

Latitudinal Gradient Project
Cape Hallett Camp
Initial Environmental Evaluation
June 2003





SUMMARY

This Initial Environmental Evaluation (IEE) documents the environmental impact assessment process for the Latitudinal Gradient Project (LGP). This IEE has been prepared in accordance with Annex I (Article 2) of the Protocol on Environmental Protection to the Antarctic Treaty, and in accordance with the requirements of the New Zealand Antarctica (Environmental Protection) Act, 1994.

The LGP is aimed at increasing our understanding of the coastal marine, freshwater and terrestrial ecosystems that exist along the Victoria Land coastline in the Ross Sea region, and describing potential environmental variability that may occur in the future.

Antarctica New Zealand is providing the logistical capabilities for research camps to be located at specific sites along the Victoria Land coast. Thus, the opportunity to work at particular locations in collaboration with other scientists from various disciplines and National Antarctic Programmes is provided.

This IEE is submitted to cover the envisaged impacts of the LGP camp at Cape Hallett over a two year period, as well as the cumulative impacts of the science that has been proposed to be undertaken at Cape Hallett over the 2003/04 season. Specific actions associated with the project that have the potential to cause impacts include waste disposal, camp set up, emissions, camp activity and personnel movement, visual intrusion (albeit temporary), possible fuel spills, and disturbance to flora and fauna. The evaluation of potential impacts shows that the proposed activities are likely to have no more than a minor or transitory impact on the environment.



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1. INTRODUCTION

The Latitudinal Gradient Project (LGP) is a framework within which interdisciplinary and international collaborations can be supported logistically towards the common goal of understanding the complex ecosystems that exist along the Victoria Land coast and determining the effects of environmental change on these ecosystems.

The development of such a framework has been prompted by Antarctic scientists who identified the need for co-ordinated research along the latitudinal gradient. This document is one of several put forward as a response to this need. Other key documents can be viewed at <http://www.antarcticanz.govt.nz/Pages/Science/LatProject.msa>.

1.1 What is the LGP?

The Victoria Land coastline spans 14° of latitude from 72°S at Cape Adare to 86°S at the southern end of the Ross Ice Shelf (see Figure 1), within a narrow longitudinal band. Important environmental factors such as solar radiation, temperature and sea ice cover predictably vary with latitude along the Victoria Land coast. Other environmental gradients such as depth below sea level, height above sea level and distance from the coast complicate the latitudinal gradient influence on the coastal ecosystems.

The Latitudinal Gradient Project proposes to study five sites along the Victoria Land coast in detail. The information gained from the different sites along the coast will increase our understanding of polar ecosystems and help create a predictive knowledge of the future effects of environmental change on these ecosystems.

Although various studies have been, and are still being undertaken which attempt to describe ecosystems and environmental variations (e.g. the Long Term Ecological Research project (LTER) in the McMurdo Dry Valleys, the International Trans Antarctic Scientific Expedition (ITASE) across the Polar Plateau, and Antarctic Aquatic Ecosystems at locations around McMurdo Sound), none have attempted a latitudinal coastline, marine and terrestrial survey of physical and biological parameters. The results from the LGP are therefore expected to break new ground and open up new areas of scientific understanding. The LGP's success is dependent on the interdisciplinary aspects of the project and the interaction of researchers at each site, forming a complete picture of the ecosystems studied.

The five terrestrial sites situated along the latitudinal gradient are to be the centre of intensive research for two consecutive years each, with a yearoff between each site. The life span of the project is therefore expected to be 15 years starting in the 2003/04 season. The five proposed sites are: Cape Hallett, Terra Nova Bay, Granite Harbour, Darwin Glacier and the Beardmore Glacier (Figure 1). Other than Cape Hallett, these sites are still open to discussion.

Marine studies from research vessels will be conducted along the Victoria Land coastline at predetermined times through the project's lifetime. A marine research voyage is scheduled for February/March 2004 supported by the Ministry of Fisheries (under the BioRoss programme) and Land Information New Zealand. A separate IEE will be completed by these agencies for the ship-based operations.

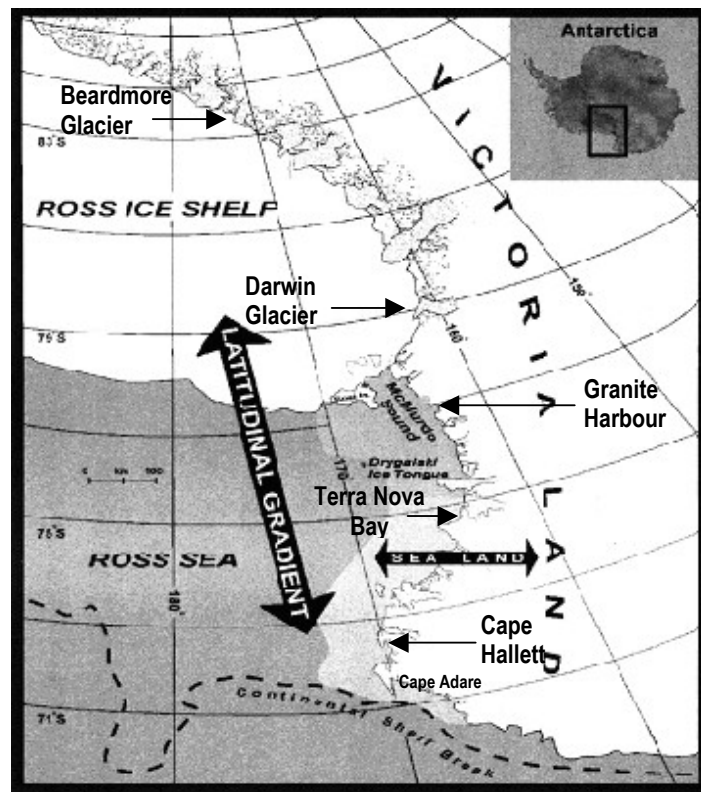


Figure 1. The Victoria Land coastline

There are two central elements to the success of the LGP initiative:

- Interdisciplinary collaboration; and
- International collaboration.

A number of scientists and national Antarctic programme managers from New Zealand, Italy and the U.S. (the three countries with scientific bases in the Ross Sea region) representing a broad range of disciplines have been instrumental in bringing the LGP initiative to fruition.

The expertise of the scientists who have shown interest in the LGP are:

- Limnology and oceanography;
- Marine and terrestrial ecology;
- Physiology and genetics;
- Soil science and microbiology;
- Meteorology and climate modelling;
- Glaciology and geomorphology; and
- Sediment- and ice-core paleoclimatology.

Collaborations between other countries besides those mentioned are currently minimal, but welcomed.



1.2 Environmental Impact Assessment

All activities supported by Antarctica New Zealand must have an Environmental Impact Assessment (EIA) approved under the Antarctica (Environmental Protection) Act before they can take place. Preliminary Environmental Evaluations (PEEs) have been submitted for each science event involved in the LGP. These have been summarised and collated to form an Initial Environmental Evaluation (IEE), which was deemed the appropriate level of EIA for the LGP, as the predicted impacts are likely to be minor or transitory.

This IEE has been prepared in accordance with Annex I (Article 2) of the Protocol on Environmental Protection to the Antarctic Treaty, and in accordance with the requirements of the New Zealand Antarctica (Environmental Protection) Act, 1994. An IEE will be completed for the activities at each site that LGP proposes to visit. These will be supplemented by information from the individual science PEEs to provide an overview of the cumulative impact of the science at the sites.

This IEE has been submitted to cover the envisaged impacts of the camp at Cape Hallett over a two year period, as well as the cumulative impacts of the science that has been proposed to be undertaken at Cape Hallett over the 2003/04 season. The IEE has been prepared by Antarctica New Zealand and reviewed by the participating scientists. It will be submitted to the Ministry of Foreign Affairs and Trade for consideration. The Ministry use an independent Environmental Assessment and Review Panel to provide expert advice on EIAs. In accordance with Annex I, Article 6, notification will be provided to the Antarctic Treaty Consultative Parties that an IEE has been prepared, and copies will be available on request.

Once the science planning for the second season at Cape Hallett is further advanced, the details of sampling, chemical use and other specific science activities will also be submitted to the Ministry, for approval as a modification to this IEE.



2. DESCRIPTION OF THE PROPOSED ACTIVITY

2.1 Purpose and Need

This section describes the purpose and need for the proposed LGP activity covering issues such as the scientific justification, the location of the LGP camp, Cape Hallett as an Antarctic Specially Protected Area (ASPA), the duration of the project, the nature and intensity of the proposed activity, the science activities around Cape Hallett and alternatives investigated.

2.1.1 Scientific Justification

The culmination of the discussions and workshops on the LGP concept is an overarching, general hypothesis for the project. This hypothesis is that:

Ice-driven dynamics control the structure and function of ecosystems (marine, terrestrial and freshwater) near the limits of life at high latitudes.

Eight key questions have been formulated to test this hypothesis (Appendix A). It is envisaged that these key questions are to be the driving force for the studies undertaken within the framework of the LGP, however additional questions are encouraged and will be sought as our understanding of the ecosystems under study increases.

