Management Plan

For Antarctic Specially Protected Area No. 131 CANADA GLACIER, LAKE FRYXELL, TAYLOR VALLEY, VICTORIA LAND

1. Description of values to be protected

An area of approximately 1 km^2 between the east side of Canada Glacier and Lake Fryxell was originally designated in Recommendation XIII-8 (1985) as SSSI No. 12 after a proposal by New Zealand on the grounds that it contains some of the richest plant growth (bryophytes and algae) in the McMurdo Dry Valleys. The Area is designated primarily to protect the site's ecological and scientific research values.

The boundaries of the Area were increased by Measure 3 (1997) to include biologically rich areas that were previously excluded. The Area was redesignated by Decision 1 (2002) as Antarctic Specially Protected Area (ASPA) No. 131. and a revised Management Plan was adopted through Measure 1 (2006), Measure 6 (2011) and Measure 6 (2016).

The ecological values of the Area stem from the rich plant communities mostly found in a wet area (referred to as "the flush") close to the glacier in the central part of the Area. The Area comprises sloping ice-free ground with summer ponds and small meltwater streams draining from Canada Glacier towards Lake Fryxell. The composition and distribution of the moss, lichen, cyanobacteria, bacteria and algae communities in the Area are correlated closely with the water regime. Thus, hydrology and water quality are important contributors to the ecological values of the site.

The Area has been well-studied and documented, which adds to its value for scientific research. The vegetation communities, particularly the bryophytes, are vulnerable to disturbance by trampling and sampling. Damaged areas may be slow to recover. Sites damaged at known times in the past have been identified, which are valuable in that they provide one of the few areas in the McMurdo Dry Valleys where the long-term effects of disturbance, and recovery rates, can be measured.

The Area is of regional significance and remains of exceptional scientific value for ecological investigations. Increasing pressure from scientific, logistic and tourist activities in the region, coupled with the vulnerability of the Area to disturbance through trampling, sampling, pollution or introduction of non-native species mean the values of the Area require ongoing protection.

2. Aims and objectives

Management of Canada Glacier aims to:

- Avoid degradation of, or substantial risk to, the values of the Area by preventing unnecessary human disturbance to the Area, including over sampling;
- Allow other scientific research in the Area provided it is only for compelling reasons which cannot be served elsewhere;
- Prevent or minimise the introduction to the Area of alien plants, animals and microbes; and
- Allow visits for management purposes in support of the aims of the management plan.

3. Management activities

The following management activities are to be undertaken to protect the values of the Area:

- Copies of this Management Plan, including maps of the Area, shall be made available at adjacent operational research stations and all of the research hut facilities located in the Taylor Valley that are within 20 km of the Area.
- Rock cairns or signs illustrating the location and boundaries, with clear statements of entry restrictions, shall be placed at appropriate locations on the boundary of the Area to help avoid inadvertent entry.
- Markers, signs or other structures erected within the Area for scientific or management purposes shall be secured and maintained in good condition and removed when no longer required.
- The Area shall be visited as necessary, and no less than once every five years, to assess whether it continues to serve the purposes for which it was designated and to ensure that management activities are adequate.
- National Antarctic Programmes operating in the Area shall consult together with a view to ensuring the above management activities are implemented.

4. Period of designation

Designated for an indefinite period.

5. Maps

Map 1: ASPA 131 Canada Glacier: Regional Map.

Map 2: ASPA 131 Canada Glacier: Helicopter access zone.

Map 3: ASPA 131 Canada Glacier: Vegetation density map.

Map specifications: Projection - Lambert conformal conic. Standard parallels - 1st 77° 35′ 00″ S; 2nd 77° 38′ 00″S. Central Meridian - 163° 00′ 00″ E. Latitude of Origin - 78° 00′ 00″ S. Spheroid - WGS84. Contours are derived from combining orthophotograph and Landsat images. Precise areas of moist ground associated with the flush are subject to variation seasonally and inter-annually.

6. Description of the Area

6(i) Geographical coordinates, boundary markers and natural features

Canada Glacier is situated in the Taylor Valley, in the McMurdo Dry Valleys. The designated Area encompasses most of the glacier forefront area on the east side of the lower Canada Glacier, on the north shore of Lake Fryxell (77° 37′ S, 163° 03′ E: Map 1). It comprises gently to moderately sloping ice-free ground at an elevation of 20 m to 220 m with seasonal meltwater ponds and streams draining Canada Glacier into Lake Fryxell.

The southern boundary of the Area is defined as the shoreline of Lake Fryxell, to the water's edge. The lake level is currently rising. This boundary extends northeast for approximately 1 km along the shoreline from where Canada Glacier meets Lake Fryxell (77° 37.20′ S, 163° 3.64′ E) to the southeast corner of the boundary which is marked with a cairn (77° 36.83′ S, 163° 4.88′ E) adjacent to a small island in Lake Fryxell. The island was once a part of a small peninsula extending into Lake Fryxell but lake level rise has turned it into an island (Map 3). The peninsula was once marked by a large split rock surrounded by a circle of rocks which was a benchmark for the 1985 NZ survey of the original SSSI, but is no longer visible. A wooden post marking the Dry Valley Drilling Project Site 7 (1973) is still visible on the island.

