new station

The construction of the new station is planned to be initiated and completed by 4 austral summers. The new station is designed to be a minimum lifetime of 25 years.

The new station has the following characteristics:

- The new station will be staffed with engineers, mechanics, electricians, doctors, and other managing staff for their year-round operation. It will also accommodate researchers in various fields such as atmospheric science, geophysics, oceanography, biology, and ecology, etc.
- The maximum expected number of occupancies is 30 during winter while adding to 80 during summer if more international research staff and visitors are anticipated. The expected ratio of science to support personnel is 1:1 in summer and 1:2 in winter.
- The new station's routine facilities and emergency shelter are designed for 30 people.
- Expected design lifetime: 25 years.
- The total building area of the new station will be about 5250 m^2.
- The total area occupied and disturbed does not exceed 0.10 square kilometers (including solar energy facilities and wind turbines, fuel storage areas, dock areas, etc.).

- The new station will be equipped with instruments and facilities to meet scientific needs and transport facilities suitable for field operation.
- The construction, operation, and dismantlement of the station will be conducted in compliance with the regulations concerning the reduction of the environmental impact to the minimum in the Environmental Protocol.
- The system design of the station follows the principles of environmental protection, safety, minimization of material utilization and technologies of sustainable and efficient renewable energy.
- The health and safety risks should be reduced as much as possible. The design, plan, and supply of the new station will ensure the least health and safety hazards.
- The construction of the new station will combine the prefabricated building modules with assembly building modules made in China to reduce field construction workload.
- The building will be designed for easy maintenance, repair, and control. The equipment maintenance should keep a minimum.
- The new station is designed to allow room for extension and upgrading capabilities. It will be easy to integrate updated technologies.
- The renewable energy including wind power and solar power will be the priority energy source for the operation of the new station. To assure the supplement of energy and meet the emergency needs for a year-round station in a long-term expectation, backup generators for emergency use will be installed.
- The new station will use micro-grid system and energy management system to ensure wind power, solar energy, and fossil fuels to be supplemented each other.
- The environmental impact will be minimized during its lifetime operation.

2.4.2 Materials and personnel required

2.4.2.1 Major materials and mode of preparation

The major materials needed for the construction of the new station include building materials, windmills, solar panels, power generators and heating facilities, engineering machineries and equipment, vehicles, fuels, oils, various kinds of spare parts for maintenance and repair, communication facilities, medical devices, fire extinction equipment, foods, labor protection articles, daily use necessities, safety and emergency facilities and part of materials for scientific purpose, etc. Fully considering the environmental protection, the material of the structure frame for the buildings are steel and the material for the surface of the buildings are Ti-Zn composite board and most of the components will be pre-fabricated in mainland of China and checked before shipping to the Antarctica. No material banned under the Environmental Protocol to the

Antarctic Treaty will be utilized.

Except for building materials and Antarctic Diesel, most of the materials and fuels needed for the construction and transportation are featured by less amount and greater varieties. The supply must consider the principles of procurement mainly from the domestic market, cost-effectiveness, time-saving, flexibility and convenience and quality guarantee. In general, the greater part of the materials and fuels needed for the construction of the new station and the vehicles for land transportation will be purchased from the domestic market and part of the machinery and equipment and their assemblies might be purchased in the international markets.

2.4.2.2 Total amount of materials required

The new station requires about 8948 tons of materials for the construction and about 530 tons for its yearly operation. Considering the uncertainty of the weather in the proposed site and the limit of the annual transportation capacity of the vessel Xuelong and Xuelong 2, the major materials for the construction will be shipped to the proposed site in four austral summers, as shown in Tab 2-1 to Tab 2-5.

Table 2- 1 Materials needed for the new station in the first austral summer

No	Items	Weight (in tons)
1	Materials for wharf &station construction	1000
2	Temporary facilities	190
3	Fuels	Antarctic Diesel 180 tons (135 for the station and 45 for machines and vehicles in one austral summer） Aviation kerosene 80 tons
4	Machinery and vehicles and Auxiliary and spare parts for those repair	100 tons (Wheel crane, Wheel loader, excavator bulldozer, compactor, concrete mixer, tracked trailer, light snow vehicle, truck etc.)
5	Materials for maintenance and repair of construction facilities	10
6	Auxiliary parts for environmental protection facilities	2
7	Auxiliary parts for repairing and maintaining power generators and power facilities	2
8	Auxiliary parts for repairing and maintaining heat insulation facilities	1
9	Auxiliary parts for satellite communications	0.2
10	Articles for medical uses	0.3
11	Fire extinction materials	1
12	Foods and beverage	20
13	Garments and articles for labor protection and prevention	0.5
14	Articles for daily life	3
15	Parts for repairing and maintaining other facilities and equipment	2
16	Safety and emergency equipment	2
17	Materials for scientific purpose	2
	Subtotal	1596

Table 2- 2 Materials needed for the new station in the second austral summer

No	Items	Weight (in tons)
1	Materials for station construction	2200
2	Fuel Containers	240
3	Fuels	Antarctic Diesel 210 tons (135 for the station and 45 for machines and vehicles in one austral summer, other 30 for emergency） Aviation kerosene 80 tons
4	Materials for maintenance and repair of construction facilities	10
5	Auxiliary parts for environmental protection facilities	2
6	Auxiliary parts for repairing and maintaining power generators and power facilities	2
7	Auxiliary parts for repairing and maintaining heat insulation facilities	1
8	Auxiliary parts for satellite communications	0.2
9	Articles for medical uses	0.3
10	Fire extinction materials	1
11	Foods and beverage	40
12	Garments and articles for labor protection and prevention	0.5
13	Articles for daily life	3
14	Parts for repairing and maintaining other facilities and equipment	2
15	Safety and emergency equipment	2
16	Materials for scientific purpose	2
	Subtotal	2796

Table 2- 3 Materials needed for the new station in the third austral summer

No	Items	Weight (in tons)
1	Materials for station construction	2000
2	Windmills and solar panels and accessories	90
3	Fuels	Antarctic Diesel 210 (135 for the station and45 for machines and vehicles in one austral summer, other 30 for Fuel Containers） Aviation kerosene 80 tons
4	Auxiliary and spare parts for repair of machinery and vehicles	16
5	Materials for maintenance and repair of construction facilities	10
6	Auxiliary parts for environmental protection facilities	2
7	Auxiliary parts for repairing and maintaining power generators and power facilities	2
8	Auxiliary parts for repairing and maintaining heat insulation facilities	1
9	Auxiliary parts for satellite communications	0.2
10	Articles for medical uses	0.3
11	Fire extinction materials	1
12	Foods and beverage	40
13	Garments and articles for labor protection and prevention	0.5
14	Articles for daily life	3
15	Parts for repairing and maintaining other facilities and equipment	4
16	Safety and emergency equipment	2
17	Materials for scientific purpose	5
	Subtotal	2467

Table 2- 4 Materials needed for the new station in the fourth austral summer

No	Items	Weight (in tons)
1	Materials for station construction	1200
2	Fuels	Antarctic Diesel 700 (for two years storage) Aviation kerosene 80 tons
3	Auxiliary and spare parts for repair of machinery and vehicles	16
4	Materials for maintenance and repair of construction facilities	2
5	Auxiliary parts for environmental protection facilities	2
6	Auxiliary parts for repairing and maintaining power generators and power facilities	2
7	Auxiliary parts for repairing and maintaining heat insulation facilities	1
8	Auxiliary parts for satellite communications	0.2
9	Articles for medical uses	0.3
10	Fire extinction materials	1
11	Foods and beverage	60
12	Garments and articles for labor protection and prevention	0.5
13	Articles for daily life	3
14	Parts for repairing and maintaining other facilities and equipment	4
15	Safety and emergency equipment	2
16	Materials for scientific purpose	15
	Subtotal	2089

Table 2- 5 Materials required for the new station during the year-round operation period

No	Items	Weight (in tons)
1	Fuels-Aviation Kerosene	78.2
2	Fuels- Antarctic Diesel	342.3
3	Auxiliary and spare parts for repair of machinery and vehicles	16
4	Materials for maintenance and repair of construction facilities	2
5	Auxiliary parts for environmental protection facilities	2
6	Auxiliary parts for repairing and maintaining power generators and power facilities	2
7	Auxiliary parts for repairing and maintaining heat insulation facilities	1
8	Auxiliary parts for satellite communications	0.2
9	Articles for medical uses	0.3
10	Fire extinction materials	1
11	Foods and beverage	60
12	Garments and articles for labor protection and prevention	0.5
13	Articles for daily life	3
14	Parts for repairing and maintaining other facilities and equipment	4
15	Safety and emergency equipment	2
16	Materials for scientific purpose	15
	Subtotal	529.5

2.4.2.3 Personnel required

It is planned to send no more than 120 people including scientists, engineers and construction workers each year in the four austral summers to the proposed site for the construction. They will go there by the vessel Xuelong.

- For the first construction year, no more than 120 people including scientists, engineers and construction workers will stay for 60 days during the austral summer.
- For the second construction year , no more than 100 people including scientists, engineers and construction workers will stay for 60 days during the austral summer.
- For the third construction year, no more than 40 people including scientists, engineers and construction workers will stay for 60 days during the austral summer.
- For the last construction year, no more than 40 people including scientists, engineers and construction workers will stay for 60 days during the austral summer.
- During the operation period, approximately 80 people in summer and no more than 30 people in winter will be reasonable.

2.4.3 The mode of transport

Xuelong and Xuelong 2 will ship the personnel and materials for the construction of the new station.

They will leave Shanghai and sail along the conventional route pass by New Zealand to the Chinese stations in Antarctica. There are two possible transportation routes as follows:

For route A, firstly, **Xuelongs** will arrive in the water area of the new station on the Inexpressible Island through New Zealand and unload the personnel and materials, secondly, they will leave the new station and navigate along East Antarctica to the Zhongshan Station, cargoes for the Zhongshan Station and Kunlun Station will be unloaded at the Zhongshan Station, thirdly, they will leave the Zhongshan Station and sail back to the new station on the Inexpressible Island and pick up all the personnel then go back to China as shown in Figure 2-3.

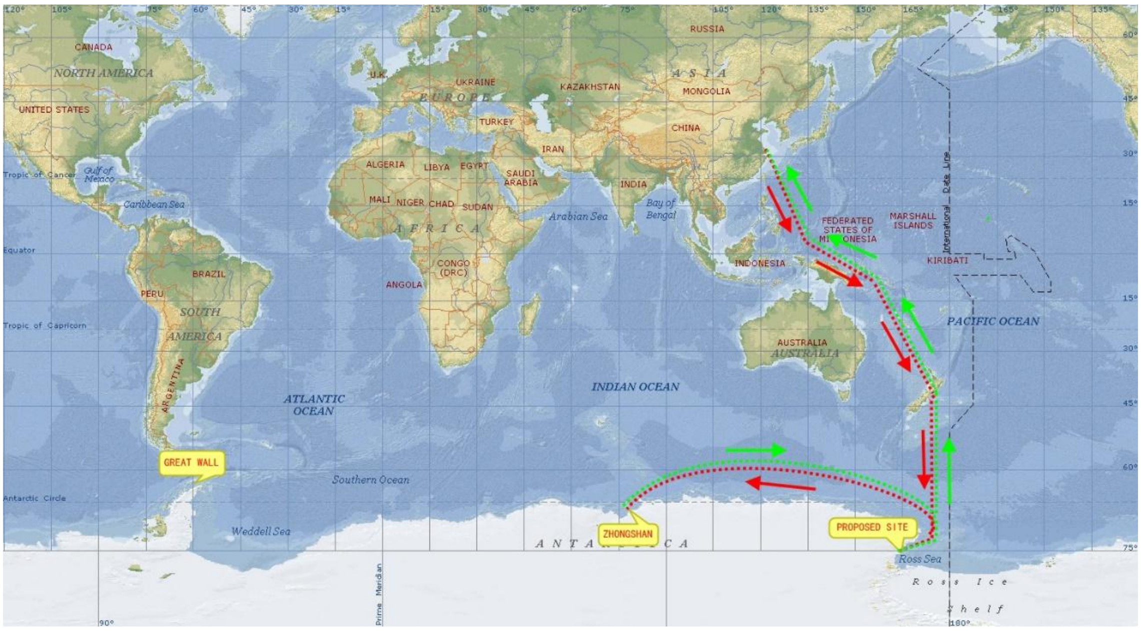


Figure 2- 3 Navigation route A of R/V Xuelongs to and from Antarctica

For route B, firstly, **Xuelongs** will arrive in the water area of the new station on the Inexpressible Island through New Zealand and unload the personnel and materials, secondly, they will leave the new station and navigate along East Antarctica to the Zhongshan Station, cargoes for the Zhongshan Station and Kunlun Station will be unloaded at the Zhongshan Station, thirdly, they will leave the Zhongshan Station and navigate to the Great Wall Station, personnel and materials for the Great Wall Station will be unloaded there, lastly, they will leave the Great Wall Station and navigate back to the new station on the Inexpressible Island and pick up all the personnel then go back to China as shown in Figure 2-4.

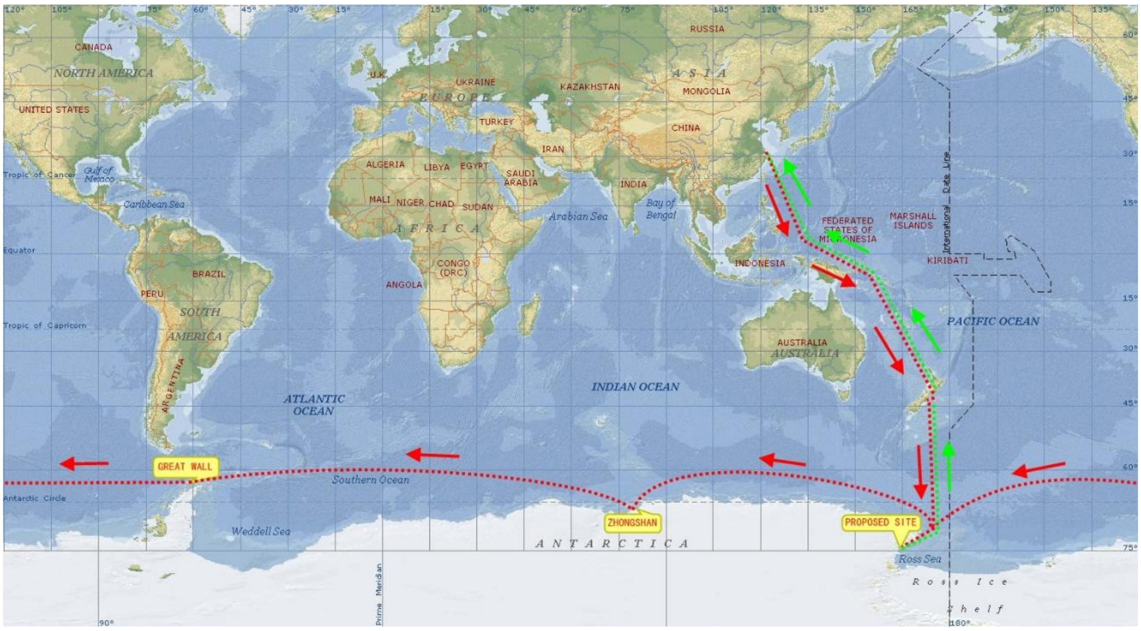


Figure 2- 4 Navigation route B of R/V Xuelongs to and from Antarctica

After **Xuelongs** anchor near the proposed site less than 1 nm, barge ships and helicopters will carry the workers and cargos from the ship to the land. Tracked vehicles will be needed for the additional 300m ground transportation from the unloading point to the proposed site.

Cargos for the new station will be transported to the sea area near Victoria Land by the icebreaker. Affected by the influence of the coastal topography and sea ice condition near the coast, there will have two kinds of alternative ways for the cargos to be discharged from the icebreaker to land at designated places, which respectively is unloading by the helicopter (Figure 2-5) and unloading by the landing barge boat (Figure 2-6).

Figure 2- 5 Unloading by the helicopter

Figure 2- 6 Unloading by the barge boat

Unloading by the helicopter means that the cargos are transported by helicopter, which usually transports less than 4 tons of cargos. Firstly, the cargos will be stored and fixed in a special lifting container. Secondly, the cargos will be lifted through special steel wire ropes by the helicopter. Thirdly, the cargos will be transported from the icebreaker to the land by helicopter.

Unloading by the barge boat means that the cargos are transported by landing ship, which usually transports the cargos that cannot be transported by the helicopter. Firstly, cargos are lifted and moved by the icebreaker to the landing ship by ship-based lifting equipment. Secondly, the landing ship will be navigated to the unloading port. Thirdly, the cargos are transported from the landing ship to the land by shore-based lifting equipment. Meanwhile, vehicle equipment can be driven to land by personnel.

2.4.4 Medical security system

It is an important premise to guarantee the life safety and work efficiency of the expeditioners during the construction period of the new station under the harsh environments. Therefore, a system for medical care, disease prevention and control and field rescue will be set up, and in the future, a remote medical system will also be possible to set up to develop a Chinese medical security system in Antarctica. This is of great importance for the smooth implementation of the exploration and survey in Antarctica. The medical post will be created by the expedition team which will be manned by medical staff with experiences on specific diseases. Necessary training is provided for the medical staff and the expeditioners. The expedition will be equipped with various types of steel oxygen bottles, oxygen producers, emergency medicines for critical diseases and other conventional medicines and medical instruments.

In case of any injuries or emergency, a contingency plan for evacuation will be placed before construction.

2.5. Station construction and operation plan

The new station will be built to support the field survey and study on Victoria Land, Antarctic. The new station will meet both the needs for scientific purpose and the requirements of environmental protection. Therefore, the new station will use as much as possible sustainable and higher energy- efficiency technologies and renewable energy to minimize the production of wastes. The design of the new station has considered its capacity for extension and upgradeability and easy application of new technologies to support a year-round station with the least material consumption and environmental impact in the future.

2.5.1 Principles for design and construction

1. Giving priority to environmental protection

In order to protect the Antarctic environment, which receives the least impact from human activities, the principle of giving top priority to environmental protection will adhere to the whole process of the new station construction in Antarctica as shown in Figure 2-7. Every step, either the selection of materials, equipment, and engineering process, the operation of the station or the disposal of wastes must follow the regulations stated in the Environmental Protocol to minimize unfavorable environmental impact.

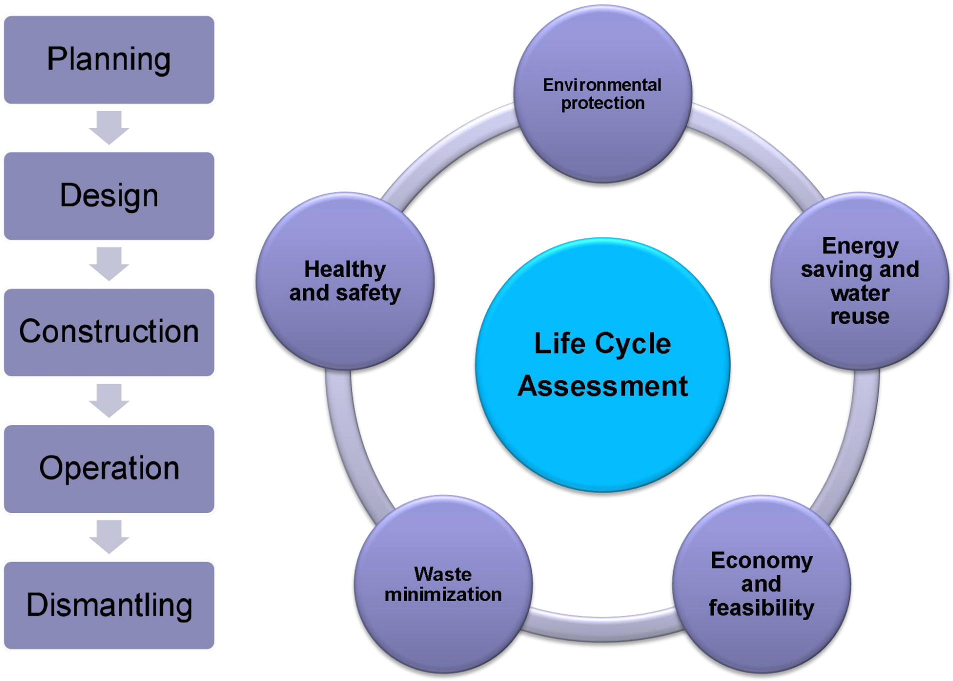


Figure 2- 7 Life cycle assessment and principle of environmental protection

2. Safety and feasibility

The harsh environmental conditions of Antarctica require special safety measures. Considerations have been given to some extreme conditions including low temperature, transport difficulties, and other unexpected issues in ensuring personnel safety.

We attach great importance to the safety of personnel and facilities and the programs have been fully considered in advance. There are appropriate contingency plans. Systematic training and education on emergency treatment before expedition on operation procedures of related facilities and equipment. Related security and contingency plans include:

- Station safety regulations
- Outdoor activities regulations
- Rubber boat regulations
- Station electricity regulations
- Station fire emergency plan
- Station dangerous goods regulations
- Safety requirements for discharge and transport in station
- The overall emergency plan of CHINARE
- The station emergency response plans

3. Energy-saving and waste-reduction

Energy saving and waste reduction is a key principle for the design of the new station. The fuel stored and re-provisioned in the new station will be with higher costs for limited amounts, so a reduction in the consumption of fuel means the reduction of environmental impact and cost for the station.

Following the Environmental Protocol and the Energy Conservation Law of the People's Republic of China, the design of the new station has fully taken into account the principle of saving energy and tring to achieve the best balance among the harsh climate, logistic capabilities, construction capacity and technical capacity, and among the practicability, economy, feasibility and creativeness. Various energy-saving measures have been adopted for developing renewable energy, the way of heating, recycle of residue heat, structure maintenance, and reduction of ventilation energy and the control of water consumption to minimize environmental impact as much as possible.

4. Economy and feasibility

Constructing a station in Antarctica cannot be completed in a short period, normally it would take several years to complete the whole construction due to the extremely harsh environmental conditions. A simple construction may be completed in a short period, but a construction without integrated design may lead to the overlapping and lower utilization rate, as an independent construction which may not be favorable for its maximum use under such harsh environmental conditions. Therefore, there should be an integrated design, and the construction and operation of each building should be accomplished step by step.

The philosophy of construction by steps may adapt to the harsh conditions in Antarctica and to ensure the earlier operation of a part of the finished construction. Once the whole construction project is accomplished, various parts can be integrated into an organic complex with high operational efficiency.

Comprehensive consideration is also given to the short-term and long-term efficiency. Some constructional items require a larger amount of investment, such as solar energy facilities, wind turbines and heating by solar energy, but the advantages they bring will effectively reduce the cost for maintenance and operation and earn better long-term efficiency and benefits to environmental protection.

2.5.2 Overall Layout

The overall planning and architectural design of the new station was adjusted in accordance with the requirements of the Environmental Protection Protocol and the feedback content of the 2018 ATCM meeting to make it more suitable for the site environment of the planned construction area. Facing the special harsh environmental impacts such as freezing cold, strong wind, radiation, and high environmental sensitivity requirements in the Ross Sea area, the building adopts a centralized form, and the long axis is consistent with the dominant wind direction. The main building and the logistics center cleverly make use of the three-dimensional connection of the site height difference to reduce the floor space and reduce environmental disturbance. With the help of CFD simulation technology, combined with the surrounding terrain, the pressure distribution on the building surface is accurately calculated, reducing the impact of strong winds on the building, and at the same time minimizing the impact of snow. Through the above adjustments, the new station is committed to achieving the following goals in terms of overall layout:

- Safer site elevation: The main building is moved up from a shallow 15m above sea level to a hill ridge with an altitude 28m above sea level. Considering the iceberg collapse event in this area in 2016 and the difficulty of fixed ice condition, the higher site elevation can prevent the new station from the invasion of icebergs or sea ice, and reduce the risk of local snow accumulation;
- A more convenient scientific research platform: The marine laboratory located in the east wing of the main building is closer to the sea, combined with the in-situ comprehensive observation system installed on the experimental platform, to fully support the all-weather observation and monitoring operation about the ocean;
- More intensive land use: The main building and the logistics center are further integrated in volume, and traditional energy and new energy facilities are centrally installed to minimize the footprint of various facilities and reduce environmental disturbance;
- More solid geological conditions: At present, the main building is in an exposed area of bedrock, and the basic conditions are more stable, which is conducive to resisting strong winds and avoiding uneven settlement.

According to the principle of main function planning, the entire new station shown in Figure 2-8 is divided into the facility area, the near-field scientific observation and environmental monitoring area, and the extended scientific observation area. Special protection areas are delimited according to functional utilization methods and environmental impacts.

2.5.2.1 The facilities zone

It's a relatively flat coastal slope area, with the land area about 5 hectares. The main functional facilities are laid out here, including the comprehensive building, the garage buildings, the helicopter storages, the parking aprons, the small boat depots and wharf, the marine water intake, the oil tanks, the wind power facilities, the storage yards, the outdoor pipelines and so on.

2.5.2.2 The near-site scientific observation and environmental monitoring zone

It includes the hilly highlands on the northeast side and the northwest side, with a range of about 1-2 square kilometers. The independent observation rooms and facilities, the satellite ground stations, and shelters are laid out here.

2.5.2.3 The extended scientific observation zone

This area is in the middle of Inexpressible Island, separated from the new station area by a ridge. The walking distance is about 1.5km. It is close to the three freshwater lakes and is basically not affected by the station area. It is suitable for developing investigation work on lakes, oceans, geology, etc., conducive to the installation of relevant scientific research observation facilities.

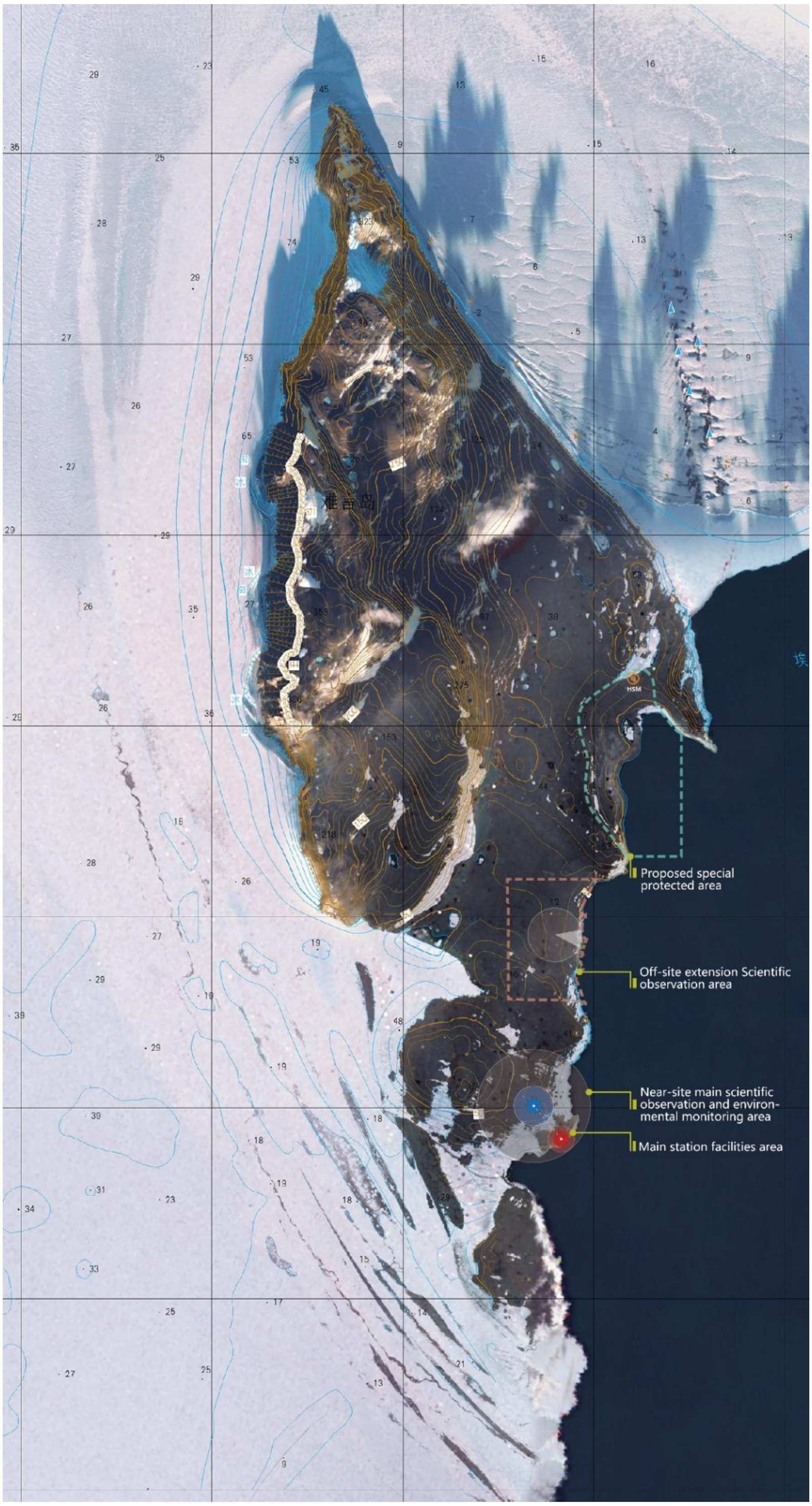


Figure 2- 8 Overall view of the Inexpressible Island

2.5.2.4 Antarctic Specially Protected Area (Approved in 2021)

China, Italy and the Republic of Korea jointly propose the designation of a new Antarctic Specially Protected Area at the Inexpressible Island and Seaview Bay, Ross Sea. The co-authors prepared the draft Management Plan and submitted the proposal to the CEP and ATCM for consideration in 2019 and approved by ATCM in 2021.

Inexpressible Island and Seaview Bay is in Terra Nova Bay, Victoria Land, Western Ross Sea at 74° 54.2' S, 143° 43.5' E. The ASPA area is distinctive and the primary reasons for its designation as an ASPA is the need to protect environmental and outstanding scientific values. In particular, this Area hosts one of the oldest Adélie penguin (*Pygoscelis adeliae*) colony and an important breeding site of South Polar Skua (*Stercorarius maccormicki*). The Area was identified as an important bird area (IBA 178) by BirdLife International on the basis of the South Polar Skua colony and the concentration of seabirds, in particular Adélie Penguin (Resolution 5, 2015). Its particular ecosystem is related to the adjacent Terra Nova Bay polynya and allows comparison with other nearby sites with different sea ice dynamics along the year. Moreover, in the ASPA, several lakes are influenced by guano nutrient inputs, while others are not impacted.

The first documented record of an Adélie penguin breeding group in the ASPA area was in 1963, and continuous monitoring has been carried out from the 1980s to the present, with so far one of the earliest statistical records of the Adélie penguin in the Ross Sea region. The active penguin colony in this area has had continuous occupation for the past ~7,000 years, which is the longest existing Adélie penguin colony in the Ross Sea region. There are more than 20,000 breeding pairs of Adélie penguins. The ASPA includes crucial penguins' foraging access area to Terra Nova Bay polynya.

The ASPA is located within Domain S (McMurdo-South Victoria Land geologic) based on the Environmental Domains Analysis for the Antarctic continent (Resolution 3, 2008). Moreover, the ASPA sits within Antarctic Conservation Biogeographic Region (ACBR) 8 Northern Victoria Land (Resolution 3, 2017).

2.5.3 Scale and Function

2.5.3.1 Scale

In the limited building space of the new station, the function of the building should take safety, healthy, efficiency and interaction into consideration. Based on 30 years of Antarctic expedition experience of China's Great Wall Station and Zhongshan Station as well as research requirements of the new station, the total building area of the station will be 5250 m^2. Solar energy facilities and windmills area are not included. All the buildings will be constructed in phases. The station size of the current plan is decided after taking into full account of the research requirements, security of the personnel, and the logistic support. The size and details of the function area are shown in Table 2-6.

Table 2- 6 Size and details of the function area

Functional area	Room name	Unit area	Number	Building Area （m²）
Research operations, observation and command area	Ocean Observation(Monitoring) Room and Laboratory	420	1	420
	Meteorological and Atmospheric Observation Room	40	1	40
	Communication satellite ground station and its ancillary facilities		1	
	High-altitude physical observation room	50	1	50
	Geophysical Observation Room（including earthquake, Geomagnetic, Gravity and so on）	15	2	30
	General Laboratory Wet and Dry Laboratory Cryogenic Laboratory Data Center File Reference Room	420	1	420
	Command and control room that can observe the whole station area communication and network room station room conference room public office			
Subtotal				**960**
Living and medical area	Overwintering dormitory wing	440	1	440
	Summer dormitory wing	440	1	440
	Public toilet	15	2	30
	Medical center	136	1	136
	Restaurant and kitchen	240	1	240
	Multimedia audio-visual room and library	174	1	174
	Storage room	15	2	30
	Function Room	130	1	130
	Cloakroom	84	1	84
	Exhibition room	40	1	40
Subtotal				**1744**
Logistics facilities area	Electricity supply system	150	1	150
	Heating system	100	1	100
	Water supply and drainage system	95	1	95

Functional area	Room name	Unit area	Number	Building Area （m²）
	Sewage treatment building	65	1	65
	Desalination and utilization system for seawater	30	1	30
	Equipment maintenance processing workshop and garage	540	1	540
	Solid waste treatment building	65	1	65
	Treasury and storage room	400	1	400
	Helicopter parking lot	280	1	280
	Dinghy parking lot	140	1	140
	System control room	65	1	65
Subtotal				**1930**
Other traffic space				**616**
Total building area				**5250**

2.5.3.2 Functional area partition

As shown in Figure 2-9 and Figure 2-10, According to the environmental characteristics such as terrain, slope, prevailing wind direction, ocean current direction and so on, and take the necessary function and site scale into consideration, 5 functional zones were planned as shown in Figure 2-11. They were situated at east and west highlands and the relatively flat landscape near shore.

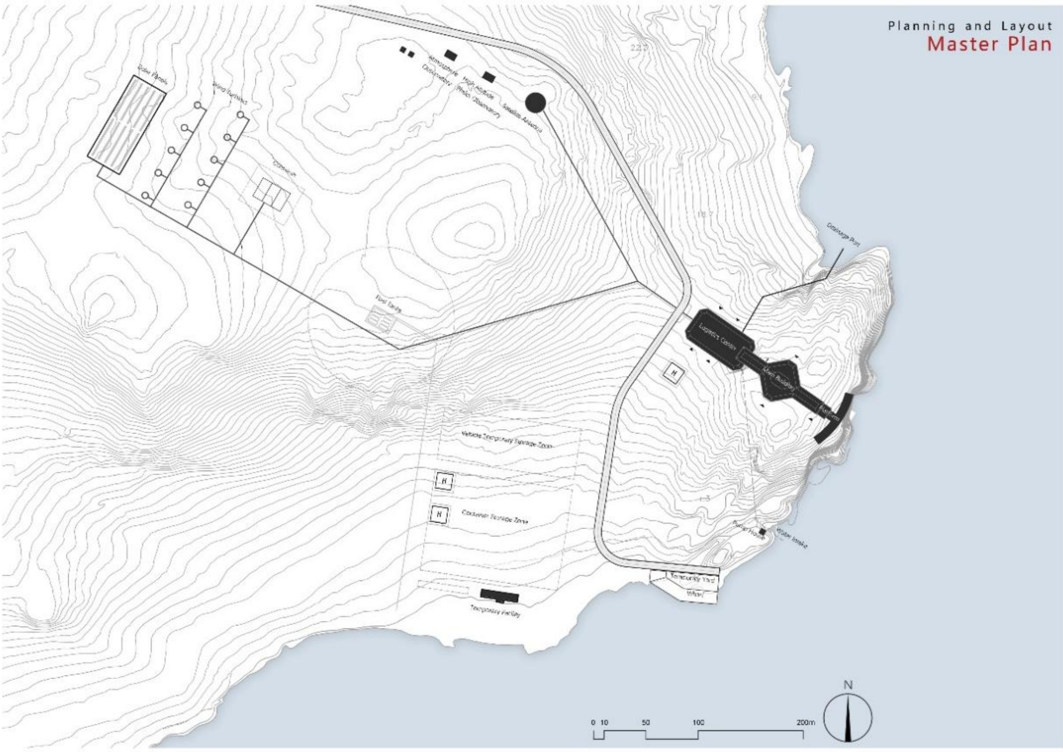


Figure 2- 9 Overall layout of the proposed station

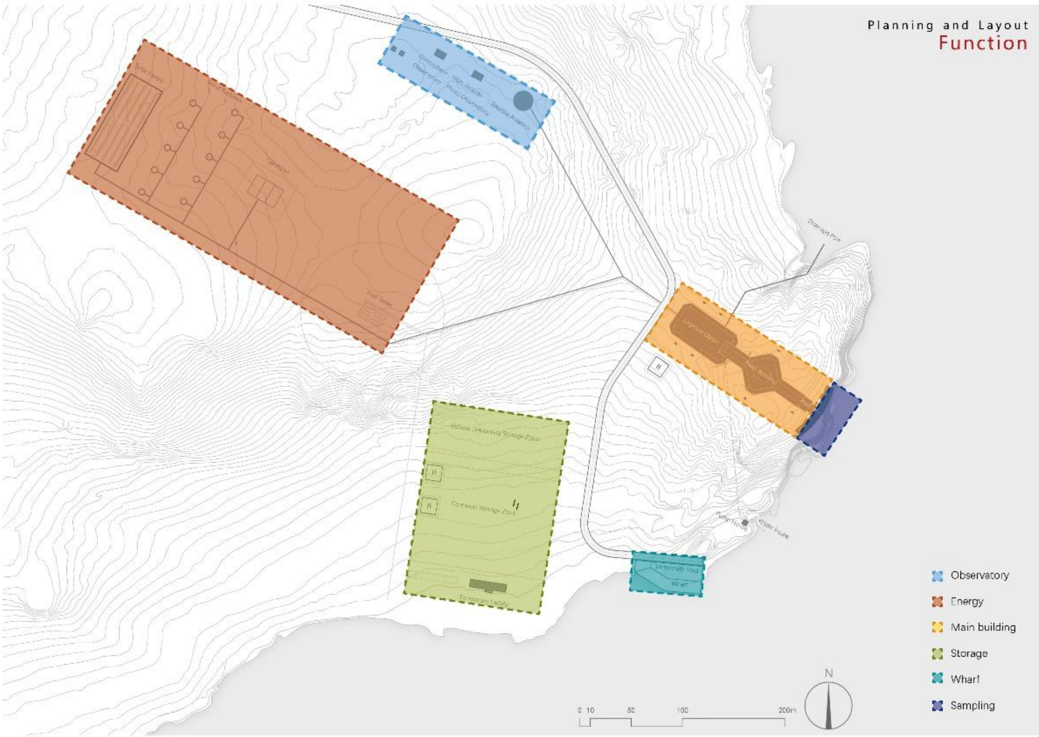


Figure 2- 10 Functional Zoning Map of the new station

- **Scientific research and observation area**

It is located at the north side of the west highland, upwind of the prevailing wind direction, and can be directly reached through the main road in the station area. Satellite ground station and various independent observation rooms such as high-altitude physical observation blocks and geophysics observation blocks were set.

- **Energy facility area**

It is located at the south side of the west highland. Solar photovoltaic power generation equipment, wind power generation equipment and oil tanks were arranged and connected to the station area through the bridge and oil pipeline respectively. The oil supply pipeline runs along the edge of the southern snow line to the southern Bay, which can be connected to the wharf through oil hose.

- **The main building and square area**

It is in the eastern coastal highland area, the main building is horizontally extended along an angle of 30 degrees from the east to the west, the long axis keeps in accordance with the prevailing wind direction. It faces the sea on the east side, and faces the Square and the North Bay on the north and south. The logistics center is arranged on the west side in combination with the topography, facing the western highlands.

- **Logistics facility area**

It is in the gentle slope area in the south of the site, including temporary storage area for vehicles, container storage area, helicopter landing area, dangerous goods storage area and emergency facility area (large temporary buildings).

- **Wharf operating area**

It is located at the southeast of the coast, including coastwise wharf, water supply pump house, oil pump house and temporary storage yard.

2.5.3.3 Streamline organization

Take overall consideration of sea, land, air supply and transfer streamlines to make the shortest route to connect the various functional areas and to minimize the number of roadworks and the disturbance to the environment.

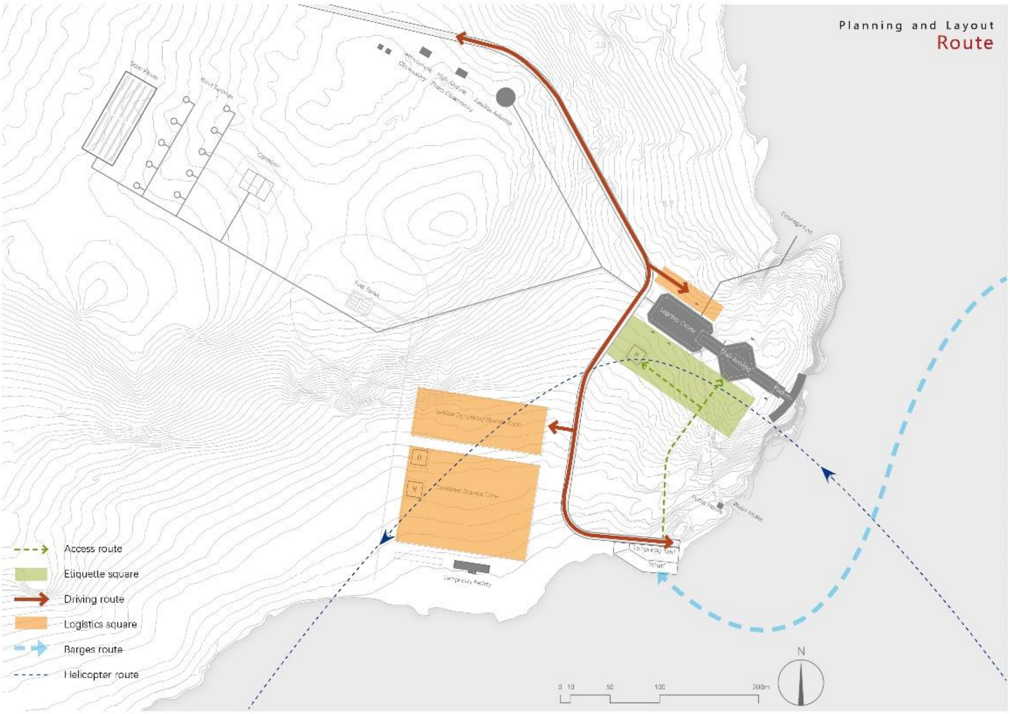


Figure 2- 11 Streamline Organization of new station

2.5.4 Functions of the Main buildings

The main building of the investigation station consists of the main building and the logistics center, which are located on the east and west sides of the site respectively according to the height difference of the site.

Figure 2- 12 Side view of the main building

The main building

The main building includes marine laboratory, warehouse, catering facilities, scientific office, command and control room, and accommodation rooms, which are distributed on the overhead floor, the first floor, the second floor and the top floor.

The entrance hall, dressing room, fire control room and small warehouse (vertical hoisting pulleys and mechanical three-dimensional shelves are set up in the local high space) are arranged in the middle of the overhead layer. The north side of the warehouse is directly connected to the logistics platform, and the south corner can reach the entrance hall, which is convenient for the access of daily supplies. The personnel at the station can enter the entrance hall from the steel grating platform at the south entrance, and go to other floors from the stairwells at both sides through the dressing room. The entrance hall can reach the marine laboratory directly to the east, and the experimental room uses the middle corridor style. The versatility is considered in the function to support different types of scientific experiments in the limited space. The experimental platform, shelves and cabinets can be flexibly disassembled or reorganized. The east side of the laboratory faces the sea, with a water sample operation room and an operating equipment room, and an operation deck is attached. The west side of the entrance hall is provided with an equipment maintenance gallery that leads directly to the logistics center, and the side walls and the ceiling integrate the equipment pipelines of the main building.

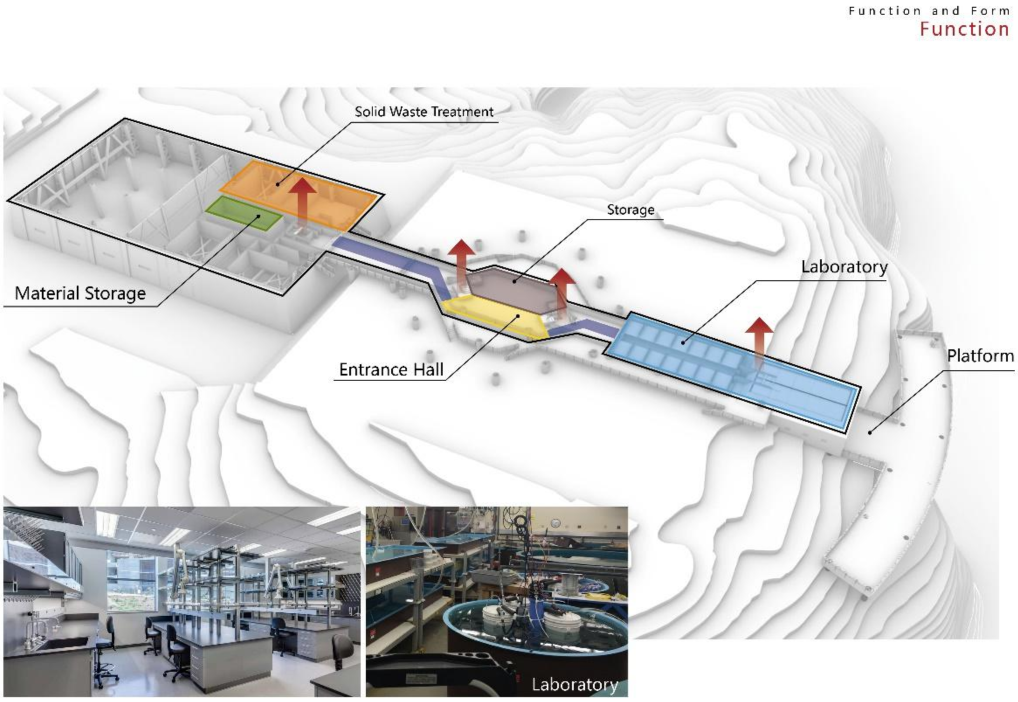


Figure 2- 13 Functions zones of the overhead floor of the main building

The central part of the first floor adopts the layout of the ring gallery. The dining/kitchen at the northern end and the multi-function room and the aquarium room at the southern end are space of semi-open modes that create a good dining and exchange space. The multi-functional room and warehouse occupy the inner area of the ring corridor and adopts light guide tube for lighting. Medical, scientific office, public office, communication network room, toilet, etc. are in the outer area of the corridor with good natural lighting. The aquarium room is in the south central area, responding to the marine science theme of the investigation station, and providing a vibrant living and working environment for the investigation team. The kitchen adopts a semi open island layout, which is close to the warehouse. The upper part of the warehouse is connected to the first floor by vertical hoisting equipment. Both the east and west wings are summer dormitories. Shower, toilet, sauna and laundry facilities are set up near the central interface of both wings.

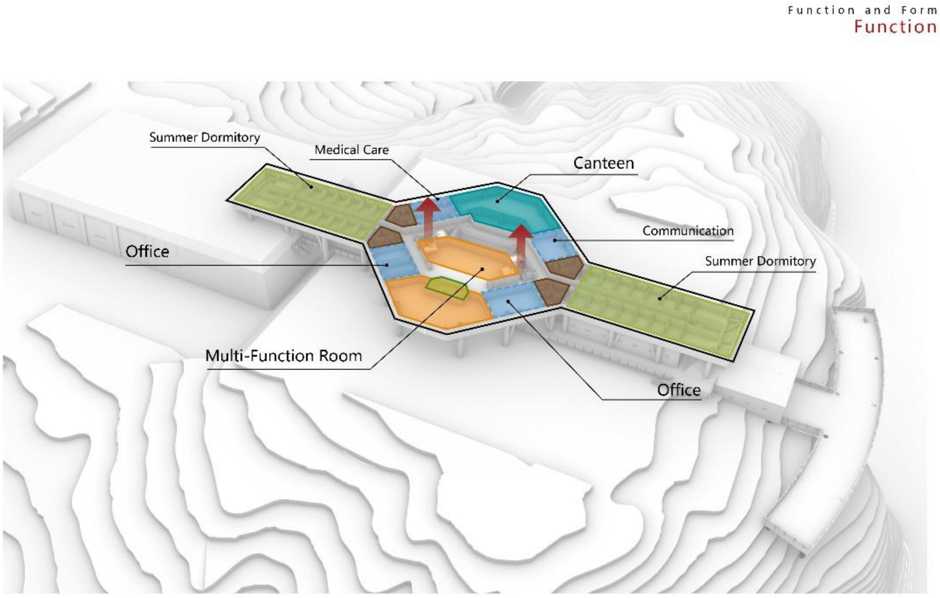


Figure 2- 14 Functions zones of the first floor of the main building

Figure 2- 15 Canteen interior space **layout**

The second floor is the winter dormitory area. The inner area of the ring corridor is over the small warehouse and multi-functional activity room, and 16 dormitories are arranged along the outer ring. There are rest areas at the north and south ends of the ring corridor, and opposite entrances are set at the east and west ends, which can directly reach the roof of the east and west wings. The roof is equipped with an equipment platform for installation of observation equipment, atmospheric sampling and BGAN satellite antenna.

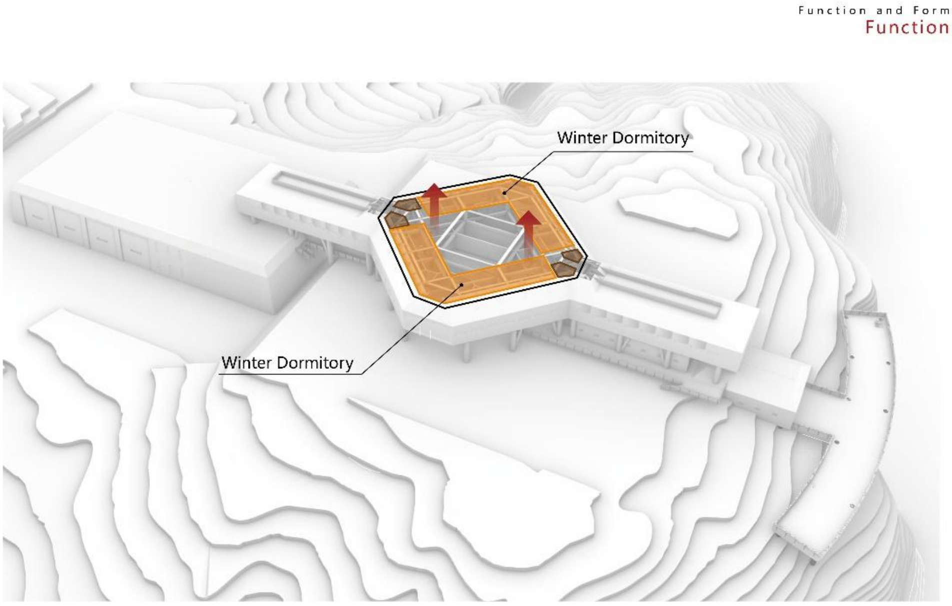


Figure 2- 16 Functions zones of the second floor of the main building

The top floor is the command and control room, the station master room, the reception room and the data center room. The command and control room faces the station area and has a good field of view. The operation area of the yard, helipads and wharf area can be conveniently observed through the room.

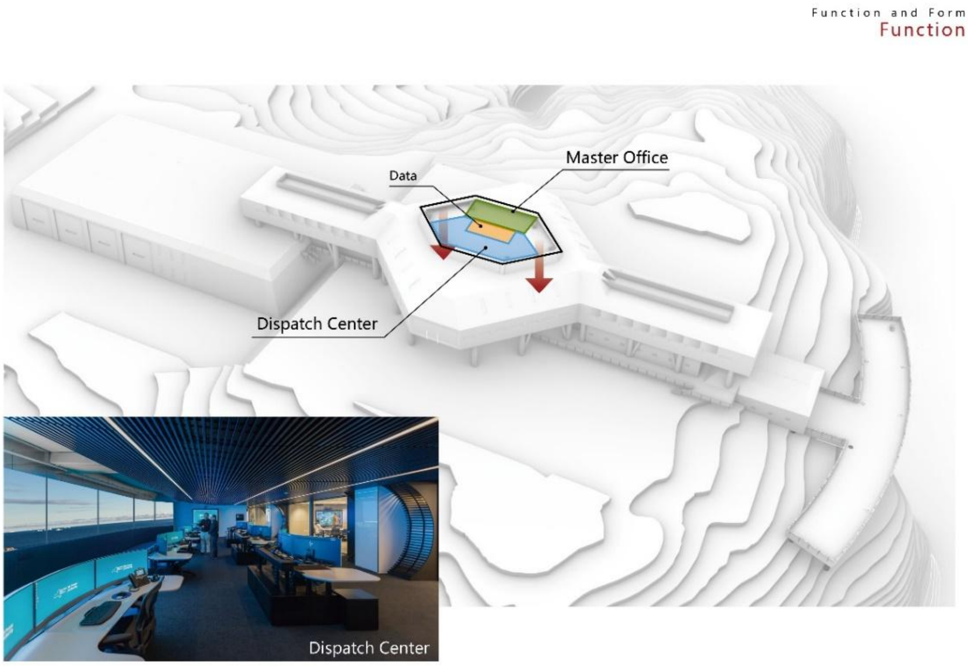


Figure 2- 17 Functions zones of the top floor of the main building

Logistics center

It is divided into warehouse area and equipment area, with sectional functional layout. From west to east, helicopter hangar, vehicle maintenance depot, comprehensive room and mechanical and electrical equipment room are successively set. Among them, all warehouse areas are full height spaces with a clear space of 8m, which are used for storage and maintenance of various vehicles in the station. Part of the equipment area has two floors, the north side is centralized with energy rooms, the first floor is power system room, oil storage room, duty room and heating system room, and the second floor is garbage classification and incineration room. The south side is centralized with water equipment rooms, including water supply and drainage system room, desalination room and sewage treatment room.

The main building and the logistics center are connected through a central interface that integrates staircases and equipment pipe wells, forming an integrated operation of the main functions of the station area.

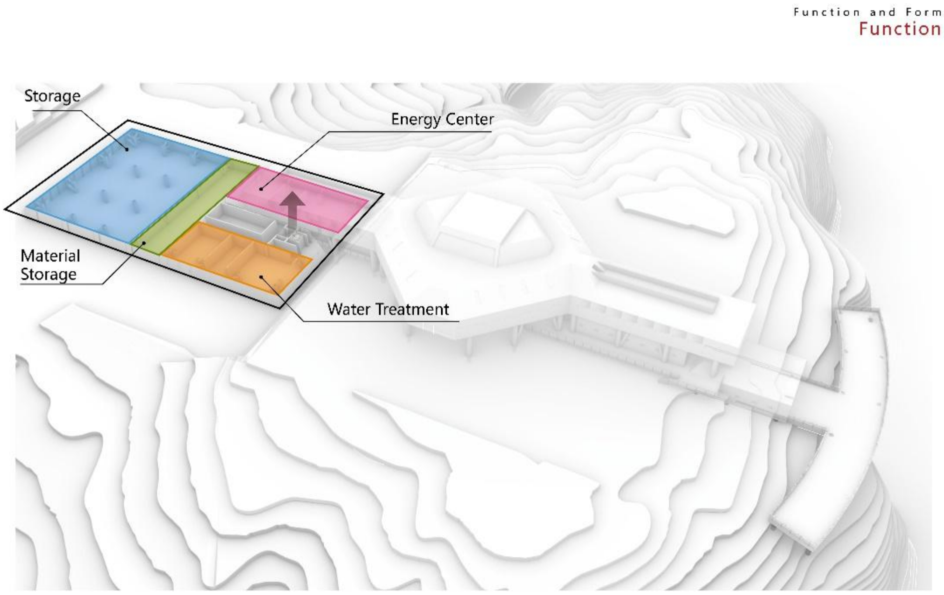


Figure 2- 18 Functions zones of the logistics center building

2.5.5 Architectural appearance optimization

Facing the sensitive environment requirements in the Ross Sea region such as strong katabatic wind and freezing cold in the winter, centralized module has been suggested to minimize the land use and the disturbance to the local pristine environment. All the architecture appearance has been optimized based on the CFD modeling to decreasing the impact of the strong wind to the main buildings and to prevent the possibility of the snow accumulation on the area as shown in Figure 2-19.

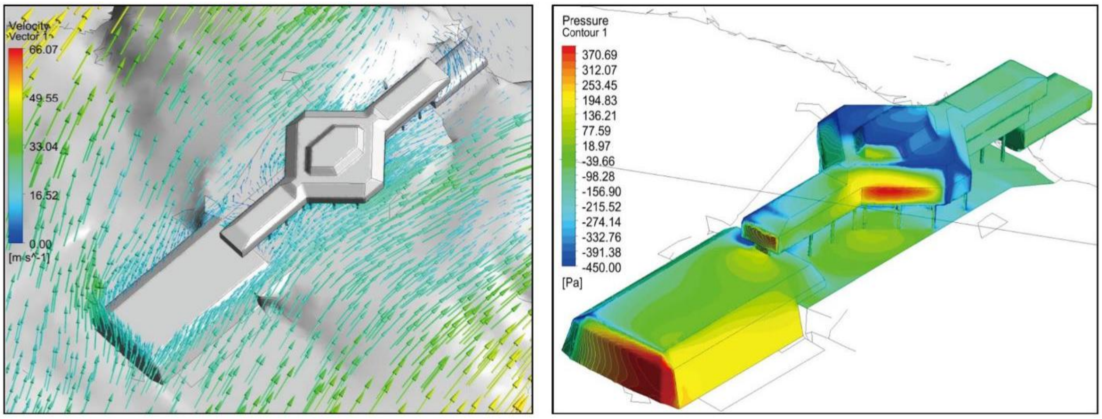


Figure 2- 19 Architectural appearance optimization with CFD modeling

2.5.6 Fuel storage system

2.5.6.1 Intelligent monitoring and control system

Fuel storage system in the new station will be divided into two separated systems as Antarctica diesel storage system and aviation kerosene storage system, for preventing a mixture with each other. Each system will have its own oil storage tanks, turnover oil tank, pipelines, pumps, underground anti-static devices, environmental leak proof sump, fuel trucks and Intelligent Monitoring System based on Internet of Things (including automatic control operations, security monitoring, safety warning and remote data transmission and so on) as shown in Figure 2-20.

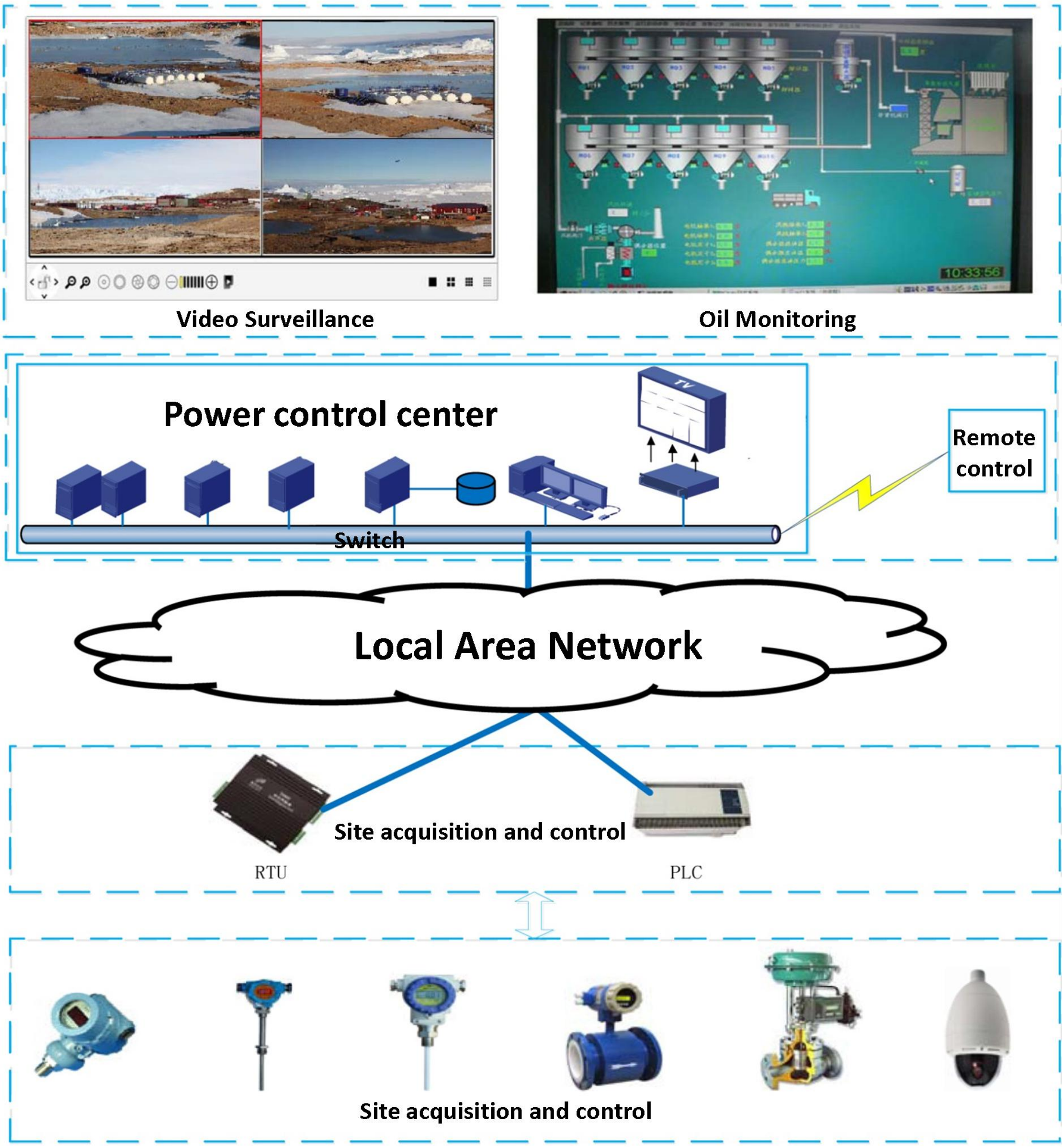


Figure 2- 20 Intelligent Monitoring System of the fuel storage system

2.5.6.2 Estimation of the diesel consumption during the construction period

During the initial construction stage of the station, the working time of the generator shall be calculated in 90 days. The power of the generator is 200KW, the fuel consumption for a generator is about 27.8 L/h. Therefore, the total diesel fuel consumption for a year is about 60048 L, 50.4 tons per year.

During the initial construction stage of the station, the annual working time of mechanical equipment such as vehicles will be calculated in 60 days. The working time of a loader is calculated at 6h per day, the fuel consumption for a loader is about 20L/h, therefore the fuel consumption for a loader is about 14400L per year. The working time of an excavator is calculated at 5h per day, the fuel consumption for an excavator is about 15L/h, therefore the fuel consumption for an excavator is about 9000L per year. The working time of a crane is calculated at 6h per day, the fuel consumption for a crane is about 15L/h, therefore the fuel consumption for a crane is about 10800L per year. The fuel consumption for other mechanical equipment such as vehicles is about 50L per day, therefore annual fuel consumption for other mechanical equipment is about 3000L per year. During the construction period, the total consumption of fuel for all mechanical equipment is about 37200L, 31.2 tons per year.

In order to ensure the construction requirements of the generators and vehicles of the new station for a year, the consumption of diesel fuel is about 97248 L at least, 82 tons/year.

Table 2- 7 The consumption of fuel during the construction period

Item	Fuel Consumption/per year
Generator	60048L
Loader	14400L
Excavator	9000L
Crane	10800L
Other Mechanical Equipment	3000L
Total	97248 L at least, 82 tons/year

To meet the needs of continuous power generation and emergencies, at least 76 tons diesel fuel should be stored. The fuel storage tank will be used to store diesel fuels. In advance, the fuel tank will be full-filled with Antarctica diesel in China as shown in Figure 2-21. When the icebreaker arrives near the Antarctic, the fuel tank will be transported from the icebreaker to the land by barge, and then will be transported to the designated spot by a specific truck.

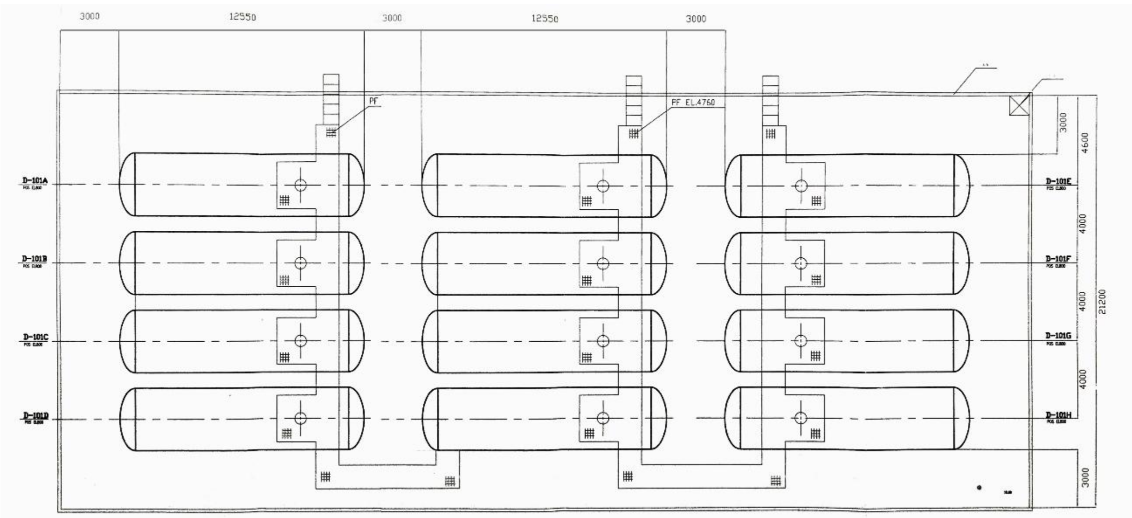


Figure 2- 21 Fuel storage tank layout

2.5.6.3 Estimation of the diesel consumption during the year-round operation period

During the full-year operation of the station in future, the fuel storage system in the new station will be divided into two separated systems as Antarctica diesel storage system and aviation kerosene storage system.

During the full-year operation period, the working time of the generator shall be calculated in 365 days. The power of the generator is 240 kW in summer and 200 kW in winter, the fuel consumption for a generator is about 57.5 L/h in summer and 39.9 L/h in winter in average. Therefore, the total diesel fuel consumption for a year is about 387540 L, 325.5 tons/year. If the renewable system including the 100kW solar power plus 100kW wind power run successfully in 2025, 32.5 % diesel will be saved for one year, the consumption is about 219.7 tons/year.

Table 2- 8 The consumption of fuel during the operation period

Item	Fuel Consumption/per year
Generator	325.5 tons/year
Loader	7200L
Excavator	5400L
Crane	4050L
Other Mechanical Equipment	5400L
Total	344.0 tons/year
Note: If the renewable system including the 100kW solar power plus 100kW wind power run successfully in 2025, 32.5 % diesel of the generator will be saved for one year, the consumption of the generator is about 219.7 tons/year.	

During the full-year operation period, the annual working time of mechanical equipment such as vehicles will be calculated in 180 days. The working time of a loader is calculated at 2h per day, the fuel consumption for a loader is about 20L/h, therefore the fuel consumption for a loader is about 7200L per year. The working time of an excavator is calculated at 2h per day, the fuel consumption for an excavator is about 15L/h, therefore the fuel consumption for an excavator is about 5400L per year. The working time of a crane is calculated at 1.5h per day, the fuel consumption for a crane is about 15L/h, therefore the fuel consumption for a crane is about 4050L per year. The fuel consumption for other mechanical equipment such as vehicles is about 30L per day, therefore annual fuel consumption for other mechanical equipment is about 5400L per year. During the operation period, the total consumption of fuel for all mechanical equipment is about 22050L, 18.5 tons per year.

In order to ensure the normal operation of the generators and vehicles of the new station for a year, the consumption of diesel fuel is about 409.59 cubic meters, 344.0 tons/year.