2.1.2 Project Facilitation

Antarctica New Zealand has assumed the role of project facilitator for the New Zealand portion of the LGP and will fulfil two main functions:

- (a) The provision of logistical support to New Zealand events working within the framework of LGP.
- (b) The development of international linkages.

Antarctica New Zealand has planned the logistic support needed for the terrestrial portion of the project on the basis that there will be equitable logistical support from other countries when they become involved in the project. At present, planning is for the support of New Zealand scientists and one US science event. It is hoped and anticipated that further US involvement and new Italian collaborations will occur in the near future.



2.2 Location

2.2.1 Cape Hallett Site Description

Cape Hallett (72°19'S 170°16'E) is located at the southern end of Moubray Bay, northern Victoria Land, in the western Ross Sea (Figure 2). It forms the northern tip of the 32 km long by 8km wide, north-south aligned Hallett Peninsula which extends south to Cape Wheatstone and is joined to the mainland by a narrow ridge between Tucker Glacier and Edisto Inlet. The low point of this ridge is the broad Football Saddle (700m). Projecting about 1200m west from the high rocky ridge forming Cape Hallett is Seabee Hook (Figure 3), a low (generally less than 5m above sea level), curved spit composed of coarse volcanic material, between 130 and 575m wide, with a total area of approximately 41.1 ha. Willett Cove is a small bay enclosed on the south side of Seabee Hook.

Hallett Station

Hallett Station was established on Seabee Hook at Cape Hallett in 1957 as part of the International Geophysical Year (IGY). The joint New Zealand/US year-round research undertaken at this station was primarily concerned with auroras and airglow, ionospheric physics, geomagnetism, seismology and meteorology. Biological studies became more prominent in the 1960s, especially after 1964 when summer only operations started. The station was also useful for providing weather reports, supporting communication systems and as an emergency landing field as it was located along the flight path between New Zealand and McMurdo and Scott Base stations. Hallett Station was finally abandoned in February 1973.

Between 1984 and 1987 a joint New Zealand/US clean up operation demolished buildings and burnt them on site. Non-burnable items such as scrap steel, old vehicles and other equipment were hauled out onto the sea ice and allowed to melt through the ice. The site has been gradually cleared up since it closed 29 years ago, but it is still the most significant remaining deactivated station or camp site in the Ross Sea region (Gilmore, 2001). A recent assessment of the area (Gilmore, 2001) has suggested further remediation for the site. Such remediation is currently being cooperatively planned by the environmental departments of the New Zealand and US Antarctic programmes.

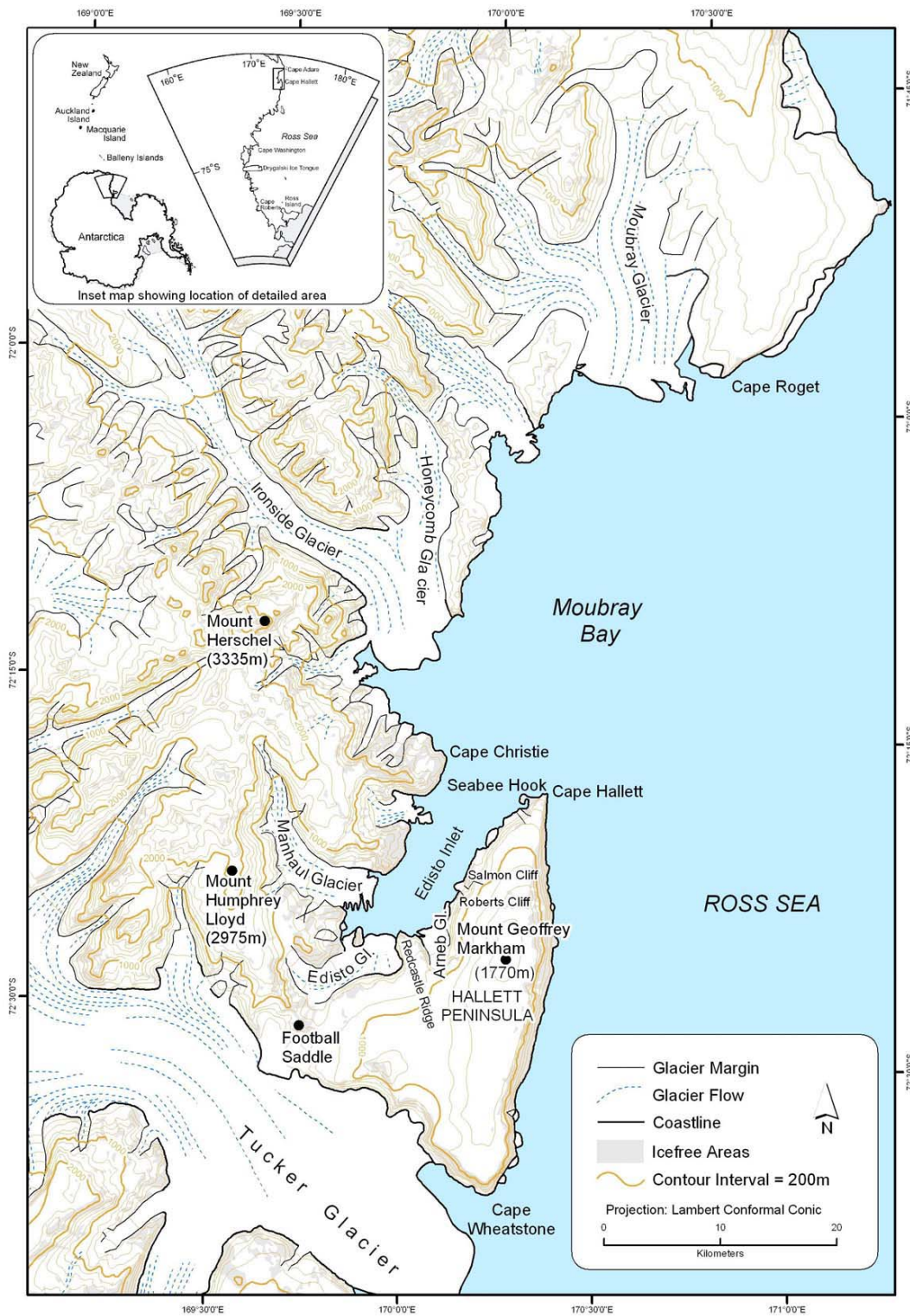


Figure 2. Hallett Peninsula and surrounding areas.

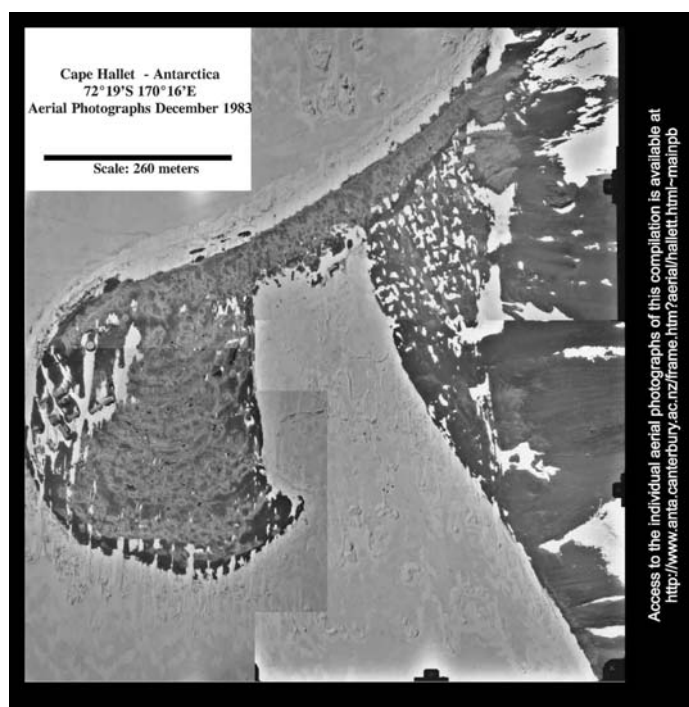


Figure 3. Composite aerial photographs of Seabee Hook. Courtesy of Gateway Antarctica and Brent Sinclair.

2.2.2 LGP Camp Location

The Cape Hallett Management Plan gives the location of a designated campsite on the eastern shore of Willett Cove (72°19'13"S, 170°13'34"E) (Figures 4 and 5). This site comprises unconsolidated beach gravels, is not colonised by birds or significant plant communities and lies on the site of a former station road. The site lies within the Cape Hallett Antarctic Specially Protected Area (ASPA 106).

