6. IDENTIFICATION AND PREDICTION OF IMPACTS

6.1 Methods and Data used for Prediction of Impacts

For the prediction of likely impact and assessment, various environmental indicators have been selected subject to the value judgment, relevance to the area and project activity. The baseline information has been collected from primary and secondary data available from scientific publications. Relevant site-specific baseline information for environmental monitoring has also been collected to establish the environmental condition prior to commencement of the project activity. Specific project activities including energy, water supply, waste management, scientific activities and associates logistics etc. have been clearly defined to demarcate station footprints.

Necessary references were adopted from USEPA, the Greenhouse Gas Inventory and the Emission Source Classification, Central Pollution Control Board, New Delhi, National Atmospheric Emission Inventory etc. U.K. EIA guidelines are considered while identification and prediction, and mitigation measures were defined by putting the benchmark of Madrid Environmental Protocol. From construction to decommissioning, strict environmental conservation measures will be implemented under the supervision of NCAOR.

Further, direct, indirect, cumulative and unavoidable impacts were examined and matrix has been drawn to assess the predictive impact. Following area have been identified for studying the possible impacts :

- Physical disturbance
- Air
- Water
- Noise
- Oil spill and other waste
- Flora and Fauna

6.2 Impact due to Construction Activities

6.2.1 Physical Disturbance

The project activity will take place in form of construction of the building for living and laboratory complexes, utility services, fuel storage, associated pipelines, helipad and landing point. Wind turbine is proposed to be installed in order to supplement the energy demand. This turbine will occupy some area for erection of the tower in the vicinity of the station. From the platform of landing site to the station, access pathway will be developed which will be around three meters wide and about 800 meters long. Two helipads covering an area of 60 sq. m in front of the main building will also contribute to the physical disturbance to the area. Equipment needed to construct the building, laying pipe and cables placed at the site will occupy about 150 sq. m. There will be some disturbance to the rocks that will be used as foundation for the stilts to be anchored to these rocks.

6.2.2 Impact on Air Quality

There will be some transient effect on the air quality because of the ship and air operations, use of generators as also due to the construction activities. Fossil fuel consumption will result in emissions of SO_2, NOx, CO, CO_2 and suspended particulate matter to the atmosphere.

6.2.2.1 Impact due to supply ship

It is estimated that two austral summers will be required to build the station.. The ship will be anchored near the site for a minimum period of 50 days to facilitate the construction activity. Supply ship will use Intermediate Fuel Oil (IFO) and Marine Diesel Oil (MDO). For the calculation of fuel consumption and emission, the data of Ice class ship Emerald Sea has been used. However, cumulative and daily fuel consumption may change depending upon the weather, sea ice condition and speed of the ship during operation. Fuel consumption during drifting in the ice may vary from 35 MT/day to 42 MT/day of IFO and 3.5 MT/day of MDO. However at idling stage, this consumption may drop to 4 to 4.5 MT/day of IFO and 3.5 MT/day of MDO. In open sea area, fuel consumption pattern appears to be 26.5 to 45 MT/day IFO and 3.5 MT/day of MDO considering ship's run on single or twin engines.

The details of the emission during the voyage in open sea, ice navigation and idling period are given in Table 3.

Table 3 : Predicted Air emission from Ship during Ice Navigation

Emission Factor

Emission Factor Kg/m^3 of fuel Burn*	PM	SO_2	NOx	CO	TOC	Methane	NMTOC
IFO	0.84	27	5.64	0.6	0.1248	0.0336	0.0912
MDO	0.24	28.26	2.88	0.6	-	-	-

**Emission factor calculation is referred from USEPA air chief, AP-42 Ver 8.0. IFO is considered as No 4 fuel oil and MDO is considered as No 2 fuel oil with uncontrolled burning. Sulfur content in the fuel oil is considered as 15000 ppm*

Total Emissions

Type of Fuel	Fuel Consumption in 50 Days (m^3)		Total Emission of Pollutant considering 50 days alongside (kg)-35 days idling 15 days ice navigation						
	Ice Navigation	Idling Condition	PM	SO_2	NOx	CO	TOC	Methane	NMTOC
IFO	555.5	148	591	19000	3969	422	88	24	64
MDO	62	145	50	5846	596	124	-	-	-
Total	617.5	293	641	24846	4565	546	88	24	64

