Document Amendments

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Executive Summary

Part C – Environmental Impact Statement is the third of a series of ten documents that contain all decision-making processes, methodology and planning details for the Macquarie Island Pest Eradication Project. The proposed operation is a large-scale project with the aim of facilitating the restoration of natural ecosystems and indigenous species on Macquarie Island by eradicating European rabbits, ship rats and house mice. The project has the potential to impact on numerous aspects of the environment on and around Macquarie Island.

Most of the potential environmental impacts of this proposed eradication operation are positive. The removal of rabbits from Macquarie Island will allow the native vegetation to grow without the unnatural effects of grazing. This will not only give the island’s vegetation a chance of returning to its natural state, but will also - over time - increase slope stability and reduce erosion. The regrowth of vegetation cover is a major habitat recovery factor that will facilitate increases in breeding burrowing petrel numbers, and provide an opportunity for invertebrate assemblages to return to pre-grazing numbers and distribution. The removal of rodents will allow populations of many burrowing seabird species to recover and/or re-establish on the main island. Invertebrate populations are also expected to expand significantly in the absence of rodent predation.

There is potential for the proposed eradication operation to have a number of negative impacts. The use of helicopters to distribute bait could cause disturbance to wildlife; the toxic baits could cause poisoning of non-target species and the use of hunters and dogs for several years will potentially have negative environmental impacts; albeit minor in scale and effect. The island’s flora, biosecurity, human health and community well-being may also be adversely affected. All potential adverse effects are discussed in detail, the likely level of impact is identified and actions taken to avoid, remedy or mitigate these impacts are provided.

On balance, it is the conclusion of this report that the benefits of the proposed eradication operation are expected to far outweigh any of the potential negative impacts. Macquarie Island has been under sustained, severe pressure from vertebrate pests for nearly 200 years and their impacts have significantly altered the ecosystems and appearance of the island. The proposed eradication operation will provide, for the first time, a chance for the island to return to a more natural state, similar to that prior to the establishment of these pest species.
## Summary of Proposed Management Actions

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<td><strong>Soil and water quality</strong></td>
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<td>1</td>
<td>Bait spreading operations will utilise experienced pilots, satellite imagery and GPS to minimise contamination of water bodies.</td>
<td>5.2.3</td>
</tr>
<tr>
<td>2</td>
<td>Water supply dam disconnected and flushed immediately prior to the first bait drop over the catchment.</td>
<td>5.2.3</td>
</tr>
<tr>
<td>3</td>
<td>After baiting, staff to remove bait in and within 1m of the creek and dam before the water supply is reconnected.</td>
<td>5.2.3</td>
</tr>
<tr>
<td>4</td>
<td>Water supply to be filtered using absolute filter bags.</td>
<td>5.2.3</td>
</tr>
<tr>
<td>5</td>
<td>Disconnection of downpipes that collect water from roofs.</td>
<td>5.2.3</td>
</tr>
<tr>
<td>6</td>
<td>Staff to remove bait from roofs and guttering. Roofs to be washed down.</td>
<td>5.2.3</td>
</tr>
<tr>
<td>7</td>
<td>No disposal of human waste on plateau. All solid waste to be taken to coast for disposal. Dog faeces around field huts or plateau areas will be collected and buried locally.</td>
<td>5.2.3</td>
</tr>
<tr>
<td><strong>Non-target species</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Timing of the bait spreading to coincide with most inactive period for most non-target species.</td>
<td>5.3.8</td>
</tr>
<tr>
<td>9</td>
<td>Any unusual occurrence of dead wildlife will be noted and samples taken.</td>
<td>5.3.8</td>
</tr>
<tr>
<td>10</td>
<td>Australian standards and label procedures to be followed to minimise accidental poisoning of non-target species.</td>
<td>5.3.8</td>
</tr>
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<td>11</td>
<td>Field staff on-ground at Wandering albatross nests during bait spreading will manually remove all baits in nest vicinity.</td>
<td>5.3.8</td>
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<td>12</td>
<td>All hunting team members to be made aware of the location of vulnerable burrowing petrel colonies and undergo training to minimise impacts.</td>
<td>5.3.8</td>
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<td>13</td>
<td>Staff to be briefed on reasons for Special Management Area zoning, and minimising impacts when working within these zones.</td>
<td>5.3.8</td>
</tr>
<tr>
<td>14</td>
<td>Minimum bait dispersal altitude of helicopters will be 500 ft within 1000m of King penguin colonies.</td>
<td>5.3.8</td>
</tr>
<tr>
<td>15</td>
<td>When fumigating burrows, hunters to check for presence of burrowing petrels and undertake alternative methods if necessary.</td>
<td>5.3.8</td>
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<td><strong>Vegetation and soil</strong></td>
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<td>16</td>
<td>Hunters to be thoroughly briefed on strategies to minimise damage to vegetation, soils and screes.</td>
<td>5.4.2</td>
</tr>
<tr>
<td>17</td>
<td>Where possible, staff to avoid entering fragile or densely burrowed areas</td>
<td>5.4.2</td>
</tr>
<tr>
<td>18</td>
<td>Additional field huts and other infrastructure are temporary and will be removed at conclusion of the project.</td>
<td>5.4.2</td>
</tr>
<tr>
<td>19</td>
<td>Where possible, huts to use same locations as past huts.</td>
<td>5.4.2</td>
</tr>
<tr>
<td>No.</td>
<td>Proposed management action</td>
<td>Section</td>
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<td>20</td>
<td>All staff working on the bait spreading operation to be comprehensively trained.</td>
<td>5.5.2</td>
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<td>21</td>
<td>Antidote (Vitamin K) will be available and medical practitioner appropriately trained. Staff to be screened for coagulopathy at monthly medicals.</td>
<td>5.5.2</td>
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<tr>
<td>22</td>
<td>Adherence to standards for bait use including handling, label compliance, storage, disposal, use, preparation etc.</td>
<td>5.5.2</td>
</tr>
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<td>23</td>
<td>Compliance with specifications for personal protective equipment.</td>
<td>5.5.2</td>
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<td>24</td>
<td>Establishment of procedures to manage and record accidents, loss of bait or poisoning.</td>
<td>5.5.2</td>
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<td>25</td>
<td>Field staff to be briefed on location and management prescriptions for historic sites.</td>
<td>5.5.3</td>
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<td>26</td>
<td>Monitoring of distribution and abundance of alien plants.</td>
<td>5.6.2</td>
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<td>27</td>
<td>Monitoring of prey switching by skua.</td>
<td>5.6.2</td>
</tr>
<tr>
<td>28</td>
<td>All materials and temporary infrastructure will be removed.</td>
<td>5.6.2</td>
</tr>
<tr>
<td>29</td>
<td>Apply for permit to use vehicles off formed roads.</td>
<td>5.6.2</td>
</tr>
<tr>
<td>30</td>
<td>Dogs to meet biosecurity requirements.</td>
<td>5.7.2</td>
</tr>
<tr>
<td>31</td>
<td>All Australian and Tasmanian biosecurity guidelines will be followed for shipping and aircraft.</td>
<td>5.7.2</td>
</tr>
<tr>
<td>32</td>
<td>Project Manager will brief all staff on biosecurity requirements. All staff must thoroughly clean belongings and equipment. All materials, equipment, transport and foodstuffs to be suitably cleaned and/or fumigated. Inspections will be carried out by qualified staff.</td>
<td>5.7.2</td>
</tr>
<tr>
<td>33</td>
<td>Vessels must be certified rodent-free; no wharves or mooring to be attached to the island; vessels must be anchored &gt;200m from the coast.</td>
<td>5.7.2</td>
</tr>
<tr>
<td>34</td>
<td>Only hunters with extensive experience in firearms use to be employed.</td>
<td>5.8.2</td>
</tr>
<tr>
<td>35</td>
<td>Dogs trained not to kill, but to locate the presence of rabbits. Field staff will kill rabbits with most humane techniques possible.</td>
<td>5.8.2</td>
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<tr>
<td>36</td>
<td>Any traps set will be checked within every 24 hour period.</td>
<td>5.8.2</td>
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1. Introduction

1.1 Background

Funding provided in 2004 by the Department of the Environment and Heritage facilitated the compilation of Drafts of Part A (Overview) and Part B (Operations Plan) of a Macquarie Island Pest Eradication Plan (Eradication Plan). The overall Macquarie Island Pest Eradication Plan will comprise of the following documents:

- Part A - Overview
- Part B - Operational Plan
- Part C - Environmental Impact Statement (this document)
- Part D - Occupational Health and Safety Plan
- Part E – Project Biosecurity Plan
- Part F – Monitoring Plan
- Part G - Communications Plan
- Part H - Project Plan
- Part I - Procurement Plan
- Part J – Staff Recruitment and Training Plan.

