

Management Plan for Antarctic Specially Protected Area No. 143

MARINE PLAIN, MULE PENINSULA, VESTFOLD HILLS, PRINCESS ELIZABETH LAND

Introduction

Marine Plain is located approximately 10 km south-east of Davis station in the Vestfold Hills (68°37'50.2" S, 78°07'55.2" E). The Marine Plain Antarctic Specially Protected Area (the Area) covers an area of 23.4 km² and opens into an arm of Crooked Fjord on the southern side of Mule Peninsula, the southernmost of the three major peninsulas that comprise the Vestfold Hills.

The Area is representative of a major Antarctic terrestrial ice-free ecosystem and is primarily designated to protect outstanding fossil fauna and rare geological features. It is of exceptional scientific interest because of its relevance to the palaeoecological and palaeoclimatic record of Antarctica.

The Area was originally designated as Site of Special Scientific Interest No. 25 Recommendation XIV-5 (1987) after a proposal by Australia. In accordance with Decision 2 (2002) the site was redesignated and renumbered as ASPA No. 143. A revised management plan for the area was adopted under Measure 2 (2003).

1. Description of values to be protected

The Area is representative of a major Antarctic terrestrial ice-free ecosystem with outstanding fossil fauna and rare geological features. It is of exceptional and ongoing scientific interest because of its relevance to the palaeoecological and palaeoclimatic record of Antarctica. It has been subject to several detailed geological, palaeontological, geomorphological and glaciological studies.

The Area has yielded outstanding vertebrate fossil fauna including *Australodelphis mirus*, the first higher vertebrate named from the Oligocene-Pleistocene interval on land in Antarctica, and the first cetacean fossil from the polar margin of circum-Antarctic Southern Ocean that postdates the break-up of Gondwana. It has also revealed four other species of cetaceans; a species of fish; and a diverse invertebrate fauna comprising molluscs, gastropods, marine diatoms and the first Pliocene decapod crustacean from Antarctica.

The Area contains a roughly horizontal section of ca 8 m thick Pliocene marine sediments known as the Sørødal Formation (Map C), which is in some areas exposed, but elsewhere underlies Holocene sediments up to 1 m thick. A diatom biostratigraphy placed the Sørødal Formation in the *Fragilariopsis barronii* Zone, Early Pliocene (ca 4.5-4.1 Ma). The early Pliocene deposits are crucial as a source of information on the environment at this stage of Antarctic history.

The fossil fauna provides insight into the early Pliocene Antarctic environments, including high-latitude climate and oceanography. By examining the diatom microfossils, it is possible to reconstruct the probable palaeoenvironmental conditions relating to the Sørødal Formation and test hypothetical models of ice sheet behaviour against the geological record. This will also provide insight into the Antarctic ice sheet's response to climate change.

The Vestfold Hills cover an ice-free area of approximately 413 km². The hills are typically less than 180m in elevation. They have been subject to intermittent glaciations and exposed rocks are characterised by polishing, striation and fracturing. The glacial striae show the direction of past ice movements. These features, together with other periglacial and glacial features, have been extensively studied to investigate the region's geomorphological and glacial history.

In addition, the Area possesses the largest periglacial thermokarst in East Antarctica. Sediments are normally cemented by permafrost (in addition to any cement formed during diagenesis), however thawing can lead to undercutting and collapse. The thermokarst landforms have been produced by thermal back wearing of low scarps and include thaw pits, thaw lakes, ground ice sumps, linear depressions and very small scale beaded drainage features. Human impact may accelerate the permafrost thawing which may disturb important geomorphological values and threaten fossils contained in the diatomite.

The Area is intrinsically linked to Burton Lake. Located west of Marine Plain, Burton Lake is a hypersaline lagoon with a seasonal connection with the marine environment. This lagoon represents a stage in the biological and physio-chemical evolution of a terrestrial water body (i.e. the geological creation of a lake).

The meromictic and saline Burton Lake, together with several smaller lakes and ponds around the Area, provide important examples in the spectrum of hypersaline to fresh water lake types in the Vestfold Hills and present opportunities for important geochemical and limnological research. The interrelationships between environment and biological communities in such lakes provide considerable insight into the evolution of lake environments and more broadly Antarctic environmental development. Burton Lake is currently the only meromictic lagoon that has been protected within East Antarctica.

Given its proximity to Australia's Davis station, there is a risk that the scientific values of the Area may be compromised or damaged by accidental interference. The Area lies on the pedestrian route (Map B) to the Mule Peninsula lakes (Clear, Laternula, and McCallum) from Ellis Rapids and is easily accessible.

The Area merits protection given there is a demonstrable risk of interference which may jeopardise scientific investigation. Accordingly it is critical that the Area's fossil fauna is protected from unrecorded sampling, collection or interference.

2. Aims and objectives

Management for the Marine Plain ASPA aims to:

- avoid degradation of, or substantial risk to, the values of Marine Plain by preventing unnecessary human disturbance in the ASPA;
- allow scientific research for geological, palaeoclimatic, palaeontological, geomorphological and limnological purposes, while ensuring protection from over-sampling;
- allow other scientific research provided it is for compelling reasons that cannot be served elsewhere;
- minimise damage to landforms, particularly Marine Plain; the plain south of Poseidon Lake and east of Pickard Ridge (68°37'22.8"S, 78°07'9.9"E); glacial and periglacial features; and potential fossil sites; and
- allow visits for management purposes in support of the aims of this management plan.