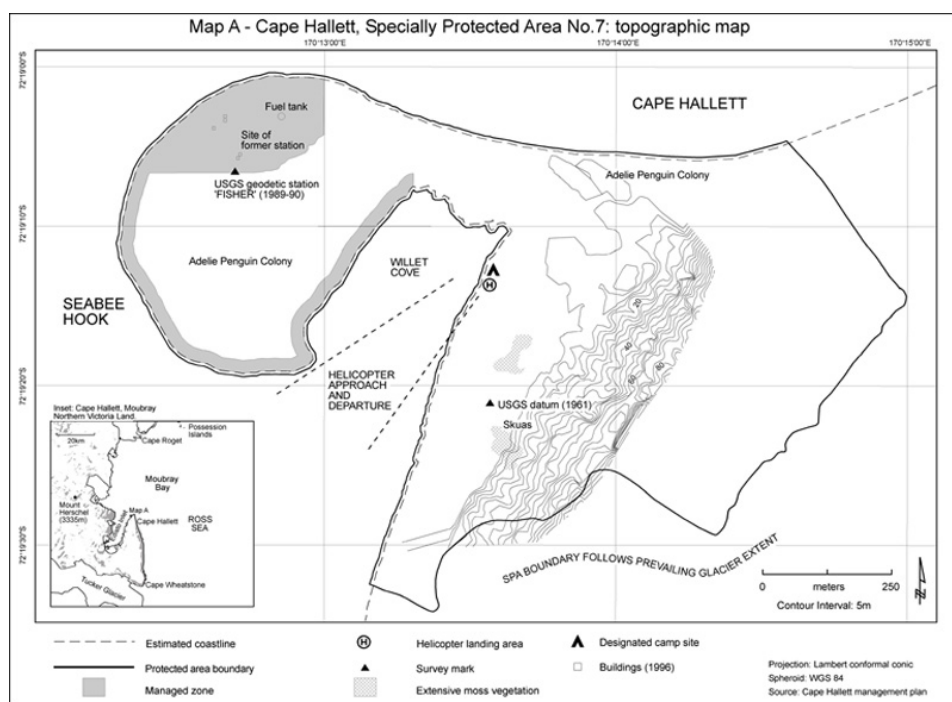


Figure 4: Location of Cape Hallett designated camping site.



There are two options for the location of the LGP camp. These are:

Option 1: Rac tents in designated camping area on land and accommodation tents on sea ice in Willett Cove;

Option 2: Entire camp in designated camping area on land.

Figure 5: View of designated campsite looking South. (Photo courtesy of Bill Gilmour)

The sea ice in Willett Cove is relatively stable compared to the sea ice on the Ross Sea and Edisto inlet sides of Seabee Hook. In the 02/03 season, a New Zealand event of four camped on Willett Cove from mid-November to the end of January (Figure 6). The only problem encountered over this period was the development of melt pools on the surface, and no instability was noted. However, the sea ice in Edisto Inlet is renowned for its rapid break-out, and once this has occurred, the ice in Willett Cove is susceptible to break out.

Given this experience, use of the sea ice for tentage is feasible and would minimise impacts on the land. However, the Rac tents would take a considerable amount of time to empty and relocate on land in the event of an impending ice breakout. The smaller accommodation tents, on the other hand, could be dismantled and moved quickly into the designated camping area if sea ice conditions deteriorated. As a result, the preferred option for the location of the tents is Option 1. Option 2 would be a backup in case of sea ice breakout.

As the beach in the designated campsite is sloped, a bearer system has been designed for the Rac Tents to ensure that the floors will be level. This also serves to reduce the footprint left by these tents as the floor will be raised from the ground (See Section 4.1.1).



Figure 6: View of 02/03 camp in Willett Cove. (Photo courtesy of Brent Sinclair)



2.3 Cape Hallett as an Antarctic Specially Protected Area

An area of Cape Hallett was designated a Specially Protected Area (SPA) in 1966 under Resolution IV-7 of the Antarctic Treaty. This was done on the grounds that “Cape Hallett includes a small patch of particularly rich and diverse vegetation which supports a variety of terrestrial fauna and that the ecosystem which includes a rich avifauna, is of outstanding scientific interest.” (Specially Protected Area No. 7 Management Plan). With Annex V of the Protocol now in force, Cape Hallett has become an Antarctic Specially Protected Area (ASPA 106).

This management plan was revised in September 2002. Its boundaries have been extended from the original SPA to include the whole of Seabee Hook, increasing the size of the Area from 12ha to 74ha.

The Management Plan at Cape Hallett aims to:

- Avoid degradation of, or substantial risk to, the values of the Area by preventing unnecessary human disturbance to the Area;
- Permit scientific research, in particular on the plant and bird communities, while ensuring these are protected from over-sampling;
- Allow environmental clean-up and remediation activities associated with the decommissioning and removal of the former Hallett Station as required and appropriate, provided the impacts of these activities are not greater than those arising from leaving material *in situ*;
- Minimize the possibility of introduction of alien plants, animals and microbes into the Area;
- Allow visits to the Managed Zone for historical, educational, wildlife and scenic viewing purposes under control by permit;
- Allow visits for management purposes in support of the protection of the values and features of the Area.

Entry into the Area is prohibited except in accordance with a permit. Conditions for issuing a permit to enter the Area are that:

- Outside of the managed zone a permit should be issued only for scientific study of the ecosystem or for essential management purposes consistent with plan objectives such as assessment or remediation of impacts, inspection or review;
- The actions permitted will not jeopardize the ecological, scientific or aesthetic and wilderness values of the Area;
- Access to the managed zone may be permitted for scientific, management, historical, educational or recreational purposes providing they do not conflict with the objectives of this plan;
- The permit, or a copy, shall be carried within the Area;
- A report or reports shall be supplied to the authority or authorities named in the permit;
- Permits should be valid for a stated period.



In addition to these, there are clearly stated regulations on:

- Access to and movement within the Area;
- Activities that may be conducted in the Area;
- Installation, modification or removal of structures;
- Location of field camps;
- Restrictions on materials and organisms that can be brought into the Area;
- Taking or harmful interference with native flora or fauna;
- Collection or removal of anything not introduced by a visitor;
- Disposal of waste.

It is intended that the operation of the LGP camp at Cape Hallett and the science research undertaken there will be compliant with the conditions set out in the Cape Hallett Management Plan.

2.4 Duration

The duration of the Cape Hallett section of the LGP is two years. Most of the LGP equipment was shipped down to Scott Base in January 2003 and is expected to be flown into Cape Hallett in November 2003. The gear will remain at this site until February 2005, although there is a possibility that some of it may remain over the 2005 winter until it can be pulled out in the 2005/2006 season.

The Cape Hallett component fits within the longer time scale of the LGP project as a whole, the planned duration of which is 15 years (Table 1).

Activity	Years
Cape Hallett	03-04 and 04-05
Year out and reconnaissance	05-06
Darwin Glacier	06-07 and 07-08
Year out and reconnaissance	08-09
Terra Nova Bay area	09-10 and 10-11
Year out and reconnaissance	11-12
Granite Harbour	12-13 and 13-14
Year out and reconnaissance	14-15
Beardmore Glacier	15-16 and 16-17

Table 1. Duration of the LGP.

2.5 Nature and Intensity of the Proposed Activity

2.5.1 Camp Structure

The camp at Cape Hallett will be equipped to support a maximum of 15 people, inclusive of two non-science personnel. The main camp infrastructure is as follows:

- 1 x Rac Tent (24'x16') - this will be used as a mess (see Figure 7a and b);
- 2 x Rac Tents (20'x12'): - one as a computer and lab; one as a workshop/science equipment storage;
- 3 x Endura tents for accommodation and sea ice research;
- 5 x Polar tents for accommodation;
- 2 x skidoos with box sleds;
- 1 x All Terrain Vehicle (ATV) with wheeled trailer;
- 2 x 4.7kva Yanmar diesel generator;
- 2 x 3kva Honda petrol generator;
- 2 x 2kva Honda petrol generator;
- 3 x Sigmar Marine heaters (diesel fuelled) to heat Rac Tents.

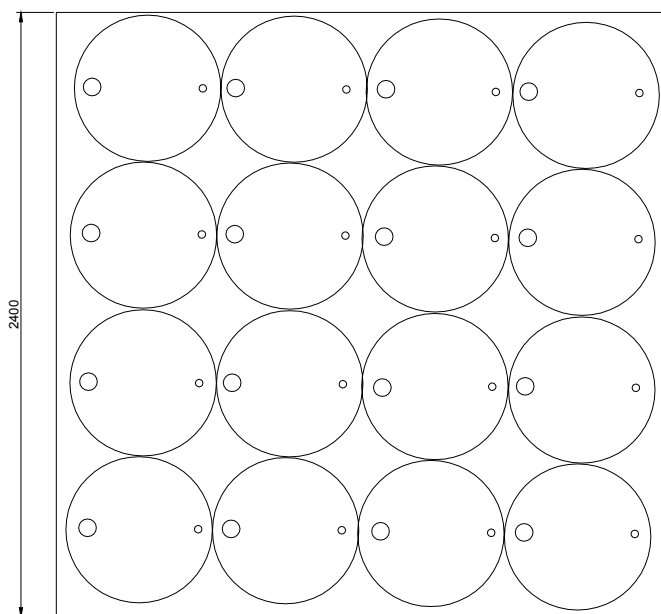


Figure 7 and b: Rac tent exterior and interior. (Photos courtesy of Jim Davis)

The use of this infrastructure is discussed in more detail below. The potential impacts of the camp are discussed in Section 4.