A moraine ridge extending upslope from the southeast corner of the boundary in a northerly direction defines the eastern boundary of the Area. A cairn (77° 36.68′ S, 163° 4.40′ E) is located on a knoll on this ridge 450 m from the southeast corner of the boundary. The ridge dips sharply before joining the featureless slope of the main Taylor Valley wall. The northeast boundary corner of the Area is in this dip and is marked by a cairn (77° 36.43′ S, 163° 3.73′ E).

From the northeast boundary cairn, the northern boundary slopes gently upwards and west for 1.7 km to Canada Glacier, to the point where the stream flows from the glacier and snow field, through a conspicuously narrow gap in the moraine (77° 36.42′ S, 162° 59.69′ E).

The western boundary follows the glacier edge for about 1 km, down a slope of lateral moraine of fairly even gradient to the southwest corner of the boundary where the glacier meets the lake shore (77° 37.20′ S, 163° 3.64′ E).

The flush area at Canada Glacier is believed to be the largest high-density area of vegetation in the McMurdo Dry Valleys (Map 3). The summer water flow, in conjunction with the microtopography, has the greatest influence in determining where mosses, lichens, cyanobacteria, bacteria, and algae grow. The glacier face also provides protection from destructive winds which could blow the mosses away in their freeze dry state, and from abrasion from wind borne dust.

The flush is located close to the glacier edge. There are two main vegetated areas, separated to the north and south by a small, shallow pond (Map 3). The flush area is gently sloping and very moist in summer with areas of wet ground, numerous small ponds and rivulets. The slopes above this area are drier, but vegetation colonises several small stream channels which extend parallel to the glacier from the upper boundary of the Area down to the flush. Undulating moraines assist accumulation of persistent snow patches on this slope, which may also provide moisture for plant growth. Stream channels, and associated vegetation, become less obvious with distance from the glacier (Map 3). These slopes and the central flush are drained to the southeast by Canada Stream. Prior to 1983, Canada Stream was informally known as Fryxell Stream.

Four moss species have been identified from the flush area: *Bryum argenteum* (previously referred to as *Bryum subrotundifolium*) and *Hennediella heimii* (previously referred to as *Pottia heimii*) dominate, with rare occurrences of *Bryum pseudotriquetrum* and *Syntrichia sarconeurum* (formerly known as *Sarconeurum glaciale*). *B. argenteum* occurs mainly in areas of flowing water and seepage. Where water is flowing, a high proportion of this moss has epiphytic *Nostoc* communities associated with it. Towards the edges of the flowing water zones or on higher ground, *Hennediella heimii* dominates. Sporophytes of *Hennediella heimii* are found at this location and may be one of the most southerly recorded fruiting locations for a moss.

Lichen growth in the Area is inconspicuous, but the epilithic lichens, *Carbonea vorticosa, Sarcogyne privigna, Lecanora expectans, Rhizoplaca melanophthalma* and *Caloplaca* citrina may be found in a small area near the outflow of the pond near Canada Glacier. Chasmoendolithic lichens also occur in many boulders throughout the flush area.

Over 37 species of freshwater algae and cyanobacteria have been described at the site. The upper part of Canada Stream superficially appears sparse but encrusting communities dominated by cyanobacterium grow on the sides and undersides of stones and boulders. Cyanobacterium *Chamaesiphon subglobosus* and a green alga *Prasiola* species, originally identified as *P. calophylla* but subsequently erected as a new species, *P. glacialis*, have been observed only in this upper part of the stream. Prasiola glacialis, growing in dense green ribbons beneath stones in the stream, is generally only apparent when stones are overturned. Cyanobacterial mats, comprising a diverse assemblage of species (including *Oscillatoria, Pseudanabaena, Leptolyngbya, Phormidium, Gloeocapsa, Calothrix* and *Nostoc*), and heterotrophic bacteria are extensive in the middle and lower reaches of the stream and more diverse than those in the upper stream. Mucilaginous colonies of *Nostoc commune* dominate standing water in the central flush and grow epiphytically on mosses in the wetted margins of water courses, while cyanobacterial mats cover much of the mineral fines and gravels in flowing sections. The filamentous green alga

Binuclearia is found streaming out in the flow in the middle reaches of the stream. The lower stream is similar in floral composition to the upper, although the algae *Tribonema elegans* and *Binuclearia* have been reported as abundant, but *Prasiola glacialis* is absent. *Tribonema elegans* is rarely encountered in this region of Antarctica.

Invertebrates from six phyla have been described in the Area: the three main groups are Rotifera, Nematoda and Tardigrada, with Protozoa, Platyhelminthes, and Arthropoda also present. There are no records of Collembola found in the Area, though there are records where they have been found nearby outside the Area.

The Canada flush vegetation has been described as profuse but lacking in diversity, when compared to other botanically rich sites in Antarctica. This may be attributable at least in part to the oligotrophic nature of the site. Water flowing through the stream is similar to glacial ice melt, with conductivity in December 2014 of close to 35.32 µS cm-1 from the point where it left the glacier to the delta where it enters the lake. The prevalence of nitrogen fixing cyanobacteria (*Nostoc* and *Calothrix* species) further supports the view of a low nutrient status.

Canada Glacier is located within Environment S – McMurdo - South Victoria Land geologic based on the Environmental Domains Analysis for Antarctica (Resolution 3 (2008)) and in Region 9 – South Victoria Land based on the Antarctic Conservation Biogeographic Regions (Resolution 6 (2012).