This document (Part C - Environmental Impact Statement, hereafter referred to as the EIS) assesses the actual and potential environmental effects of eradicating rabbits and rodents from Macquarie Island. The proposed two-phase operation involves an initial bait drop of the second generation anti-coagulant poison brodifacoum, followed by 3-5 years of hunting rabbits with the assistance of specially trained dogs.

Brodifacoum has been used around the world to control and/or eradicate rats, mice and rabbits, as well as for control of wallabies and Brushtail possums (Eason and Spurr 1995a).

Brodifacoum can present risks to public health and non-target native species. The use of hunting teams and dogs on the island, and the infrastructure required to support them, present additional potential environmental impacts.
Other potential impacts include disturbance to native wildlife (by helicopters, dogs and people) and biosecurity risks through the transportation of aircraft, equipment, people and dogs to the island.

This EIS outlines the degree and significance of these potential impacts and the means by which identified risks will be managed, to ensure that adverse effects are avoided, remedied or mitigated. The EIS also provides an assessment of these potential impacts and will be used as a reference document for a referral to the Australian Government Minister for the Environment for assessment in accordance with the requirements of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

### 1.2 Objectives of the Environmental Impact Statement

The Tasmania Parks and Wildlife Service (PWS) has prepared this Environmental Impact Statement to:


- describe the proposed operation

- describe the location and physical environment for the eradication

- assess the impact of the proposed operation on the environment

- identify the actual and potential effects of the proposed operation and outline appropriate management of these effects.
2. **Scope**

The primary aim of this EIS is to assess all of the potential and actual environmental impacts of the proposed eradication operation in detail, including management options and strategies to prevent or mitigate identified impacts.

The scope includes:

- a brief summary of the planned eradication operation
- an overview of the treatment area (i.e. Macquarie Island)
- an assessment of all predicted potential impacts on the Macquarie Island environment arising from implementation of the eradication plan
- a description of the relevant legislation and planning documents.

It does not include:

- an examination of the options for pest control (covered in *Part A – Overview* )
- detailed recommendations for biosecurity measures needed during the eradication operation or future post-eradication measures required to maintain a rabbit and rodent free Macquarie Island (to be covered in *Part E – Biosecurity Plan*, but summarised in this plan)
- detailed recommendations for future monitoring (to be covered in *Part F - Monitoring Plan*).

This EIS also fulfils the requirements of the PWS Reserve Activity Assessment for a Development Proposal and Environmental Management Plan.
3. Overview of the Proposed Eradication Operation

3.1 Introduction
This section provides an overview of the proposed operation by briefly describing:
- the parameters of the operation
- the eradication methodology proposed
- the objectives of the operation
- the reasons for eradication and the adverse impacts of rabbits and rodents
- the statutory requirement to eradicate rabbits and rodents on Macquarie Island.

3.2 Summary of operation parameters
The eradication operation will be carried out on Macquarie Island, a small (12,870 ha) elongate sub-Antarctic island approximately 1500 km south-south-east of Tasmania (see map - Appendix 1) and 1000 km south-south-west of New Zealand.

The target pest species are:
- European rabbits (*Oryctolagus cuniculus*)
- Ship (Black) rats (*Rattus rattus*)
- House mice (*Mus musculus*).

The main purpose of the proposed operation to eradicate rabbits and rodents from Macquarie Island is to facilitate the recovery and restoration of the landscape, ecosystem and indigenous species.

3.3 Proposed methodology
A detailed and comprehensive range of methodologies, toxins and combinations were considered before it was decided to proceed with a two-phase operation consisting of bait drops of brodifacoum from helicopters (Phase 1), followed by an intensive period of ground hunting (Phase 2). A review of the negative and positive aspects of each option and the justification for the final choice of methodology, can be found in *Part A – Overview*. That document also discusses the ramifications of not acting at all to manage invasive species.

Aerial distribution of bait was recommended as the only feasible technique to ensure that all target individuals will have a chance to encounter bait. A comprehensive review of the use of
brodifacoum and its effect on both target and non-target species is also provided by the New Zealand Department of Conservation Internal Publication ‘Brodifacoum – A review of current knowledge’ (Fisher and Fairweather 2006).

3.3.1 Phase 1
The initial phase will target all rodents and the majority of the rabbit population during winter. The recommended technique to target all individuals is aerial broadcasting of the second-generation anticoagulant brodifacoum (a coumarin toxin: \(3\text{-}[3\text{-}(4''\text{-bromobiphenyl-4yl})\text{-1, 2, 3, 4\text{-tetrahydro-1naphthyl]}\text{-4-hydroxycoumarin}\)) in the form of cereal bait pellets across the whole island.

Brodifacoum has been selected because:

- It is the best poison currently available and known to be effective for multi-species animal pest control, especially for the control or eradication of rodents (Eason & Wickstrom 2001, Courchamp et al. 2003)
- Its delayed action obviates the need for pre-feeding with non-toxic bait (Eason & Wickstrom 2001).

The poison is delivered via 10mm (diameter), 2g cereal based pellets (brodifacoum concentration = 20ppm or 0.002%). Two whole-island applications (average distribution 16 kg/ha on the plateau and 32 kg/ha on escarpment slopes and the coast), plus additional coverage on areas of high rabbit density, will be conducted to ensure that sufficient bait is available for all three species and to avoid one species being outcompeted by another for bait. It is estimated that approximately 300 tonnes of bait will be required. Hand baiting will be used to supplement the aerial baiting in some areas, such as buildings and caves. Helicopters will be equipped with satellite-based navigation systems to enable pilots to maintain flight lines with a high degree of accuracy, to ensure that the prescribed bait coverage is achieved and that bait distribution into sensitive areas, such as freshwater bodies and the marine environment, is minimised.

3.3.2 Phase 2
The second phase involves immediate and intensive hunting pressure on the remaining rabbit population, expected to be less than 2% of the original population (Torr 2002). Hunting teams will use rabbit detection dogs and employ trapping, shooting and burrow fumigation techniques until rabbits have been reduced to undetectable levels on the island. At this stage, two years of monitoring for pest presence or absence will commence.
3.3.3 Timing
Logistics and regulatory planning began soon after the funding agreement between the Australian and Tasmanian Governments was reached in June 2007. The ‘on-ground’ operation is scheduled to begin in the austral winter of 2010, with an available window for aerial baiting operations of late May to late August. This timeframe will minimise impacts on non-target species (because many native species leave the island during winter) and takes advantage of the winter scarcity of natural food resources of the target species. At this time, pest populations are at the lowest point in their annual cycle, meaning that fewer animals need to be removed to achieve eradication (PWS unpublished data). This effectively increases the amount of bait available per individual and ensures that all target animals should have access to a lethal dose. Under the current plan the on-ground phase of the eradication operation will continue for five years after the completion of aerial baiting.