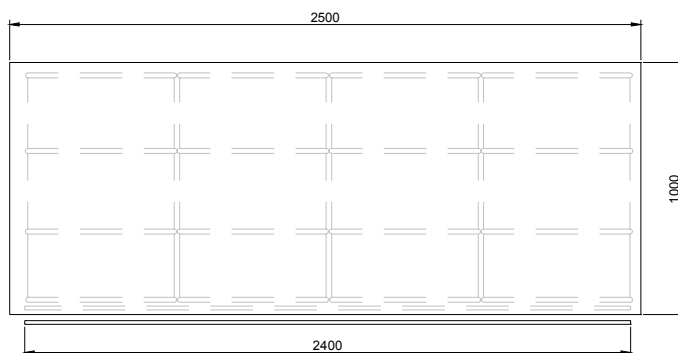
2.5.2 Power and Fuel

An estimated 30 x 209L drums of JP8 and 15 x 209L drums of petrol will be needed for the 2003/04 season. These drums will be stored on land in the designated camping area in secondary containment. The containment consists of four heavy duty PVC canvas bunds, sandwiched by sheets of plywood (Figure 8). Each bund holds 16 drums and has the capacity to hold the entire volume of fuel held in the drums should this unlikely scenario arise.



Plan View

Bunding consists of 2@ 2400x1200 Plywood laid down on ground then PVC bund measuring 2500x2500 x 1000 high another 2 sheets of ply for drums to sit on Eyelets around the top of PVC will enable bund material to be drawn tight over the top of drums Each bund contains 16@ 209 litre drums



Elevation

Figure 8: Fuel containment.

The Rac tents will be heated using diesel burning Sigmar Marine heaters. The fuel tanks for these will be located outside the tents, on a tank stand which will lie in a drip tray (Figure 9).

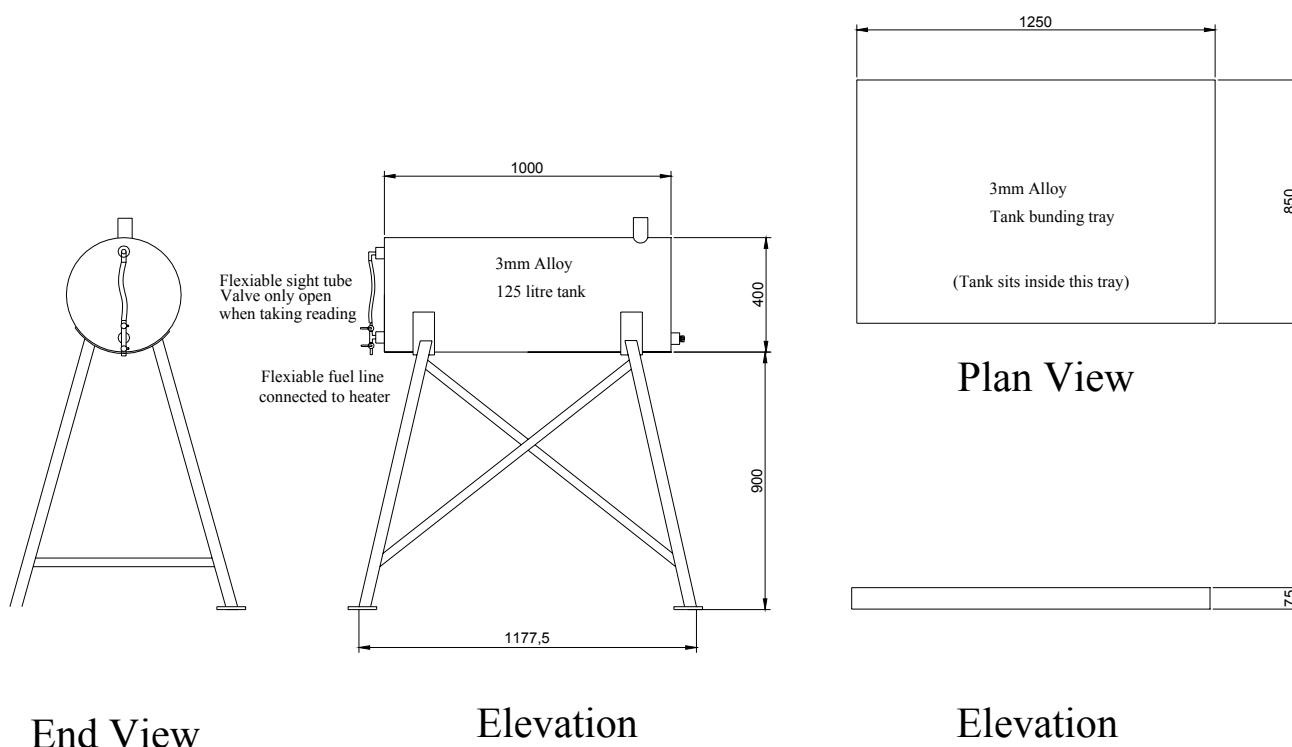


Figure 9: Sigmar fuel tank set up.

All generators will be operated over drip trays. Emissions into the air will occur while the generators are running.

Fuel handling will follow Antarctica New Zealand fuelling guidelines and any vehicle fuelling will occur in a designated area.

Four 10 litre and one 100 litre spill kits will be available at the camp.

Ten 9kg bottles of LPG will be stored at the camp and used for the LPG stove.

Three 80 amp hour gel cell batteries will provide power for computer use and battery recharging to minimise generator use. These batteries will be recharged from generators when they are running for other purposes. The use of solar power is being investigated, but it is advisable to obtain a realistic estimate of how much power is needed before sourcing appropriate solar equipment. It is therefore intended to source solar equipment after the first operational season.



2.5.3 Waste

Waste disposal will be in accordance with Article 5 of Annex II (Waste Disposal and Waste Management) of the Protocol, which states that, "*Sewage and domestic liquid wastes and other liquid wastes may be discharged directly into the sea....*". All grey water (domestic liquid wastes) will be sieved and disposed of in safely accessible open water (e.g. tide cracks while sea ice persists, at the shore if necessary). As far as practicable, disposal will be on the northern side of Seabee Hook for maximum dispersal, rather than in the sheltered Willett Cove.

While conditions are favourable, toilet tents will be positioned on the sea ice and the human waste disposed of directly into sea ice holes. Eventually the ice will break out and melt, releasing the waste offshore where rapid dispersal can be expected. Should sea ice conditions deteriorate, the toilet tents will be moved onto land and the human waste will be disposed of in the same way as grey water. There is a possibility that Scott Base may have the ability to process field human waste in its waste water treatment plant in the future. If this occurs, consideration will be given to sending human waste back to Scott base for disposal.

All other waste will be sorted and packaged appropriately and returned to Scott Base for disposal.

2.5.4 Water supply

Water will be sourced from a nearby glacier and/or icebergs that are often found close to the Cape. A melter is currently being designed to use the heat from the Sigmar Marine heaters in the Rac tents to melt the ice, requiring no additional energy use. When the opportunity arises, snow will also be collected and melted in plastic bins. These methods have been used successfully by previous events at Cape Hallett.

2.5.5 Vehicles

Two skidoos will provide access to sea ice areas while conditions are favourable and allow for cargo to be moved around easily. An ATV with wheeled trailer will also be used on the sea ice, and to provide additional assistance for moving equipment around within the designated camping area. Emissions into the air will be generated while the vehicles are running.

2.5.6 Air Transport

Twin Otter support will be used to transport the cargo to Cape Hallett. Landings will be made on the sea ice and cargo transported to the campsite by skidoo and ATV.

Helicopter support will also be used through the season. Helicopter guidelines included in the Cape Hallett Management Plan will be strictly adhered to.

2.5.7 Movement of People

As the designated campsite is located within the Cape Hallett ASPA, the movement of people will be regulated to ensure that unnecessary foot traffic on land is avoided.



2.5.8 Over-winter Storage

As the camp is to be used for two seasons, it will be packed up and stored on land over the 2004 winter to allow re-establishment in November 2004. At present it is proposed to dismantle the camp and remove it at the end of the 2004/2005 season. However, there may be a need to store the camp gear for a second winter and move it at the start of the 2005/2006 season, depending on logistical constraints.

The Rac tents pack away into self contained boxes (which double as the flooring units) and the remaining gear will be stored appropriately. Selected items will be covered and secured by several tarpaulins for added protection. The cached equipment will be located within the designated campsite. The cache is estimated to cover approximately 50m². This was approved in the PEE submitted in August 2003.

2.6 Science Activities at and Around Cape Hallett

There will be eight main science activities undertaken at Cape Hallett in the 2003/2004 season. These involve the:

- Sampling of marine invertebrate larvae to allow for the detailed study of the meroplankton community (organisms that spend part of their life cycle in the plankton but also spend time in the benthic environment) at Cape Hallett. This will involve daily quantification of the distribution and abundance of common larval forms;
- Collection of marine and terrestrial animals to determine their phylogenetic (evolutionary) histories;
- Measurement of algal productivity, biomass and biodiversity, pigment content, and nutrients from sea ice and from the water underneath to provide ground truth data of total primary productivity and biodiversity in the region;
- Characterisation of freshwater ecosystems by surveying the periphyton (layer of small plants and animals attached to surfaces projecting above the bottom) of the major streams in the region, determining how nutrients are transformed as they flow downstream, and measuring rates of respiration, photosynthesis and nitrogen fixation;
- Assessment of the genetic relationships of non-marine algal populations;
- Description and analysis of the soils in the area including work on microbial activity;
- Determination of soil biodiversity;
- Mapping and description of terrestrial vegetation.