Evidence of past human activity is noticeable within the Area. Indications of past human activity are likely to be found in the soils adjacent to the original New Zealand hut and helicopter landing site. These may be in the form of localised areas of petrochemical residues and soil nutrients. Within the flush area, damage to the vegetation including paths and footprints and sites of experimental removal of core samples and larger clumps from moss turfs are visible. A number of old markers are also present in the flush area.

A plastic greenhouse was erected within the Area close to the flush from 1979 to 1983 for research and experimental growth of garden vegetables. The structure was removed at the end of each season until 1983 when it was used for the storage of equipment over winter. The structure. was destroyed by a storm that winter. Remains of the greenhouse found in the Area have since been removed.

Near the flush area, the first site of the New Zealand hut at Canada Glacier consisted of paths marked by lines of rocks, areas cleared for use as campsites, an old helicopter pad, and several low rock structures. A series of at least four shallow pits (~1 m in depth) were also dug close to the site. This site was relocated to a second site in 1989 and the first hut site was remediated. The second hut site comprised two small buildings, several new campsites, and a helicopter pad. The buildings were removed completely in the 1995–96 season. The helicopter pad remains and is the only helicopter landing site in the Area. The campsite area was removed in 2021, however, the paths marked by lines of rocks and areas previously used as campsites are still present.

A weir is present on Canada Stream (see Section 6(iii)). Hydrological data collected from this stream measured the average discharge rate of Canada Stream when it was flowing as 22.13 L/s [min = 0.0 L/s and max = 395.76 L/s] from November 2014 to February 2015. The average water temperature over this time was 1.99 °C [min = -1.1 °C and max = 11.34 °C] (*http://www.mcmlter.org/*).

A path from the Lake Fryxell Camp Facilities Zone is located between the lake shore and the weir on Canada Stream (Maps 2, 3). Another path exists between the designated helicopter landing site and the Canada Glacier edge, crossing a moist area of plant growth, but is not indicated on the map. An access route is also located between the Lake Hoare Camp Facilities Zone and the Lake Fryxell Camp Facilities Zone running just above the northern boundary (Maps 1, 2 and 3).

6(ii) Special zones within the Area

None.

6(iii) Location of structures within and adjacent to the Area

A rock weir was constructed in the constricted part of Canada Stream in the 1981/1982 season and was fully removed at the end of the season. In 1990, a more substantial weir and 9-inch Parshall flume were installed nearby (Map 3). The flume is made of black fibreglass. The weir consists of polyester sandbags filled with alluvium from near the stream channel. Areas disturbed during construction were restored and after one season were not evident. The upstream side of the weir is lined with vinyl-coated nylon. A notch has been built into the weir for relief in case of high flow. Clearance of seasonal snow from the channel has been necessary to prevent water from backing up at the weir. Data logging instrumentation and batteries are stored in a plywood crate located nearby on the north side of the stream. The weir is maintained by the McMurdo Dry Valleys Long Term Ecological Research project.

Three cairns mark the Area boundaries.

The Lake Fryxell Camp Facilities Zone (USA) is located 1.5 km to the east of the Area (20 m asl) midway along Lake Fryxell on the north side of the lake. The F6 Camp Facilities Zone (USA) is located approximately 10 km to the east of the Area on the south side of Lake Fryxell. The Lake Hoare Camp Facilities Zone (USA) is located 3 km to the west of the Area (65 m asl) on the western side of Canada Glacier at the base of the glacier on the north side of Lake Hoare. The Taylor Valley Visitor Zone is located to the south of the Area at the terminus of Canada Glacier (Map 1).

6(iv) Location of other protected areas in the vicinity

The nearest protected areas to Canada Glacier are:

- Lower Taylor Glacier and Blood Falls, Taylor Valley, McMurdo Dry Valley (ASPA No. 172) approximately 23 km west in the Taylor Valley;
- Linnaeus Terrace, Asgard Range (ASPA No. 138) approximately 47 km west in the Wright Valley; and
- Barwick and Balham Valleys, Southern Victoria Land (ASPA No. 123) approximately 50 km to the northwest (Map 1, Inset).

7. Terms and conditions for entry Permits

Entry into the Area is prohibited except in accordance with a Permit issued by an appropriate national authority. Conditions for issuing a Permit to enter the Area are that:

- It is issued for compelling scientific reasons that cannot be served elsewhere, or for reasons essential to the management of the Area;
- The actions permitted will not jeopardise the ecological values or value for scientific research of the Area;
- Access to any zone marked as possessing vegetation density higher than 21% (Map 3) and to any zone within 5 meters of streams should be carefully considered and special conditions to access such areas should be attached to the Permit;
- Any management activities are in support of the aims of the Management Plan;
- The actions permitted are in accordance with the Management Plan;
- The Permit, or an authorized copy, shall be carried within the Area;
- A visit report shall be supplied to the authority named in the Permit; and
- Permits shall be issued for a stated period.

7(i) Access to and movement within or over the Area

Access to the Area shall be primarily by foot. Access by helicopter shall be for essential scientific or management reasons only and specifically authorised by Permit. Vehicles are prohibited within the Area and all movement within the Area should be on foot.

Pedestrians travelling up or down the valley shall not enter the Area without a Permit. Permitted visitors entering the Area are encouraged to keep to established paths where possible. Visitors should avoid walking on visible vegetation, whether dry or wet, or through stream beds. Care should be exercised when walking in areas of moist ground, where foot traffic can easily damage sensitive soils, plant, algal and bacteria communities, and degrade water quality: walk around such areas, on ice or rocky ground, and step on larger stones when stream crossing is unavoidable. Care should also be taken around salt-encrusted vegetation in drier areas, which can be inconspicuous. Pedestrian traffic should be kept to the minimum necessary consistent with the objectives of any permitted activities and every reasonable effort should be made to minimise effects.