Considering the steady operation of the new station and the impact of the emergency on the operation of the station, the capacity of diesel for the station should be replenished for 2.5 years, which means that the capacity of diesel storage tanks in the station will be more than 1024 cubic meters.

Therefore, there will be 12 diesel tanks, and each volume will be 88 cubic meters plus one fuel truck and necessary pipelines and pumps.

2.5.6.4 Estimation of the aviation kerosene consumption during the construction period

The station is mainly equipped with two types of helicopters, which calls the Dolphin model and the KA-32 model as shown in Figure 2-22 and Figure 2-23. The consumption for the Dolphin model is about 260 kg/h, the annual working time is calculated at 40h, therefore the annual consumption of aviation kerosene for a Dolphin model helicopter is about 13333 L, 10.4 tons/year.

The consumption for the KA-32 model is about 700 kg/h, the annual working time is calculated at 100h, therefore the annual consumption of aviation kerosene for a KA-32 model helicopter is about 89744 L, 70.0 tons/year.

2.5.6.5 Estimation of the aviation kerosene consumption during the year-round operation period

In order to ensure the normal operation of the station during the full-year operation period, helicopters and fixed-wing aircraft are required. The consumption for the fixed-wing aircraft is about 600L/h per hour, the annual working time is calculated at 100h, therefore the annual consumption of aviation kerosene for a fixed-wing aircraft is about 60000L, 46.8 tons/year.

The station is mainly equipped with two types of helicopters, which calls the Dolphin model and the KA-32 model. The consumption for the Dolphin model is about 260kg per hour, the annual working time is calculated at 40h, therefore the annual consumption of aviation kerosene for a Dolphin model helicopter is about 13333 L, 10.4 tons/year.

The consumption for the KA-32 model is about 700kg per hour, the annual working time is calculated at 30h, therefore the annual consumption of aviation kerosene for a KA-32 model helicopter is about 26923 L, 21.0 tons/year.

Figure 2- 22 KA-32 model

Figure 2- 23 Dolphin model

Therefore, during the full-year operation period, the annual consumption of aviation kerosene for the helicopters and fixed-wing aircraft is about 100256 L (equals to 501 barrels).

Considering the steady operation of the new station and the impact of the emergency on the operation of the station, the capacity of aviation kerosene for the station should be replenished for 2.5 years, which means that the capacity of aviation kerosene storage tanks in the station will be about 250 cubic meters.

Therefore, there will be several aviation kerosene tanks or 200L standard fuel buckets that should be full-filled with aviation kerosene.

2.5.6.6 Fuel transport scheme

Fuel for the new station is mainly composed of Antarctic Diesel and Aviation Kerosene. Antarctic diesel is mainly used in power generation and mechanical equipment such as vehicles. Aviation kerosene is mainly used in fixed-wing aircraft and helicopters. Fuels for the new station will be transported to the sea area near Victoria Land by the icebreaker, then be transported from the icebreaker to the land by barge or helicopter.

Barges are used to transport fuels (mainly diesel) from the icebreaker to the unloading port by sea. To meet the needs of usage and storage of the fuels, there should be a tank usage and storage system with a modern offshore pumping station and fuel tanks through the fuel line connections in the station. The diesel will be transported from the barge to the fuel tanks by the offshore pumping station through fuel lines.

If the near shore sea ice is heavy and the barges cannot successfully land, the alternative unloading approach by the helicopter will be the option. Unloading by the helicopter means that the aviation kerosene is directly transported from the icebreaker to the land by helicopter. 200L standard oil bucket and the specific aviation kerosene tank will be used to transport the aviation kerosene as shown in Figure 2-24 and Figure 2-25.

Figure 2- 24 200L standard oil bucket

Figure 2- 25 Specific aviation kerosene tank

2.5.7 Water supply system

2.5.7.1 Water sources

Water sources for Antarctic research stations normally include the snow, ice, lakes or seawater. The proposed site is an ice-free area during summer with limited snow or ice which means not sufficient freshwater during summer. The only possible water source nearby will be the seawater during the construction period and year-round operation period. While in the first construction year before the normal operation of the water supply system, some bottle drinking water will be used. In addition, the grey water recycling system will be applied during the operation of the station to meet the non-drinking water requirements.

The planned intake is situated on the western seashore of Terra Nova Bay, opposite to and at sufficient distance from the wharf facility and the discharge point (Figure 2-25). The water pipes will be installed above ground with heating wires and insulation to prevent freezing and strong wind.

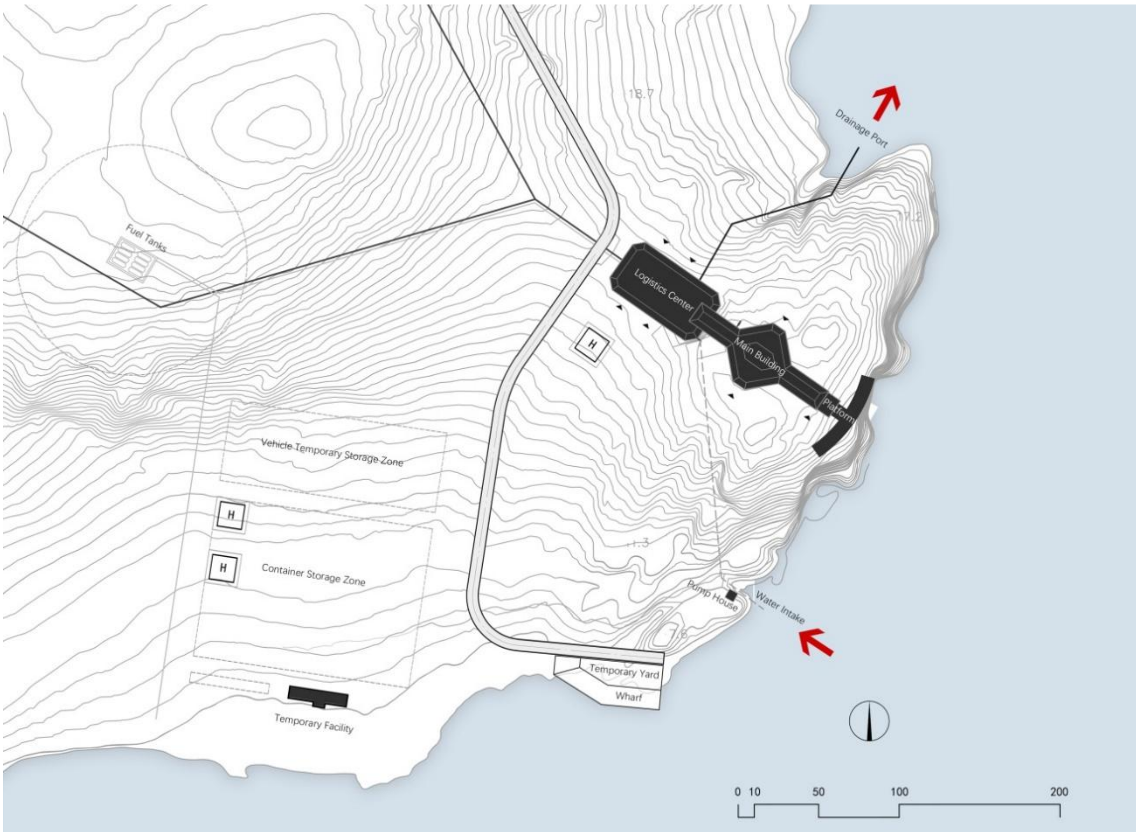


Figure 2- 26 Intake and drainage locations

2.5.7.2 Seawater reverse osmosis system

After technical comparison and research, the seawater desalination project selects reverse osmosis seawater technology. Reverse osmosis desalination technology is the mainstream seawater desalination technology in the world, which has the advantages of mature technology, low operation cost, convenient maintenance, and high-cost performance.

A complete drinking water system comprised of multi-media filters pretreatment, cartridge filtration, and a single pass, single stage Seawater Reverse Osmosis (SWRO), followed by a re-mineralization system will be used in the new station, considering the low temperature of the seawater, the additional heat exchanger will be necessary before the feed pump. The diagram of the SWRO is shown in Figure 2-27.

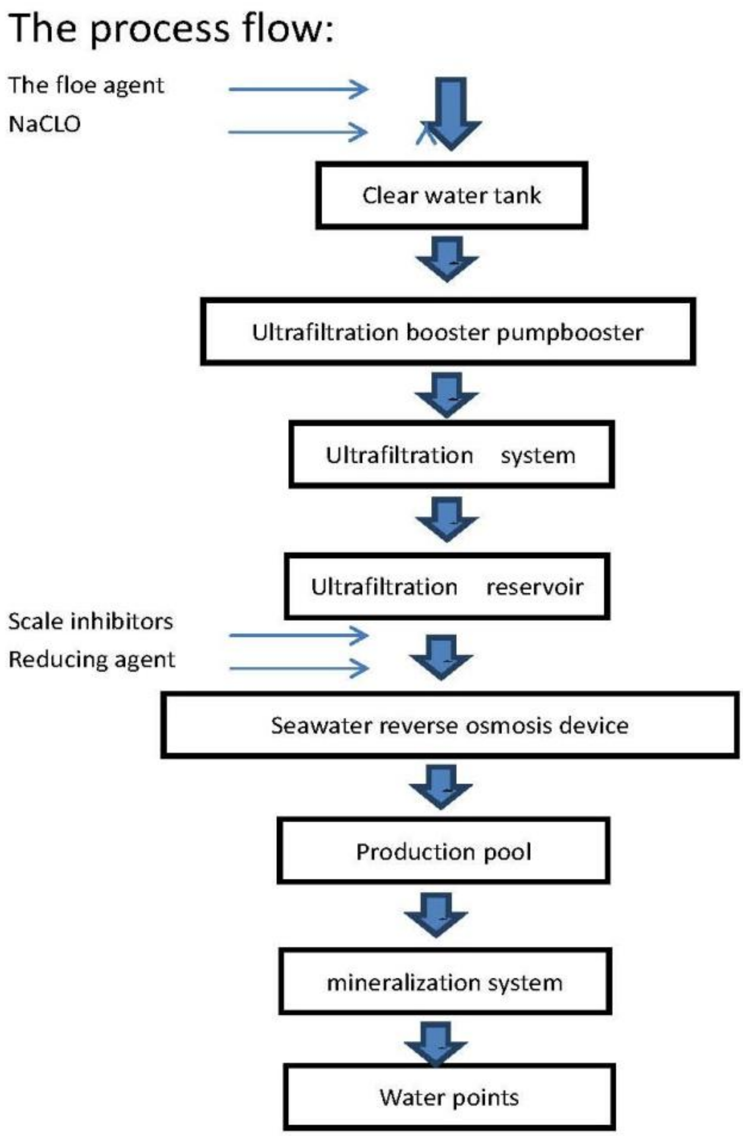


Figure 2- 27 Diagram of the SWRO system

Reverse osmosis pretreatment process is important to the safe operation of reverse osmosis. Combined with the characteristics of seawater quality of the project, the water quality of raw seawater is relatively clear and the turbidity is low. As a result, the pretreatment program selects ultrafiltration process, which has a good water quality adaptability to resist the impact of future changes in water quality and a high assurance of water quality.

After the pretreatment system, a 5μm security filter was placed before the high-pressure pump of the reverse osmosis desalination device. Security filter is a precision filter, and the purpose is to prevent large particles of water from entering the reverse osmosis desalination system to damage reverse osmosis membrane. After acceleration of the high-pressure pump, particles may break down the modules of reverse osmosis membrane, which can result in many salt leaks and scratch the impeller of the high-pressure pump.

High-pressure water supply system provides sufficient water pressure for the reverse osmosis desalination membrane group. The high-pressure pump uses variable frequency control program to control speed. Reverse osmosis high-pressure pumps, pipes and accessories consider using corrosion-resistant materials. Sealing methods consider corrosion-resistant mechanical seals. Inlet and outlet of the reverse osmosis high-pressure pump set pressure switch. Alarm and stop the pump when the inlet pressure is low and the outlet pressure is high.

Reverse osmosis desalination membrane group is the core of the entire desalination system, which is responsible for the removal of soluble salt in seawater, colloids and organic matter to enable the effluent quality to meet user requirements.

When the reverse osmosis desalination device at downtime, the membrane of the sea water has already been in a concentrated state, which likely to cause membrane assembly scale and pollution. Therefore, the surface of the membrane needs to be rinsed with fresh water to displace the concentrated water on the membrane surface to prevent the deposition of contaminants on the surface of the reverse osmosis membrane and affect the performance of the membrane.

Post-mineralization system: Reverse osmosis desalination water is filtered through a neutralization filter into a freshwater tank. Then freshwater pumps deliver the freshwater into the municipal water distribution network. According to the delivery of fresh water flow rate, Dosing pump add chlorine dioxide and sodium carbonate to control chlorine dioxide of 0.15 ~ 0.20mg / L, pH value of 6.5 ~ 8.0.

All components, except for the optional feed water pump and membrane unit, are installed in a customized 20' ISO shipping container, pre-piped and wired as shown in Figure 2-28.

Figure 2- 28 Integrated SWRO installed in a customized 20' ISO shipping container

The planned reverse-osmosis desalination system is easy to operate and energy efficient. An outside seawater storage tank will be installed with double-skinned for durability. Desalinated water will be stored in the tanks located in the power plant, which will be distributed in the station after treatment. Pipelines will be heat-wired to prevent freezing.

2.5.7.3 Emergency water supply system

Due to the low winter temperatures in the polar regions, ice and snow can be used as a backup source of conventional water in the station area to prevent water anomalies in the seawater desalination system.

Using residue heat from the CHP plant, the snow and ice melting facility can provide up to 20 tons of water per day during winter. The snow melting may be operated in parallel with ice melting when snow supply at the site remains sufficient. An emergency electric-based snow melting facility including a 20-ton water tank will also be constructed as a part of the emergency power plant. The effluent of snowmelt water tank flow into the normal desalination system for treatment, and then into the water supply system for staff to use.

2.5.7.4 Water consumption

The data of water consumption of several Antarctica research stations were collected but limited. German Neumayer Station is located on Ekström Ice Shelf, where the water consumption per person per day is 117 liters (Enss, 2004). In the American Amundsen-Scott Station, the water consumption per person per day is estimated at 95 liters (Number of personnel living there in summer is 230 -235；NSF, 2004). The water supply required was calculated to be 150 liters per person per day in the Korean Jang Bogo station, which includes water needed for cooking, washing and personal hygiene.

When the new station is in operation, it will need 7200 liters per day for 80 summering expeditioners' daily use (average 90 L/head/d) including drinking, cooking, brushing, washing, bathing, medical use, sanitary water and cleaning. Among which, 4320 liters are from seawater desalination, for daily drinking, cooking, brushing and so on, the rest 2880 liters of daily use water will be recycled gray water up to the standard after treatment as shown in Tab 2-9. The water consumption of the scientific laboratories is not included.

Table2- 9 Estimation of water consumption in summer

No.	Use	Number of people	Water used (L/d)	source
1	Drinking and Cooking including medical facility use	80	1600	Seawater desalination
2	Utensil's cleaning, Brushing and washing, and bathing	80	2720	Seawater desalination
3	Simple cleaning of clothes and articles	80	1440	Reuse of grey water
4	Sanitation cleaning，toilet flushing and mechanical workshops cleaning	80	1440	Reuse of grey water
	Subtotal		7200	

Once the new station is in operation in winter, it will need 2700 liters water per day for 30 winter expeditioners' daily use (average 90 L/head/d) including drinking, cooking, brushing, washing, bathing, medical use, sanitary water, and cleaning. Among which, 1620 liters are from seawater desalination, for daily drinking, cooking, brushing and so on, the rest 1080 liters of daily use water will be the recycled gray water up to the standard after treatment as shown in Tab 2-10. The water consumption of the scientific laboratories is not included.

Table2- 10 Estimation of water consumption in winter

No.	Use	Number of people	Water used (L/d)	source
1	Drinking and Cooking including medical facility use	30	620	Seawater desalination
2	Utensil's cleaning, Brushing and washing, and bathing	30	1000	Seawater desalination
3	Simple cleaning of clothes and articles	30	540	Reuse of grey water
4	Sanitation cleaning，toilet flushing and mechanical workshops cleaning	30	540	Reuse of grey water
	Subtotal		2700	

2.5.8 Wastewater treatment and greywater recycling system

To minimize environmental impact, firstly, the principles of guiding the design of the wastewater treatment and greywater recycling system are priority, secondly, make the rational layout to minimize land use, and thirdly, operate safely and reliably and make the system easy to manage and operate with higher auto-control functions. We will use the grey water for mechanical workshops cleaning and so on.

2.5.8.1 Water saving products and source separation system

Well-designed products can be helpful to the environment and high-efficiency faucets, clothes washers and toilets etc. will be applied. Upon the consideration of the small amount of water consumption, environmental protection, easy management, and simplification of treatment facilities, a negative pressure free-of-flushing system will be used in the toilet to reduce the capacity of black water.

2.5.8.2 Sewage treatment and greywater recycling process

The new station will set up an integrated container-type of sewage treatment and greywater recycling system as shown in Figure 2-28. The indoor temperature can be controlled to ensure the proper operation of the membrane bioreactor.

The system mainly consists of a sewage tank, regulation tank, membrane biological reactor tank, granular activated carbon (GAC) tank, desalination water tank, Ultra-Filtration/reverse osmosis tank, out-tank pump valve, and filters. It is a sealed unit made of stainless steel plate. Without special attendee, it will operate continuously or intermittently stops at night. One person might be appointed to make routine inspection and maintenance. Residual black water coming from the super-filtering unit will flow into a combined rector. According to the dimensions of the container, the sewage treatment and recycling system will be installed in several standard containers (3700 x 2700 x 2400 mm as an integrated unit).

The black water (including night soil and urine) together with the organic solid waste and sludge of the MBR system will be treated by fermentation tank. The dried sludge after dehydration unit will be treated by the magnetization pyrolysis furnace, the biogas produced during the anaerobic reaction will be supplement energy source for the boilers.

The lower contaminated wastewater through Membrane Biological Reactor will be further treated by GAC, Ultrafiltration or Reverse Osmosis. The treated water will be in compliance with the standards of Category Ⅲ of Surface Water in China (GB 3838-2002), higher than the emission standards of other scientific research stations in similar areas of Antarctica. It will be recycled for simple cleaning of clothes in the station and toilet flushing and the excess treated water will be discharged back to the sea.

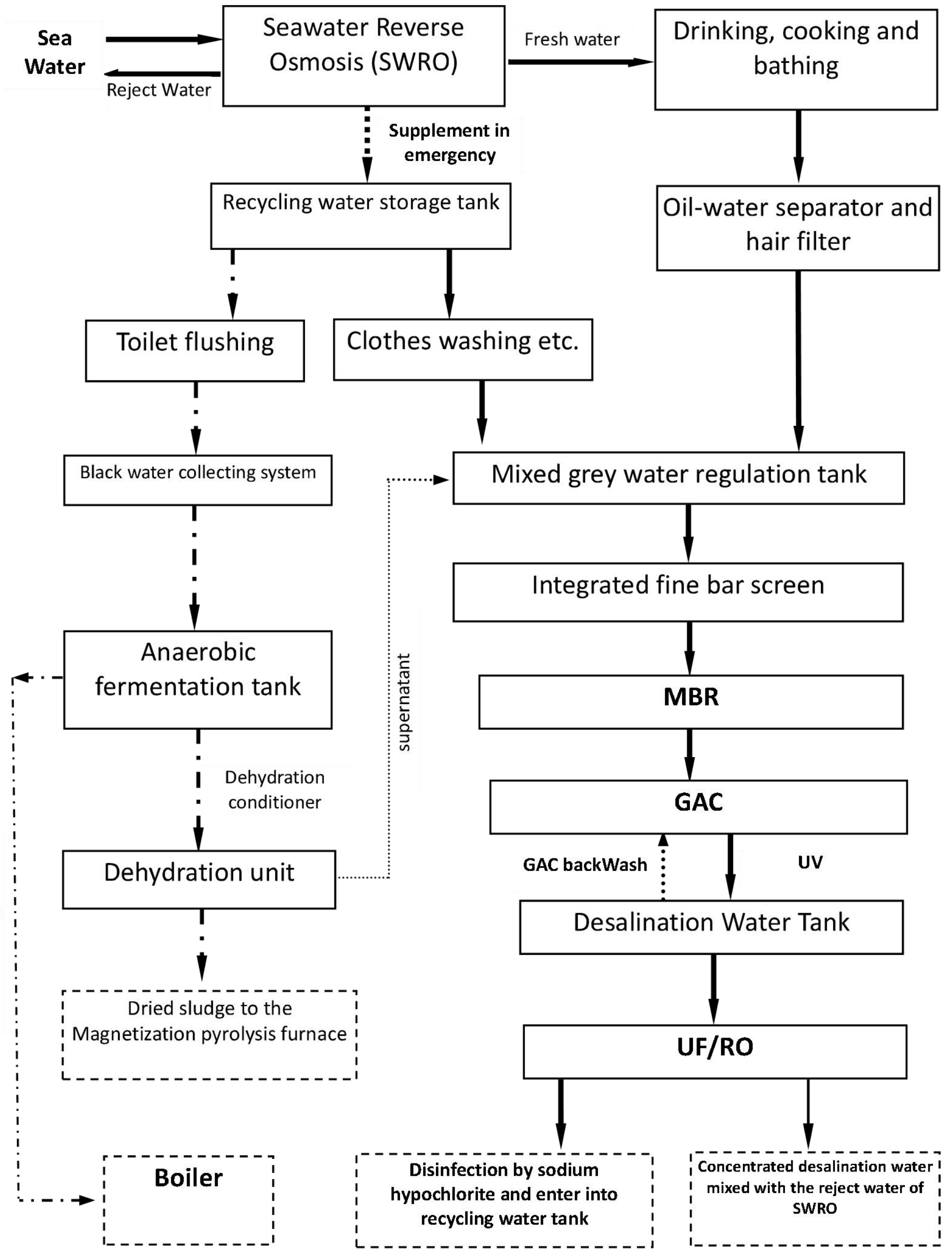


Figure 2- 29 Diagram of greywater recycling and black water treatment system

2.5.8.3 Designed water quality of influent and effluent

The sewage of the station is mainly from the living rooms and kitchen. No black water will mix with the grey water collecting system. The water quality of the influent is shown in Tab 2-11.

Table2- 11 Designed influent water quality

Indicator	pH	COD_{Mn} (mg/L)	BOD_5 (mg/L)	SS (mg/L)	NH_3-N (mg/L)	Fecal colon bacillus (ind/L)
Designed input water quality	6～9	350～450	180~250	200～300	35～45	100000

The water quality of the swage treated for recycling use or discharge will be in compliance with the standards of Category Ⅲ of Chinese Water Quality Standards for Surface Water (GB3838-2002). The control indicators for water quality are shown in Tab 2-12.

Table2- 12 Quality of recycling and discharged water

Indicator	pH	COD_{Mn} (mg/L)	BOD_5 (mg/L)	SS (mg/L)	Turbidity (NTU)	NH_3-N (mg/L)	Fecal colon bacillus (ind/L)
Recycling water	6～9	≤6	≤4	≤5	≤1	≤1	≤200
Discharged water	6～9	≤6	≤4	≤5	≤1	≤1	≤200

2.5.9 Hybrid Solar- Wind-Hydrogen-Diesel power supply system

The hybrid Solar-Wind-Hydrogen-Diesel power system is a relatively mature micro-grid technology in the world. There are success stories of this kind of system in the United States, Japan, the European Union, and China. Now in the Provinces of Zhejiang, Qinghai, Xinjiang, Henan and other places, the technology is relatively mature.

We will fully consider the requirements of the Environmental Protection Protocol, reduce the environmental impact and use renewable energy as much as possible. We will learn the experience of the existing new energy integration at the Antarctica stations, such as United States' McMurdo Station, New Zealand's Scott Base, Belgian Princess Elizabeth Station, Australian Mawson Station, German Neumyer Station, Chinese Zhongshan Station, and Taishan Summer Camp. etc.

In order to obtain better design parameters of the microgrid system of the new station, we chose the Taishan summer camp as it has similar latitude and lower temperature to carry out technical system testing. In the summer of 2019, the new energy system of Taishan continued to operate for more than 50 days, supplying power to the main building. In the case of sufficient wind and light, the new energy system can generate 50kW of electricity. In the grid-connected mode with diesel engines, it can meet the power demand of 30kW in the Taishan, and has accumulated experience in the use of solar-wind-diesel power systems in the Antarctic region. From 2019 to 2020, Taishan completed a micro-grid power generation system with multi-energy complementary photovoltaics, wind turbines and diesel engines, the installed capacity of photovoltaics is 40KW, wind turbines 20KW, and diesel generators are used as backup power sources. The measured power generation of wind turbines and photovoltaics during the one-month power generation cycle from January 25, 2020 to February 24, 2020 is shown in the figure below.

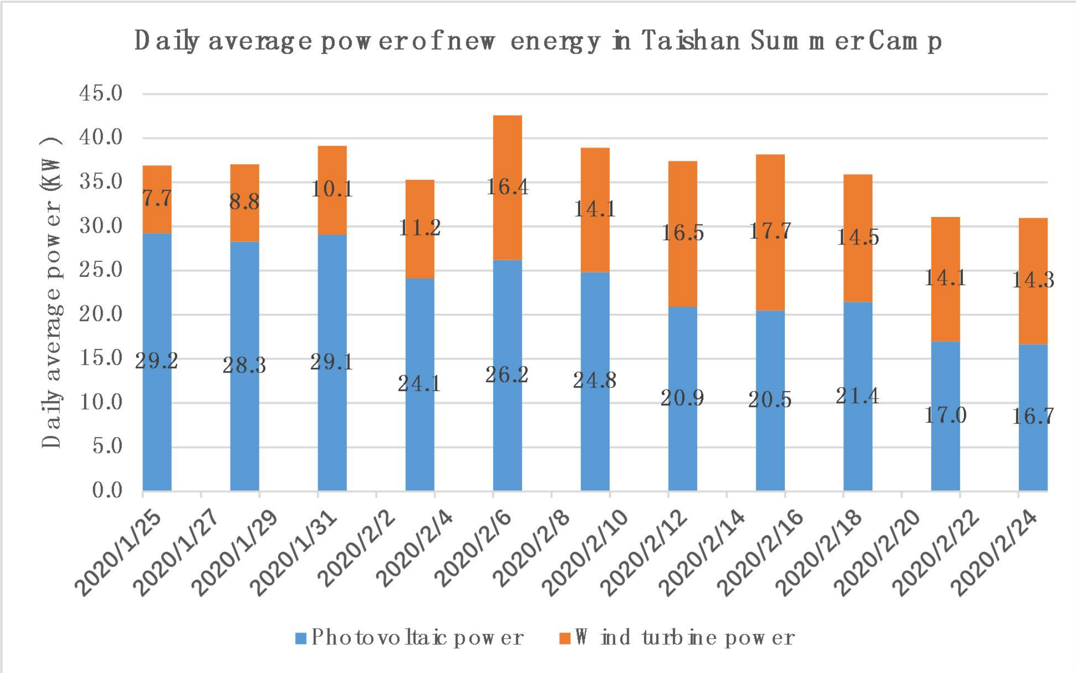


Figure 2-30 Power generation of new energy test system of Taishan summer camp

It can be seen from the figure that over time, the power of photovoltaic power generation has gradually decreased, from 29.2kw on January 25 to 16.7kw on February 24. This is due to the gradual shortening of the duration of sunshine in the southern hemisphere and the lower amount of solar radiation. As a result of the gradual decrease, the change trend of daily radiation near the Taishan is shown in the figure. Wind power generation is greatly affected by wind speed, but since February 6, the amount of wind power generation has not changed much.

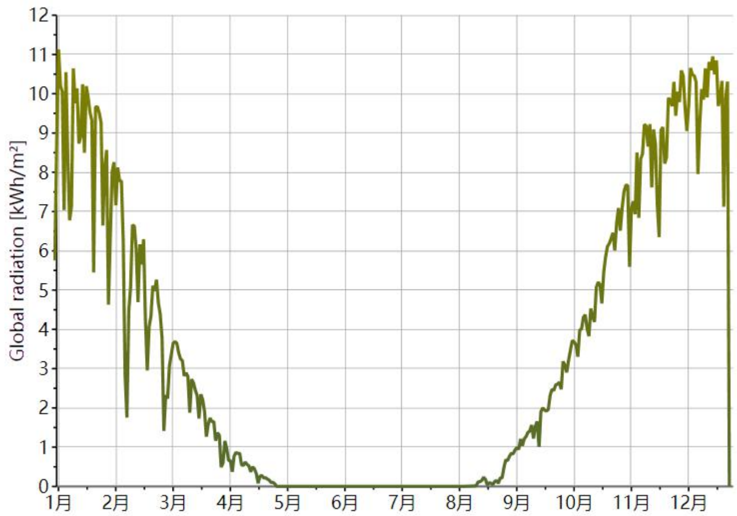


Figure 2-31 Variation Curve of Solar Radiation in the Test System of Taishan

If the average electricity load of the Taishan is 50kw, the power generation of photovoltaics, wind turbines and diesel engines will be as shown in the figure below. In summer, photovoltaic power generation accounts for the main part, but as the sunshine time becomes shorter, the power generation of diesel engines gradually increases. The proportion of wind turbine power generation has not changed significantly.

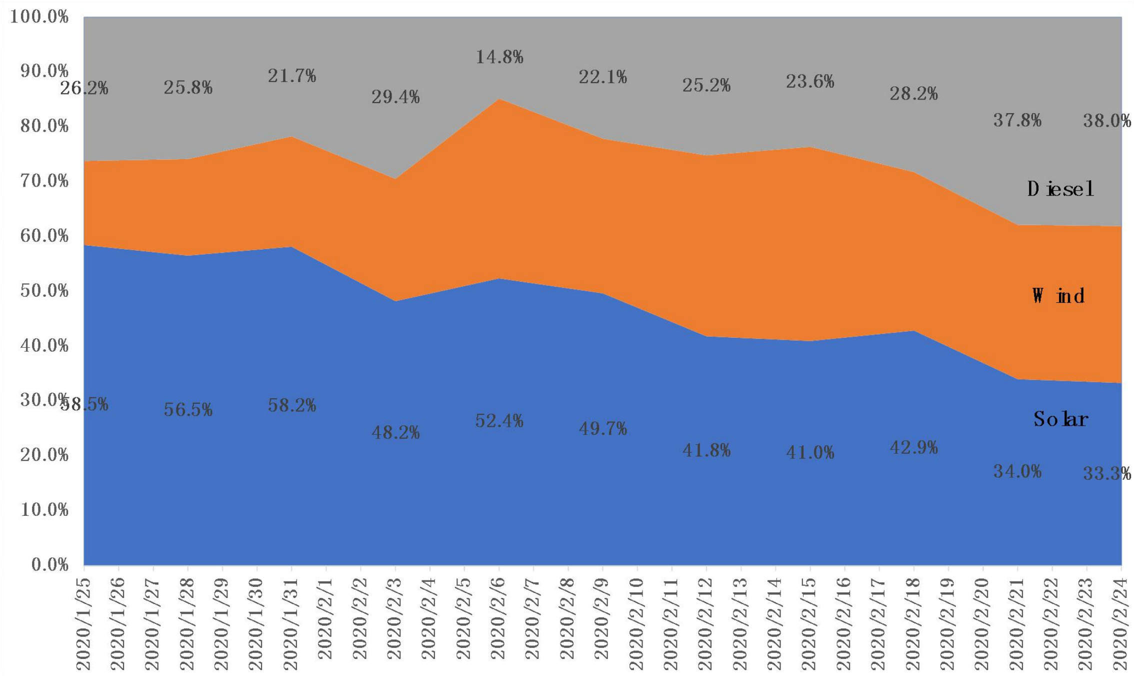


Figure 2- 32 Schematic diagram of the proportion of renewable energy in the Taishan test system

During the construction, we mainly rely on our traditional energy and focus on the integrated management of the traditional energy and the efficient application. We will try to install parts of the renewable energy system in the third year of construction. If all run well, the renewable energy system will be partly used as a supplementary energy during the construction period. During the construction, some of our temporary facilities will be equipped with the photovoltaic solar heating system.

2.5.9.1 Power and heating load estimation

As the outdoor temperature will be very low, it is planned to use the concentrated ventilation system with heat recovery units.

For energy-saving and comfort feeling, room temperature will be controlled between 8 to 25°C. The specific heating parameters for various rooms are indicated in Table 2-13.

According to the previous long-term observatory data produced by Manuela station, the annual average temperature of the regions is -18.5 ℃ respectively. The recorded extreme low temperature is -42.3℃ (September. 1st, 1992), the recorded highest temperature is 6.9℃.

Table 2- 13 Design parameters for heating and ventilation

Room function	Indoor temperature (℃)	Fresh air volume/ output air volume(time/h)	Exhaust air volume(time/h)	Noise criteria(dB)
Bedroom	20	30	—	40/35
Storage room	8	—	—	50
Scientific research, office and meeting room	18	30	—	45
kitchen	16	48/4.8	60/6	50
Living room and recreation room	18	30	—	40
Tool room	8	3	4	50
Toilet	16	—	10	45
Bathroom	25	—	10	50
Sewage disposal room	8	6	8	—
Water pumps room	8	3	4	—
Boiler room	8	12+3	12	—
Electricity facilities room	8	6	8	—

It is estimated that the power consumption of the new station in summer is about 185 kilowatts, as shown in Table 2-14, that in winter is about 210 kilowatts, as shown in Table 2-15.

Table 2- 14 Estimated Table of Electricity Consumption in Summer at the new station

Serial number	user name	Rated Capacity	Calculated capacity after adjustment (kx=0.7)
		kW	kW
1	Scientific research operations, observation, and command areas (excluding ocean observation and laboratories)	32	22.4
	Marine laboratory	25	17.5
2	Living medical area (excluding winter dormitory wing, summer dormitory wing, restaurant kitchen)	31	21.7
	dormitory	35.2	24.64
	Restaurant kitchen	48	48
3	Logistics facilities area (excluding equipment maintenance and processing workshops and garages, helicopter hangars, and boat garages)	40	28
	Equipment maintenance and processing workshop and garage	22	15.4
	Helicopter hangar	15	10.5
	Boathouse	7.5	5.25
4	Other traffic space	12	8.4
5	Sea water desalination and utilization system	15	15
6	Hot water pump room	5	4
7	Living water pump room	5	4
8	Integrated solid waste treatment system	15	12
9	Sewage treatment system	12	10
10	Boiler room etc.	60	30
11	Communication room and fire duty room	30	20
12	Outdoor pipeline insulation	30	6
13	Venue lighting	5	5
total			307.79

total（kt=0.6）KW		185

Table 2- 15 Estimated Table of Electricity Consumption in Winter at the new station

Serial number	user name	Rated Capacity	Calculated capacity (kx=0.7)
		kW	kW
1	Scientific research operations, observation and command areas (excluding ocean observation and laboratories)	22	17.6
	Marine laboratory	8	6.4
2	Living medical area (excluding winter dormitory wing, summer dormitory wing, restaurant kitchen)	25	20
	Winter dormitory	18	14.4
	Summer dormitory	17.2	13.76
	Restaurant kitchen	48	48
3	Logistics facilities area (excluding equipment maintenance and processing workshops and garages, helicopter hangars, and boat garages)	15	12
	Equipment maintenance and processing workshop and garage	22	17.6
	Helicopter hangar	15	12
	Boathouse	7.5	6
4	Other traffic space	12	9.6
5	Sea water desalination and utilization system	15	15
6	Hot water pump room	5	5
7	Living water pump room	5	5
8	Integrated solid waste treatment system	15	15
9	Sewage treatment system	12	12
10	Boiler room etc.	60	60
11	Communication room and fire duty room	30	24
12	Outdoor pipeline insulation	30	30
13	Venue lighting	5	5
total			348.36
total（kt=0.6）			**210**

2.5.9.2 Overall design of energy power system

In summer, the new station may consider adopting new energy power supply + traditional energy backup in all phases, and adopting some new energy + traditional energy power supply in winter to ensure that the energy supply system of the new station is safe, reliable, scientific, efficient, energy-saving and environmentally friendly.

The total power consumption of the new station in summer is about 185kw. According to the principle of energy saving and environmental protection, combined with short-term, medium-term and long-term technological innovation and support capabilities, it will be equipped with 100kw wind power generation + 100kw solar power generation + 65kw micro-gas turbine in summer (summer New energy supplement, clean emissions); The whole station is equipped with 3 300kw diesel generators (2 sets alternately operating, 1 set as an emergency guarantee) as the annual energy base guarantee.

The peak total energy consumption of the whole station in winter is 210kw (according to the number of wintering team members and the actual demand for wintering), in accordance with the principle of safety and reliability first, taking into account the failure of the solar power system during the polar night in winter, the safety protection of the wind turbines, the brakes and equipment maintenance conditions are limited and other factors, the recent 100kW wind power generation during the polar night period is an effective supplement to the power of diesel generators, reducing power generation, reducing fuel consumption, and achieving energy conservation and environmental protection.

As a clean energy, hydrogen storage fuel cell system has the characteristics of pollution-free and zero emission, and is an important direction for future international and domestic energy development. At present, there are no application cases in other stations in the Antarctic. China will innovatively establish 30kW of hydrogen storage. The fuel cell is used as a pilot. In the case of solar and wind power generation in the extreme day, hydrogen is produced by electrolysis and stored. During the extreme night, hydrogen storage fuel cells can be used for power generation, providing winter power supply for some independent scientific research facilities. In the future, it can be expanded and upgraded according to the application situation.

As electric distribution technology moves into the new century, many trends are becoming apparent, which will change the requirements of energy delivery. These changes are being driven by both the demand side where higher energy availability and efficiency are desired and the supply side where the integration of distributed generation and peak-shaving technologies must be accommodated. Distribution systems possessing distributed generation and controllable loads with the ability to operate in both grid-connected and standalone modes are an important class of the so-called Micro-grid power system.

The new station intends to adopt a composite power energy technology integrating wind power generation, solar photovoltaic power generation, hydrogen fuel power generation, diesel power generation heat, and power storage - wind, light, hydrogen, fuel, heat storage, and energy storage complementary smart micro-grid energy system. The energy system is integrated by distributed power sources, energy storage devices, energy conversion devices, load and monitoring devices, and protection devices. It is an autonomous system that can realize self-control, protection and management. The energy system includes solar photovoltaic power generation subsystem, wind power generation subsystem, hydrogen fuel cell subsystem and conventional diesel power generation. The entire energy system is managed through a unified energy management system to realize functions such as distributed power generation, intelligent load distribution and system monitoring.

When the supply of new energy is sufficient, priority is given to using wind and photovoltaic power generation, and the rich electricity is stored in the form of hydrogen; when the new energy is insufficient, diesel generator sets are used as a supplement. The composite energy system can solve the problem of building energy in all weather conditions in the new station, and at the same time realize the maximum utilization of new energy and the optimization of energy utilization efficiency.

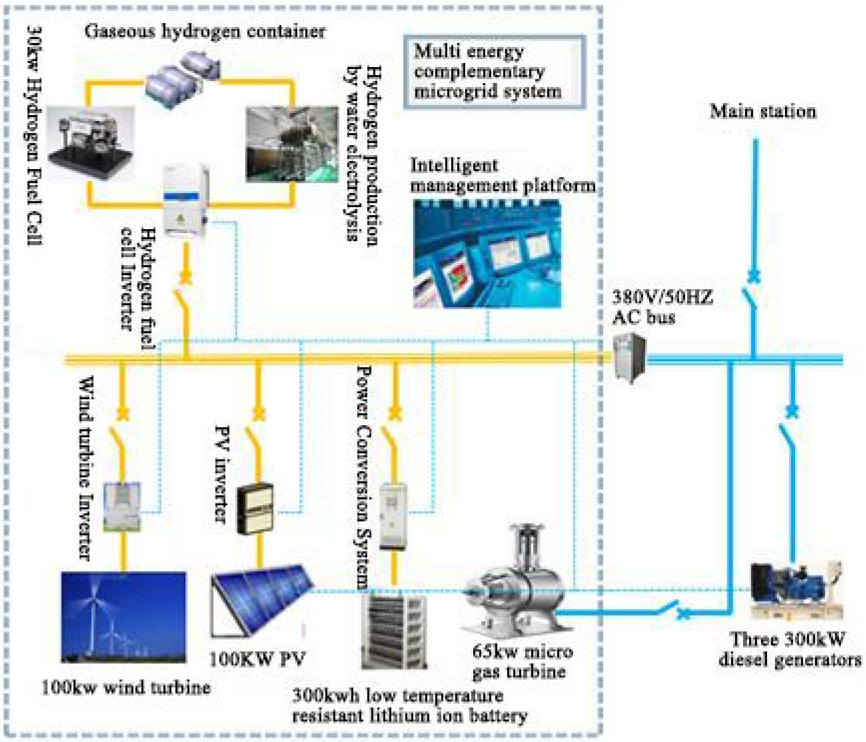


Figure 2- 33 Scheme of micro-grid system

There will be probably three alternative power supply systems in the new station and a unified energy monitoring system will be set up for effective power management, load distribution, and system monitoring. The micro-grid power system will serve as the whole station.

A distributed power supply and load-place controller will be applied to micro-grid power system, to achieve power balance control, system operation optimization, fault detection and protection and power quality control. The principle of the micro-grid system design is to prioritize the use of renewable energy including wind and solar and to minimize the output power of the diesel generator.

The solar and wind power generation is given priority to the new station's energy system, and the diesel generator is complementary to guarantee the load application of the new station in case of the peak load and unstable situation of the renewable energy system. Solar power installed capacity of 100 kW and wind power installed capacity of 100 kW will be set up before 2025, additional more capacities will be equipped in the long term according to the development of the new station, to make a hybrid Solar-Wind-Diesel power supply system. In summer, solar power and wind power is given the priority, while wind power is given the priority in winter. The monitoring system will be set up to the operation of the system.

Solar photovoltaic power generation is to use the solar cell array changing solar energy into DC energy. Wind power generation is converting wind energy to DC energy. Through the DC/AC inverter, the DC out of solar or wind power will be changed into AC, as a power supply for Antarctic research. The surplus energy will be stored in the battery. Figure 2-30 shows the solar and wind power generation system diagram. Reduce the capacity of the battery in this system as far as possible. Because battery could increase cost and system complexity when designing solar and wind power, generation capacity should be balanced with the load power consumption as much as possible. In addition, the system can also be combined with a diesel generator to get a hybrid power supply system, which can improve the system efficiency and reliability.

2.5.9.3 Solar photovoltaic power generation system

The total capacity of the solar photovoltaic power generation system is up to 100 kW. The photovoltaic as shown in Figure 2-31 is composed of solar cell array (Table 2-14), photovoltaic combining manifolds and photovoltaic grid-connected inverter. A photovoltaic system which is connected to diesel power generating set does not directly utilize battery storage system. It is more economical and practical. And it also improves the security.

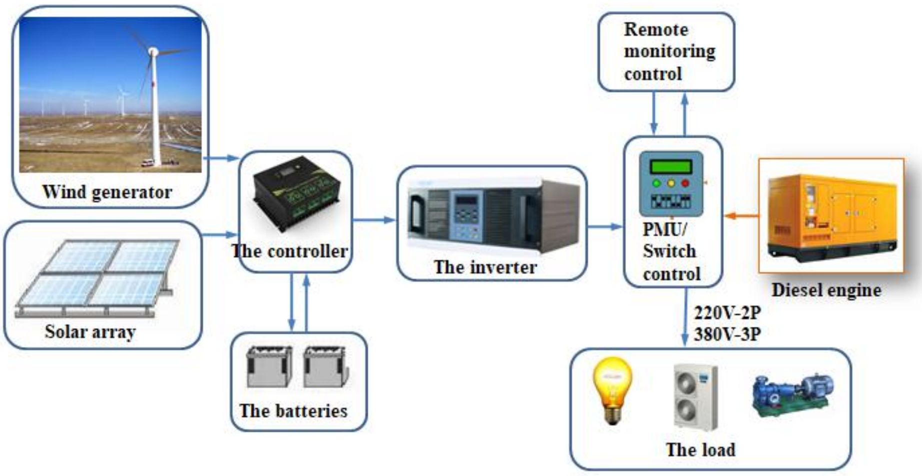


Figure 2- 34 Photovoltaic power generation structure

Table 2- 16 Solar cell technical parameters

Technical indicators	Unit	Parameters
Peak power P_{mpp}	W	5.5
Peak voltage V_{mpp}	V	0.6365
operating current I_{SC}	A	9.2361
Size	mm	156.75× 156.75

According to the maximum generating power of single solar cell on the day of winter solstice, the number of solar cells used in photovoltaic power station is calculated. Through simulation, the maximum generating power of single solar cell on the day of winter solstice is at 13:00 local time on December 22, when the maximum generating power is 3.4W. Therefore, the photovoltaic power station for calculating 100kW power is based on the actual maximum generating power of each solar cell According to the calculation of 3.4W large power generation, 30000 solar cells are needed in total. As the photovoltaic energy system will relate to 3P / 380V / AC in the future, it is recommended to use the module installation to improve the overall efficiency of the system. The form of photovoltaic modules is that each photovoltaic module is composed of 60 solar cells. 100 kW photovoltaic array requires 500 modules in series and parallel to form a 765v / 25.8a photovoltaic array consisting of 20 series and 25 parallel.

The solar cell module has related patent products. The Chinese patents are:

1. High efficiency thin film crystalline silicon solar cell and its independent energy chip integration technology, patent No.: **ZL201410608127.1**
2. Crystalline silicon solar cell and its preparation method, patent No.: **ZL201510394993.X**

There are also related patented products in the micro grid system direction, with the patent number as follows:

1. A battery performance testing device, patent No.: **ZL 201610855166.0**
2. Adaptive overcurrent protection circuit, patent No.: **ZL 201610833043.7**

According to the simulation calculation results, when the photovoltaic installation direction is 0 degrees as shown in Table 2-15, the power generation is the highest, and considering that the photovoltaic panel has a certain angle of inclination to prevent the photovoltaic panel from snowing, the side of the photovoltaic panel is facing the main wind direction, which can effectively reduce the stress of the photovoltaic panel, therefore, considering the power generation capacity and snowing prevention design of the Taiyang battery, the solar cell is installed at an angle of 30 degrees.

Table 2- 17 Power generation of the same battery in different azimuth

Computation time	The Angle between solar cell and the horizontal plane（degree）	Power generation（Wh） on the winter solstice, December 22
December 22, 2017	**0 degrees**	**47.65**
	10 degrees	45.02
	20 degrees	45.21
	30 degrees	**45.59**
	40 degrees	45.21
	50 degrees	43.95
	60 degrees	41.70
	70 degrees	38.17
	80 degrees	33.86
	90 degrees	28.86

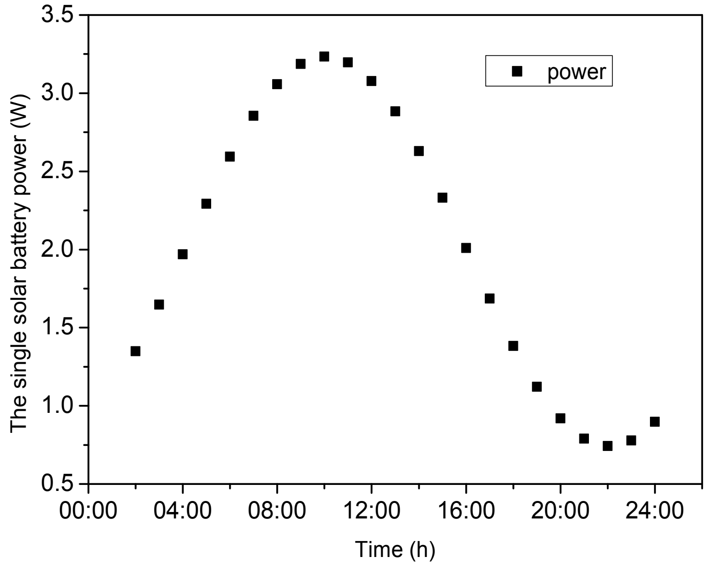


Figure 2- 35 Single solar cell power in a single day during the winter solstice

The size structure of solar cell components is shown in Figure 2-33.

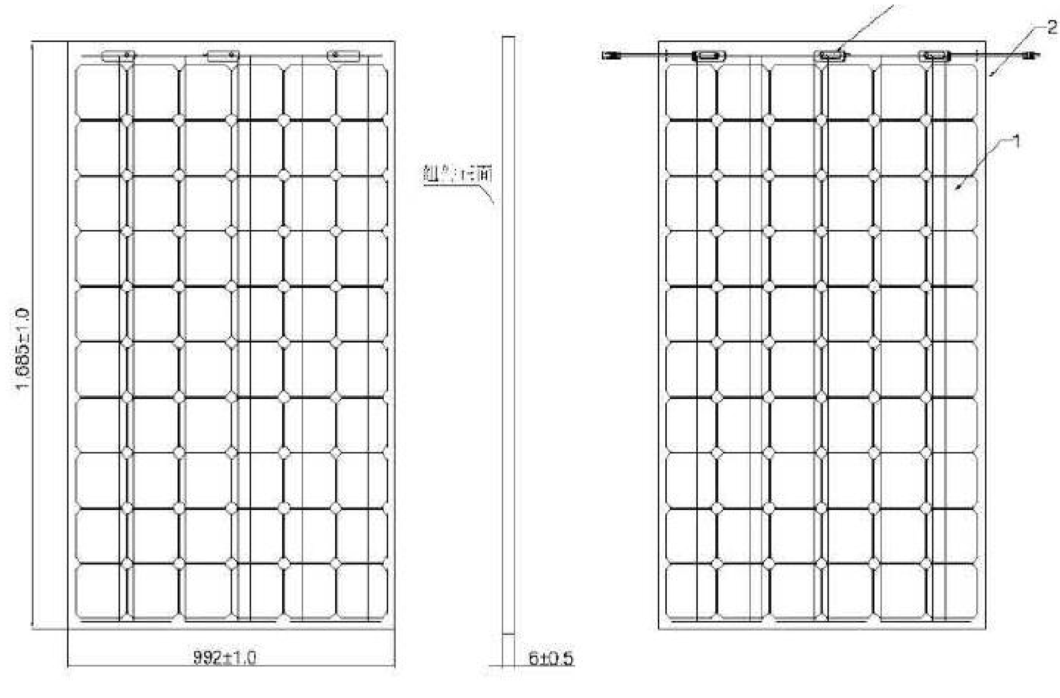


Figure 2- 36 schematic diagram of solar cell component size

The solar cell power generation system consists of 500 solar cell modules in total. Each solar cell sub array is composed of 50 solar cells. Each sub array is connected in front and back directions by 2 parallel and left and right directions by 25 strings. A total of 10 sub arrays forms a 100kW solar cell system. The battery board is installed with a bracket structure, with an interval of 1.5m between the front and rear rows.

According to the above calculation method, the calculation for the RSNRS annual power generation predictive results by simulation as shown in Figure 2-34:

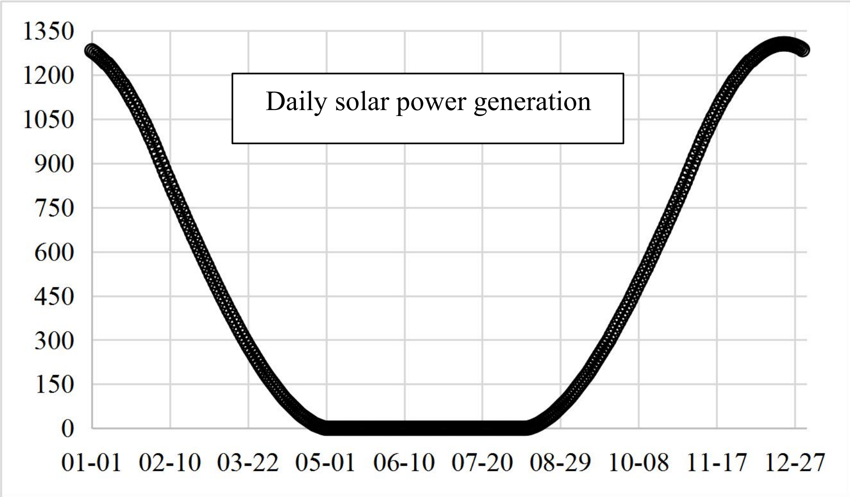


Figure 2- 37 RSNRS 100kW Photovoltaic energy system annual power generation

Compared with the ideal power generation, considering the installation angle, orientation and other shielding effects of solar cells, the solar cell power generation is about 90% of the theoretical value. RSNRS predictive annual power generation is 168300 kWh, and the monthly output is shown in Figure 2-35.

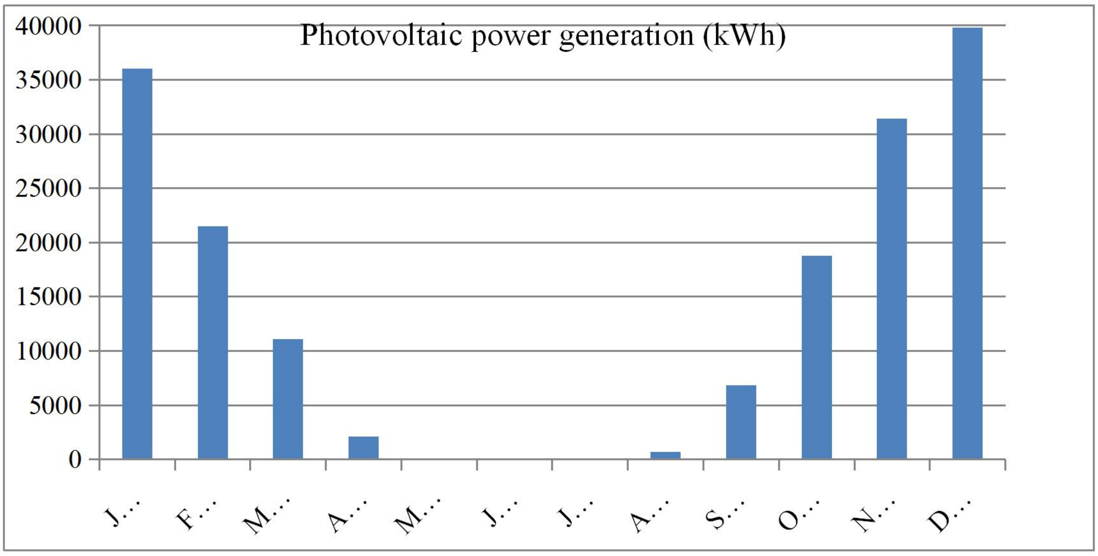


Figure 2- 38 Monthly power generation from 100kW Photovoltaic energy system

According to the objective of location and geographic features, the installation considers adopting steel brace. It suggests using fixed installation integrating geographical location of the 100kW photovoltaic system, maintenance, and investment costs.

RSNRS would adopt the solar cell is parallel to the surface of the point of view, using anchor bolt steel foundation and 21 lines 24 column configuration method, spacing before and after 1 ~ 1.5 meters. It covers an area of about $30m^2$ to $45m^2$. RSNRS would utilize hot dip galvanized carbon steel material, cooperating with anchor bolt steel foundation and steel components of the guide rail bracket structure such as the component are fixed on the ground.

The installed capacity of solar power generation system will be up to 100 kW, and the capacity will be 150kW after operating for 5 years.

2.5.9.4 Wind power generation system

According to the results of the monitoring of the temperature, humidity and wind speed conditions of AWS China on the Inexpressible Island from 2016 to 2020, considering the environment and state that the wind power generation system can work stably at present, it is necessary to design a wind-resistant special structure for the wind turbine of the wind-power generation system and to carry out a loop-controlled design of the operating temperature of the wind turbine.

After the theoretical calculation, the composition of the wind power generation system can be given, but the actual operation and the actual generation energy of the wind power generation system at the proposed site still need to be verified in the field. As a result, wind power generation systems, as part of power supply for micro-grid systems, have the potential to be power generation alternatives.

The installed capacity of wind power generation system will be up to 100 kW, and the capacity will increase to 200 kW or 300 kW. Wind turbine selection is according to the matching of the voltage level, demand power, installation conditions determined, space saving, convenient for the construction, low maintenance and minimization of noise. For a single wind turbine, if it is larger and higher, it will be more difficult for transportation and installation.

After operation, ten sets of 10kW wind turbines will make up 100kW wind power generation system. The performance curve of the 10kW wind turbine selected in the program is shown in Figure 2-36. As shown in Figure 2-36, blue curve indicates the power of fan in different wind speed, while the red one indicates the performance coefficient of fan in different wind speed, the chart shows, the 10-kW fan can reach full power work when the wind speed up to 12 m/s, while wind speed between 3m/s and 12m/s, the power of fan have a straight upward tendency.

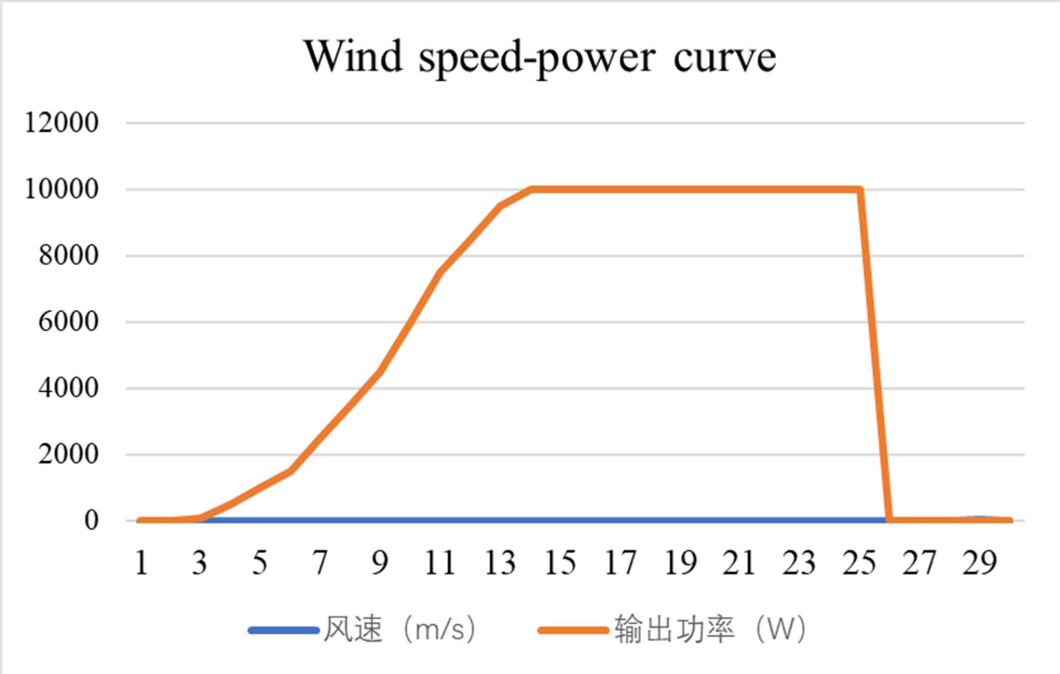


Figure 2- 39 Wind speed-power curve of a single 10kW variable pitch wind turbine

According to the wind velocity statistics on the proposed site for the whole year, theoretically, calculation of annual generating capacity of 100-kW wind generator systems is shown in Table 2-18. The annual wind power generation for the 100-kW system will up to 410040 kWh after operation, the estimated wind power generation will be 820080 kWh after operating for 5 years.

Table 2- 18 Daily, monthly and annual average power generation of a single 10kW variable pitch wind turbine

Month	Daily Average Power Generation (kWh）	Monthly Average Power Generation (kWh）
January	67	2074
February	114	3181
March	125	3868
April	144	4305
May	120	3712
June	143	4291
July	115	3555
August	97	3012
September	147	4419
October	107	3311
November	101	3039

Month	Daily Average Power Generation (kWh）	Monthly Average Power Generation (kWh）
December	72	2237

2.5.9.5 Hydrogen fuel storage power generation test system

The hydrogen storage fuel cell system has no pollution as a product, and there is no pollution in the process of hydrogen production-hydrogen storage-hydrogen use. It is an important direction for future international and domestic energy development. Therefore, this solution uses a 30kW hydrogen storage fuel cell to be used in extreme days. In the best case of wind and solar power generation, hydrogen is produced and stored. When the wind and solar power generation capacity declines during the polar night, hydrogen storage fuel cells can be used for power generation. As a way of energy storage, hydrogen storage fuel cell supplies power to independent scientific research equipment, and it can be expanded and upgraded according to the application situation in the future.

The Hydrogen Fuel Energy Storage and Power Generation Test System at the new station uses PEM electrolyzed water to produce hydrogen.

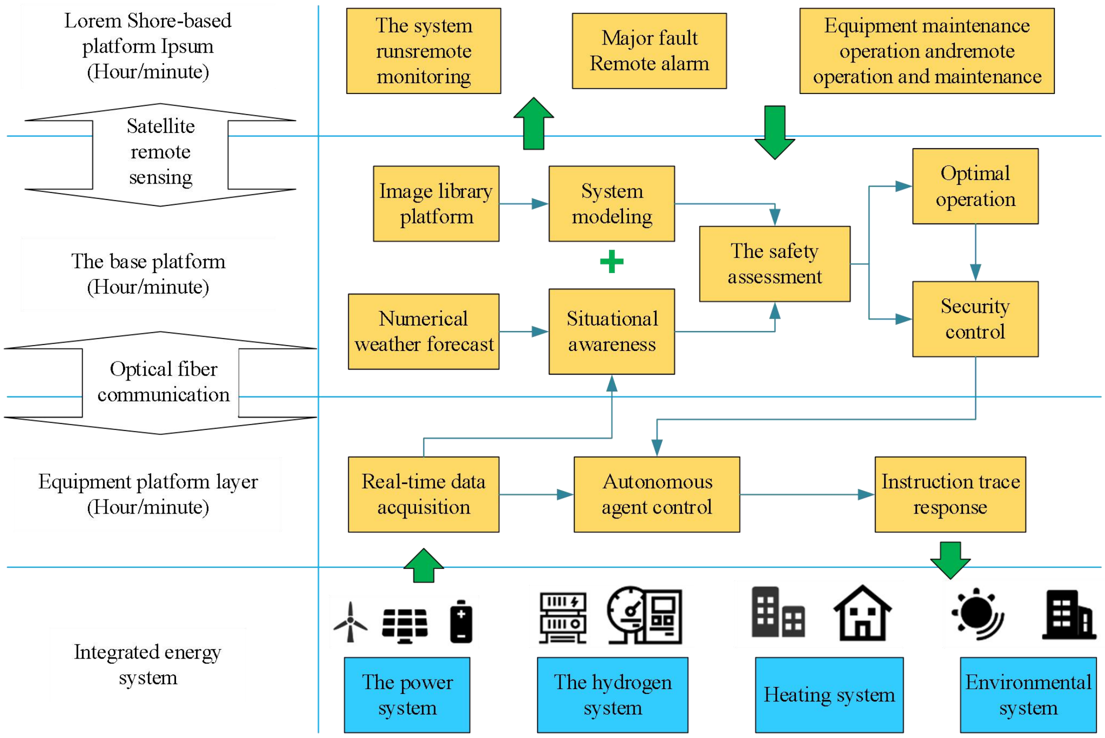


Figure 2- 40 Framework diagram of hydrogen production system

The hydrogen storage is planned to use metal hydrogen storage, that is, a metal hydrogen storage container with a hydrogen storage medium pressure of 4MPa, which can store 80kg of hydrogen, requires a total of 13 tanks, and runs for 60 days.

The single 30kw fuel cell power generation system to be used in this test system is integrated with the combined heat and power system. The heat generated by the electrolytic cell and the heat generated by the fuel cell are used in a comprehensive manner. The overall efficiency is more than 90%.

The fuel cell adopts the current international advanced water-cooled self-humidifying technology, which can be stored at -40° C and started at a low temperature of -30° C，power density ≥ 4.0kW/L; system power of 30kW fuel cell life is 10,000 hours; hydrogen in the hydrogen storage tank is decompressed and supplied to the 30kW hydrogen storage fuel cell for power generation, and DC/DC for load use.

Figure 2- 41 Schematic diagram of water electrolysis hydrogen production equipment

2.5.9.6 Micro-gas turbine test system

Since the solar photovoltaic power generation subsystem cannot work in winter, and the wind power generation system in winter faces problems such as excessive wind speed and brakes, in order to make up for the power supply gap of the new energy system, further improve the efficiency of diesel power generation, and further reduce the emission of air pollutants, it is proposed to be configured a 65KW micro-gas turbine, strives to achieve a power supply mode based on solar energy + wind energy + hydrogen energy + micro-gas turbine in summer, and wind energy + hydrogen energy + micro-gas turbine as the main power supply mode in winter, and diesel generators are supplemented throughout the year.

After extensive technical research, it is planned to select the C65 micro-gas turbine of Capstone Company. For related technical parameters, please refer to https://www.capstonepowersoutions.com/products/c65.

Figure 2- 42 Schematic diagram of Micro-gas turbine

2.5.9.7 Diesel power supply system

It is recommended that there will have 3 sets of diesel generators (300kW each) in the new station, one in operation, one at standby and one under maintenance. The 380V 50Hz AC output of the generator can serve the entire station when the renewable energy is not sufficient.

The number of the running generators is dependent on the consumption load and the efficiency of the renewable energy system. The centralized control and shift system will automatically adjust the generators to improve the efficiency and reliability.

2.5.9.8 Low-temperature lithium battery energy storage system

In combination with the needs of the smart microgrid system of the new station, the design goal of the energy storage battery system is to effectively realize demand-side management by introducing energy storage into the system, stabilize the volatility of new energy power generation, smooth the load, and make more effective utilization, reduce power supply costs, and promote the application of new energy.

The energy storage battery system is composed of battery packs and two-way energy storage inverters. The capacity of the energy storage battery of this project must be designed considering the daily photovoltaic power generation curve and load power consumption curve, power supply and load absorption capacity. For the inverter in this project, it is recommended to use a mature technology and a capacity of 300kW energy storage bidirectional inverter as the core of stable control of the microgrid.

The rated voltage of the energy storage battery system platform is 400V, the battery string parallel scheme is 170 strings, 21 parallel, the nominal voltage is 400V, and the total capacity is 300kWh.

The energy storage battery pack and supporting electronic control equipment are placed in the equipment room. The environmental requirements are mainly temperature. The ideal working temperature of the energy storage battery is not less than 0℃. There is no problem in using low-temperature lithium batteries in the Ross Sea area of Antarctica. The use of ordinary lithium batteries also requires the energy storage system to independently perform environmental control settings, and the storage temperature of the energy storage battery is not lower than -40℃. Even if no other measures are taken at the new station, the reliable use of the energy storage battery can be ensured. In addition, for the special requirements of the new energy system of the new station on salt spray corrosion and other characteristics, the battery pack can be designed to meet the requirements of salt spray corrosion resistance by treating the electrical column.

2.5.9.9 Emergency power supply system

Safety is the most important factor for each research stations in Antarctica. The emergency power supply system is necessary to ensure the survival during the accidents of the normal power supply system. The capacity of the emergency power supply system depends on the location of the station and the availability of rescue. In any case, it will be difficult during winter. So, the capacity of the emergency power supply system should cover all the necessary supply for living and communication of the over-winter personnel. The estimated emergency load will be around 60-80kW.

The hybrid Solar-Wind-Diesel power supply system is more reliable than the single power supply system when one of the power systems is damaged, the micro-grid system can shift to another available energy system automatically. The renewable power system is around 200m away from the station, so the probability of suffering damage together is limited. In case of the unstable of the wind power during winter, in order to protect the power distribution facilities in the power center, the diesel emergency power supply system will be prepared. In case of emergency, when the hybrid Solar-Wind-Diesel power supply system is abnormal, the emergency generator can supply electricity. Since the station load then will be up to 70kW, it is recommended that there will be 2 sets of 150kW generators to ensure the emergency power demand.

2.5.9.10 Power distribution system

A power distribution cabinet will be equipped in the power generation room. In addition, an emergency power distribution cabinet that switches to the emergency power source will be also equipped.