The sections below contain a collation of the PEE attachments submitted by these events, thus giving an overview of the combined impacts of the science activities. The potential direct, indirect and cumulative environmental impacts of these events are discussed and tabulated in Section 4.8.



2.6.1 Use of Chemicals

The chemicals listed in Table 2 are planned for use at Cape Hallett. Use of these chemicals will mostly be in laboratory tents. Samples will be brought back from the field and preserved in the laboratory tents on site. Lined drip trays and/or absorbent pads will be used when the chemicals are handled and any waste chemicals or used absorbent pads will be marked appropriately and returned to Scott Base for disposal. Remaining preservatives will either be stored in a hazardous cargo container on site over winter for use in the second season at Cape Hallett, or returned to Scott Base for storage over winter.

Some ^{14}C incubations will be performed in bottles deployed under the ice. Neither ^{14}C nor any other chemicals will be released into the environment in any form.

Chemical Name	Quantity	Purpose
Steedman's Fix: Formalin CH_2O Propylene phenoxetol Propylene glycol	2 litres 1 litre 4 litres	Preservative
Ethanol	10 litres	Preservation of samples, sterilise soil sampling equipment, solute extractant
RNAlater™	0.5 litre	Preservative
Sodium Hydroxide (NaOH)	10mL of 1 M and 100g	Preservation of samples, O ₂ measurement
^{14}C (1/2 life of 5730 y)	1GBq	Productivity of algae
Methanol	10 L	Extraction of algae
Glutaraldehyde (25%)	200ml	Preservation of samples and fixation of algae
HCl (10%)	50mls	Chlorophyll measurements
Sodium sulphite	500g	O ₂ measurement
Sodium ascorbate	100g	O ₂ measurement
Acetone	2.5L	Preparation of samples
KOH (10% solution in water)	50ml	Lichen tests
Para-phenylamine diamine solution in alcohol	50ml	Lichen tests
Sodium Hydrochlorite (3% solution in water)	100ml	Lichen tests
Paraformaldehyde	100 ml	Preservative

Table 2. Chemicals to be used at Cape Hallett, 2003/2004.



2.6.2 Interference with Plants or Animals

Activities involving plants or animals are listed in Table 3 and summarised as follows:

- Plankton sampling will be undertaken using a plankton net which samples a small volume of sea water (estimated 3.92m³ per tow). As the target organisms are seasonally abundant, and there is replacement of the water mass under the ice, there will be an insignificant removal of animals from the plankton community. Sampling is therefore expected to be of minimal impact.
- Fish will be caught with a hand line, fin sampled, tagged and released. They will be monitored by video after release.
- Small samples of earth will be processed to recover nematodes. Processed soil will be returned to the site of origin.
- Algae from under the sea ice will be sampled. Only sufficient cores and dive holes will be drilled at each location. Each core hole will be filled with ice shavings once the sample has been withdrawn and the hole allowed to re freeze.
- Small samples of mixed microbial mats will be taken from ponds and streams. The samples will be taken from widely spaced locations within water bodies to facilitate rapid recovery.
- Terrestrial algae will be sampled by collection into test tubes. The minimum material required will be moved and wherever possible plants will not be disturbed or walked on during collection.
- Lichen and moss will be collected by hand and insects by hand and using traps. No disturbance to the sites is envisaged except for the removal of the species. Any stones moved will be replaced in original positions. Lichen and moss will only be removed if samples are required for identification, and only the minimum insects needed for analysis will be taken. All collected samples of lichens and mosses will be lodged in a suitable herbarium with identification. All insect specimens not used for DNA work will be stored with identification for future use.



Species	Nature of disturbance	Number or quantity	% of local population
Zooplankton	Removal of plankton samples from ocean; sorting into invertebrate (returned to ocean) and fish larvae (permanent removal).	120 samples	<1%
<i>Trematomus bernacchii</i> <i>T. hansonii</i> <i>T. pennellii</i> <i>T. nicolai</i> <i>Gymnodraco acuticeps</i> <i>Notothenia coriiceps</i> Unexpected/ undescribed species	Fish will be caught, tagged and a small section of fin (2x4mm) removed.	1000	Probably <1% of population, but population size is unknown
<i>Panagrolaimus davidi</i>	Collected from soil and preserved for DNA analysis in NZ.	250	
Sea ice algae, phytoplankton, benthic algae	Small samples taken for study on return to NZ	Less than 10g dry weight	Negligible
Mixed microbial mats	Sampling of ponds and streams around the Cape Hallett area	Approximately 50 samples each of 2-3 g	<1%
Moss species	Removal for identification	Minimum	<1%
Lichen species	Removal for identification	Minimum	<1%
Insects (collembola) and mites and nematodes?	Removal to establish identities and genetic analysis	20-50 per site	<1%
<i>Prasiola</i> spp. Other green algae and cyanobacteria (species not yet known)	Sampling for taxonomic work in NZ. Non-invasive measurements of habitat on site	3 Eppendorf tubes, each containing <2g of material, for each sampling point. Up to 30 sampling points (depending on populations)	<1%

Table 3. Activities involving plants and animals.



2.6.3 Physical Samples

Specimen	No. / weight	Purpose
Soil and pebbles	Unknown	Inadvertently collected substrate attached to sampled lichen
Soil and water associated with algal populations	<2g per sample	To assist growth and viability of algal samples in transit and lab culturing in NZ
Pond and stream water samples	Approx 50 samples of 100 ml	Chemical analysis in NZ
Soil	120/ 1kg	Laboratory analyses of soil properties

Table 4. Physical samples to be taken.

2.6.4 Installation of Equipment

Item installed	No. / weight	Purpose
Rods	Unknown (<20kg)	Marking sites during vegetation cover estimates
Bamboo poles on sea ice	55	Define experimental site
Small PVC tubes	8cmx10cm approx. 10	Trap insects and mites
Automatic weather station	1	Collection of continuous environmental data
Plans for removal		
Poles, rods and PVC tubes will be removed when all sampling is completed.		
AWS will remain in position for the duration of the LGP. Please note that an AWS is already installed at the site. The current one will be replaced by an AWS provided by the US LTER event.		

Table 5. Equipment to be installed.

2.6.5 Disturbance to Ice Free Areas

The overall activities may result in some trampling of soil by foot traffic, although the vast majority of the land area has already been disturbed by the station operation and removal. Soil, oil spill and hydrological investigations will require digging approximately 20 soil profiles and sampling up to 120kg of soil. Soil profile pits will be refilled after use.



2.7 Alternatives

2.7.1 Alternative of not proceeding

With the long record of science conducted in the Ross Sea region it is difficult to see how not proceeding with the proposed activity would have significantly different consequences for the intrinsic, wilderness or aesthetic values of the region.

LGP is about conducting a marine and terrestrial ecosystem study, of physical and biological parameters along a latitudinal coastline, which no other study has ever done before. The results of LGP are expected to increase our understanding of polar ecosystems and help create a predictive knowledge of future effects of environmental change on these ecosystems. Scientific values of the region will be enhanced by the project, assuming that the LGP will not have significant impacts on the sites.

The alternative of not proceeding would be to remain in ignorance of these aspects, the consequences of which are very difficult to assess objectively.

2.7.2 Location of the LGP camp

An alternative camp option explored was the idea of placing the entire camp on the sea ice in Willett Cove. Environmentally this is one of the preferred options but for safety reasons this option was discarded. The uncertainty of the sea ice behaviour and the possibility of a rapid breakout which would not allow time for the camp to be dismantled and moved on to the land were the reasons this option was discarded.

Consideration was given towards locating the camp at Cape Adare for the most northerly point along the Victoria Land coast, but this was rejected due to logistical difficulties.

2.7.3 Set up

The Rac tents were chosen for their durability, ease of set-up and usable space offered. Alternatives to using Rac tents for mess and lab space would be the use of Polarhavens or Enduras. Polarhavens have proven to be not as resilient as Rac tents, are more difficult to erect, and provide less usable space per square metre (due to sloping walls). The use of Enduras to cook for a camp of 15 people would not be efficient.

Power is supplied to the camp by 2 small diesel generators and four portable petrol generators. These have an efficient use of fuel and allow flexibility of movement for scientific experiments. An alternative power supply would be a 10kva generator. These weigh in excess of 1000lbs and would be inconvenient to transport and position at the field camps. This would also not allow flexibility for the placement of science experiments on the sea ice, for example.

Alternatives for fuel bunding were considered. Individual 'overpack' drums for each fuel drum were sourced. However the price was prohibitive and each overpack added extra weight to the cargo that would have made the overall weight of the camp that needed to be transported prohibitive.



3. INITIAL ENVIRONMENTAL STATE

3.1 Physical Geography

3.1.1 Geology

The Cape Hallett-Tucker Glacier district is characterised by alpine-type ranges to the west rising to heights of 3800m. A linear chain of coastal volcanic mountains up to 1800m is separated from the interior mountains by a topographic corridor extending from Robertson Bay to the north through Edisto Inlet and the Whitehall Glacier to Lady Newnes Ice Shelf in the south (Wood, 1963).

The basaltic, dome-shaped Hallett Peninsula is bound by cliffs of 1500m on its eastern seaboard and 300m on its western side. Its highest point is the extinct 1770m shield volcano, Mt Geoffrey Markham. Volcanic rocks are exposed along the cliff sections of the peninsula, in particular at Salmon Cliff and Roberts Cliff on the eastern face of the peninsula. These are separated by the Bridgeman Glacier.