By default, helicopters should land at existing landing sites in nearby Facilities Zones (Lake Hoare and Lake Fryxell). Access to the Area by helicopter shall be by exception and may only occur if specifically authorised by Permit. Helicopters shall land only at the designated landing site (163° 02.88′ E, 77° 36.97′ S: Map 2). Pilots should follow the Helicopter Access Zone to access the designated landing site (Map 2). Over flight of the Area below 300 feet (c.100 m) is prohibited. Exceptions to these restrictions will only be granted for an exceptional scientific or management purpose and must be specifically authorised by Permit. Use of helicopter smoke grenades within the Area is prohibited unless absolutely necessary for safety, and then these should be retrieved.

Pilots, air crews and other passengers are prohibited from moving on foot beyond the immediate vicinity of the landing site during a landing event. Only personnel authorized by Permit may do so.

7(ii) Activities which may be conducted in the Area

- Scientific research that cannot be served elsewhere and that will not jeopardise the ecosystem of the Area;
- Essential management activities, including monitoring and inspection.

In view of the importance of the water regime to the ecosystem, activities should be conducted so that disturbance to watercourses and water quality is minimised. Activities occurring outside of the Area (e.g. on the Canada Glacier) which may have the potential to affect water quantity and quality should be planned and conducted taking possible downstream effects into account. Those conducting activities within the Area should also be mindful of any downstream effects within the Area and on endorheic Lake Fryxell.

Activities which cause disturbance to the flush area should take into account the slow recovery rates of the vegetation at this site. In particular, consideration should be given to minimising any required sample sizes and sample numbers and conducting the sampling regime in such a way that full recovery of the vegetation community is likely.

The use of Remotely Piloted Aircraft Systems (RPAS) in the Area is prohibited except in accordance with a Permit. RPAS use within the Area should follow the Environmental Guidelines for Operation of Remotely Piloted Aircraft Systems (RPAS) in Antarctica (Resolution 4 (2018)).

7(iii) Installation, modification or removal of structures

No structures are to be erected within the Area, or scientific equipment installed, except for compelling scientific or management reasons, as specified in a permit. All markers, structures or scientific equipment installed in the Area must be authorised by a Permit and clearly identified by country, name of the principal investigator, year of installation and date of expected removal. All such items should be free of organisms, propagules (e.g. seeds, eggs) and non-sterile soil, and be made of materials that pose minimal risk of contamination of the Area. Removal of specific structures or equipment for which the Permit has expired shall be a condition of the Permit. Permanent structures or installations are prohibited.

7(iv) Location of field camps

Camping within the Area is prohibited. Nearby Facilities Zones outside of the Area should be used as a base for work in the Area (Map 1).

7(v) Restrictions on materials and organisms which may be brought into the Area

No living animals, plant material or microorganisms shall be deliberately introduced into the Area and precautions listed in 7(ix) shall be taken against accidental introductions. No herbicides or pesticides shall be brought into the Area. Any other chemicals, including radio-nuclides or stable isotopes, which may be introduced for scientific or management purposes specified in the Permit, shall be removed from the Area at or before the conclusion of the activity for which the Permit was granted. No fuel or other chemicals shall be stored in the Area. Any other materials introduced shall be for a stated period only, shall be removed at or before the conclusion of that stated period, and shall be stored and handled so that risk of their introduction into the environment is minimised.

7(vi) Taking or harmful interference with native flora or fauna

Taking of, or harmful interference with, native flora and fauna is prohibited, except in accordance with a separate permit issued in accordance with Annex II to the Protocol on Environmental Protection to the Antarctic Treaty. Where taking or harmful interference with animals is involved this should, as a minimum standard, be in accordance with the SCAR Code of Conduct for the Use of Animals for Scientific Purposes in Antarctica.

Material may be collected or removed from the Area only in accordance with a Permit and should be limited to the minimum number of samples necessary to meet scientific or management needs. Sampling is to be carried out using techniques which minimise disturbance to the Area and from which full recovery of the vegetation from sampling can be expected.

7(vii) The collection or removal of materials not imported by the Permit holder

Materials of human origin likely to compromise the values of the Area, and which was not brought into the Area by the Permit holder or otherwise authorised, may be removed unless the impact of removal is likely to be greater than leaving the material in situ. If this is the case, the appropriate authority should be notified and approval obtained prior to removal of the items.

7(viii) Disposal of waste

All wastes, including all human wastes, shall be removed from the Area.

7(ix) Measures that may be necessary to continue to meet the aims and objectives of the Management Plan

Permits may be granted to enter the Area to:

- Carry out biological monitoring and Area inspection activities, which may involve the collection of a small number of samples or data for analysis or review;
- Erect or maintain signposts, structures or scientific equipment;
- Carry out protective measures;

Any specific sites of long-term monitoring shall be appropriately marked on site and on maps of the Area. A GPS position should be obtained for lodgement with the Antarctic Master Directory system through the appropriate national authority.

To help maintain the ecological and scientific values of the plant communities found at the Area, visitors shall take special precautions against introductions. Of particular concern are microbial or vegetation introductions sourced from soils at other Antarctic sites, including stations, or from regions outside Antarctica. To minimise the risk of introductions, visitors shall thoroughly clean footwear and any equipment to be used in the area, particularly sampling equipment and markers before entering the Area.