3. Management activities

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

- information on the location of the Area (stating special restrictions that apply) shall be displayed prominently and a copy of this management plan kept available:
 - at the adjacent Davis station;
 - at the Marine Plain Refuge; and
 - on ships visiting the vicinity;
- installation of boundary markers to identify boundary turning points;
- signs that illustrate the location and boundaries, with clear statements of entry restrictions, shall be placed at appropriate locations at the boundaries of the Area to prevent inadvertent entry;
- markers, signs or structures erected within the Area for scientific or management purposes shall be secured and maintained in good condition and removed when no longer required;
- abandoned equipment or materials shall be removed to the maximum extent possible provided doing so does not adversely impact on the values of the Area;
- the Area will be visited no less than once every five years to facilitate an assessment as to whether the Area continues to serve the purposes for which it was designated and to ensure that management activities are adequate; and
- review of the management plan at least every five years and update as required.

4. Period of designation

Designated for an indefinite period.

5. Maps

Map A: Vestfold Hills, East Antarctica, showing the locations of Marine Plain ASPA; Davis station and surrounding refuges. Inset: The location of the Vestfold Hills in Antarctica. Map Specifications: Projection: UTM Zone 44 Horizontal Datum: WGS84.

Map B: The region immediately surrounding Marine Plain ASPA including topography and fauna distribution. Map Specifications: Projection: UTM Zone 44 Horizontal Datum: WGS84 Contour Interval: 20m.

Map C: Geological map of Marine Plain ASPA including the Sørsdal Formation. Map Specifications: Projection: UTM Zone 44 Horizontal Datum: WGS84.

6. Description of the Area

6(i) Geographical co-ordinates, Boundary Markers and Natural Features

General description

The Area is located approximately 10 km southeast of Davis station in the Vestfold Hills (68°37'50.2" S, 78°07'55.2" E). It covers an area of 23.4 km² and opens into an arm of Crooked Fjord on the southern side of Mule Peninsula, the southernmost of the three major peninsulas that comprise the Vestfold Hills.

The Vestfold Hills are a largely ice-free oasis of approximately 512 km² of bedrock, glacial debris, lakes and ponds on the eastern side of Prydz Bay, Princess Elizabeth Land.

The Area includes Marine Plain (approximately 3 km²) which occupies the centre of the Area in a north-south orientation. Pickard Ridge (maximum elevation of 70 m) separates this site from Poseidon Basin in the northeast.

Both locations are low-lying areas with elevations less than 20 m. Sections elsewhere above 20m are mostly low rugged hills of Precambrian rock which are characterised by a marked change in slope at their base which may represent a Holocene shoreline. The surface of the lower area below 20 m is marked by a series of concave-to-the-south recessional moraine ridges. A series of south westerly facing sand slopes occupy Marine Plain east of Burton Lake.

Starting at the most northerly point of the Area, the boundary description is as follows:

Commencing at 68°36'34"S, 78°09'28"E, then south-easterly to 68°36'45"S, 78°10'30"E; then south-easterly to 68°37'30"S, 78°12'30"E, then south along meridian of longitude 78°12'30"E to its intersection with the northern shore of Pineapple Lake; then west along that shore to the edge of the Sørsdal Glacier; then westerly along the northern edge of the Sørsdal Glacier to its intersection with the low water mark of the north eastern shore of Crooked Fjord; then westerly along the low water mark of the northern shore of Crooked Fjord (cutting across the outlet of Burton Lake into Crooked Fjord) to its intersection with the meridian of longitude 78°03'0"E; then north along meridian of longitude 78°03'0"E to its intersection with the parallel of latitude 68°37'30"S, then north-easterly to 68°36'56"S, 78°05'39"E, then north-easterly to the point of commencement.

Geology and palaeontology

The three major lithologies forming the Vestfold Hills (Map C) are (in order of age) Chelnock Paragneiss, Mossel Gneiss and Crooked Lake Gneiss. This is repeated in units from east-northeast to west-southwest. Intruded into these are groups of mafic dykes in a rough north-south orientation (Map C). These dykes are a major feature of the Vestfold Hills.

The Precambrian rock is overlain in low-lying areas (approximately 10–17 m above sea level) by ca 8 m of early Pliocene (ca 4.5–3.5 Ma) diatomite with limestone lenses in the upper half. The limestone contains molluscs, especially bivalves including *Chlamys tuftsensis*. Holocene (ca 6.49 ka) glacial debris

disconformably covers the marine deposit (0.5-1 m), extending over an area of 8-10 km². A layer of lenticular sandstone separates the Pliocene and Holocene units.

Low scarps in the Pliocene marine sediments have yielded a diverse array of fossil marine vertebrates and invertebrates. The cetacean specimens occur as large assemblages of vertebral columns, skulls and complete specimens approximately 2m or more in length in the upper 2m of the Marine Plain section. The main occurrences are along the margins of the "Big Ditch" near Burton Lake and in the scarp on the eastern side of Marine Plain. One notable cetacean fossil is *Australodelphis mirus* which illustrates a remarkable convergence between living dolphins (Family Delphinidae) and the living beaked whale genus *Mesoplodon*.

Marine Plain has also yielded the first Pliocene decapod crustacean from Antarctica. The specimen is incomplete, making it difficult to identify precisely, although it probably belongs with the Palinuridae. Other species include a beaked whale and baleen whale (and others not yet studied), possibly penguins, fish, bivalves, gastropods, serpulid worms, bryozoans, asteroids, ophiuroids, echinoids and abundant leiospheres that are probably planktonic in origin.