6.2.2.2 Impact due to air operations

The major shifting of men and material during construction phase will be by two helicopters each capable of carrying at least 4-5 ton under slung. Approximate 2040 kg per day of the ATF (Jet A-1), will be required to operate both the helicopters (All calculations are based on fuel consumption of MI8 helicopter). This consumption will emit pollutant as line source as shown in Table 4:

Table 4 : Predicted emission from helicopters

Parameters	Pollutant (kg) for 200 hours of helicopter operation (2 helicopters)						
	PM*	**SO_x**	**NOx**	**CO**	**CO_2**	**Methane**	**NMVOC**
Emission Factor (kg/t) of fuel consumption	0.2	0.72	0.19	12	859	1.43	2.84
Emission Load (kg)	16	59	15.5	979	70094	117	232

Source: Emission factors are considered from UK National Atmospheric Emission Inventory (2002)

** Particulate Matter refers to particle produced by fuel consumption with a diameter less than or equal to 10 µm*

6.2.2.3 Impact due to generators

Generators of 35 kW shall be in use during the construction activity to provide electricity to the equipments needed for building erection, carpentry and for electric radiator in shelter hut. These generators will run on lead-free gasoline. Considering gasoline consumption as 315 g (382 cc) per kw-hr, it is estimated that around 13.5 litre per hour will be consumed by generators. The generators may be run for around 10 hours a day. Considering 40 days operation, the emissions from the generators are provided in Table-5 .

Table 5 : Emission from the Generators

Parameters	Pollutants (kg)				
	PM-10#	**NOx**	**SOx**	**CO**	**CO_2****
*Emission factor (kg/kW-hr) of energy generated	4.38E-04	6.69 E-03	3.59 E-04	2.67 E-01	6.56 E-01
Pollution Load (kg) In span of 40 days run Daily 10 hours	6	94	5	3738	9193

**Emission factors are calculated referring AP-42 of USEPA, 2000 of uncontrolled gasoline fuel burning in industrial engine.*

#PM-10= particulate matter assumed to be less than or equal to 10 µm aerodynamic diameter and greater than and equal to 1 µm diameter

***Assumes 99% conversion of carbon in fuel to CO2 with 86% weight % carbon in gasoline*

6.2.2.4 Impact due to ATVs

Terrain at the site is undulated which needs suitable All-Terrain Vehicles (ATVs) to drive on this surface. Two ATVs which will run on gasoline will be in operation during construction activity to facilitate transportation in limited area. The expected emissions from the ATVs are provided in Table 6.

Table 6 : ATV Emission Rate (FAQ ATV Riders, 2000)

Emission rate

Category	ATV emission rates (gram per mile)			
	PM	NOx	CO	HC
Baseline four stroke	0.1	0.4	48.5	2.4
ATV meeting EPA standards	0.1	0.3	42.9	1.6

Pollution Load

Category	Total ATV emission (kg) in 15 miles run by 2 vehicles			
	PM	NOx	CO	HC
Business as usual scenario	0.12	0.5	58	3
ATV meeting EPA standards	0.12	0.4	51	2

6.2.2.5 Impact due to use of forklift

Forklift will be unavoidable during the construction phase. However, the operation shall be limited to move material from the landing to the construction site. This machine will operate on gasoline and will be operated for 6-8 hours in a day with the 2 t capacity. Air emission from the forklift is estimated to be very insignificant (Table 7).

Table 7 : Emission Standards for fork lifter (Emission Standards for New Nonroad Vehicles, 2002-USEPA)

Year to be implemented	NO_X+HC	CO
2007	2.7 g/kW-hr	4.4 g/ kW-hr

6.2.2.6 Impact due to Crane

Two cranes of 5 tons capacity each, one near the landing site and other at the construction site, will be operated. In the operational phase, cranes will have limited use for maintenance purpose only. The air emission from these cranes will be very insignificant.

6.2.3 Impact on Water Quality

6.2.3.1 Waste from Ship

All the workers engaged in construction work would be staying on board the ship. Including the crew members, around 95 people will be on board, which will produce approximately 10 m^3 of waste per day.