7(x) Requirements for reports

The principal permit holder for each visit to the Area shall submit a report to the appropriate national authority as soon as practicable, and no later than six months after the visit has been completed. Such visit reports should include, as applicable, the information identified in the recommended visit report form [contained in Appendix 4 of the Guide to the Preparation of Management Plans for Antarctic Specially Protected Areas appended to Resolution 2 (1998)] [available from the website of the Secretariat of the Antarctic Treaty *www.ats.aq*].

If appropriate, the national authority should also forward a copy of the visit report to the Party that proposed the Management Plan, to assist in managing the Area and reviewing the Management Plan. Parties should maintain a record of such activities and report them in the Annual Exchange of Information. Parties should, wherever possible, deposit originals or copies of such original visit reports in a publicly accessible archive to maintain a record of usage, for the purpose of any review of the management plan and in organising the scientific use of the Area.

8. Bibliography

Broady, P.A. 1982. Taxonomy and ecology of algae in a freshwater stream in Taylor Valley, Victoria Land, Antarctica. Archivs fur Hydrobiologia 32 (Supplement 63 (3), Algological Studies): 331-349.

Conovitz, P.A., McKnight, D.M., MacDonald, L.H., Fountain, A.G. and House, H.R. 1998. Hydrologic processes influencing stream flow variation in Fryxell Basin, Antarctica. Ecosystem Processes in a Polar Desert: The McMurdo Dry Valleys, Antarctica. Antarctic Research Series 72: 93-108.

Downes, M.T., Howard Williams, C. and Vincent, W.F. 1986. Sources of organic nitrogen, phosphorus and carbon in Antarctic streams. Hydrobiologia 134: 215 225.

Fortner, S.K., Lyons, W.B. and Munk, L. 2013. Diel stream geochemistry, Taylor Valley, Antarctica. Hydrological Processes 27: 394-404.

Fortner, S.K., Lyons, W.B. and Olesik, J.W. 2011. Eolian deposition of trace elements onto Taylor Valley Antarctic glaciers. Applied Geochemistry 26: 1897-1904.

Fountain, A. G., Fernandez-Diaz, J. C., Obryk, M., Levy, J., Gooseff, M., Van Horn, D. J., ... & Shrestha, R. (2017). High-resolution elevation mapping of the McMurdo Dry Valleys, Antarctica, and surrounding regions. Earth System Science Data, 9(2), 435.

Green, T.G.A., Seppelt, R.D. and Schwarz, A-M.J. 1992. Epilithic lichens on the floor of the Taylor Valley, Ross Dependency, Antarctica. Lichenologist 24(1): 57-61.

Howard Williams, C., Priscu, J.C. and Vincent, W.F. 1989. Nitrogen dynamics in two Antarctic streams. Hydrobiologia 172: 51 61.

Howard Williams, C. and Vincent, W.F. 1989. Microbial communities in Southern Victoria Land streams I: Photosynthesis. Hydrobiologia: 172: 27 38.

Howard Williams, C., Vincent, C.L., Broady, P.A. and Vincent, W.F. 1986. Antarctic stream ecosystems: Variability in environmental properties and algal community structure. Internationale Revue der gesamten Hydrobiologie 71: 511 544.

Levy, J.L., Cary, S.C., Joy, K. and Lee, C.K. 2020 Detection and community-level identification of microbial mats in the McMurdo Dry Valleys using drone-based hyperspectral reflectance imaging. Antarctic Science 32(5): 361-381. doi:10.1017/S0954102020000243

Lewis, K.J., Fountain, A.G. and Dana, G.L. 1999. How important is terminus cliff melt? A study of the Canada Glacier terminus, Taylor Valley, Antarctica. Global and Planetary Change 22(1-4): 105-115.

Lewis, K.J., Fountain, A.G. and Dana, G.L. 1998. Surface energy balance and meltwater production for a Dry Valley glacier, Taylor Valley, Antarctica. International Symposium on Antarctica and Global Change: Interactions and Impacts, Hobart, Tasmania, Australia, July 13-18, 1997. Papers. Edited by W.F. Budd, et al; Annals of glaciology, Vol.27, p.603-609. United Kingdom.

McKnight, D.M. and Tate, C.M. 1997. Canada Stream: A glacial meltwater stream in Taylor Valley, South Victoria Land, Antarctica. Journal of the North American Benthological Society 16(1): 14-17.

Pannewitz, S., Green, T.G.A., Scheiddegger, C., Schlensog, M. and Schroeter, B. 2003. Activity pattern of the moss *Hennediella heimii* (Hedw.) Zand. in the Dry Valleys, Southern Victoria Land, Antarctica during the mid-austral summer. Polar Biology 26(8): 545-551.

Seppelt, R.D. and Green, T.G.A. 1998. A bryophyte flora for Southern Victoria Land, Antarctica. New Zealand Journal of Botany 36: 617-635.

Seppelt, R.D., Green, T.G.A., Schwarz, A-M.J. and Frost, A. 1992. Extreme southern locations for moss sporophytes in Antarctica. Antarctic Science 4: 37-39.

Seppelt, R.D., Turk, R., Green, T.G.A., Moser, G., Pannewitz, S., Sancho, L.G. and Schroeter, B. 2010. Lichen and moss communities of Botany Bay, Granite Harbour, Ross Sea, Antarctica. Antarctic Science 22(6): 691-702.