3.3.4 Bait application rate
Three or four helicopters (most likely to be single-engine models) will conduct aerial baiting applications. Helicopters will sow the bait using underslung broadcasting buckets fitted with a mechanised spinner that throws the pellets out to an effective swathe width of 80 metres (40m either side of helicopter flight path). Helicopters will fly parallel lines guided by Geographical Positioning System (GPS) units to ensure accurate coverage. Bait-spreading helicopters may be supported by an additional helicopter, which will maintain the supply of bait and fuel during aerial operations, and may spread bait as other support functions are fulfilled. Wind, reduced daylight hours and visibility conditions are the primary factors affecting helicopter activity.

Bait application rates will be sufficient to ensure that the whole island receives a minimum coverage of 16 kg/ha in total over two drops, with a third drop on steep slopes and areas of high rabbit density. Coastal areas and escarpment slopes will receive approximately 32 kg/ha to reflect the great numbers of rabbits and rats living in these areas. Prescription rates and calculations for the initial two whole-island drops and the additional drops in high rabbit density areas indicate these areas will require a total of about 250 tonnes of bait. An additional 20% will be provided for contingency purposes, resulting in a total bait quantity of approximately 300 tonnes. Bait drops (except immediate follow-up applications to account for identified gaps) will preferably take place between seven and 14 days apart. Any contingency bait that is unused after scheduled applications will be distributed on the island in areas identified as being of high risk for holding surviving target animals, for example rock stacks, cliffs, and areas of known high rabbit density.
3.4 Objectives of the proposed operation

3.4.1 Project Vision

Macquarie Island biodiversity and geodiversity is restored to a natural balance - free of the impacts of introduced pest species. Vegetation, seabird and invertebrate populations have recovered to levels naturally supported by the environment.

The project vision reflects the Vision for the Future statement in the *Macquarie Island Nature Reserve and World Heritage Area Management Plan 2006* (Management Plan) that states:

“**The Vision Statement – 50 years hence**

Macquarie Island is a nature reserve where all of the World Heritage values, biosphere reserve values, National Estate values and state nature reserve values are protected and conserved. There is a relatively unaltered natural diversity, including geodiversity and biodiversity. The populations of some threatened species in the reserve appear to be recovering, even if their populations are still threatened elsewhere. Human visitation and use of the reserve is controlled and carefully managed to minimise adverse impacts on the reserve. Scientific research, monitoring and management programs continue with minimal and/or transitory impacts on the natural and historical values of the reserve. *There have been no apparent further introductions of alien species. Rabbits, rats and mice have been eradicated.* There is full awareness and appreciation of the special conservation value and character of the reserve by the international community, the Australian federal, state and local governments, scientists, tourists and the Australian public, to the extent that protection of the reserve is recognised to be of utmost importance."

(Emphasis added).

3.4.2 Natural values and status

Macquarie Island and its environs have outstanding global conservation, geological, ecological and scientific values. In recognition of its natural and cultural values, it has been accorded the highest possible status under international, national and state protected area classification systems.

These designations include:

- Nature Reserve (designated in 1972 under the *Nature Conservation Act 2002*)
- World Heritage Area (designated in 1997 under the *EPBC Act 1999*)
Environmental Impact Statement

- National Estate place (since 1977)
- Critical Habitat (EPBC Act 1999)
- Biosphere Reserve (designated in 1977 under UNESCO Man in the Biosphere program).

Rabbit grazing is a significant threat to World Heritage values. The extensive occurrence of rabbit grazing has also led to significant and ongoing habitat loss. The implications of this damage are far reaching with impacts affecting plant distribution and abundance, burrowing petrel and albatross breeding success, geological features such as caves and raised beach deposits, and overall slope stability. Feral rats have been identified by the Australian Government as a Key Threatening Process on Australian Islands under 100,000 ha (DEWR 2007a). Land degradation by rabbits is also listed as a Key Threatening Process. Eradication of alien vertebrate species is therefore a high priority for the reserve and is a priority management action in the Management Plan.

3.4.3 Conservation outcomes
The main conservation outcome that PWS hopes to achieve by eradicating animal pests is the re-establishment of more ‘natural’ vegetation and wildlife communities. That is, vegetation and wildlife that is more representative of the island before rabbits and rodents became established. As rabbits and rodents are the only introduced mammals remaining on the island, the eradication will be the most crucial step towards ecological restoration that will largely occur through natural processes, i.e. the recovery of vegetation, invertebrate and seabird populations; and a return to natural erosional processes and rates. A number of studies have reported natural recovery of species or ecosystems once invasive species have been eradicated (summarised in Eason and Spurr 1995a and Towns et al. 2006).

The success of the conservation outcomes will be determined by monitoring programs described in more detail in Part F – Monitoring Plan (in preparation) and briefly outlined in Section 7 of this document.

3.4.4 Operational objectives
There are three main operational objectives for the eradication operation:
- To eradicate rabbits and rodents from Macquarie Island
- To conduct the operation without serious accident or incident
- To minimise operational impacts on non-target species and the environment.
Environmental Impact Statement

The presence or absence of rabbits and rodents following the eradication operation will be determined through the monitoring methodology as set out in Part F – Monitoring Plan.

An on-site Health and Safety Officer will be appointed to monitor all procedures and practices during the operation on Macquarie Island. Initially this person will be the Assistant Project Manager, and then the Eradication Team Leader in later stages. This person will ensure that all aspects of Part D – Occupational Health and Safety Plan (in preparation) are implemented, as well as liaising with helicopter pilots, other operational staff and the Australian Antarctic Division (AAD) Station Leader to address any safety issues or concerns.

3.5 Summary of reasons for eradication

Pest control options are considered to be more expensive and less effective than eradication in the long term and require ongoing and indefinite financial commitment. Control programs involve sustained use of toxins, trapping and shooting; increased long-term environmental risks, such as mortality of non-target species; increased total animal deaths compared with short eradication campaigns; and, are more expensive and time consuming in the long-term. No control options are considered feasible or practical on more than a localised basis at Macquarie Island for either rabbits or rodents.

Eradication of rabbits and rodents will vastly improve the natural and conservation values of this World Heritage Area. In less than 200 years humans have greatly impacted the island by exploiting native wildlife and facilitating the arrival of feral animals. Removal of rabbits and rodents should provide an opportunity for the island to eventually return to a state similar to that existing prior to the arrival of humans.

Failure to eradicate rabbits and rats from Macquarie Island will result in:

- Further degradation of the geological and natural values for which the island was listed as a World Heritage site
- Losses to the biodiversity of the island and subantarctic region, a criterion for which the island was declared a Biosphere Reserve
- Non-fulfilment of relevant objectives and prescriptions outlined in the legislation and in documents listed in Section 3.6
- Compromising the protection and recovery of several species listed as endangered or vulnerable under Australian and/or Tasmanian legislation
- Failure to assist in the restoration of natural ecological processes on the island.
3.6 Statutory Requirement to Eradicate Rabbits and Rodents

Macquarie Island is managed by the Tasmania Parks and Wildlife Service as a Nature Reserve. The eradication of rabbits, rats and mice is identified in the Management Plan as one of the highest management priorities for the reserve (PWS 2006). As a Nature Reserve, it is a statutory requirement under Schedule 1 of the *National Parks and Reserves Management Act 2002* to

> protect the nature reserve against, and rehabilitate the nature reserve following, adverse impacts such as those of fire, *introduced species*, diseases and soil erosion on the nature reserve’s natural and cultural values and on assets within and adjacent to the nature reserve (emphasis added).

Macquarie Island is a World Heritage Area, a Biosphere Reserve, is listed on the Register of the National Estate and on the Register of Critical Habitat. Its World Heritage and Critical Habitat status mean that the Australian Government also has a management responsibility for the island. In addition to global conventions to which Australia is a signatory, there are also legislation, government guidelines, reviews, plans and strategic policies that - either through their objectives or regulations - effectively provide a statutory requirement for both Australian and Tasmanian Governments to support the eradication of rabbits and rodents from Macquarie Island. A summary of these documents is provided below. For further detail see *Part A – Overview*.

3.6.1 Global Multilateral Conventions

- Convention on Biological Diversity
- Convention for the Protection of the World’s Cultural and Natural Heritage (World Heritage Convention)
- Agreement on the Conservation of Albatross and Petrels.