3.1.2 Glaciology

A mantle of undulating ice covers all but a few protruding scoria ridges on Hallett Peninsula. Most of this ice drainage is westward, mainly into Edisto Inlet, where glaciers drape the cliffs on the east side of the bay (Harrington et al., 1967). Much of the drainage from the central part of the peninsula is concentrated into the Arneb Glacier which flows into Edisto Inlet. The Arneb, Edisto and Manhaul Glaciers are the three main glaciers that flow in to Edisto Inlet and terminate in floating tongues.

Satellite data from 1979 to the present (Falconer and Pyne, 2000) demonstrates that the sea ice at Cape Hallett usually breaks-out on an annual basis. This break-out starts around the end of December to early-January. The sea ice closes back in around the beginning of March.

3.1.3 Geomorphology

The coarse volcanic material of Seabee Hook which extends westwards into Edisto Inlet from Cape Hallett is deposited in a series of beach ridges, with gently undulating terrain of hummocks and depressions and a number of level areas. The depressions are prone to filling with water during the summer melt. The spit is an extension from a slightly earlier, rougher, triangular beach, on the leeward side of Cape Hallett (Harrington and McKellar, 1958) with an apron of scree at the base of the high cliffs of the cape.

Much of Seabee Hook is occupied by an Adèle penguin rookery. In the area covered by the rookery, the beach is composed of: pebbles; guano; flattened, hard, permanently frozen bodies of penguins; and the general debris of penguin occupation overlying 60cm and more of clean beach gravel devoid of organic remains (Harrington and McKellar, 1958).

Chemical analysis of Cape Hallett soils were undertaken by Boyd et al. (1966). The soil at three Seabee Hook sites have also been described (McCraw, 1967): on the scree slope below Cape Hallett; on the beach gravel of the spit; and on the guano covered part of the spit. Guano soils have been termed 'ornithogenic soils' (Campbell and Claridge, 1987) as the organic matter in these soils does not accumulate by biosynthesis in situ but is brought to the rookery during the summer period when the penguins are ashore. The organic matter is contributed in the form of droppings, feathers and bird remains. The organic matter in



these soils (low grade guano) is described as having a reddish brown colour to depths of 10-15cm, grading into darker coloured organic horizons, then into underlying mineral deposits (McCraw, 1967).

3.2 Meteorology

Year-round meteorological measurements were taken at Hallett Station during its operation from February 1957 to February 1963, and some summer data were collected after 1963 (U.S. Weather Bureau 1962-1965). Three-hourly surface temperature data shows that summer temperatures range from 4°C to -8°C (Figure 8). Average summer wind speeds are 15 knots predominantly from the south (Figure 9). Summer precipitation in the form of snow is not uncommon (Sinclair 02/03).

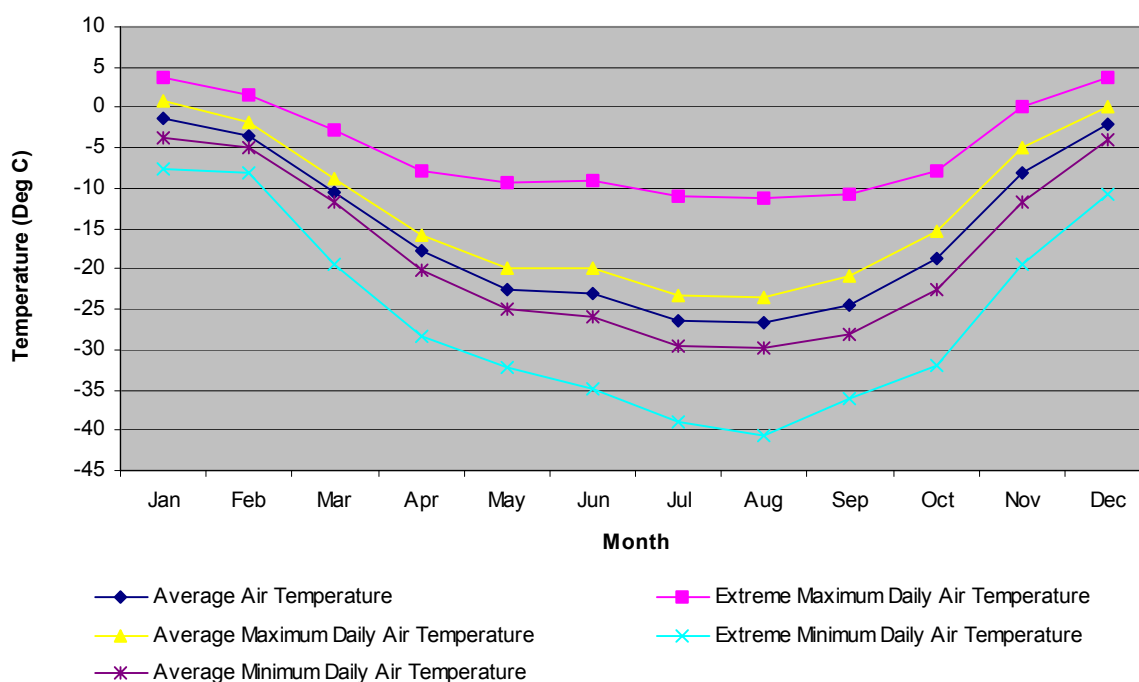


Figure 8. Mean monthly temperatures at Hallett Station 1957-1964.

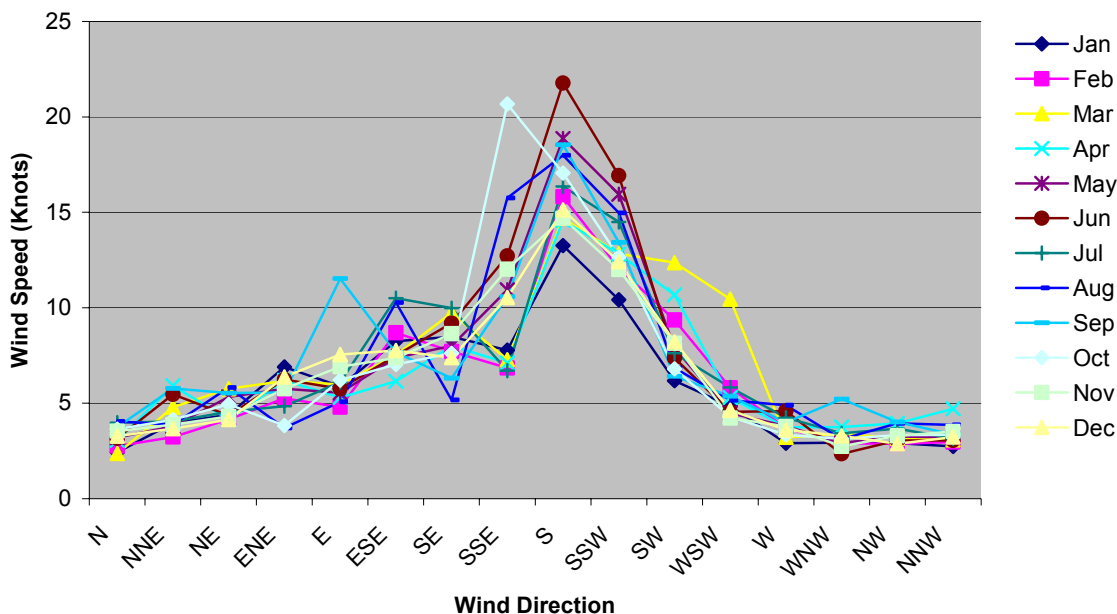


Figure 9. Mean wind speed and direction at Hallett Station 1957-1964.

3.3 Terrestrial Biology

3.3.1 Avifauna

Seabee Hook is the site of an Adèlie penguin colony with a recently estimated population of 39,014 breeding pairs (pers. comm. K. Barton from 1998/99 breeding season). On the spit, penguins nest on well-drained ridges and hummocks where snow does not accumulate. Large subcolonies are also found on scree fans at the base of the cliffs where there is irregular sloping terrain and where neither snow nor meltwater can accumulate (Wilson et al., 1990).

A major skua colony is also present at Cape Hallett. The skuas nest in loosely knit colonies located on the scree slope just above the penguin colony, on adjacent areas of lowland, and in the depressions within the penguin colony (Maher, 1966). The last recorded census of the skua colony counted 84 breeding pairs (Wilson 1983; Pascoe 1984). The skuas have been observed to arrive at Cape Hallett in late October after the penguins, where they re-occupy old territories and breed with former partners.

Although not permanent residents at Cape Hallett, other birds have been observed in the area besides Adèlie penguins and south polar skua. Reid (1961) banded 30 snow petrels in a colony located about 8 km across the sea ice of Edisto Inlet from Cape Hallett nesting on steep, rotten slopes at 9-300 m above sea level. Snow petrels were also observed during other expeditions at Cape Hallett (Harrington, 1958; Reid, 1960, Wilson, 1983; Gill, unpublished).