Schwarz, A.-M. J., Green, J.D., Green, T.G.A. and Seppelt, R.D. 1993. Invertebrates associated with moss communities at Canada Glacier, southern Victoria Land, Antarctica. Polar Biology 13(3): 157-162.

Schwarz, A-M. J., Green, T.G.A. and Seppelt, R.D. 1992. Terrestrial vegetation at Canada Glacier, South Victoria Land, Antarctica. Polar Biology 12: 397-404.

Sjoling, S. and Cowan, D.A. 2000. Detecting human bacterial contamination in Antarctic soils. Polar Biology 23(9): 644-650.

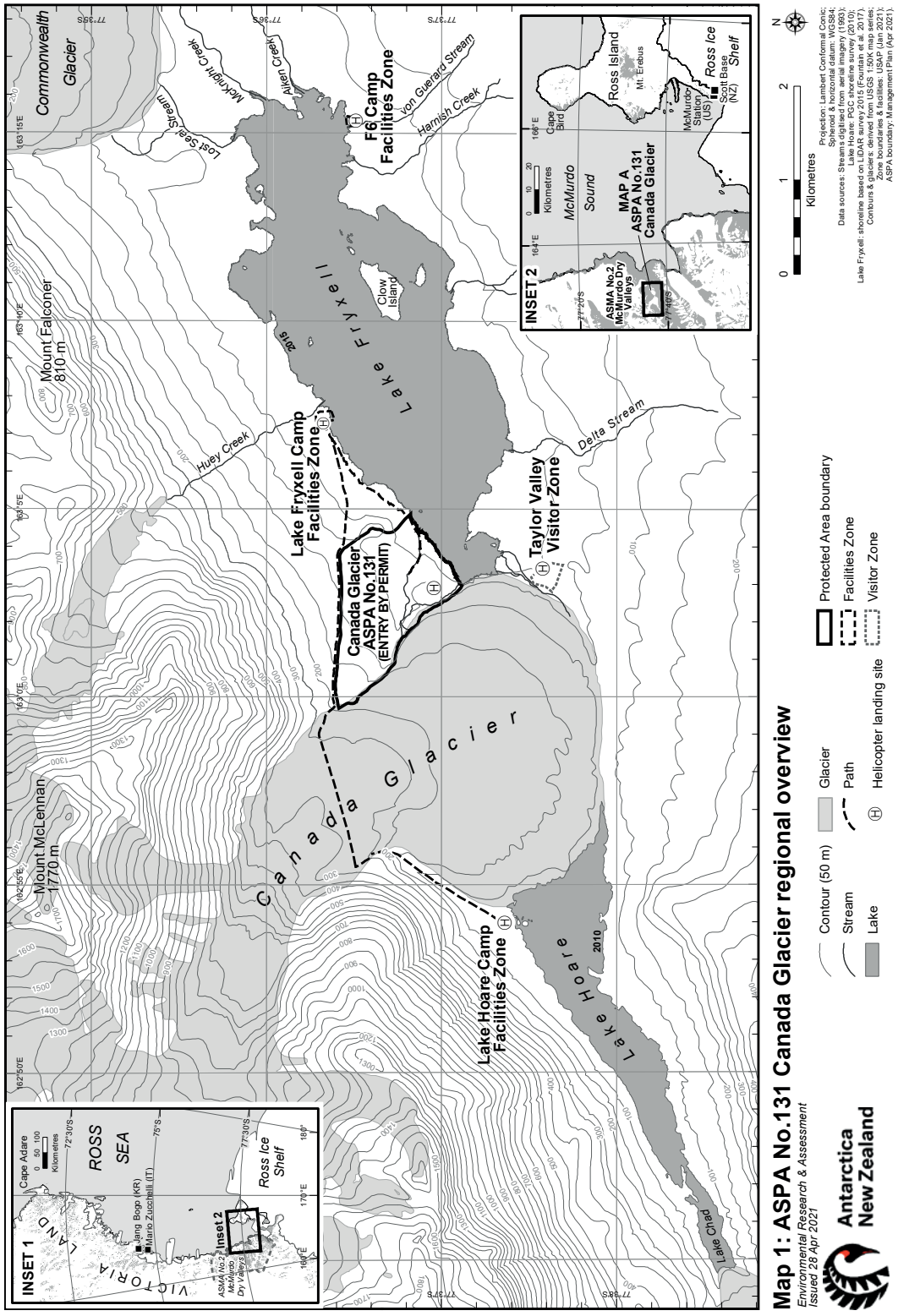
Skotnicki, M.L., Ninham, J.A. and Selkirk, P.M. 1999. Genetic diversity and dispersal of the moss *Sarconeurum glaciale* on Ross Island, East Antarctica. Molecular Ecology 8(5): 753-762.