3.6.2 Australian Acts/Documents

- *Environment Protection and Biodiversity Act 1999*
- *Review of the National Strategy for the Conservation of Australia's Biological Diversity* (Environment Australia 2001a)
- *Macquarie Island Marine Park Management Plan* (Environment Australia 2001b)
- *National Recovery Plan for Albatrosses and Giant-petrels* (Environment Australia 2001c)
Environmental Impact Statement

- Draft Threat Abatement Plan for Rats as Threatening Process on Offshore Islands (DEWR 2007a) see also Advice document to the Minister on Rats as a Key Threatening Process on Offshore Islands (TSSC 2006b)
- Issues Paper – Population status and threats to southern seabirds listed as threatened under the Environmental Protection and Biodiversity Conservation Act 1999 (DEH 2005b).

3.6.3 State Acts/Documents

- Threatened Species Protection Act 1995 (Tasmania)
- National Parks and Reserves Management Act 2002 (Tasmania)
- Nature Conservation Act 2002 (Tasmania)

3.7 Adverse impacts of rabbits and rodents and reasons for eradication

Rabbit numbers and impacts have been increasing on Macquarie Island in recent years until a peak in 2006. Since then, rabbit numbers appear to be declining (Terauds 2009). No medium to long term rabbit population control options are considered to be viable and effective for the island. There are no known viable and effective control options for rodents with meaningful ecological benefits. The combined cumulative impacts of rabbits and rodents are having devastating impacts on native fauna and flora, natural landscape values and nutrient recycling systems. Many of the impacts caused by rabbits and rodents involve complex interactions and ecological consequences (Courchamp et al. 2003).

3.7.1 Negative impacts of rabbits

The effect of rabbits on the native flora on Macquarie Island is widespread, severe and well documented (e.g. Costin and Moore 1960, Selkirk et al. 1983, Scott 1988, Copson and Whinam 1998, Carmichael 2008, Scott and Kirkpatrick 2008, Bergstrom et al. 2009). Negative rabbit impacts of rabbits on vegetation include:

- Rabbits favour large leafy megaherbs and grasses, which are not adapted to cope with grazing. Macquarie Island supports a large, population of two species of
megaherbs, Macquarie Island cabbage (*Stilbocarpa polaris*) and the daisy *Pleurophyllum hookeri*. These species have been subject to extensive grazing damage, as have the two large tussock grasses *Poa foliosa* and *P. cookii*. Recovery of these communities may take a significant period of time especially where the root systems have been destroyed over large areas.

- *Poa foliosa* dominated tussock grasslands on the eastern coastal slopes of the island declined by over 55% between the mid-1990s and 2005 as a result of increased rabbit grazing. Qualitative surveys of the coastal slopes between 2005 and 2007 showed that the number of lightly grazed areas decreased by over 50%, whilst the number of heavily grazed areas increased by over 70%. These and other island-scale measures indicate that a significant level of tussock grassland loss has occurred since the late 1990s (Carmichael 2008).

- Rabbit grazing also negatively impacts on plant communities by influencing species richness and altering successional processes (Copson and Whinam 1998, Scott 1988, Scott and Kirkpatrick 2008). By preferentially grazing some plant species and not others, the entire structure of many vegetation communities has been altered. In some cases, these alterations, such as the increase and spread of stands of homogenous Aceana spp, may make it difficult for the original species to recolonise these areas.

- At a species level, some plant species with restricted distributions have been severely affected by rabbit grazing. Four plant species on Macquarie Island have recently been listed under the Tasmanian Threatened Species Protection Act 1995, as threatened due to a population reduction caused by rabbit grazing (*Polystichum vestitum*, *Poa cookii* and *Nematoceras sulcatum* as endangered, *N. dienemum* as vulnerable). It has also been noted that *Huperzia australiana* on Macquarie Island requires special observation and protection due to its rabbit-induced decline, resulting in the survival of less than 50 individuals on the island.

- Rabbits not only remove and damage leaves, but kill seedlings, destroy flowers and root systems, contributing to the erosion of steep peat-covered slopes. Apart from impacting the above-ground vegetation, rabbits also negatively affect the long-term viability of some vegetation by removing the seed bank in the soil through physical activity and eating below-ground rhizomes (Selkirk *et al.* 1983).

- Rabbits disrupt the natural structure of the plant communities by altering vegetation sequences, disturbing ground and transporting seeds in their fur around the island.
Rabbits degrade the geoconservation values which underpin the island’s World Heritage listing. The impacts include erosion of raised beach deposits linked to the emergence of the island from the ocean; erosion of cave deposits, erosion of cliff-top dunes associated with island uplift; and erosion of lunettes and dune systems related to fluctuating palaeoclimates (Houshold and Dyring 2007).

Rabbit grazing (wide-scale removal of vegetation) and burrowing has consequential impacts on slope stability. Grazing exacerbates natural erosion processes or contributes directly to slope failure in naturally stable areas; resulting in increasing frequency and scale of landslips (Houshold and Dyring 2007). Rabbit burrows also compete with burrowing seabirds in some areas (Courchamp et al. 2003).

Removal of vegetation through grazing exposes geological features to the elements, increasing weathering and exposure to erosional processes such as wind, frost heave, rainfall and temperature variations.

Rabbits frequently utilise caves for shelter and cause significant disturbance to cave floors through burrowing and turning over soil.

Rabbits have a negative impact on the island’s biodiversity. Rabbits are negatively impacting on some of the 350 invertebrates species that live in the soils and on the plants, by removal of native vegetation.

In addition to the above, much of the vegetation that is preferentially targeted by rabbits provides critical breeding habitat for a range of albatrosses and burrowing petrel species. Rabbit grazing affects all colonies of burrowing seabirds on Macquarie Island (DPIW 2007). In conjunction with rodent predation, heavy grazing by rabbits has decreased breeding success or caused or contributed to a localised deterioration of burrowing petrel nesting habitat and breeding success. The loss of vegetation also contributes to destabilisation and erosion of steep peat-covered slopes, which has a consequential effect on albatross nesting and some burrowing petrel colonies.

The removal of rabbits from the island will halt these negative processes and provide an opportunity for vegetation communities to return to a more ‘natural’ state. Whilst this process may not happen quickly in all areas, the removal of rabbits is the key factor for vegetation recovery and has subsequent benefits for other plant and animal species. This has been comprehensively demonstrated by vegetation regrowth within rabbit exclusion plots (Copson and Whinam 1998, Bergstrom et al. 2006, Scott and Kirkpatrick 2008, PWS unpublished data) and by studies of vegetation regrowth after the introduction of myxomatosis.
substantially reduced the rabbit population (Copson and Whinam 1998, Scott and Kirkpatrick 2008). See Appendix 1 for maps of the vegetation on Macquarie Island.