The output cable will be laid in a radiation way to various buildings along the bridges in the intercalated layer of the buildings. An overall power distribution box or power distribution cabinet will be equipped in each functional zone from which power is distributed to each electric equipment or systems. The lines inside the room that uses combustion-preventive or fire-preventive cables for safety will be arranged in the cable tray. The out-door cables can tolerate as low temperature as -90˚C for working and -50˚C for installation.

2.5.10 Lighting system

The lighting system consists of general room lighting, outdoor lighting and emergency lighting by functions. The indoor lighting source will consist of fluorescent lamps and LED lamps and the outdoor lighting source will consist of LED lamps (working temperature lower than -90˚C), more tolerant of low temperature. The emergency lamps equipped with individual batteries will be installed in the power distribution rooms, the key engine rooms, the stairs and the corridors. Emergency indicator lamps will be arranged in the evacuation route and the exits for safe evacuation.

2.5.11 Grounding and safety system

In consideration of the reliability of power supply, the power distribution system in the new station will adopt the mode of non-grounding of the neutral point. The safety measures will include the connection between the overall iso-electric potential and local iso-electric potential for balancing the potential and decreasing the contact voltage to bring the voltage below the safe value and prevent electric shock accidents. An insulation monitoring unit with warning function will be connected to the outlet of the general power distribution board, which will remind the manager of examination and repair by sending out warning signals. No neutral line or single-phase load will be allowed for the power distribution system and a 400/230V transformer and an RCD will be used for protection. Static electricity prevention measures (by static electricity prevention ground coiled material) will be used on the special electronic facilities. Special soft grounding cables buried under ice will be used as the grounding unit.

Grounding resistance: The grounding of the electric appliances will be made together with the grounding in the overall iso-electric potential combination in the station.

2.5.12 Automatic fire alarm system and fire-fighting linkage control system

The central alarming controller for a fire alarm that monitors the entire station area will be installed in the room with people on duty. Regional warning controllers are distributed inside the building base on needs. Fire alarming lines, linkage control lines, fire protection telephone lines and broadcasting lines are laid in steel tubes inside the wall. The circuits out of door are armored and laid along the supporters of the facilities.

The system leaves a remote terminal in advance by which the communication system may transmit important data and information.

The fire-fighting system has been fully considered which can cover the whole station in the design. The “Prevention First” principle will be followed and the research staff will be educated. Fire prevention has been taken full into account in the design, choice of building layout and corridors. The buildings are separated by the fire-proof doors.

Fire-proof, thermal insulation materials are used as in the main structure and the building interiors. As for the functional layout of the station area, there are adequate fire extinguishers in the storeroom. The critical areas or facilities are equipped with fire-fighting devices and facilities separately. The diesel generator room is equipped with carbon dioxide fire extinguishers and other locations with a mono ammonium phosphate dry-chemical fire extinguisher.

2.5.13 Monitoring and control system for facilities installed

The monitoring and control center for facilities installed is set up in the building of power generators.

The monitoring and control system will monitor and control the boiler system, ventilation system, water supply and drainage system, indoor and outdoor lighting system and power distribution system in the station for energy-saving operation and intelligent management.

The monitoring and control cables will be deployed openly in the wire through on the wall inside the generator room and the out-door trunk cable are armored and will be deployed along the supporters of the facilities.

The system leaves a remote communication terminal in advance by which the communication system can transmit important data and information.

2.5.14 Communication and information system

Considering its remote location and harsh environmental conditions, it is imperative to build up a reliable telecommunication system. There will be three remote communication centers distributed on the Inexpressible Island supported by the renewable energy except for the centralized communication center in the new station as shown in Figure 2-37.

The maintenance of no interruption of the telecommunication system, in any case, will be a major issue to be considered in the design of the communication system. Therefore, the system design considers not only the preparation of the duplicate equipment for that between different and in the same communication systems but also the distribution of the location of the communication equipment. The construction of the communication and information system will include radio telecommunication system, local computer network, telephone auto-exchanger system inside the station, radio communication system inside the station, remote tracking and management system for the transport vehicles, aircraft radio communication system and the software application system.

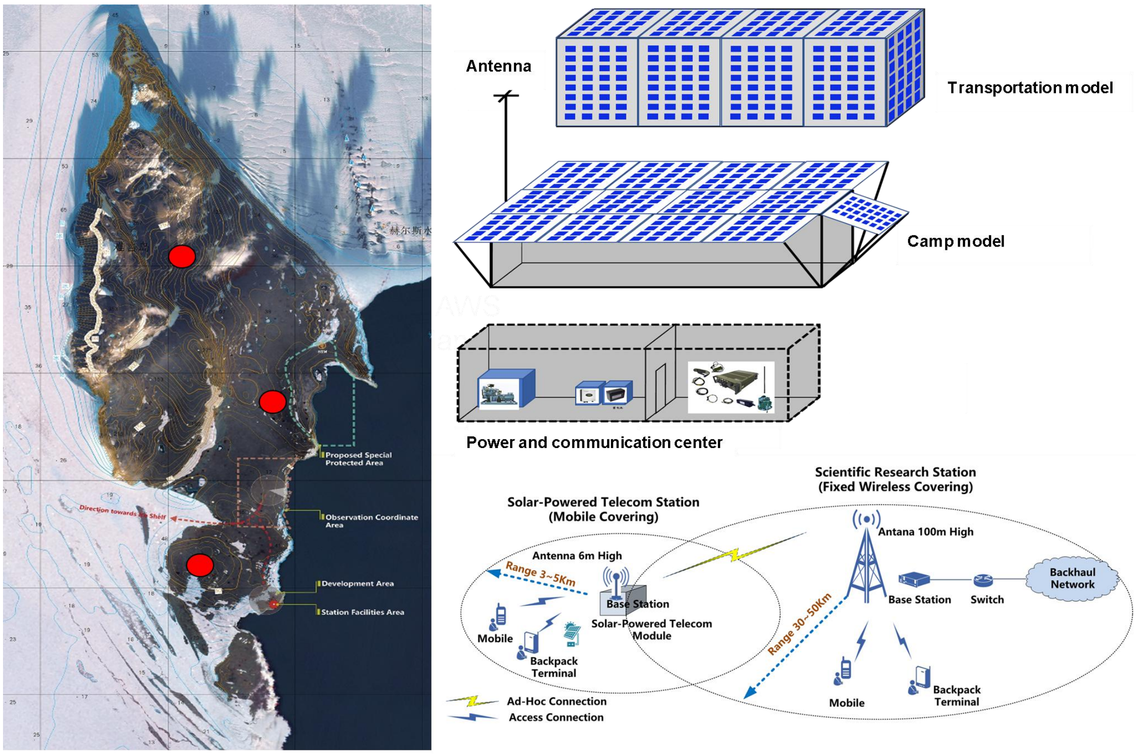


Figure 2- 43 Distributed solar powered Telecom station on the Inexpressible Island

2.5.15 Integrated thermal management system

Generator cooling water is used for hot water heating， steam is used for sewage treatment facility and flue gas pipe insulation, phase change thermal storage system as shown in Figure 2-38 is used for water supply, and air heat pump technology is used to enhance the fresh air temperature and lower the emission air temperature.

The patent technology possessed by Tongji University will be used. The main substance is the eutectic salt of non-toxic Sodium chloride and calcium chloride which is also non-toxic and the melting point is 494 degrees. It can help the device of heat conservation reach over 500 degrees, while the phase change materials will not resolve, thus making it easier to accumulate heat under circumstances of high temperature.

In order to minimize the heat loss and energy consumption, try to keep the external transfer pipelines above freezing point, and reduce the temperature difference between inside and outside of the pipelines, reduce the length of outside pipelines and try to install pipelines within the building and the corridor.

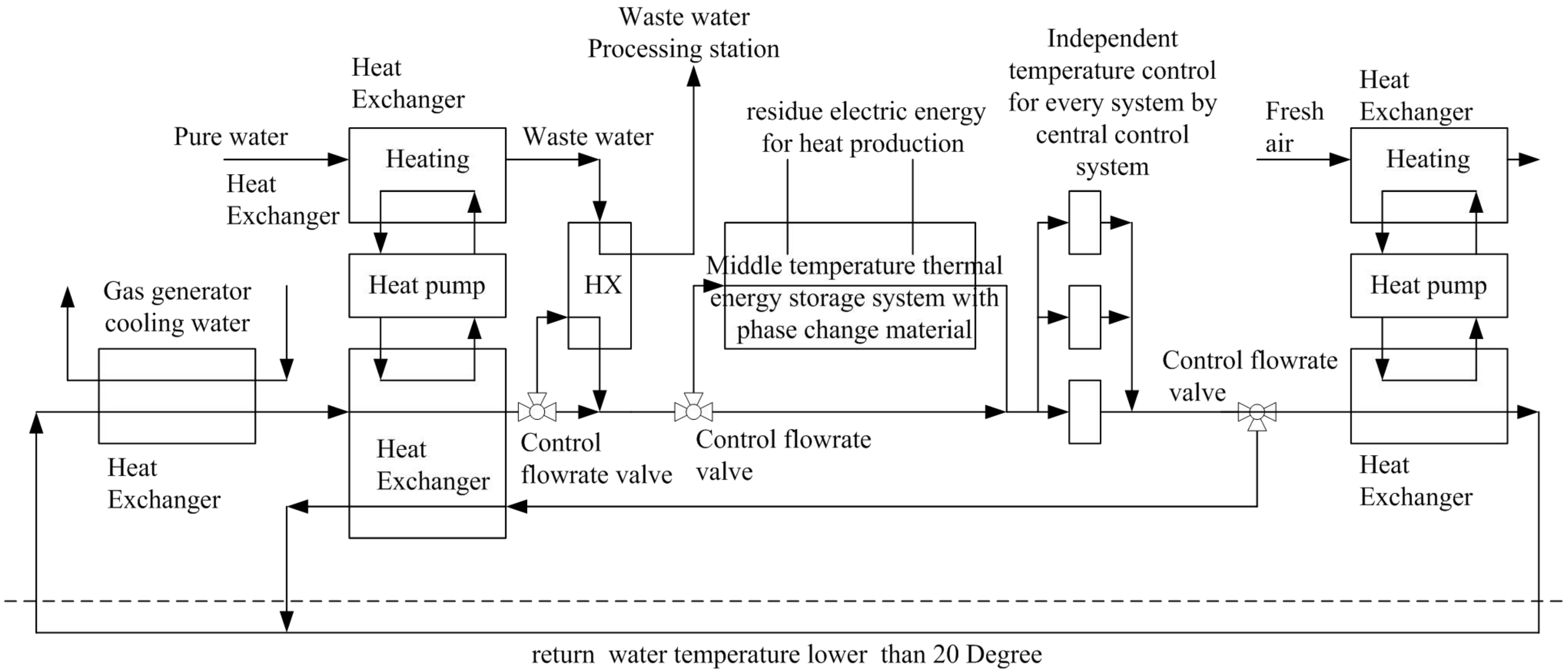


Figure 2- 44 Diagram of thermal control system

2.5.15.1 Thermal source

Thermal sources of the new station include windmills, solar thermal exchanger, generator residue heat and boiler. Windmill and solar photovoltaic power generation will be the primary thermal source for the new station. The sufficient wind power will be able to change to thermal source and be stored. There are 3 sets of 300kW generators in the station. At the same time, the cooling water of the generator can provide 60kW of heat, which can also be used to circulate water of the heating system and the domestic hot water. Altogether, when the generator is working normally, residue heat that can be recovered is about 60kW. The station can use residue heat to satisfy its heating demand without the boiler when domestic water demand is at its peak and the boiler will be started as supplementary.

2.5.15.2 Thermal storage system

Medium temperature phase change thermal storage devices will be suggested to store the heat from the high-grade redundant power generation, the theoretical maximum storage temperature is up to 400℃ as shown in Figure 2-39. Comparing to the water storage system, the volume of the phase change thermal storage devices is reduced significantly and the leakage problem is also prohibited. The module phase change thermal storage devices will be equipped with electric heating pipe and heat exchanger to make the water hot. The system design and prototype machine of phase change thermal storage devices are shown in Figure 2-40. Using air as heat transfer fluid can improve and ensure the safety of the high-temperature thermal energy storage system.

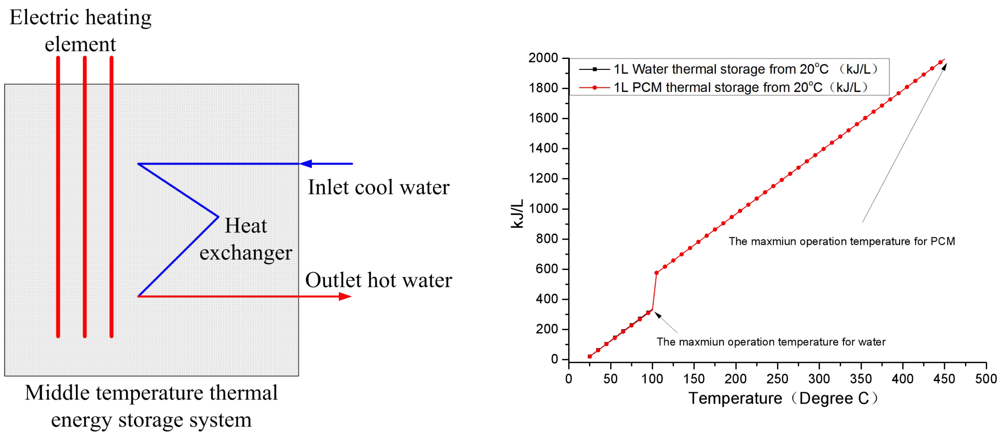


Figure 2- 45 Schematic diagram of middle-temperature thermal energy storage system with PCM

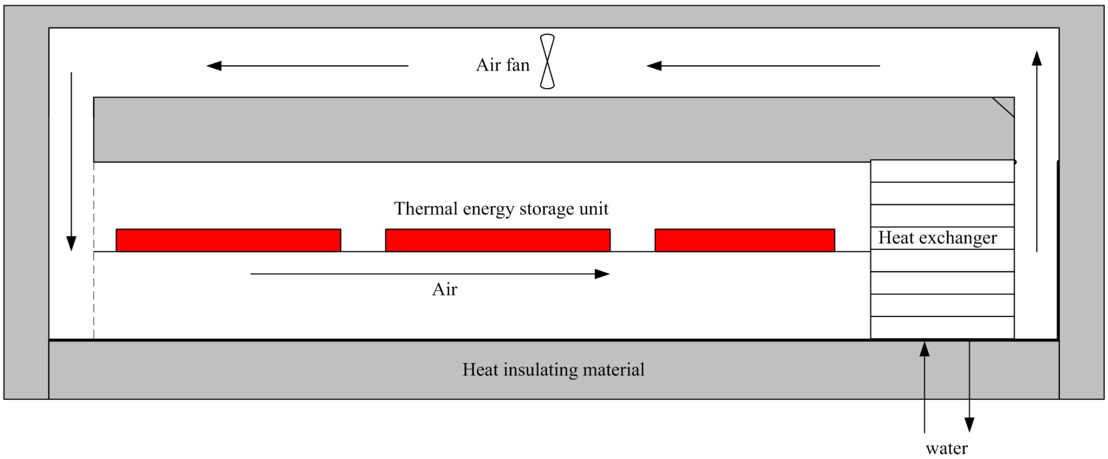


Figure 2- 46 System design and prototype machine of phase change thermal storage devices

2.5.15.3 Heating system for buildings

1. Centralized buildings

The centralized buildings including the accommodation, office, living rooms, scientific observation, and communication etc., the circulated heating water system will be used. Both of automatic centralized control system and manual control system will be applied to adjust the temperature inside different functional areas. Phase change thermal storage floor will be used for all the buildings as shown in Figure 2-41.

2. Decentralized buildings

The garage, storehouse, and other decentralized buildings are far from the heat sources, the electronic radiator will be applied to reduce the heat loss of long-distance transmission. Most of the electricity will come from the renewable windmills and photovoltage cell plates, and the phase change thermal storage floor will preserve the heat better.

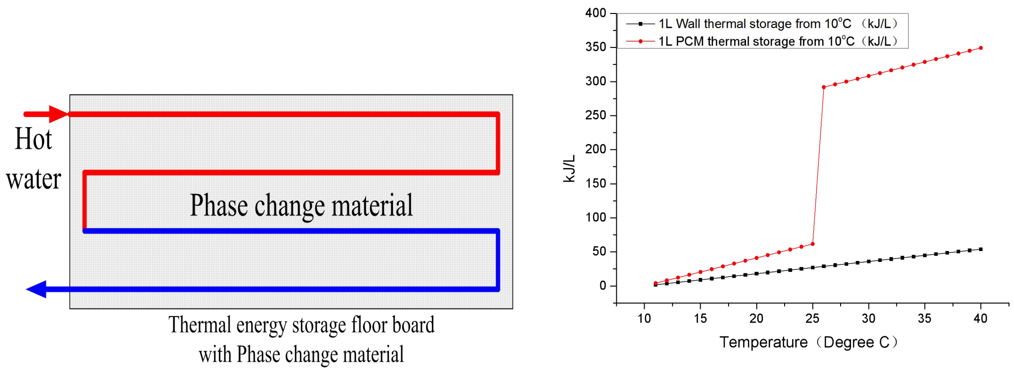


Figure 2- 47 Schematic diagram of thermal energy storage system with PCM

2.5.15.4 Ventilation and fresh air heating system

The ventilation system includes fresh-air handling unit and heat recovery unit. Fresh air from outdoor will transfer heat with the discharged air (around 20 ℃) in the heat recovery system, and then be further heated and humidified to around 40℃ before it is sent indoor, while the cooled air will be discharged.

Considering the low temperature in the proposed site, the energy consumption of the heating for the fresh air before entering the rooms is high. A vacuum tube solar air heating system as shown in Figure 2-42 is proposed to preheat the fresh air during summer, it is an effective supplement to the wind power and the efficiency is higher than the photovoltaic systems.

The centralized buildings will have two separated fresh air ventilation system, one is for accommodation area and the other is for scientific activities.

There will be process ventilation system in the logistics module and complex storage, to satisfy ventilation and safety demand of the powerhouse, boiler house, pump house and the switch house.

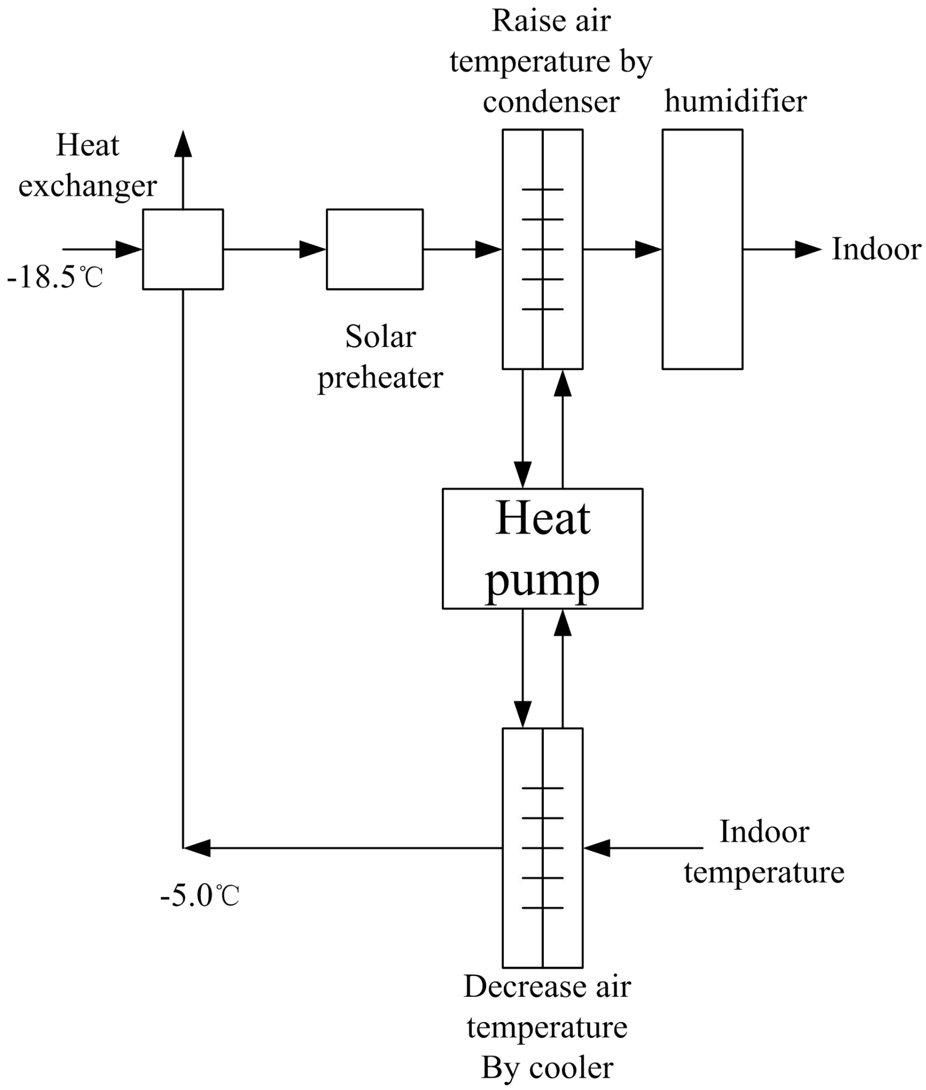


Figure 2- 48 Schematic diagram of fresh air preheating system

2.5.16 Structure and foundation

2.5.16.1 Structural design and construction

Owing to the restrictions of construction conditions, climate and working time window, the design adopts precast concrete structures and steel structures to minimize concrete dosage and pouring volume of the site.

The main building of the proposed station is self-contained with a steel frame structure. The steel structure is entirely supported on a precast reinforced concrete platform independently. The anti-pull rock bolt is installed under the platform to resist the action of wind load. At its design stage, the main building of the new station is properly raised and combined with the flow lines of the building body in order to obtain a good wind-resistant body type and reduce the impact of wind pressure effectively.

The floor, cap and part of the accessible roof are made of the reinforced concrete prefabricated structure. The non-accessible roof and the rest of the retaining system are made of light metal cladding system.

In addition to some key nodes and irregular parts using cast-in-place concrete, the rest are precast reinforced concrete or field assembly steel structure.

Precast concrete parts and steel structure are processed at home or purchased in New Zealand, then transported to the construction site through the research vessels. Building sand and gravel can be processed on site. Among them, coarse sand can be obtained directly from the relatively thick section of loose stony soil on the west side of the site by sieving, and gravel, melon or other different sizes of gravel stones can be obtained by crushing boulder through small crusher or selected on the west side of the proposed site to reduce the number of the vessel shipments. Drilling equipment has installed a dust-proof system to minimize the flow of rock dust into the environment.

Increase the steel support diagonal of the wind turbine steel structure without affecting the operation of the wind turbine.

2.5.16.2 Geological characteristics of the proposed site

Overall, the terrain of the proposed site is high in the east and low in the west, high in north and south while low in the middle. The landform type of which is modern marine accumulation and glacial till accumulation. The standard terrain elevation in the scale of the proposed site is about 6m-30m, the emergence stratums are of the quaternary system which has glacial till accumulation and modern marine accumulation and granite stratum formed in Silurian, middle Paleozoic during Caledonian.

The reference to engineering geological exploration is limited in the proposed site, and the detailed investigation has been carried out during the 30th CHINARE in January 2014 and 31st

CHINARE in January 2015. Combined with previous experience in the Antarctic projects, considering the minimization of on-site construction works and environmental impact, relatively flat areas for the proposed site was chosen after careful consideration. No ground leveling is needed for elevated structure and minimum leveling will be carried out in situ for other buildings.

In January of 2014 and 2015, geological prospect was carried out in the proposed site and got the valuable data as shown in Figure 2-43, the site is hilly and the bedrock surface is exposed or shallow, situ reinforced concrete pier foundation with rock anchorage can be used directly on the bedrock. At present China plans to draw on the experience of the construction of Zhongshan Station. Buildings, turbines, and other supporting facilities will adopt the rock anchorage technology which has minimum impacts on the present environment.

Intrusive rock stratum in Silurian, middle Paleozoic during Caledonian: was mainly formed of intrusive magmatic rock such as granite and can be divided into two kinds: fine-grained granite and coarse-grained granite, distributed throughout the proposed site. Coarse-grained granite was the main rock kind, which accounts for 80-90% of the whole, and the fine-grained granite intruded in it like the head of dukes, with the width of 5cm-10cm differently. The investigation this time failed to drill through the stratum, so its thickness remains to be unknown. A representative of the drilled core is shown in the following figure.

Figure 2- 49 Geological characteristics investigation of the proposed site in December 2014

The Stone drift stratum and the weathered granite stratum of the site can be used as the natural ground-holding stratum of the proposed road. The main structure part is recommended to use the weathered granite as the basic holding stratum.

Based on the results of surface geological and engineering survey, the most representative float stone soil and granite on the Inexpressible Island was chosen to test the various types of rock property parameters. It mainly consists of natural density γ (KN/m3), the characteristic value of bearing capacity fak (kPa) and fa (kPa), modulus of compression Es (Mpa) and modulus of deformation E0 (Mpa). The results showed that the bearing capacity is high for the bedrock on Inexpressible Island as shown in Table 2-17.

Table 2- 19 Main parameters obtained from the on-site geological investigation

Name of the geotechnical	Rate of decay	Natural density	Characteristic value of bearing capacity	Modulus of deformation	Modulus of compression
		γ（kN/m^3）	f_{ak} (f_a)(kPa)	E_0 (MPa)	E_s (MPa)
Boulders soil	medium density	23.50	500	35.0	18.0
Fine-grained granite	Central weathered	25.40	10000		incompressible stratum
Coarse-grained granite	Central weathered	25.84	6000		incompressible stratum
Monzonite	Central weathered	26.79	13000		incompressible stratum

2.5.16.3 Anchor bolt steel foundation

The proposed facilities are integrated with the medium weathered granite through the rock bolt, which can be used as an uplifting load against wind uplift load. Rock bolt design parameters are shown in the table below.

Anchor bolt steel foundation is selected in design to overcome the disadvantages of the traditional foundation. It uses prefabricated steel foundation instead of reinforced concrete, which can save its self-weight dramatically and be installed easily. As shown in Figure 2-44, the foundation is constituted by a steel box instead of the concrete foundation. The pre-stress anchor bolt is used in this type of foundation to decrease the bottom area of the foundation. As the result, the execution volume is significantly decreased in anchor bolt foundation comparing to that of traditional foundation.

To apply the anchor bolts, the special expending drill is used to make the expending foot at the end of the hole. This aiguille needs to drill a 0.7m depth's expending hole on the bottom of the normal hole. Percussion drilling machine will be compatible with this kind of aiguille, which is easily executed and transported to the site.

After drilling the expending hole, the rhombus expanding anchor bolts should be put into the expanding hole to let it develop automatically. Then use grouting to connect the rhombus expending feet and rock hole. Finally, pre-stress on the top of the anchor bolts after the concrete meets the strength.

The geological survey data from the latest investigation will be considered to determine the final plan. And the ability to pull anti-fan units and wind loads is fully considered. Expanding head bolt technology will be adopted, and the expected drilling depth is 2 ~ 3m, and currently, the technology has been widely used in installing multiple units of MW of large wind turbine equipment to withstand several extreme events including the strong katabatic wind.

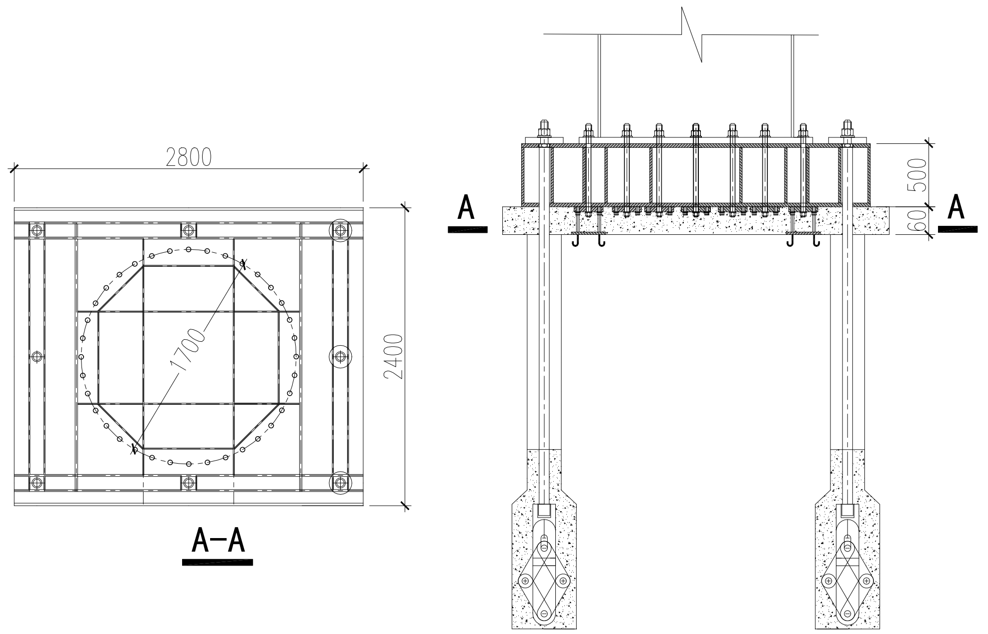


Figure 2- 50 Rock anchor bolt foundation sketch (Unit: mm)

2.5.17 Emergency facilities

To guarantee human life and living safety, the new station will construct emergency facilities, which consist of emergency power generation cabin, emergency accommodation cabin, emergency living cabin, life vests, tents and other emergency facilities.

The maximum personnel size in winter is 30 people, including the scientific research personnel and the logistic support personnel. According to this figure, we designed maximum capacity of the emergency facilities.

The maximum personnel size in summer is 80 people, including the scientific research personnel, the logistic support personnel, and the possible foreign visitors. In summer, it can be relied on Xuelong vessel and the local international aviation network to carry out the emergency rescue.

In order to further reduce the environmental impacts, the emergency facilities are equipped according to the maximum personnel size in winter.

We will further the consultation with other countries, build a joint emergency rescue system, and share the logistic support facilities, thus to guarantee the security of the people and reduce the cumulative environmental impacts to the greatest extent.

Their specification and quantity are described in Tab 2-20.

Table 2- 20 Description of emergency construction

No.	Item	Description	Remarks
1	Emergency power generation cabin	1 container	80kW, 2 sets
2	Emergency accommodation cabin	4 containers	30 people, each for 8 people
3	Emergency living cabin	1 container	Cooking and communication
4	Emergency storage	2container s	30 people, foods etc.
5	Emergency freeze storage	2container s	30 people, foods etc.
6	Life vests	30 sets	30 people
7	Tents	15 sets	2 people in each
8	Other emergency facilities	1 container	30 people, Snow sticks, bags, ropes, walky-talkies

2.5.18 Special types of machinery

The machinery and vehicles in the proposed station will be mainly used for the construction project, construction maintenance and repair, loading and unloading operation, clearance of road surface and accumulated snow, haunting and lifting operations and materials transport, etc. The transport vehicles are used inside the station or for short-distance transport in the field.

1) Environmental requirements for special machinery and transport vehicles

Firstly, the storage batteries, starters, hydraulic, oil lines and electricity systems for special machinery and vehicles should tolerate low temperature and meet the operating requirements in the proposed site. For these facilities, electricity or boiler pre-warming systems will be installed to guarantee the normal starting. Secondly, as the annual average wind velocity is 12m/s in the proposed region, the particularly selected machinery should have excellent properties of sealing and heat insulation, and be easy to remove effectively accumulated snow from them. Thirdly, the low oxygen concentration maybe happen in the proposed investigated region on the glacier or mountains around the new station will cause lower combustion and dynamic of the vehicles and machinery. Therefore, these challenges have been taken into consideration in the selection of the vehicles. At the same time, measures should be adopted to control the hydraulic oil overflowing and anti-freeze liquid under lower atmospheric pressure.

2) Selection and composition of special machinery and vehicles for the construction project

In consideration of the mission of the station and the composition of machineries and vehicles in other stations, the new station will be equipped with one light snow vehicle, one caterpillar carrier and five snow motor vans, among which the light snow vehicle will be used for the clearance of road surface and accumulated snow as well as the handling of small articles inside the station, the caterpillar will be used for construction engineering, piling of materials and snow removal and melting and the snow motor vans will be used for the transport of small articles between buildings as shown in Tab 2-19.

Table 2- 21 Construction vehicles and special machinery

Items	Number	Weight (ton/per)
25-ton Crane	1	18.8
50-ton Crane	1	24.4
Excavator	2	47.2
Loader	3	12.6
compactor	1	1.2
concrete-mixer	2	3.6
Light snow vehicle	1	5.7
caterpillar	1	22.6
all-terrain vehicle	2	1.6
Self-acting truck	1	12.3
Tracked trailer	1	23

2.5.19 Wharf design and operation

During the construction and operation period of the new station, many materials, equipment, supplies and other goods need to be shipped from China and unloaded to designated areas. Considering the limited water depth, small motorized barges will be used to transport the goods from Xuelong to the wharf, after which the goods will be lifted on the wharf to the land.

（1）Proposed location of the wharf

The southern part of the Inexpressible Island is a small bay with small water depth. It is covered with pebbles and the boat is difficult to enter. Therefore, the northern region of the gulf is selected as the wharf construction area. The area is a rocky coast with twists and turns. According to the coastal topography and hydrological conditions in the south of the Inexpressible Island as shown in Figure 2-44, the construction site of the new station is in the northern area of the South Bay, see the location of the new station.

The area is directly exposed to the Terra Nova Bay and is susceptible to the waves with a maximum tidal range less than 1.0 meter based on the on-site investigation during December 28th, 2014 to January 5th, 2015 as shown in Figure 2-45.

The tide survey data from January 3th to February 15th, 2020 are sampled according to the tidal changes every hour. During the observation period, the overall tidal range of the coastal waters is maintained between 80cm-90cm, as shown in Figure 2-46.

China carried out shore water depth surveys in 2014 and 2017 respectively. The water depth (as shown in Figure 2-47) of the shore meets the requirements of the Yellow River Tugboats and the Yangtze River Barge, and is near to the new station construction area, making it easy to build roads.

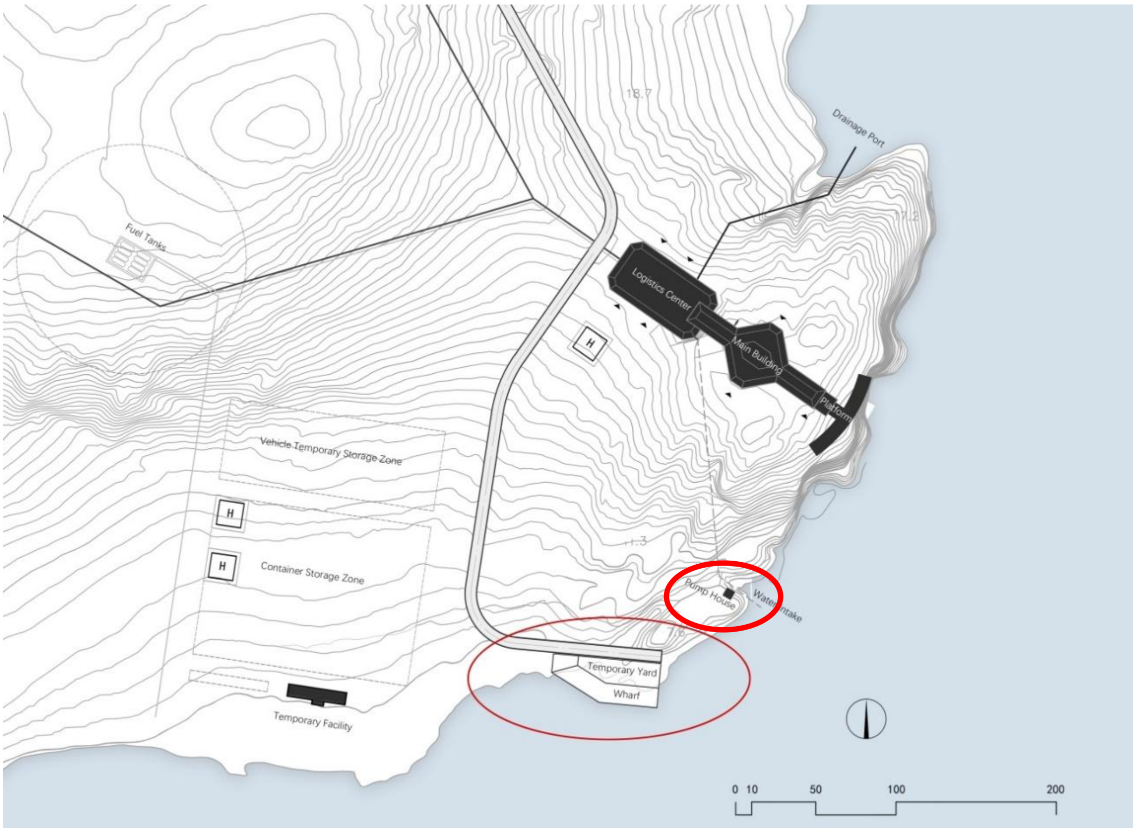


Figure 2- 51 Proposed location of the wharf

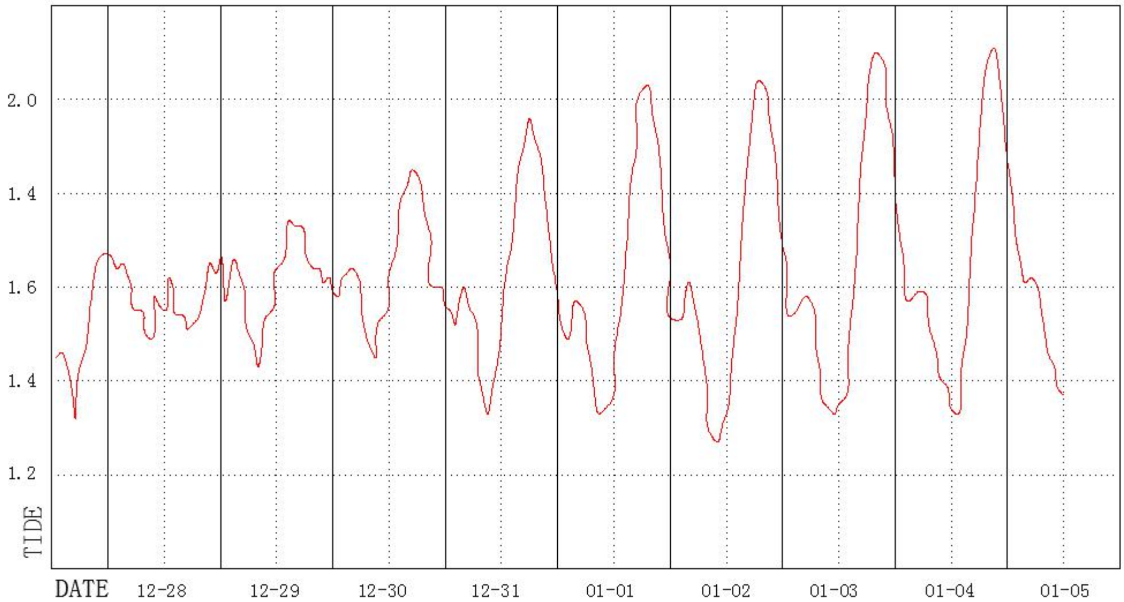


Figure 2- 52 Estimation of the tide in the proposed area during Dec 28th, 2014 to Jan 5th, 2015

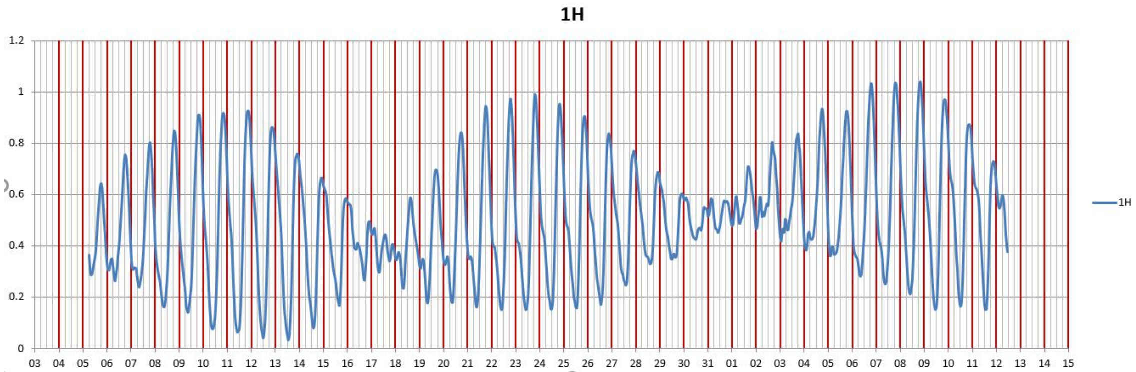


Figure 2- 53 Estimated tides in the proposed area from January 3th to February 15th, 2020

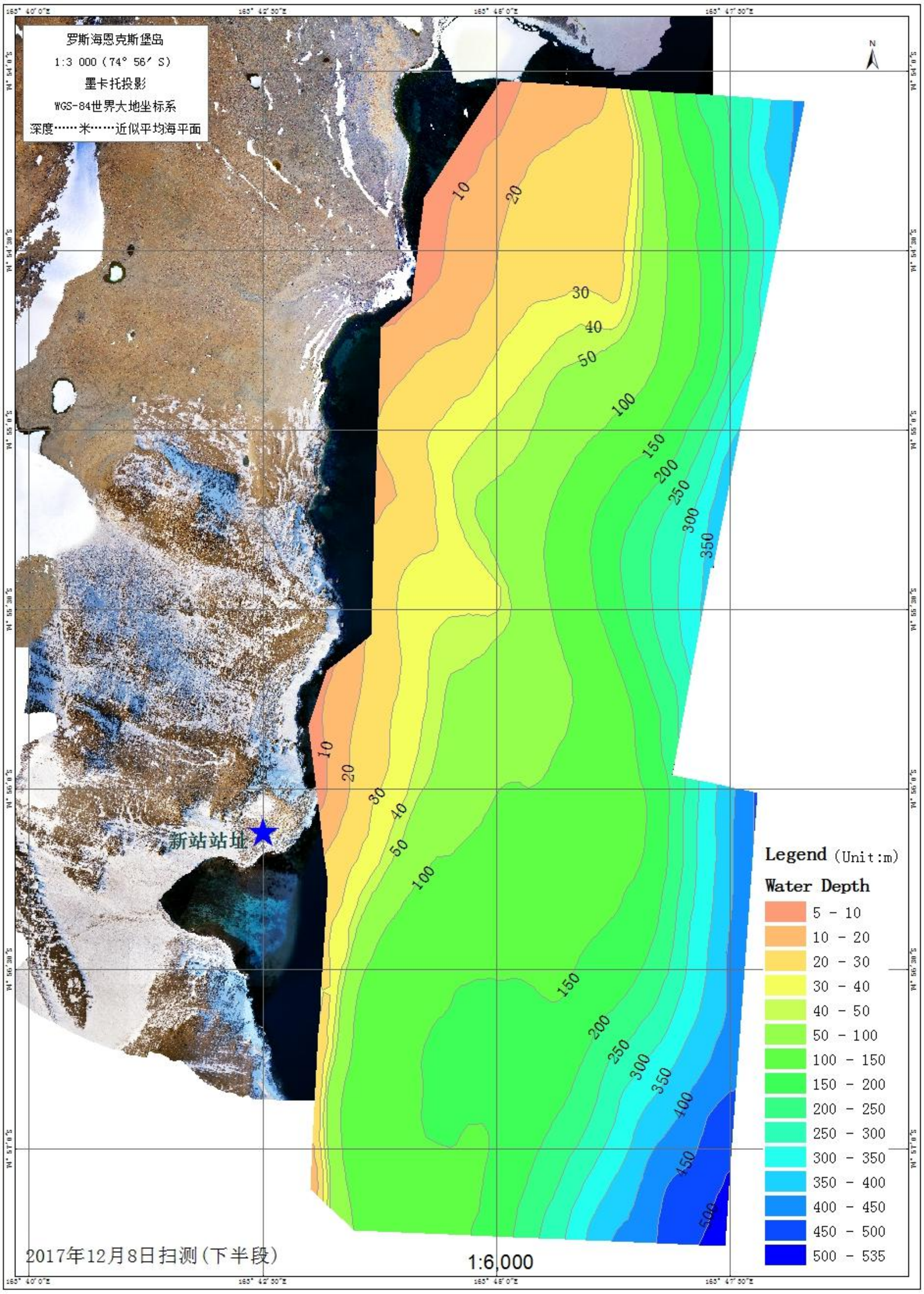


Figure 2- 54 Nearshore water depth investigation (CHINARE 2014 and 2017)

（2）Function and technical design parameters of the wharf

The new station is mainly used for berthing the Yellow River tugboat, the Yangtze River barge, lifting crane containers and pieces of miscellaneous materials, discharging all kinds of vehicles, wharfyard can be temporarily stacked cargo.

The new wharf area contains wharf, portable crane， storage yard and access road and so on as shown in Figure 2-48. Both crawling crane and crane truck can be chosen to be a portable crane. Storage yard consists of the bottom rock-filled structure and grille rock-filled road surface. The access road relates to wharf surface and roads of the station area and can be used for going through and transportation.

Due to the existence of reef in the water of the wharf construction area, the wharf was designed to avoid influencing the long-time berthing. The inner length of the wharf is about 36.7m， the outer length is about 35m, the width is about 12m, all can let the ship berth. There is a ramp outside the wharf for the ship to going alongside against the Yangtze River barge and roll loading and unloading goods.

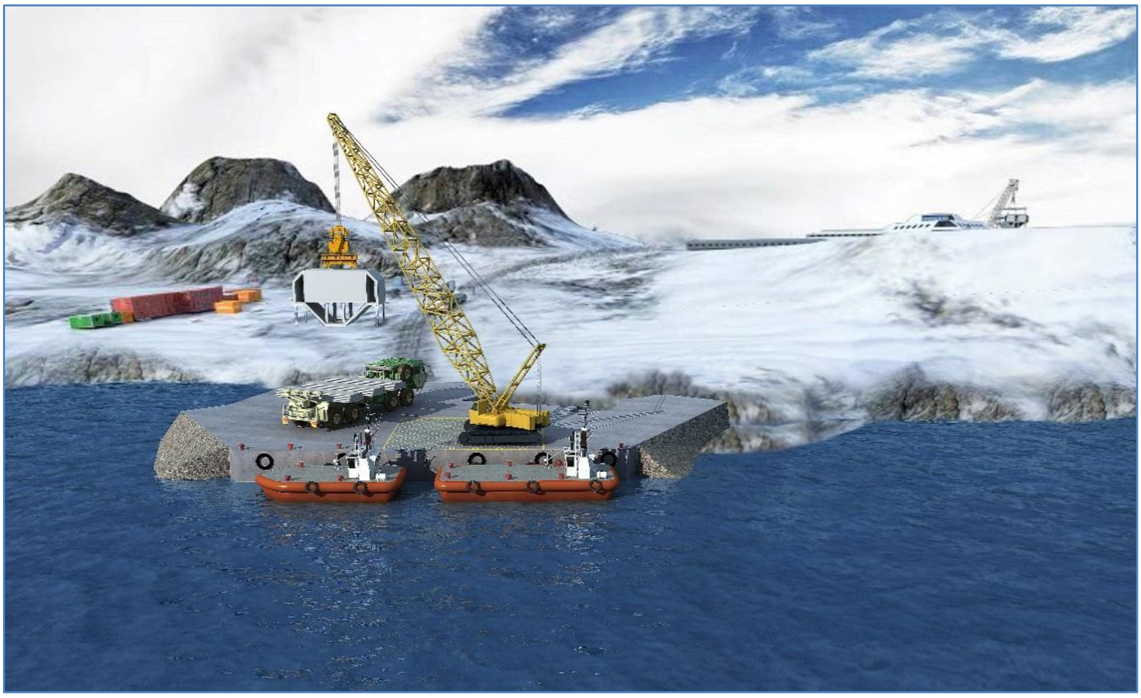


Figure 2- 55 Effect graphic of the proposed wharf area

（3）Supporting structure design of the wharf

The bottom of wharf and storage yard is rock-filled structure, which is mainly piled up by gabion and partly by macadam. This structure is featured by using raw materials locally and only the gabion box needs to be made in advance. The gabion has good stability and impact resistance to wave.

The surface of wharf uses steel structure, supported by the steel caisson, enabling the vehicle traffic. The mobile crane can also be set to load and unload containers, goods, and materials. The outside ramp can roll upload goods from vehicles as shown in Figure 2-48. The steel caisson supports wharf structure.

The construction process is shown in Figure 2-49.

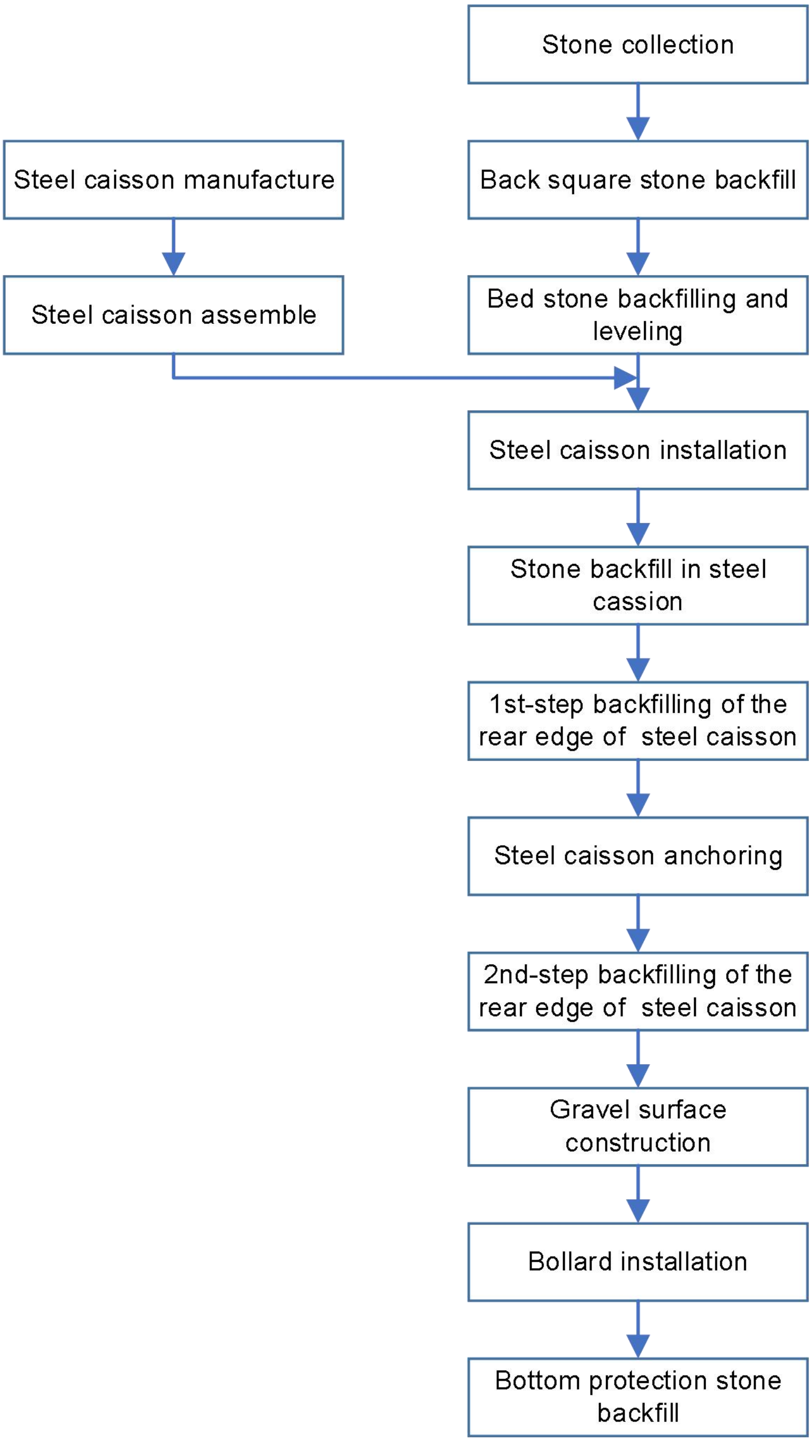


Figure 2- 56 Consutruiction process of the wharf area

The yard pavement adopts grille stone pavement. The grille is made of canvas. After unfolding, it can form a series of grid cells. The grid room is filled with graded gravel to carry heavy vehicles and cargoes.

（4）Construction approaches of the wharf

The construction plan of the new station has fully considered the topographic and environmental characteristics of the construction area. This plan meets the requirements of vehicle loading and cargo storage during loading and unloading as well as the ocean wave impact.

The structural design of the wharf takes full advantage of the favorable conditions of the local quantities of pebbles and gravels to obtain the materials locally and requires fewer prefabricated components and parts, including the wharf structure, steel caisson, gabion net and canvas grille.

（5）Rock filling

Use local stones to fill in the prefabricate gabion cage nets and orderly stack them in the outer edge of the steel wharf. For the gaps between other area under the wharf and gabion nets, pebbles and graded crushed rock will be used to fill in. This construction method has advantages of good stability, resistance to sea waves and can improve safety and reliability of the wharf greatly. After the Rock filling operation is finished, a steel surface will be paved to ensure goods and vehicles land smoothly.

After the completion of steel wharf Rock filling operation, and graded crushed rock will be used to fill in the cargo yard area, and then grid type pavement will be laid in the cargo yard area to ensure the road surface is flat and level.

The total amount of earth and rock required is approximately 1930 m^3.

2.5.20 Test and acceptance

Test and acceptance of the prefabricated buildings will be made one by one in accordance with the performance in the design. The major buildings of the new station will be pre-assembled and comprehensively tested in China first. In addition, the test will be made on some key systems such as the power generation system, solar energy photovoltaic system, wind power system and sewage treatment system to ensure their designed function and reliability.

After passing the test, these buildings were demolished and packed into ISO standard containers for transportation. During normal transportation, the building materials will not be damaged. After the packing is completed, the container can be directly transported.

2.5.21 Transportation during construction period

Once the test is finished, the buildings will be dismantled and packed for shipping in ISO-norm containers. No damage is ensured to the building materials during normal shipping. After the installation and internal of containers are completed, then the containers can be transported directly.

During the construction period, on the way to the proposed scientific investigation site, foods for the staff will be mainly aviation food that is ready once heated. The packing articles are compressed and stored.

The vehicles will also bring with it a packet free of water toilet and all the human excretions will be packed and brought back. The vehicles will bring with it a small solar energy boiler for melting snow and heating water by solar energy for daily brushing and washing. At present, the solar energy water boiler has been on trial in the inland Antarctic.

2.5.22 Engineering work in situ

In consideration of the extreme geographical and climatic conditions, especially the low temperature and strong wind at proposed site as well as to reduce the environmental impact to a minimum, the construction will be done mainly by assembling prefabricated containers in the field to reduce as much workload as possible.

The solar-wind energy power generation system will be built up with the battery boards prefabricated at home and by assembling them in situ. The parts relate to plug-pull connectors before the shipping. This way of design will not only be convenient to the installation but also reduce the risks of electric shock against the expeditioners in the field.

2.5.23 Upgradeability

The new station is designed to have a minimum lifetime of 25 years. The design has taken into full consideration its upgradeability, such as the routine facilities (including kitchen, sanitary facilities, and offices) and emergency shelters. According to the advanced design concept, the new station will be suitable for accommodating more people. For the supply of energy to the station, the issues of keeping sustainable power and heat supply have been considered. Therefore, it will be easy to use new technologies in the future, to reduce the fuel consumption and pollutant emission.

2.5.24 Archive management

To manage the new station more properly, relevant data and documents will be recorded and preserved, which include users' manuals, maintenance manuals, assembly drawings and instructions, spare part lists and emergency procedures. Two sets of backup data will be available for the filing in the new station and the domestic management platform for guaranteeing the exchange of ideas and solving technical problems.

2.5.25 Dismantle of the new station

The design of the new station will take environmental protection, safety, energy saving and the economy as the principles. It will use as much as possible the sustainable and high energy efficiency technology as well as the renewable energy to reduce the waste to the maximum extent. Once the new station must be closed due to technical reasons or other requirements, the station will be easily dismantled, disassembled and removed.

For the main buildings above the ground, we will remove all, and ship them back to China.

Some research facilities such as automatic weather stations will be left for the region to provide long-term observation data. So, the GPS anchor point, gravimeter and mapping datum, locus of control and others will be set. Underground rock anchorage is not obvious ground targets. We believe that there is feasible environmental technology to remove them in 25 years. But there is uncertainty. According to the relevant provisions of the Environmental Protocol to the Antarctic Treaty, after the 25-year operation and before dismantling, the environmental impact report will be submitted, and a series of measures such as field recovery will be included in this report.

2.5.26 Objectives of minimum environmental impact

2.5.26.1 Design criteria

- The estimated maximum computational load is 185kW in summer and 210 kW in winter, excluding a few scientific equipment and support vehicles. The new station is designed to use the hybrid Solar-Wind- Hydrogen -Diesel system during the process of operation. For long-term objectives, the solar energy, wind power and hydrogen energy will provide most of the power for the whole station and the diesel will only be used in emergency situations.
- An experiment on photovoltaic solar energy and wind power for heating and storage by phase change-thermal storage system will be conducted in 3-5 years.
- Research on hydrogen fuel power generation technology and micro-combustion engine power generation technology will be supported in 3-5 years.
- The new station will use as much recycled water and solid waste as possible, minimize the disposal of solid wastes and discharge treated wastewater up to the standards.
- The new station has been designed to guarantee to keep the environmental impact to a minimum degree during the construction, operation and dismantling

2.5.26.2 Construction and operation principles

The principles of construction, operation and dismantle must meet the requirements of the Protocol on Environmental Protection to the Antarctic Treaty and follow the relevant Chinese domestic laws and regulations.

The management of construction, operation and dismantling of the new station will be under the Framework of the Environmental Management Plan. During all stages including construction, operation and dismantling, it has been planned to minimize health and safety risks. The training courses and necessary protection equipment will be provided for all personnel involved to reduce the likelihood of major health or safety incidents. The construction team will be managed by PRIC. The key-construction team has already been involved in the pre-construction in Shanghai in order to become acquainted with the construction of the station. Expeditioners and constructors will be briefed by the staff of PRIC prior to their departure for Antarctica to ensure that they understand and fully comply with the relevant provisions of the Protocol on Environmental Protection to the Antarctic Treaty and its Annexes and related domestic laws. Environment officers will also be appointed to practice and monitor the environmental protection in situ.

2.6 Area of disturbance

2.6.1 Operation area

The area of disturbance includes construction site, material storing area, the route between the Xuelong and the new station and the area around the new station, the total operation area is limited to 0.10 km^2.

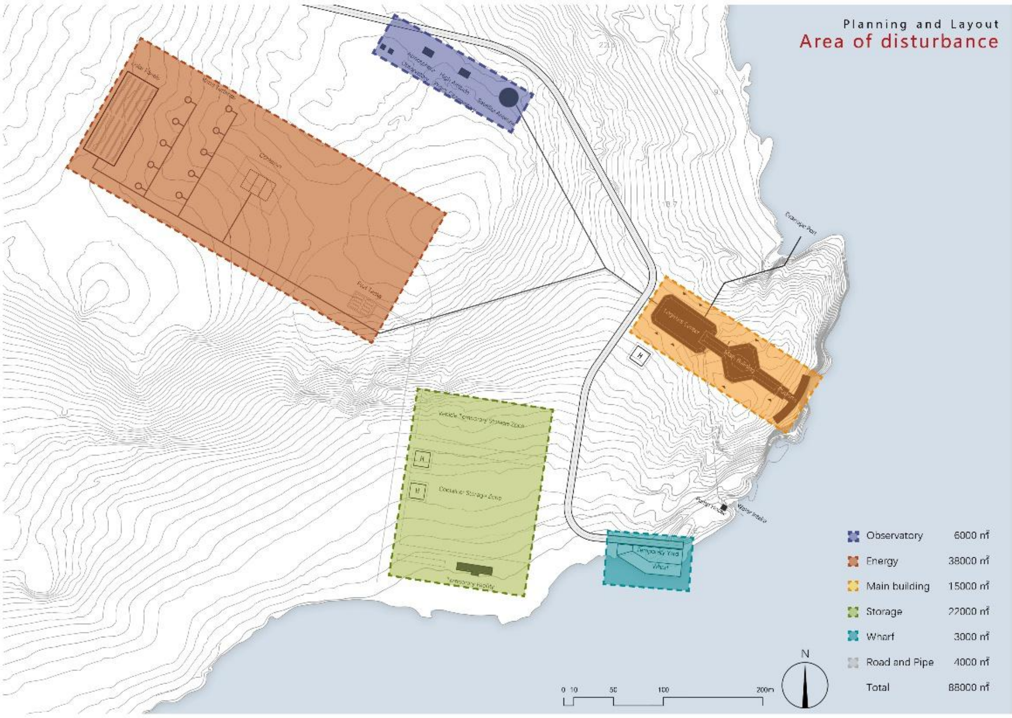


Figure 2- 57 Schematic diagram of the distribution of disturbance areas during the construction of the new station

2.6.2 Duration and intensity of the construction

The construction of the new station is planned to be completed within four austral summers. The minimum lifespan of the new station will be 25 years. Of course, the duration of the construction depends on weather conditions and transport availability. The capital construction projects consist of the main buildings (scientific research section, technology-supportive section, and medical service, etc.), accommodation building, hybrid Solar-Wind-Diesel power supply system and logistical support building, garage and storehouse, emergency system, fuel storage and independent science observation section.

The construction plan will be carried out by PRIC in accordance with Chinese relevant laws and regulations. PRIC will issue bidding calls for the construction and the company which wins the bidding will be the contractor for the construction. A supervising company will undertake the responsibility for supervising the construction. PRIC and the supervising company will jointly check and accept the construction work. A small part of scientific facilities will be installed after 2024/2025, namely the first planned season for scientific and logistic operation.

2.6.3 Measures in line with standards

PRIC is developing a series of measures and standards for the management of the operation of the new station in order to guarantee safe and effective operation of the station. The measures and standards will minimize the risks facing the Antarctic expedition and environmental impact to the maximum extent.

PRIC, with the support from station leaders, will oversee and ensure the effective enforcement of the environmental management plan, scientific programs, the rescue plan, medical service plan and other emergency response plans dealing with emergency matters.

2.7 Waste collection and disposal system

A Waste Management Plan (WMP) will be drawn up that will comply with all the requirements of Annex III of the Protocol on Environmental Protection to the Antarctic Treaty. The plan will comprise waste reduction, storage, and disposal, removal of treated waste out of Antarctica, as well as the training and education on environmental protection to the expeditioners.

The Waste Management Plan will consist of two parts. The first part will cover the management of the waste produced due to the construction of the new station and the relevant activities. The second part will cover the management of the waste produced due to the ongoing operation of the new station. The Plan will be regularly reviewed and updated.

The Waste Management Plan covers: waste minimization, waste storage, management and responsibilities, waste handling and disposal, and prohibited products not to be brought into and used in Antarctica.

2.7.1 Waste sorting

In the new station, all the wastes will be classified and separately stored in different cans. The new station will adopt a waste management system. All the solid wastes can be classified into five categories, namely the recyclable wastes, organic wastes, hazardous wastes, unclassifiable wastes and fuel drums, and they will be stored in different rubbish containers respectively. The integrated containerized fermentation machine will be applied for the treatment of the food and other organic wastes. All the human excrement will be treated by fermentation tank, while the residue sludge will be treated by the magnetic pyrolysis furnace.

All kinds of organic matters can be thoroughly thermal decomposed into ashes, the volume of ashes which is about 2% of original weight and volume. According to the Annex III to the Protocol on Environmental Protection to the Antarctic Treaty for Waste Disposal and Waste Management, combustible wastes, other than those referred to in Article 2 (1), which are not removed from the Antarctic Treaty area shall be decomposed in the magnetic pyrolysis furnace which to the maximum extent practicable reduce harmful emissions.

Inorganic matters, metal, liquid and fluid container etc. cannot be thermal decomposed.

Freshwater animals and plants whose moisture contents are more than 35%, kitchen waste, etc. cannot be thermally decomposed until they are combined with other organics containing less water. If the moisture content of the waste is too high, it must be dried first.

Most of the wet organic garbage will be treated with the fermentation machine in advance. Occasionally, the combination of organics and inorganics are pyrogenic decomposed, the organic parts turn to ashes and inorganics including metal and glasses can be sifted out for reuse.

This project uses a magnetized electrolysis furnace to treat organic domestic waste. The magnetized electrolysis furnace is a novel pyrolysis technology for the treatment of solid organic waste. A small amount of magnetized air is passed through the pyrolysis furnace to partially burn the combustibles in the treated solid waste and the combustible products produced by pyrolysis. The heat causes the organic matter in the solid waste to undergo continuous thermal decomposition. Since the magnetized air indirectly magnetizes the object to be treated, the energy required for pyrolysis is reduced, and the pyrolysis efficiency is improved. Therefore, the pyrolysis gasification can be realized at a low temperature of 350°C, thereby basically avoiding the production of dioxins.

Figure 2- 58 Schematic diagram of the magnetized pyrolysis furnace at the new station

Compared to the traditional waste disposal methods, the magnetic pyrolysis furnace has significant advantages as follows:

- High efficiency

It takes only one and half hour to dispose of one ton of garbage averagely, and the weight of remained dust is a one-three percentage of the original weight and volume.

- Low energy consumption

The traditional incineration furnace needs to maintain the temperature higher than 1000 ℃ by heavy oil, and magnetic pyrolysis furnace can be operated at a lower temperature, which conserves energy greatly. And the products after the magnetic pyrolysis can be reused as an energy source. The additional energy source is only used in ignition and exhaust smoke purification.

- Low investment and separate

The investment cost of the magnetic pyrolysis furnace is only one-third of the incineration facility when disposing of the same amount of garbage.

- Environmentally friendly

The magnetic pyrolysis furnace can get rid of generating dioxin which is produced between 340-850℃ during the traditional incineration and will do great harm to the human health and environment in the Antarctic.

Table 2-22 Comparison between the incineration and magnetic pyrolysis

Item comparison	**Incineration**	**Magnetic pyrolysis**	**remarks**
Occupation of land	large	**small and separate**	
Site selection	difficult	**easy**	Incineration could do long-term harm to local water and soil environment
Construction investment	quite high	**low and separate**	
Environmental pollution	Serious	**tiny effect**	Utilizing **magnetizing pyrolysis as a solution has no concern for follow-up pollution**
Energy consumption	high	**relatively low**	Low energy consumption and could be driven thoroughly by electricity, which is suitable for garbage digestion in outbreak control in the wild and military process.
Garbage classification	strict classification	**no need**	

The amount of unclassifiable waste will be controlled to the maximum extent. These wastes will be sealed and stored timely. The wastes will be taken and stored in the turnover wastes van in the waste container and will be compacted if necessary.

The wastewater will totally be treated and recycled, and the limited residual treated wastewater meeting the standards will be discharged into a point optimal for rapidly mixing and dilution. The water quality of the swage treated for recycling use or discharge will be in compliance with the standards of Category Ⅲ of Chinese Water Quality Standards for Surface Water (GB3838-2002).

Packing material should be minimized as much as possible in the process of logistic preparation to reduce the production and transportation of the waste.

The container will be brought back to China by Xuelong. When the ship arrives, the container full of wastes will be exchanged for an empty one. Additionally, the transport boxes are designed to be easy-moved out of the container for relocation when necessary.

2.7.2 Fuel drums

The empty drums will be reused repeatedly in situ after a serious quality check. Those which do not comply with the requirements will be compacted and transported back to China. JPY-T30 Oil Drum Press Machine as shown in Figure 2-52 will be used and the features are as following:

- This machine will use hydraulic drive with independent motive structure and electrical system.
- The air and liquid will be discharged when machine compress, inner with liquid trough to prevent liquid pollution.
- It's suitable for compress oil drum, paint drum and other kinds of drums (50-200L) to reduce the size.
- Be equipped with protective device.
- Adopt high quality sealing parts, improve the life time of oil cylinder.
- Oil pipe joint adopts conical without gasket form, no oil leakage phenomenon.
- Adopt high quality superposition type valve group.
- Adopt connect motor with pump directly, to ensure 100% concentricity, and extend use life of pump.
- Equipped with waste oil collector in the bottom.