Marine Plain has been subject to significant fluvial activity since the mid-Holocene resulting in small patches of lake sediment on its eastern side. Stream valleys and source lakes (now virtually empty) have been identified.

The Pliocene diatomite at Marine Plain appears to be the only such deposit in the Vestfold Hills. In some areas the Holocene till and glacials are very thin and consequently are easily disturbed. A thin crust over the loose powdery surface is easily crushed by footfall, releasing a plume of diatom and sand rich dust which leaves a sharply defined colour-contrasting footprint.

Permafrost occurs below ca 1m depth and the local landforms have evolved due to very slow progressive melting of ground ice. Terrain produced by this process is known as periglacial thermokarst because the resulting depressions give the topography an appearance similar to that of conventional limestone karst.

The Sørsdal Glacier (near the edge of the Antarctic ice sheet) is the southern boundary for the ice-free Vestfold Hills. A 1 km length of the northern edge of Sørsdal Glacier has retreated c. 800 m away from the southern edge of Marine Plain in the 40 years from 1947. This retreat is due to movement through the deep channel that the glacier fills and the formation of ice ridges in the glacier which subsequently collapse into Crooked Fjord.

Lakes

Burton Lake is a major feature of the western side of the Area. There are several unnamed ponds and small lakes within the Area. Burton Lake is a seasonally isolated marine lagoon with a maximum depth of 18m. It is meromictic and hypersaline. Burton Lake is ice-covered for 10-11 months of the year and is seasonally connected to Crooked Fjord by a tidal channel approximately 20 m wide and up to 2 m deep. The lake is isolated from Crooked Fjord for about 6-7 months of the year by ice.

The lake contains a range of photosynthetic bacteria. The dominant species are *Chlorobium vibriofome* and *C. limiola* while minor species are *Thiocapsa roseopersicina* and *Rhodopseudomonas palustris*. The lake also harbours psychrophilic bacteria which are relatively uncommon in Antarctic coastal ice zones. These thrive on the increased availability of nutrients from continental inputs, pelagic algal blooms and the breakout of pelagic algae into the water column from melting ice. One novel species of bacterium is *Psychroserpens burtonensis* which has not been cultured from or recorded in any other environment.

Marine algae are abundant in Burton Lake. A diatom floristic study of the lagoon revealed 41 diatom species.

The ultrastructure of *Postgaardi mariagerensis* was reported for the first time from research in Burton Lake. This very unusual organism is not a euglenid but rather a member of the clade *Euglenozoa – Euglenozoa incertae sedis*. Additionally, Burton Lake is one of two Antarctic lakes from which the first account of choanoflagellate (including *Diaphanoeca grandis*, *Diaphanoeca sphaerica* and *Saepicula leadbeateri*) were reported. It is also type location for *Spiraloecion didymocostatum* gen. et sp. nov.

Four metazoan species have been regularly recorded in the zooplankton of Burton Lake: *Drepanopus bispinosus* and *Paralabidocera antarctica* (Copepoda), *Rathkea lizzioides* (Anthomedusae) and an un-named cydippid ctenophore. Many holotrichia, at least two species of nematode and a large marine amphipod have been recorded in the benthic community. Tardigrades are also present.

One species of fish, *Pagothenia borchgrevinki*, has been observed in the lake on one occasion. This species is common in coastal areas and fjords of the Vestfold Hills, however it does not appear to inhabit the lake

continuously. Due to the seasonal marine connection it remains probable that additional algae, zooplankton and fish enter the lake but do not survive the winter.

Vegetation

Mosses and lichens occur in the vicinity of small ephemeral watercourses that drain radially down the 'talus skirt' fringing the Precambrian hills. Numerous small crevices and cracks in the knoll jutting into the northern end of Burton Lake provide a rich lichen site, while the northern end of Poseidon Lake is rich in mosses. The moss and lichen flora of the Area has not been documented, however the Vestfold Hills supports at least six moss species and at least 23 lichens.

Vertebrates

Several vertebrates occur sporadically within the Area between November and February. Wilson's storm petrels (*Oceanites oceanicus*) and Snow petrels (*Pagodroma nivea*) nest in the higher Precambrian rocks. South polar skuas (*Catharacta maccormicki*) nest on Marine Plain and occasionally around the water's edge. Weddell seals (*Leptonychotes weddellii*), Southern Elephant seals (*Mirounga leonina*), Adélie penguins (*Pygoscelis adeliae*) and Emperor penguins (*Aptenodytes forsteri*) also occur in small groups in the Area but have not been specifically studied here.

Climate

Meteorological data for the Area are confined almost entirely to observations at Davis station, 10 km northwest of Marine Plain. The Vestfold Hills area has a polar maritime climate that is cold, dry and windy. Summer days are typically sunny with a midday temperature from -1C to +3C and a summer maximum of +5C. For most of the year temperatures are below 0C. During winter the temperature may fall as low as -40.7C. The maximum temperature recorded at Davis station from 1957 to 2001 was +13°C. The record illustrates the seasonal climate expected for high latitudes but on average Davis station is warmer than other Antarctic stations at similar latitudes. This has been attributed to the "rocky oasis" which results from the lower albedo of rock surfaces compared to ice (whereby solar energy is absorbed and re-radiated as heat).

Environmental domains analysis

Based on the Environmental Domains Analysis for Antarctica (Resolution 3 (2008)) Marine Plain is located within Environment D *East Antarctic coastal geologic*.