Other birds sighted include southern Giant Petrel (Wilson, 1983; Gill, unpublished); Wilson's storm petrel (Harrington, 1958; Wilson 1983; Gill, unpublished); Chinstrap penguin (Crawford, 1974; Wilson 1983; Gill, unpublished); Emperor penguin (Reid, 1960); and the Southern Black-backed gull (Derksen, 1975).

3.3.2 Flora

The plant life at Cape Hallett has been the subject of several studies. A recent expedition to Cape Hallett by a group from Waikato University in collaboration with the Australian Antarctic Division described the plant (lichen and moss) distribution at Cape Hallett (Green, 1998/99). A full plant list was completed which included several unrecorded lichen and moss species (Table 6), and plant distributions were mapped.

Lichen	Mosses
<i>Acarospora gwynnii</i>	<i>Bryum subrotundifolium</i>
<i>Amandinea petermannii</i>	<i>Bryum pseudotriquetrum</i>
<i>Buellia frigida</i>	<i>Sarconeurum glaciale</i>
<i>Caloplaca athallina</i>	<i>Ceratodon purpureus</i>
<i>Caloplaca citrina</i>	<i>Schistidium (Grimmia) sp.</i>
<i>Candelaria murrayi</i>	
<i>Candelariella flava</i>	
<i>Lecanora chrysoleuca</i>	
<i>Lecanora expectans</i>	
<i>Lecidea cancriformis</i>	
<i>Physcia caesia</i>	
<i>Pleopsidium chlorophanum</i>	
<i>Rhizocarpon geographicum</i>	
<i>Rhizoplaca chrysoleuca</i>	
<i>Rhizoplaca melanophthalma</i>	
<i>Usnea sphacelata</i>	
<i>Xanthoria elegans</i>	
<i>Xanthoria mawsonii</i>	

Table 6. Mosses and lichen identified at Cape Hallett in 1998/99. (Source: Allan Green, University of Waikato, and Rod Seppelt, Australian Antarctic Division.)

3.3.3 Terrestrial invertebrates

Three species of Antarctic springtails have been observed at Cape Hallett (Wise and Shroup, 1967; Sinclair 02/03), and arthropods have been collected (Sinclair 02/03).

3.4 Marine biology

Observed marine fauna either from Cape Hallett or from ships moored in the vicinity of Cape Hallett include: crabeater seal, Weddell seal, elephant seal, leopard seal, minke whale and fin whale (Reid, 1960; Wilson, 1983; Gill, unpublished). Other than the Weddell seal, these animals are visitors to Cape Hallett. A small and scattered Weddell seal colony was observed by Reid (1960), but further mention of such a colony has not been found in the literature.

In February 2001, the *Tangaroa* undertook dredges and videographic transects off Cape Hallett for the Ministry of Fisheries' baseline study of the biodiversity of the Ross Sea (Mitchell, 2001). These enabled descriptions of the sea floor bed along with the benthic and pelagic organisms observed.



4. ENVIRONMENTAL IMPACTS OF THE CAMP AND SCIENCE ACTIVITIES

The environmental impacts of the camp and science activities outlined in Section 2 are identified and discussed. These impacts are also summarised in table format (Table 8).

4.1 Topography and Soils

4.1.1 Earthworks

Limited earthworks are required to install the wooden blocks that will support the framework for the Rac tent bases. This was approved in the PEE for K002 (LGP) submitted in August 2002 for work that had been proposed for February 2003, but was not able to be undertaken due to logistic constraints. As outlined in that PEE, an estimated surface area of 3.6m² and a volume of 0.72m³ would be disturbed. The blocks will remain in the ground until the camp is decommissioned in February 2005, when they will be removed and the holes subsequently re-filled.

Approximately 20 soil profile pits will be dug in and around the former Cape Hallett Station. Groundsheets will be used when excavating the soil profiles and all soil sampling pits will be backfilled and the surface restored as much as possible. Any stones moved will be replaced. The soils in this area are unconsolidated beach gravels which should recover very quickly.

The location of the LGP camp has had previous human disturbance as it is the designated campsite for ASPA 106 and was also the former site of a road for the Cape Hallett Station. Compaction of soils has therefore already occurred in this area.

4.1.2 Tracks

Foot tracks will occur in the area around the designated campsite, between the campsite and the shore where access to the sea ice will be gained, and to areas that will be visited for sampling. When conditions allow, access to the former Cape Hallett Station can be gained by walking across Willett Cove, thus reducing the impact on the land. Wherever possible, existing tracks will be used.

No impact to land will be caused by skidoos as these will only be operated on the sea ice. ATV tracks will occur within the designated campsite. These will be limited to specific areas, and will stay on snow cover and dry land wherever practicable.

4.1.3 Fuel Spills

Fuel spills may occur during re-fuelling of generators, Sigmar Marine fuel tanks and vehicles. They may also occur during the transfer of fuel from the 209 litre drums to 20 litre containers, which will be used for re-fuelling. Drip trays will be used to prevent the spillage of fuel onto the ground. Regular maintenance of fuel lines should also reduce the risk of a fuel leak from this source. The bunding of the 209 litre fuel drums should contain any fuel spill/leak for this source.

Spill kits will be stationed at the fuel sources and camp staff will be given specific spill response training.



4.1.4 Chemical Spills

Chemical spills could occur during scientific procedures. Should they occur, then it is expected they will be contained in the laboratory tents, so should not pose a threat to the environment. Those procedures carried out in the field will use drip trays and absorbent pads to reduce the risk of soil contamination.

4.2 Air Quality

4.2.1 Emissions

Emissions into the air will be caused by the use of generators and vehicles. Generators will not be run for 24-hour cycles, unless necessary for science purposes. Skidoos will only be operational for approximately 30 days as deteriorating and unsafe sea ice conditions will likely preclude their use later in the season. The ATV will be in use the entire time the camp is operational. Use of all vehicles and generators will be minimised where possible. The quantities of emissions will be negligible compared to those generated by existing station and transport activities in the McMurdo Sound area.

Emissions will also result from helicopter and twin otter operations in the area. Such operations will be limited to specific periods through the season.

The LGP will only operate for two to four months each season and will be interspersed with off seasons where the camp will remain in storage.

4.2.2 Dust

Dust emissions could originate from ATV use on land and helicopter operations on the beach, after the early season snow cover has melted and the surface has dried out. These conditions would only exist later in the season, thus minimising this impact.

4.3 Visual and Aesthetic Values

4.3.1 Visual

The proposed camp is a temporary facility that will be disassembled and stored during the winter between the two seasons, and completely removed at the end of the second season. Nothing will remain of the camp once it is removed. During camp operation, the site will be kept orderly and well maintained. It is recognised that Cape Hallett is a landing site for tourist operations. It is thus seen as the utmost importance that this camp is not seen as a visual mar on the landscape and that the tourists or any other potential visitors see this camp as an efficient base supporting important scientific work.

The Automatic Weather Station will remain a permanent feature at the site for the duration of the LGP. This will provide vital, continuous environmental data. The equipment will be well maintained and kept as visually un-intrusive as possible.

The over-winter cache will consist of storage boxes and equipment covered by tarps. Everything will be firmly secured against the elements and will take up as small an area as possible. Snow build up may occur over the winter around this cache.



After the camp is removed permanently, all efforts will be made to return the site to its former condition, should any disturbances be noted.

4.3.2 Noise

Noise will be created from the use of generators and vehicles as well as helicopters and twin otters supporting the camp. Use of generators and vehicles will be kept to a minimum wherever practicable. Air operations will be limited to specific periods through the season and helicopter guidelines will be followed which prohibit landings within the ASPA, and stipulate overflight distances and preferred approach paths to avoid the disturbance of flora and fauna in the area.

4.4 Flora and Fauna

4.4.1 Flora

Mosses and lichens are common in the Cape Hallett area (one of the main reasons why the SPA was originally initiated) and do exist in the designated campsite. These flora will be impacted at the designated campsite from the movement of people and the use of the ATV as well as the placement of the Rac tents, the fuel cache and remaining equipment. However, this impact will be reduced by having the Rac tents on bearers, thus lifting them from the ground and by having set paths for people to follow. ATV use will be kept to essential usage only.

Sampling of algae and microbial mats will affect <1% of the local population and will have a negligible affect on the flora in the area. Small samples will be taken from widely spaced locations to facilitate recovery.

4.4.2 Fauna

Fauna likely to be disturbed by the situation of the camp are skuas and Adélie penguins. There is a skua colony a few hundred metres from the campsite, and an Adélie penguin colony on Seabee Hook. However, no fauna breed directly in the designated campsite, so impacts on the fauna and penguins are likely to be indirect from noise and movement of vehicles and people. In accordance with Antarctica New Zealand's *Poultry Diseases Prevention Policy*, no poultry products will be used at the site, to minimise the risk of transmitting any diseases to the local bird life.

Some personnel will require entry into the penguin colony for their research. The *Antarctica New Zealand Environmental Code of Conduct* states that a minimum distance of 10m should be maintained from any animal and this will be followed whenever possible. Personnel will be briefed on other methods of minimising disturbance, such as remaining quiet, moving slowly, and staying low when possible.

Plankton sampling will cause very little impact on the populations sampled. The impact from fish sampling should be on <1% of the population, but as the actual population size is unknown, this estimation may not be accurate.



4.5 Waste Production

Waste outputs from this project will include grey water, solid waste and human waste.