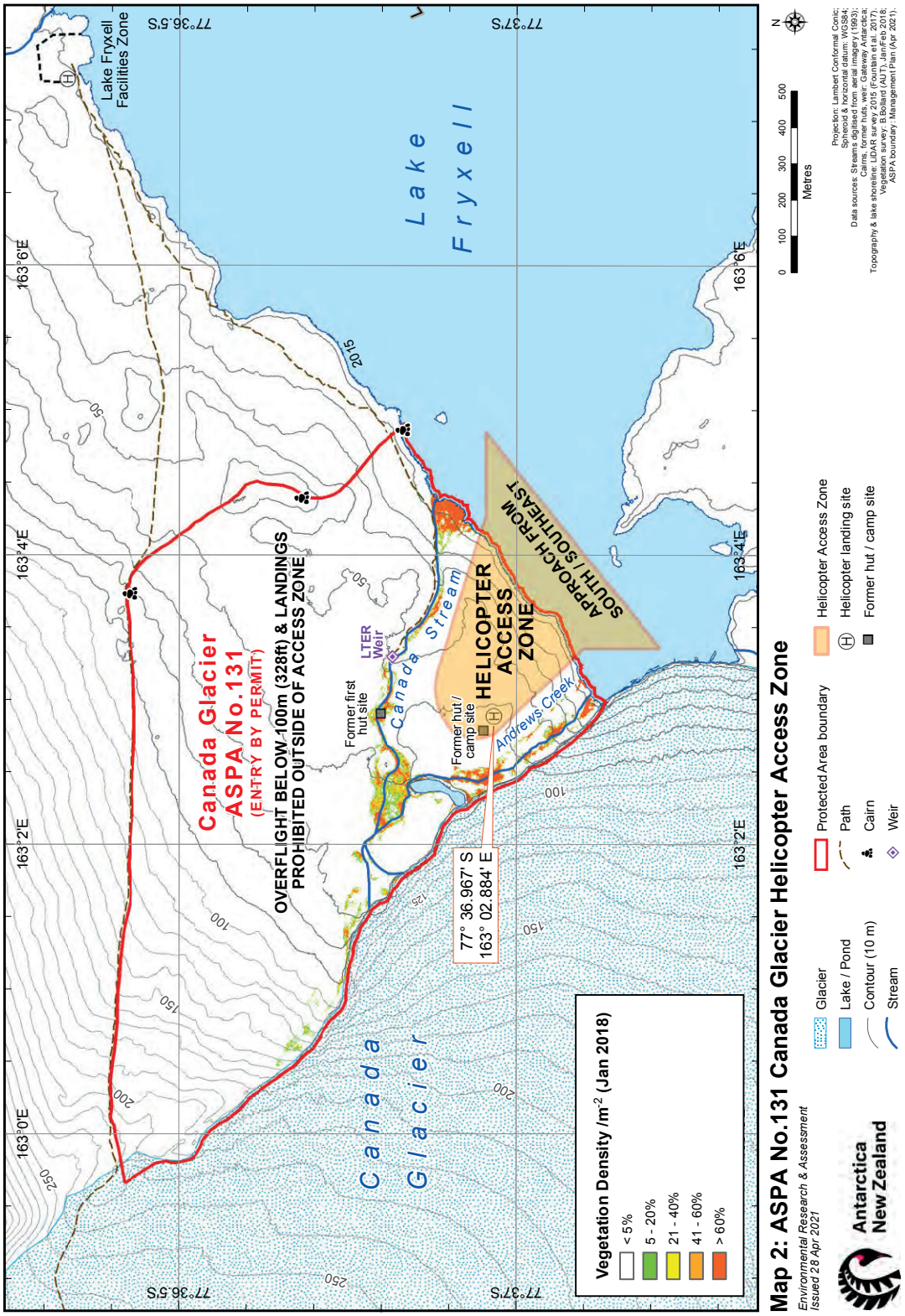
Strandtmann, R.W. and George, J.E. 1973. Distribution of the Antarctic mite *Stereotydeus mollis* Womersley and Strandtmann in South Victoria Land. Antarctic Journal of the USA 8:209-211.

Vandal, G.M., Mason, R.P., McKnight, D.M. and Fitzgerald, W. 1998. Mercury speciation and distribution in a polar desert lake (Lake Hoare, Antarctica) and two glacial meltwater streams. Science of the Total Environment 213(1-3): 229-237.

Vincent, W.F. and Howard Williams, C. 1989. Microbial communities in Southern Victoria Land Streams II: The effects of low temperature. Hydrobiologia 172: 39 49.

Appendix A


Map 1: ASPA No.131 Canada Glacier regional overview
Environmental Research & Assessment
Issued: 28 Apr 2021
Antarctica New Zealand
Contour (50 m)
Glacier
Protected Area boundary
Stream
Path
Facilities Zone
Lake
Helicopter landing site
Visitor Zone
Kilometres
Projection: Lambert Conformal Conic; Spheroid & horizontal datum: WGS84;
Data sources: Streams digitised from aerial imagery (1993); Lake Hoare: POC shoreline survey (2010); Lake Fryxell: shoreline based on LiDAR survey (2015); Features as at 2021;
Contours & glaciers: derived from USGS 1:50K map series; Zone boundaries & facilities: USAP (Jan 2021); ASPA boundary: Management Plan (Apr 2021).
INSET 1
Cape Adare
Iang Bogp (KR)
Mario Zucchelli (IT)
ROSS SEA
VICTORIA LAND
Ross Ice Shelf
INSET 2
ASMA No.2 McMurdo Dry Valleys
MAP A ASPA No.131 Canada Glacier
McMurdo Sound
Ross Island
Mt. Erebus
McMurdo Station (US)
Scott Base (NZ)
Ross Ice Shelf
Cape Bird
Commonwealth Glacier
Mount Falconer 810 m
Mount McLennan 1770 m
Lake Fryxell
Clow Island
Canada Glacier
Canada Glacier ASPA No.131 (ENTRY BY PERMIT)
Lake Fryxell Camp Facilities Zone
F6 Camp Facilities Zone
Taylor Valley Visitor Zone
Lake Hoare Camp Facilities Zone
Lake Hoare
Lake Chad
Huey Creek
Delta Stream
Von Guerard Stream
Harnish Creek
Aiken Creek
McKnight Creek
Lost Seal Stream