Antarctic Conservation Biogeographic Regions

Based on the Antarctic Conservation Biogeographic Regions (Resolution 6 (2012)) Marine Plain is located within Biogeographic Region 7 *East Antarctica*.

6(ii) Access to the Area

The vicinity of the Area can be accessed on foot, by small boat or by Helicopter, in accordance with requirements outlined in section 7(ii) of this plan.

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

There are no refuges within the Area however two refuges are located nearby. Marine Plain Refuge (68°36'54"S, 78°65'30"E) is approximately 150 m north of the northern boundary of the Area. A helicopter landing site is immediately adjacent to this refuge. Watts Hut (68°35'54"S, 78°13'48"E) is located at the eastern end of Ellis Fjord, approximately 5 km east-northeast of the Marine Plain Refuge and 2.9 km east-northeast of the northern-most point of the Area.

Evidence of past research activity remains at Marine Plain. Two parallel lines of small boulders mark out a helicopter landing site 30 m north of a fossil site (68°37'37"S, 78°08'11"E). Here a black sheet of polythene (3 m x 1.7 m) held down by rocks is currently covering an excavation site. At the north western side of the embayment there are approximately 10 wooden stakes 1m high in a rough line, north to south. In the next embayment to the north three red painted rock cairns form a triangle area (approximately 50 m in side length).

Within Marine Plain there also remains plastered hessian covering fossil bones; five shallow unfilled pits; a large unfilled pit (near Burton Lake); a major unfilled excavation occurring on one high flank of a natural

trough (the trough locally known as “Big Ditch”) and some old filled trench sites. On the north western side of Burton Lake lies a pipe and rope (possibly for lake monitoring).

Boundary markers are to be installed at boundary turning points.

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

Hawker Island Antarctic Specially Protected Area No. 167 (68°38’S, 77°51’E) is located approximately 8km east of Marine Plain.

Two Historic Sites and Monuments are located in the Vestfold Hills at least 25 km north of Marine Plain:

- 1) on the largest of the Tryne Islands (68° 18'29”S, 78° 23'44”E) in Tryne Bay (29 km north-east of Davis), HSM No. 72 is a cairn and wooden mast erected in 1935 by Captain Klarius Mikkelsen marking the first landing in the Vestfold Hills area.
- 2) Walkabout Rocks Cairn HSM No. 6 (68°22'14”S, 78°32'19”E) 40 km north-east of Davis is a rock cairn erected in 1939 by Sir Hubert Wilkins. The cairn contains a canister containing a record of his visit.

6(v) Special zones within the Area

There are no special zones within the area.

7. Terms and conditions for entry Permits

7(i) General permit conditions

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 only for scientific (palaeontological, palaeoclimatic, geological, geomorphological, glaciological, biological and limnological) research, or for compelling scientific, educational or cultural reasons, or for essential management purposes consistent with the management plan;
- the actions permitted will not jeopardise the values of the Area or other permitted activities;
- the actions permitted are in accordance with this management plan;
- the permit, or an authorised copy, shall be carried within the Area;
- a visit report will be supplied to the authority that approved the permit as soon as practicable after the visit to the ASPA has been completed but no later than six months after the visit has occurred;
- permits will be issued for a finite period;
- permit holders shall notify the appropriate authority of any activities or measures undertaken that were not authorised permit; and
- permits shall be issued for a stated period.

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

- Movement within the Area should be kept to a minimum with every reasonable effort made to minimise impact. The brittle surface crust is easily crushed under foot, risking damage to fossil material and long-term evidence of human impact. Where possible, movement on Precambrian (bedrock) areas is preferred, while movement on the scarps is to be avoided. All movement should be undertaken carefully so as to minimise disturbance to the soil, vegetation, diatomite, thermokarst, sediment outcrops and other geofeatures that provide scientific and environmental value to the site. The landing of aircraft, the use of vehicles and camping is prohibited on the Sørsdal Formation.
- Normally the helicopter landing site immediately adjacent to the Marine Plain refuge should be used. In order to minimise foot traffic within Marine Plain, a helicopter landing site within the Area may be authorised for a particular visit. The landing site shall be:
 - measured against overall usage in keeping with protected area status;

- on a debris free bedrock surface where minimal disturbance would be caused by the aircraft to water bodies, vegetation or sediment deposits; and
- at a location that will minimise the impact of passage to the intended research site.
- Motorised vessels are not to be used on Burton Lake.
- Over-flights of lakes should be kept to the minimum necessary to achieve specific research or management requirements.
- Movement within the Area by vehicle is prohibited.

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

The following activities may be conducted within the Area provided access requirements can be met:

- compelling scientific research which cannot be undertaken elsewhere and that will not jeopardise the values of the Area;
- geological sampling, which should be the minimum required for the approved research programs;
- hydrological sampling, ensuring equipment is washed prior to entry into the Area to prevent contamination from other lakes; and
- essential management activities, including monitoring.

7(iv) Installation, modification, or removal of structures

Permanent structures and installations are prohibited in the Area.

Temporary structures, installations, markers and equipment may only be established in the Area for compelling scientific or management purposes as specified in a permit.

Any temporary structures, installations, markers and equipment established in the Area must be:

- clearly identified by country, name of the principal agency, date of installation and date of expected removal;
- free of organisms, propagules (e.g. seeds, eggs) and non-sterile soil;
- made of materials that can withstand Antarctic conditions;
- made of materials that pose a minimal risk of contamination to the Area; and
- removed when they are no longer required, or upon the expiry of the permit, whichever is earlier.