3.7.2 Negative impacts of rodents
While their impact on vegetation is not as immediately obvious, rodents are adversely altering natural processes in a variety of ways:

- Rats are known to adversely affect native flora by altering seed dispersal of megaherbs by caching; inhibit regeneration by eating seeds, seedlings or foliage of many plants; and by burrowing in tussock grasslands (Shaw et al. 2005, Bryant 1994)

- The effect of rats on vegetation may be subtle and not immediately obvious, but many species have reduced health or struggle to reproduce due to rats feeding on their seeds, flowers, fruit, roots or seedlings. The structure and composition of the natural vegetation can be modified as a result

- On Taukihepa, New Zealand, extensive damage was noted to *Stilbocarpa lyalli* and to *Pseudopanax spp* following establishment of the rat population there (Brown et al. 2006). Rance (2001) suggested that Cook’s scurvy grass (*Lepidium oleraceum*), a nationally endangered species formerly present on Taukihepa, could have become locally extinct as a consequence of rats

- Following removal of rats from the Chetwode Islands, New Zealand, surveyed seedling plots revealed a 20-fold increase in seedling numbers and a 7-fold increase in species diversity (Brown 1997), strongly indicating the inhibitive effect rats have on regeneration of certain flora

- Ship rats are known to opportunistically prey on chicks and eggs of several small seabird species (Bryant 1994). Ship rats are identified as an ongoing threat to at least nine bird species that currently breed on Macquarie Island (DPIW 2007). In a recent comprehensive review of the impacts of rats on seabirds around the world, Jones et al. (2008) found that rats impact on over 70 island-based seabird species. The introduction of alien mammals such as rats to islands has been identified as one of the greatest causes of recorded global extinctions (Groombridge 1992)

- Mice cache and eat seeds of many species and are present across a wide range of vegetation types (Copson 1986)

- Mice also have the potential to predate on seabirds and their eggs. On Gough Island, mice cause wounds in Tristan albatross and Atlantic petrel chicks, in many cases leading to the death of the chick. This impacts significantly on breeding success of
these species and drives population decline (Cuthbert et al. 2004; Wanless et al. 2007)

- The impact of rodents on the invertebrates of Macquarie Island is largely unknown. Diet studies have shown that invertebrates are major components in the diet of both rodent species (Copson 1986, Pye 1993). Copson (1986) found that the diets of mice and rats on Macquarie Island are similar, although there are differences in the quantities of items eaten – mouse diet consists mainly of invertebrates, while rat diets are mainly plant matter supplemented by invertebrates. Spiders and moth larvae (Eudoria mawsoni) were the most common invertebrate food sources for mice (Copson 1986). It is extremely likely that the impact of both rats and mice on invertebrate communities has been significant, and is consistent with that documented on other sub-Antarctic islands (Pye and Bonner 1980; Chown and Smith 1993; Smith et al. 2002). Millus and Stapp (2008) noted 83% of stomach contents from grassland deer mice contained invertebrate remains on Santa Barbara Island, California.

- Mice have the potential to be vectors of disease for indigenous vertebrates, as suggested by de Bruyn et al. (2008).

3.7.3 Overall benefits of rodent and rabbit eradication

Successful eradication of rabbits and rodents from Macquarie Island is expected to return key ecosystem functions to an essentially natural state. Currently, rabbit-induced soil and land degradation - including streambank and bed erosion, sheet erosion, frost heave and landslip activity - exceeds natural rates and magnitudes of change, adversely affecting key vegetation communities and faunal habitats. Removal of pest species will greatly reduce these impacts. Geoheritage sites that underpin the island’s World Heritage listing, and are currently being degraded, will be similarly protected from further erosion.

Over 40 plant species and up to 24 bird species are expected to benefit from an eradication of rabbits and rodents. Twelve of these bird species are considered threatened under Tasmanian and/or Australian Government statutes (DEH 2005a, DPIW 2007).

A number of worldwide examples have demonstrated significant benefits to island ecosystems as a result of pest eradication programs (e.g. Towns and Ballantine 1993, Howald et al. 2007). Native (and often threatened) species have made dramatic population recoveries following removal of alien species. Recent operations such as the eradication of kiore (Pacific rat) from Codfish, Korapuki, Marotere and Tiritiri Matangi islands in New
Zealand (Towns 1991, Parrish and Pierce 1993, Graham and Veitch 2001) and ship rats from Île St Paul (Micol and Jouventin 2002), have demonstrated the overwhelming benefits of rodent eradication and the net positive effect for non-target species.

Similarly, eradication of rabbits from some small islands of the Kerguelen Island group, Enderby Island and Île St Paul has been shown to be extremely beneficial for local flora and fauna (Micol and Jouventin 2002, Torr 2002, Chapuis et al. 2004). Recent success in breeding of storm petrels in the United Kingdom following rat eradication is described at http://news.bbc.co.uk/2/hi/uk_news/wales/7618239.stm (accessed 18 September 2008).

From the examples of other islands where rodents have been eradicated, it is expected that re-colonisation of Macquarie Island by many seabird species may be rapid given restoration of habitat, cessation of grazing and lack of predatory rodents. Bird species expected to benefit from the eradication of rabbits and rodents on Macquarie Island include albatross, petrel and prion species.

While recognition of the benefits to species is valuable, it is important to recognise that the eradication project intends that the overall ecosystem will be able to recover to pre-invasive mammal conditions, over time. With improvement of soil and slope stability and vegetation regeneration, improved habitat should be beneficial for nearly all species native to Macquarie Island.

3.8 Advantages and risks of an integrated eradication attempt

There are significant advantages in attempting to eradicate both rabbits and rodents from Macquarie Island at the same time. The main advantage is that the eradication of the species can be achieved using essentially the same methods, staff and equipment (Copson 2004). Compared to undertaking separate programs, the total funding and time requirements are also reduced. In addition, concurrent species eradications prevent the possibility of unforeseen responses in one species to eradication of another, which may occur if eradications were conducted consecutively.

The main risks associated with an integrated eradication attempt are the complexity of the program and the risk that the eradication of all three species is not achieved (Copson 2004). In addition, Copson (2004) note possible scenarios that may occur if one of the target species is not eradicated:
The eradication of rabbits only could cause rats to come into contact with currently isolated small seabird colonies as tussock grassland recovers (Brothers and Copson 1988)

If rabbits are not eradicated, they would continue to modify the vegetation, exposing more seabird colonies and support a higher skua population, leading to further predation of seabirds

If only mice survive, they could greatly increase in numbers (Myers et al. 2000) and adversely impact vegetation and invertebrates.

3.9 History of previous control operations

A vertebrate pest management program conducted since the 1960s on Macquarie Island resulted in the successful eradication of weka (Gallirallus austral scotti) by 1989 and feral cats (Felis catus) by 2001 (Copson and Whinam 2001). Rabbit densities have been monitored throughout this period and management of the rabbit population remains a high priority. As part of this program, myxoma virus was introduced in the late 1970s, following the release of its vector, European rabbit fleas (Spilopsyllus cuniculus), from 1968. Myxomatosis had significantly reduced the rabbit population by 1985 (Copson and Whinam 1998). On-going release of myxoma was viewed as a medium term solution for rabbit control until eradication was feasible. Part A – Overview contains a discussion on the suitability of Rabbit Haemorrhagic Disease Virus and concludes that it would not be used as a part of this eradication operation.

Unlike rabbits, there are no viral control agents for rodents. Attempts to locally control rodent numbers were conducted between 1999 and February 2003 using brodifacoum rodenticide. Trials indicated that rodents were continually re-invading previously baited areas. It is very likely that this control program had benefits for petrel and prion colonies (N. Brothers pers. comm.), but was time consuming and labour intensive and is not seen as an effective or sustainable long-term methodology. These trials ceased in 2003 due to concerns that possible anti-coagulant tolerance or bait shyness may compromise the integrity of an eventual eradication operation.

Short-term interim control of rabbits was undertaken between 2005 and 2007 by shooting rabbits in localised areas. The most successful of these areas was on North Head and the coastal slopes around Handspike Point and Bauer Bay. A fence was constructed across the Isthmus in winter 2007 to prevent the migration of rabbits to North Head, after which rabbit numbers were reduced to enhance vegetation recovery in this area.
Rabbit shooting ceased on Macquarie Island in December 2007 to ensure that rabbits are naive to proposed eradication techniques, including shooting.

3.10 Formal Approvals Required
A number of regulatory processes and permits that are required before the proposed eradication operation can proceed:

- Approval for the operation through an EPBC Act Referral
- Permit from the Australian Pesticides and Veterinary Medicines Authority (APVMA) for aerial broadcasting of brodifacoum and for the use of brodifacoum to target rabbits (applied for June 2008 and received May 2009)
- Permits from PWS for helicopter operation, access authorities to the nature reserve and to Special Management Areas within it
- Environmental evaluation through a Reserve Activity Assessment (approved July 2009)
- Permits under the Nature Conservation Act 2002 for trapping and hunting target animals, and disturbance or by-catch of non-target species
- Methods of application for registered pesticide formulations must also be approved by Department of Primary Industries, Parks, Water and Environment (DPIPWE)
- Approval from the Animal Welfare Committee to use the proposed eradication techniques
- Permits to have dogs within the Macquarie Island Nature Reserve.
4. Description of the Treatment Area

4.1 Introduction

This section describes the treatment area, including:

- the physical characteristics of the area
- ecology of the area
- recreational and commercial values
- other pest species present.