All the residue oil will be sucked by pump and collected for additional use before compacting and the inner compress process will prevent the contaminated water, during the whole process, the operator will equip with oil suction felt and necessary separation material to deal with any spill.

Figure 2- 59 JPY-T30 Oil Drum Press Machine

2.7.3 Hazardous Wastes

The hazardous wastes include waste batteries, light tubes, adhesion agent and dissolvent agent, other hazardous rubbish, and waste fuel and oil products. The former four wastes will be stored in waste boxes separately while the waste fuel and oil products will be stored in waste fuel drums. These wastes will be fixed in a designated place in a wastes collection container.

Purchase and use of hazardous products will be strictly restricted to keep the hazardous products in a minimum quantity. For instance, it will be encouraged to use rechargeable batteries. The hazardous products and their empty packaging will be stored in specific areas and subject to strict monitoring. Those hazardous wastes will be packed in a uniform way before transportation to ensure that they will not drop or leak out. They will be shipped back to China and disposed of by qualified organizations.

3. Alternatives to the Proposed Activity

Several alternative plans of locations and designs have been examined for the construction of the new station, considering scientific, environmental, logistics, engineering, health, and safety requirements.

3.1 No-action Alternative

Starting the Antarctic expedition in the 1980s, China has established the Great Wall Station on King George Island, the Zhongshan Station in Larsemann Hills area in East Antarctica and the Kunlun Station and Taishan Summer Camp in Antarctica inland. These three stations have become not only bases for Chinese scientists scientific activities for the whole year but also a platform for international cooperation.

Without the proposed activities at the new station, the realization of the Chinese commitment toward active Antarctic research in Ross Sea region is unlikely, and the demands for more information on the change of the Antarctic Ross Sea environment by both Chinese and foreign researchers will remain insufficient. International collaborations in Northern Victoria Land with nearby stations operated by the countries of United States, New Zealand, Italy, Germany, and Korea are expected significantly synergistic for the Antarctic research.

Indeed, the no-action alternative, being void of the temporary and cumulative impact caused by the construction and operation of a new station, guarantees full prevention of the impact on the Antarctic environment. However, advantages that the new station would bring were assessed to prevail over the negative impact on the Antarctic environment by the station, which will be minimized with the proposed construction and operational design of the station that highlights energy optimization. The new station will provide comprehensive, in-depth understanding of the role of Ross Sea in global environmental changes and enhance China’s contribution to the conservation of the Ross Sea region as a Party of the Antarctic Treaty. Therefore, the establishment of the new station is highly recommended.

The new station is an independent year-round station for logistic and research activities on the Inexpressible Island in the Terra Nova Bay, Ross Sea region. It is expected to be an international platform for regional multidisciplinary research focusing on the chain reactions caused by the global changing climate and the National Antarctic Program will include studies on atmospheric and atmosphere-ice-ocean interaction, glacial and ice shelf-ocean interaction, environment and ecosystem monitoring, space physics and the geological environment evaluation studies, etc. The new station will also strength the potential logistics cooperation and collaboration with all the stations in the Terra Nova Bay and Ross Sea regions.

Meanwhile, the new station would adopt sustainable and efficient technologies, which can minimize the potential environmental impact. Therefore, China considered that the decision to establish the new station is in accordance with her ATCP status and the principles set up in the Antarctic Treaty and the Protocol.

3.2 Alternative locations around Ross Sea region

The Ross Sea and the Weddell Sea are the only two areas of the Southern Ocean with a wide and deep continental shelf as shown in Figure 3-1. Along most of the other parts of the Antarctic coast, the shelf is narrow or absent. The Ross Ice Shelf is the world's largest floating ice sheet and overlies half a million square kilometers of the southern Ross Sea as shown in Figure 3-2. A series of open water areas called polynyas, including the large Ross Sea polynya, permit light to enter the water column in early spring. These polynyas are also the source of a large portion of Antarctic Bottom Water as a key component of the global climate system.

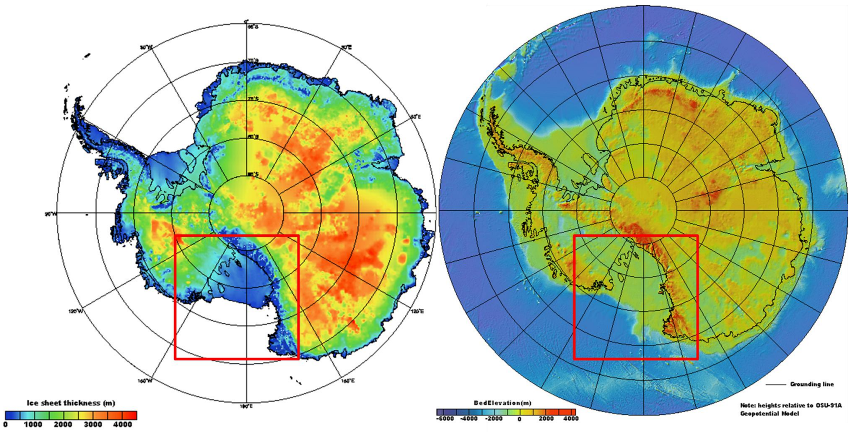


Figure 3- 1 Observed ice sheet thickness and bed Elevation of the Ross Sea area
(Base Map from Ice Bridge NSERC L1B Geolocated Meteorological and Surface Temperature Data)

Compared to the existing Chinese Antarctica stations, Great Wall Station is located on the King George Island in West Antarctic with a latitude of 62°S, Zhongshan Station is located on the Lasermann Hills in East Antarctic with a latitude of 69°S. The Ross Sea region is a special convergence zone between East Antarctic and West Antarctic with a latitude of 70°S to 90°S. The scientific research available around the Ross Sea region will fill in the blanks in several fields, such as the relationship among the Ross Sea Shelf, Ross Sea polynyas and global climate change, and comparative study on the biodiversity between Great Wall Bay, Prydz Bay and Terra Nova Bay in Ross Sea region.

China conducted preliminary surveys and evaluated three candidate regions for a new station around Ross Sea region in Antarctica. Proposed location 1 is on Oates Coast, proposed location 2 is in Terra Nova Bay of Victoria Land and proposed location 3 is located near the Cape Berks of Marie Byrd Land as shown in Figure 3-2.

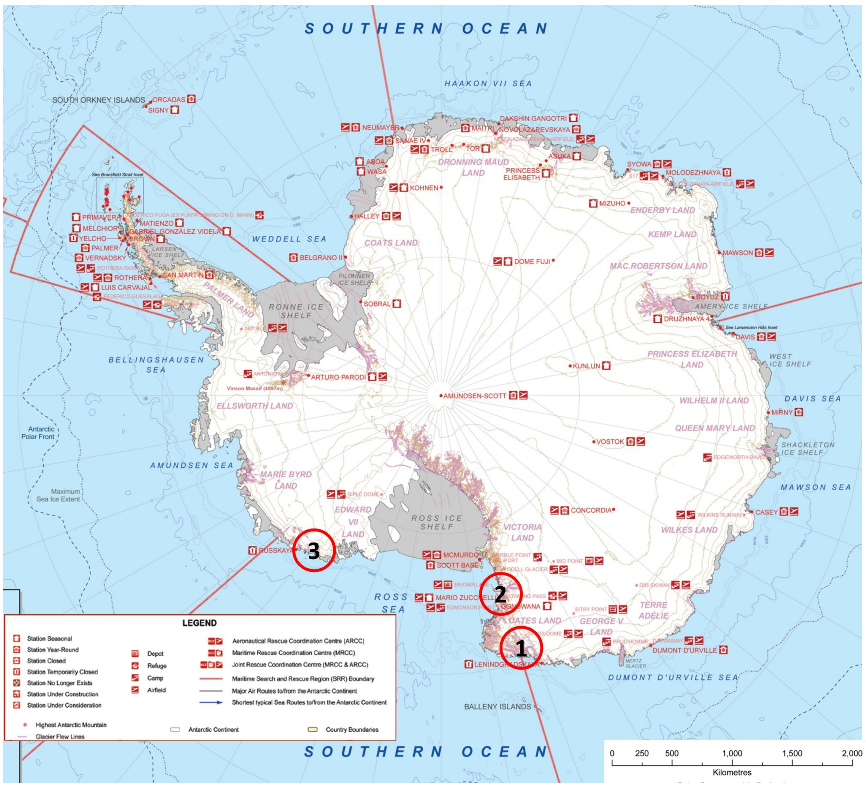


Figure 3- 2 Alternative proposed locations around Ross Sea region
(Base Map: COMNAP 2009)

3.2.1 Description of proposed location 1 in the Oates Coast region

Proposed location 1 is located in the Oates Coast region, a portion of the coast of Antarctica between Cape Hudson and Cape Williams. The area has rapidly changing weather conditions with frequent and long strong wind events from June to September. The largest wind gust was recorded by Leningradskaya station on July 9, 1989, when under conditions of persistent (several hours) storm force winds, the instrument twice recorded the maximum gust of 78.3 m/s. During the entire operation years of the Leningradskaya station, no complete ice clearance of the area in question was recorded. Moreover, on average up to 60% of its area was typically occupied by residual drifting ice of the southern periphery of the massif. Finding a new inland route is also thought to be difficult. The personnel and cargo would be delivered to the station only by helicopters.

Figure3-3 is the climatological sea ice concentration distribution of Ross Sea during December-January. Compared to climatological sea ice concentration distribution, in the Ross Sea, the outer edge of sea ice in 2012 summer is not very different, but some of the sea ice concentration was quite different from others.

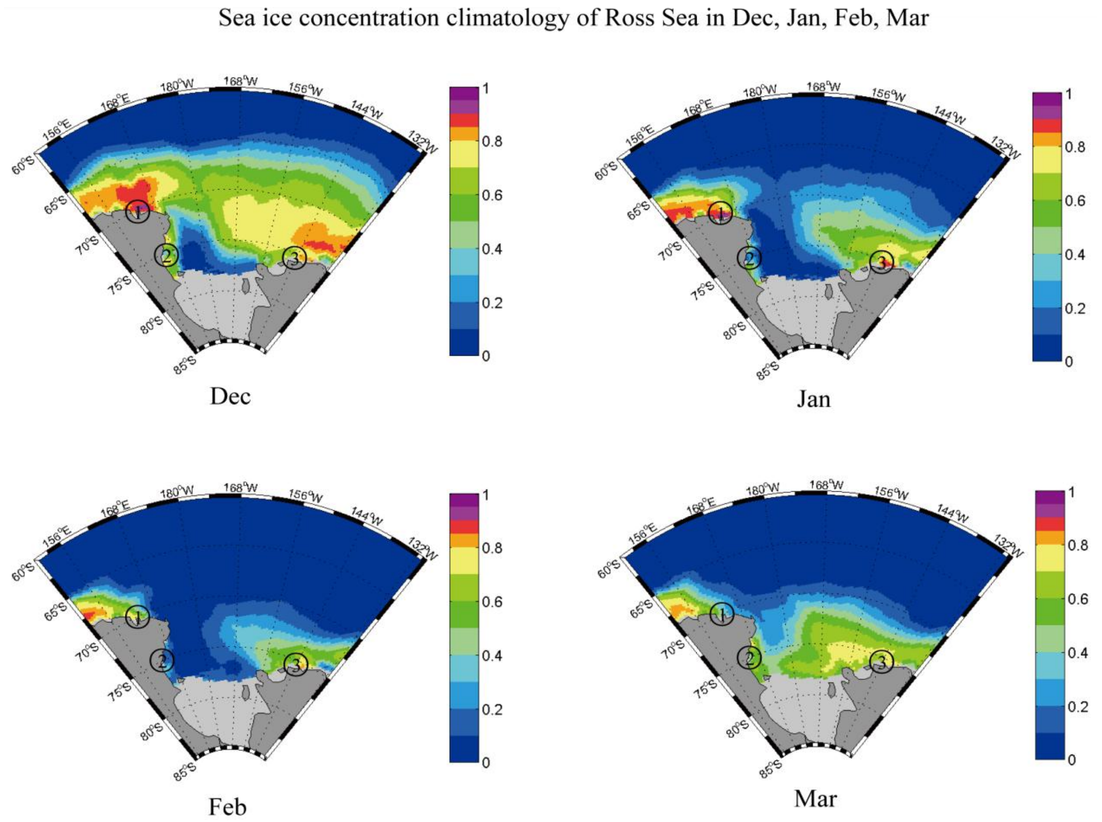


Figure 3- 3 Climatology maps of sea ice concentration

(Observation data in January, February, March, Ross Sea (mean value in 1978-2012), the three proposed locations are showed as above)

For the proposed location 1, in December 2012, the outer sea ice density reached 90% or more (Figure3-4, Dec), while the climatological sea ice in December of that location was between 60% and 80% (Figure3-4, Dec). During January 2012, the sea ice scope outside proposed location1reduced, but the intensity remained above 90 percent, which is still 10%-30% higher than climate-state intensity (Figure3-4, Jan, Figure 3, Jan).

In February 2013, outside the preselected area I there was still sea ice with the intensity of 80%-100% and 400km north-south width (Figure3-4, Feb), while in February the climatological data show that there was only sea ice with the density of 50%-70%and the north-south width of 200km (Figure3-4, Feb). The sea ice outside the proposed location1 have started to freeze since March 2013, and significantly expand outwards, but according to the climatological data in March, the sea ice in the region remains intact, and there is no apparent freeze (Figure3-4, Mar).

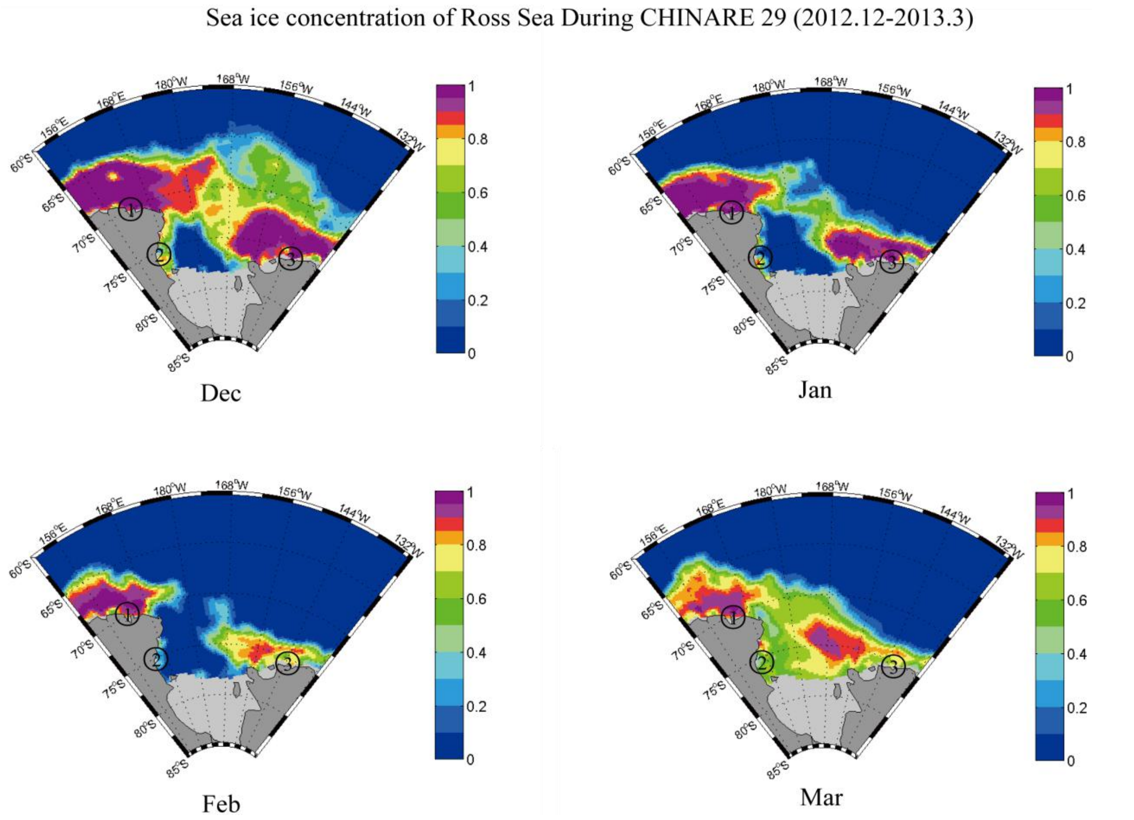


Figure 3- 4 Average Sea ice concentration maps of Ross Sea

(Observation data in Dec. 2012, Jan.2013, Feb.2013, and Mar.2013, the three proposed locations are showed as above)

The alternative locations mentioned above were ultimately evaluated inadequately on various deciding factors for constructing the station and accommodating its research activities, such as accessibility, weather conditions, safety, logistics, and impacts on the ecosystem.

3.2.2 Description of proposed location 2 near Terra Nova Bay of Victoria Land

In contrast, **Proposed Location 2** is in the region near the Inexpressible Island surrounding Terra Nova Bay which seems appropriate for the new station as it provides ample space for construction and relatively easy logistics with the absence of conspicuous local flora and fauna.

For the proposed location2 as is shown in Figure 3-3 and Figure 3-4, during December 2012 and March 2013, its outside sea, namely Terra Nova Bay, the change of whose sea ice conditions were in line with the change of climate states, but compared to the situation of the climatology in March 2013, the Ross Sea ice expands to freeze rapidly and obviously. Thus, the intensity and scope of the Ross Sea ice have obvious inter-annual variability.

More details have been described in section 4.

3.2.3 Description of proposed location 3 near the Cape Berks of Marie Byrd Land

Proposed location 3 is located near the Cape Berks located between Ruppert Coast and Hobbs Coast of Marie Byrd Land in the West Antarctic. This area is surrounded by some nunataks, and volcanic conditions should be considered in this area. The coast of this area is the snow-glacial barrier with the height from 2 to 40 m. From the western side of Berks cape, the coastline turns sharply southward.

Extremely severe weather conditions occur due to the combination of low temperatures and very strong winds. Typical for the proposed area the extremely severe weather conditions are formed by the combination of low temperatures with hurricane winds. The mean annual air temperature is -12.4℃ during all periods of observation. The warmest month is January, while the coldest one in August. The absolute temperature minimum is -46.40 ℃ , and absolute maximum is +7.40℃. In this area, the blizzards are often observed (about 150 days a year) accompanied by snowfall and by restriction of visibility up to minimal values. Due to orographic features, the easterly winds prevail.

The hardness of wind regime is the peculiarity (distinctive feature) of the climate in the region. The mean annual wind speed there is 12.9 m/s. The monthly mean maximum wind speed of 18.1 m/s was recorded in March, and the minimum of 9.6 m/s was observed in January. The maximum wind speed (excluding January and February) fluctuates in limits of 46-61 m/s. The recorded wind gust maximum velocity was 77 m/s, and it was impossible to record the stronger wind gusts due to wind anemometers destruction. Sometimes, there is the possibility of two and more cyclonic disturbances passing within a period of about a day which poses great challenges to stable operation for the station. Thus, it increases the difficulty for station operating year-round especially in case of emergency.

The annual wide, solid strip of fast ice and chain of stationary polynyas, formed along the coastline in the summer period which is the main feature of the ice regime in this area. In the spring-summer period about half of the fast ice is destroyed. In the case of breakdown of multiyear fast ice, the frequent hurricane force winds block (prevent) the formation of stable ice for a long time. Due to the heavy ice conditions, the disembarkation at the proposed station could only be carried out by helicopters.

For the proposed location 3 as shown in Figure 3-3 and Figure 3-4, it was surrounded by hundreds of kilometers of ice with the intensity of more than 80 percent during December 2012 and January 2013. The sea ice intensity was reduced to 80% or less in February and it grew rapidly in March. According to the climatological data of Figure 3-3, only in February, the ice concentration off the coast of proposed location 3is low, and that was covered by about 80 percent of the sea ice in other months.

3.2.4 Comparison of the proposed three locations

In consideration of the station construction and research accommodation, such as accessibility, weather conditions and safety, logistics convenience, and impacts on the ecosystem, the alternative locations mentioned above were ultimately evaluated as shown in Tab 3-1. Comparing all the criteria, it is more appropriate to choose the proposed location 2 in conclusion.

Table 3- 1 Comparison of the proposed three locations

Comparison Criteria		Location1	Location 2 (Selected)	Location 3
Accessibility	**Ice condition**	No complete ice clearance	**Long open-time with polynyas**	Heavy and stable in the most time
	Ship access	Limited	**Easy**	Limited
	Helicopter access	Limited	**Easy**	Limited
Weather condition and safety	Mean annual temperature	-14.6℃	**-18.5℃**	-12.4℃
	Extreme low temperature	-37.4℃	**-42.3℃**	-46.4℃
	Mean annual wind speed	8.4 m/s	**12.0 m/s**	12.9 m/s
	Extreme wind gust speed	78.3 m/s	**43.5 m/s**	77 m/s
	Relative humidity	55% - 93%	**40% - 51%**	64% - 90%
logistics convenience	Self-supporting	Limited	**Easy**	Difficult
	International cooperation and supporting	Difficult	**Easy**	Difficult
Biodiversity		Poor	**Average**	Average
Land availability		Limited	**Available**	Available
Investigation reference		Literature study and the 29th Antarctic research activity of China	**Literature study and the 29th - 35th Antarctic research activity of China**	Literature study

3.3 Alternative sites on the Inexpressible Island near Terra Nova Bay of Victoria Land

According to the site survey from December 2012 to January 2017, five possible sites on the Inexpressible Island were considered as shown in Figure 3-5: site A was coastal area in the northeast with a colony of penguins, site B was 200 meters away from the shore with a smooth platform, site C was near a fresh water lake and almost 2 kilometers away from the shore, and site D was on a small hill on the west side and 2.5 kilometers away from the shore, Site E was coastal area in the southern part of the Island.

Site A is with a shallow shore as shown in Figure 3-6 giving the advantage to be easier accessible and has a few freshwater lakes which can be used as water resource as shown in Figure 3-7. However, near the shore area, there is a penguin colony. Thus, the choice for using this site A was excluded.

Site B is a block of flat area and about 200 meters away from the shore as shown in Figure 3-8. From the point of view of logistics, this will give more advantage in respects to the unloading work and limited ground pavement work will be needed. There is a relatively high rock ridge separating the penguin colony from the location B, thus leaving a very little direct impact on the colony. During the several on-site investigations around location B, few penguins were observed on shore.

Site C is close to two big freshwater lakes, which were accumulated snow-melted water. And there is a flat area that could be a potential site for the station to be built as shown in Figure 3-9. However, the distance away from the shore means much more ground preparation of construction work to be done so that materials could be transported to the site, thus much disturbance to the local topography is required, which might result in too much environmental impact. To avoid the adverse result, this site was not chosen.

Site D is much inland from the shore and situated under the West Ridge at the Inexpressible Island as shown in Figure 3-10, where the strong katabatic wind could be shielded away leaving this area to be advantageous for station building and operation. Site D is also close to fresh waters thus providing water resource for the future facilities. However, the difficulties in transporting materials from the shore to the site mean a few of labors must be utilized thus resulting in much disturbance to the local. For the same reason to withdraw the Site C, Site D was excluded from this station sites list.

The terrain of the Site E is relatively flat, high in the west and low in the east. The west and south sides are glacier channel. The lithology of the Early Paleozoic Ordovician granite, monzonite, and other acidic intrusion rock. Judging by the characteristics of remote sensing images, the "rock-knifed" frost heave fractures with nearly north-south distribution are developed in the bedrock area of this area, and there is the moraine accumulation area in the low-lying area. However, the thickness of the deposit is unknown and needs to be detected by the geological radar. The accumulation area is not very developed, the shore is mainly bedrock and ice landform, the coast is steep.

A lot of moraines are developed only on the top of the mountain. On the remote sensing images, a series of "grid" images of north-south and east-west intersections are formed. The elevation of this highland is about 60m. The west is a north-south highland with a length of 1000m from north to south and a width of 500m approximately from east to west. The top of the mountain is about 100m above sea level. There is exposed bedrock on the top of the mountain, and most of the slopes covered by moraine. The middle depression area is covered by the moraines, forming a set of arc moraine ridge parallel to the shore, which is in the form of a terraced field. The total passing direction of the glacier is from the northwest to the southeast.

The distribution of lichens and moss on the Inexpressible Island is very uneven, because of the complex topography, heterogeneity of soil and varied microclimate. In the 5 zones for alternative proposed sites on the Inexpressible Island, only lichens with sporadic distribution were found. The diversity in Site A is high and lichens as *Acarospora gwynnii, Bullia frigida, Candelariella flava, Umbilicaria decussate, Xanthoria elegans, Xanthomendoza borealis* have been found. The diversity in Site B is low and lichens as *Acarospora gwynnii, Bullia frigida* have been found. The diversity in Site C is middle and lichens as *Acarospora gwynnii, Bullia frigida, Lecanora fuscobrunnea* have been found. The diversity in Site D is middle and lichens as *Acarospora gwynnii, Bullia frigida, Lecanora fuscobrunnea, Xanthoria elegans* have been found. The diversity in Site E is very low, only one lichen as *Bullia frigida* has been found.

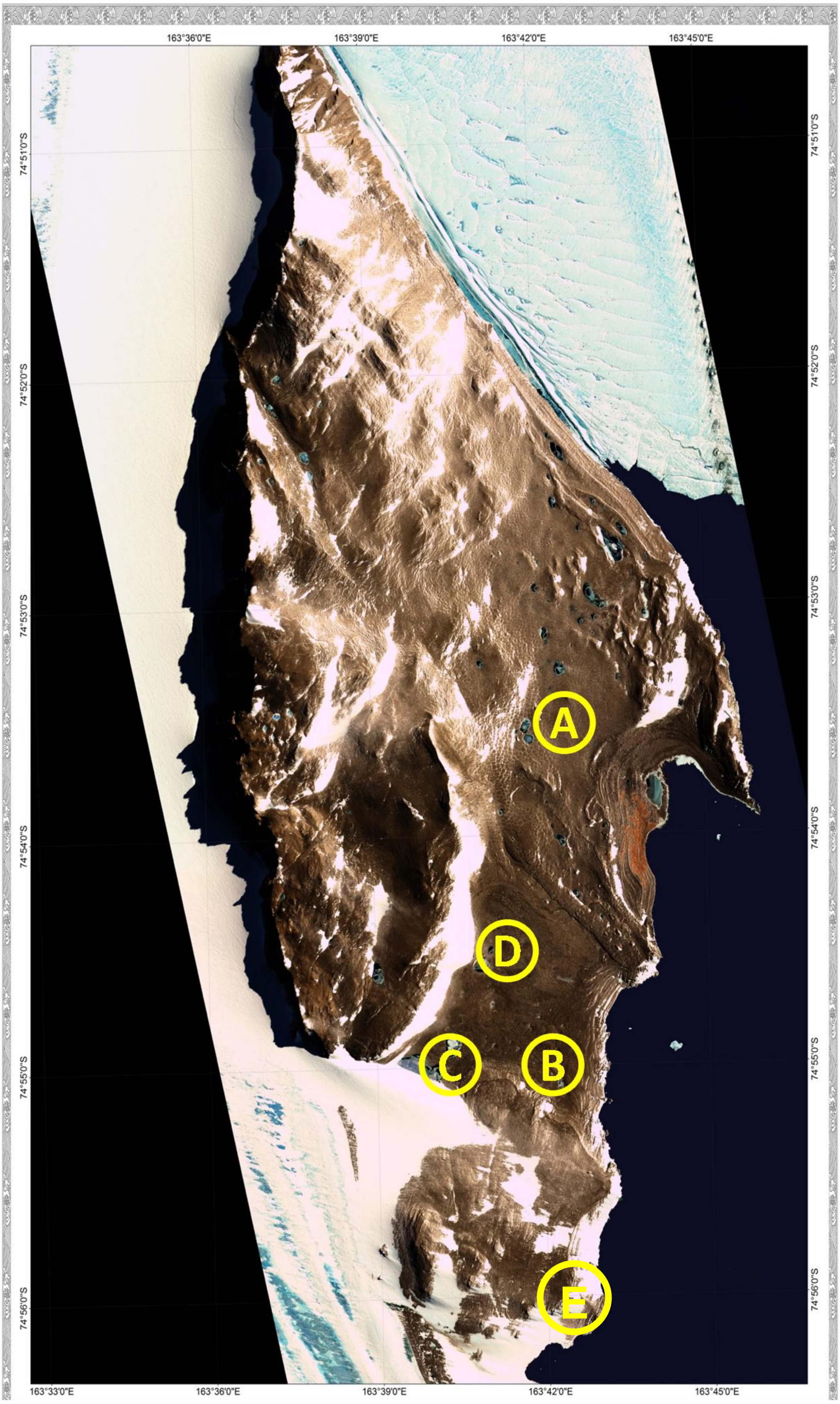


Figure 3- 5 Alternative proposed sites on the Inexpressible Island

Figure 3- 6 Coastal line near site A

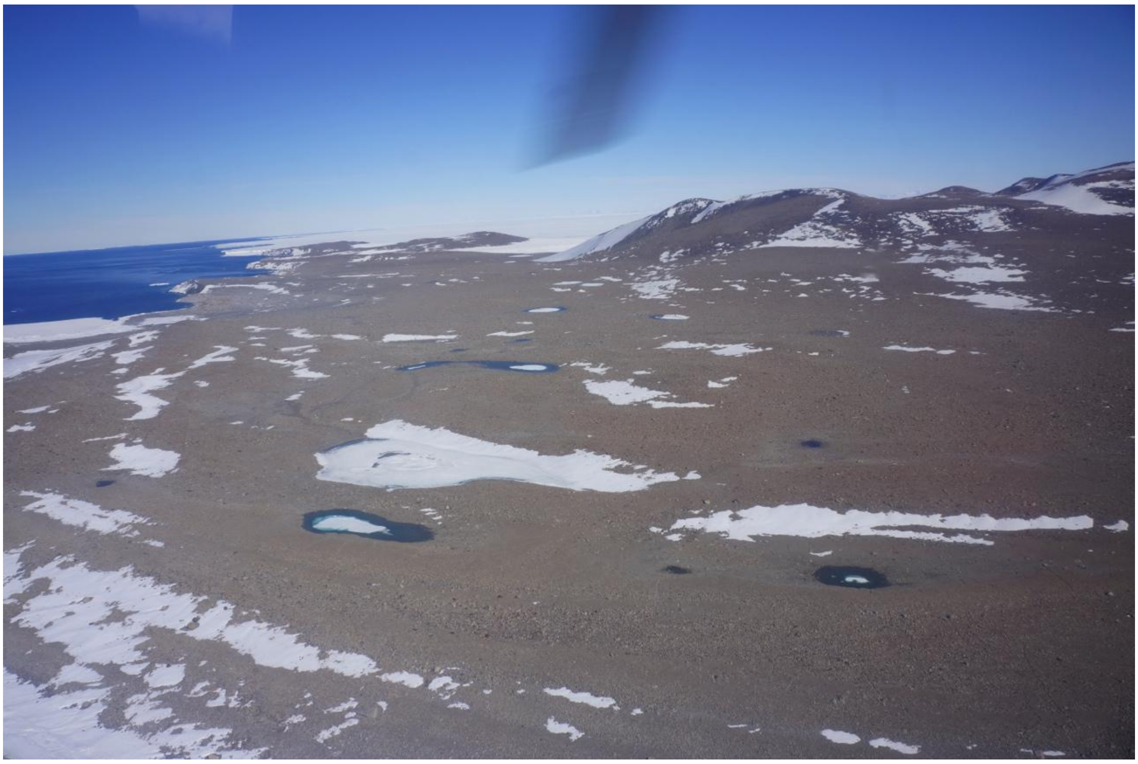


Figure 3- 7 Topography in site A

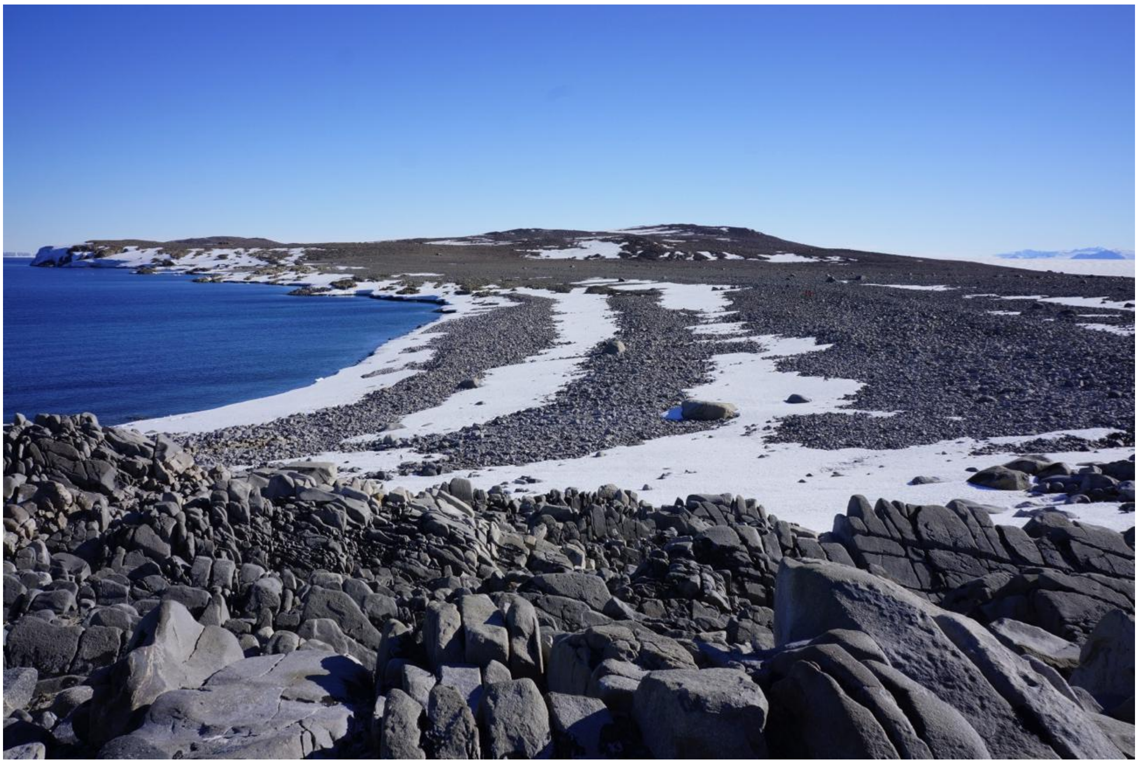


Figure 3- 8 Topography in site B

Figure 3- 9 Topography in site C

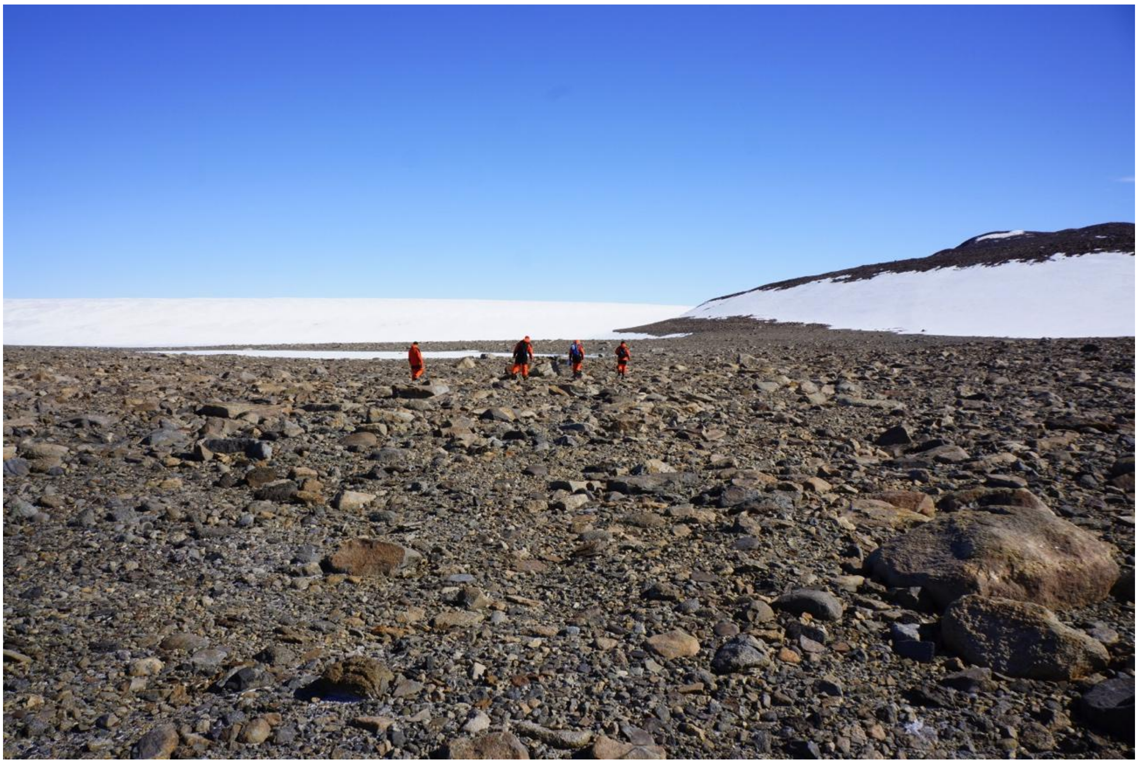


Figure 3- 10 Topography in site D

Figure 3- 11 Topography in site E

On consideration of the potential environmental impact and convenience of the station construction and operation, comparable criteria as biological sensitivity, fresh water availability, landing possibility, logistics convenience, site elevation, land flatness and snow accumulation risk were used. The alternative sites mentioned above were evaluated as shown in Tab 3-2.

By comparison, it is more appropriate to choose proposed site E in conclusion. Considering the freshwater availability is moderately difficult in site E, the advanced desalination technology will be used as described in Section 2.

Table 3- 2Comparison of the proposed sites on Inexpressible Island

Comparable criteria	Site A	Site B	Site C	Site D	Site E （Selected）
Biological sensitivity	High	Low	Low	Middle	**Low**
Freshwater availability	Easy	Moderately difficult	Easy	Easy	**Moderately difficult**
Landing possibility	Easy	Easy	Difficult	Difficult	**Easy**
Logistics convenience	Moderately difficult	Moderately difficult	Moderately difficult	Difficult	**Easy**
Site elevation	Middle	Low	Low	High	**Low**
Land flatness	Smooth	Smooth	Uneven	Uneven	**Smooth**
Snow accumulation risk	Low	Low	Middle	High	**Low**
Exposed Bedrock availability	Difficult	Moderately difficult	Difficult	Moderately difficult	**Easy**

3.4 Alternative designs

3.4.1 Alternative layout design of the main building

Three alternative layout modes were considered in the station planning, and the layout C was finally selected according to the site elevation, geological conditions, water intake distance, building area and area of operation area, environmental impact and other indicators. The advantages are as follows:

- Safer site elevation: The main building is moved up from a shallow 15m above sea level to a hill ridge above 28m above sea level, avoiding the risk of iceberg invasion and local snow accumulation in the future;
- A more convenient scientific research platform: The marine laboratory located in the east wing of the main building is closer to the sea, combined with the in-situ comprehensive observation system carried by the experimental platform, to fully support the all-weather monitoring business facing the ocean
- More intensive land use: The main building and the logistics center are further integrated in terms of volume, and traditional energy and new energy facilities are centrally installed to

minimize the footprint of various facilities and reduce environmental disturbances

- More solid geological conditions: At present, the main building is in an exposed area of bedrock, and the basic conditions are more stable, which is conducive to resisting strong winds and avoiding uneven settlement.

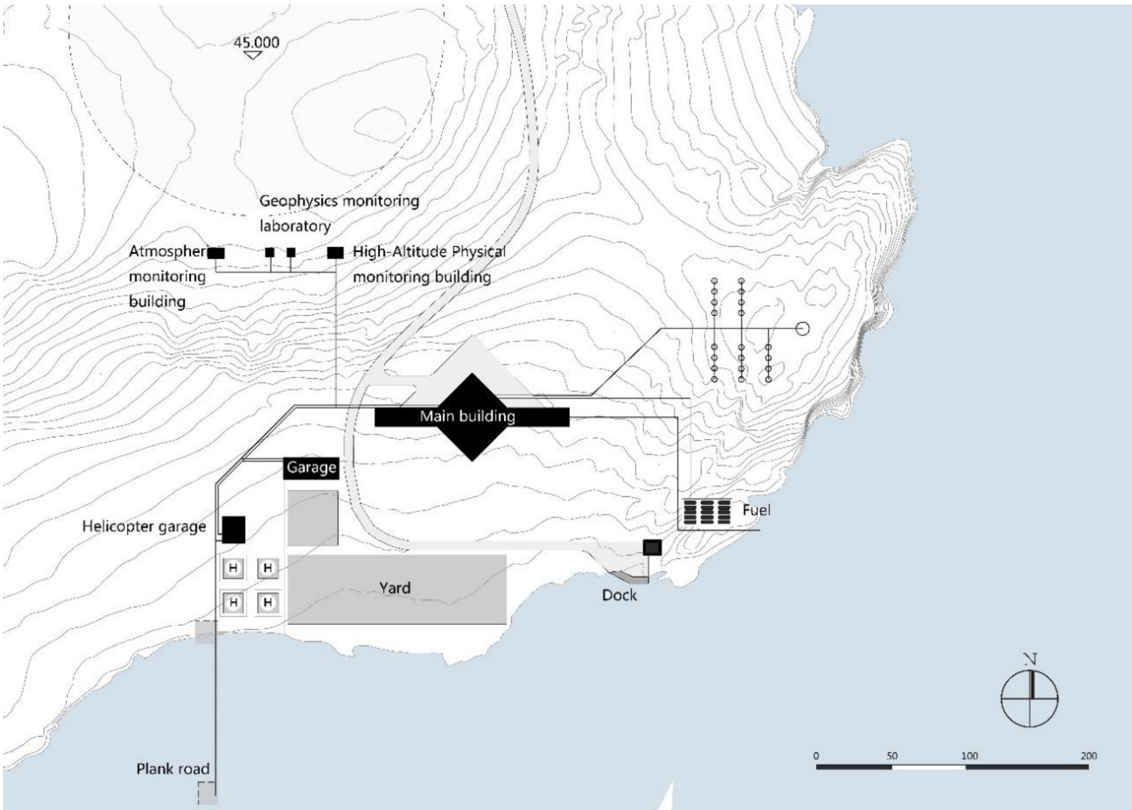


Figure 3- 12 New station area layout comparison plan A

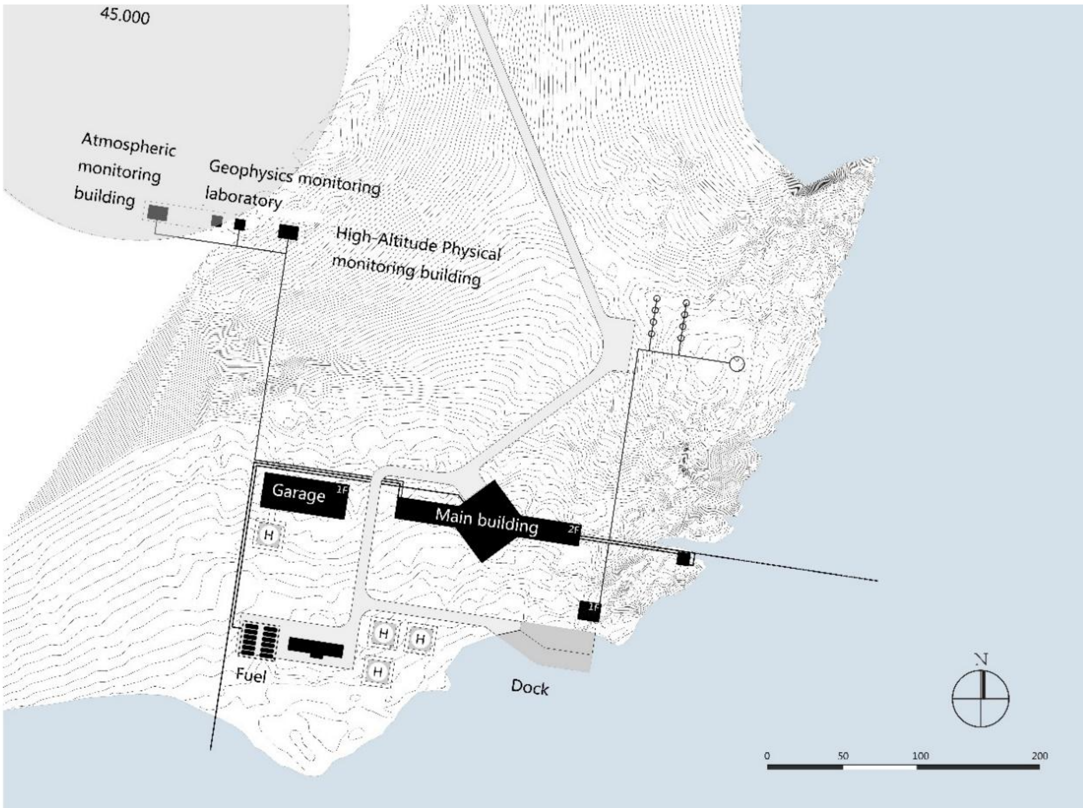


Figure 3- 13 New station area layout comparison plan B

Figure 3- 14 New station area layout comparison plan C

Scheme C has the smallest building area and operation area, and the exposed bedrock conditions are the best. Therefore, the environmental impact during the construction period is the smallest among the three schemes. The scheme comparison table is shown in Table 3-3.

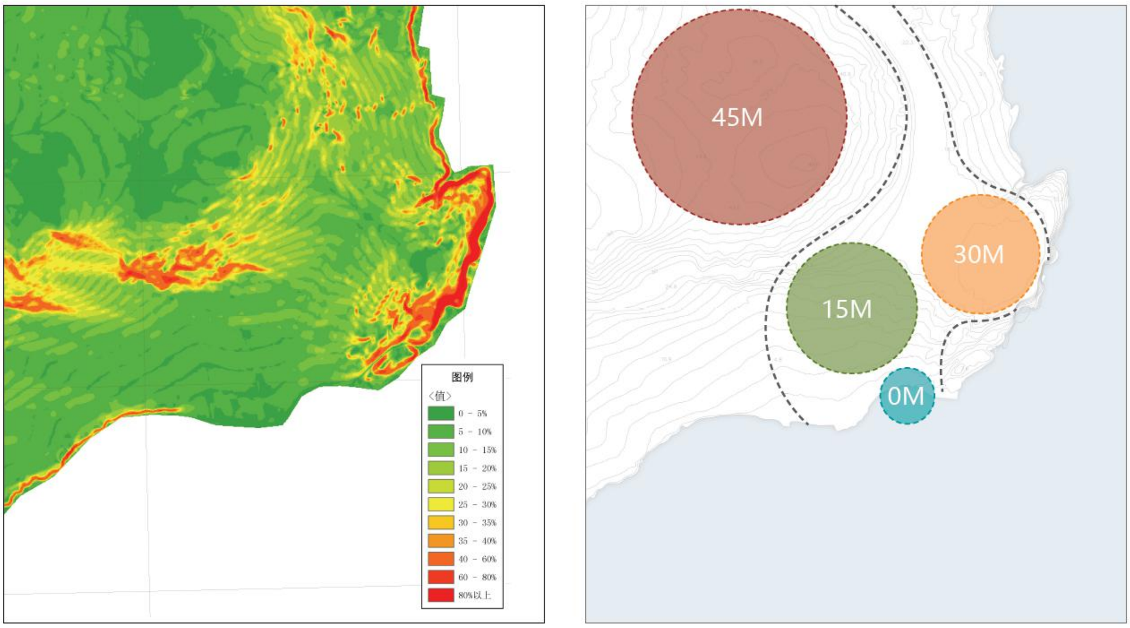


Figure 3- 15 Comparison and selection map of the average elevation of the layout of the new station area

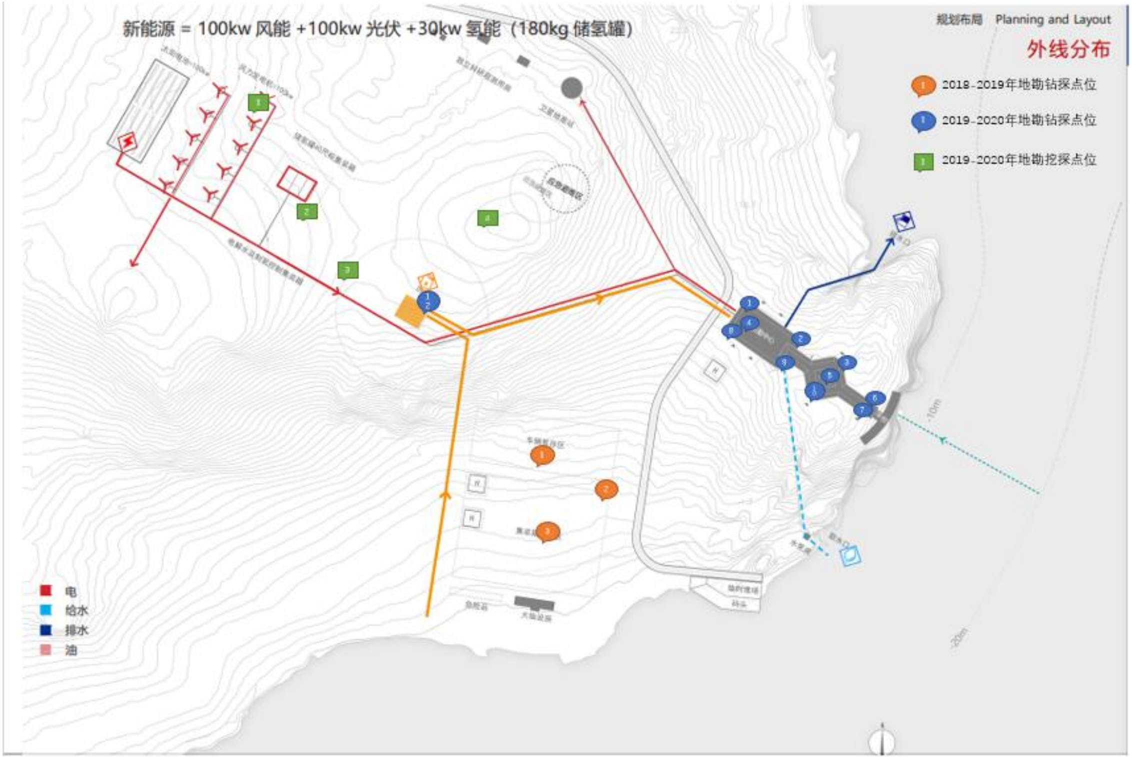


Figure 3- 16 Distribution map of survey holes at different depths of bedrock in the new station area

Table 3- 3 New station layout comparison table

	Average site elevation	Characteristic value f_{ak} of natural bearing capacity	Distance of water intake	gross floor area	Area of work area
Layout A	15m	300~800kpa	300m	4400m^2	0.15km^2
Layout B	10m	300~800kpa	120m	4200m^2	0.10km^2
Layout C	28m	300~3000kpa	130m	4100m^2	0.10km^2

3.4.2 Alternative layout design of the main building

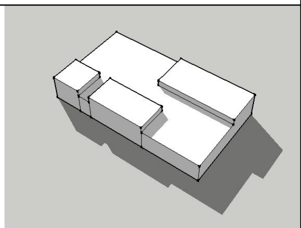
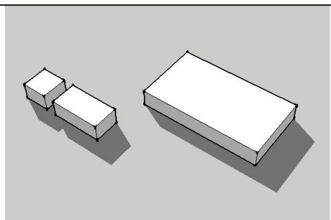
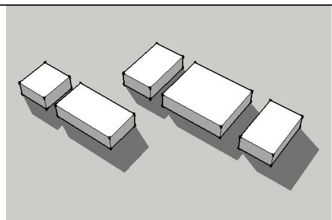
Three alternative layouts have been considered including the fully centralized (Layout A), semi-centralized (Layout B) and distributed layout (Layout C). After comparing the indicators such as fireproof safety, wind resistance, the possibility of the snow accumulation and the difficulty of the construction. Semi-centralized (Layout B) model has been suggested. The advantages are as following:

High level of fire safety: Comparing to the fully centralized layout, the semi-centralized layout separates the main buildings with the garage, helicopter parking and the boat parking lots. The main buildings will equip with automatic alarm and sprinkler system to improve the level of fire safety and to minimize the damage caused by fire.

Low wind resistance: Comparing to the distributed layout, the semi-centralized layout can decrease the wind resistance effectively, which can reduce the wind pressure on the structures and minimize the possibility of snow accumulation inside the catches of the buildings.

Convenient transportation, installation, and maintenance: Comparing to the layout A, the semi-centralized layout can separate the function zones and decrease the difficulty of big parts of the fully centralized layout. It is more efficient and convenient for on-site installation and maintenance.

Table 3- 4 Alternative designs of layout

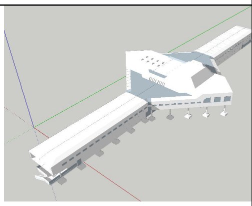
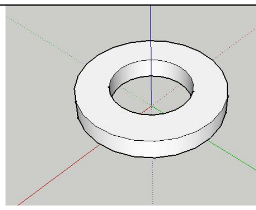
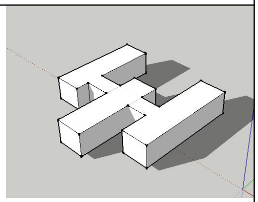
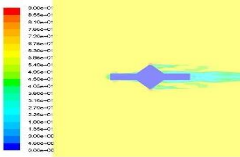
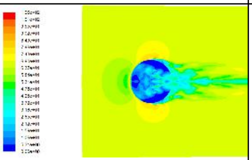
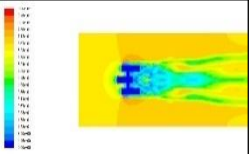
	Layout model A	**Layout model B**	**Layout model C**
			
Layout	**Fully centralized**	**Semi-centralized**	**Distributed**
Fireproof Safety	Low	**High**	High
Wind Resistance	Low	**Middle**	High
Snow Accumulation	Low	**Low**	High
Construction Difficulty	High	**Middle**	Low

3.4.3 Alternative exterior designs

In conclusion, as shown in Table 3-4, Scheme A1 was selected as the priority, the reasons are as follows:

- Designing of the body can reduce the wind resistance, and is more conducive to extremely low temperature and strong wind climate.
- The epidermal cell structure of the plate is more conducive to processing and transportation，and more convenient for integrated handling of multi-layered facade materials.
- Split designing can strengthen the ability to adapt to the diversified terrain.
- Allows more flexible functional layout.
- Overall structure designing is more convenient to deal with the phased construction.
- It is much more energy efficient and more conducive to the maintenance of fire safety and post-repair.

Table 3- 5 Alternative exterior design

	A1 Stars	A2 Rings	A3 Box
Layout			
CFD model			
Drag coefficient	**Moderate**	Low	High
Snow accumulation prevention	**Effective**	Effective	Invalid
Effective indoor space availability	**High**	Low	High
Natural lighting conditions	**Good**	Moderate	Moderate
Construction difficulty	**Easy**	Difficult	Moderate
Fieldwork period	**Short**	Long	Short

3.4.4 Alternative wind turbine designs

Based on the analysis of the annual wind resource data monitoring results of the new Station, a 100kW wind power system is planned to be constructed. According to the planning and design of the new energy system of the new station, the 100kW wind power system consists of 10 sets of 10 kW pitch wind turbines. A wind power system consists of a wind turbine, a tower, a controller and a DC converter system. The controller consists of a chopper and an unloaded load. It plays the role of rectification and protection. The output of the DC converter system is integrated into the DC bus of the micro-grid. This plan configures 10 sets of 10kW wind generators to form a wind power generation system. This system is connected to the entire micro-grid system. When the daily power supply of the wind generator is insufficient, power is supplied to the power load through solar energy and diesel engines.

Considering that the new station has abundant wind resources, wind power can be used as the main energy source in winter. At the same time, in summer, wind power systems can also be used as micro-grid systems with photovoltaic power systems. Greatly reduce diesel consumption.

Wind energy resources at the installation site are extremely rich. Select four wind turbines with different power levels for comparison: high power traditional horizontal axis, low power traditional horizontal axis, vertical H-type and vertical rotary type. The selection of fans should consider factors such as voltage level matching, power requirements, installation conditions, space saving, convenient installation, low maintenance costs and low noise pollution

Horizontal-axis wind turbines have the advantage of being easy to load, install and maintain. At the same power, horizontal-axis generators are lighter in weight, larger in power generation, and have complete safety protection functions in strong winds. In terms of use, the average CP value of the horizontal axis is greater than 0.3, and the CP value of the vertical axis is less than 0.2. Therefore, the number of wind turbines with the same power level is much larger than that of the vertical axis.

Table 3-5 shows the parameters of alternative design of wind turbines.

Table 3- 6 Comparison of alternative design of wind turbine parameters

	Horizontal axis pitch type (Selected)	Vertical axis H type	Vertical axis rotation type	Horizontal axis yaw
Wind turbine type				
manufacturer	China AnwarANE	China MUCE	Chinese Wing	China GHREPOWER
model	AH-10K-NJ	FDM 50	UGE-9M	FD16
rated power	10 kW	50 kW	20 kW	50 kW
Quantity	10	2	5	2
Wind energy efficiency	0.45	0.2	0.2	0.42
Application conditions	strong	Medium	weak	strong
Effectiveness	All wind directions	All wind directions	All wind directions	All wind directions
Certification	CE，IEC61400，Class NK	none	CE	CE，IEC61400
Wind speed	59.5m/s	45m/s	50m/s	59.5m/s
control	Active tracking of wind direction and transmission slip ring transmission	Interrupted	Interrupted	Motor-driven, actively tracking wind direction, automatic cable disassembly
control mode	Mechanical centrifugal pitch control			yaw

Structure and load	Light weight at the same power, easy to install, without crane	Heavy weight at the same power, difficult to install	Heavy weight at the same power, difficult to install	Light weight at the same power, requiring installation of heavy equipment such as cranes
diameter	7m	22m	10m	21.5m
Pole height	8m	20m	18m	24m
windage	medium	medium	little	large
noise (dB)	50	38	38	55
Minimum operating temperature	-50	-35℃	-35℃	-40
failure rate	Low	High	Medium	medium
Maintenance	Simple	Hard	Medium	Medium
Dumping velocity ratio	6~7	1.5~2	1.5~2	6~7
Scenic beauty	harmonious	Medium	Medium	Discord

3.5. Alternative transportation routes

During the construction and operation stages of the new station, both personnel and cargoes will be shipped from home to the new station by the Xuelong. The alternatives of air and marine transportations were compared for the routes from Zhongshan Station to the new station.

3.5.1 Air plus land transportation

Air transportation route to Gerlache Inlet north of Mario Zucchelli Station and then the cargos and personnel will be transited through the land transportation. People and cargos are needed to be carried by snowmobiles and sleds for about 30 km to the proposed site. When frozen layer in Gerlache Inlet is thick, large-size airplanes such as C130 can land as well. However, this is limited to the freezing season, but not the whole summer. According to the currently available data, thick sea ice rarely forms in this region during the austral summer when most of the transportation will be made.

3.5.2 Marine plus land transportation

U.S. National Snow and Ice Data Center (NSIDC) provide ice drift distribution data near the proposed site between 2002 and 2017. The data shows that an icebreaker can gain access to the Terra Nova Bay area between mid-December and late-February, and hence the availability of the cost-effective marine transportation of construction staff, material, and equipment during the period.

According to the expedition result of the Xuelong and Xuelong 2 from 2012 to 2019, ships can approach closely up to 0.5 miles near the coast of the proposed site. The ships may then be anchored at appropriate distances from the coast, and barges can be hired to relay the cargos and equipment to land vehicles for the final hundred meters to the site. A helicopter can be used as a contingency option if ice drift impedes access during this period. This option of limited cargo capacity, however, may eventually require barges and slow the overall construction rate.

3.5.3 Evaluation of means of Transportation Alternatives

Disadvantages of people and cargos being transported by aircraft in this region during summer time include limitations of sizes and types of aircraft depending on the conditions of the runway as well as the limitations on takeoff and landing time on sea ice runways. Furthermore, uneven weather conditions of the Antarctic region increase the uncertainties of scheduling, causing aircraft delays.

Besides, small cargo capacities of aircrafts may not be suitable for carrying heavy equipment such as cranes. Aircrafts are also not as cost-effective as ships. Therefore, marine plus land transportation was selected over air plus land transportation in consideration of cost, convenience, and on-time performance under uneven weather conditions.

3.6 Alternative waste management plans

Waste management alternatives for the site construction and operation were compared considering potential impact to the Antarctic environment, particularly to the atmospheric environment, as well as the operation and management costs.

3.6.1 Incineration

On-site treatment of combustible waste with an incinerator accompanied with ash retrieval can effectively reduce the overall volume of waste. It can also prevent possible scavenging by Skua inhabiting near the proposed site.

However, gas emissions from an incinerator are expected to adversely impact the Antarctic air quality. Its operation will also increase the fuel use. A high-temperature combustion method and the multi-filtering system will minimize pollutants such as dioxin to be generated, but the additional cost associated with the operation of such systems on top of the incinerator itself is expected substantial.

3.6.2 Off-continent disposal together within-vessel composting system

Waste produced during construction and operation of the new station, after necessary treatment, can be stored and transported outside of the Antarctic region. The integrated containerized in-vessel composting system will be applied for the treatment of the food and other organic waste. This alternative is desirable as it does not adversely impact the air quality and is also cost-effective compared to the on-site incineration. The on-site treatment for storage including sorting, compacting, drying and packaging can be done with appropriate work area and an operation manual provided.

3.6.3 Magnetization pyrolysis furnace

Magnetization pyrolysis as shown in Figure 3-12, is an integrated technology of thermal energy, magnetic energy, and radiation. Under certain conditions, organic waste will be rapidly decomposed into the gas, water and inorganic substances such as ash by magnetic ionized air, making the full realization of reduction, harmless and resource purposes. Most of the waste produced during the operation of the new station has been estimated as organic waste, paper, and plastics. Magnetization pyrolysis is particularly effective for these items. Compared to the incineration process, almost no dioxin will be produced and lower temperature as 180-230 ℃ is needed. Compared to the off-continent disposal, the magnetization pyrolysis process can reduce the volume and weight of the original waste to 2%, which will greatly reduce the storage and transportation costs.

In order to keep the clean Antarctica baseline environment, considering the quantity of the solid waste during the year-round operation and the difficulty for storage and transportation in Antarctica regions, magnetization pyrolysis furnace will be suggested for the new station.

Figure 3- 17 Magnetization pyrolysis furnace

4. Initial Environmental Reference State of the Proposed Region

4.1 Location

The Ross Sea is one of the last stretches of the ocean which is minimally affected by the direct human impact. It is also one of the fastest changing environments on earth in the context of global climate change, making it a spectacular laboratory to examine the effects of climate change on the polar biota.

The proposed site is in the junction of the Ross Sea and Victoria Land, west of Terra Nova Bay, with a geographic coordinate of 74 ° 55' S,163°42'E (Figure1-1).

The new station is designed to be built on the Inexpressible Island, whose south latitude is from74 ° 50 'S to 74 ° 57' S, and from 163 ° 35 'E to 163 ° 46' E, the island is about 50km^{2}along a north-south direction. The island is surrounded by two glaciers divided from the Priestley Glacier in the north and faces the Terra Nova Bay to the east. (Figure 2-1).

Table 4- 1 Details of surroundings

Name	Location	Description
Mount Melbourne	74º21'S, 164º42'E	A massive stratovolcano that makes up the projection of the coast between Wood Bay and Terra Nova Bay, on Victoria Land.
Eisenhower Range	74º15'S, 162º15'E	a mountain range, about 72 km (45 mi) long with an altitude of 3,070 m (10,072 ft), which rises between Reeves Névé on the west, Reeves Glacier on the south, and Priestley Glacier on the north and east, on Victoria Land. The range is flat-topped and descends gradually to Reeves Névé, but is a steep cliff and marked by sharp spurs along the Priestley Glacier.
The Deep Freeze Range	74º15'S 163º45'E	A rugged mountain range, over 128 km (80 mi) long and about 16 km (10 mi) wide, situated between Priestley and Campbell glaciers on Victoria Land, and extending from the edge of the polar plateau to Terra Nova Bay.
Cape Russell	74º54'S, 163º54'E	A rock cape in Terra Nova Bay along the coast of Victoria Land, forming the southern extremity of the Northern Foothills.
Mount Larsen	74°51'S, 162°12'E	A mountain, peaked at1,560 m, with sheer granite cliffs on the northern side, situated 0.6 nautical miles (6 km) southwest of Hansen Nunatak at the southern side of the mouth of Reeves Glacier.
Mount	74°59'S,	A prominent mountain of 980 meters (3,220 ft) high, standing on

Name	Location	Description
Gerlache	162°26'E	the northeast side of Larsen Glacier between Widowmaker Pass and the Backstairs Passage Glacier, in Victoria Land, Antarctica.
Mount Crummer	75°3'S, 162°34'E	A massive, brown granite mountain, 895 meters (2,940 ft) high, immediately south of Backstairs Passage Glacier on the coast of Victoria Land.
Campbell Glacier Tongue	74°36'S, 164°24'E	The seaward extension of Campbell Glacier into the northern Terra Nova Bay, on the coast of Victoria Land.
Campbell Glacier	74°25'S, 164°22'E	A glacier, about 60 nautical miles (110 km) long, originating near the southern end of the Mesa Range and draining towards southeast between the Deep Freeze Range and Mount Melbourne and discharging into the north Terra Nova Bay.
Priestley Glacier	74°20'S, 163°22'E	A major valley glacier, about 96 km (60 mi) long, originating from the edge of the polar plateau of Victoria Land. The glacier drains southeast between the Deep Freeze and Eisenhower ranges to enter the northern end of the Nansen Ice Sheet.
Reeves Glacier	74°45'S, 162°15'E	A broad glacier originating from the interior upland and descending between the Eisenhower Range and Mount Larsen and merging with the Nansen Ice Sheet along with the coast of Victoria Land.
Larsen Glacier	75°6'S, 162°28'E	A glacier flowing southeast from the Reeves Neve, through the Prince Albert Mountains and entering the Ross Sea just south of the Mount Crummeron Victoria Land.
David Glacier	75°19'S, 162°00'E	The most imposing outlet glacieronVictoria Land fed by two main flows which drain an area larger than 200,000 square kilometers of the East Antarctic plateau, with an estimated ice discharge rate of 7.8 +/- 0.7 km^3/year.
Terra Nova Bay	74°50'S, 164°30'E	A bay which is often ice free, about 64 km (40 mi) long, lying between Cape Washington and the Drygalski Ice Tongue along the coast of Victoria Land.

In addition, three other stations have been built on the northeast part of the new station. They are Italian Mario Zucchelli Station, German Gondwana Station and Jang Bogo Station of Republic of Korean. They are 29 kilometers, 37 kilometers and 38 kilometers apart from the new station, respectively.

4.2 Topography and Geology

4.2.1 The geological and geomorphological features of the Inexpressible Island

The Inexpressible Island is in the south of the Terra Nova Bay where east Antarctic continent the Ross Sea meets the Victoria Land. The geographical coordinates are 74°50'- 74°57' S, 163°35'- 163°46' E. The island has an area of about 50 square kilometers, the overall north-south diamond type. The north, west and south sides of the island are glaciers, the north side is the PRIESTLEY glacier, the west and south sides are Nansen Ice Sheet, and the east side is near the Terra Nova Bay of the Ross Sea (Fig. 4-1).