6.2.4 Oil Spill and other waste

Fuel is required at the construction site for ship, barge, helicopter, generator and other vehicles. Mainly IFO/MDO, ATF, gasoline and lubricants shall be in use for various operations. For helicopter operations, refueling will be done on the ship and ATF will be stored in 10 kl double-skin tanks or drums. At the site, the fuel will be stored in 5 kl tanks and 20 barrels containing ATF for emergency purposes. Fuel spill may occur during filling the tanks from the barge, leakage from the vehicle engines and from the barrels filled with ATF and lubricants. Fuel spill may also take place while refueling. This fuel after spilling may contaminate the top soil and may be toxic in nature.

Construction activity will generate non-hazardous waste comprising mainly packing material, plastics, wood, small tin etc. and hazardous waste comprising batteries, waste fuel, lubricants, paints sealant etc.

6.2.5 Impact on Flora and Fauna

Even though there are no rookeries at the site, stray penguin visits have been noticed occasionally. Seals have also been observed near the site. The noise produced during construction activity may result in some disturbance to these animals. There is also a threat of introduction of alien species to the environment.

6.2.6 Impact on aesthetic and wilderness values

Machineries associated with construction activity will have minor visual impact and loss of the wilderness value.

6.2.7 Impact of Noise

Noise pollution is recognized as emerging threat in Antarctica. Anthropogenic noise impact may have detrimental impact on human being as well as marine life. Helicopter is one of the sources of noise pollution which generates more than 140 dBA noise. Other vehicles and generators which will remain in operation at the site for longer duration will have adverse impact on the workers.

6.3 Impact due to Operation Activity of the Station

6.3.1 Physical Disturbance

Equipment installation for scientific experiment may be for long term or short term, which will contribute to physical disturbance. Electrical cables will be required to transmit the electricity from the generator room to the building, laboratory and other modules. This encased cabling will result in physical disturbance. Piping for wastewater discharge from the treatment plant to the discharge site at sea will occupy some area. It is estimated that approximately 1650 square meters of land area will be required to build the structure inclusive of the main building, fuel and food depot, platform at landing site etc. Around 200 metres piping is required for water intake from lake, 400 metres for intake from sea and around 500 metres piping is to be laid for wastewater discharge to sea. In addition, a 700 metres long fuel distribution line is proposed from the fuel depot to the station building. All these structures and piping will cause physical disturbance to the area. The likely footprint of the activity have been shown in the Figure 6 a and 6 b.

6.3.2 Air emission

During the operation of the station, air emission will be produced from supply vessel, generators, incinerators, vehicles etc. Fugitive emissions are also expected from stored fuel tanks. These emissions will comprise, carbon dioxide, carbon monoxide, oxides of sulfur, nitrogen and other gases along with heavy metals if they cross the permissible limits.

6.3.2.1 Supply Ship

Ice-class ship will be used for supply of the material, fuel, bringing back the harmful undisposable waste of the station and transportation of scientists and logistics personnel to the station. The emissions from the ship will be as given in Table 3, depending upon the period of stay of ship at the outer anchorage near the station.

6.3.2.2 Helicopter

When station will be fully in operation, use of higher capacity helicopters will be replaced by smaller varieties such as AS 350, Bell 407 etc., which will be used for traverses to inner mountain ranges. Fuel consumption of this type of machine shall be in order of 170 liter/hr of ATF (Jet-A1). Around 20 sorties are anticipated for transferring to and fro, ship to station and another 25-30 for scientific traverses beyond the limits of the station. It is estimated that total fuel consumption for the operation confined to station site will be in order of 950 kg. The predicted emission from the helicopters is shown in Table 8:

Table 8 : Predicted emission from helicopters around the site

Parameters	Pollutant (kg)						
	PM	SO_x	NOx	CO	CO_2	Methane	NMVOC
Emission Factor (kg/t) of fuel consumption	0.2	0.72	18	12	859	1.43	2.84
Emission Load (kg)	0.2	0.7	0.2	11.5	820	1.5	2.5