The ecological description of the area includes an assessment of the ecological significance of values and habitat of the island.

4.2 Description of the Receiving Environment

4.2.1 Location, physiography and area

Macquarie Island is a small, elongate sub-Antarctic island 34 km in length and 5 km wide at its widest point. It lies approximately 1500 km southeast of Tasmania at latitude 54°38'S and 158°52'E. Much of the island is surrounded by steep coastal slopes (100m-250m), which culminate in an undulating plateau region that reaches a maximum height of 433m. Parts of the coastal slope region are very steep and difficult to access. Most of the underlying rock is basalt, mainly in the form of pillows that were formed when super-hot lava cooled under the ocean millions of years ago. The island is unique in that it is the only place in the world where the rocks have formed deep in the oceanic crust. Important geomorphic features include coastal terraces and spectacular steep escarpments, extensive peatlands, sea caves with preserved beach deposits, and river systems. Many of these features are now identified as World Heritage values (DEWHA 2008, PWS 2006).

There are 24 named lakes on the plateau and several named lagoons on the coastal margins. In addition, there are many smaller unnamed water bodies occurring around the island. Most of these smaller water bodies occur in the coastal regions, in the mire environment of the featherbed. Major Lake is the largest lake on the island covering an area of 0.5 km² metres and reaching a depth of 16m. Waterfall Lake, draining onto the steep slopes of Carrick Bay on the west coast is the second largest lake, covering an area of approximately 0.35 km² with a deepest point of 25m. The deepest lake that has been measured on the island is Prion Lake (32m), the third largest in area at 0.3 km² (Selkirk et al. 1990).
The island has an uncorrected planar area of 12,870 ha. Using GIS spatial analyses (Manifold Professional 7.0), the actual area of the coastal slopes was calculated and with this correction the total area of the island was calculated to be 14,630 hectares. See Appendix 1 for maps of the island.

4.2.2 Climate
Due to the island’s maritime location there is little seasonal variation in climate. The temperature is remarkably consistent throughout the year with little variation between winter and summer. The average temperature in January is 7°C, only slightly higher than the average temperature in July of 3.5°C. It can snow throughout the year. While it is not uncommon for snow to fall in January, it generally only settles in winter, and rarely for longer than a week. Temperatures can vary between -10°C in winter and 12°C degrees in summer. The temperature is generally colder on the plateau than at sea level with a drop of around 1°C in temperature for every 100m gained (Selkirk et al. 1990). The mean annual wind speed is around 20 knots but gusts up to 90 knots have been recorded. Winds are strongest in September with August, October, March and April also tending to have above average mean wind speeds and fog (Selkirk et al. 1990, Pendlebury and Barnes-Keoghan 2007).

4.2.3 Research Activity
The island houses a research station occupied by staff from the Australian Antarctic Division, weather observers from the Bureau of Meteorology, researchers from various scientific institutions and universities and PWS staff. Research is conducted under permit from Tasmanian Government agencies. In recent years the winter population has been approximately 13, with numbers increasing to about 35 over summer. Most of the research on the island is conducted under the auspices of the Australian Antarctic Science Program. Field huts are located around the island, linked by a network of walking tracks.

4.3 Natural Values
4.3.1 Geology and soils
Macquarie Island is an exceptional geological feature of international significance. It was listed as a World Heritage site in 1997 partly because of its geoconservation significance. Geologically it is totally oceanic in origin - all rocks have been formed on or beneath the ocean floor. As the geological origin of the island differs from that of other sub-Antarctic islands, so does the landscape and the processes shaping it. Marine erosion processes
have shaped most of the landscape as it has risen above sea level. In contrast, most volcanic islands tend to develop in major explosive events when growth above sea level is very rapid and the only erosive effects occur around the coastal perimeter. Most other sub-Antarctic islands have been eroded by ice action.

A description of the geological features of Macquarie Island and an outline of soil development and types can be found in the Management Plan (PWS 2006).

Lowland peat bogs around parts of the northwest coast may be as deep as 6m and are thought to have formed over the last 5 000 to 10 000 years (Selkirk et al. 1990).

**4.3.2 Vegetation – plant communities and species**

There are no trees or shrubs on the island. The vegetation consists of 45 species of vascular plants - four of which are endemic; over 80 moss species and 50 species of hepatics (liverworts); more than 150 lichen species; at least 127 species of freshwater and terrestrial algae; and over 200 species of macro-fungi. No endemic species of non-vascular plants have been identified to date. There are three alien vascular plant species, two alien species having been eradicated (Copson and Whinam 2001). Grasses and herbs - including several species of megaherbs - dominate the vegetation. There is only one true freshwater aquatic vascular plant, which grows in upland freshwater lakes. Although the rest of the vascular plants are terrestrial, some of the smaller herbs are able to survive in extremely wet or even submerged environments. A full list of vascular plants found on Macquarie Island is provided in Appendix 2.

Vascular plants are distributed on Macquarie Island in a range of different communities. Underlying the formation of these communities is a suite of complex factors that include: available water and drainage; the underlying geology and soil structure; aspect; exposure to weather or salt spray; altitude above sea level; nutrient availability and - more recently - impacts of introduced herbivores. The following communities are recognised today: tall tussock grassland including fernbrake, short grassland, herbfields, mires and feldmark (Selkirk et al. 1990, Parks and Wildlife Service 2006).

Tall tussock grassland is dominated by the large tussock grass *Poa foliosa* and the megaherb *Stilbocarpa polaris*. It occurs on most steep coastal slopes, in sheltered well-drained valleys, and on drier sections of coastal terraces. It is less common in exposed areas with severe wind or in locations where the water table is very high (PWS 2006).
Locally, tall tussock grassland can be dominated by the large fern *Polystichum vestitum*, forming a fernbrake community (Selkirk *et al.* 1990). Tall tussock grassland has been significantly impacted by rabbit grazing to the extent that only local remnants now remain in many areas. Localised patches of fernbrake have been particularly affected.

Short grassland occurs extensively on sheltered upland areas as well as coastal terraces and mid-altitude slopes with moderate to high water table and/or wind exposure (Taylor 1955). It is dominated by species of small grasses and herbs, and has been substantially affected by rabbit grazing in some areas (PWS 2006). Herbfields are dominated by different combinations of the megaherbs *Pleurophyllum hookeri* and *Stilbocarpa polaris*, the woody herb *Acaena magellanica* and the small fern *Blechnum penna-marina*. Herbfields occur on sheltered slopes, flats and valleys to a maximum altitude of 380 metres in sheltered valleys, and on raised coastal terraces (PWS 2006). These communities have been badly damaged by selective rabbit grazing in many areas.

Mires incorporate bogs and fens, communities where the water table is at or near the surface. They occur on valley floors, on the plateau and in small patches on raised coastal terraces, sometimes with peat to a depth of 6m (PWS 2006). On the northwest coastal terraces extensive areas of ‘featherbed’ or quaking mires occur, dominated by bryophytes (Rich 1996). Feldmark is the most widespread vegetation community on the island, occurring on the most wind-exposed areas of the plateau and upland areas, and supporting vegetation dominated by the endemic cushion-forming plant *Azorella macquariensis*, bryophytes and lichens. Vegetation cover varies from less than 5% to over 50% in less exposed sites (PWS 2006), and periglacial and wind effects are the major contributors to the vegetation structure (Selkirk *et al.* 1990). Mires and feldmark vegetation have been locally impacted by rabbit grazing, but not to the extent that tall tussock grassland, fernbrake, short grassland and herbfield communities have been.