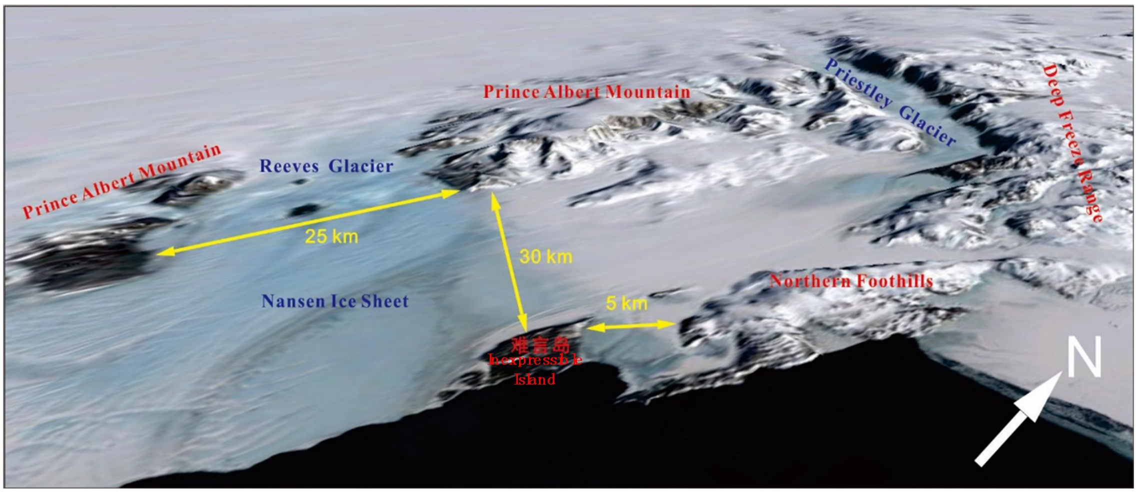


Figure 4- 1 The location of the Inexpressible Island

The Inexpressible Island is characterized by the topography East-West high low. Its west side is a ridge towards the north and south, the highest elevation reached 370.2 m. Its eastern part consists of several trenches with northwest-southeast direction, three trenches developed from north to south (Fig.4-2). The northern valley is mainly inhabited by penguins, the whole slope is sloping, the southeast gradually increased to the northwest; the central concave valley is the preselected site area of the early investigation, the terrain is overall level, the average altitude is about 10m, and there is a high gap of about 5m near the eastern coastline; the southern valley is located on the north side of the new preselected area, the terrain is level, the average elevation is about 40m, and gets steeper near the shoreline.

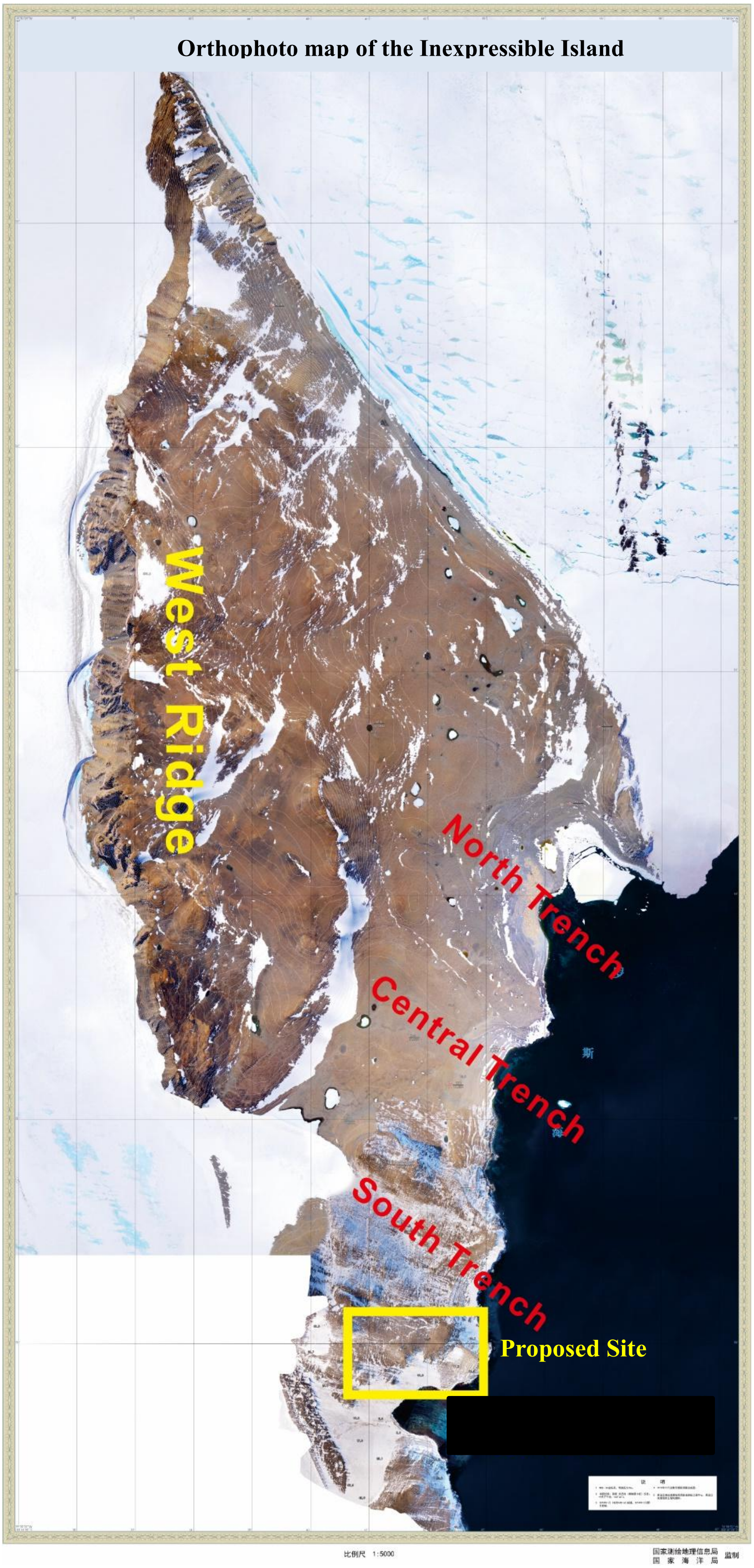


Figure 4- 2 Topographic characters of the Inexpressible Island

The Inexpressible Island is located at the Ross Orogenic Belt in the regional structural location, which represents the collision between southern Antarctica continent and peripheral plates in the early Paleozoic period, and there are many Paleozoic magmatic rocks have been developed in this tectonics belt. Influenced by Cenozoic tectonic activities in this tectonic belt, many Cenozoic volcanic rocks and the north-west trend fractures are also developed. The most recently active volcano near the Inexpressible Island is the Melbourne Mountain. This volcano mountain is in the northeast direction to the Inexpressible Island with the distance of about 60 km.

The geological survey and mapping of 2013-2017, except that some areas are covered by snow cover, the main material composition of the Inexpressible Island could be basically clear. The surface of the Inexpressible Island is covered by the moraine deposit; bedrock is mainly exposed to the western ridge and the eastern coastline, and some higher top of the hill (Fig.4-3). In addition, there is a typical modern coastal accumulation in the coastal attachment. There are also large melting lakes in the central and northern valleys and in the middle ground, most of the lakes are salt water, and a small amount is freshwater (Fig.4-3).

The rock in the bedrock area is mainly monzonite and granite dikes, there are also some diabase dikes and trachybasalt (Fig.4-4). The monzonite is the maximum exposed area rock type in the Inexpressible Island region, there is a strong cleavage structure in the rock, which is the result of the interaction between early geological structure and presented glacial thaw (Fig.4-5).

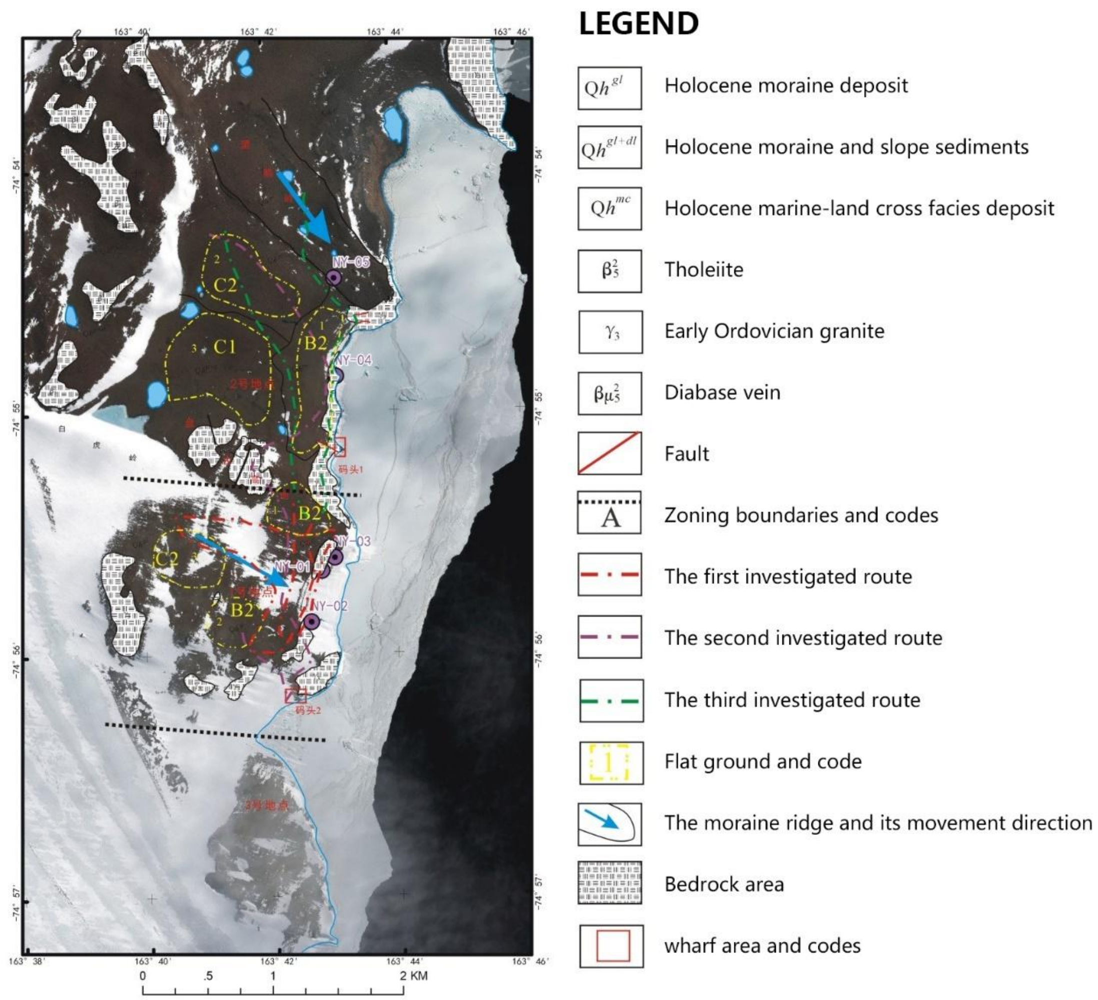


Figure 4- 3 The surface rock characters of the Inexpressible Island

(Base Map: WorldView2 February 2012)

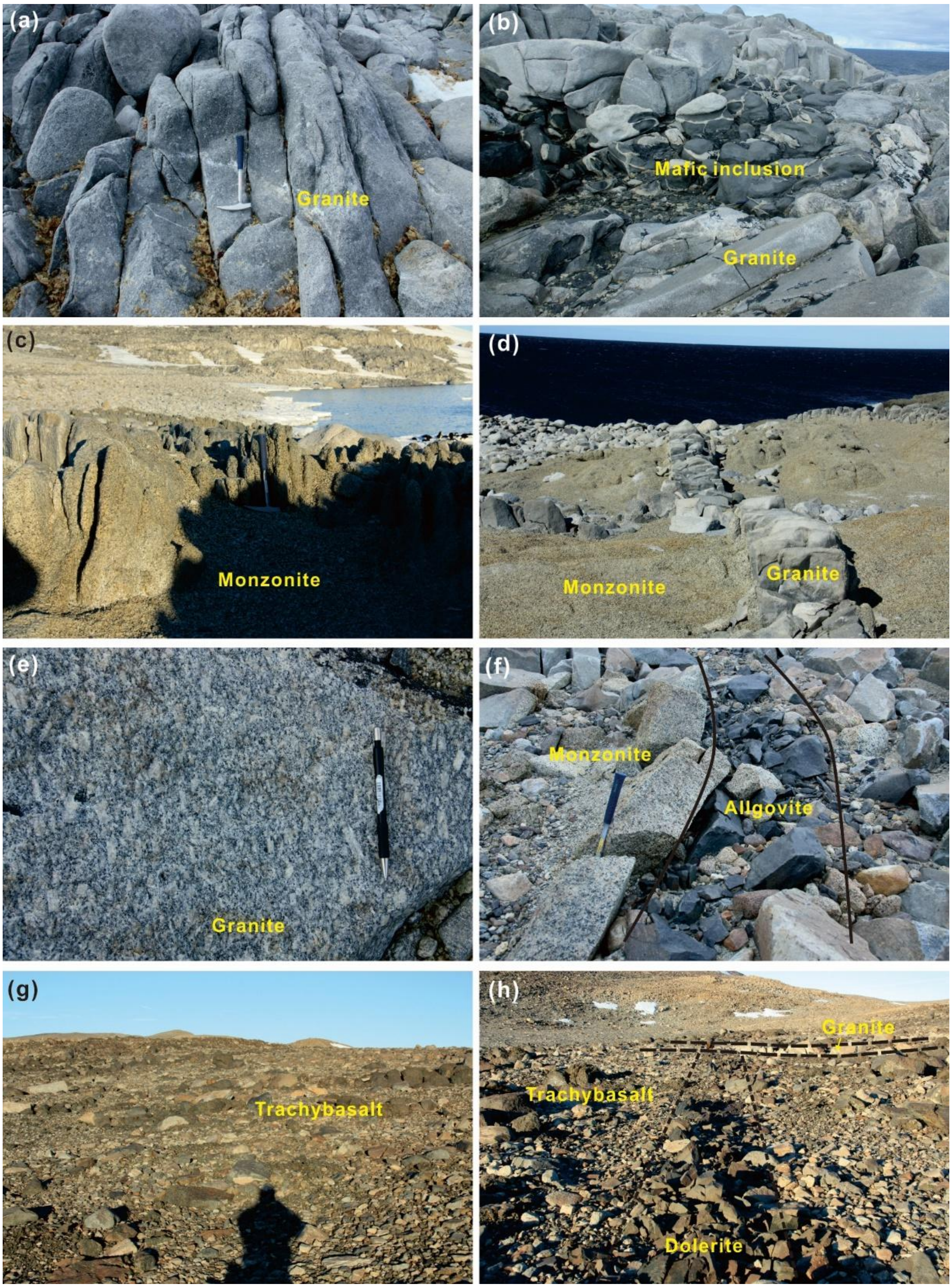


Figure 4- 4 The rock characters in the bedrock area

Figure 4- 5 The cleavage planes in the Monzonite

4.2.2 The geological and geomorphological features of the proposed site

The new station locates at the southern tip of the island, both north and south are concave valleys, and the south side is a bay with a north-south width of about 500m and east-west length of about 600m. The new station area is generally characterized by the west high east low in topography, and there are three geomorphic steps (Fig.4-6). The eastern step (Plate1) near the coastline, the average altitude is about 10m, and the terrain is relatively flat, the slope is less than 5°. This step is generally rectangular, which is about 500m in length and the width is about 300 m, and the total area is about 150,000 m^2. The central step (Plate2) and the eastern step have about 30m geomorphic scarp. The central step is generally low-grade, the average altitude is about 50 meters, and the slope is less than 10°. This step is generally in an oval shape with the length of about 1200m and about 500m width, the area is about 0.6 km^2. the western steps (Plate3) are close to the Nansen ice shelf, the terrain is overall level, but the average elevation reached to 90m, the step is generally rounded with a diameter about 250 m, and the area is about 200,000 m^2.

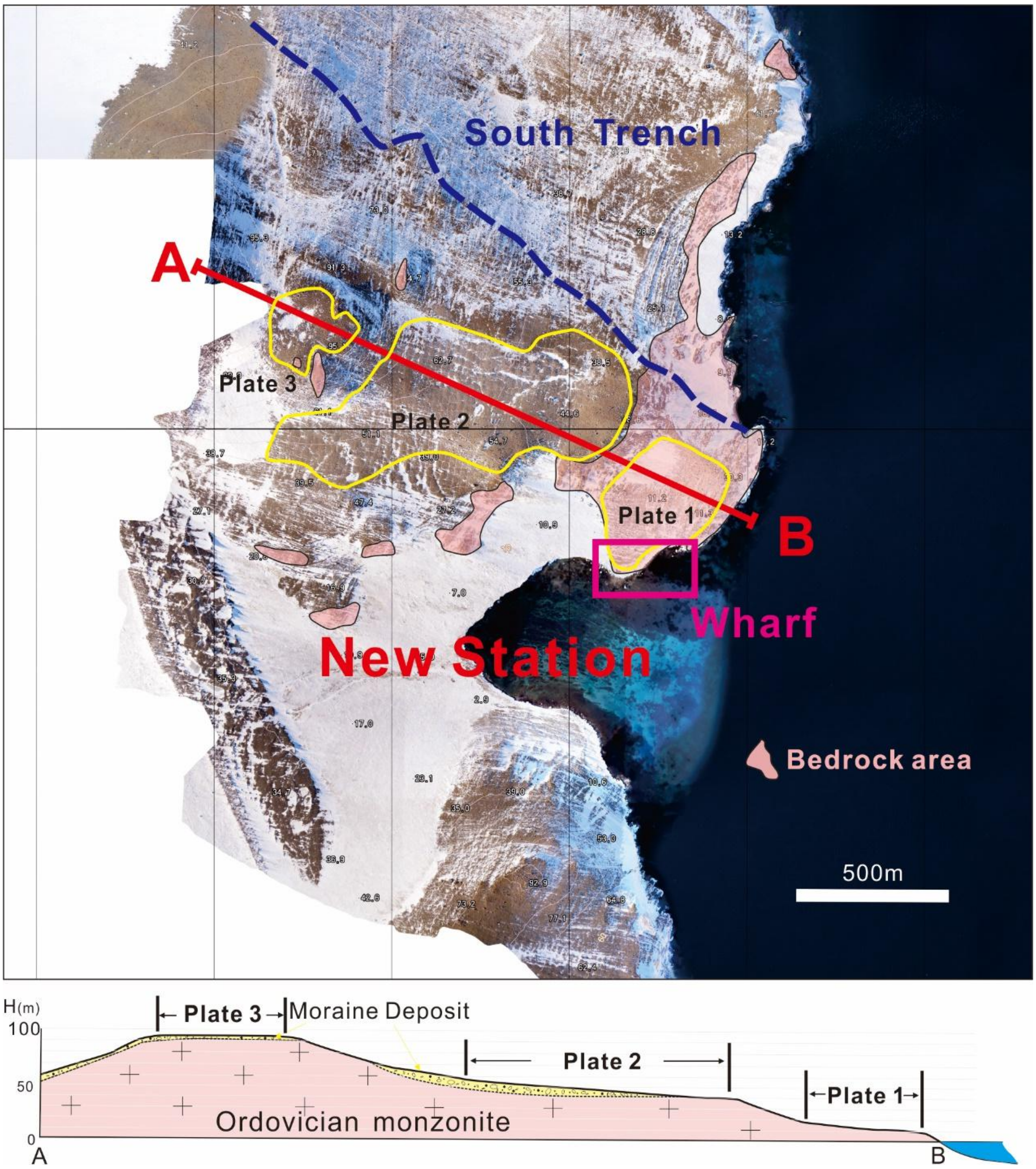


Figure 4- 6 The topographic and geological characters of the new station area

The geological and geomorphological features of the proposed site in the southern part of the Inexpressible Island are consistent with the overall characteristics of the Inexpressible Island region.

In the geomorphology, the general geomorphology near the new station area has the characteristics of low-West High East, the west and south sides are the glacier channel. The region is generally NNW-SEE trending, fit the movement of the glacier. The average elevation of the area is about 40-50 m, and the length is about 1500 m, and ~500 m for the width. And the topography is a stairway（Fig 4-6）. In isolated peaks and near shoreline areas there is bedrock outcrop, most of the rest is covered by moraine（Fig 4-6）.

The granite bedrock is mainly distributed along the coastline. The main lithology is medium coarse-grained monzonite, massive structure, and the main mineral composition is feldspar and plagioclase, with a small amount of quartz and biotite. The rock is weathered with sugar-granular and cactus landform（Fig 4-7）. A steep cliff along the coast, the height is about 10 meters, and two granite veins were found. The characteristics of the bedrock above are consistent with that of the Inexpressible Island.

Figure 4- 7 The outcropping characteristics of the Monzonite in the new station area

The moraine in this area is mixed with glacial drifts of different sizes, gravel diameter is mainly 5-10 cm, the gravel has a sharp edge, and composition has granite, gneiss, basalt and so on. In the moraine area, a series of the "grid" of frost bulge cracks which towards N-S and W-E are intersected found in the field trips. And near the coast, form a set of arc-shaped moraine furrows parallel to the shore（Fig 4-8）, terraces shaped, it is reflected that the early moraine gravel has been subjected to the late seawater erosion. These features are the same with the moraine properties that are exposed in the Inexpressible Island region.

Figure 4- 8 Arcuate moraine ridge

Much of the coastline in the area is covered with ice and snow, However, the coastal area is mainly bedrock coast based on the characteristics of outcropping rock（Fig 4-9), this is different to the modern coastal gravel deposits in other parts of the island.

Figure 4- 9 Characteristics of coastal outcrop

In general, the terrain of the proposed site is high in the east and low in the west, high in the north and south, and low in the middle. The landform types are modern marine accumulation and moraine accumulation. The standard terrain elevation of the proposed site is about 6m-30m, and the exposed stratum is the Caledonian Meso-Palaeozoic Silurian Quaternary, including moraine deposits, modern marine deposits and granite strata.

The engineering geological survey of the proposed site has limited reference materials. The detailed survey has been carried out during the 30th Chinese Antarctic Expedition in January 2014 and the 31st Chinese Antarctic Expedition in January 2015. Combining the experience of previous Antarctic projects, considering the minimization of on-site construction projects and environmental impact, after careful consideration, we chose a relatively flat area for the proposed site. The elevated structure does not require ground leveling, and other buildings will be leveled on the spot.

In January 2014 and January 2015, geological exploration was carried out on the proposed area, as shown in Figure 4-10. This area is a hilly area with shallow bedrock exposed, and the cast-in-place reinforced concrete pier foundation anchored by the rock can be directly applied to the bedrock. At present, we plan to learn from the construction experience of Zhongshan Station. Buildings, turbines and other supporting facilities will use rock anchoring technology that has the least impact on the current environment.

The intrusive rocks of the Silurian in the Caledonian, Meso-Palaeozoic, are mainly formed by intrusive magmatic rocks, such as granite, which can be divided into two types: fine-grained granite and coarse-grained granite, which are distributed throughout the proposed site. Coarse-grained granite is the main rock type, accounting for 80-90% of the whole, and fine-grained granite is intrusive, with a width ranging from 5-10 cm. This investigation failed to drill through the formation, so its thickness is unclear. The picture below shows an example of a drilled core.

Figure 4- 10 Geological characteristics investigation of the proposed site in December 2014

The Stone drift stratum and the weathered granite stratum of the site can be used as the natural ground-holding stratum of the proposed road. The main structure part is recommended to use the weathered granite as the basic holding stratum.

Based on the results of surface geological and engineering survey, we chose the most representative float stone soil and granite in the Inexpressible Island region to test the various types of rock property parameters. It mainly consists of natural density γ (KN/m^3), the characteristic value of bearing capacity fak (kPa) and fa (kPa), modulus of compression Es (Mpa) and modulus of deformation E0 (Mpa). The results showed that the bearing capacity is high for the bedrock in Inexpressible Island as shown in Table 2-19.

Table 2-19 Main parameters obtained from the on-site geological investigation

Name of the geotechnical	Rate of decay	Natural density	Characteristic value of bearing capacity	Modulus of deformation	Modulus of compression
		γ（kN/m^3）	f_{ak} (f_a)(kPa)	E_0 (MPa)	E_s (MPa)
Boulders soil	medium density	23.50	500	35.0	18.0
Fine-grained granite	Central weathered	25.40	10000		incompressible stratum
Coarse-grained granite	Central weathered	25.84	6000		incompressible stratum
Monzonite	Central weathered	26.79	13000		incompressible stratum

4.2.3 Supplementary survey of geological features of the new station area

In the summer of 2018 and 2019, according to the architectural features of the main building and logistics center, a total of 10 exploration holes were arranged; for new energy, satellite ground stations and expansion land, a total of 12 exploration holes were completed, and the final hole depth 4.0 to 10.1 meters, with a total footage of 93.0 meters; 4 exploration pits with a depth of 1.4 to 2.2 meters, with a total footage of 7.1 meters. The total footage is 100.1 meters. The longest core is about 1.4 meters.

The survey showed that no adverse geological effects were found in or near the proposed site, and no active faults passed through the site. The proposed site is a stable site.

The landform unit of the proposed site is single, and the stratum of the site exposed within the survey depth of 10.1m in this survey is mainly gravel, block stone and slightly weathered monzonitic granite. Therefore, the foundation of the proposed site is uneven foundation.

The special rock and soil within the scope of the proposed site for this survey is frozen soil. Divided into two kinds of seasonal frozen soil and permafrost. Because the content of particles with a particle size of less than 0.075mm in the site is not more than 15%, the site's rocky soil and seasonal frozen soil are less frozen soils, and the thawing sedimentation level is non-thaw sedimentation. The foundation soil cannot be considered in the design. Melt down impact.

Seawater is moderately corrosive to concrete structures and highly corrosive to the steel bars in concrete structures. Groundwater (snow melt water) is slightly corrosive to concrete structures according to environmental types and stratum permeability, to steel bars in concrete structures under long-term immersion in water, and moderately corrosive under alternate dry and wet conditions. Shallow soil is slightly corrosive to concrete structures, moderately corrosive to steel bars in concrete structures, and slightly corrosive to steel structures.

According to the analysis of the ground temperature observation results in the site by Professor Wang Ninglian of Northwest University on January 24, 2019 (shown in Figure 4-11): The depth of influence of frost heave and thaw settlement of the frozen soil layer is about 0.6 meters; during the 36th team research period, according to the excavation According to the exposure of the 4 exploration pits, the depth of influence of frost heave and thaw settlement of the frozen soil layer is 0.8 meters. Considering that the observed time node is not necessarily the highest temperature in the past years on site, it is recommended that the depth of influence of frost heave and thaw settlement in the foundation design is less than 1.5 meters.

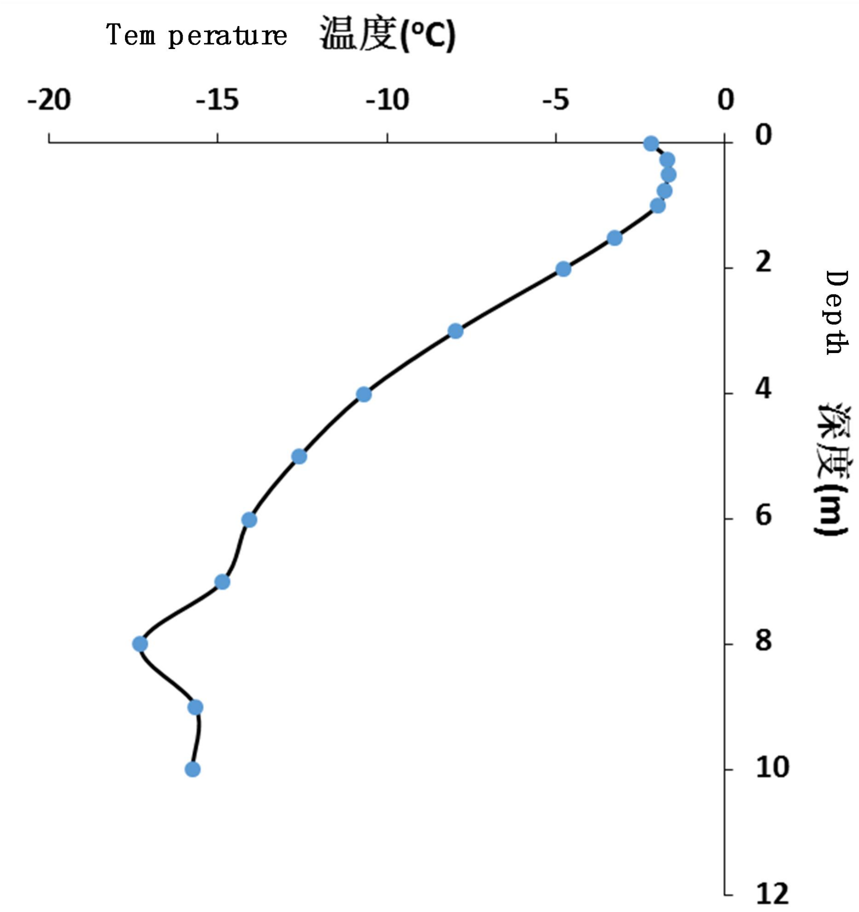


Figure 4- 11 Temperature-depth change graph

4.3 Sea ice

4.3.1 Analysis of long-term ice conditions in the Ross Sea area (1978-2017)

According to the sea ice conditions based on the data provided by NSIDC, the earliest suitable time for expedition sailing into the Terra Nova Bay is in late December. Sea ice continues to decrease in January and reaches its minimum coverage of the year in February, the most suitable time for ship based in situ investigation. Sea ice begins to freeze in late March, and sea ice covers the entire Ross Sea till late March. The maximum sea ice is in August as shown in Figure 4-12.

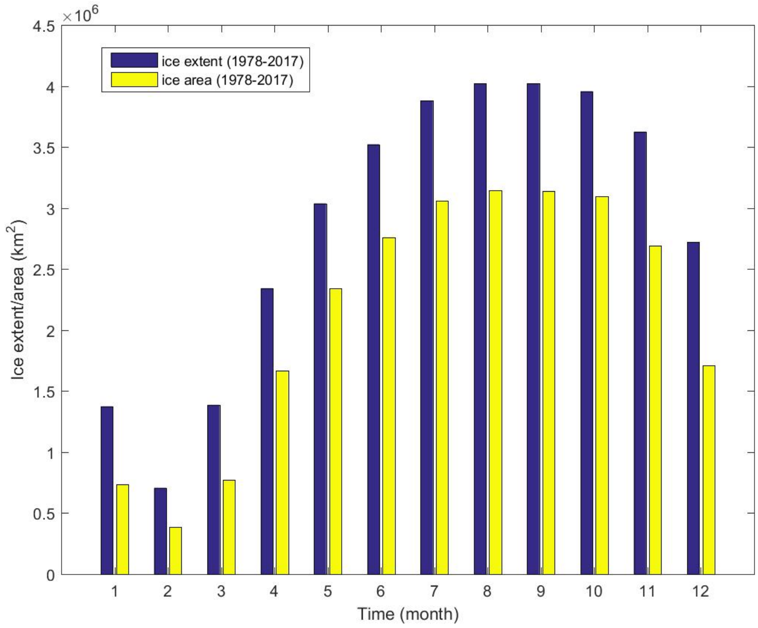


Figure 4- 12 Monthly variations of sea ice coverage and area in the Ross Sea (1978-2017)

4.3.2 Analysis of ice conditions in the Ross Sea area during summer seasons (2012-2017)

In December, the sea ice extent is around 63°S, the sea ice condition is serious but most of the polynya is open water. The concentration of the sea ice is around 50 to 70 percent existing in the western Ross Sea southern than 75°S with the width more than 200 km as shown in Figure 4-13 a.

In January, the sea ice melt quickly, the concentration of the sea ice between 175°E-175°W is only 10 to 20 percent, the polynya in the northern Ross Sea is increasing and the width of the floating ice in the southern Ross Sea has decreased, and the concentration decreasing too as shown in Figure 4-13 b.

In February, the sea ice extent is around 71°S, and the sea ice southern than 75°S has decreased significantly and most of the area is below 10 percent as shown in Figure 4-13 c.

In March, the sea ice increasing very quickly, the extent of the sea ice has reached 69°S, and the concentration of the sea ice between the area of 160°E to 145°W remains as shown in Figure 4-13 d.

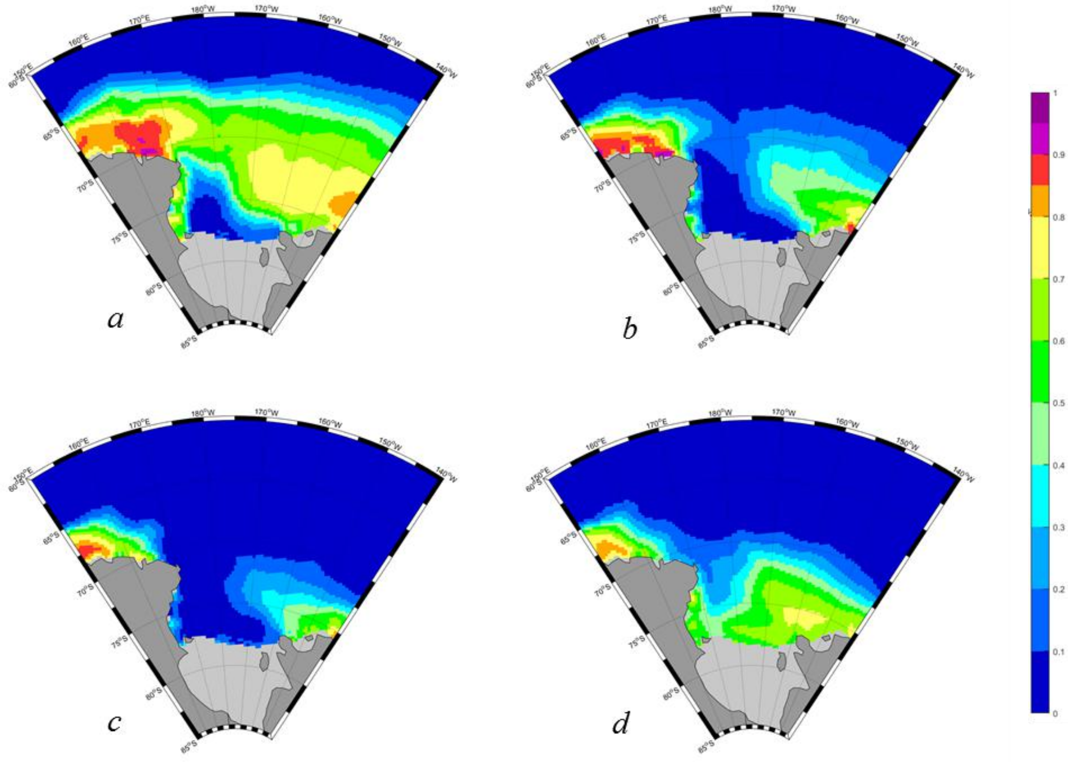


Figure 4- 13 The average sea ice coverage and concentration in the Ross Sea during December to March

Note:（a、December，b、January，c、February，d、March）（1978−2017），(light gray is Ross Shelf and the dark gray is continent)

According to the detailed analysis of the sea ice conditions from December to March as shown in Figure 4-14, the Ross Sea polynya gradually expanded northward through the entire Ross Sea. After March, the sea ice will grow rapidly. The best time for the icebreakers will be January and February.

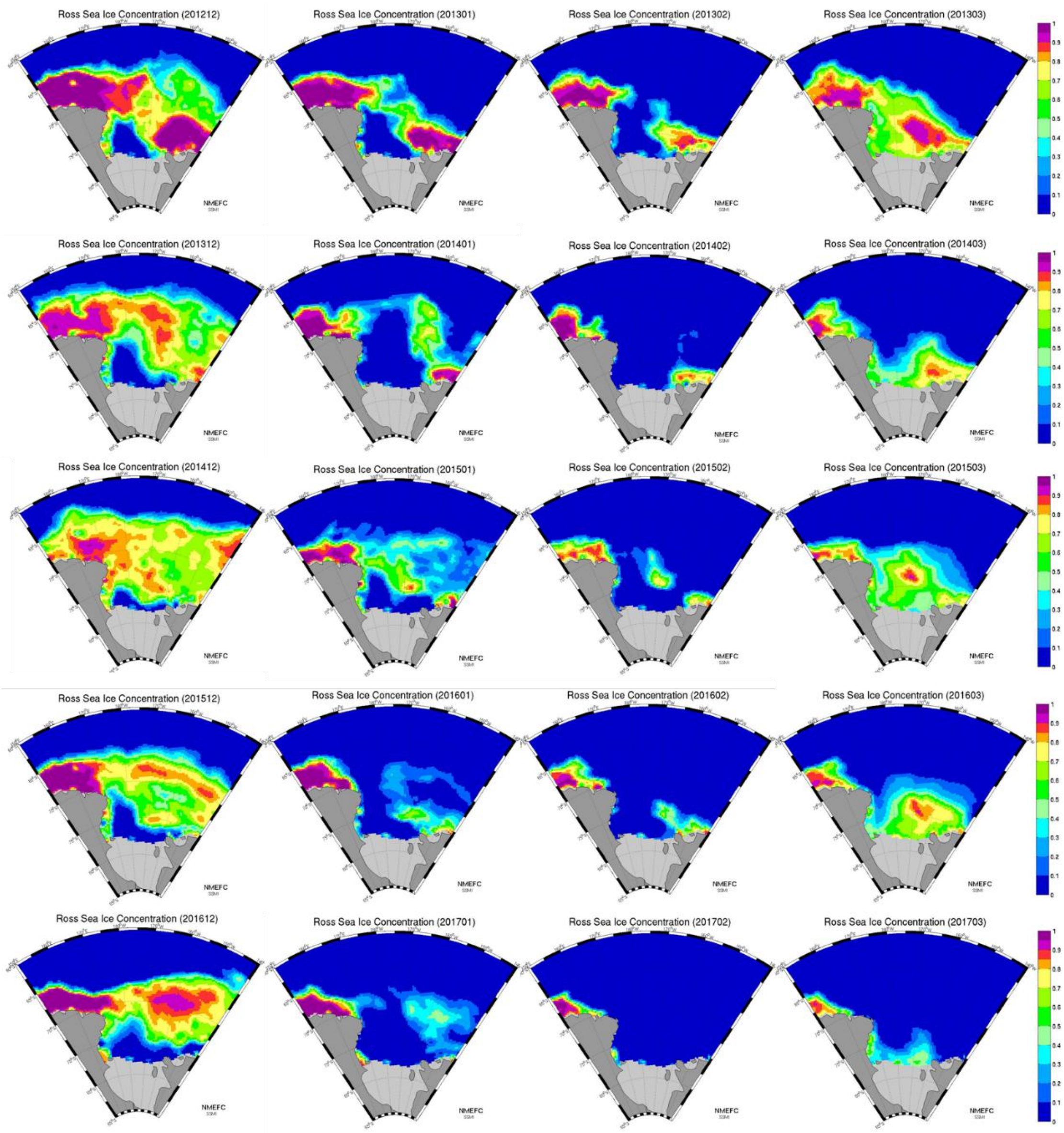


Figure 4- 14 Monthly average of the sea ice concentration in the Ross Sea during
December 2012 to March 2013 (a)、December 2013 to March 2014 (b)、December 2014 to March 2015 (c)、December 2015 to March 2016 (d)、December 2016 to March 2017 (e)

4.4. Glaciers and snow

4.4.1 Glaciers

According to data available from the National Ice Center, of the 53 icebergs larger than 1000 km^2 that have calved into Southern Ocean waters since 1976, more than 50% (28) traveled northward at speeds of below 1 km d^{-1}.

Reeves Glacier (74°45′S 162°15′E) is a broad glacier originating on the interior upland and descending between Eisenhower Range and Mount Larsen to merge with the Nansen Ice Sheet along with the coast of Victoria Land. It was discovered and named by the British

Antarctic Expedition, 1907–09, under Shackleton. The New Zealand Antarctic Place-Names Committee (NZ-APC) reported that the glacier was probably named after William Pember Reeves, former New Zealand Cabinet Minister, and the Agent-General for New Zealand in London, 1896-1909.

When Reeves Glacier flows into Nansen Ice Sheet it divides into three streams because of the interaction with Teall Nunatak and buried topography, which creates the divergence. The Priestley and Reeves glaciers are the main paths through which the cold, gravity-driven air flows from the Antarctic plateau toward the bay.

Larsen Glacier (75°6′S 162°28′E) is a glacier flowing southeast from Reeves Neve, through the Prince Albert Mountains and entering the Ross Sea just south of Mount Crummer in Victoria Land. It was discovered by the South Magnetic Party of the Shackleton Expedition during 1907 to 1909, who followed its course on their way to the plateau area beyond. They named it Larsen Glacier because it flowed past the foot of Mount Larsen, which was constantly in view as they ascended the course of the glacier.

David Glacier is the most imposing outlet glacier in Victoria Land, Antarctica, fed by two main flows which drain an area larger than 200,000 km^2 of the East Antarctic plateau, with an estimated ice discharge rate of 7.8 ± 0.7 km^3/year. The northern flow drains from Talos Dome to the Ross Sea, but the main branch of the stream is fed by a network of tributaries which drain a common area of the inner plateau around Dome C and converge in a spectacular icefall normally known as the David Cauldron. As the David Glacier flows into the Ross Sea, it forms a floating mass known as the Drygalski Ice Tongue.

4.4.2 Snow

Snow transportation by saltation (within 0.3 m in elevation) starts at wind speeds of between 2 and 5 m/s, transportation by suspension (drift snow) starts at velocities faster than 5 m/s (within 2 m), and blowing snow (snow transportation higher than 2 m) starts at velocities between 7 and 11 m/s (see Frezzotti et al. 2004 and references therein).

Snow accumulation at Terra Nova Bay is about 150–200 kg m^{-2} $year^{-1}$(Stenni et al. 2000, Frezzotti et al. 2004) in a relatively undisturbed wind area. The Larsen site Q_T (2.5 × 10^6 kg m^{-1} $year^{-1}$), integrated over a 12 m height, is about four orders of magnitude greater than the annual snow accumulation. At the MidPoint site, Q_T is about 0.05 × 10^6 kg m^{-1} $year^{-1}$, three orders of magnitude greater than the snow accumulation (40–60 kg m^{-2} $year^{-1}$).

There is heavy snowing on the most parts of the island. But there is perennial snow on the leeward, and the positions and ranges of the perennial snow in different years are nearly in the same places. In the rest areas, the snow-cover will disappear in a short period and leave a thin layer. The reason is presumed to be katabatic wind and temperature as shown in Figure 4-15.

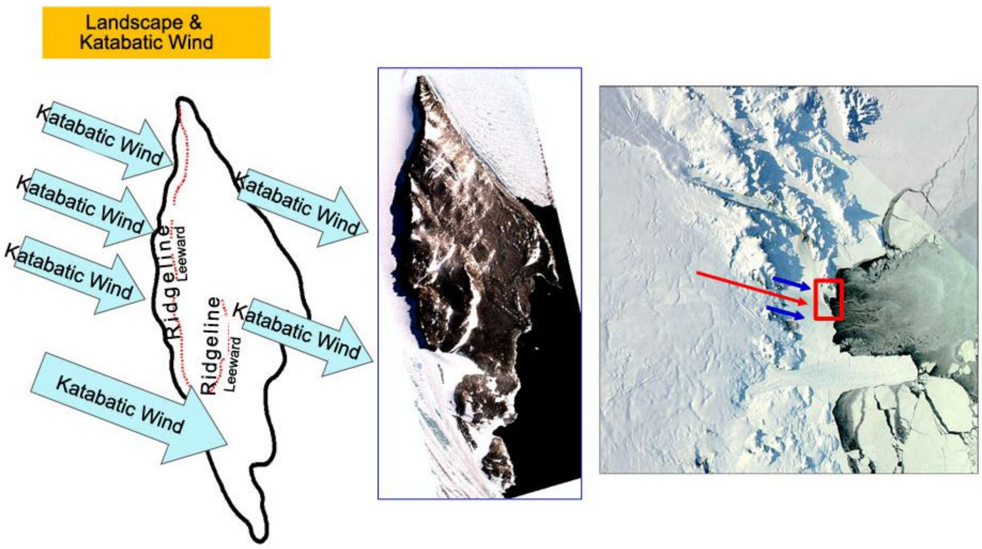


Figure 4- 15 Katabatic wind in the proposed site

4.5 Climate

The proposed site is in the Antarctic hinterland, facing the Terra Nova Bay. Because of steep terrain from the inland to coast and the canyon effect caused by the nearby glacier canyon, the katabatic wind is most common in this region. Meanwhile, influenced by the local topography, great wind speed changes within short distances may occur.

The Inexpressible Island is located in the Terra Nova Bay on Victoria's north-west Rothschild, Antarctica, with the Reeves Glacier to the west. To the north of the glacier is a towering mountain with the narrow Priestley glacier to the north of the mountain. South of the Inexpressible Island is David Glacier and the associated Dryglaski ice tongue. Foreign observations and studies show that the Terra Nova Bay is one of the strongest descending wind areas in the Antarctic. The strong descending wind flows along the glaciers and blows sea ice off the coast to form a perennial polynya.

In December 2012, a new Automatic Weather System has been installed at the proposed site as shown in Figure 4-16. The AWS Manuela is close to the proposed site and the long-term climate data is available.

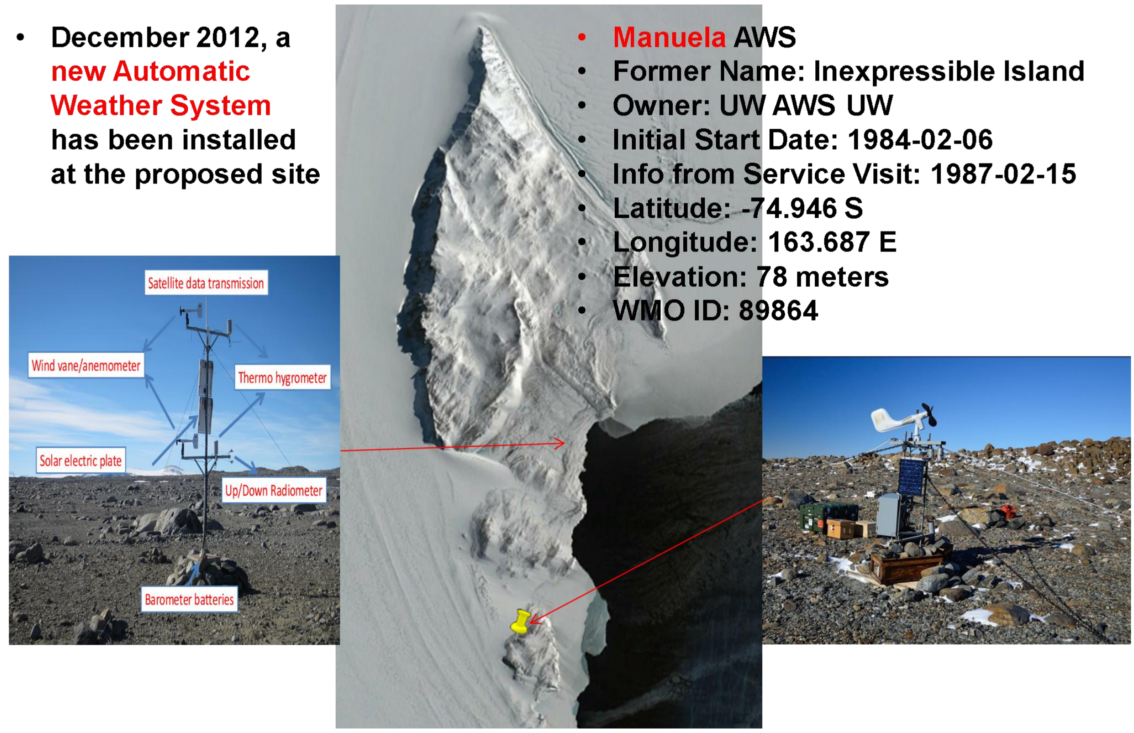


Figure 4- 16 Automatic Weather System installed at the proposed site

4.5.1 Long-term climate data analysis (AWS Manuela)

4.5.1.1 Temperature

The temperature variation from AWS Manuela (1988-2012) is given in Figure 4-17. Apparently, the temperature has significant seasonal variation caused by the regular reciprocating motion between hemispheres of the sub-solar point. The average temperature of observed years is -18.5 ℃. The observed minimum annual mean temperature is -19.2 ℃ (1998) while the maximum is -17.4℃ (2012). The lowest value is -40.6℃ (Sept.2nd, 1992) of daily mean and -42.3℃ (Sept 1st, 1992) of instant value. In summer, the daily mean value is above 0℃ in most 17 years except in 1992, 2000 and 2011, with the highest value of 2.8℃ (Jan 11th, 2002) of daily mean and 6.9℃ (Dec 26th, 2010) of instant value. The average daily mean temperature above 0℃ lasting in a year is 2.4 days with the longest time of 11 days in 2010, while in other situations daily mean temperature below -35℃ lasting in a year is 4.2 days with the longest time of 9 days in 1997.

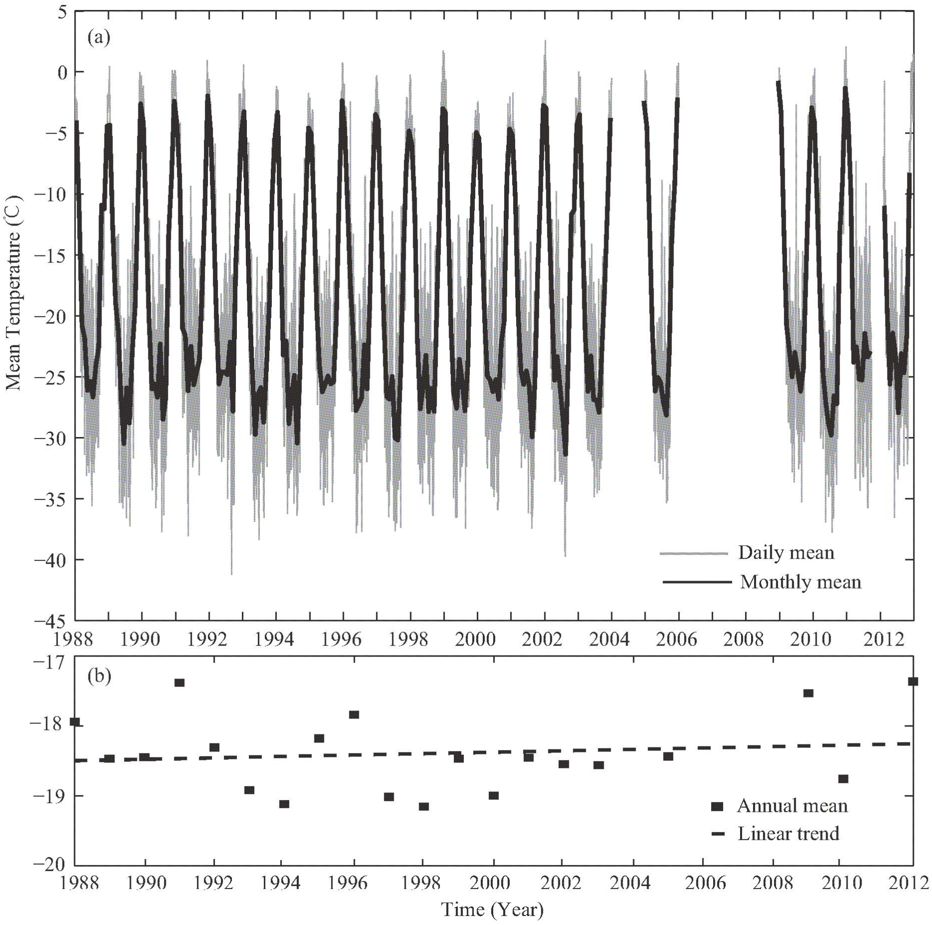


Figure 4- 17 Time series of observed temperature at AWS Manuela (1988-2012)

(Daily mean (a, grey line), monthly mean (a, black line), and annual mean (b, dot) and linear trend (b, dashed line) were shown.)

4.5.1.2 Wind velocity and direction

According to the wind speed and wind direction based on the observation data during 1988-2012 at AWS Manuela, the average yearly wind speed was 12.0m/s and the wind direction was 265.3° (westerly) as shown in Figure 4-18. Observed instantaneous wind speed could peak at 43.5m/s (July 2003) and the maximum value of daily mean speed was 34.2m/s (July 1989).

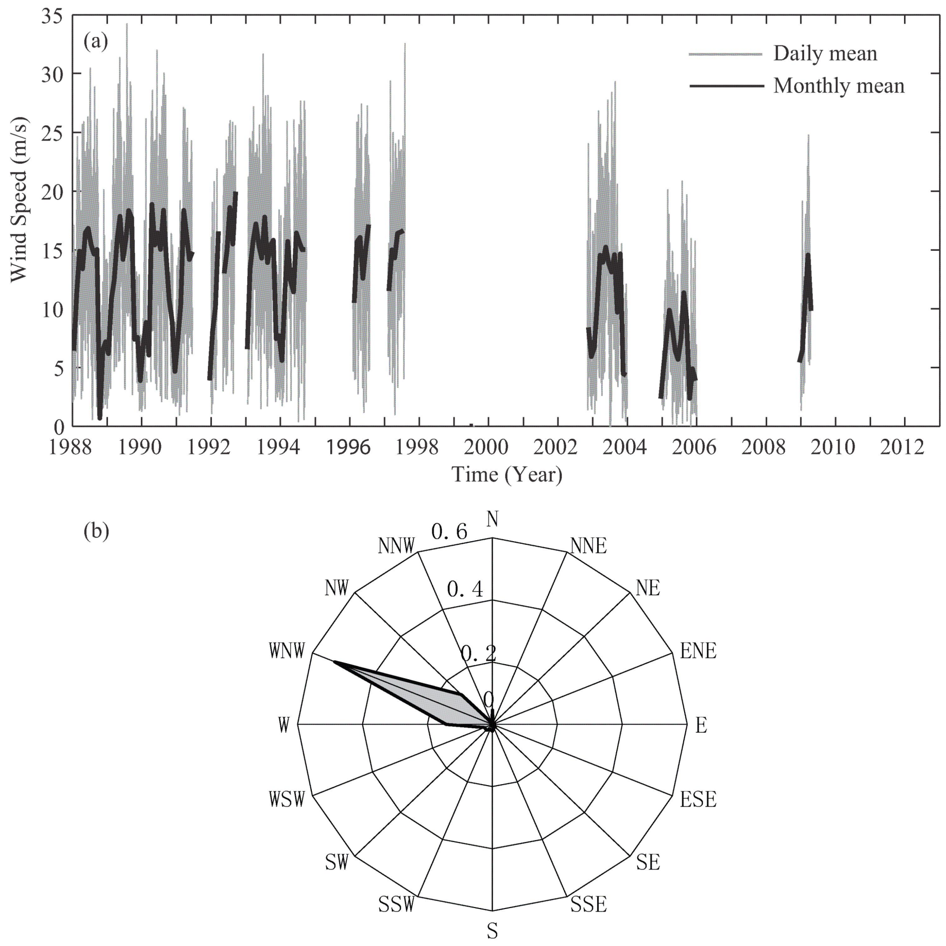


Figure 4- 18 Time series of observed wind speed and direction at AWS Manuela

(Grey line is daily value and the black line is monthly value.)

During November-January the wind speed was under 15m/s in 90% cases, indicating the main distribution range in these months. More than half cases in December and January observed wind speed was under 5 m/s and never surpassed 35 m/s. In February the main distribution range was between 5~15 m/s in nearly 60% cases and never surpassed 35 m/s as well. During March to June, wind speed between 5~15 m/s and 15~25 m/s are regarded as the main distribution range. Wind speed at 35 m/s occurred in this period. During July to September, the wind speed between 15~25 m/s ranged 40% and that was regarded as the main case while 5~15m/s ranged 30% and that was regarded as the second distribution range. Wind speed between 25~35 m/s ranged more than 10% and in approximately 1% cases the speed could reach more than 35 m/s.

4.5.1.3 Humidity

The observed variation of relative humidity at AWS Manuela is shown in Figure 4-19. With a multi-year average value of 45%, the relative humidity was low in this site.

In more than 72% of the time the relative humidity was between 30%-60%, while it is only 16% when the value was above 60%.

Except in cloudy and snowy weather when relative humidity was higher than 60%, the relative humidity maintained at 30% - 50% in the rest of the time.

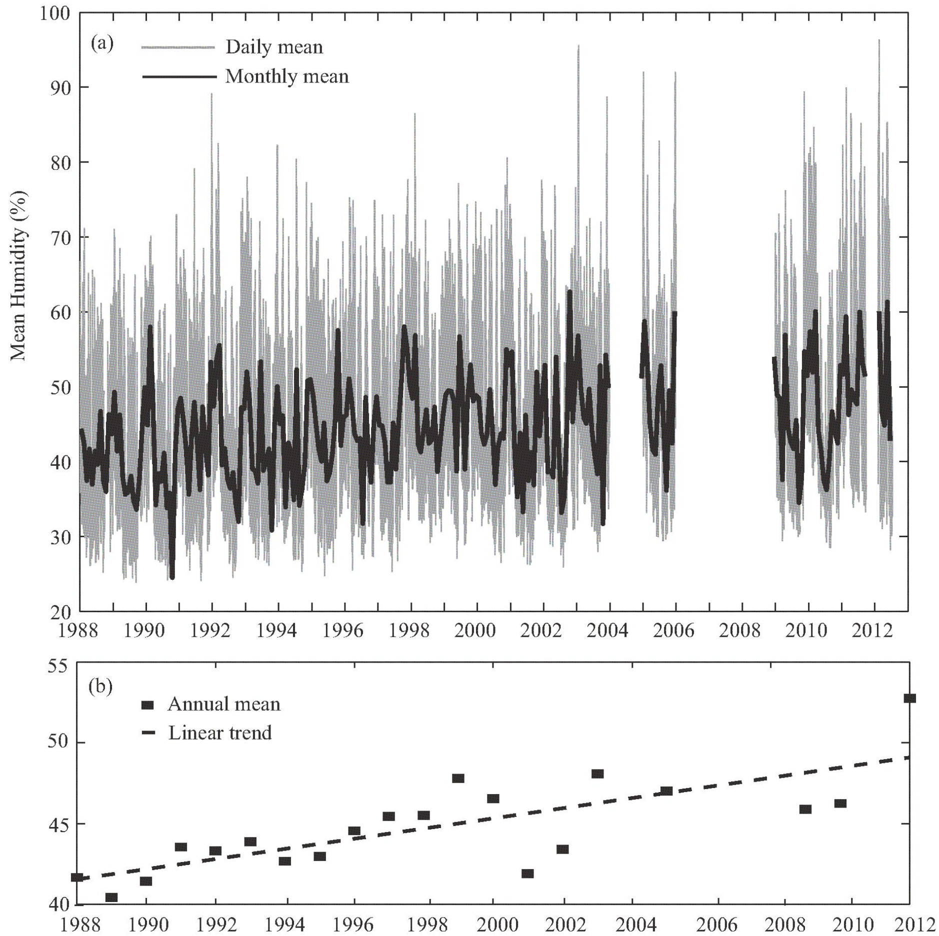


Figure 4- 19 Time series of observed humidity at AWS Manuela (1988-2012)

(Daily mean (a, grey line), monthly mean (a, black line), and annual mean (b, dot) and linear trend (b, dashed line) were shown.)

4.5.1.4 Air Pressure

The observed air pressure variation at AWS Manuela is shown in Figure 4-20 with an average value of 979.7hPa. Without obvious monthly pressure change, the maximum value was 984.40 ± 6.55hPa in June and minimum was 977.36 ± 4.48hPa in November (the comparative lowest value was not considered because the data of October were only available for two years). The average atmospheric pressure was almost constant between 970-985hPayear-round with a standard deviation between 3-6hPa in each month.

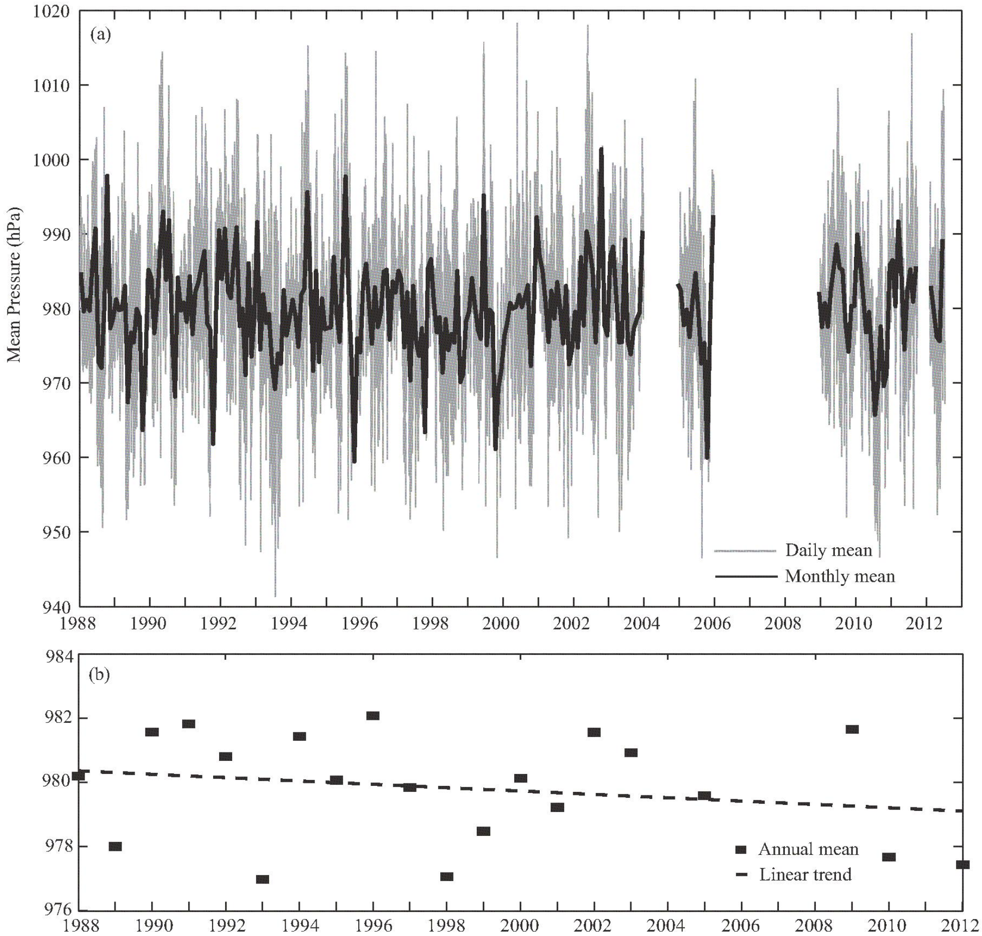


Figure 4- 20 Time series of observed pressure from AWS Manuela, daily mean (a, grey line), monthly mean (a, black line), annual mean (b, dot) and linear trend (b, dashed line) were shown.

4.5.2 Monthly average climate data analysis (AWS Manuela and AWS China new)

4.5.2.1 Temperature

Comparing the monthly climate data from 2012 to 2017, the trend of the temperature on the Island is similar and has significant seasonal variation as shown in Figure 4-21. The highest monthly average temperature is in December and January all above -5℃, while the lowest monthly average temperature is in July and up to -28℃. During the observation period from 2012 to 2017, the lowest daily temperature is -39.5℃ and the highest daily temperature is 9.0℃.

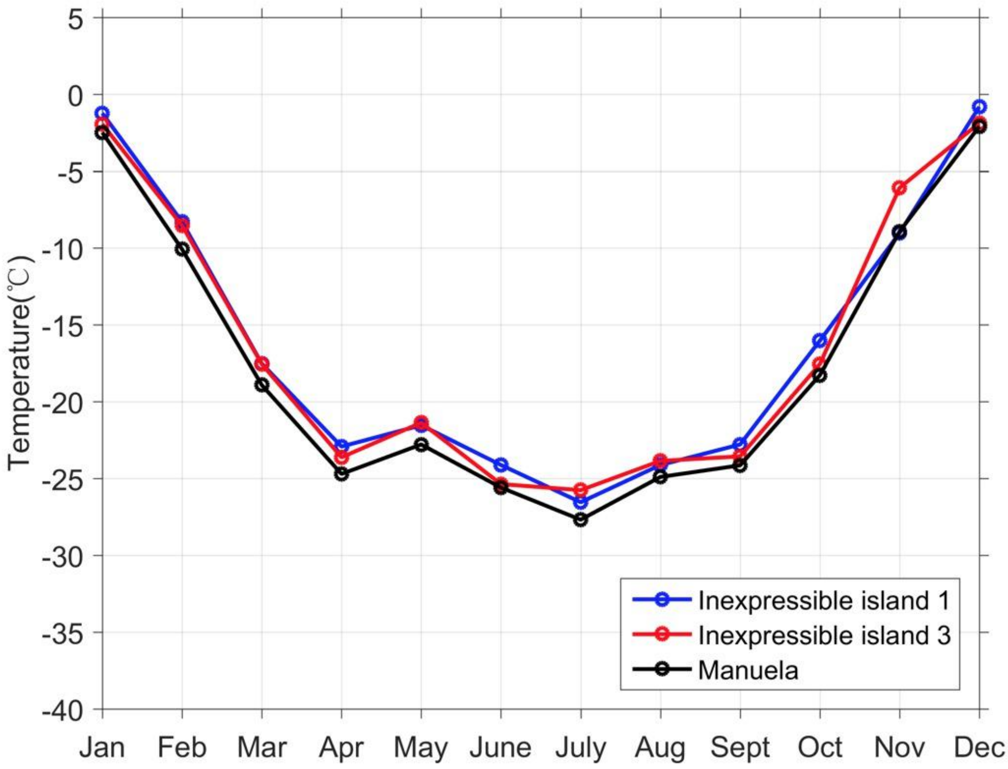


Figure 4- 21 Monthly average temperature of the three AWS on the Inexpressible Island

4.5.2.2 Wind velocity and direction

The altitude of the AWS Manuela is higher than the AWS China, so the monthly average wind velocity observed from 2012 to 2017 is also higher. The trends of the wind velocity on the Island is similar and has significant seasonal variation as shown in Figure 4-22. From March to September, the wind velocity is strong and the monthly average is all above 12 m/s. After September, accompany to the increasing temperature, the wind velocity decreasing fast, the lowest monthly average wind velocity happens in December and January which is below 8 m/s. The extreme strong wind is 44 m/s happened in July.

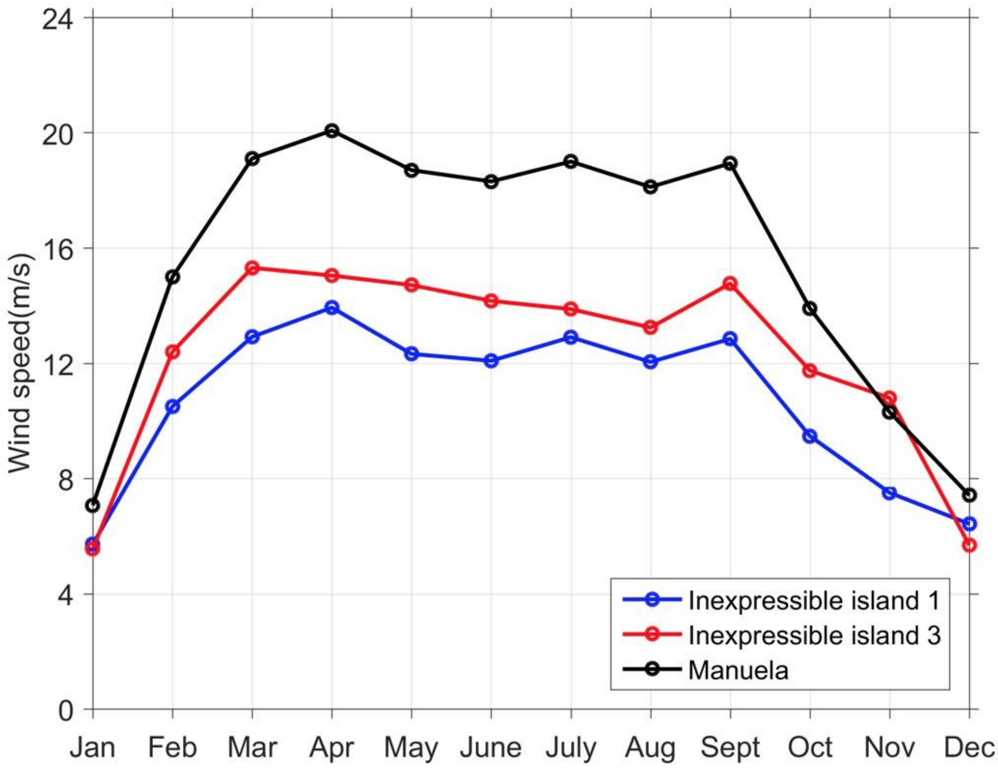


Figure 4- 22 Monthly average wind velocity of the three AWS on the Inexpressible Island

The wind direction of the katabatic wind is stable. As shown in the wind rose of Figure 4-23, the wind direction is westerly for the whole year, while during the summer season from December to February, the range of the wind direction is wide.