Map 2: ASPA No.131 Canada Glacier Helicopter Access Zone

Environmental Research & Assessment
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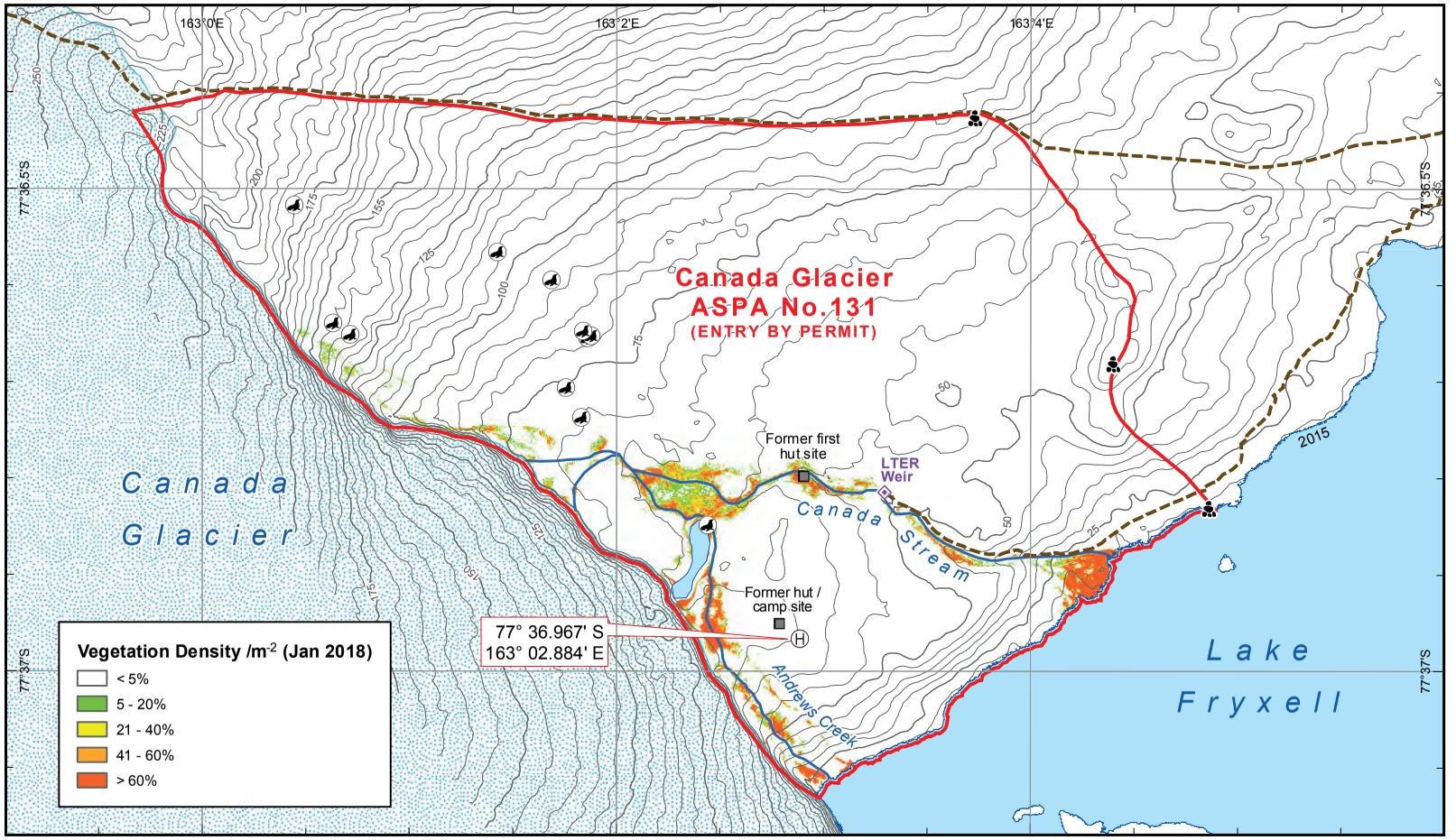
Antarctica New Zealand

Glacier
Lake / Pond
Contour (10 m)
Stream
Protected Area boundary
Path
Cairn
Weir
Helicopter Access Zone
Helicopter landing site
Former hut / camp site



Map 3: ASPA No.131 Canada Glacier vegetation density

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0 100 200 300 400 500
Metres

N

Antarctica New Zealand

Index Contour (25m)
Contour (5m)
Stream
Lake / Pond
Glacier
Protected Area boundary
Former hut / camp site
Path
Cairn
Helicopter landing site
Weir
Mummified seal

Projection: Lambert Conformal Conic;
Spheroid & horizontal datum: WGS84;
Data sources: Streams digitised from aerial imagery (1993);
Contours, cairns, former huts, weir: Gateway Antarctica;
Lake shoreline: based on LiDAR survey 2015 (Fountain et al. 2017).
Vegetation survey: B.Bollard (AUT), Jan/Feb 2018;
ASPA boundary: Management Plan (Apr 2021).