Descriptions and location coordinates of temporary structures, installations, markers and equipment shall be submitted to the permitting authority.

7(v) Location of field camps

Camping is prohibited on the Sørsdal Formation.

Camping is only permissible elsewhere in the Area if the use of the Marine Plain Refuge (68°36'54"S, 78°6'30"E; see 6(iii)) would pose greater risks to the Area's values.

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

The following restrictions apply:

- no living animals, plant material or microorganisms shall be deliberately introduced into the Area and precautions 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 authorised for scientific or management purposes, must be removed from the Area upon or before the conclusion of the activity for which the Permit was granted;
- organic materials (wood, cotton, hessian, etc.) are not to be used for scientific markers or other research unless absolutely necessary. Inorganic materials (stainless steel, polythene, etc.) are to be used;
- fuel is not to be stored in the Area unless required for essential purposes connected with the activity for which the Permit has been granted. Fuel must be removed from the ASPA upon or before completion of the associated activity. Permanent fuel depots are not permitted in the Area; and

- all material introduced to the Area shall be for a stated time period only. All material introduced will be removed upon or before the conclusion of that stated time period, and will be stored and handled in a manner that will minimise the risk of environmental impacts.

7(vii) Taking of, or harmful interference with, native flora and fauna

Taking of or harmful interference with native flora and fauna is prohibited except in accordance with a Permit. 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.

7(viii) Collection or removal of materials not brought into the Area by the permit holder

- Sample material may only be collected or removed from the Area in accordance with a Permit and should be limited to the minimum necessary to meet scientific or management needs.
- Permits shall not be granted if there is a reasonable concern that the sampling proposed would take, displace, remove or damage such quantities of rock, soil, water or native flora or fauna that their distribution or abundance at Marine Plain would be significantly affected. Excavation of fossils is exempted from this requirement.
- Material of human origin likely to compromise the values of the Area, which was not brought into the Area by the Permit holder or otherwise authorised, may be removed unless the impact of the removal is likely to be greater than leaving the material *in situ*. In this event, the appropriate national authority should be notified.

7(ix) Disposal of waste

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

7(x) Measures that may be necessary to ensure that the aims and objectives of the Management Plan can continue to be met

- Permits may be granted to enter the Area to carry out monitoring, site inspections (which may involve the small-scale collection of samples for analysis or review) or protective measures.
- Any specific sites of long-term monitoring shall be appropriately marked and a GPS position obtained for lodgment with the Antarctic Data Directory System through the appropriate national authority.
- To help maintain the geological, palaeontologic, geomorphological, biological, limnological, and scientific values of Marine Plain, persons shall take special care walking or skiing over slopes, moraines, rock exposures and diatomite soil. To minimise the risk of damage to these values, foot traffic to and from Marine Plain and the plain south of Poseidon Basin and east of Pickard Ridge shall be restricted wherever possible.
- To help maintain the ecological and scientific values derived from the relatively low level of human impact within the Area, special precautions shall be taken against introductions. To minimise the risk of introductions, footwear and any equipment to be used in the Area shall be thoroughly cleaned prior to entry into the Area.
- The stratigraphic integrity and endolithic communities of the Area shall be preserved through the closure and securing of excavation sites. Recommended measures include:
 - the placement of excavated soil onto a polythene sheet of adequate thickness;
 - the replacement of soil and sediment in layers in the order in which they were removed;
 - the replacement of larger clasts by correct orientation;
 - the removal of unnatural surface irregularities; and
 - the reorientation of rock and till during closure.
- Abandoned scientific equipment shall be removed and excavations rehabilitated to the maximum extent possible.

7(xi) 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.

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, 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. Supporting Documentation

Adamson, D.A. & Pickard, J. (1983) Late Quaternary Ice Movement across the Vestfold Hills, East Antarctica. In: Oliver, R.L., James, P.R. & Jago, J.B. (eds.) *Antarctic Earth Science: Proceedings of the Fourth International Symposium on Antarctic Earth Sciences, University of Adelaide, South Australia, 16-18 August 1982*, Australian Academy of Science, Canberra, pp. 465-469.

Adamson, D.A. & Pickard, J. (1986a) Cainozoic history of the Vestfold Hills. In: Pickard, J. (ed.) *Antarctic oasis: Terrestrial environments and history of the Vestfold Hills*. Academic Press Australia, Sydney, pp. 63-98.

Adamson, D.A. & Pickard, J. (1986b) Physiography and geomorphology of the Vestfold Hills. In: Pickard, J. (ed.) *Antarctic oasis: Terrestrial environments and history of the Vestfold Hills*. Academic Press Australia, Sydney, pp. 99-139

Bayly, I.A.E. (1986) Ecology of the zooplankton of a meromictic Antarctic lagoon with special reference to *Drepanopus bispinosus* (Copepoda: Calanoida). *Hydrobiologia* 140:199-231.

Bowman, J.P., McCammon, S.A., Brown, J.L., Nichols, P.D. & McKeekin, T.A. (1997) *Psychroserpens burtonensis* gen. nov., sp. nov., and *Gelidibacter algens* gen. nov., sp. nov., psychrophilic bacteria isolated from Antarctic lacustrine and sea ice habitats. *International Journal of Systematic Bacteriology* 47: 670-677.