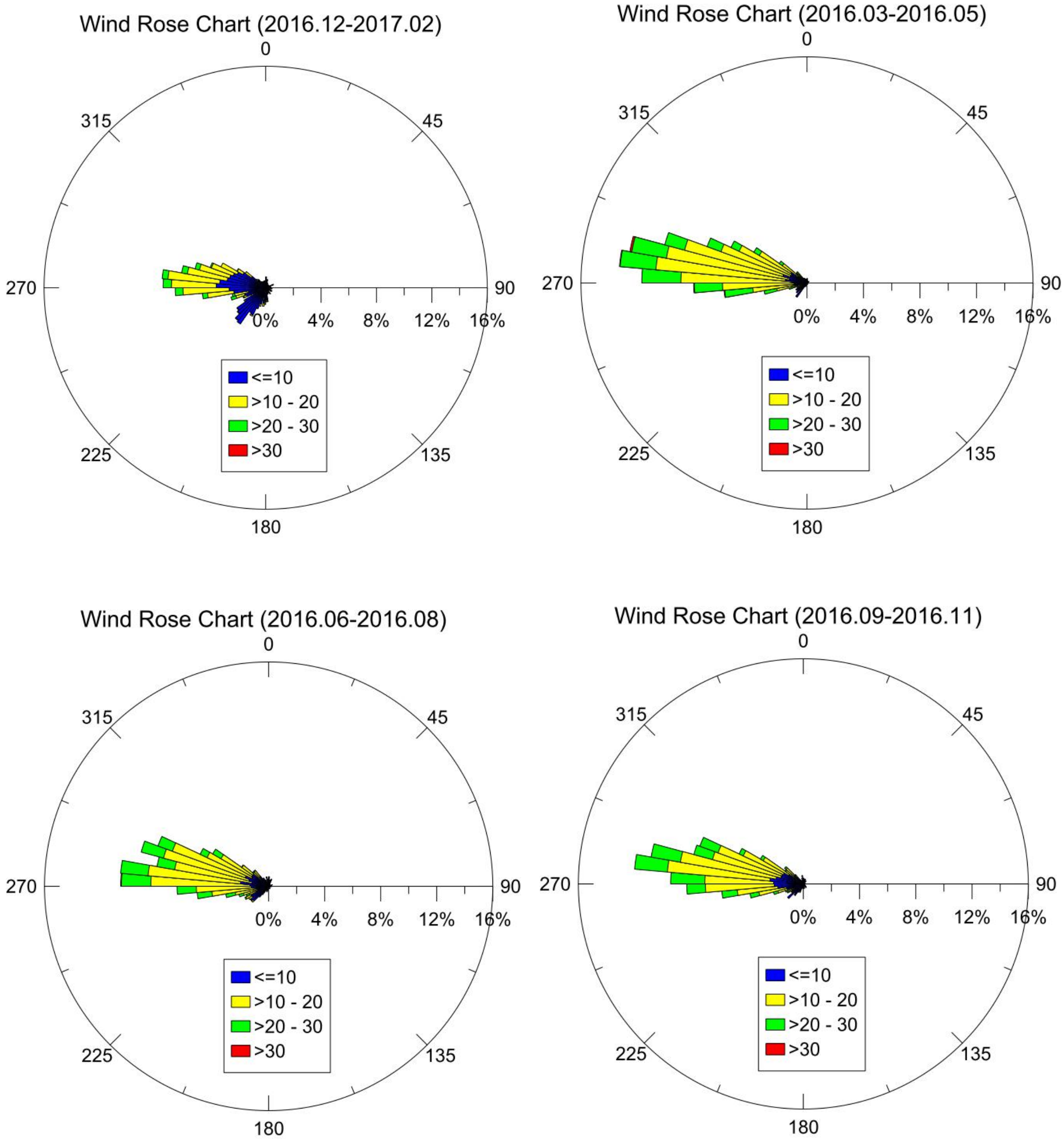


Figure 4- 23 Wind rose chart of the AWS China

4.5.2.3 Humidity

The relative humidity of all the three sites is under 60%, and the AWS Manuela is a little wetter than the AWS China. The trend is similar with significant seasonal variation as shown in Figure 4-24. The relative humidity is stable during March to September and a little more during the summer season from December to February.

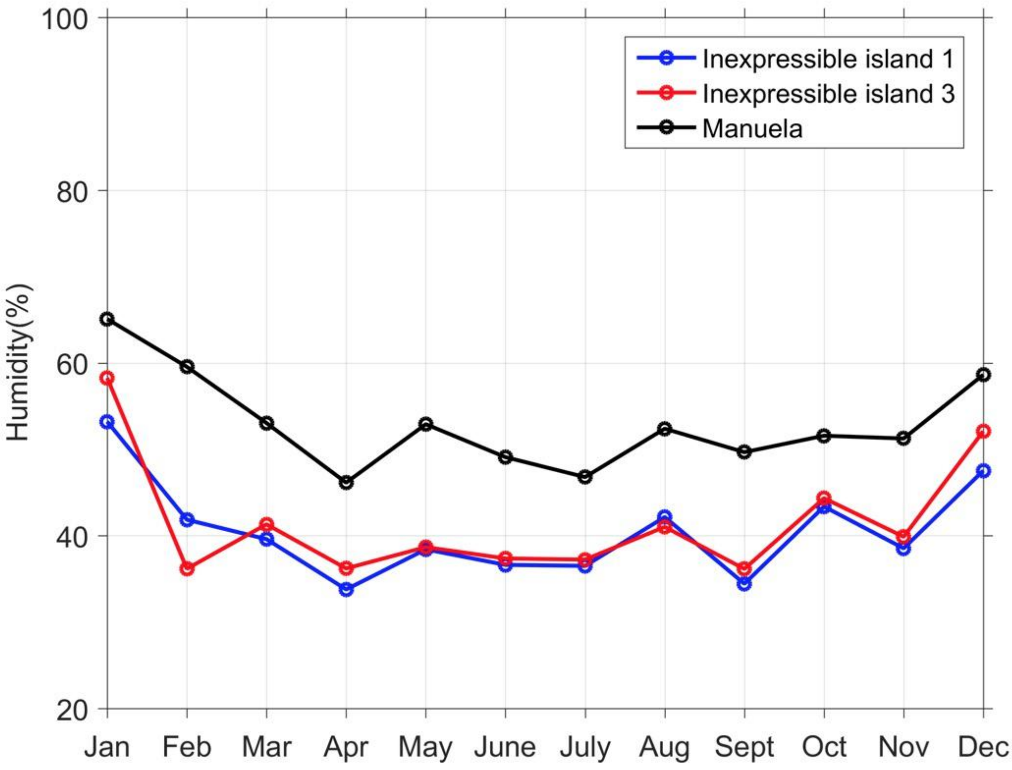


Figure 4- 24 Monthly average relative humidity of the three AWS on the Inexpressible Island

4.5.2.4 Air pressure

The air pressure in AWS Manuela is lower than AWS China owing to the difference of the altitude. There is no significant seasonal variation as shown in Figure 4-25.

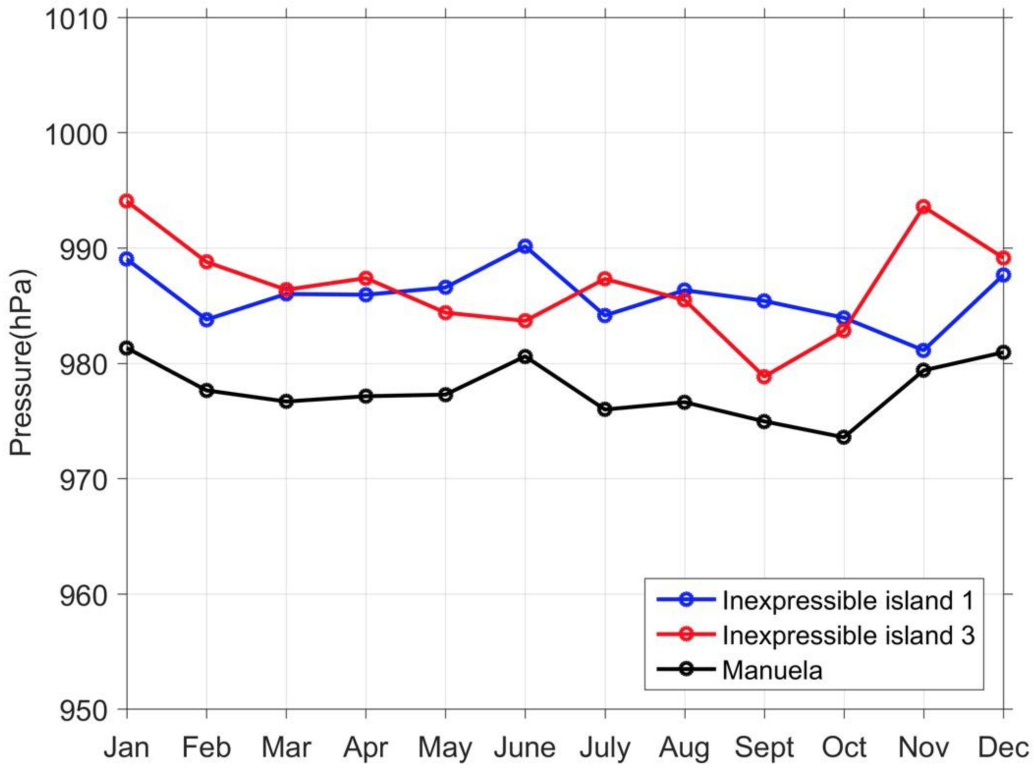


Figure 4- 25 Monthly average air pressure of the three AWS on the Inexpressible Island

4.5.3 Katabatic wind analysis

4.5.3.1 Frequency and intensity

According to a standard above and the data obtained from Manuela, there were 298 strong katabatic events based on the available data of limited 10 years during 1988-2012. 49.8% of them occurred in winter (21% occurred in July) and the average lasting time was approximately 10 hours. There were no such events in December and January of summer time. The proportion of strong katabatic events was 2.5% in late summer (February) and lasted for 6.9 h on average.

More frequent katabatic events took place when it came to autumn (started from March). They accounted for 10.1% of all the cases in March and lasted for 9.7 h. The most frequent events at a proportion of 21% were observed in July lasting 11.6 h in average. The occurrence ratio and lasting time of strong katabatic events began to decrease after that and reached 1% and 4.5 h in November. We can see that these events take place mostly in winter and last for a relatively long time.

The average wind speed of strong katabatic event is between 25~30 m/s and sometimes it could be more than 40 m/s (as shown in Figure 4-26). Both average and maximum wind speed start to increase from late summer (February) and decrease in winter (start from August). The instantaneous speed peaks in July while the average speed in August. Therefore, the strong katabatic events take place more frequently with higher wind speed and long-lasting time in winter while it's opposite in summer.

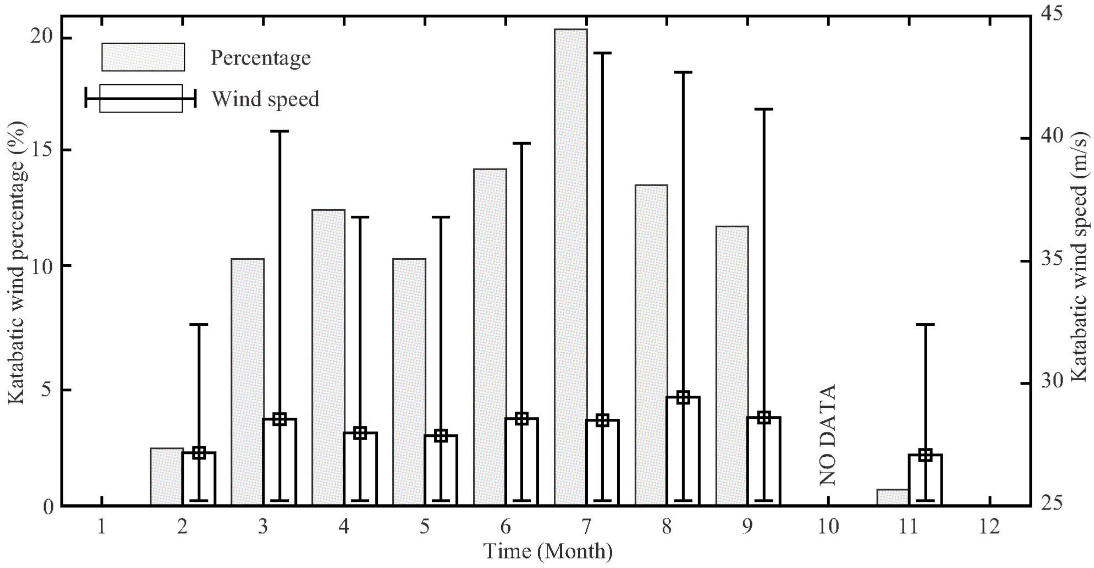


Figure 4- 26 Statistics of the strong katabatic wind events (partly years of 1988-2012)

4.5.3.2 Horizontal distribution characteristics of the Katabatic wind

Based on the near-surface observation data from 2014 to 2015 as shown in Figure 4-27, the Katabatic wind on the Inexpressible Island is mainly from Reeves Glacier and David Glacier as the second collection area. The near-surface wind field is stable all year round which means the mechanism of the katabatic wind on the Inexpressible Island is owing to the local geography difference and glacier temperature gradient, not related to the climate system from the Southern Ocean.

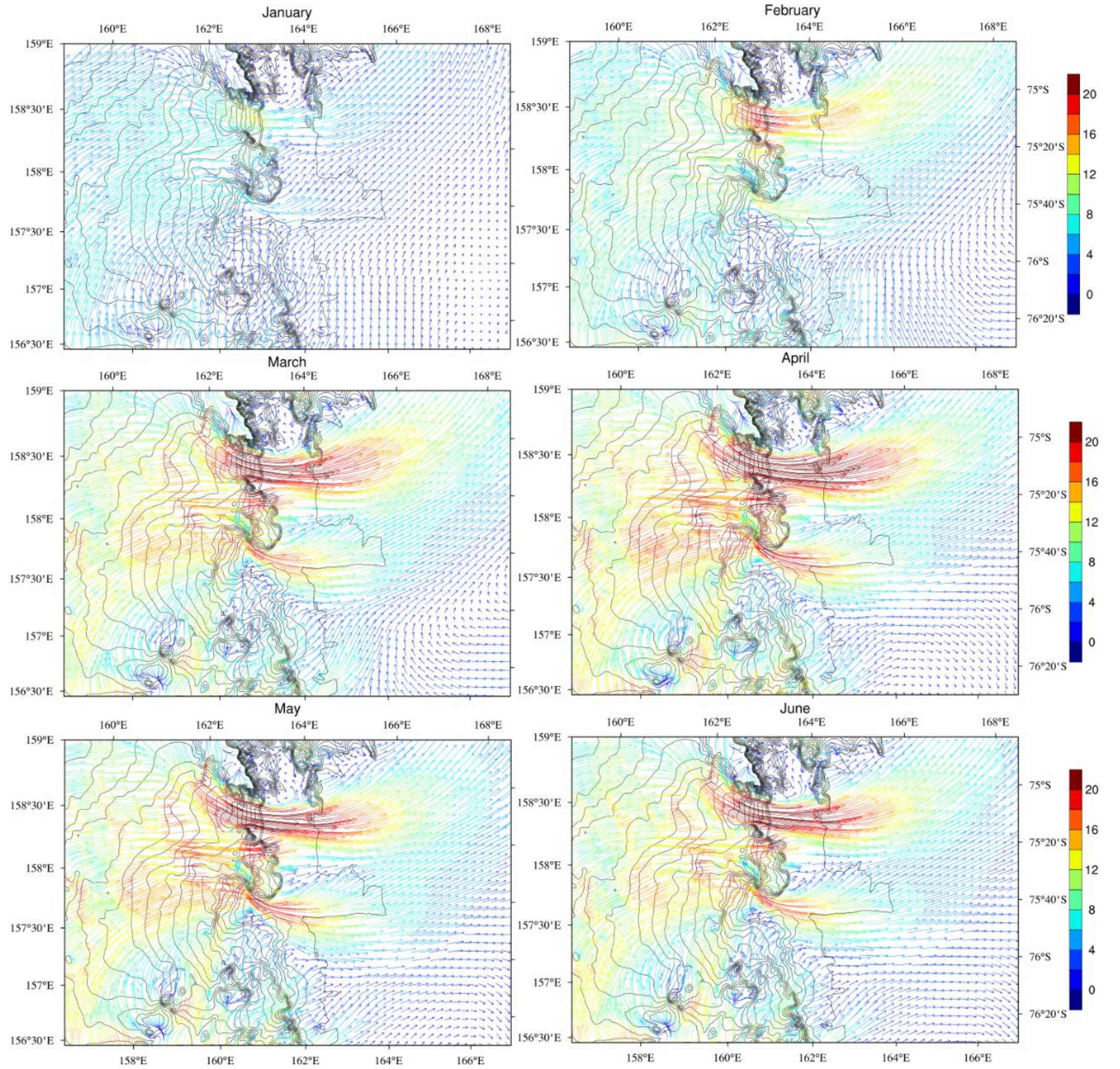


Figure 4- 27 Horizon wind field on the Inexpressible Island during January to June (2014-2015)

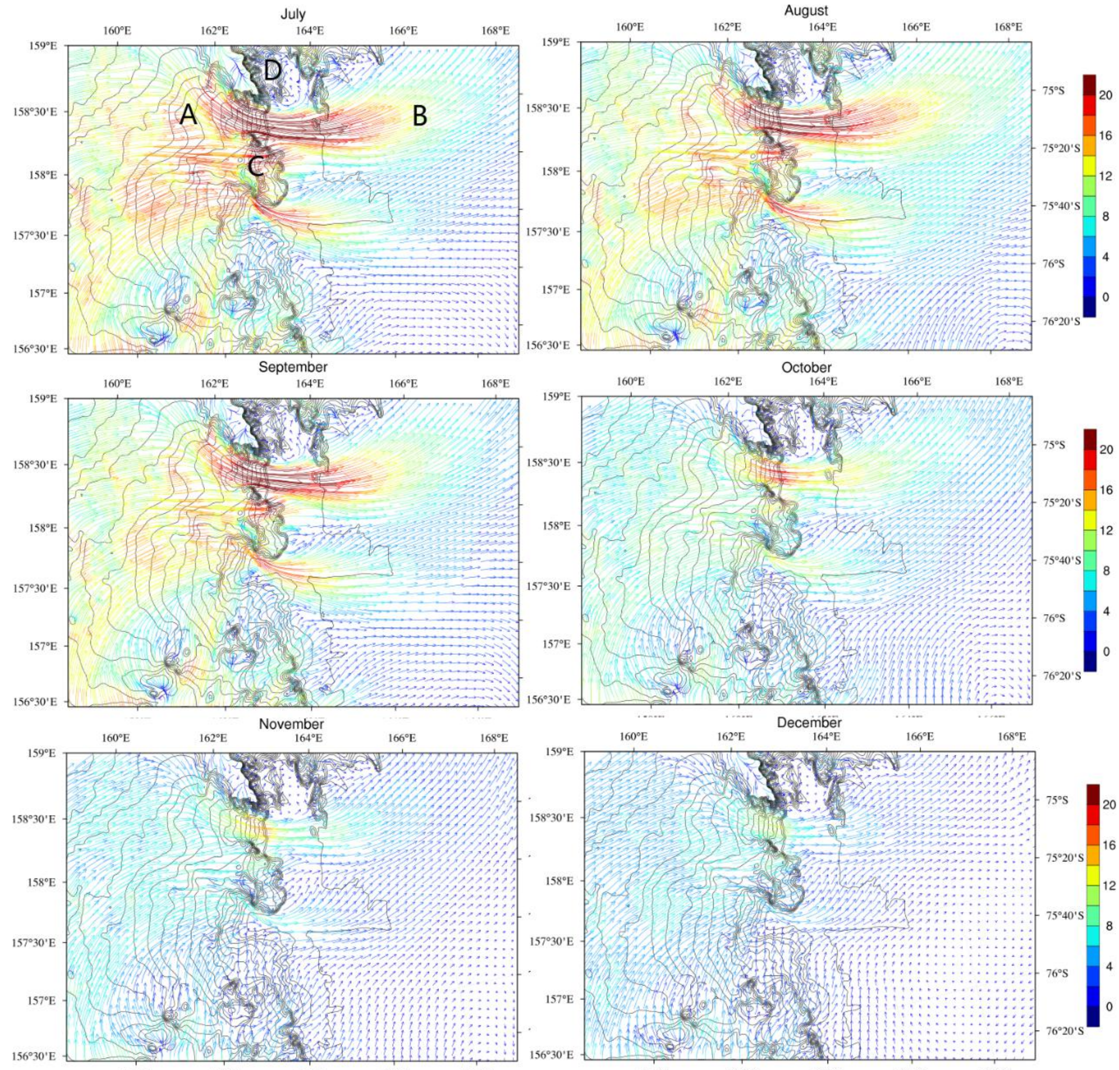


Figure 4- 28 Horizon wind field on the Inexpressible Island during July to December (2014-2015)

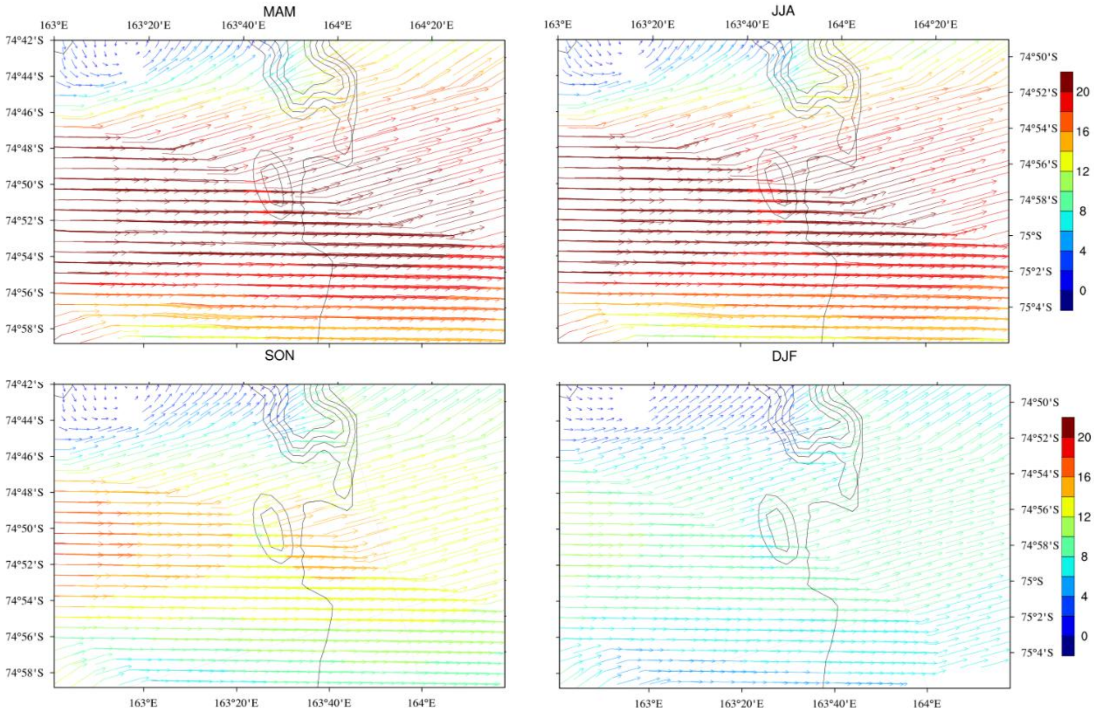


Figure 4- 29 Seasonal horizon wind field variation on the Inexpressible Island 2014-2015
（MAM：March-May，JJA：June- August；SON：September to November；DJF：December to February）

In order to describe the precise seasonal variation of the horizontal wind field on the Inexpressible Island, AMPS model has been used as shown in Figure 4-30 (a). Reeves Glacier is the main source of the katabatic wind on the Inexpressible Island. The strong wind is intensified after the cross over the Island. During December to February, the katabatic wind is weak.

4.5.3.3 Vertical distribution characteristics of the Katabatic wind

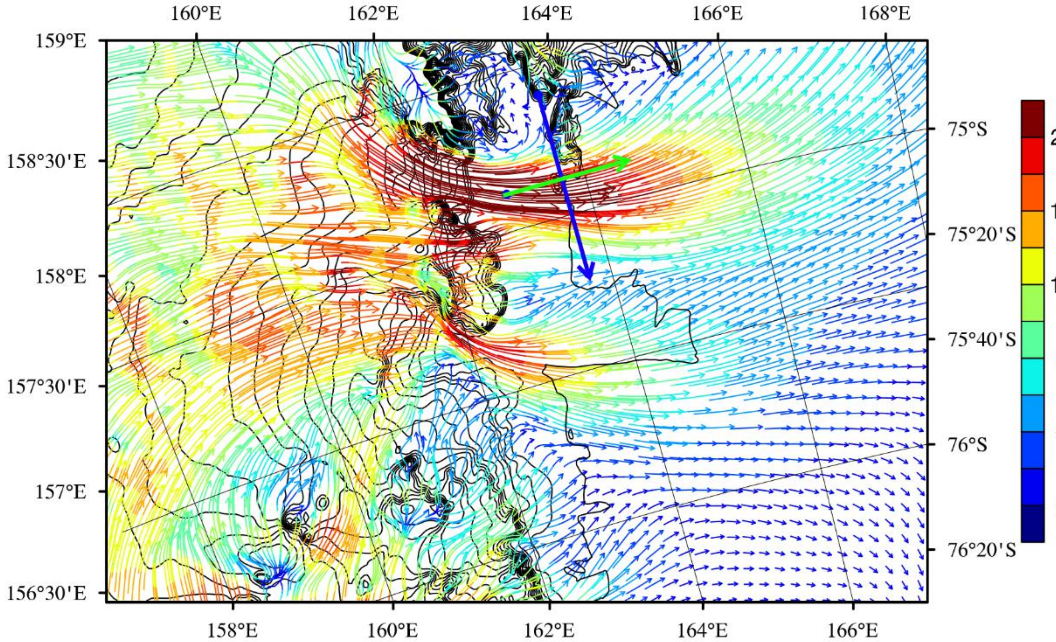


Figure 4- 30 (a) Mean spatial distribution of the katabatic winds in the Terra Nova Bay area in July

(extracted from the AMPS 2014-2015 archive on 06 UTC July 10th, 2016)

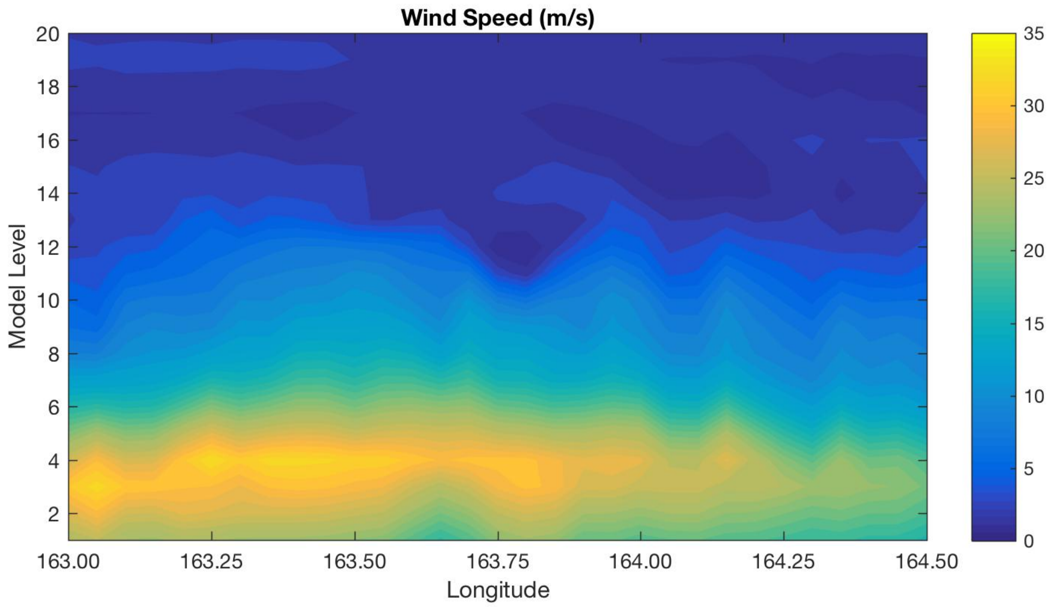


Figure 4- 30 (b) Vertical distributions of the katabatic winds crossing (Green Line) the Inexpressible Island in the Terra Nova Bay area in July

(extracted from the AMPS 2014-2015 archive on 06 UTC July 10th, 2016)

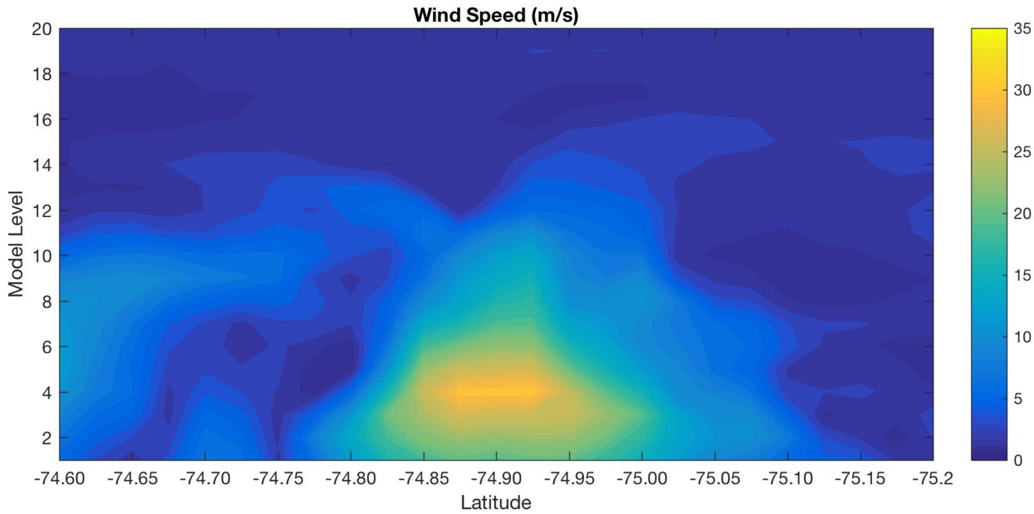


Figure 4- 30 (c) Vertical distributions of the katabatic winds crossing (Blue Line) the Inexpressible Island in the Terra Nova Bay area in July

(extracted from the AMPS 2014-2015 archive on 06 UTC July 10th, 2016)

The katabatic wind stream from the Reeves glacier has sharp boundaries at its top and it's both sides. In the East-West direction, the Inexpressible Island significantly blocks the katabatic winds between 163.60 E and 163.75 E, and the katabatic stream resumes after it traverses the island, as indicated by Figure 4-30 (b). Figure4-30 (c) shows that the whole Inexpressible Island (between 74.85S and 74.95S) is affected by the strong katabatic winds. Strong winds locate at around 100-300 m above ground level.

4.6 Flora and fauna

4.6.1 Flora

4.6.1.1 Lichens and mosses in Victoria Land

The first confirmed landing on the Antarctic continental mainland was recorded as being at Cape Adare, Victoria Land, in 1895 by Carsten Egeberg Borchgrevink (Campbell and Huxley 1913). During this expedition, Borchgrevink also made the first lichen collections. The first moss collections of Victoria Land was made in 1899 by the British Antarctic Expedition(Gepp 1902, Darbishire 1910). Over the next decade, further collections and studies of the lichens and mosses were undertaken during a series of British Antarctic Expeditions in 1907-1909 and 1910-1913.

After these expeditions, there was a period of quiescence in the exploration of this area. It was not until 1958-1959, that further botanical exploration was undertaken (Rudolph 1963, Dodge 1965, Stirling 1969, Hale 1987). and after the 1990s, a series of works have been published (Adams et al. 2006, Cannone 2006, Castello et al. 2006, Cannone and Seppelt 2008, Cannone and Guglielmin 2010, Smykla et al. 2011, Zucconi et al. 2014, Singh et al. 2015).

Most of Antarctica is covered by snow, and just less than 1% of the continent (55000 km^2) is ice-free (Bockheim and Hall 2002). Compared to similar latitudes in the Arctic, the terrestrial biodiversity in Antarctica is low, which is mainly due to the isolation of the continent and the adverse conditions for life. Compared with other regions of Antarctica, Victoria Land has more abundant vegetation. In Victoria Land, most of the lichens are crustose (71%) and foliose (22.2%), and only 6.7% are fructicose (Singh et al. 2015). And moreover, 48.9% of the lichen species here are endemic to Antarctica (Singh et al. 2015). Most of these taxa live in the ice-free area of Victoria Land, where suitable climate and soil conditions occur at a lower latitude than most of the continent.

Species-rich areas exist on Apostrophe Island, Edmonson Point, Gondwana, Cape Sastrugi, Boulder Clay, Adelie Cove, Prion Island, Starr Nunatak, and Finger Point. The taxa in these areas number 20 or more, of which Edmonson Point and Prior Island are the richest (Figure 4-31).

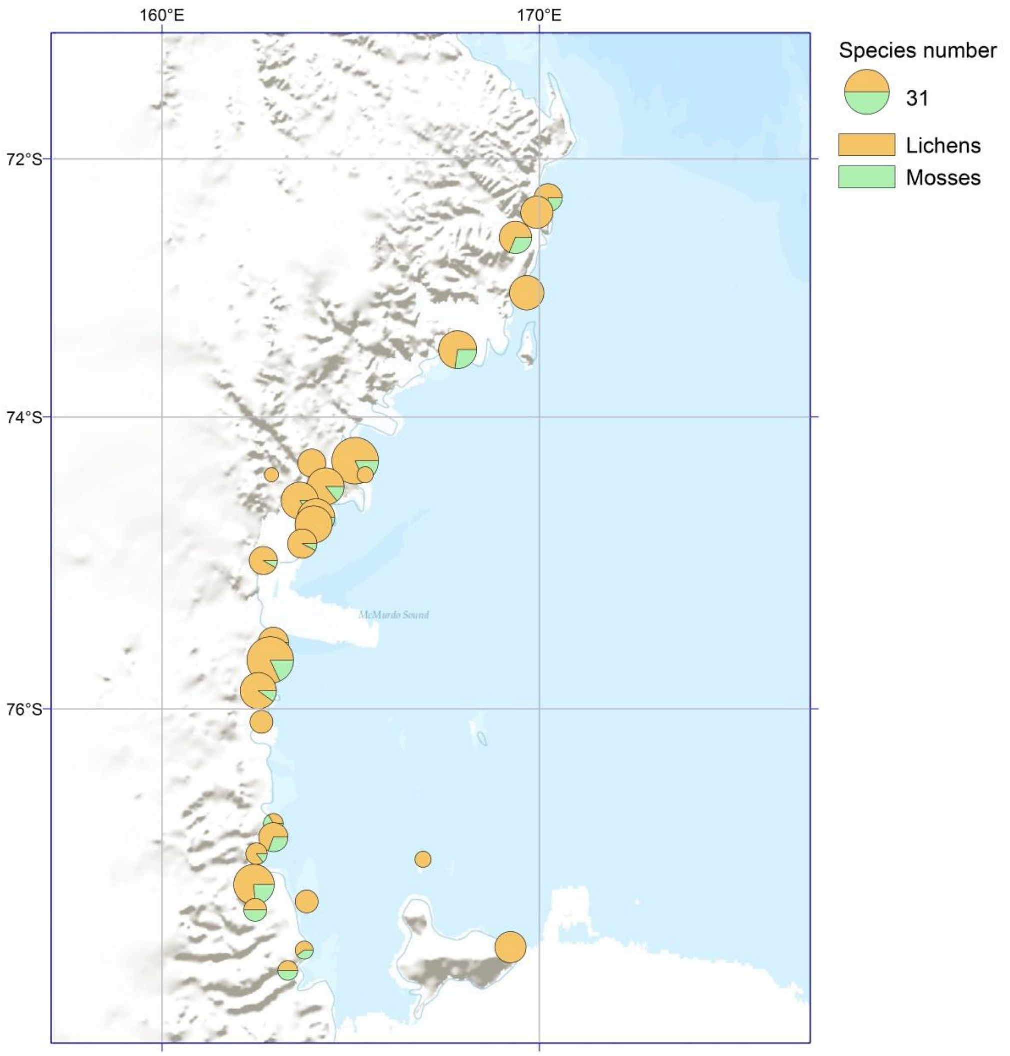


Figure 4- 31 The biodiversity of vegetation in Victoria Land

4.6.1.2 Vegetation of the Inexpressible Island

The Inexpressible Island is located in the west of the Ross Sea near Terra Nova Bay (74º54'S, 163º45'E). It named by R. N. Campbell after he and his five colleagues had to spend the whole winter on this Island (Compell, 1913). Scientists began to conduct research on this island in the summer of 1964-1965. In subsequent years 1969-1970, 1981-1982, 1982-1983, 1984-1985, 1989-1990, 1993-1994, 1994-1995, 1995-1996, 2004, 2005, etc., investigations continued.

In 1966 Campbell and Claridge (1966) began their research in this area, studying the soil. They also studied the uplift around the coast of the island. Fumanti et al. (1997) collected the algae in the lake of the Inexpressible Island and indicated that the microflora of the Inexpressible Island was similar to that of Gondwana Lake and Dry Valleys Lake. Cannon (2005, 2006) reported 6 species of lichens in the proglacial slope of the Inexpressible Island and Smykla et al. (2011) discovered and reported 9 species of lichens adjacent to the penguin colony on the island. A total of 12 species of lichens have now been reported from the Inexpressible Island and they are Acarospora gwynnii, Buellia frigida, Buellia pallida, Buellia papillata, Caloplace tominii, Candelariella flava, Lecanora expectans, Lecanora fuscobrunnea, Lepraria alpina, Physica caesia, Xanthoria elegans, Xanthomendoza borealis.

4.6.1.3 Lichens and moss on the Inexpressible Island

To fully understand the distribution of lichens and moss on the Inexpressible Island, an investigation was carried out during the 32nd and 33rd CHINARE from December 26th, 2014 to January 4th, 2015 and February 3rd – 5th, 2017. A total of 8 lichens and 1 moss was recorded on Inexpressible Island.

The eight lichens are:

- ***Acarospora gwynnii***
- ***Bullia frigida***
- ***Candelariella flava***
- ***Lecanora expectans***
- ***Lecanora fuscobrunnea***
- ***Umbilicaria decussate***
- ***Xanthoria elegans***
- ***Xanthomendoza borealis.***

The distribution of Lichens and Moss on the Inexpressible Island is shown in Figure 4-32.

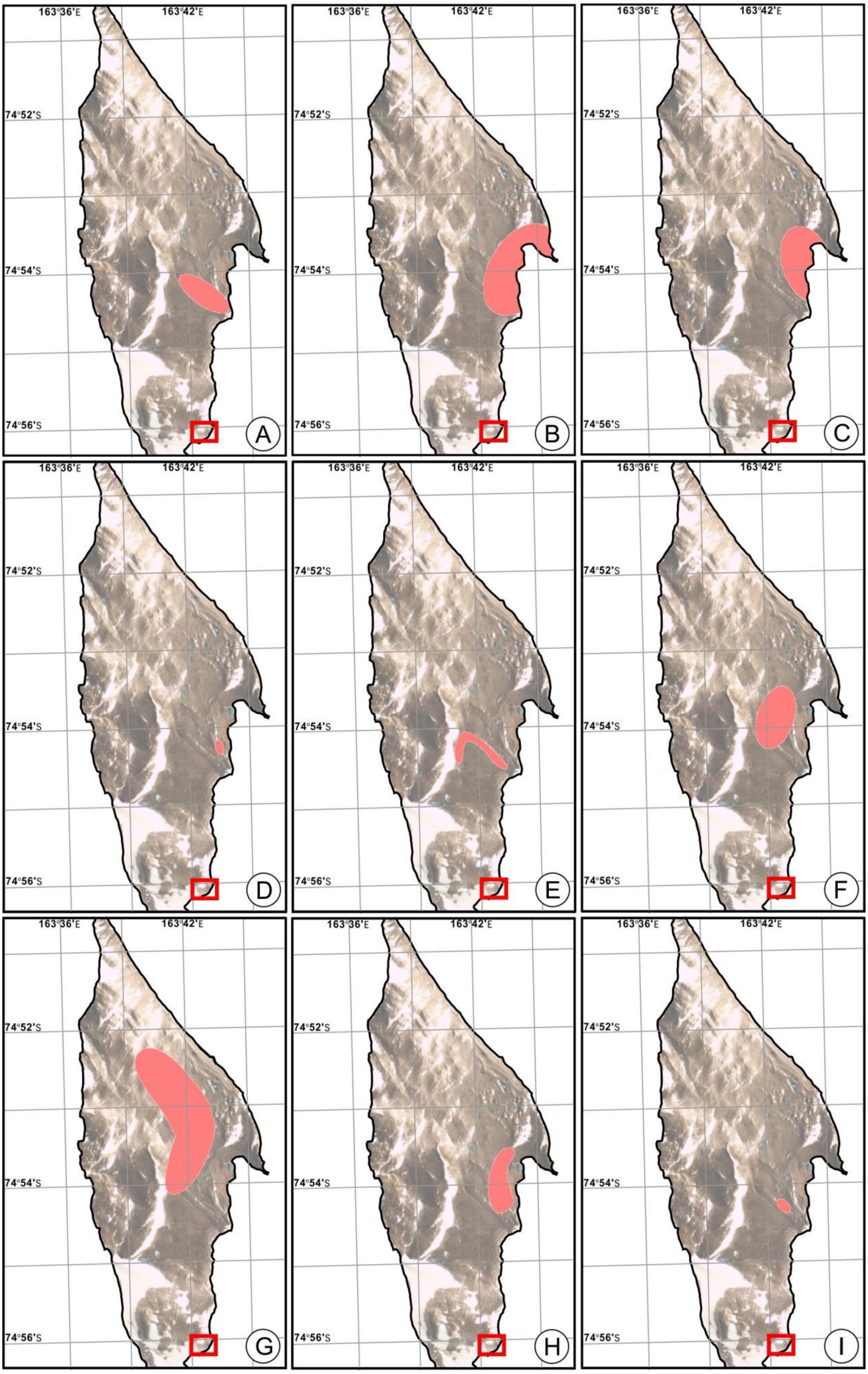


Figure 4- 32 The distribution of Lichens and Moss in Inexpressible Island

A. *Acarospora gwynnii** **B.** *Bullia frigida** **C.** *Candelariella flava* **D.** *Lecanora expectans* **E.** *Lecanora fuscobrunnea* **F.** *Umbilicaria decussate* **G.** *Xanthoria elegans* **H.** *Xanthomendoza borealis* **I.** *Bryum argenteum*

*It is the main distribution region.

1. ***Acarospora gwynnii***

A. gwynnii was first collected from the A.N.A.R.E. weather station on Mawson, Mac Robertson Land, by medical officer Dr. A. M. Gwynn (Dodge and Rudolph 1955). It is distributed across Antarctic regions and South America (Castello 2003). This species is widespread in continental Antarctica and is also found on the Antarctic Peninsula and sub-Antarctic regions (Lindsay 1974).

The species is recorded from many localities on Victoria Land, including Red Castle Ridge, Crater Cirque, Cape Phillips, Apostrophe Island, Edmonson Point, Gondwana, Mount Keinath, Boulder Clay, Campo Icarus, North Adelie Cove, the Inexpressible Island, Cape Sastrugi, and Tarn Flat (Cannone 2005, Smykla et al. 2011). It is one of the most common epilithic lichens of Victoria Land (Hale 1987).

On the Inexpressible Island, A. gwynnii (Figure 4-33) is found in the western uplands and occasionally on the eastern plain. In the western mountain area, A. gwynnii is distributed along rock crevices and to the leeward side of rocks. Its distribution is most dense close to the penguin colonies in the northwestern part of the island.

Figure 4- 33 Acarospora gwynnii

2. *Bullia frigida*

The type specimen of *B. frigida* was collected from Granite Harbor by the British National Antarctic Expedition (Darbishire 1910). It is endemic to Antarctica with a circumpolar distribution(Castello 2003). *B. frigida* is the most widespread lichen of continental Antarctica.

This species is found in many localities on Victoria Land from north to south. It is the most common lichen of Victoria Land (Cannone 2005, Smykla et al. 2011).

B. frigida (Figure 4-34) can be found throughout the Inexpressible Island and is locally abundant around penguin colonies in the northwest part of the island.

Figure 4- 34 Bullia frigida

3. Candelariella flava

C. flava grows on bryophytes, rock epiphytes or on other lichens(Castello 2003). It is endemic to Antarctica and is distributed throughout continental Antarctica, maritime Antarctica and the subantarctic region. It is distributed widely in Victoria Land and has been found on Cape Hallett, Red castle Ridge, Cape Phillips, Apostrophe Island, Edmonson Point, Cape Washington, Gondwana, Boulder Clay, Campo Icarus, North Adelie Cove, Inexpressible Island, Prion Island, Starr Nunatak, Gregory Island, Finger Point, Cape Hickey, Dunlop Island and Marble Point (Cannone 2005, Smykla et al. 2011).

This species (Figure 4-35) only occurs near penguin colonies in the northwestern part of the Inexpressible Island.

Figure 4- 35 Candelariella flava

4. Lecanora expectans

The type specimen of *L. expectans* was collected by the British National Antarctic Expedition (Darbishire 1910). It is distributed throughout continental and maritime Antarctica (Castello 2003). It has been reported from Crater Cirque, Cape Phillips, the Apostrophe Island, Edmonson Point, Gondwana, Boulder Clay, Campo Icarus, North Adelie Cove, the Inexpressible Island, Prion Island, Starr Nunatak, the Gregory Island, Finger Point, Cape Hickey, Marble Point and Cape Crozier in Victoria Land (Cannone 2005, Smykla et al. 2011).

L. expectans (Figure 4-36) is only found in the penguin colonies in the northwestern part of the Inexpressible Island.

Figure 4- 36 Lecanora expectans

5. Lecanora fuscobrunnea

The type specimen of *L. fuscobrunnea* was collected from Durham Point, Queen Maud Mountains, South Victoria Land (Dodge and Baker 1938). It grows on rock and is distributed only in continental Antarctica (Castello 2003)

In Victoria Land, it was found in Edmonson Point, Campo Icarus, the Inexpressible Island, the Prion Island, and Cape Hickey (Smykla et al. 2011).

The distribution of *L. fuscobrunnea* (Figure 4-37) is limited to the region of the periglacial slope and the ridges near to the penguin colonies in the northwestern part of the Inexpressible Island.

Figure 4- 37 Lecanora fuscobrunnea Dodge et Baker

6. Umbilicaria decussate

U. decussate is a worldwide distributed lichen. In Victoria Land, it was found in Red Castle Ridge，Crater Cirque，Cape Phillips，Apostrophe Island，Edmonson Point，Gondwana，Mount Keinath，Boulder Clay，Adelie Cove，Cape Sastrugi,，Tarn Flat，Starr Nunatak，Finger Point，and Prior Island (Cannone 2005, Smykla et al. 2011).

U. decussate (Figure 4-38) is the only foliose lichen on the Inexpressible Island. The distribution of *U. decussate* is limited to the periglacial slope region and ridges near the penguin colonies in the northwestern part of the Inexpressible Island.

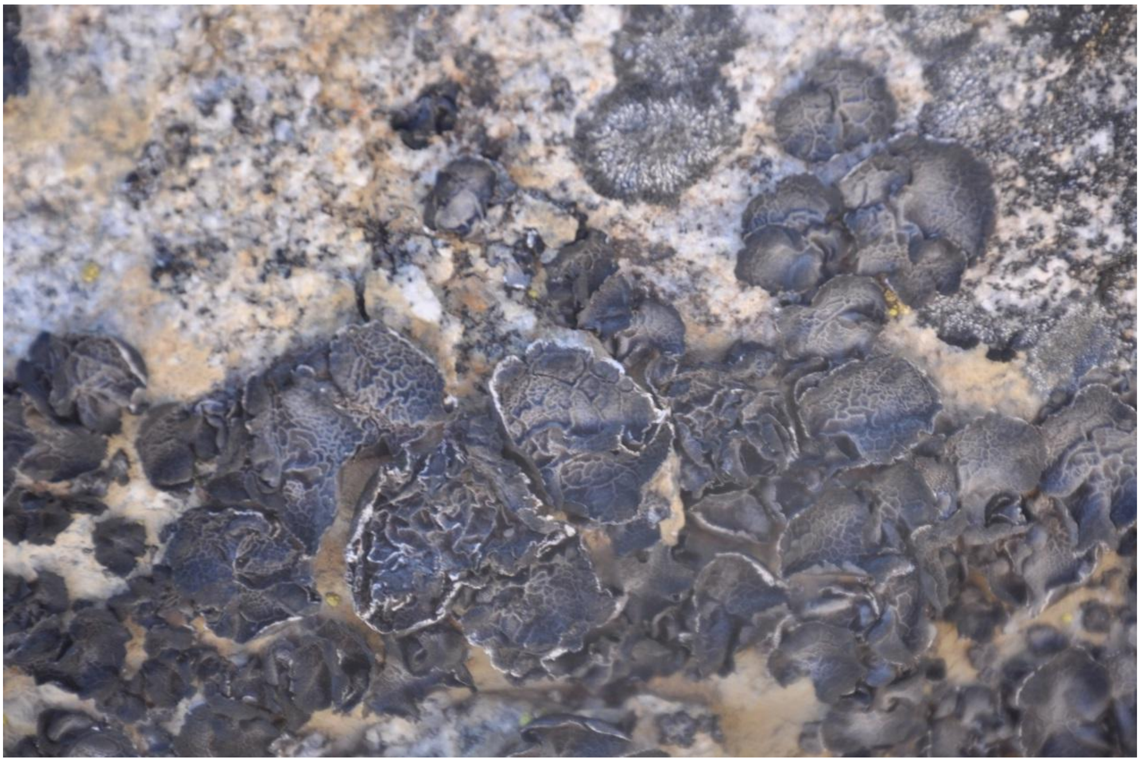


Figure 4- 38 Umbilicaria decussate

7. Xanthoria elegans

X. elegans is distributed worldwide and is always found in alpine areas. It can be found in Beijing, Shanxi, Inner Mongolia, Jilin, Jiangsu, Yunnan, Xizang, Shannxi, Gansu, Qinghai, and Xinjiang in China.

In Victoria Land, it is found in Redcastle Ridge, Crater Cirque, Cape Phillips, the Apostrophe Island, Edmonson Point， Gondwana， Boulder Clay, the Inexpressible Island, Tarn Flat, the Lamplugh Island, the Prion Island, Starr Nunatak, the Gregory Island, Kar Plateau, and Finger Point (Cannone 2005, Smykla et al. 2011).

On the Inexpressible Island, *X. elegans* (Figure 4-39) is distributed on the ridges close to the penguin colonies in the northwestern part of the Inexpressible Island and is also found on the slopes of the northwestern mountain area.

Figure 4- 39 Xanthoria elegans

8. Xanthomendoza borealis

X. borealis is distributed worldwide (Lindblom and Sochting 2008). In Victoria Land, it can be found at Edmonson Point, Campo Icarus, North Adelie Cove, the Inexpressible Island, the Prior Island and Cape Hickey (Cannone 2005, Smykla et al. 2011).

X. borealis (Figure 4-40) is distributed over the ridges close to the penguin colonies in the northwestern part of the Inexpressible Island.

Figure 4- 40 Xanthomendoza borealis

Only one moss is found as ***Bryum argenteum.***

B. argenteum distributed widely throughout the world. In Victoria Land, it is found on Cape Hallett, Crater Cirque， the Apostrophe Island， Edmonson Point， Gondwana， Boulder Clay， Cape Sastrugi，Tarn Flat，the Lamplugh Island，the Prior Island，Starr Nunatak，Cape Ross， the Gregory Island，Kar Plateau，Finger Point，the Dunlop Island， Marble Point and around Fryxell Lake (Cannone 2005).

B. argenteum (Figure 4-41) is found on the ridges nearby the penguin colonies in the northwestern part of the Inexpressible Island.

Figure 4- 41 Bryum argenteum

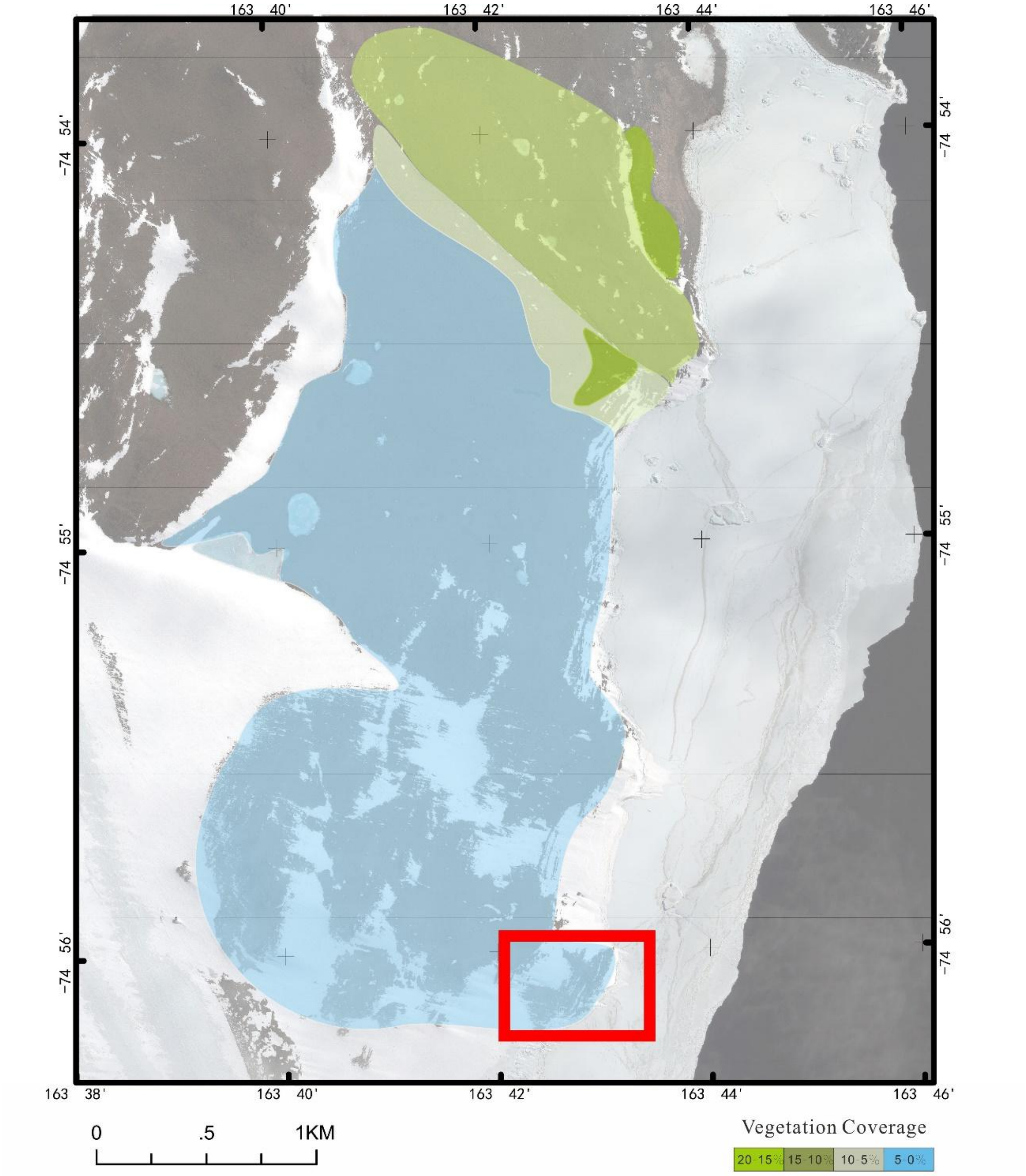


Figure 4- 42 Vegetation coverage of the proposed site on the Southern Inexpressible Island

There are 8 lichens and 1 moss species (see Figure 4-42) found on the Inexpressible Island. And all of the 8 lichens are crustose. The most widespread taxon on the island is *Bullia frigida*, and all of the other species are widely dispersed. Hence, the vegetation coverage descriptions mainly refers to *Bullia frigid*.

As the mean wind velocity is quite strong on the Inexpressible Island, lichens are mainly grow on the lee side of the rocks. So the distribution of the lichens is generally related to the size and distribution of the moraine rocks.

At the central trench (see Figure 4-2) of the island, it is relatively plain and mainly covered by small moraine rocks, the vegetation coverage is pretty low. At the south trench and the most south part of the island, outcropping of the bed rock (see Figure 4-3) was recorded. The weathering of the bed rock is serious, and the vegetation coverage is very low.

The moraine ridge between the north trench and the middle trench is a heap of big cobblestones. The katabatic wind from the glacier is relatively weak here, and the water vapor from the sea can easily reach to this region. On the lee side of these cobblestones, lots of *Bullia frigida* are growing. The coverage is higher than those from the two aforementioned areas.

The highest vegetation coverage was found in an area of few hundred meters wide at west side of the Adélie penguins colony, it is believed that penguin Adélie faeces provide adequate nutrition for the growth of the vegetation. At the southeast of the moraine ridge, there is also a small area is with very high vegetation coverage.

4.6.2 Fauna

In the proposed site, animals found are mainly Adélie penguins, Antarctic skuas, and Weddell seals. The Adélie penguin colony is one of the earliest monitoring population in Antarctic. It also has the most continuous Holocene historical record of penguin occupation in the Ross Sea region, reserving penguin guano and remains through the past 7000 years. Additionally, Terra Nova Bay has a great potential to be the Adélie penguin refuge in the Ross Sea region during the Last Glacial Maximum.

An average of ~24 450 breeding pairs of Adélie Penguin were present each season from 1981 – 2012 (Lyver et al. 2014). Approximately 60 breeding pairs of South Polar Skuas were present on the Inexpressible Island both within and near the vicinity of the IBA (ANT 178) in 1982 (Ainley et al. 1986), although the precise breeding area has not been defined (IBA, 2015).

The breeding area of the Adélie penguin and South Polar skua are limited in the area in Seaview bay and north of South bay, where is at least 3 km far away from the potential station site. Few Skuas may fly over the potential station, there is not any individual stay or forage in the area as the strict rubbish management rule.

Based on the on-site investigation from 2012 to 2017 as shown in Figure 4-43, on the Inexpressible Island, mainly Adélie Penguin (*Pygoscelis adeliae*), Antarctic Skua (*Stercorarius maccormicki*) and Weddell seals (*Leptonychotes weddellii*) were investigated. There are about 20000 pairs of breeding penguins in a small bay, along with the northern coast of the island. And the altitude of the nest is from no more than 1m to 33m. There is a separated small colony, including about 130 breeding pairs of Adélie Penguin, in the south of 600m away from the larger one. Around the rookery of the Penguin, about 60 breeding pairs of Antarctic Skua are distributed there. According to GPS data and on-site estimation, the penguin community covers an area of 0.5 square kilometers. In the northernmost part of penguin colony, there is a small lagoon, where small amount Weddell seals appear occasionally. There are some seal bodies nearby, some has already been air-dried.

The penguin colony is located to the northern part of the Inexpressible Island while the proposed site is in the southern part of the Inexpressible Island. The discovered seal bodies are also located to the northern part of the Inexpressible Island. China has decided to move the planned station site to the southern part, after a careful assessment of the possible impact and the distance between the southern boundaries of the colony to the new station is more than 3.5 km.

The overall distribution in the band area also presents a small circular community distribution pattern. In Nov 2017, there is 16115 breeding pairs of penguin (by photo census), and chicks make up about 30% of the total population. And at least 60 breeding pairs of south polar skua in the rookery and 1000m around the rookery. The historic data of the penguin population size according to the investigation by New Zealand scientists since 1984 is from 9217 to 36117.

(https://www.landcareresearch.co.nz/resources/data/adelie-census-data/inexpressible-island)

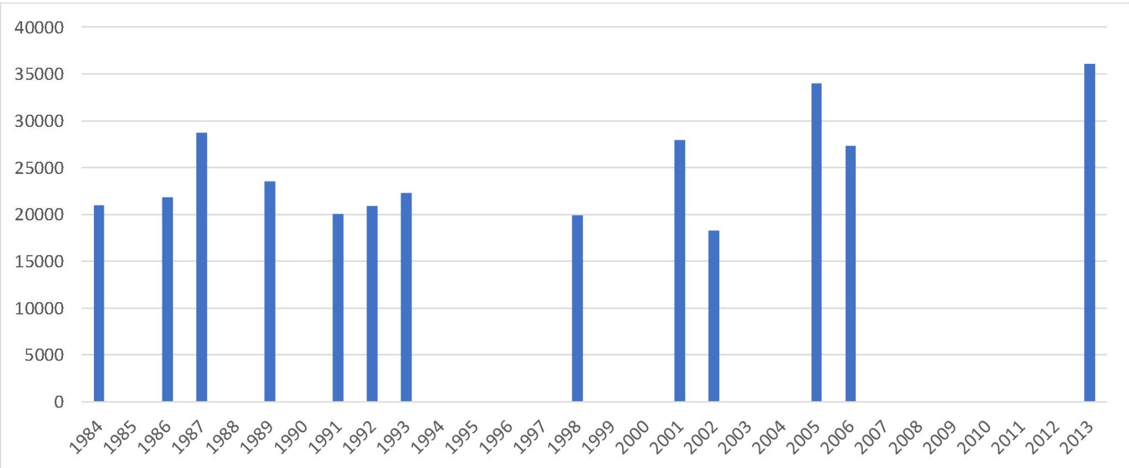


Figure 4- 43 The historic data of the penguin population size (1984-2013)

The number of individuals in each community is about 200-300, as shown in Figure 4-44 and Figure 4-45. According to GPS data and on-site estimation, the penguin community covers an area of 0.5 square kilometers approximately. The penguin colony is located to the north of the proposed site, and the distance between them is more than 3.5 km and separated by a buffering rock ridge with an elevation around 50 meters.

Figure 4- 44 Penguin Bay panorama in the northern part of the Inexpressible Island

The latest count of 2017 reported 25,089 breeding pairs of Adélie penguin (MOE, 2019). The penguins are mainly distributed in the central part of Seaview Bay, and there are about 100 breeding pairs (131 breeding pairs in 2017) in South Bay.

Up to 60 breeding pairs of South Polar skua were recorded in the Area (Ainley et al., 1986). The South Polar skuas mainly breed in the rock belt around the Adélie penguin breeding colony, and in some areas the nests of both bird species present a mosaic distribution (above Map for 2018 breeding points). There is not any nest was observed in other area on the Inexpressible Island. Sometimes the colony of 20-30 South Polar Skuas is observable. In the survey in late December 2016 and 2017, there were 2 eggs or 2 chicks in each nest of South Polar skuas. However, in the January 2018 survey, only one chick was found in every nest. The success rate of skua's breeding and the factors affecting reproduction on the Inexpressible Island require further investigation.

On the Inexpressible Island, emperor penguins (Aptenodytes forsteri) (1 individual was observed in South bay in 2017). Wilson's Storm Petrels (Oceanites oceanicus), Snow Petrels (Pagodroma nivea), Antarctic Petrels (Thalassoica antarctica) can be observed in Terra Nova Bay and nearby inexpressible island, but no nest has been found in the island. .

In the northernmost part of penguin colony, there is a small salty lake as shown in Figure 4-45. In the shore of the lake, eight seal bodies were found without any big seal communities, some has been air-dried and some are bare bones. The discovered seal bodies are also located to the north of the proposed site as show in Figure 4-46.

Weddell seals (*Leptonychotes weddellii*), Leopard seals (*Hydrurga leptonyx*) and less frequently Crabeater seals (*Lobodon carcinophagus*) can be observed in the seawaters near the Area. The Weddell seals also often habit in Seaview bay and South bay, and occasionally appeared around the proposed station. On the basis of our investigation in recent three years (from December to February), no pups has been observed in the inexpressible island.

The influence on these animals will be seriously considered during the building and operation of the new station. Furthermore, the new station will be in favor for the observation and research of the ecosystem and its response to climate in this region.