Some plant species have undergone significant range contraction or reduced abundance as a result of rabbit grazing. Such species include the tussock grasses *Poa cookii* and *P. litorosa*, large fern *Polystichum vestitum*, orchids *Nematoceras dienemum* and *N. sulcatum*, and the club-moss *Huperzia australiana*. The two species of endemic orchid *Nematoceras dienemum* and *N. sulcatum*, are the most southern orchids in Australasia (Clements *et al.* 2007). In late 2008 these species were classified as eligible for formal listing as threatened species under the *Threatened Species Protection Act 1995* due to threats posed by rabbits. The cushion-forming plant *Azorella macquariensis* is endemic to the island (Orchard 1989), representing the western most extent of the genus *Azorella*. The small grass *Puccinellia*
macquariensis is also regarded as endemic to Macquarie Island (Australian Government Publishing Service 1993), although there are anecdotal reports of it occurring on Campbell Island.

Most of the vegetation communities on Macquarie Island have been impacted by introduced herbivores over the past 130 years (Copson 1984, Copson and Whinam 1998, 2001). An escalation of damage over the past decade has meant that several communities are now substantially damaged and altered throughout their range (Carmichael 2008, Scott and Kirkpatrick 2008, Bergstrom et al. 2009). Several individual species have been listed as threatened or endangered species (Section 3.7.1).

Dieback of Azorella macquariensis has been observed on Macquarie Island since December 2008. Although the causes of dieback are still being investigated and the impact and management of dieback will not be resolved in the short term, interim hygiene and access guidelines are in place to manage the potential human pathways for plant pathogen spread. Further assessment of management responses will be needed as further information on the causes and progression of the disease are available.

The vertebrate pest eradication activities have the potential to cause spread of soil and plant material that may spread Azorella dieback. However as the current distribution of dieback symptoms appear not to be related to human activities it is unlikely vertebrate pest control activities will significantly affect Azorella dieback distribution on the island. Rabbits and rodents may similarly spread soil and plant material acting as vectors for plant pathogen spread. They may also contribute to infection of plants or additional grazing stress affecting plant health. Should rabbit and rodent activity be a contributing factor to the dieback, their eradication may be beneficial in the long term management of the dieback. It is unlikely that rabbits and rodents would reduce dieback pressure on Azorella. The potential for human spread of Azorella dieback may be managed by appropriate hygiene and access prescriptions applied to field activities and this should be kept under review as new information comes to light (T. Rudman and J. Whinam. pers. comm. 2009).

Macquarie Island represents the southern global limit of several vascular plants (Stilbocarpa polaris, Poa cookii, Polystichum vestitum, Isolepis aucklandicus, Carex trifida, Poa litorosa). The importance of species conservation at their range edge has long been recognised (see criteria of the EPBC Act).
Three alien plant species are currently known to occur on the island (*Poa annua, Cerastium fontanum* and *Stellaria media*) and are common and widespread (PWS 2006). All three are early colonisers, and *Poa annua* is a rapid and widespread coloniser of rabbit-damaged areas (Scott and Kirkpatrick 2008). It is predicted that all three species will decline once rabbit disturbance ceases (Copson and Whinam 1998). *Poa annua* disappears within a decade in tall tussock grassland communities in the absence of rabbit disturbance, although it is likely to remain common and widespread in coastal areas that are seasonally disturbed by seals and seabirds (Scott and Kirkpatrick 2008). The current degraded state of much of Macquarie Island’s vegetation makes it potentially vulnerable to the establishment of additional alien plant species (Scott and Kirkpatrick 2008) and detailed quarantine policies and procedures are currently in place to prevent such introductions (PWS 2006).

Some plant species on Macquarie Island may contain unknown concentrations of Vitamin K, a known antidote for brodifacoum. The possibility of target species consuming enough foliage to act as an antidote against the action of the toxin is unknown.

### 4.3.3 Native bird species

Macquarie Island is a haven for seabirds in the Southern Ocean with millions of individuals coming ashore to breed in the summer months. Penguins are the most common seabirds, with four species breeding on the island. Royal penguins (*Eudyptes schlegeli*) are the most abundant penguin with up to a million breeding pairs. King penguins (*Aptenodytes patagonica*) and Rockhopper penguins (*Eudyptes chrysocome*) are the next most common penguin species with 200 000 - 400 000 breeding pairs and >32 000 pairs respectively. King penguins are the only penguins that are present at their breeding colonies throughout the year. Gentoo penguins (*Pygoscelis papua papua*) occur on the island, with around 4 000 pairs breeding in the coastal areas during spring and summer months (DPIW/PWS unpublished data).

Four species of albatross breed on Macquarie Island, with small populations of Wandering albatross (*Diomedea exulans* – approx. 5-10 annual breeding pairs), Black-browed albatross (*Thalassarche melanophrys* – approx. 41 annual breeding pairs) and Grey-headed albatross (*Thalassarche chrysostoma* – approx. 60 annual breeding pairs) restricted to the south-west corner with only a few pairs of Wandering albatross breeding on the flats of the north-west coast. Light-mantled sooty albatrosses (*Phoebetria palpebrata* – 1280 annual breeding pairs) breed on the coastal slopes. Albatrosses are only present on the island between the months of August and May, with the exception of the Wandering albatross chicks that stay
on their nests over the winter months. The Wandering, Grey-headed and Black-browed albatross are all listed as vulnerable under the EPBC Act 1999.

Macquarie Island is home to both Southern giant petrels (*Macronectes giganteus* - 2570 annual breeding pairs) and Northern giant petrels (*Macronectes halli* - 1800 annual breeding pairs) and several species of burrowing petrel, including Grey petrels (*Procellaria cinerea*), Blue petrels (*Halobaena caerulea*), White-headed petrels (*Pterodroma lessonii*), Soft-plumaged petrels (*Pterodroma mollis*), Antarctic prions (*Pachyptila desolata*), Sooty shearwaters (*Puffinus griseus*) and one species of small surface-nesting petrel; the Cape petrel (*Daption capense*). Northern giant petrels are listed as vulnerable under the EPBC Act and Southern giant petrels as endangered. The nesting habitat of many petrels is currently under threat on Macquarie Island from damage caused by rabbit grazing. See Table 1 (below) for a complete list of species and their current status. Appendix 6 provides a map of the location of Burrowing Petrels on Macquarie Island in 2007.

Other seabirds on the island include skua (*Catharacta lonnbergii*), Macquarie Island (Blue-eyed) shag (*Phalacrocorax albiventer purpurascens*), Kelp gull (*Larus dominicanus*) and Antarctic tern (*Sterna vittata bethunei*). Macquarie Island shags are listed as vulnerable and Antarctic terns are listed as endangered under the EPBC Act. Skua, gulls, terns and shags are present on the island all year round. Most skua tend to leave the island at the end of autumn, with only a few individuals over-wintering. Those skua that leave the island start to return in mid-August but most do not return until early September (Jones and Skira 1979, PWS unpublished data).

Bird counts over predetermined routes have been conducted on Macquarie Island in order to gain an estimate of population fluctuations for commonly observed species on an annual basis. These data are presented in Appendix 10.
TABLE 1.
Species found on Macquarie Island; their classification under the Tasmanian Government Threatened Species Protection Act 1995 (TSP Act 1995) and the Australian Government Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act); and the assessed level of potential risk during the eradication program.