Burke, C.M. & Burton, H.R. (1988) The ecology of photosynthetic bacteria in Burton Lake, Vestfold Hills, Antarctica. In: Ferris J.M., Burton H.R., Johnstone G.W. & Bayly I.A.E. (eds.) *Biology of the Vestfold Hills, Antarctica*. Kluwer Academic Publishers, Dordrecht, The Netherlands, pp. 1-12.

Collerson, K. D. & Sheraton, J.W. (1986) Bedrock geology and crustal evolution of the Vestfold Hills. In: Pickard J. (ed.) *Antarctic oasis: Terrestrial environments and history of the Vestfold Hills*. Academic Press Australia, Sydney, pp. 21-62.

Dartnall, H. (2000) A limnological reconnaissance of the Vestfold Hills. *ANARE Reports* 141: 57 pp.

Daniels, J. (1996) Systematics of Pliocene Dolphins (*Odontoceti: Delphinidae*) from Marine Plain, Antarctica. M.Sc. Thesis University of Otago, Dunedin, New Zealand.

Feldmann, R.M. & Quilty, P.G. (1997) First Pliocene decapod crustacean (Malacostraca: Palinuridae) from the Antarctic. *Antarctic Science* 9 (1): 56-60.

Fordyce, R.E., Quilty, P.G. & Daniels, J. (2002) *Australodelphos mirus*, a bizarre new toothless ziphiid-like fossil dolphin (Cetacea: Delphinidae) from the Pliocene of Vestfold Hills, East Antarctica. *Antarctic Science* 14: (1) 37-54.

Gibson, J.A.E. (1999) The meromictic lakes and stratified marine basins of the Vestfold Hills, East Antarctica. *Antarctic Science* 11: 175-192.

Gibson, J.A.E. (2001) Personal Communication. 10 December 2001.

Gore, D.B. (1993) Changes in the ice boundary around the Vestfold Hills, East Antarctica, 1947 – 1990. *Australian Geographical Studies* 31 (1): 49-61.

Harwood, D.M., McMinn, A. & Quilty, P.G. (2002) Diatom biostratigraphy and age of the Pliocene Sørdsdal Formation, Vestfold Hills, East Antarctica. *Antarctic Science* 12: 443-462.

Kiernan, K. & McConnell, A. (2001a) Impacts of geoscience research on the physical environment of the Vestfold Hill, Antarctica. *Australian Journal of Earth Sciences* 48: 767-776.

Kiernan, K. & McConnell, A. (2001b) Land surface rehabilitation and research in Antarctica. *Proceedings of the Linnean Society of NSW* 123: 101-118.