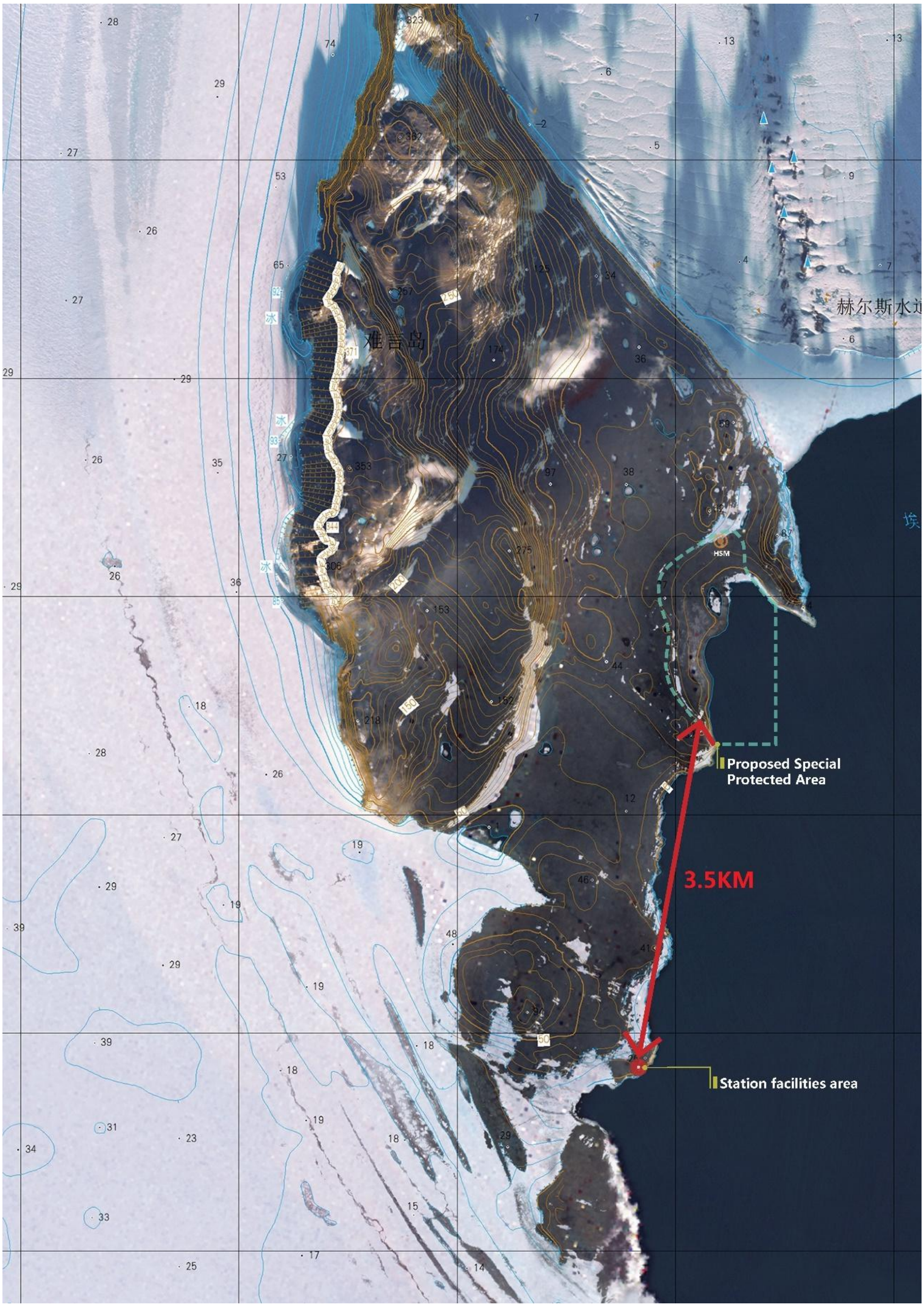


Figure 4- 45Fauna distribution on the Inexpressible Island and the distance from the proposed station

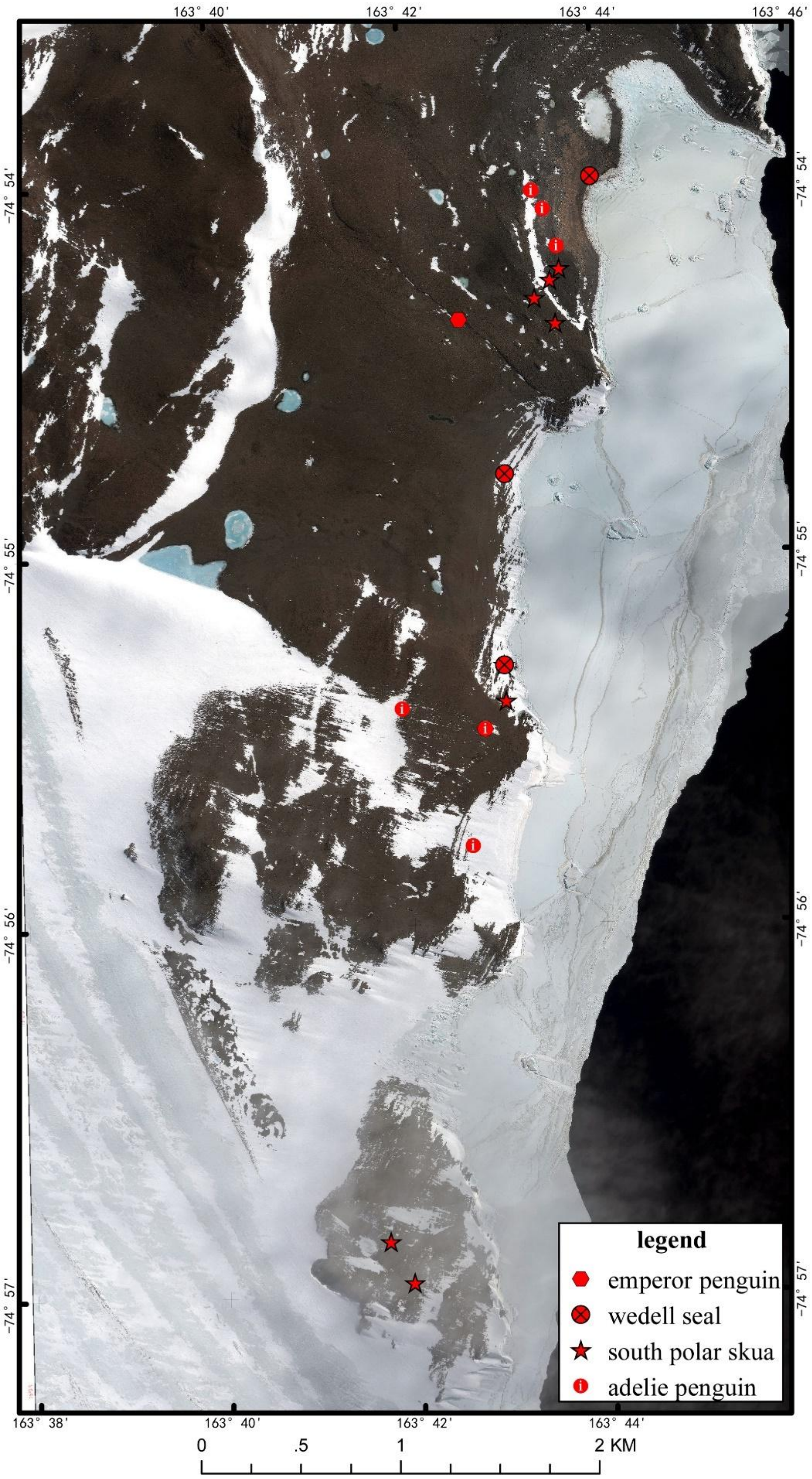


Figure 4- 46 Fauna distribution on the Inexpressible Island and the distance from the proposed station

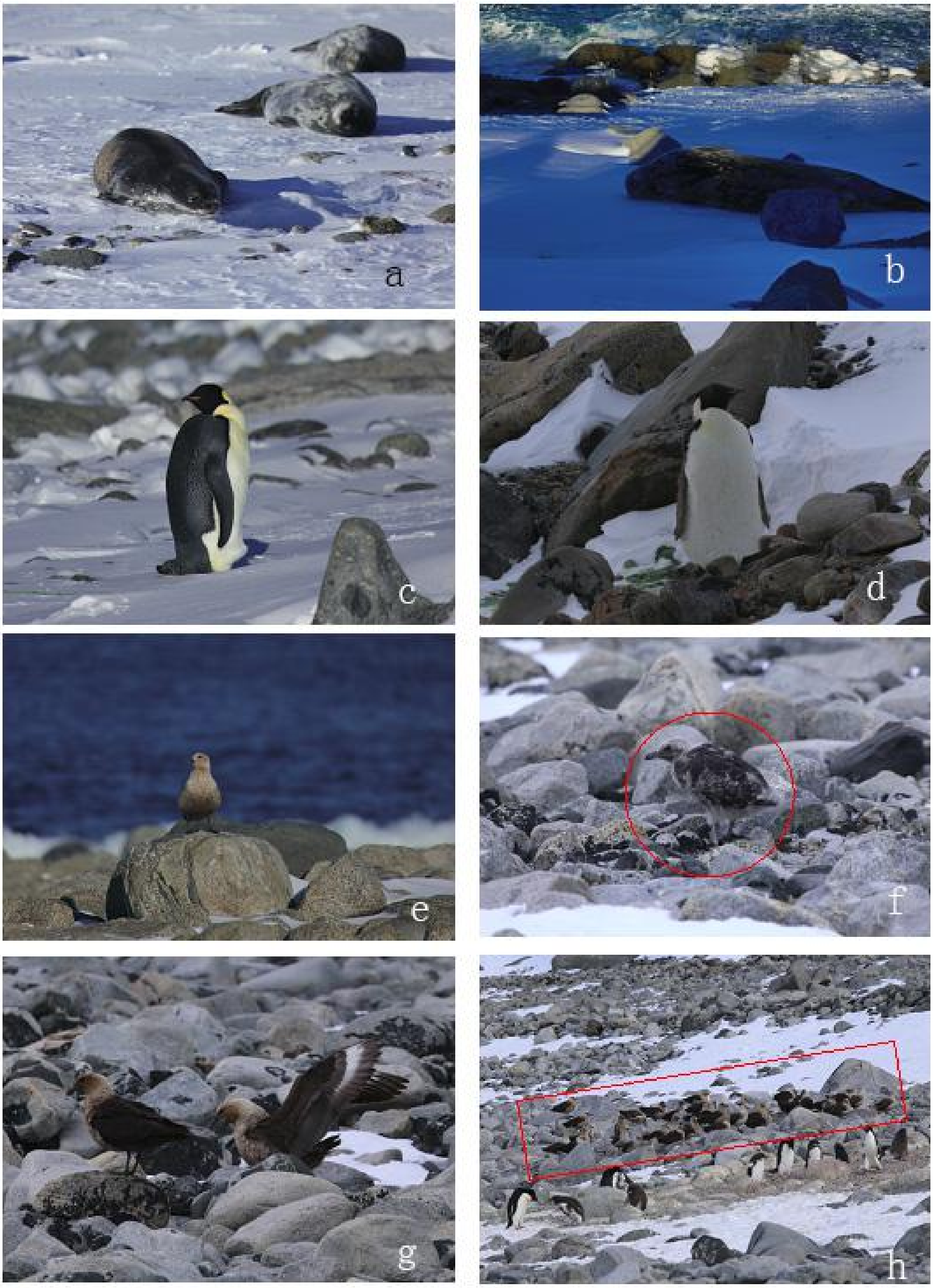

a
b
c
d
e
f
g
h

Figure 4- 47 Fauna investigated on the Inexpressible island

Note:

a-b. Weddell seals in southern bay,

c-d. Two emperor penguins in southern bay,

e. South polar skua in southern bay,

f. a chick of south polar skua in Seaview bay (near penguin rookery),

g. a pair south polar skuas in Seaview bay to protect their territory,

h. 27 south polar skua individuals in the Seaview bay,

i-n, Adelie penguin in Seaview bay, and k is an albino individual.

4.6.3 Terrestrial (soil) invertebrates and microbes

Only Gressittacantha terranova (*Collembola, Entognatha*) were recorded by Fanciulli et al.

(2001) in the first study on population genetics of Antarctic soil microarthropods and Acutuncus antarcticus (*Eutardigrada, Hypsibiidae*) recorded by Cesari et al. (2016).

The cold-tolerant fungi as Chrysosporium verrucosum Tubaki, Thelebolus microspores Kimbrough and White yeasts were found from penguin guano and soil (Del Frate and Caretta, 1990). A fungal strain, isolated from the Inexpressible Island, was plate-screened for its ability to produce extracellular enzymes (Fenice et al., 1997). The bacteria in five different lakes from this Area were recorded in 2017/2018 summer season by Illumina Miseq sequencing, genera Flavobacterium within Bacteroidetes was the most occurring in all the lakes, and other genus as Polaribacter (Bacteroidetes) and Cyanobacteria were very abundant in two of those lakes, respectively. Michaud et al. (2012) have documented in a lake of Inexpressible Island the consistently pronounced abundance of the Gammaproteobacteria (which are typically marine), the lack of Actinobacteria (which are of major importance in freshwater environments), as well as the low abundance of pico-cyanobacteria (whose presence is not favored by relatively high N: P ratio).

Algal species diversity in lakes of the Area is similar to that one of Lake Gondwana and Dry Valleys lakes. The typical prokaryotic (*Synechococcus*) and eukaryotic (Chlorella) genera were determined by both flow cytometry and electron microscopy (Andreoli et al., 1992).

In lacustrine sediments pigments confirmed that Cyanophyta was the most important algal group, followed by Chlorophyta and Bacillariophyta (Borghini et al., 2011). The microbial eukaryotes in five different lakes from this area were recorded in 2017/2018 summer season by microscopy and Illumina Miseq sequencing, genus Geminigera (*Cryptophyceae*) was significantly predominant in three lakes, and in the other two lakes were dominant by Chlamydomonas (*Chlorophyta*) and Spumella (*Chrysophyta*).

4.7 Terra Nova Bay polynya

The TNB polynya is the key region of the Southern Ocean because of its crucial role in the sea-ice production and for dense water formation processes which affect the regional ocean properties. In last decades both meteorological and oceanographic conditions showed relevant changes.

The Terra Nova Bay (TNB) occupies an area of 6000 km^2 (65 km north/south by 92 km east/west) in the western Ross Sea near 75°S, 164°E. It is located in northern Victoria Land, along with the western margin of the Ross Sea, bordered on the south by the floating Drygalski Ice Tongue, on the north by Cape Washington, and on the west by the Nansen Ice Shelf, which is fed by the Reeves and Priestley Glaciers. The TNB polynya is a large, stable, annually recurring feature in the western Ross Sea, which markedly influences sea ice dynamics and physical oceanography in that region.

Kurtz and Bromwich (1983) estimated the monthly mean extent of open water in the TNB polynya through the winter (March to October) of 1979 using infrared satellite images, and found that throughout the winter, the area of open water fluctuated quasi-periodically with a period of 15-20 days, and the average polynya area was 1000 km^2, maximum area was approximately 5000 km^2. The fluctuations were associated with the magnitude of the zonal geostrophic wind, with a closing polynya related to strong, persistent easterlies. Bromwich et al. (1984) used qualitative trajectory calculations to find that the katabatic winds maintain their identity for some distance seaward of the coast and this distance is on the order of the observed polynya width. Polynya size varies by migration of its eastern boundary, the maximum eastward extent of the polynya is limited by the length of the Drygalski ice tongue (Kurtzand Bromwich 1983, Bromwich et al., 1984).

4.8 Lakes

There are three lakes near the proposed site area around 1.5-2.0 km away in the north. All the lake are melting freshwater from the snow and the ice. The depth and ice information were investigated as shown in Figure 4-48.

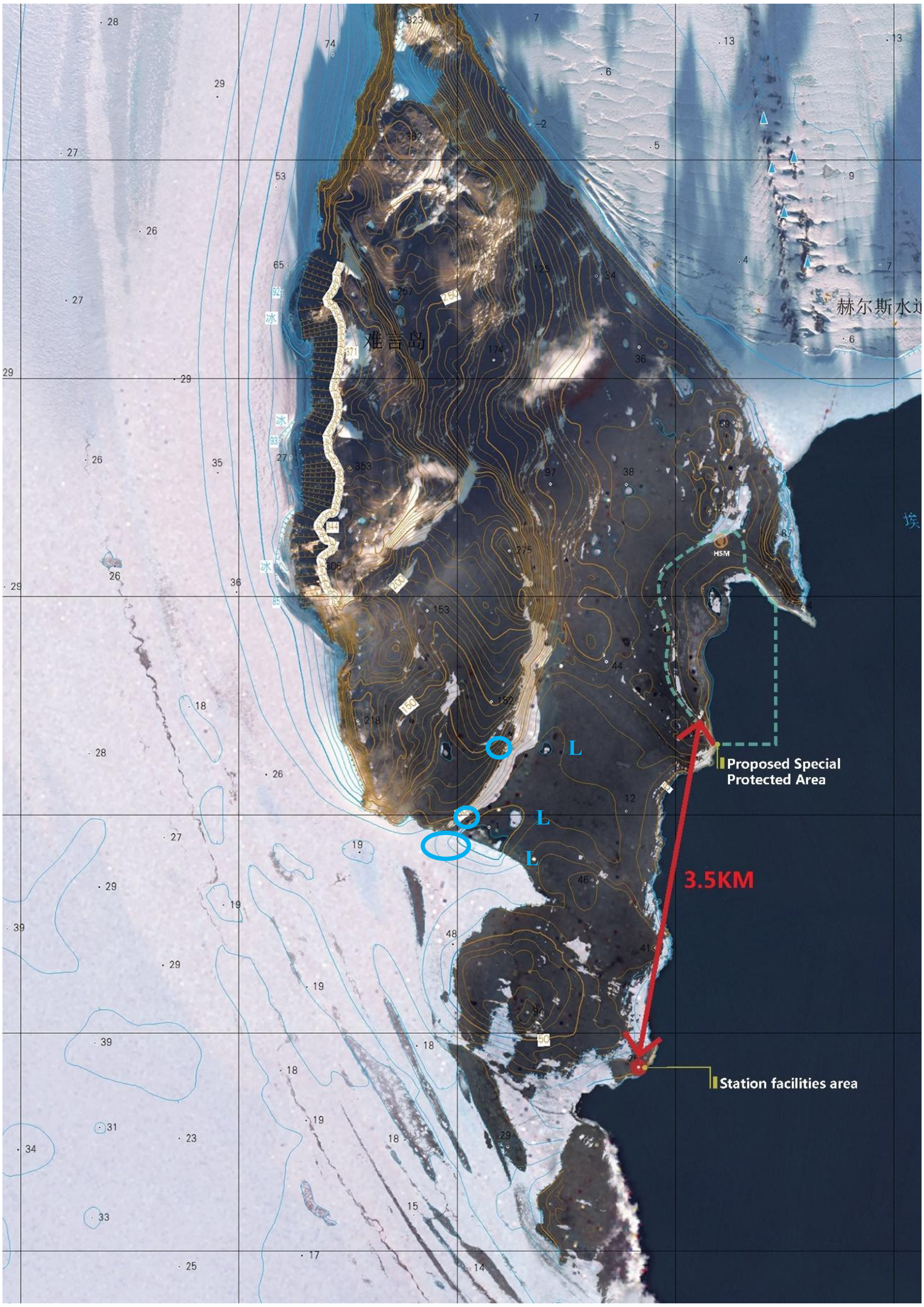


Figure 4- 48 Location of the lakes on the Inexpressible Island

Lake 1 is about 546 meter in perimeter measured by GPS on January 3, 2013. It covers an area of about 21235 m^2. It is an independent circular lake, surrounded by glacier deposit. The depth

of the lake is 270-280 cm, and the thickness of liquid water under the ice is 20-60cm.
The sampled ice thickness is 215 cm, and the air temperature is 4 °C. The measurement points are shown in Figure 4-49. Of the top 65 cm of the ice is about -0.20 °C, temperature declines with the increase of depth. In 200-220 cm, the temperature reduces to -1.1 °C.

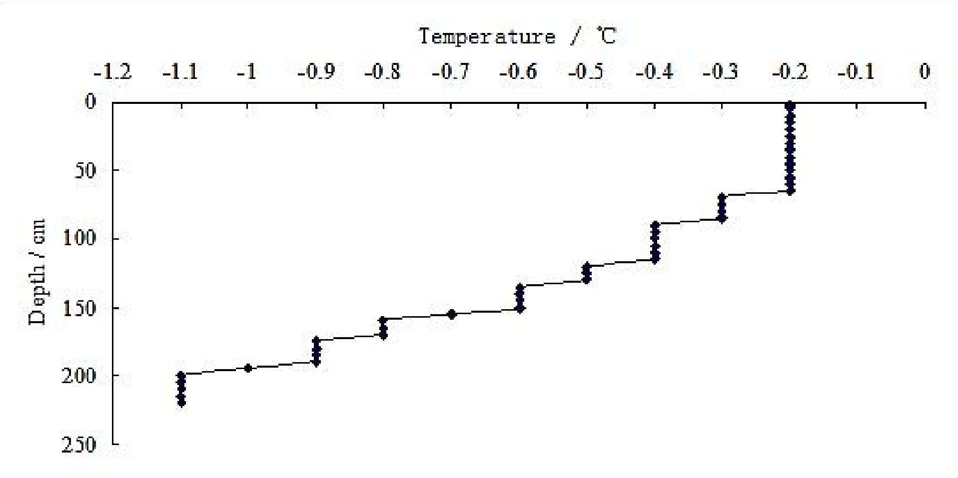


Figure 4- 49 Temperature profile of Lake 1#

Lake 2 is about 1127m in perimeter measured by GPS on January 3, 2013. It covers an area of 49540 m^2. The lake is connected to the glacier with a narrow channel. The ice thickness at the site is 169 cm, with a depth of 175cm, and the air temperature is 4 °C (Figure 4-50). The ice temperature is stable close to 0°C, indicating a melting process.

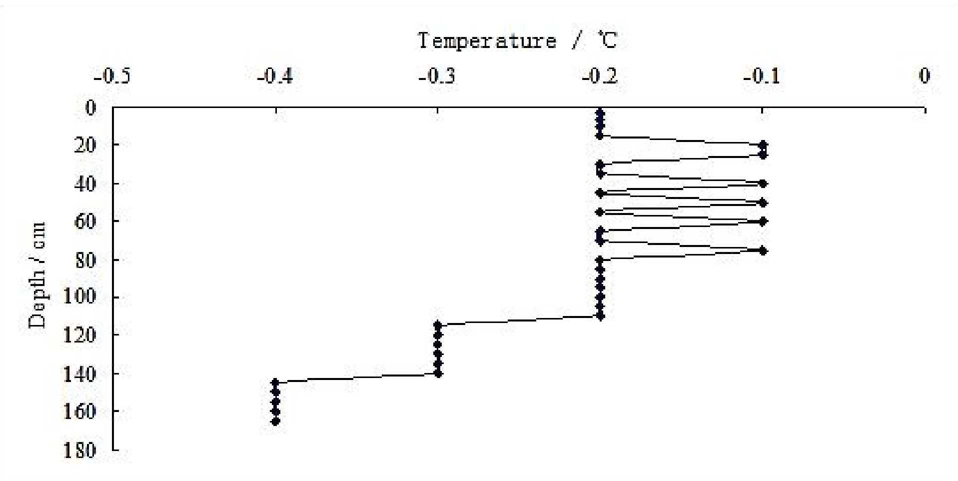


Figure 4- 50 Temperature profile of Lake2#

Lake 3 is about 408 meter in the perimeter, covering an area of about 11566 m^2 measured by GPS. The ice melting at the lake 3 is severe, preventing the landing on the ice surface, thus no depth and ice information was retrieved.

4.9 Marine environment and benthic community

Benthic associations of the shallow hard bottoms of Terra Nova Bay, are characterized mainly by rhodophycean macroalgae dominating the first 30-35m depth, and by associated vagile invertebrates, mainly represented by polychaetes, molluscs and peracarid crustaceans.
The coastal is composed of granitic and /or clastic rocks and descends towards the sea in very steep slopes. In some places, where sheer cliffs occur, the cliffs extend to 50-70 m depth.
Three species have been recorded from the Inexpressible Island: Iridaea cordata (Turner) Bory (as I.obovata Kützing), Phyllophora antarctica A. et E.S. Gepp and Plocamium cartilagineum Dixon since 1966.
Due to special geographical and environmental conditions, polar macrobenthic communities present high spatial heterogeneity (Thrush et al., 2006; Lin et al., 2016). Compared with the strong species exchange between the Arctic and the adjacent sea areas（Grebmeier et al., 2006）, the Antarctic has a high degree of geographical isolation, and the macrobenthic organisms have a unique community structure. The appropriate biogeographical classification of the Southern Ocean continental shelf benthos was divided into six major provinces by Clarke, and Rose sea located in Continental High Antarctic province, with high of sampling frequency and benthic biodiversity (Clarke et al., 2007).
The macrobenthic fauna of Terra Nova Bay has been widely investigated in the last 20 years since the establishment of the Italian Mario Zucchelli Station. Attention has been focused on community structure and distribution and the ecology of key species.
The macrobenthic vegetation is rather poor: only 9 Rhodophyceae (Erythrotrichia carnea, Clathromorphum lemoineanum,Gainia mollis, Iridaea cordata, Gymnogongrus antarcticus, Phyllophora antarctica, Plocamium cartilagineum, Ballia sertularioides, Phycodrys antarctica), 4 Fucophyceae (Lithoderma antarcticum , Petroderma maculiforme, Geminocarpus geminatus, Syringoderma sp) and 4 Chlorophyceae (Urospora penisulliformis, Monostroma hariotii, Prasiola crispa, and Lola irregularis) were found, which are widely distributed in Antarctic circumpolar and polar regions. The benthic associations were dominated by two macroalgal species (Iridaea cordata and Phyllophora antarctica) and by few animal taxa (mainly polychaetes, molluscs and peracarid crustaceans) in this area.
In shallow waters, gastropod fauna is represented by 31 species, among which Neobuccinum eatoni, Onoba gelida, Powellisetia deserta, Philine cf. apertissima and Austrodoris kerguelenensis are the most abundant, while among bivalves (25 species) the commonest species are Adamussium colbecki, Yoldia eightsi, Laternula elliptica and ``Montacuta" nimrodiana. At present, most of the Antarctic mollusc species are known as having circumantarctic distribution and are considered eurybathic. The gastropods characterize the

superficial algal belts dominated by the red algae Iridaea cordata and Phyllophora antarctica, bivalve distribution is wider. Adamumssium colbecki is the dominant species in the upper 100m, both on soft and hard bottoms, if the slope is suitable.

Sponges represents a major component of the Antarctic zoobenthos, remarkably contributing to the species richness of this continent. 49 demosponge species have been recorded in Terra Nova Bay, the most common species are Tedania charcoti, Axociella nidificata, Calyx arcuarius, Isodictya erinacea, I. cactoides, I. conulosa, Gellius rudis, Gellius spp., Myxilla elongata and Phorbas glaberrima. Most of the sponges were collected at 70-120 m depth.

The rocky substrate of the shallower (<500 metres) aspects of the study area favors animals and plants that attach themselves to the seabed, perhaps most notably sponges, and bryozoans. Bryozoans, commonly known as “moss animals” due to their formation of large colonies composed of tiny (less than 1 mm) individual animals that together resemble moss, where they form a substantial fraction of the biomass; Echinoderms (a phylum that includes sea urchins, starfish, and brittle stars) are typically important in benthic habitats, and the Terra Nova Bay is no exception.

There are 34 species of echinoderms in the study area, and in some areas, echinoderms are second only to bryozoans in population density. The Ross Sea boasts over 230 species of sponges and is home to some especially interesting and diverse sponge communities. For example, glass sponges are relatively rare throughout the world’s oceans but are abundant in McMurdo Sound. The McMurdo Sound Glass Sponge Assemblage is particularly notable. Many of these sponges are very long-lived and slow-growing, and thus are likely to be vulnerable to disturbance. These and other Ross Sea sponges play a critical role in increasing habitat complexity and species diversity, as they form microhabitats that are used by both mobile and sessile (animals that are permanently attached) invertebrates. Many benthic invertebrates are heavily reliant on sponges for survival, whether for food or for habitat.

4.10 Soil

During the on-site investigation in 2014/2015, three soil samples have been collected from the Inexpressible Island as NY01，NY02，NY03，the altitude and the coverage of the samples have been shown in Table 4-2.

Table 4- 2 Soil sample information

Sample	Location	Site	Altitude (m)
NY01	74°54.397′S;163°38.305′W	Inexpressible	140

NY02	74°51.241′S;163°37.582′W	Island	318
NY03	74°55.017′S;163°42.592′W		-1

The pH value, water content and organic matter content of the three soil samples have been analyzed. The range of the pH value is 6.72-7.75, the range of the water content is 1.98%-14.3 %and the range of the organic matters is 2.96% -5.08 %. NY 01 has the highest pH value and water content while NY 03 has the highest value of organic matter as shown in Table 4-3.

Table 4- 3 Analysis of the pH, water content and organic matter of the soil samples

	NY01	NY02	NY03
pH	7.75	6.72	6.69
Water Content（%）	14.3	1.98	4.77
Organic Matter Content（g/kg）	4.13	2.96	5.08

19 elements including O, Na, Mg, Al, Si, P, S, Cl, K, Ca, Ti, Cr, Mn, Fe, Cu, Zn, Rb, Sr, Zr have been analyzed as shown in Table 4-4.

Table 4- 4 Analysis of the 19 elements of the soil samples

Element	NY01(%)	NY02(%)	NY03(%)
O	45.79	47.68	47.61
Na	1.23	1.89	2.04
Mg	5.567	0.523	0.880
Al	7.295	8.461	8.307
Si	25.88	31.47	31.19
P	0.113	0.051	0.0938
S	0.027	0.013	0.045
Cl	0.038	0.049	0.028
K	1.97	4.506	4.240

Ca	3.406	1.53	2.29
Ti	0.359	0.296	0.299
Cr	0.0421	0.124	0.0928
Mn	0.129	0.0411	0.0474
Fe	8.078	3.3000	2.655
Cu	0.0084	-	0.0053
Zn	0.014	0.0069	0.0044
Rb	0.0077	0.0212	0.0134
Sr	0.0243	0.0136	0.0330
Zr	0.0136	0.0141	0.0194

We have obtained almost 150 strains of bacteria from NY01, NY02 and NY03, they are mostly *Proteobacteria* (46.60%)*, Bacteroidetes* (42.00%)*, Bacteroidetes* (10.60%) *and Firmicutes* (0.60%) as shown in Figure 4-51.

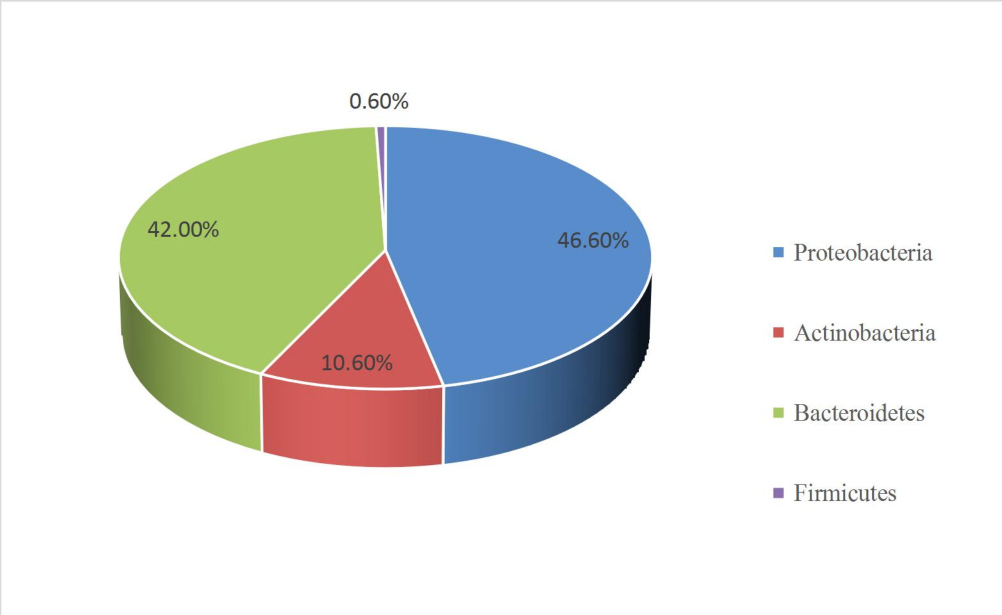


Figure 4- 51 The percentage of 150 strains of bacteria

The 150 strains of the bacteria are belonging to 22 species including *Arthrobacter, Massilia, Pseudomonas, Hymenobacter, Brevundimonas, Plantibacter, Flavobacterium, Aeromicrobium, Leifsoma, Aureimonas, Sphingopyxis, Rhodoferax, Altererythrobacter, Variovorax, Subtercola, Streptomyces, Sphingomonas, Rhodanobacter, Polaromonas, Paenisporosarcina, Nocardiodes and Dokdonella,* and the percentage of *Arthrobacter* is 28.67%*, Massilia* is 21.33%*, Pseudomonas* is 10.00% *and Hymenobacter* is 10.00% as shown in Figure 4-52.

We have separated 35 strains of bacteria belong to 6 species from soil sample NY01, *Althrobacter* is the richest as 80% as shown in Figure 4-53. We have separated 60 strains of bacteria belong to 15 species from soil sample NY02 as shown in Figure 4-54, *Massila* is the richest as 35 %. We have separated 55 strains of bacteria belong to 15 species from soil sample NY03, *Hymenobacter* is the richest as 25 % as shown in Figure 4-55.

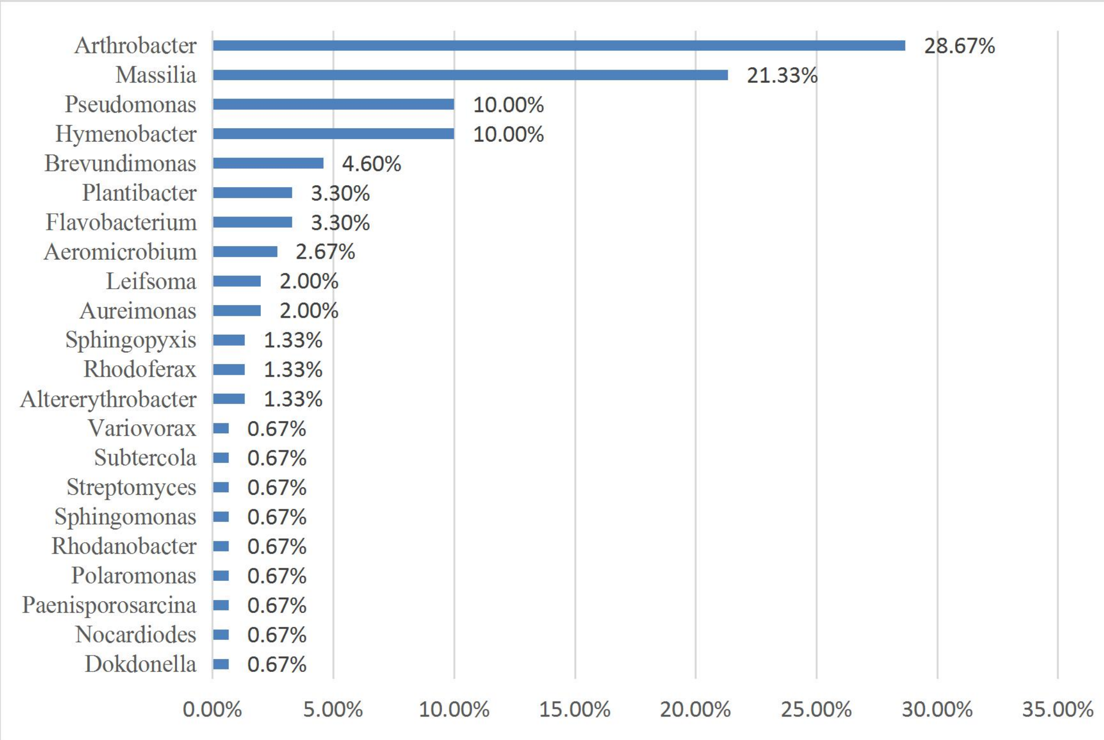


Figure 4- 52 The percentage of the species in the 3 soil samples

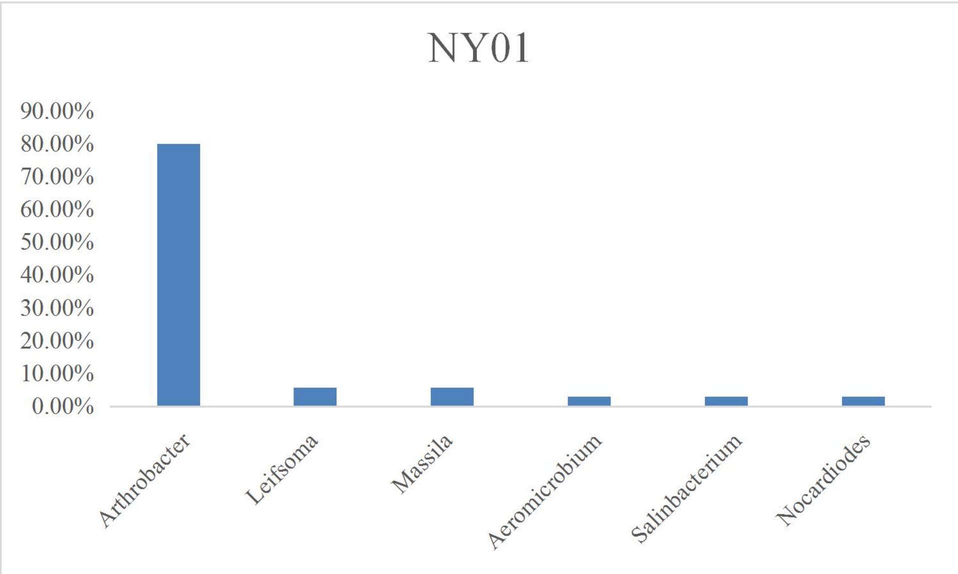


Figure 4- 53 The percentage of the species in the NY01

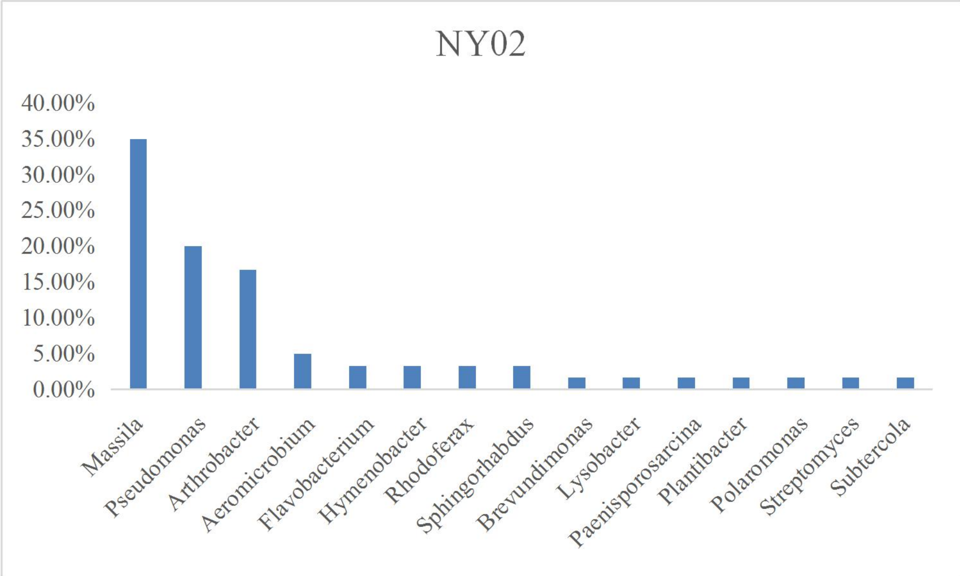


Figure 4- 54 The percentage of the species in the NY02

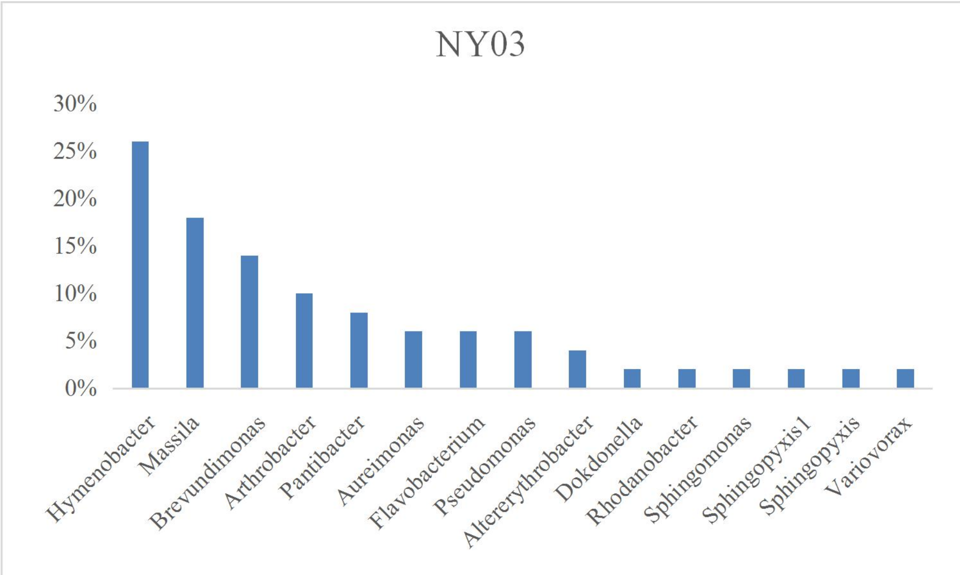


Figure 4- 55 The percentage of the species in the NY03

4.11 Human activities

The island was discovered in 1901-1903 by Scott's *Discovery* Antarctic expedition. In January 1912, during Scott's second Antarctic expedition (Terra Nova, Antarctic expedition), a six-member expedition team landed on the island. This group had to live on the island until September because Terra Nova ship failed to pick them up on time. The camping position has been listed as a historical site (HSM 14, 74°55'S, 163°43' E). The current human activities on the island mainly include research and tourism.

Two Italian helicopter operations were observed during the on-site investigation, including one operating for more than three hours to transport construction materials and other supplies to the island. The Italian scientists on the island mainly focuses on geological, seismic and oceanographic studies. During the on-site investigation, the Republic of Korean scientist also visited the island for one time.

Tourism is the other main human activities on the island (see IAATO's website). The main purpose of the tourism on this island is to watch the Adélie penguins and historical relics.

According to the environmental impact assessment database search on the official website of the Antarctic Treaty Secretariat, since 2010, activities in other countries that have a greater impact on the environment in the region include the comprehensive environmental impact assessment of the new gravel runway project proposed by Italy, and the comprehensive environmental impact assessment of the new construction project of the Jang Bogo Station in Republic of Korea. In the impact assessment, all countries have implemented standardized environmental management measures in accordance with the relevant requirements of the Antarctic Treaty to ensure that the cumulative environmental impact of the region is minimized.

PERIOD	PARTY	CATEGORY	TITLE	ACTIVITY
2017/2018	ITALY	Comprehensive Environmental Assessment Report	Final Comprehensive Environmental Evaluation for the construction and operation of a gravel runway in the area of Mario Zucchelli Station, Terra Nova Bay, Victoria Land, Antarctica	Construction of a gravel runway for heavy aircrafts.
2013/2014	CHINA	Comprehensive Environmental Assessment Report	Proposed Construction and Operation of a New Chinese Research Station, Victoria Land, Antarctica. Draft Comprehensive Environmental Evaluation	Construction/Operation of new facilities
2010/2011	KOREA (ROK)	Comprehensive Environmental Assessment Report	Comprehensive environmental evaluation; Construction and operation of the Jang Bogo Antarctic Research Station, Terra Nova Bay, Antarctica	Activity aims to establish a plan that will minimize the impact of the construction and operation of a new Korean research station on the Antarctic

According to the environmental impact assessment database search on the official website of the Antarctic Treaty Secretariat, since 2010, activities in other countries that have less environmental impact in the region include the David Glacier subglacial lake survey activity carried out by Republic of Korea based on the Jang Bogo Station, and the Ross Sea Marine Reserve The ecosystem structure research activities and the supporting work of Jang Bogo station site selection are detailed in the attached table; relying on Mario Zucchelli Station, Italy mainly carried out the ice core drilling work of Dome C; Germany carried out the repair activities of Gondwana station.

PERIOD	PARTY	CATEGORY	TITLE	ACTIVITY
2018/2019	KOREA (ROK)	IEE	Initial Environmental Evaluation of the expedition to find candidate subglacial lake for exploration near David Glacier, Victoria Land	Traverse and scientific activities
2017/2018	KOREA (ROK)	IEE	Initial Environmental Evaluation of the activities for the research project 'Ecosystem structure and function of Ross Sea MPA'	Scientific activities including camp installation
2017/2018	KOREA (ROK)	IEE	Initial Environmental Evaluation of the expedition to find candidate subglacial lake for exploration near David Glacier, Victoria Land	Traverse and scientific activities
2010/2011	KOREA (ROK)	IEE	Initial Environmental Evaluation of the investigation activity on the construction site of the Jang Bogo Antarctic Research Station, Antarctica	Activities aim to make a plan for the construction of a new Korean research station in Antarctica

Relying on the related investigation activities carried out by Zucchelli Station in Italy, the IEE includes:

PERIOD	PARTY	CATEGORY	TITLE	ACTIVITY
2019/2020	ITALY	IEE	Beyond Epica	The foreseen activity will last 5 years and its objectives are to drill, recover and analyse an Antarctic ice core covering up to 1.5 Million years.

Relevant infrastructure renovation activities were carried out at Gondwana Station of Germany.

PERIOD	PARTY	CATEGORY	TITLE	ACTIVITY
2015/2016	GERMANY	IEE	Modernisation and onward operation and of Gondwana Station	Operation of scientific summer station

The scientific expeditions carried out by other countries in the region are regarded as activities with less than minor impacts that do not require IEE or comprehensive environmental assessment reports, and can be carried out directly, so they will not cause related cumulative environmental impacts in the region.

All countries that have prepared preliminary environmental impact assessment reports and environmental assessments are about 30km away from this site. All countries have implemented standardized environmental management measures in accordance with the relevant requirements of the Antarctic Treaty to ensure that the cumulative environmental impact of the region is minimal. It will have a significant cumulative environmental impact on the environment around Inexpressible Island.

In order to further optimize the location of the new station and the precise positioning of the main building, and to cooperate with the investigation of the environmental baseline value of the special protection zone, since 2018, China has completed the construction of temporary facilities, including 11 accommodation cabins with a total area of approximately 250 square meters. (22 beds), 2 power generation cabins (100kw each power generation cabin), a set of seawater desalination equipment, a daily production of 1,500 liters of fresh water, a kitchen waste treatment system, a sewage treatment system, and two independent crew cabins. I t basically has the ability to meet the normal life and work of up to 30 logistics support personnel. Through learning from the experience of the apron at the Korean station and the Italian station, the existing idle materials on the site was used. By choosing a safe location with convenient transportation and open surroundings, the temporary helipad was completed, which greatly improved the safety of helicopters taking off and landing at the new station.

All construction activities are within the scope of the draft comprehensive environmental impact assessment report in 2018 and other processes, and relevant environmental management regulations have been strictly implemented. The minor environmental impacts that may be caused by the temporary facilities have been assessed in accordance with relevant requirements. After the construction of the station is completed, the temporary facilities will be completely demolished, the waste will be transported back to the country, and the temporary construction site will be restored to its original status.

4.12 Protected areas, historic sites, and monuments

The historic sites on the Inexpressible Island are mainly associated with the 1910-1913 Antarctic expedition by British explorer Scott's Terra Nova.

This area has two historic sites as shown in Figure 4-56. One is the snow house where they overwintered, as HSM14 (74°54' S, 163°43'E) shown in Figure 4-57, the other is in the northeast of the island, where they stored supplies as HSM68 (74°52' S, 163°50'E).

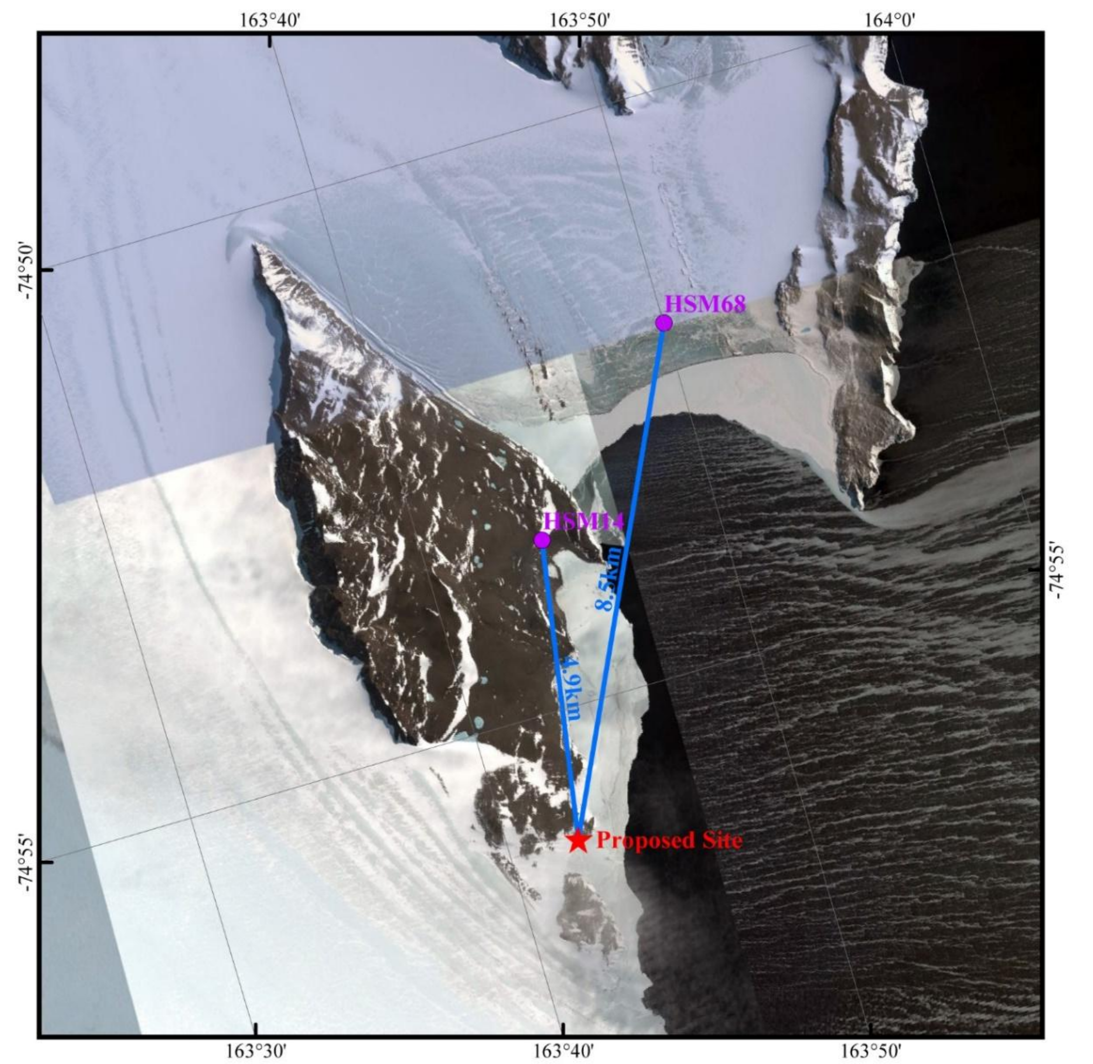


Figure 4- 56 The distance between the HSM 14, HSM 68 to the proposed site

Figure 4- 57 HSM 14 Campbell's igloo

An Antarctic Specially Protected Area (ASPA 161 Terra Nova Bay, Ross Sea, 74°45'S, 164°10'E) is located 23 km away from the northeast of the proposed station location.

4.13 Prediction of the future environmental trends without the proposed activities

Due to the short period of sea ice melting, the number of tourists in this area is limited. Only did the Italian and Korean groups do some scientific investigations on the island. Therefore, without new station construction, pollution and terrain changes related to the construction of the new station do not exist.

A small number of the Adélie penguins occasionally visit the freshwater lake on the island in the middle part. Without the station-related activities, these penguins will not be affected.

A wharf at the coast will be set up for the logistics of the new station. Without the related construction, such as leveling of the land, the terrain will not be changed.

The regular station operation and logistics related activities will not involve the use of the fresh water in the lake, but still have the sewage disposal to the sea. Without these activities, the surrounding lake and marine environment will remain intact.

5. Identification and Prediction of Environmental Impact, Assessment and Mitigation Measures of the Proposed Activities

An Environmental Impact Assessment comprises three major phases: analysis of proposed activities and identification of the impacts on the current environment, prediction and assessment of the impacts, and suggestion for mitigation measures and following monitoring and verification. This Final CEE for the construction and operation of the new station is prepared according to this process.

Additionally, the marine transportation route will also be considered. The following sections define the direct impact of the proposed construction, operation and logistic supporting activities of the new station on the local environment (refer to Section 2). The inputs and outputs of the activities, as well as their potential impact on the environment, are assessed by means of the source-pathways-receptors process. And then, measures for the mitigation of the impact are presented. Assessment of the impact and measures of mitigation of them are provided in the Impact Matrix at the end of this chapter.

The direct environmental impact of ice, snow, air, ecosystem and other environmental attributes will cause by the activities of construction and operation of the station, construction and operation of the wharf, emission of exhausted gas and oil spilling, discharge of treated sewage up to the standard after treatment, noise from vehicles and personnel, and influence from the interference of visitors.

Among the impact, air pollution and particle fallout are considered as the most important. However, the probability of large-scale oil leakage is relatively low. The adverse impact of residual water is relatively low as the related treatment meets the required standards and the discharge is little. Due to the limited snow-compaction and snow-collection, the impact on ice and snow is easy to recover. As far as the scientific research is concerned, the estimated impact includes the air pollution caused by consuming fossil fuel which may affect atmospheric chemical determination, interference to snow surface which hence affect the meteorological observation. The potential impact of light haze deriving from the construction of the new station which also affects meteorological observation and interferes of electro-equipment and vehicles of the new station in electromagnetic observation.

As a matter of course, this plan also formulates the prevention and mitigation measures in order to avoid or reduce all the estimated impact.

All construction work and operation activities at the new station, as well as any other activities in the actual process beyond the original plan, must meet the requirements of the Protocol on

Environmental Protection to the Antarctic Treaty. CAA will carefully supervise the implementation of the plan, and provide environmental protection education and pre-departure training for the personnel who will participate in the station construction and scientific expedition activities.

Sustainable and highly efficient techniques are taken into full consideration on the aspect of materials selection, the utilization of renewable energy resources, the maintenance and management, the waste treatment, recycling and utilization, and the development, dismantlement, and clearance of the station in the future. Therefore, it will be of great advantage to mitigation of environmental impact.

Description of indirect impact and cumulative impact are discussed in Section 5.6.

5.1 Methodologies and data

The following criteria are used to identify the character of the impact and to make the qualitative and quantitative assessment of the potential environmental impact in Sections 5.3. These criteria and assessment guidelines are applied to the impact matrix of Section 5.5.

Nature

“Nature” here means the character of the impact caused by the activities on potential receptors.

Extent

“Extent” here means affected geographical areas ranging from local, regional, Antarctic to global areas.

Duration

The duration of impact is classified as “very short term” (minutes to days), “short” (weeks to months),” medium” (years), “long” (decades), “permanent” and “unknown”. There may be a lag time between the occurrence of the result and the time of the impact.

Intensity

General impact level is assessed at different degrees (low, medium and high). Low degree means that there is only small effect on the natural function or process, and this effect is reversible；Medium degree means that there is an effect on the natural function or process, but the process is not affected by a long-term change and this influence is reversible；High degree means there is a long-term or cumulative effect on the natural function or process, and such impact is probably irreversible.

Probability

The possibility of impact is described as different extents like low, medium, high and certain.

Significance

The overall significance of an impact is assessed at different degrees (very low, low, medium, high and very high).

Description of impact

The specific impact is qualitatively classified as the direct impact, indirect impact, and cumulative impact. Specific descriptions of these three categories of impact are shown in Article 3 of Annex 1 of the Protocol Environmental Protection to the Antarctic Treaty. Various definitions made by the CEP (2016) are adopted in this CEE.

(1) **Direct impact**: Any first order effect, impact or consequence that may be associated with activities.

(2) **Indirect or second order impact**: Any second order effect, impact or consequence that may be associated with activities.

(3) **Cumulative impact**: The effect, impact, and consequence that may come from similar or varied sources, as well as the additive, antagonistic or synergistic effects that can occur.

5.2 Source, pathways, and receptors

The source-pathways-receptors principle has been used for identification of the impact possibly associated with the activities and it is in compliance with the Environmental Protocol. The impact may be worse than estimated.

The sources of environmental impact arising from construction and operation of the new station, emission of exhausted gas and oil spilling, discharge of treated sewage up to the standard after treatment, noise from vehicles and personnel, and influence from the interference of visitors.

The geographical areas to be affected mainly include the marine transport route and the new station. The area where scientific activities are conducted will also be affected to some extent.

The location where the new station will be built is close to the glacier. As ice is a kind of medium, the wastes produced or discharged on snow or ice in some areas may move to another area with the floating medium such as the ocean, though it may take a long time.

5.3 Environmental impact identification, prediction, and assessment

5.3.1 Impact on air

Fuels to be used during the construction and operation of the station include:

- Antarctic Diesel (Marine transport by the icebreaker Xuelong and Xuelong 2)
- Antarctic Diesel (Vehicles and power supply)
- Aviation Kerosene (Helicopter and Fixed wing)
- Lubricating oil and hydraulic oil (Mechanical equipment and vehicles)
- Magnetic pyrolysis furnace

The atmospheric emission during the construction period will mainly arise from the consumption of fuels used for vehicle's operation and power supply. Besides, carbon dioxide emitted from the process of sewage treatment will also give rise to a slight impact on the atmosphere. During the operation period, magnetic pyrolysis furnace will be used instead of the traditional incinerator to minimize the atmospheric emission arising from the waste disposal.

5.3.1.1. Estimation of fuel consumption

During the initial stage of station construction and operation, the fuel will be mainly used for five purposes: 1) for power generation, 2) for the operation of machinery and transportation vehicles, 3) for boiler heating, 4) for the operation of the aircraft, and 5) for scientific survey and equipment operation. After the successful installation of the hybrid Solar-Wind-Diesel power supply system, the solar energy and windmill will be fully used as primary energy. So, the fuels will mainly be used for the operation of construction machinery, transportation vehicles, the aircraft and the scientific equipment and in emergency cases.

The approximate fuels consumption by the new station during the construction and operation stages, before and after the use of the renewable energy is shown in Tab 5-1 and Tab 5-2. Data regarding the construction of Antarctic stations by other countries have also been taken for reference when making the estimation.

Because maritime transportation constitutes part of China's regular annual Antarctic expedition activities, and there are 120 berths on the vessel of Xuelong, hence there will be no increase of berths during construction and operation of the station, the extra increase of the fuel is related to the additional fuel needed between the Zhongshan station and the new station.

Table 5- 1Estimated fuel consumption required during construction of the new station (tons)

Source	Fuel Type	2021/2022 Consumption (ton)	2022/2023 Consumption (ton)	2023/2024 Consumption (ton)	2024/2025 Consumption (ton)	Total Fuel Consumption (ton)
Additional Marine transportation (Xuelong, Cargo ship, Tugboat, Rubber boat)	Antarctic Diesel	1000	1000	1000	1000	4000
Air transportation	Aviation kerosene	80.4	80.4	80.4	80.4	321.6
Generator used for (camps and facilities	Antarctic Diesel	50.4	50.4	50.4	50.4	201.6
Construction equipment and vehicles	Antarctic Diesel	31.2	31.2	31.2	31.2	124.8
Emergency fuel	Antarctic Diesel	10	10	10	10	40
Subtotal		**1172**	**1172**	**1172**	**1172**	**4688**

Table 5- 2 Estimated fuel consumption required during operation of the new station (tons/year)

Source	Fuel Type	2025 (ton)	2026-2030 (ton/year)	2031-2035 (ton/year)	After 2036 (ton/year)
Capacity of solar power	**-**	**100 kW**	**100 kW**	**150 kW**	**150 kW**
Capacity of wind power	**-**	**100 kW**	**100 kW**	**200 kW**	**300 kW**
Additional Marine transportation (R/V Xuelongs, Cargo ship, Tugboat, Rubber boat)	**Antarctic Diesel**	**1000**	**1000**	**1000**	**1000**
Air transportation	Aviation kerosene	**78.2**	**78.2**	**78.2**	**78.2**
Generators	Antarctic Diesel	**219.7**	**219.7**	**130.2**	**58.6**
Vehicles	Antarctic Diesel	**18.5**	**18.5**	**18.5**	**18.5**
Emergency fuel	Antarctic Diesel	**10**	**10**	**10**	**10**
Subtotal		**1326.0**	**1326.4**	**1236.9**	**1165.3**

5.3.1.2. Assessment of the impact on air

Unloading from the vessel will be carried out mainly by barges, some staff and some cargos would be carried to the new station by helicopter. The days for unloading depend on several factors such as sea ice, weather conditions, and time required for transporting oil or construction materials to the station. 15 days may be needed for unloading during the construction and operation of the new station. Emissions along the coast will spread out rapidly. Therefore, no obvious impact will be brought on the wildlife, oceanic system or atmospheric quality.

During construction, there will be more human and vehicle activities. Without solar energy power and windmills during the construction period, the fuel consumption at the new station as well as the atmospheric emission will be relatively high. However, once the solar energy power and windmills are put into operation, the fuels will mainly be used to support the field survey and the operation of limited vehicles, as a result, the atmospheric emissions will be reduced distinctly.

Other sources causing an impact on the atmosphere are carbon dioxide arising from the sewage treatment. The fallout of burnt substances occurring in the new station may possibly deteriorate snow and ice. Heavy particulates may deposit in the areas near the new station, which may result in the adverse impact on the future study of snow and ice. The study conducted by the stations of other countries show that pollution to snow and ice in downwind direction may reduce rapidly at the place of 10 km away from the location where the pollution originates, the new station is near the shorelines and the pollutants downwind is limited.

1) Estimated atmospheric emission in the construction stage

The construction stage will cover four austral summers, and each construction stage will last for approximately 90 days. During the construction period, it is estimated that each year 1000 tons of Antarctic Diesel will be needed for marine transportation, 80.4 tons of Aviation kerosene will be needed for air transportation, 50.4 tons of Antarctic Diesel will be needed for the operation of the generator and another 31.2 tons of Antarctic Diesel will be needed for construction equipment. Referred to the emission factors given by the Appendix 5 of Korean Final CEE for Jang Bogo Station, the total annual emissions of various pollutants in each year during the construction will be as follows: CO, 1.76 ton, NO_x, 4.62 ton, SO_2, 33.57 ton, PM_{10}, 0.40 ton, CO_2, 998.17 ton as shown in Tab 5-3.

The total amount of pollutants during the construction stage for four seasons will be as follows respectively: CO, 7.03 ton, NO_x, 18.49 ton, SO_2, 134.30 ton, PM_{10}, 1.60 ton, CO_2, 3992.66 ton as shown in Tab 5-3.

2) Estimated atmospheric emission in the operation stage

During the first year of the new station operation in 2025, it will take the highly efficient fuel as the main power source and adopt the hybrid Solar-Wind-Diesel power supply system. It is estimated that 1000 tons of Antarctic Diesel will be needed for marine transportation, 78.2 tons of Aviation kerosene will be needed for air transportation, 219.7 tons of Antarctic Diesel will be needed for the operation of the generator and another 18.5 tons of Antarctic Diesel will be needed for vehicles. The total annual emissions of various pollutants in that year will be as follows: CO, 1.89 ton, NO_x, 6.92 ton, SO_2, 33.72 ton, PM_{10}, 0.60 ton, CO_2, 1092.42 ton as shown in Tab 5-4. Renewable systems reduce emissions as follows：CO, 0.11 ton, NO_x, 1.55 ton, SO_2, 0.10 ton, PM_{10}, 0.14 ton, CO_2, 64.97 ton as shown in Tab 5-4.

After operation(2026-2030), if the hybrid solar-wind-power system (100kW solar+100kW wind) is successfully installed and operated, the renewable energy will be the priority energy source for the whole station. Thus, the estimated consumption of Antarctic Diesel for the operation of the generator will decrease to 219.7 tons/year. The total annual emissions of various kinds of pollutants will be as follows: CO, 1.89 ton, NO_x, 6.92 ton, SO_2, 33.72 ton, PM_{10}, 0.60 ton, CO_2, 1092.42 ton as shown in Tab 5-5. The reduction of the emission by renewable energy system will be as follows: CO, 0.11 ton, NO_x, 1.55 ton, SO_2, 0.10 ton, PM_{10}, 0.14 ton, CO_2, 64.97 ton as shown in Tab 5-5. The total emission reduction for CO_2 in this period is about 260 ton.

After operating for 5 years(2031-2035), if the hybrid solar-wind-power system (150kW solar+200kW wind) is successfully installed and operated, the renewable energy will be the priority energy source for the new station. Thus, the estimated consumption of Antarctic Diesel for the operation of the generator will decrease to 130.2 tons/year. The total annual emissions of various kinds of pollutants will be as follows: CO, 1.80 ton, NO_x, 5.60 ton, SO_2, 33.63 ton, PM_{10}, 0.49 ton, CO_2, 1037.48 ton as shown in Tab 5-6. The reduction of the emission by renewable energy system will be as follows: CO, 0.20 ton, NO_x, 2.87 ton, SO_2, 0.19 ton, PM_{10}, 0.25 ton, CO_2, 119.91 ton as shown in Tab 5-6. The total emission reduction for CO_2 in this period is about 1199 ton.

After operating for 10 years(2036-), if the hybrid solar-wind-power system (150kW solar+300kW wind) is successfully installed and operated, the renewable energy will be the priority energy source for the new station. Thus, the estimated consumption of Antarctic Diesel for the operation of the generator will decrease to 58.6 tons/year. The total annual emissions of various kinds of pollutants will be as follows: CO, 1.73 ton, NO_x, 4.56 ton, SO_2, 33.57 ton, PM_{10}, 0.39 ton, CO_2, 993.51 ton as shown in Tab 5-7. The reduction of the emission by renewable energy system will be as follows: CO, 0.27 ton, NO_x, 3.91 ton, SO_2, 0.25 ton, PM_{10}, 0.35 ton, CO_2, 163.88 ton as shown in Tab 5-7. If considering the life time of 25 years for the new station, the total emission reduction for CO_2 in this period is about 2130 ton.

Table 5- 3 Estimated fuel consumption and total emission during the construction period

Source	Fuel Type	Total Fuel Consumption(ton)	Annual consumption(ton)	Emission Pollutants	Emission factor (g/kg)	Annual Emission(ton)	Total Emission(ton)
Marine transportation	Antarctic Diesel	4000	1000	CO	0.71	0.71	2.84
				NO_x	3.41	3.41	13.64
				SO_2	33.44	33.44	133.76
				PM_{10}	0.28	0.28	1.12
				CO_2	879	879	3516
Air transportation	Aviation kerosene	321.6	80.4	CO	12	0.9648	3.8592
				NO_x	0.19	0.015276	0.061104
				SO_2	0.72	0.057888	0.231552
				PM_{10}	0.2	0.01608	0.06432
				CO_2	859	69.0636	276.2544
Generator used for (camps and facilities	Antarctic Diesel	201.6	50.4	CO	1.01	0.050904	0.203616
				NO_x	14.66	0.738864	2.955456
				SO_2	0.93	0.046872	0.187488
				PM_{10}	1.28	0.064512	0.258048
				CO_2	614	30.9456	123.7824
Construction equipment and vehicles	Antarctic Diesel	124.8	31.2	CO	1.01	0.031512	0.126048
				NO_x	14.66	0.457392	1.829568
				SO_2	0.93	0.029016	0.116064
				PM_{10}	1.28	0.039936	0.159744
				CO_2	614	19.1568	76.6272
Subtotal				CO	-	1.757216	7.028864
				NO_x	-	4.621532	18.486128
				SO_2	-	33.573776	134.295104
				PM_{10}	-	0.400528	1.602112
				CO_2	-	998.166	3992.664

Table 5- 4 Estimated annual fuel consumption and total emission in 2025

Source	Fuel Type	Annual consumption(ton)	Emission Pollutants	Emission factor (g/kg)	Annual Emission(ton)
Marine transportation	Antarctic Diesel	1000	CO	0.71	0.71
			NO_x	3.41	3.41
			SO_2	33.44	33.44
			PM_{10}	0.28	0.28
			CO_2	879	879
Air transportation	Aviation kerosene	78.2	CO	12	0.9384
			NO_x	0.19	0.014858
			SO_2	0.72	0.056304
			PM_{10}	0.2	0.01564
			CO_2	859	67.1738
Generator used	Antarctic Diesel	325.5	CO	1.01	0.221987
			NO_x	14.66	3.220802
			SO_2	0.93	0.204321
			PM_{10}	1.28	0.281216
			CO_2	614	134.8958
Construction equipment and vehicles	Antarctic Diesel	18.5	CO	1.01	0.018685
			NO_x	14.66	0.27121
			SO_2	0.93	0.017205
			PM_{10}	1.28	0.02368
			CO_2	614	11.359
Subtotal			CO	-	1.888982
			NO_x	-	6.91687
			SO_2	-	33.71783
			PM_{10}	-	0.600536
			CO_2	-	1092.4286

Table 5- 5 Estimated annual fuel consumption and total emission in 2026-2030

Source	Fuel Type	Annual consumption(ton)	Emission Pollutants	Emission factor (g/kg)	Annual Emission(ton)
Marine transportation	Antarctic Diesel	1000	CO	0.71	0.71
			NO_x	3.41	3.41
			SO_2	33.44	33.44
			PM_{10}	0.28	0.28
			CO_2	879	879
Air transportation	Aviation kerosene	78.2	CO	12	0.9384
			NO_x	0.19	0.014858
			SO_2	0.72	0.056304
			PM_{10}	0.2	0.01564
			CO_2	859	67.1738
Generator used	Antarctic Diesel	219.7	CO	1.01	0.221897
			NO_x	14.66	3.220802
			SO_2	0.93	0.204321
			PM_{10}	1.28	0.281216
			CO_2	614	134.8958
Construction equipment and vehicles	Antarctic Diesel	18.5	CO	1.01	0.018685
			NO_x	14.66	0.27121
			SO_2	0.93	0.017205
			PM_{10}	1.28	0.02368
			CO_2	614	11.359
Subtotal			CO	-	1.888982
			NO_x	-	6.91687
			SO_2	-	33.71783
			PM_{10}	-	0.600536
			CO_2	-	1092.4286

Table 5- 6 Estimated annual fuel consumption and total emission in 2031-2035

Source	Fuel Type	Annual consumption(ton)	Emission Pollutants	Emission factor (g/kg)	Annual Emission(ton)
Marine transportation	Antarctic Diesel	1000	CO	0.71	0.71
			NO_x	3.41	3.41
			SO_2	33.44	33.44
			PM_{10}	0.28	0.28
			CO_2	879	879
Air transportation	Aviation kerosene	78.2	CO	12	0.9384
			NO_x	0.19	0.014858
			SO_2	0.72	0.056304
			PM_{10}	0.2	0.01564
			CO_2	859	67.1738
Generator used	Antarctic Diesel	130.2	CO	1.01	0.131502
			NO_x	14.66	1.908732
			SO_2	0.93	0.121086
			PM_{10}	1.28	0.166656
			CO_2	614	79.9428
Construction equipment and vehicles	Antarctic Diesel	18.5	CO	1.01	0.018685
			NO_x	14.66	0.27121
			SO_2	0.93	0.017205
			PM_{10}	1.28	0.02368
			CO_2	614	11.359
Subtotal			CO	-	1.798587
			NO_x	-	5.6048
			SO_2	-	33.634595
			PM_{10}	-	0.485976
			CO_2	-	1037.4756

Table 5- 7 Estimated annual fuel consumption and total emission after 2036

Source	Fuel Type	Annual consumption(ton)	Emission Pollutants	Emission factor (g/kg)	Annual Emission(ton)
Marine transportation	Antarctic Diesel	1000	CO	0.71	0.71
			NO_x	3.41	3.41
			SO_2	33.44	33.44
			PM_{10}	0.28	0.28
			CO_2	879	879
Air transportation	Aviation kerosene	78.2	CO	12	0.9384
			NO_x	0.19	0.014858
			SO_2	0.72	0.056304
			PM_{10}	0.2	0.01564
			CO_2	859	67.1738
Generator used	Antarctic Diesel	58.6	CO	1.01	0.059186
			NO_x	14.66	0.859076
			SO_2	0.93	0.054498
			PM_{10}	1.28	0.075008
			CO_2	614	35.9804
Construction equipment and vehicles	Antarctic Diesel	18.5	CO	1.01	0.018685
			NO_x	14.66	0.27121
			SO_2	0.93	0.017205
			PM_{10}	1.28	0.02368
			CO_2	614	11.359
Subtotal			CO	-	1.726271
			NO_x	-	4.555144
			SO_2	-	33.568007
			PM_{10}	-	0.394328
			CO_2	-	993.5132

3) Impact of emission

Substances derived from fuel combustion are carbon dioxide, sulfur dioxide, nitrogen oxide and particulates etc. These substances will cause some impact on air quality. However, generally speaking, the impact is small. Firstly, the emission of all the fossil fuels during construction will only take place in two months in summer (including the time of transportation), which will be relatively short, secondly, there are relatively good out-spreading conditions during the operation stage around the station area where there are no plants or animals.