6.3.2.3 Generator

It is estimated that the total requirement of power will be about 200 kW during summer and 170 kW during winter. Fuel operated generators will be used as main power source. The heating system inside the station will work on Combined Heat and Power (CHP) mechanism. This will help to reduce power demand by 95 kW during summer and by 65 kW during winter. One 125 kVA generator plus a stand-by would be installed to meet these power requirements. The following emissions are expected to impact the air quality (Table 9):

Table 9 : Emission from diesel generators during station operation in a Year

Generator	Fuel Const. (m^3/year)	Total Emission of Pollutant (kg)				
		PM 10#	SO_2	NOx	CO	TOC
*Emission Factor (kg/m^3) of fuel burn		1.0248	0.744	11.724	0.8064	0.2856
125 kVA Genset (24 hours run for 365 days)	182	187	136	2136	147	52

**USEPA, AP-42 of electric generation from internal combustion engine, uncontrolled operation*

#PM-10= particulate matter assumed to be less than or equal to 10 µm aerodynamic diameter and greater than and equal to 1 µm diameter

6.3.2.4 Vehicles

During operational activities of the station, two ATVs shall ply between station, food depot and laboratories to ferry material and scientific equipments. Considering 15 miles run of two ATVs and maximum number of 100 days of plying in a year, total emission into the air will be of the order of 0.3 kg of particulate matter, 0.9 kg of oxides of nitrogen, 130 kg of carbon monoxide and 2.4 kg of hydrocarbon.

Cranes and forklift will have limited use once the station would be in operation. Crane will be used only for replacement of the panel, vehicle maintenance and transfer of the material from barge to the platform. Forklift will also be used occasionally to place the material. Use of these vehicles is limited to the confined area and for very few hours in a year. Operation of these vehicles will release insignificant pollutant into air. It is estimated that fuel required for the crane is 500 liters of ATF and for forklift it is 200 litres of gasoline every year.

6.3.3 Impact on Water Quality

Total water requirement for the station will be of the order of 2.6 m^3/day based on 100 litre per person per day for 25 persons. Twenty percent of the water requirement of the toilet will be met through recycled water, thereby reducing the water requirement of potable type to 2.3 m^3 per day during summer and 1.5 m^3 during the winter period. The quality of water in the lakes is likely to be affected if the water is overdrawn as the lakes are shallow in depth. The

station structure will be located so as to keep the lake eco system free of any effect of the emissions from the generators and the vehicular movement

About 2.3 m^3 of wastewater will be generated per day from the toilet, laundry, and kitchen during summer and 1.3 m^3 per day in winter. The wastewater will be discharged into sea through pipes after treatment. There are chances of leakage through the pipes. Wastewater discharge into the sea may temporarily affect the quality of water.

6.3.4 Waste (Solid and semi solid)

Approximately fifteen kg of solid waste is expected to be generated per day in the form of organic waste from the kitchen during winter and about 20 kg during summer. Other solid waste will include packing material, unserviceable items such as steel, tin, wood, glass, etc., sludge generated from wastewater treatment system and dewatering unit and ash from the incinerator unit. Some waste will also be generated from the vehicle workshop. Organic waste will be incinerated at the site which will emit particulate matter, carbon soot, CO, oxides of nitrogen and sulfur.

Waste generated inside the station will be of different categories. If left unattended, it may be hazardous to the environment and have both short and long term effects. Waste will also be generated from launching of the meteorological balloons and other laboratories.

6.3.5 Noise Quality

During the operation of the station, noise will be generated from the helicopter operation, generator operation and vehicular movement. Helicopter will produce around 125 dBA at 10 meter distance. Keeping engine on for longer duration may cause temporary hearing impairment if persons remain present near the helicopter.

Although the generators will be fitted with acoustic enclosures for noise barrier and will maintain the USEPA and CPCB standards for the noise emission, some noise would be generated.

6.3.6 Fuel Spill

Fuel will be needed for various operations at the stations. Oil spill may occur from leakage from engine, overflow from the tanks, accidents and during the process of decanting.

6.3.7 Aesthetic and Wilderness Value

Station is designed to be a two-storey building which will cover around 1650 sq. m area including the laboratories, food and storage facilities. Operation of the station and movement of the rotor of the wind turbine at the site will have some impact on the visitors. The Station would be visible from the sea only if the line of the sight is clear.

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