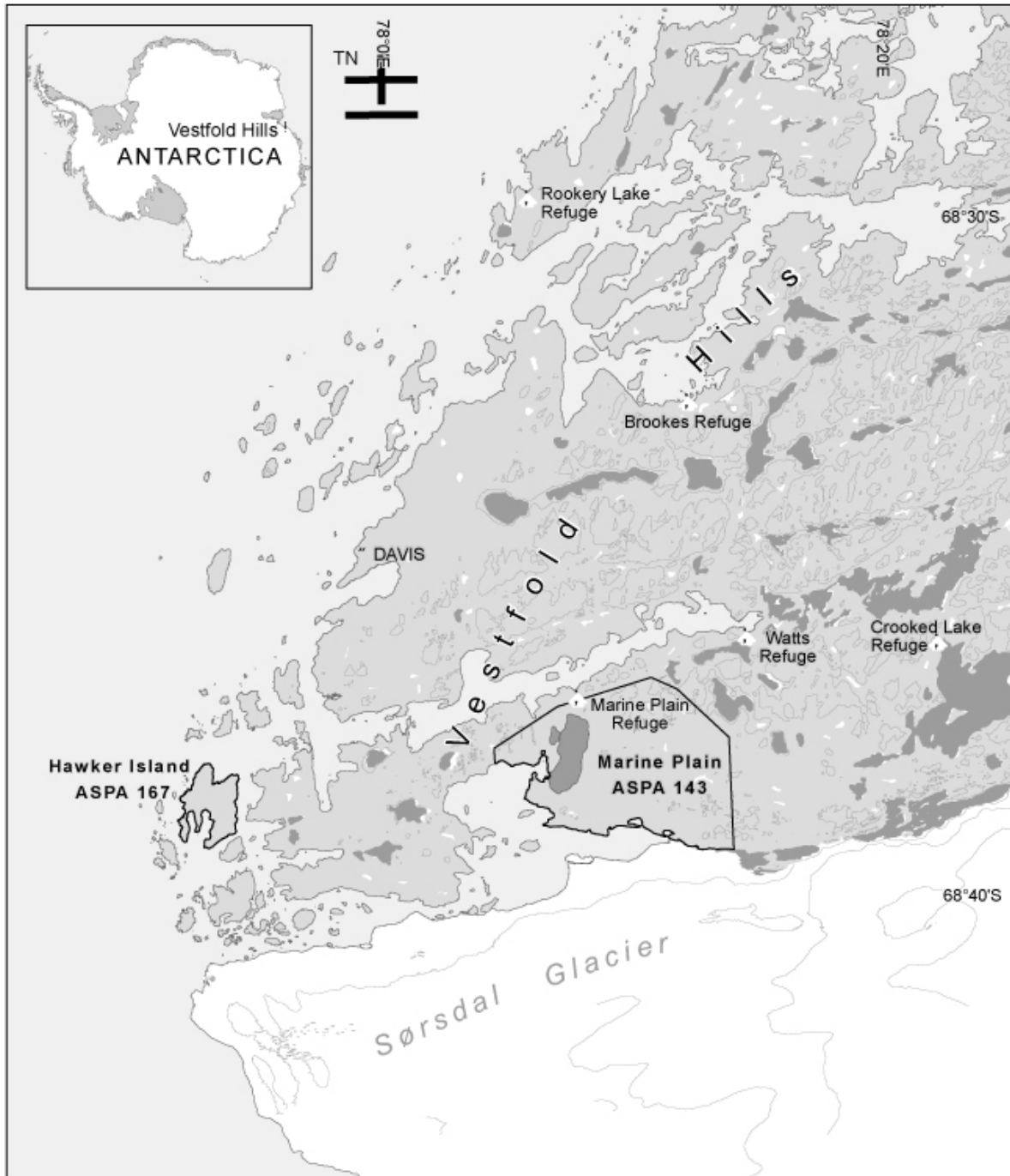
- Kiernan, K., McConnell, A. & Colhoun, E. (1999) Thermokarst landforms and processes at Marine Plain, Princess Elizabeth Land, East Antarctica. *INQUA XV International Congress, 3-11 August 1999, Durban, South Africa. Book of Abstracts 1998*.
- Marchant, H.J. & Perrin, R.A. (1986) Planktonic Choanoflagellates from two Antarctic lakes including the description of *Spiraloeicion Didymocostatum* Gen. Et Sp. Nov. *Polar Biology* **5**: 207-210.
- Miller, J.D., Horne, P., Heatwole, H., Miller, W.R. & Bridges L. (1988) A survey of terrestrial tardigrada of the Vestfold Hills, Antarctica. In: Ferris, J.M., Burton, H.R., Johnstone, G.W. & Bayly, I.A.E. (eds.) *Biology of the Vestfold Hills, Antarctica*. Kluwer Academic Publishers, Dordrecht, The Netherlands, pp. 197-208.
- Pickard, J. (1985) The Holocene fossil marine macrofauna of the Vestfold Hills, East Antarctica. *Boreas* **14**: 189-202.
- Pickard, J. (1986) Antarctic oases, Davis station and the Vestfold Hills. In: Pickard, J. (ed.) *Antarctic oasis: Terrestrial environments and history of the Vestfold Hills*. Academic Press Australia, Sydney, pp. 1-19.
- Pickard, J., Adamson, D.A., Harwood, D.M., Miller, G.H., Quilty, P.G. & Dell, R.K. (1988) Early Pliocene marine sediments, coastline, and climate of East Antarctica. *Geology* **16**: 158-161.
- Quilty, P.G. (1989) Landslides: Extent and economic significance in Antarctica and the subantarctic. In: Brabb, E.E. & Harrod, B.L. (eds.) *Landslides: Extent and Economic Significance*. Balkema, Rotterdam, pp. 127-132.
- Quilty, P.G. (1991) The geology of Marine Plain, Vestfold Hills, East Antarctica. In: Thomson, M.R.A., Crame, J.A. & Thomson, J.W. (eds.) *Geological Evolution of Antarctic*. Cambridge University Press, Great Britain.
- Quilty, P.G. (1992) Late Neogene sediments of coastal East Antarctica – An Overview. In: Yoshida, Y., Kaminuma, K. & Shiraishi (eds.) *Recent Progress in Antarctic Earth Science*, Terra Scientific Publishing Company, Tokyo, pp. 699-705.
- Quilty, P.G. (1996) The Pliocene environment of Antarctica. *Papers and Proceedings of the Royal Society of Tasmania* **130**(2): 1-8.
- Quilty, P.G. (2001) Personal Communication. 9 May 2002.
- Quilty, P.G., Lirio, J.M. & Jillett, D. (2000) Stratigraphy of the Pliocene Formation, Marine Plain, Vestfold Hills, Antarctica. *Antarctic Science* **12** (2): 205-216.
- Roberts, D. & McMinn, A. (1999) Diatoms of the saline lakes of the Vestfold Hills, Antarctica. *Bibliotheca Diatomologica*, Band 44, pp. 1-83.
- Roberts, D. & McMinn, A. (1996) Relationships between surface sediment diatom assemblages and water chemistry gradients in saline lakes of the Vestfold Hills, Antarctica. *Antarctic Science* **8**: 331-34.
- Seppelt, R. A., Broady, P.A., Pickard, J. & Adamson, D.A. (1988) Plants and landscape in the Vestfold Hills, Antarctica. In: Ferris J.M., Burton H.R., Johnstone G.W. & Bayly I.A.E. (eds.) *Biology of the Vestfold Hills, Antarctica*. Kluwer Academic Publishers, Dordrecht, The Netherlands, pp. 185-196.
- Simpson, R.G.B., Van Den Hoff, J., Bernard, C., Burton, H.R. & Patterson, D.J. (1996) The ultrastructure and systematic position of the euglenozoon *Postgaardi Mariagerensis*, Fenchel Et Al. *Archiv fur Protisten Kunde*, 147.
- Streten, N.A. (1986) Climate of the Vestfold Hills. In: Pickard, J. (ed.) *Antarctic oasis: Terrestrial environments and history of the Vestfold Hills*. Academic Press, Sydney pp. 141-164.
- Whitehead, J.M., Quilty, P.G., Harwood, D.M. & McMinn, A. (2001) Early Pliocene palaeoenvironment of the Sørsdal Formation, Vestfold Hills, based on diatom data. *Marine Micropaleontology* **41**: 125-152.
- Williams, R. (1998) The inshore marine fishes of the Vestfold Hills region, Antarctica. In: Ferris J.M., Burton H.R., Johnstone G.W. & Bayly I.A.E. (eds.) *Biology of the Vestfold Hills, Antarctica*. Kluwer Academic Publishers, Dordrecht, The Netherlands, pp. 161-167.