Therefore, the emitted pollutants will spread to a very low concentration condition.

Xuelong sail along their regular navigational route, the people and cargoes only stopover in the facility zone for a short time, the aircraft would only fly from the Xuelong to the new station for each austral summer, so the pollutants emission from the exhausted gas will spread out quickly and will not generate obvious impact on wildlife, ocean, and atmospheric quality.

The estimated impact includes those on the snow and ice surface of the station area. This kind of pollution may affect part of the scientific value of the area. The particulates may exist in the snow and ice for a long time.

The pollutants will accumulate, and some emitted gas will affect the atmospheric environment of the area. CO (like NO_x, the catalyst consumed by ozone) will stay in the air for about 1 month, and will finally change to CO_2. CO_2 is the product of maximum quantity in the combustion process. It will not directly affect human's health. However, as a greenhouse gas, it will obstruct heat spreading from the earth into the atmosphere, thus having the possibility of warming up the earth.

5.3.2 Impact on snow, ice, and ocean

5.3.2.1. Risk assessment of oil spill

The aviation fuels, lubricating oil, and hydraulic oil will be used for the transportation of materials during the construction and operation of the new station. Most fuels will be transported in sledded fuel tanks and a small amount of fuel and oil will be stored and carried in oil drums during the investigation of the new station. Fuel and oil consumption is shown in Section 5.3.1.

Fuel and oil spill may occur in the following processes: in the maintaining and refueling process of generators, vehicles and, the aircraft (including at the relay site), in the leakage of fuel tanks or oil drums, in an accident of vehicle driving process when carrying fuel tanks or oil drums, in the process of refueling, pipeline breaks or leaks, and the leakage of broken fuel tanks, etc. Among all the cases mentioned above, the refueling of vehicles and the leakage of broken tanks may be the main causes of the spill.

Besides, fuel spill accidents can also occur in the ship's navigation. However, as the navigation of Xuelong have become one of the regular activities in China's Antarctic expedition, the fuel spill risk in the maritime transportation process is not covered in the assessment of this CEE.

Fuel has relative volatility and the spilled fuel volatilizes rapidly. However, its residues will still exist. Some fugitive emissions depend on the range of fuel spill. If fuel spills onto the snow or ice, it will move down and may be wrapped up and kept there until it is released again. Obviously, the oil spill will cause pollution to the atmosphere, ice and snow. It may cause an indirect impact on regionally scientific value and cumulative impact as well. The assessment of these risks of the estimated oil spill is given in Tab 5-8.

Table 5- 8 Assessment of the risks of estimated fuel oil spill at the proposed station

Type of spill	Probability	Max. Spill (L)	Type of fuel oil
Barges' collision on sea ice	Low	30,000	Antarctic Diesel and other oil product
Catastrophic accident of bulk oil tank	Low	15,000	Antarctic Diesel and other oil product
Damage of fuel tanks or oil drums on the sea ice	Low	5000	Antarctic Diesel and other oil product
Breakage or spill of daily-used oil tanks	Low	<4000	Antarctic Diesel and other oil product
Breakage or spill of boiler tank	Low	<2000	Antarctic Diesel
Breakage or spill of waste oil drum	Low	<2000	Waste oil and lubricating oil
Pipeline breakage or leakage during refueling	Low	1000	Antarctic Diesel
Damage upon lifting of fuel tanks	Medium	200	Antarctic Diesel
Leakage of oil/fuel caused by generator	Medium	40	Antarctic Diesel/ lubricating oil
Small-scale spill during refueling vehicle or aircraft	Medium	5	Antarctic Diesel/ lubricating oil

5.3.2.2. Impact on snow and ice

Since most construction work of the new station will be set up on the ground without snow in summer, the environmental impact resulting from the construction of the new station will be limited.

The exhausted gas arising from all the activities will reach to snow area. However, it is a small amount and due to the stable westerly wind directions, it will not deposit in any fixed snow surface in the upwind direction, and the downwind direction is open sea.

5.3.2.3. Impact on the ocean

In the construction and operation stages of the new station, the personnel and cargoes will be transported by Xuelong which will sail once a year along with their regular navigational routes.

The operation of the vessel will give rise to solid and liquid waste. The discharge of the waste up to the standard after treatment will still bring about some impact on the marine environment and its ecosystem.

In the construction and operation stages of the new station, the potential risk of the oil spill during the transportation of the oil by barges should be considered.

5.3.3 Impact on ecosystem

The construction and operation of the new station may not affect the surrounding ecosystem significantly because no conspicuous colonies or breeding grounds of designated species have been found near the proposed site.

The construction of the wharf will result in a small reduction in the local marine benthic habitat within the footprint of the new wharf. The wharf design has sought to reduce the amount of sea bed preparation required and therefore the extent of this potential impact. Additionally, a long-term monitoring programme is already underway to verify the predicted impacts.

The flora, most of which are lichens and mosses, is very sporadic with a low distribution density and a coverage degree of less than 1% nearby the proposed site. They are expected to be disturbed during the construction of the new station, especially by the grading work. However, as there are very few lichen growths on the proposed site, the disturbance to vegetation will be transitory only for the construction and thus not be so significant.

The shortest distance between the habitat and the proposed site is about 3.5 kilometers. The Antarctic skua and Adelie penguin habitats on the north coast of the Inexpressible Island will not be directly disturbed by the construction and operation of the new station, only possible Less than minor or short-term environmental impact

Several Weddell Seals were founded on the north end of the Inexpressible Island but no colony was found, hence they will not be directly disturbed by the construction and operation of the station, the distance is more than 3.5 km.

5.3.3.1 Impact on flora and fauna during construction

1) Transportation and construction activities

Human disturbances can be induced by a variety of construction and land transportation activities, but the impact on lichens and mosses is almost negligible given their locations far away from the proposed site and relative low densities of distribution.

Antarctica Skua were observed during the investigation since the summer season of 2012/13 approximately 3.5 km away from the proposed site. However, the current existing skua nests in the northern part of the Inexpressible Island may be temporarily indirect affected during the construction.

The nearest community of the Adélie penguin has located about 3.5km away in the north direction. The proposed site was selected in a location approximately 3.5 km away from the boundary of the Adélie penguin colony, approximately 4.5 km from the center of the colony, in order to minimize any disturbances caused by the construction.

2) Helicopters and fixed wing

The helicopter strictly abides by the relevant requirements of the COMNAP flight manual during the unloading process. The negative impact on the Jaeger population is small, but the duration is very short, and only minor or short-term environmental impacts are possible.

3) Marine transportation and unloading

Marine transportations may disturb the marine environment and ecosystem. The unloading from the barge to land will have a particular potential impact on the marine ecosystem along the coastal line.

5.3.3.2 Impact on flora and fauna during operation

1) Research activities and visitors

Human disturbances can be induced by a variety of research activities and summer visitors from tourist ships authorized by IAATO, but the impact on lichens and mosses is almost negligible given their locations and densities of distribution. In addition, the impact on skua and Adélie Penguin habitats will be indirect and minor during the operation of the station because the colonies are located at a safe distance from the proposed site.

2) Transportation and unloading in case of an oil spill during transportation or unloading, the marine ecosystem may be subject to adverse impact.

3) Skuas are scavengers, therefore food or food waste left outside of the new station may disturb their dietary habits.

5.3.4 Impact on wilderness and aesthetic values

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

The proposed site is an island where there are exposed bedrock outcrops and glacial moraines.

The horizontal glacial sedimentary layers develop relatively flat topography, and the construction of buildings and routes may nevertheless result in, though minor and local, a visual disturbance to the natural landscape of the region.
The station layout is intended to have a minimum impact on the landscape and maintain the aesthetics of the region. The buildings and facilities at the new station will be contained within the proposed site to reduce the influence on the local scenery as much as possible. Tracked vehicles will only be used on the designated routes to minimize the disturbances to the land surface.
The new station will recycle water to its great extent, with only a small amount of standard-meeting treated water being discharged to the ocean, the impact on the ice or snow is prohibited.
The use of vehicles and mechanical equipment at the new station will leave traces on the snow surface. However, these traces will soon be covered by snow, hence, having only transitory and minor impact.
The new station will implement its Waste Management Plan to bring waste out of Antarctica. In addition, the Environmental Management Plan will also be implemented to reduce the negative impact on the local environment.
The environmental impact will be evaluated according to the dismantling and clearance of the new station, whenever it is necessary. The impact shall be reduced to a minimum level and great efforts will be made to remove all the buildings and facilities as much as possible without leaving any obvious traces on the local environment.

5.3.5 Impact of wastewater treatment and discharge

Domestic sewage will mainly come from cooking, daily washing and brushing, laundering, bathing, dish-washing and human excrement (See Section 2).
According to the design of the new station, the production of wastewater will be minimized, and the sewage treatment system will be provided. In the system, the techniques of MBR (Membrane Biological Reactor), UF (ultra-filtration) and RO (reverse osmosis) will be used for filtration, sterilization, and treatment, and the treated water up to the standards will be reused for laundering, bathing, and sanitary cleaning, etc. The filter residues will be collected and treated on the spot by magnetic pyrolysis furnace after drying.
Wastewater produced with hazardous chemical components from laboratories will be contained, specially sealed and transported back to China. In addition, water-saving devices will be installed.
In the construction stage of the new station, packing type water-free onboard toilet will be used with which all human excrement will be packed up and carried out of Antarctic area, In the operation stage of the new station, a negative pressure flush-free system will be used to

reduce the volume of excrement. The black water with human excrement will be treated by the fermentation tank, and the sludge will be treated by the magnetic pyrolysis furnace installed.

In addition, oil-polluted matters left from washing will also be collected and carried out of Antarctica. As the baseline value of the target pollutants in the environmental baseline value of the proposed area is very low, the indirect impact and cumulative impact of the treated water discharged after the standard-reaching treatment of reverse osmosis will be the extension of the contamination area and lessen the scientific value of the contamination area to some extent. However, since the volume of water to be discharged will be very small, an advanced and efficient treatment system of ultra-filtration membrane plus reverse osmosis will be adopted, and the treated water will meet and surpass the quality standard Category Ⅲ of P.R.C. Standards on Surface Water Environmental Quality (GB 3838-2002), equals to the water quality standard for drinking water source. In this way, the impact on the local environment will be very limited.

5.3.6 Impact of solid waste collection and disposal

During the stages of construction and operation, a certain amount of solid waste will be produced, and the solid waste produced during the construction stage will be obviously more than the operation stage. All solid wastes are sorted and packaged on site, and then temporarily stored, then packaged and shipped back to China.

According to the definition of Annex III (Paragraph 8) of the Protocol on Environmental Protection to the Antarctic Treaty and China's relevant management regulations on Antarctic garbage, solid waste is classified into the following categories:

- Recoverable garbage (Metal, plastic, paper, wood, and glass, etc.)
- Organic waste (Mainly from foodstuff)
- Hazardous waste (Batteries, adhesive agent, waste fluorescent lamps and oil sludge etc.)
- Unclassifiable garbage
- Fuel drums

1. Solid waste produced in the construction stage

In the construction stage of the new station, solid waste from construction materials should be reduced at source wherever possible in priority. Although a considerable amount of innocuous solid waste will be produced, which will mainly be packing materials and building materials, including metal, plastics, glass, and wood, etc.

Capital construction will also produce a relatively small amount of hazardous waste, such as adhesive agent, batteries, solvent, oily waste, and paint as well as solid domestic waste and food waste. The estimated amount of wastes possibly produced in the construction stage of the station is shown in Tab 5-9).

Table 5- 9 Estimated quantity of wastes to be produced in the construction stage of the new station

Items	Quantity	Unit
Empty fuel drum	5	Drum
Packing materials	5	20 ft. container
Kitchen/food	2	20 ft. container
Hazardous waste	2	Small box
Others	1	20ft. container

2 Solid waste produced in the operation stage

Total domestic waste including combustible, non-combustible and recycled waste may reach as much as 20kg/day during winter and 60kg/day during summer. Besides food waste as much as 5kg/day during winter and 15kg/day during summer are expected according to the daily food waste unit. However, given the living condition in the Antarctic, the amount of food waste produced is expected to be significantly lower than the predicted value, so the estimated weight of the solid waste will be less than 9 tons per year. According to the calculation based on the figure above, the volume of solid waste produced yearly at the new station will be estimated up to 45m^3(Table 5-10). The waste produced during field operation for scientific expedition should be brought back to the station for appropriate disposal. The solid waste will be treated in accordance with the principle of classified treatment and disposal. Combustible waste will be processed by the magnetized pyrolysis furnace. All non-combustible waste will be packaged and sealed and brought back to the country. Recyclable waste will be packaged and sealed and brought back to the country except for on-site use.

Table 5- 10 Estimated amount of waste to be produced in the operation stage of the station

Items	Quantity	Unit
Empty fuel drum	9	Drum
Packing materials	2	20ft. container
Kitchen/food	1	20 ft. container
Hazardous waste	2	Small box
Others	2	20 ft. container

5.3.7 Impact of noise

1. Source of noise in general

The noise levels during construction and operation are estimated and associated mitigation measures are established accordingly.

Noise will come from:

- Unloading activities of vessels and aircrafts
- Land transportations
- The operation of aircraft, vehicles, generators and the facilities for science activities

2. Source of noise during construction

Noise will be generated from loading and unloading activities, equipment operations and other construction activities including dock construction.

The noise level will arise from construction are estimated mainly considering according to equipment and other construction activities. However, the estimated noise levels, which are based on flat topography, are too conservative, as flat topography is the preferable condition for the propagation of noise.

Noise will be kept at the level without disturbing the Antarctic skua or penguin colonies by appropriately uses of construction equipment. The maximum temporarily noise level of the construction facilities will no more than 85 dB, the noise will decrease to less than 35 dB within 200m.

Therefore, while noise disturbance may influence the habitats of birds and mammals, the colonies of penguins where are located approximately 3.5 km away from the proposed site and separated by the buffering rock ridges, will not be significantly impacted by the noise generated during the construction.

3. Source of noise during operation

The noise generated from the station during its operation and associated scientific activities may leave an adverse impact on fauna such as the skuas and penguins. The operations of ships and aircrafts will also produce inevitable noise, whose impact is temporary and limited most occurring during summer, it will decrease to the baseline noise level (25 dB) within 1.5 km.

Windmills will also produce constant noise, and the estimated noise levels are expected to exceed 60dB temporarily at a distance of 300m, it will decrease to the baseline noise level (25 dB) within 1.5km.

Therefore, the colonies of penguins which are located approximately 3.5 km away from the proposed site will not be significantly impacted by the noise generated during the operation.

Power generators and radiators will produce constant noises well. However, their levels are expected to be significantly lower than 35dB, the indoor noise standard applied to the station in its operation stage.

5.3.8 Impact of artificial light

When the personnel live and work at the new station, the light source will be needed for illumination. As man-made light source will be added to the area where there is only original natural light, the certain impact will be brought to the surrounding environment. However, the man-made light source can only affect, to some extent, the scientific research projects which are sensitive to light. During the operation stage in the austral summer, the new station will be in the period of polar daylight. Therefore, light impact arising in this period will be very small. During the operation stage in the austral winter, the new station will be in the period of polar day night, therefore, light impact arising in this period will be significant.

5.3.9 Introduction of alien species

During the construction and operation of the new station, the risks of introducing alien species or transmitting diseases into Antarctica will be very low. Firstly, all the team members to Antarctica must pass a strict physical examination, making sure the occurrence of infectious disease almost impossible. Secondly, cooked food and dried food will be adopted as much as possible. Thirdly, wastes will be put under effective control, properly preserved and be taken out of Antarctica as much as possible.

5.4 Mitigation Measures

5.4.1 Mitigation measures for atmospheric pollution

Efforts will be made to use renewable energy as much as possible. The hybrid Solar-Wind-Diesel power supply system will be used in the new station. Utilization of renewable energy such as wind power and solar power will not only reduce the energy consumption of fossil fuel, but also lower the operation cost, reduce transportation risks and the labor intensity of the expeditioners, and play a good role in the protection of the Antarctic environment.

Meanwhile, high efficient fuel energy will be used as supplementary energy besides for some specific scientific purposes. The operation of the new station and vehicles will all use high efficient fossil fuel-Antarctic Diesel. The Antarctic Diesel has appropriate density, high calorific value, and good combustion performance. The combustion process is fast, stable, continuous and complete. It has few carbon deposits but high cleanliness. It has no mechanical impurity or water content. Its content of Sulphur, especially mercaptan is low, thus resulting in much less corrosion to machine elements. Light oil will also be used as ship oil to the utmost, so as to meet the criteria of air emission stipulated in Appendix VI of MARPOL. The fuel used will greatly reduce atmospheric emission and environmental impact.

High efficiency exhaust gas treatment using particulate filter systems will be equipped with the diesel generators. The impact on air caused by the diesel generators could be significantly reduced PM_{10} emission by applying the exhaust gas treatment during construction phases as well as during operation phase.

Efforts will be made to select highly efficient equipment. The combustion efficiency and environmental protection are the principal standards for equipment selection. For example, a set of VOLVO generators will be selected as its low exhausted gas emission can meet the EU standards when diesel is used. Other selected power installations should also have excellent performance and advanced technology. In addition, the periodical maintenance and service shall be conducted, with the dust remover air cleaner fixed at the outlet ends. Vehicles will also be selected with high combustion efficiency and low environmental effect. Vehicles purchased or under the plan to be purchased shall also meet the latest EU Standards.

Efforts shall be made to adopt energy-saving measures and/or technology, e.g. reducing the use of vehicles. In the operation stage, only 1-2 heavy vehicles will be used, and periodical maintenance and service will be provided for the vehicles. Catalytic converters will be installed in the vehicles to reduce the pollutant emission. In the meantime, reducing the operation of mechanical equipment, and provide skillful maintenance and service for the equipment so as to prevent extra fuel consumption as well as leakage. Meanwhile, the centralized ventilation device with heat recovery will be adopted. Phase change materials will be tested to use in the new station such as the floor radiation, pipelines insulation, thermal storage tank etc. to improve the efficiency of insulation.

Additionally, perfect integrated energy management system will be set up in the new station. Sound energy management will not only reduce the atmospheric emission of pollutants but also reduce the operation cost.

5.4.2 Mitigation measures in case of fuel and oil spill

Fuel storage system in the new station will be divided into two separated systems as Antarctica Diesel storage system and aviation kerosene storage system, which are prohibited to be mixed with each other. Each system will have its own oil storage tanks, turnover oil tank, pipelines, pumps, underground anti-static devices, environmental leak proof sump, fuel trucks and Intelligent Monitoring System based on the Internet of Things（including automatic control operations, security monitoring, safety warning and remote data transmission and so on）.

In respect of storage facilities, the sledded fuel tanks will be made of stainless steel, which is characterized by low-temperature tolerance. Each tank is fixed with a fuel-collecting plate at its bottom. In respect of transportation, the scientific plan will be made to reduce transportation of fuel tanks. In respect of fuel storage, the fuel storage area is separated with the refueling area where the fuel is used for the operation. The sledded oil tanks are only used as fuel storage in the storage area, so there should be no fuel leakage without outside force. The refueling area is just outside the power generation house where the only one sledded oil tank will be used. When the oil tank is empty, it will be moved back to the storage area and a new one will be transferred to the refueling area to replace it. In respect of connection for power supply, the sledded fuel tank is connected to the fuel pump in the power generation house through a pipe. There is a valve fixed at the end of each pipe, and the connection is done by a fast switching joint. The connection point between the fuel tank and the pipe is located just above the fuel collecting plate to ensure that there will be no fuel spill.

In respect of management, the standard procedures for the transportation, handling, transferring and using of fuels will be formulated and team members will be trained to conduct operation correctly in order to avoid the occurrence of fuel and oil spill.

For fuel spill handling facilities, vehicles, the refueling area of the new station and relay site will be equipped with appropriate fuel absorption felt, fuel spillage-preventing container and cleaning device, as well as the storage of polluted ice and snow etc., so that the spill can be handled in time.

Oil spill contingency and response plan will be formulated. COMNAP have drawn up the guidelines of Oil Spill Contingency Plan, covering small-scale area-based fuel and oil spill (Facility Plan) and large-scale hazardous spillage of fuel that needs joint efforts by several countries in Antarctica (Multi-Operator Plan). In the period of transportation and construction, the new station will make fuel and oil spill contingency plan according to the guidelines of COMNAP, as well as the detailed implementation plan for itself. Besides, it is necessary to conduct training for the staff involved in refueling and provide simulation training for dealing with oil spill accidents. Fuel and oil handling and fuel and oil spill response procedures will be reviewed periodically. All oil spill accidents will be reported to the manager of the new station and CAA and will be recorded in accordance with the monitoring requirements. The new station will formulate safety measures for the spill accidents of other oils, such as machinery lubricant. The detail oil spill contingency plan for specific activities are as follows:

(1) Oil Spill in oil transportation pipelines

To ensure safety, it is recommended that all pumping facilities in the upper reaches of the spill area shall be shut down urgently, valves of pipelines shall be closed, and the pipelines shall be cut off. Personnel shall promptly determine the point of leakage of the oil, after that, sufficient oil spill recovery containers (pumps, oil absorbing mats, recovery containers, etc.) shall be used immediately to retrieve the remaining oil from the spilled points. The oil leaking on the ground is collected as much as possible. The oil leaked on the indoor landing is adsorbed with oil-absorbing material (wood chips, cotton yarn, oil-absorbing mats, etc.) and packed into an oil spill recovery container. If the spill occurs on snow-covered area, shovel the snow and oil mixture into the oil spill recovery container in time. All kinds of oil wastes shall be disposed of in accordance with relevant international regulations. Determine the level of safety hazards in the assessed oil spill area, in case of fire or explosion in the oil spill area, fire-fighting measures (fire extinguishers, etc.) shall be promptly taken to avoid the occurrence of secondary accidents during and after the oil spill treatment process.

(2) Oil spill in oil storage tanks

The oil tank adopts a double-layer design, and the oil storage system is provided with an overflow tank. The design criteria of the oil spill tank are to meet the total oil spillage of a single oil tank. When spills occur in the oil storage system, fire prevention measures must be deployed in the tank area at the first time, and an enough amount of large-scale fire extinguishing equipment must be arranged around the tanks, and all unsafe operations with hidden safety hazards must be prohibited. To ensure the safety of personnel, close the pipeline valve between the leaking tank and other tanks urgently and locate the leakage point of the tank simultaneously, an effective and timely plugging measure shall be adopted. On the premise that safety measures are in place, the oil in the leaking tank can be pumped into other tanks to minimize any further spillage. For oil spills that have leaked into the oil spill tank, if there is a large scale of leakage, pumping equipment (electric pumps, etc.) must be used to remove the oil spilled into the oil spill recovery container, and then use absorbent material (oil absorption felt) to remove and clean the residual oil in the bottom.

(3) Oil spill in oil refueling operations

Ensure that the refueling tools, including hand-operated pumps, electric pumps, refueling pipes, etc., are in good working condition to prevent unnecessary leakage of oil during refueling. In the process of refueling mechanical vehicles, it is necessary to observe the amount of refueling at any time to prevent excessive fueling and oil spillage. Place oil pans, oil absorbing mats and fire extinguishers under the interface and valves.

(4) Oil spill during use of vehicle equipment

During the use of vehicle equipment, fuel drums need to be checked frequently. If there is an unnecessary leakage happened in the operation of the vehicle, immediately initiate the oil spill emergency in-site disposal plan, place the oil pan at the leakage point, and use the oil absorbing mats to absorb the oil on the snow surface or on the sand. Leakage of oil at the landing is buried in place, and the oil leaked on the indoor ground is adsorbed by oil absorbing material (oil-absorbing mats, sawdust, cotton yarn, etc.) for subsequent treatment. If the spill occurs on snow-covered area, shovel the snow and oil mixture into the oil spill recovery container in time (See Management Regulations: *Polar Expedition Emergencies Overall Contingency Plan(Trial))*

(5) Oil spill in offshore oil transportation operations

For oil spill occur on the sea surface during the oil tanker refueling operation period, spray chemical dispersants in time to decompose and spread oil spills on the sea rapidly, or use oil traps to control spilled oil on the surface and adopt the oil skimmer (required for the station)) to separate the oil from the water, then removing oil spills from the sea.

5.4.3 Mitigation measures for reducing impact on snow and ice

The issue of reducing the impact on snow and ice has been taken into full consideration in the design of the new station. For example, the logistic structures will be located in the area, where flat and smooth to reduce the physical impact on the snow surface. The high combustion-efficient fuel- Antarctic Diesel will be used to minimize the impact on the snow and ice arising from the exhausted gas emission. All vehicles and mechanical equipment will be selected and procured under the condition that they must have excellent performance and are technically advanced. The land vehicles will try its best to drive on the relatively smooth ground surface where fewer snow dunes so that the impact on the snow surface can be reduced as much as possible. Besides, the station will do its best to recycle water so as to minimize the water to be drained into the sea.

5.4.4 Mitigation measures for reducing impact on ocean

All solid waste will be packaged, compressed and shipped back to China for processing. Discharge of treated sewage and part of food strictly complies with the requirements set out in Appendix IV of MARPOL.

The vessel should keep the discharge record for some solid waste, ballast water, sewage, and foodstuffs, etc.

The ship hull will be scraped and rubbed by sea ice, thus inevitably leading to the breaking-off of the antifouling paint on the hull. However, the antifouling paint used on the Xuelong will contain no poisonous organic tin compounds and other hazardous chemicals.

The time needed for unloading at the wharf of the new station would be only 15 days, which means the impact on the ocean will be very transitory and minor. As the environmental issues that may arise have already been specified in the relevant chapters of environmental impact evaluation, hence, they will not be specified again here.

In addition to the above, the wastewater and spilled oil will eventually flow into the ocean, leaving an impact on the marine environment.

Therefore, pre-manufactured pier and wharf will be used to shorten the construction period as well as to reduce potential impact on the marine environment and preserve the natural coastal landscape.

5.4.5 Mitigation measures for ecosystem protection

5.4.5.1 Mitigation measures during construction

Impact on the local ecosystem due to the construction and operation of the new station can be reduced if the mitigation measures are properly implemented.

The direct and/or indirect impact on a few number of skua nests observed near the proposed site are inevitable during construction, thus additional protective measures are necessary to minimize the impact, such as the installation of barriers.

To conserve the skua community in the northern area apart from the proposed site, unnecessary visiting by either construction workers or other personnel will be strictly c restricted during the construction period.

In addition, all the personnel will be given a specific site-guidance on minimizing anthropogenic disturbance to the skua and Adélie Penguin colony. Biweekly monitoring on the skua and Adélie Penguin colony will be taken by biologists to devise additional effective mitigation measures in case unexpected impact occurs.

In order to minimize the impact of helicopter operations on the colonies of skua and Adélie Penguin, a flight route which can minimize the impact will be taken into account. Moreover, guidelines related to flying in the Antarctic, "Guideline for the operation of aircraft near concentrations of birds in Antarctica" will be followed (ATCM, 2004b). These guidelines will also be followed during the operation of the station.

Impacts on the marine ecosystem may vary depending on the alternative access routes to the new station. Considering the distributions of the flora and fauna, the best transportation route for the protection of biodiversity and ecosystem will be selected.

5.4.5.2 Mitigation measures during operation

1) Research activities and visitors

The impact caused by research activities and activities of the summer visitors from tourist ships authorized by IAATO are expected insignificant on the flora and fauna of the region. In particular, the major populations of skua and Adélie Penguin are not exposed to direct impact during operation. However, the temporary indirect impact is still expected, thus the limits on the number and the scope of such activities will be planned in advance in the annual plans of operation of the station.

2) Transportation and unloading

For transportation and unloading, an oil spill contingency plan has been set up to protect the marine ecosystem. Prevention and treatment materials such as oil absorption fabrics and recovery equipment will be prepared for immediate responses to oil spill accidents.

In order to minimize the potential environmental influence caused by the road construction and use, we have taken the full account of site selection of the wharf and the layout of the buildings. We will try our best to shorten the distance between the wharf and the new station, thus to minimize the environmental influence.

As for the site selection of the roadway tendency, we have given full consideration to avoiding the terrestrial vegetation with scientific value and soil distribution areas. We are planning to make full use of the gravel in site to smooth the road surface in situ.

As for the scientific research scope for future field studies such as the layout of the seismic station, we use helicopters to carry out these long-distance research activities, which has no influence on the ice-free area ecosystem.

Skua and Adélie Penguin in the northern coast will be observed as one of the possible indicators responding to any kind of impact and changes in the terrestrial ecosystem. During the operation, the population fluctuation of skua and penguin will also be carefully analyzed to conserve the core spot of skua's and penguin's habitats as well as the scientific research. In detail, the size and distribution of skua and penguin populations around the station will be recorded annually by establishing a post-monitoring program in order to investigate any changes in the ecosystem.

In consideration of skua as a scavenger, food and food wastes will be managed and treated according to a proper management plan.

All the personnel including visitors will be given the guidance on minimizing the disturbance to the skua and penguin colony. The helicopter will not overfly the skua community or penguin colony and its operation will follow the guidelines related to flying in the Antarctic, "Guideline for the operation of aircraft near concentrations of birds in Antarctica" (ATCM, 2004b).

3) Bird strike prevention system

The simplest way to keep birds away from wind turbines is to not build wind turbines where lots of birds are known to fly. The proposed site of the wind farm is in the southern part of the Inexpressible Island where is limit birds have been investigated. The proposed wind farm is more than 3.5 km away from the nests of the Skua in the northern part of the island.

All the fans and the supporting steel frame of the windmill will be painted with red, red and blue color which is warning information for the bird to prevent the bird strike.

In contrast to long range wide area radar, short range radar tracks birds in 3D with GPS accuracy and applies bird deterrents only when a bird is on a collision course with an individual turbine. Applying a deterrent only occasionally avoids the problem where deterrents work initially and then eventually become less effective as birds begin to become habituated to them.

Multiple types of deterrents are possible. A narrow bright flashing light beam (focused LEDs or unfocused laser) that can be pointed directly at the bird since the bird's 3D position is known to within a couple of meters. It is doubtful that any bird will continue to fly directly into the light as most bird strikes occur simply because they don't see the obstruction. Presumably, birds will simply alter course to move away from the light and wind turbine. The proposed radar is low power, low cost, and non-scanning (no moving parts). This short-range protection system will work in day, night, snow, or bright sunny day.

5.4.6 Mitigation measures against the loss of wilderness and aesthetic values

In the design of the new station, the local environmental conditions will be taken into full consideration. The harmonization with the local environment will be made to the great possible extent so as to minimize visual impact.

The new station will use renewable energy and highly efficient fuel as much as possible. Besides, highly efficient vehicles and mechanical equipment will also be adopted so as to minimize the emission to the atmosphere.

The new station will reduce the use of vehicles, mechanical equipment, and aircraft as much as possible and gradually mark out the driving lines of vehicles to ensure that the number of tracks can be kept at the lowest level.

The new station will do its best to recycle water so as to minimize the impact on the local environment.

At the end of the operation of the new station, all the equipment will be disassembled, dismounted and transported out of the station as much as possible, thus no obvious traces will be left. The dismounting and clearing work of the station will be done in accordance with the requirements of environmental impact evaluation.

5.4.7 Mitigation measures for wastewater treatment and discharge

Water-saving facilities will be provided in the design of the new station in order to reduce the amount of water needed and to minimize the production of sewage. At the new station, techniques of MBR, Uganda RO process will be used to filter, sterilize and treat the sewage. The treated water up to the standards will be reused for laundering, bathing, and sanitary cleaning.

Several methods for proper and safe disposal of the concentrated brine produced by the desalination process will be considered to reduce the environmental impact of desalination. The generated brine is expected to be relatively small in volume. Meanwhile, a discharge points optimal for rapidly mixing and dilution will be selected for the brine. In addition, pre-discharge mixing of the brine with treated sewage will be another alternative to reduce salt concentration.

5.4.8 Mitigation measures for minimizing solid waste

The following measures will be taken to reduce solid waste: drawing up scientific and detailed construction plans in advance and not taking unnecessary materials to the construction site, striving to prefabricate and assemble container buildings at home and reducing unnecessary packing materials to the minimum extent, not taking prohibited products (See Appendix III of the Protocol on Environmental Protection) to Antarctica, keeping the quantity of hazardous articles to the absolutely minimum extent, appropriately classifying, labeling and storing solid waste into a fixed position of the waste container for transportation, making the great possible effort to reuse the solid wastes, like empty fuel drums, formulate a waste management plan for the construction activity, training the personnel to have a good command of the classification, storage and disposal of wastes, appointing a team member as the environmental officer to direct and supervise the implementation of waste management procedures, and appoint another one as the waste manager to implement the waste management procedures properly and make regular supervision.

Eventually, all the solid waste and the human excrement will be brought back to China for the final disposal when the personnel leaves Antarctica.

A special magnetic pyrolysis furnace will be set up to reduce the volume of the solid waste as described in section 2. Food waste, which contains approximately 80% water, is planned to be dried and reduced in volume before put into magnetic pyrolysis furnace.

Hazardous waste produced from laboratories and waste oil will be stored separately and eventually transported outside of Antarctica.

5.4.9 Mitigation measures for noise prevention

As heliport has a higher acoustical level, we are carefully planning to transfer the noise sections such as helicopter more southerly to the south of the main building group. We will minimize the impact on the penguin habitat as much as possible through the blocking of the main building group, the northern mountain ridge, and the noise attenuation of more than 3.5 km.

Helicopters are mainly used to transport part of the supplies from Xuelong to the new station as well as when the field surveys are implemented. The wharfing location is in the south of the Inexpressible Island, thus the proposed entrance/exit of the helicopter flight path is also in the south, in order to minimize the impacts on the penguin protection area.

We will strictly abide by the relevant regulations on the helicopter in Antarctic region, realize the airspace management over the penguin habitat, and thus reduce the impacts on penguin habitat.

The simultaneous operation of construction equipment will be limited in order to minimize the impact of noise on the colonies of penguins, although the predicted levels of noise under the simultaneous operation condition are insignificant. In addition, construction machines of low noise and vibration-reduction technologies will be used and the idling of vehicles will be minimized.

Efforts will be made to minimize the operations of vessels, aircraft, vehicles and mechanical equipment etc. Noise-absorbing materials will be installed in power generation facilities. If it is necessary to operate aircraft, its flight will be kept within the height and space limitation stipulated in the Antarctic Flight Information Manual formulated by COMNAP, Maintenance and service will be provided regularly for vehicles, generators and mechanical equipment etc. so as to keep noise to the lowest level.

The windmills will be set up on the southwestern side of the station at least 300 meters away, and the distance between the windmills and the colonies of penguins will be more than 3.5 km.

5.4.10 Mitigation measures for artificial light pollution

Try to reduce the use of illuminating light, and scattering light, especially the light above the horizon, as much as possible in the design of external light especially in the austral winter.

We are planning to use LED lighting and control the brightness and duration of the outdoor lighting. We will use LED lighting, and try our best to reduce unnecessary lights and the light volume. We will use the light with the orange-red appearance to reduce the possibility of a bird strike. The decreased light spectrum of blue and violet (350-510nm) is to minimize the visual stimulus to birds.

We will fully considering the additional mitigation measures such as timers and motion detectors for outdoor lights near doors; and shading lights to direct the beams downwards.

5.4.11 Mitigation measures against transmission of diseases

Paragraphs 4 of Annex II of the Protocol on Environmental Protection and the stipulations of the Appendix will be strictly observed. The introduction of alien species and the migration of diseases will be limited to the great possible extent. A permit system will be applied, preventing any alien species from beginning brought into Antarctica without permission. The permit should be issued in strict accordance with the regulations of Annex II of the Protocol and the requirements of the scientific program.

In order to prevent the introduction or dissemination of alien species possibly transferred by people, equipment or supplies, the regulation of Annex II (Article 4) of the Protocol on Environmental Protection to the Antarctic Treaty and Resolution 6 ATCM XXXIV-CEP XIV with Non-native Species Manual annexed to the resolution will be strictly followed (ATCM, 2017). Items such as shoes, clothes and organic matters will be thoroughly cleaned and sanitized before being transported into Antarctica. In particular, tracked and wheeled vehicles will be carefully rinsed on the ship before unloading.

Meanwhile, following the normal practices of the Chinese Antarctic Expedition team, a comprehensive and strict physical examination will be carried out for the team members so as to prevent the occurrence of infectious diseases, foodstuff will be kept under control so as to ensure all the foodstuff, including the food provided at the new station and the food for field encampment, be safely stored and processed. A cleaning process will be applied to all clothing, scientific instruments, mechanical and field-operational equipment etc. before being transported into Antarctica and particularly, the railed and wheeled vehicles will be rinsed before entering Antarctica. All the wastes will be well managed and properly disposed of and be brought out of Antarctica to the great possible extent (as mentioned in Section 5.6 and 5.7).

5.4.12 Mitigation measures against alien species

There are risks of introducing alien species during proposed activities in the construction and operation phase. Due to strict physical examination for expeditioners, the risks can be controlled. Seeds should be fully disinfected and sealed to be transported to Antarctic, engineering workers should be well equipped and pre-cleaned in accordance with the standards of the Chinese National Antarctic Expedition, building materials should be pre-treated in China. By doing so, the risks of introducing alien species and spreading disease is negligible.

Equip research stations with the means to clean and maintain clothing and equipment that is to be used in the field, particularly in distinct or multiple locations.

Check cargo to ensure it is clean of visible contamination before loading on board the aircraft or vessels.

Confirm vessels as being rodent free before departure to the Antarctic.

Pack, store and load cargo in an area with a clean, sealed surface (e.g., bitumen, concrete free from weedy plants, soil, rodents and areas of waste ground). These areas should be regularly cleaned and inspected.

Containers, including ISO containers and boxes/crates, are not moved from one Antarctic site to another, except if cleaned before arrival at the new station.

Preventive measures to diminish risks of introduction of diseases to Antarctic wildlife could include, for example, specific guidance for handling field and station waste to minimize introduction of non-native species.

Expert advice should be sought as quickly as possible when a non-native species (including diseases of wildlife) is detected. A network of experts (taxonomists and specialists of eradication or control of non-native species) should be identified, including a list of names, details and e-mail available on the ATS website, in order to react as quickly as possible when a non-native species or disease event is discovered. This network should primarily 1) provide advice and 2) facilitate action by Parties.

Consider a ‘rapid response guideline’, including possible guide with practical eradication tools/means.

5.4.13 Mitigation measures against station dismantling

The new station will be constructed using the modular construction system. A detailed dismantling program including plans to dismantle and reuse the new station will be established in accordance with the guidelines of the Protocol on Environment Protection to the Antarctic Treaty.

More specifically, a detailed work schedule will be planned including the time schedule of dismantling, packing and transporting of the new station. For the estimated environmental impact, relevant mitigation measures will be prepared for all the tasks associated with the dismantling process.

When the new station is dismantled, all the building modules and steel frames of the main buildings and other facilities will be removed from Antarctica, and ship them back to China. Some research facilities such as automatic weather stations will be left for the region to provide long-term observation data. So do the GPS anchor point, gravimeter and mapping datum, locus of control, etc. Underground rock anchorage is not obvious ground targets. We believe that there is environmental technology to remove them in 25 years. But there is uncertainty. According to the relevant provisions of the Environmental Protocol to the Antarctic Treaty, after the 25-year operation and before dismantling, we will submit the environmental impact report, and a series of measures such as field recovery will be included in this report.

After the dismantling is completed, the region will be monitored for a certain period to assure the minimization of dismantling impact and determine whether additional measures are needed to recover the site.

5.5 Impact matrix

According to the analysis mentioned above, the table of impact matrix which summarizes the environmental impact of the construction and operation activities is established as shown in Tab 5-12 to Tab 5-16. The output and the resulting environmental impact of each activity are identified. Based on the references given in Section 5.1, the extent, duration, intensity, probability, and significance of the impact are then ranked in Tab 5-11.

Table 5- 11 Criteria for impact ranking

Title	Content	Details
Activity		
Nature	Type of activity	
Output		
	Description of the potential results of activities that may cause impact	
Impact		
Extent	Geographical area affected	specific, local, regional ,continental and global
Duration	Duration of impact	Very short (minutes to days), Short (weeks to months), medium (years), long (decades), permanent and unknown
Probability	Likelihood of impact occurring	Low, medium, high, certain
Intensity	Influence on the natural function or process and whether effects are reversible	Low, medium, high, certain
Significance	Importance of impact	Less than minor and transitory， Minor and transitory， More than minor and transitory
Direct impact	Qualitative description of what is direct, indirectly and cumulatively impacted by the Activities /Output	
Indirect impact		
Cumulative impact		

Table 5- 12 Impact Matrix 1

Activity	Output	Predicted impact	Probability	Extent	Duration	Intensity	Significance	Mitigation or preventive measures
Loading, unloading, and storage of construction materials at the proposed station	Exhausted gas emission	Very small, but cumulative contribution may lead to air pollution, deposition of particulates and heavy metal particles in certain area	Certain	Local	Long	Very low to low	Less than minor and transitory	● Use renewable energy as much as possible. ● Use combustion efficient fuel as much as possible. ● Minimize the use of the vessel, vehicles, mechanical equipment and aircraft.
	Disturbance to penguins, skuas, and seals	Increase energy expenditure of animals	Low	Area-specific (vicinage of the proposed station including coastal sea area)	Very short	Very low	Less than minor and transitory	● After deliberation and approval at the ATCM meeting in 2021, China has established a special reserve in the northern part of Inexpressible Island with Republic of Korea and Italy to protect the penguin community. ● Educate the expeditioners to avoid the interference of animals to the great possible extent. ● Take periodical monitoring. ● Minimize the use of the vessel, vehicles, mechanical equipment and aircraft. ● Formulate the best transportation route.

Bulk fuels transfer and storage	Over 208L. fuel oil spillage and the max. spill volume could be 30,000L.	Contamination of snow and ice, air pollution caused by volatile agent, there will be no direct impact but may cause delay impact to marine environment, indirect impact to scientific value in certain area	Medium (leakage in small volume) Very low (leakage over 1000l., in large volume)	Area-specific	Long	Low (leakage in small volume) High (leakage over1000l., in large volume)	Less than minor and transitory	● Use stainless steel oil tank with an oil-collecting plate at its bottom to minimize the risks of spillage arising from oil tank breakage. ● Check the oil tanks and pipelines periodically. ● Formulate oil spill contingency plan, examine periodically the procedure of fuel handling and oil spill response. ● Train and educate relevant personnel to enable them to operate correctly and canonically and prevent the occurrence of oil spillage accident. ● Provide oil spill handling apparatus, oil absorption felt, oil spill prevention container and cleaner and storage to store oil-polluted snow etc. so as to timely tackle potential oil spill accident. ● Once oil spill accident takes place, report to the Head of the station, CAA, PRIC and undertake to monitor.

Table 5- 13 Impact Matrix 2

Activity	Output	Predicted impact	Probability	Extent	Duration	Intensity	Significance	Mitigation or preventive measures
General construction activities	Solid and liquid waste	Contamination of ice and snow. The solid waste and drained sewage up to the standards will cause impact to the marine environment.	Certain	Local	Medium Impact caused by drained water may remain for a long time	Low	Less than minor and transitory	●Formulate waste management plan. ●Train relevant personnel to enable them operate according to procedure stimulated. ●The great efforts should be made not to use hazardous articles, if it is inevitable, hazardous articles to be taken to the new station region should be kept at minimum level. ●The great efforts should be made to reuse as many articles already taken there as possible. ●All solid wastes will be classified, stored and taken out of Antarctica during the construction period. ●All human excrement will be packed, cased and brought out of Antarctica during the construction period. ●Advanced technology will be adopted for sewage treatment, the wastewater after treatment should meet the relevant standards before discharge, reuse gray water to the great extent to reduce water consumption and discharge.
	Physical impact of snow and ice	The construction site needs to be compacted. The driving of the vehicles will press the snow and ice.	Certain	Local	medium	Low	Less than minor and transitory	●Try to set up logistic base or scientific operation field at the smooth area. ●Drive in the flat and smooth area, mark out routes for driving operations to reduce the impact of snow and ice.
	Construction of the Wharf	Movement of rock and gravel to create flattened areas and fill the dock structure. Disturbance of benthic near the wharf.	Certain	Local	short	Medium	Minor and transitory	●Pre-fabricated wharf structure will be used. ●The wharf design has sought to reduce the amount of sea bed preparation required and therefore the extent of this potential impact. ●Additionally, a long-term monitoring programme is already underway to verify the predicted impacts.

	Construction of the station	Loss part of the of wilderness value.	Certain	Local	Medium	Low	Less than minor and transitory	●Environmental protection issue has been fully considered since the design of the station. ●To make maximum use of renewable energy, recycling water and equipment with advanced technology and high environmental efficiency. To reduce the environmental impact as much as possible. ●When the operation of the station to be terminated, the station will be completely cleared away from Antarctica as much as possible and no obvious trace will be left there.

Table 5- 14 Impact Matrix 3

Activity	Output	Predicted impact	Probability	Extent	Duration	Intensity	Significance	Mitigation or preventive measures
Operation of the vehicles, power generators, and other mechanical equipment	Exhausted gas emission	Minor but a cumulative contribution to local air pollution including greenhouse gas emission and the deposition of part of the particulates.	Certain	Local	Long	Medium	Minor and transitory	●Maintain the operation of vehicles, generators and other mechanical equipment to a minimum level. ●Adopt vehicles, generators and other mechanical equipment with high combustion efficiency, advanced technology, excellent performance and low emission. ●Use highly combustion efficient fuel. ●Set up perfect energy management system. ●Using as much renewable energy as possible. ●If possible, install catalytic converters on vehicles and provide periodical maintenance and service as much as possible.
	Small volume oil spillage during refueling	Contamination of snow and ice, air pollution caused by volatile agent, there will be no direct impact but may cause delay impact to marine environment, indirect impact to scientific value in certain	High	Area-specific	Long	Very low	Less than minor and transitory	●Maintain the operation of vehicles, generators and other mechanical equipment to a minimum level. ●Check the oil tanks and pipelines periodically. ●Formulate standard procedure for fuel transportation and management, provide training to relevant personnel to enable them to operate correctly and canonically and prevent the occurrence oil spillage accident. ●Formulate oil spill contingency plan, examine periodically the procedure of fuel handling and oil spill response. ●Provide oil spill handling facilities, fuel absorption felt, fuel spillage-preventing container and cleaner device and storage to store oil-polluted snow etc. so as to timely tackle potential oil spill accident. ●Once oil spill takes place, report to the Head of the

								station, CAA, PRIC and undertake to monitor.
	Physical impact of ice and snow	Operation of the vehicle and the taking off and landing of aircraft will exert pressure to the surface, which will cause physical impact to the snow	Certain	Local area	Short	Low	Less than minor and transitory	●Maintain the operation of vehicles, and aircraft to a minimum level. ●Select a flat and smooth area to drive vehicles and a runway for aircraft to reduce pressing on the snow and ice there.

Table 5- 15 Impact Matrix 4

Activity	Output	Predicted impact	Probability	Extent	Duration	Intensity	Significance	Mitigation or preventive measures
Operation activities of the station	Solid waste	It may contaminate snow and ice if it blows away by the wind.	Low	Local	Long	Low	Less than minor and transitory	●Formulate waste management plan. ●Train relevant personnel to ensure their work is done according to the job specification. ●Solid wastes, especially hazardous waste, to be taken to the new station will be minimized, ●Try best to reuse articles already taken there. ●Most of the garbage will be recycled and sorted waste will be treated by the magnetic pyrolysis furnace. ●All the human excrement will be treated by fermentation tank, the residue sludge will be treated by the magnetic pyrolysis furnace.
	Sewage	Contamination of ocean and cause pollution to the marine environment.	Certain	Specific area	Long	Low	Less than minor and transitory	●Adopt water-saving measures to reduce water consumption and discharge. ●Efforts are made to recycle water by advanced technologies and drained waste water should meet the relevant standards.
	Physical impact of snow and ice	The operation of vehicles will exert pressure on the snow and ice.	Certain	Specific area	Medium	Low	Less than minor and transitory	●Try to set up logistical base or scientific operation field in the smooth area. ●Drive in the smooth area and set routes for driving operation to reduce the impact of snow and ice.
	Light pollution	The possible impact of some scientific studies sensitive to light.	Medium	Local	Long	Very low	Less than minor and transitory	●Minimize the use of lightening lamps outdoor. ●Reduce the scattered light, especially the horizontal scattered light.

	Constructions and human activities at the station	The impact to the wilderness value	Certain	Local	Long	Low	Less than minor and transitory	●Full consideration was given to the view of the surrounding area during designing of the layout of the constructions of the station. ●Efforts were made to minimize visual impact to the surrounding area. ●When the operation of the station to be terminated, the station will be completely cleared away from Antarctica as much as possible and no obvious trace will be left there.

Table 5- 16 Impact Matrix 5

Activity	Output	Predicted impact	Probability	Extent	Duration	Intensity	Significance	Mitigation or preventive measures
Scientific activities	Observation of interaction studies	Physical impact of snow and ice, Air pollution caused by exhausted gas due to operation of generators, The potential oil spill may cause air pollution, ice and snow contamination, Oil sludge in ice and snow may cause marine pollution.	The physical impact of snow and ice and air pollution due tithe operation of generators is certain to happen, the possibility of oil spill is low	Local	Long	Very low	Less than minor and transitory	● Use generators with high efficiency. ● Use renewable power source as much as possible. ● Provide training to personnel on fuel refilling and oil spill handling, equip with necessary oil spill dealing apparatus, oil absorption felt, oil spill prevention container and cleaner and storage to store oil-polluted snow etc. so as to timely tackle potential oil spill accident.
	Observation of flora and fauna	Disturbance to habitat and breeding activities	Medium	Regional	Long	Medium	Minor and transitory	● A Specially Protected Area will be suggested to protect the penguin colony. ● Limit access to habitat. ● Limit activities aside from those with a scientific purpose.
		Disturbance caused by sampling	Medium	local	Medium	Medium	Minor and transitory	● Observe Recommendation “Guidance for Visitors to the Antarctic” during operation. ● Prevent disturbance by conducting a preliminary evaluation of the sampling plans.

	Other scientific research projects	Physical impact of snow and ice due to digging ice for placing equipment, Air pollution caused by operation of power generators if any, Potential oil spill may cause air pollution, ice and snow contamination, Oil sludge in ice and snow may cause marine pollution due to the movement of glaciers.	Medium	Specific area	Long	Very low	Less than minor and transitory	● The scientific programs will be overall planned. ● Maintain the minimum use of power generators. ● Use renewable power source as much as possible. ● Provide training to personnel on fuel refilling and oil spill handling, equip with necessary oil spill dealing apparatus, oil absorption felt, oil spill prevention container and cleaner and storage to store oil-polluted snow etc. so as to timely tackle potential oil spill accident. ● When the program to be completed, all the equipment and installations will be removed and the original conditions will be recovered as much as possible.

5.6 Indirect impact and cumulative impact

To minimize the negative environmental impact, the measures to prevent and mitigate them have been taken into full consideration in the design stage of the new station, and the Environmental Management Plan (EMP) has been formulated. The design of the new station ensures high efficiency in energy utilization. According to the design, renewable energy sources will be utilized to the maximum extent, high efficiency, low discharge, and low noise equipment will be adopted as much as possible, modular buildings will be prefabricated in China to reduce the field construction workloads, water will be treated and recycled, the production of wastes will be minimized. These measures will prevent or mitigate the estimated negative environmental impact, and play an active role in environmental protection. The new station adheres to the principles of environmental protection and energy-saving etc. in its design, and has established the waste management planning, ensuring low ecological footprint, low energy consumption, and minimum waste output. Therefore, no obvious indirect environmental impact will arise.

The cumulative impact is the combined impact of past, present, and possible future activities. Cumulative impact and indirect impact may arise from the emission to the atmosphere, oil spill, and discharge of the treated wastewater up to standards in the construction and operation stages of the station, which have been described in Section 2.

Taking into account the cumulative impact of various countries, in order to protect the area, China has established a special reserve in the northern part of the Inexpressible Island to protect the penguin community after the review and approval of the ATCM meeting in 2021. And the aims and objectives of the ASPA as follows:

- To avoid degradation of, or substantial risk to, the values of the ASPA by preventing unnecessary human disturbance to the area;
- To allow the ASPA to be used as a reference area for future comparative studies with other breeding populations of Adélie penguins and South Polar Skuas in Terra Nova Bay and neighboring areas, and research and long term monitoring of terrestrial, marine and lacustrine ecosystems, in an international collaboration framework;
- To allow to continue studies on historical clues of the evolution of the Adélie penguin and other species subfossil remains and ornithogenic soil;
- To promote coordinated research activities ensuring protection from oversampling;
- To allow scientific support activities and visits for educational purposes provided that such activities cannot be served elsewhere and that will not jeopardize the natural ecological system in the Area;

- To prevent, to the maximum extent practicable, the introduction of non-native species and pathogens that may endanger or alter the local pristine ecosystems;

The indirect and cumulative impact may contribute to air pollution in regional or even global levels. Such cumulative impact should be monitored continuously during the construction and operation of the station, and mitigated in a proper way once it is detected.

6. Environmental Management and Environmental Impact Monitoring Plan

6.1 Environmental management plan

In the systematic design of the new station, environmental protection, safety, energy saving and economy are the basis to guide the decision-making. From this aspect, the personnel responsible for environmental impact assessment have been involved in the design stage of the project at the beginning, and they have put forward a number of useful suggestions on how to reduce environmental impact.

Before the construction, PRIC will make the Environmental Management Plan, the purpose of which is in line with the stipulations specified in the Protocol and relevant Chinese regulations on environmental protection, to elaborate the management framework and detail plan, to define duties and responsibilities of relevant personnel, to fulfill mitigation measures and to ensure the minimization of environmental impact.

The Environment Management Plan will cover the application of the protection measures for penguins and skuas, refueling and fuels transportation, waste collection and disposal, sewage treatment and gray water recycling, equipment, field operation and the tackling of emergencies etc. It will guarantee the safety and orderly progress of various activities, and consequently prevent the occurrence of environmental accidents and minimize environmental impact.

CAA will guide, oversee and supervise the construction and operation the new station and also the implementation of the environmental management plan and other relevant regulations.

At the new station, environment monitoring, investigations, and analysis of environmental impact will also be conducted to find out the impact as early as possible and to eliminate or mitigate them in time.

A Contingency Plan will be developed, and correspondent personnel and materials will be prepared for any environmental or other accidents. Upon completion of the capital construction, CAA together with PRIC will draw up a report summarizing the conditions of environment, health, safety, accidents and monitoring etc.

The building of a new station will inevitably bring about some changes in the station area and its surroundings. The potential environmental impact and the corresponding mitigation measures have been specified in Section 5. To detect the impact derived from the construction and operation of the station and to evaluate the effectiveness of mitigation measures that shall be taken thereby, China will formulate an Environmental Monitoring Plan for the new station.

The baseline data and information for the program have been collected in accordance with the plan during the 2012-2020 surveys as well as the meteorological data collected from the references. This monitoring will be continued as a part of the major scientific research during and after the completion of construction of the new station. The program will be continuously reviewed and modified in coordination with other post-construction research activities. The COMNAP guidelines will be followed by the monitoring program (COMNAP, 2005b).

6.2 Environmental impact monitoring plan

China will establish environmental monitoring plan on the impact of the construction and operation of the new station. The monitoring activities can be divided into two categories. One is to monitor the potential environmental impact, to discover as early as possible the impact and take actions immediately to reduce or eliminate such impact, thus improving the understanding of the interactions between the human and the Antarctic environment.

Another is to monitor and record the relevant operation information of the new station, including fuel consumption data, fuel spill, personnel number of the station, waste products and their disposal route etc. This information will be used to verify the Final CEE and determine whether the impact conforms to those estimated. With the development of the scope and intensity of the information acquired, the validity of the proposed mitigation measures will be reviewed and evaluated.

6.2.1 Objective

The monitoring objective is to evaluate and analyze the impact on the surrounding environmental of the construction, operation and scientific activities of the new station.

6.2.2 Scope

The scope of atmosphere monitoring covers the full area influenced by the source of air pollution. Monitoring sites will be allocated around the pollution source, and samples taken outside of the influenced area will be used as background reference, snow samples will be taken from relevant points to measure their contents of metals which will be the basis for the environmental baseline study to provide reference data for the determination of the environmental standards.

The scope of monitoring on the ice and snow covers the surrounding area of the new station and transportation route.

Oil spill Monitoring covers the area of the oil tank storage, the locality with fuel operation, the transportation routes and the relay site.

The scope of monitoring of the surface water samples covers the discharging pipe and its surroundings.

6.2.3 Elements

Table 6- 1 Elements for monitoring during construction stage

Item	Object	Reporting	Frequency
Staff	Wastewater and solid waste(recycle)	Wastewater and waste logs	Once a month
Material	Construction material used/disposed/recycled	Construction material log	Once a week
Waste facility	Recycling and storage of construction waste	Recycling and storage status	Once a week
Equipment operation	Fuel supply and consumption for construction equipment	Fuel log	Once a month
	Oil change, waste oil, and disposal for construction equipment	Motor oil log	Once a month
Noise protection facility	Temporary noise barrier	Barrier status	At installation
	Temporary noise barrier	Barrier status	At installation
Ecology Status	Alien species invasion	Invasive species	Each austral summer season during construction
	Changes in habitat	Habitat observation -Skua and penguin community	Once per two weeks during construction
	(Lichen, Skua, Penguin, Weddell Seals)	Habitat observation of penguin colonies	Each austral summer season during construction
	Population dynamics and breeding success	Skua and penguin	Each austral summer season during construction
Coastal Seawater quality	TSS, DO, COD, pH, Temperature, Salinity	Seawater quality near the proposed wharf	Each austral summer season during construction
Air quality	CO_2, $PM_{2.5}$, PM_{10}, NO_x	Air quality analysis -construction area	Each austral summer season during construction
Noise	Noise level	Noise level at site near the skua and penguin colonies	Each austral summer season during construction
Fuel and Oil	Fuel supply and use	Fuel Log	Each austral summer season during construction
	Oil storage facility	Oil and waste oil storage tanks	Each austral summer season during construction
	Oil change, waste oil, and	Oil log	Each austral summer

Item	Object	Reporting	Frequency
	disposal		season during construction
Drinking Water	Water intake, desalinated water production	Desalination log -Production	Each austral summer season during construction
Wastewater	Facility operation	Wastewater treatment operation log	Each austral summer season during construction
Solid waste	Waste(recycle)	Waste management log	Each austral summer season during construction

Table 6- 2 Elements for monitoring during operation stage

Item	Object	Reporting	Frequency
Ecology	Alien species invasion	Invasive species	Once a year
	(Lichen, Skua, Penguin, Weddell Seals)	Habitat observation of penguin colonies	Once a year during operation
	Community structure changes	On-site Fauna/flora	Once a year
	Population dynamics and breeding success	Skua and penguin	Once a year
Coastal Seawater quality	TSS, DO, COD, pH, Temperature, Salinity	Seawater quality -Intake point(3 points near discharge)location (3 points near wharf)	Twice a year
Snow	TSS, pH	Snow quality Main building Comparison point	Twice a year
Soil	TPH	Soil analysis -4 points at oil storage sites -4 points at waste oil storage sites	Once a year
Air quality	CO_2, $PM_{2.5}$, PM_{10}, NO_x	Air quality analysis -Main building -Skua and penguin colony	Twice a year
Noise	Noise level	Noise level at site near the skua and penguin colonies	At equipment in operation
Fuel use	Fuel supply and use	Fuel Log	Once a week
Oil change	Oil storage facility	Oil and waste oil storage tanks	Oil Leaks
	Oil change, waste oil, and disposal	Oil log	Once a month
Water supply and discharge	Wastewater and gray water recycling system during operation, BOD, COD, and SS.	Wastewater treatment log -Generation and discharge -Treated volume -Amount of	Twice a week

Item	Object	Reporting	Frequency
		gray water -Water quality report	
	Water intake, desalinated water production, water use BOD, COD, and Cl.	Desalination log -Production -Transport -Use Water quality report	Twice a week
	Facility operation	Wastewater treatment operation log	Once a day
Waste	Recycling and monitoring of domestic waste	Recycling and storage status	Once a week
	Waste(recycle)	Waste management log	Once a month

7. Gaps in Knowledge and Uncertainties

From several expeditions conducted at the Great Wall Station, Zhongshan Station, Kunlun Station and the Ross Sea area from 1996 to 2020, CAA has acquired some knowledge on the physical environment of the new station area. However, it has not been simultaneously proceeded with the study and monitoring on the potential hazards probably caused by the construction and operation of the new station. According to experience, the changes of environmental conditions like weather etc. may bring about some uncertain factors.

Besides, technically and operationally, there are also some uncertain factors, such as the change of future activities of the new station, the application of more advanced techniques including the renewable energy and high efficiency wastewater treatment facility and advanced solid waste disposal facility and the change in the content of scientific activities etc. The designed lifespan of the station will be at least 25 years, so it is impossible for the Final CEE to integrate the changes arising in the process of operation and installation derived from the technical progress that will be obtained in such a long time, therefore, it is necessary to make an additional assessment of these changes.

Knowledge limitations and uncertainties have been fully considered in this Final CEE for the new station, including the unpredictability of environmental conditions such as global climate change and regional weather variation, the changes in future activities of the new station, the application of upgraded energy technology, the change of scientific activities, and small adjustments to the construction mode etc. These may lead to the delay of the construction and the slight changes in the conditions of scientific and logistic support in the future as shown in Tab 7-1.

Table 7- 1 Uncertainties in the Final CEE

Potential arising areas	Uncertainties	Intensity of impact
Weather conditions	Lack of full forecasting capacity to the changes of local weather, environmental conditions, and sea ice distributions. Associated transportation disruptions may affect the construction period	Medium
Fuel consumption	The ratio between the traditional generator power supply and renewable energy supply will be greatly related to the installation and operation conditions of windmills and solar panels	Medium (exhausted gas emission)
Time schedule	Seasons needed for the construction of the new station (Estimated at 4 seasons, maximum 6 seasons may be needed)	Medium(Fuel consumption)
Manpower	Personnel to be involved in the construction may be slightly different (5-8 persons).	Low (Fuel consumption, wastewater discharge, and solid waste disposal)
Total volume of freight	The total freight volume may be slightly different from the estimated figures	Low (Fuel consumption for land transportation)
Scientific activities	Some scientific programs related to international cooperation have not been finalized, so the resulted impact is not listed in this CEE, the impact on the environment will be assessed according to the proceedings of the programs.	Low

8. Conclusion

(1) The new station is an independent perennial station for logistics and research activities on the Inexpressible Island in Terra Nova Bay, Ross Sea area. It will become an international platform for international multidisciplinary research, focusing on ocean and global climate change research, including research on atmosphere and atmosphere-ice-ocean interaction, glacier and ice shelf-ocean interaction, environmental and ecosystem monitoring, space physics and geological environment assessment research, etc. The new station will also strengthen potential logistical cooperation and coordination with all stations in the Terra Nova Bay and Ross Sea region.

(2) This Final CEE has fully considered the opinions put forward by the CEP, and is further adjusted and optimized based on the draft CEE submitted to the ATCM in May 2018 and is deemed to further enhance safety and reduce the impact on the local environment. To further increase the protection of the penguin colony in the northern part of the Inexpressible Island, China, Italy, and Republic of Korea jointly proposed a new ASPA on the Inexpressible Island in 2019, and was approved by the ATCM43 online in 2021.

(3) In order to protect the Antarctic environment and minimize the impact of human activities, the new station will follow the principle of “environmental protection first” during the entire process of construction and operation. Each step, including the selection of materials, equipment and engineering process, daily operation and the disposal of waste, will comply with the provisions of the Protocol and minimize adverse environmental impacts. In the construction and operation of the new station, it will attach great importance on environmental protection, energy saving and emission reduction. Hydrogen fuel batteries and renewable energy and advanced environmental technology will be used as much as possible to minimize the impact of construction and operation on the local environment.

(4) Environmental management plans, environmental monitoring plans, pollution prevention and emergency plans will be made and implemented. Scientific management and supervision over the entire process of construction and operation of the station will be realized to minimize the impact on the Antarctic environment.

(5) This Final CEE concludes that the proposed activities are likely to have **more than minor or transitory** impact on the Antarctic environment, but the continuous, scientifical and standardized operation of the new station will make important contributions to global scientific research. The scientific value is believed to outweigh the “more than minor or transitory” impact on the Antarctic environment, and thus, it fully proves the feasibility of the proposed

activity.

9. Abbreviations

ATCM Antarctic Treaty Consultative Meeting

ATCP Antarctic Treaty Consultative Party

CEP Committee for Environmental Protection

COMNAP Council of Managers of National Antarctic Program

SCAR Scientific Committee on Antarctic Research

SOA State Oceanic Administration

CAA Chinese Arctic and Antarctic Administration

CHINARE Chinese National Antarctic Research Expedition

SCALOP Standing Committee on Antarctic Logistics and Operations

CCAMLR Commission for the Conservation of Antarctic Marine Living Resources

MARPOL International Convention for the Prevention of Pollution from Ship

EIA Environmental Impact Assessment

CEE Comprehensive Environmental Evaluation

IPY International Polar Year

ASMA Antarctic Specially Managed Area

ASPA Antarctic Specially Protected Area

EMP Environmental Management Plan

WMP Waste Management Plan

WMP1 Waste Monitoring Plan

BOD_5 Biological Oxygen Demand in Five Days

CO Carbon Oxide

CO_2 Carbon Dioxide

COD Chemical Oxygen Demand

DEM Digital Elevation Model

DGGE Denaturing Gradient Gel Electrophoresis

HC Hydrocarbon

NO_x Nitrogen Oxides

SAR Search and Rescue

SO_x Sulfur Oxides

TCV Traveling Convection Vortex

TMT Technology, Media, Telecommunication

ULF Very Low Frequency

VOC Volatile Organic Compounds

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