4.5.1 Grey water

Grey water from dishwashing and laundry will be sieved and disposed of in tide cracks. Sieved materials will be returned to New Zealand for disposal. An attempt will be made to use different tide cracks so that the grey water does not build up in a single area. Biodegradable detergent has been purchased to reduce the impact of this on the environment.

4.5.2 Solid Waste

All camp solid waste will be sorted into the appropriate bags for recycling and disposal when returned to Scott Base, according to Antarctica New Zealand's waste management policy. No disposal of solid waste will occur at the camp.

4.5.3 Human Waste

Human waste disposed of in the sea will impact the localised area into which it is disposed. An attempt will be made to dispose of the human waste where currents can disperse as much of it as possible so it does not present a concentrated amount of waste.

4.5.4 Chemicals

All chemical waste will be returned to Scott Base for appropriate disposal.

4.6 Cumulative Impacts

Cumulative impacts are those of all activities taking place in the past, occurring in the present and expected to take place in the future. Antarctica New Zealand has kept records of events visiting Cape Hallett since 1958/59. As can be seen from Table 7, tourists are greater in numbers but spend a small amount of time at the location while scientists are fewer in numbers but spend more time. This is a common trend throughout Antarctica.

Activity	Number of events/voyages	Number of people	Person Days
Tourism	29	15 voyages recorded person numbers = 1194 people	11 events recorded person days = 162 person days
Science	30	30 events recorded person numbers = 67	20 events recorded person days = 1755
TOTAL	59	45 events recorded person numbers = 1261	31 events recorded person days = 1917

Table 7. Number of people at Cape Hallett since 1958/59. Taken from records kept by Antarctica New Zealand



Note: These figures include some science that occurred from the Hallett Station, but does not include the support people at the station and some other science events.

The designated campsite is a site where much human activity has taken place. The road to the old Hallett Station was situated here and this area has been used by several science events since the old Station was shut down.

4.7 Indirect Impacts

Emissions from the vehicles, aircraft and generators may accumulate on the snow/ice surface, lowering the albedo of the surface and causing melt. This may in turn cause wet patches on the soil and slumps which could make the remediation of the soils somewhat more difficult. However, as soil compaction has occurred in this area before, the effects of the emissions on the snow/ice in this area will be negligible. The released particulates will be in trace amounts as the generators will not be running 24 hours a day and there will only be one vehicle.

Direct impacts on the snow/ice surface, such as compaction from site preparation, vehicle use and buildings, possible melt surrounding the lower albedo building surfaces, and build up of drifts around buildings or outdoor equipment, could effect localised snow/ice accumulation and ablation patterns. Melt pools may occur around the tents and buildings. The possible indirect impacts will be on soil and moisture and vegetation dynamics. However, the camp will only be set up for the short term and the impacts will be localised.

Under normal operating conditions, the project's activities are not expected to have more than minor or transitory effects on flora and fauna, water quality or the terrestrial environment, and therefore secondary impacts on natural systems are not anticipated.

4.8 Evaluation of Significance of Impacts

The previous sections have identified and evaluated the potential impacts of the proposed camp at Cape Hallett. Table 8 takes into account the extent, duration, intensity and probability of the potential impacts. Mitigation strategies are also suggested.

The activities which have a high to medium probability of occurring, are all low to medium in predicted impact. Impacts of medium significance come from the following activities:

- Earthworks
- Foot and vehicle tracks
- Disturbance to flora and fauna
- Production of waste

Proposed mitigation measures should ensure that the potential impacts from these activities are minimised. When evaluating these impacts it should be kept in mind that the site in which the designated camping will occur has already been impacted from previous use, as has the site of the former Cape Hallett Station.

Table 8. Evaluation of the Potential Impacts of the Cape Hallett Camp and Science Activities

Impact					Mitigation
Nature	Extent	Duration	Intensity	Probability	Description
Disturbance of soil from earthworks	Camp and vicinity, in and around former Cape Hallett Station.	Medium term	Medium	Definite	<ul style="list-style-type: none"> • Site management to avoid flora • Use of groundsheets for excavated soil • Backfill excavations when finished • Replace any stones that were moved • Raking of disturbed areas after removal of camp
Impact by foot and vehicle tracks	Camp and vicinity, in and around former Cape Hallett Station.	Medium term	Medium	Definite	<ul style="list-style-type: none"> • Restrict pedestrian and vehicle movement to specific areas • Use sea ice and snow patches wherever practicable • Use pre-existing tracks where possible
Potential impact on soils, non-marine and marine aquatic environments from fuel spills and leaks	Point source at fuel storage sites and generators	Long term	High	Low	<ul style="list-style-type: none"> • Procedures to minimise spill volume • Secondary containment for large fuel drums • Spill trays for equipment using fuel • Spill cleanup equipment readily available • Regular inspections and maintenance
Potential impact on soils, terrestrial and marine aquatic environments from chemical spills and leaks	Camp and vicinity where science experiments are undertaken	Long term	High	Low	<ul style="list-style-type: none"> • Procedures to minimise spill volume • Use chemicals use in lab whenever possible • Use of drip trays and absorbent pads
Decline in air quality from generator, vehicle, and air operation emissions	Camp vicinity and airspace and routes on sea ice where skidoos are used	Short term	Low	Medium	<ul style="list-style-type: none"> • Minimise vehicle movement and generator use as practicable • Use battery power whenever possible

Decline in air quality and impact on local environment (snow cover) through dust generation	Camp and vicinity	Short term	Low	Medium	<ul style="list-style-type: none"> • Avoid ATV use during high winds • Use ATV over snow patches where practicable
Local visual deterioration	Camp vicinity	Medium to long term	Low	Definite	<ul style="list-style-type: none"> • Tidy maintenance of camp • Compact cache • Well maintained AWS
Increase of noise pollution	Camp vicinity and airspace and routes on sea ice where skidoos are used	Short term	Low	Definite	<ul style="list-style-type: none"> • Minimise vehicle movement and generator use as practicable • Use of battery power whenever possible
Disturbance to flora and fauna	Camp and vicinity	Medium term	Low to Medium	Definite	<ul style="list-style-type: none"> • Site management to avoid flora if practicable • Personnel movements kept to existing tracks • Movement of personnel away from campsite restricted • Small samples from widely spaced sites • Use of advised wildlife approach distances
Production of waste	Camp vicinity	Medium term	Medium	Definite	<ul style="list-style-type: none"> • Minimisation of grey water production • Use of different tide cracks • Efficient packing and return of waste to Scott Base.



5. MONITORING AND REMEDIATION

A monitoring programme will be initiated for the LGP. Both environmental and compliance monitoring will take place at Cape Hallett for the LGP. Footprint estimates, photographic monitoring (e.g., camp site before and after) and compliance monitoring such as Environmental Management System (EMS) audits will take place. Baseline data will be collected on several different aspects of the environment including local climate, snow cover, availability of surface water and permafrost depth. This data can be used for future monitoring of the area.

At the conclusion of the activities, all equipment will be removed. A thorough, detailed search of the site will be made to collect any small items of waste or equipment. Compacted soil will be raked where appropriate to accelerate natural restoration of structure and snow/ice will be graded to loosen and restore the surface. A remediation programme at the old Cape Hallett Station will at times be working in conjunction with the LGP and it is possible that some of the scientists in the LGP will be part of the remediation effort.

6. CONCLUSION AND RECOMMENDATION

The scientific significance of the proposed LGP and how the proposal could affect the environment have been outlined in this IEE. Environmental concerns are a high priority throughout the organisation of this project, with continual consultation with the environmental section of Antarctica New Zealand. This IEE covers all aspects of camp logistics for the two years of the camp at Cape Hallett, and the first year of proposed science in the area.

The evaluation of the camp and science activities indicates that they are likely to have no more than a minor or transitory impact on the environment. Impacts from earthworks, foot and vehicle traffic, disturbance to flora and fauna and the production of waste, have the potential to have a minor impact on the environment but the impacts will be localised and transitory. In addition, there is always the impact associated with the potential for fuel spills. Mitigation measures will be used to reduce the significance of these impacts.

It is recommended that the project be approved to proceed as specified in this IEE, with the implementation of prescribed mitigation and monitoring measures, on the basis that the activities will have not more than a minor or transitory impact on the Antarctic environment.



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8. APPENDIX A – LGP KEY QUESTIONS

1. To what extent does ecosystem structure and function (diversity/complexity) change with latitude?
2. How do ice dynamics (e.g. movement, melt, accumulation and ablation) influence the relationship between solar radiation and primary producers?
3. What is the role of persistent, large-scale ice structures in defining community composition along Victoria Land (e.g. Drygalski ice tongue)?
4. How does climate affect the availability of free water and how does this change in space and time?
5. How does climate affect the predictability, persistence and extent of sea ice cover along the latitudinal gradient?
6. To what extent does soil development (e.g. degree of weathering, carbon content and nutrient accumulation) change with latitude and therefore influence terrestrial ecosystems?
7. To what extent are past conditions along the Victoria Land coast preserved in paleoindicators (e.g. glacial, lacustrine and marine cores, and biological records)?
8. How are key marine biological processes (such as respiration, photosynthesis and reproduction) influenced by sea ice extent?