Australian Government

Department of Sustainability, Environment,
Water, Population and Communities
Australian Antarctic Division

Map A: Antarctic Specially Protected Area No 143, Marine Plain Vestfold Hills, Ingrid Christensen Coast, East Antarctica



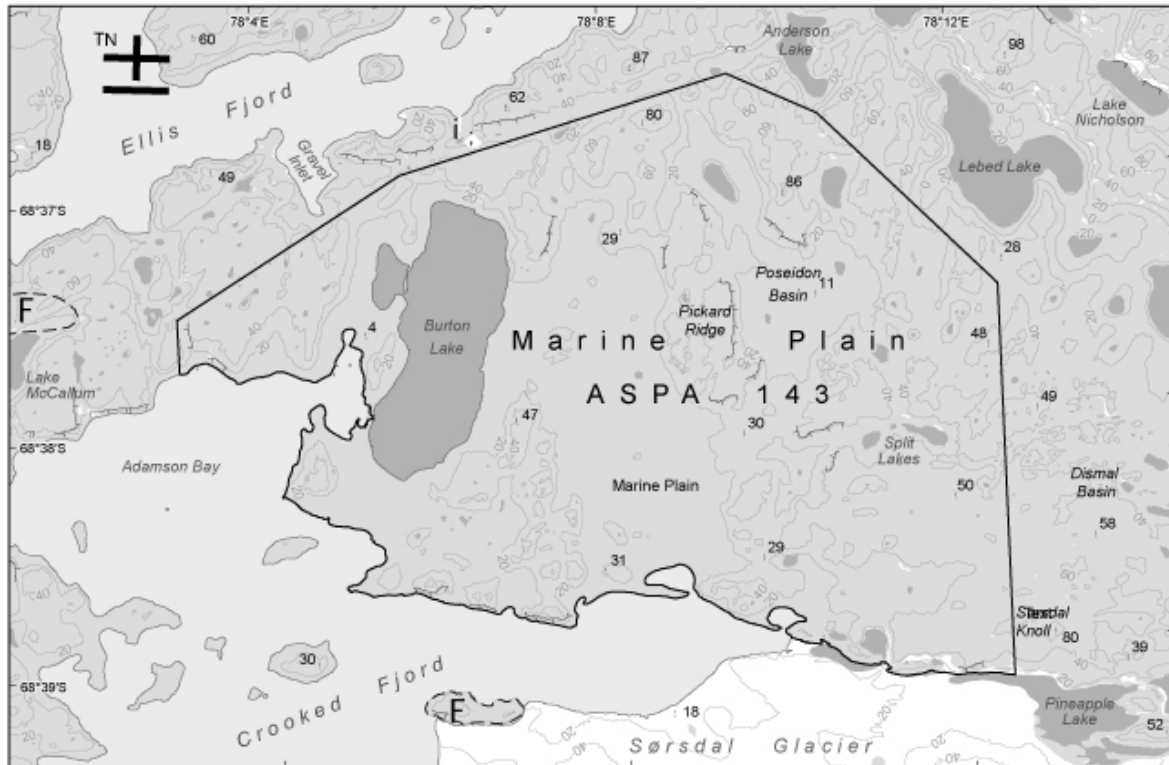
- Station ; Refuge
- Contour (50 metre interval)
- Ice-free area
- Lake
- Antarctic Specially Protected Area

0 2 4 6 Km
 Horizontal Datum: WGS84
 Projection: UTM Zone 44

Map Available at: <http://data.aad.gov.au/aadc/mapcat/>
 Map Catalogue No. 14206
 Produced by the Australian Antarctic Data Centre,
 Australian Antarctic Division, March 2013.
 © Commonwealth of Australia 2013



Map B: Antarctic Specially Protected Area No 143, Marine Plain Vestfold Hills, Ingrid Christensen Coast, East Antarctica Topography and Fauna Distribution



- Spot elevation (metres)
- Marine Plain Refuge
- Helicopter landing area
- Contour (20 metre interval)
- Cliff
- ASPAs boundary
- Ice-free area
- Lake
- Snow petrel nesting area

0 500 1000 1500
Metres
Horizontal Datum: WGS84
Projection: UTM Zone 44

Map Available at: <http://data.aad.gov.au/aadc/mapcat/>
Map Catalogue No. 14207
Produced by the Australian Antarctic Data Centre,
Australian Antarctic Division, March 2013.
© Commonwealth of Australia 2013



Map C: Antarctic Specially Protected Area No 143, Marine Plain Vestfold Hills, Ingrid Christensen Coast, East Antarctica Geology



- Spot elevation (metres)
- Marine Plain Refuge
- Helicopter landing area
- ASPAs boundary
- Lake
- Dyke
- Sørødal Formation
- Chelnock Paragneiss
- Crooked Lake Gneiss
- Mossel Gneiss

0 500 1000 1500
Metres
Horizontal Datum: WGS84
Projection: UTM Zone 44

Map Available at: <http://data.aad.gov.au/aadc/mapcat/>
Map Catalogue No. 14208
Produced by the Australian Antarctic Data Centre,
Australian Antarctic Division, March 2013.
© Commonwealth of Australia 2013