<table>
<thead>
<tr>
<th>Scientific name</th>
<th>Common name</th>
<th>Classification</th>
<th>Potential risk to species during program</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>EPBC Act 1999</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Primary</td>
</tr>
<tr>
<td>Mirounga leonina</td>
<td>Southern elephant seal</td>
<td>VU</td>
<td>E</td>
</tr>
<tr>
<td>Arctocephalus tropicalis</td>
<td>Subantarctic fur seal</td>
<td>VU</td>
<td>E</td>
</tr>
<tr>
<td>Aptenodytes patagonica</td>
<td>King penguin</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pygoscelis papua</td>
<td>Gentoo penguin</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Eudyptes schlegeli</td>
<td>Royal penguin</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Eudyptes chrysolobus</td>
<td>Rockhopper penguin</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Diomedea exulans exulans</td>
<td>Wandering albatross</td>
<td>VU, M, Mig</td>
<td>E</td>
</tr>
<tr>
<td>Thalassarche melanophris</td>
<td>Black-browed albatross</td>
<td>VU, M, Mig</td>
<td>E</td>
</tr>
<tr>
<td>Thalassarche chrysostoma</td>
<td>Grey-headed albatross</td>
<td>VU, M, Mig</td>
<td>E</td>
</tr>
<tr>
<td>Phoebetria palpebrata</td>
<td>Light-mantled sooty albatross</td>
<td>M, Mig</td>
<td>V</td>
</tr>
<tr>
<td>Macronectes giganteus</td>
<td>Southern giant petrel</td>
<td>EN, M, Mig</td>
<td>V</td>
</tr>
<tr>
<td>Macronectes halli</td>
<td>Northern giant petrel</td>
<td>VU, M, Mig</td>
<td>R</td>
</tr>
<tr>
<td>Procellaria cinerea</td>
<td>Grey petrel</td>
<td>M, Mig</td>
<td>E</td>
</tr>
<tr>
<td>Halobaena caerulea</td>
<td>Blue petrel</td>
<td>VU, M</td>
<td>V</td>
</tr>
<tr>
<td>Pterodroma lessonii</td>
<td>White-headed petrel</td>
<td>M</td>
<td>V</td>
</tr>
<tr>
<td>Pterodroma mollis</td>
<td>Soft-plumaged petrel</td>
<td>VU, M</td>
<td>E</td>
</tr>
<tr>
<td>Daption capense</td>
<td>Cape petrel</td>
<td>M</td>
<td>-</td>
</tr>
<tr>
<td>Pachyptila belcheri</td>
<td>Slender-billed prion</td>
<td>M</td>
<td>-</td>
</tr>
<tr>
<td>Pachyptila desolata</td>
<td>Antarctic prion</td>
<td>M</td>
<td>-</td>
</tr>
<tr>
<td>Pachyptila turtur subantarctica</td>
<td>Fairy prion (south)</td>
<td>VU, M, Mig</td>
<td>E</td>
</tr>
<tr>
<td>Puffinus griseus</td>
<td>Sooty shearwater</td>
<td>M, Mig</td>
<td>-</td>
</tr>
<tr>
<td>Oceanites oceanicus</td>
<td>Wilson's storm petrel</td>
<td>M</td>
<td>R</td>
</tr>
<tr>
<td>Oceanites nereis</td>
<td>Grey-backed storm petrel</td>
<td>M</td>
<td>-</td>
</tr>
<tr>
<td>Pelecanoides urinatrix</td>
<td>Common diving petrel</td>
<td>M</td>
<td>-</td>
</tr>
<tr>
<td>Pelecanoides geogicus</td>
<td>South Georgian diving-petrel</td>
<td>M</td>
<td>-</td>
</tr>
<tr>
<td>Leucocarbo atriceps purpureus</td>
<td>Macquarie Island cormorant</td>
<td>VU, M</td>
<td>V</td>
</tr>
<tr>
<td>Anas superciliosa superciliosa</td>
<td>Black duck</td>
<td>Mig</td>
<td>-</td>
</tr>
<tr>
<td>Larus dominicanus</td>
<td>Kelp (Dominican) gull</td>
<td>M</td>
<td>-</td>
</tr>
<tr>
<td>Catharacta lornbergi</td>
<td>Subantarctic skua</td>
<td>M</td>
<td>-</td>
</tr>
<tr>
<td>Sterna vittata bethune</td>
<td>Antarctic tern (NZ)</td>
<td>EN, M</td>
<td>E</td>
</tr>
</tbody>
</table>

Note: Royal penguins and Rockhopper penguins will be absent during winter and the aerial baiting phase.
4.3.4 Self-introduced bird species

There are a number of self-introduced bird species on Macquarie Island. It is probable that they arrived via natural dispersal after being introduced to Australia or New Zealand (Copson and Brothers, 2008). Self-introduced species are not considered native to Macquarie Island and include Starlings, Redpolls and Mallard ducks. Many other species such as Grey teal (Anas gracilis) and the Common blackbird (Turdus merula) (Copson and Brothers 2008) have been observed on the island but are considered to be occasional vagrants.

Three main species of duck are present on Macquarie Island and have been described in detail following studies in the 1980s (Norman 1987). Some ducks were introduced for food in the early 1900s, although most are probably self-introduced, finding their way to Macquarie Island accidentally and establishing breeding populations. Mallard (Anas platyrhynchos) and Pacific black ducks (Anas superciliosa) are both found on Macquarie Island and are known to interbreed, producing hybrids that can be difficult to identify in the field.

The established populations of Starlings and Redpolls found on Macquarie Island today are the result of self-introduction, probably via New Zealand. Redpolls feed on seed heads of Pleurophyllum hookeri and Leptinella plumosa. They are well established and are regularly seen around the island in flocks of up to a hundred birds (Copson and Brothers 2008). Starlings also occur in flocks, often in the hundreds, and nest and roost in rock cracks, crevices and caves around the coast. They have been observed feeding on the plateau or in unoccupied penguin colonies during winter (Copson and Brothers 2008).

4.3.5 Terrestrial invertebrate fauna

Terrestrial invertebrates, including insects, are common on Macquarie Island, but were little studied until relatively recently, the first comprehensive survey of invertebrates being conducted in the 1960s. Most survey work has been collated into a comprehensive book by P. Greenslade which should be consulted for more detailed information (Greenslade 2006,
van Klinken and Greenslade 2006). A study in the 1990s sampled a relatively low number of invertebrate species over a short period of time (approx. 6 weeks) across several vegetation communities (Davies and Melbourne 1999).

Insects are the most abundant of all terrestrial invertebrate groups on Macquarie Island and include aphids, thrips, at least five species of beetles, fleas, moths, butterflies, a single species of wasp, one species of booklice and several species of parasitic lice. Lice live on seal, bird and feral animal species. In addition, flies (Dipterans) are the most abundant insects on Macquarie Island with 11 species thought to be present regularly. The most common of this order are the two species of kelp fly, whose larvae live and feed in rotting kelp on the beaches around Macquarie Island.

In addition to insects there are 23 species of Springtails (Collembola) recorded on the island. There are only two terrestrial crustaceans known to live on Macquarie Island, one an isopod and the other an amphipod. Both are thought to have been introduced from New Zealand in the late 1800s or early 1900s. Three species of spider are commonly observed, while the closely related mites and ticks are one of the best represented invertebrate groups on the island with 119 species identified to date. Worms are also well represented with at least 15 species of earthworm identified, three of which are considered endemic and five are probably introduced. Two introduced predatory flatworms occur and are known to negatively impact native worms (Greenslade et al. 2007). There are also two species of terrestrial molluscs known from the island, a tiny endemic snail and an introduced slug.

4.3.6 Marine fauna

Marine fauna around Macquarie Island ranges from small intertidal animals such as molluscs and other small invertebrates that live in the intertidal zone, to the Killer whales (Orcinus orca) that hunt in coastal waters.

The intertidal fauna is best described in terms of the zones it inhabits. In the kelp zone, two species of starfish and one chiton have been found on the east coast. Other intertidal fauna in the kelp zone include at least two species of limpet, one species of holothurian (sea cucumber), a chiton, an anemone and the brightly coloured tiny red bivalve *Lasaea rubra rossiana*. In the lower red algal zone limpets, gastropods, chitons and several species of starfish have been identified. Less commonly occurring in this zone are isopods, amphipods, anemones and the bivalve. The often massive holdfasts of the Antarctic bull kelp (*Durvillaea*...
Environmental Impact Statement

antarctica) host a diverse range of organisms with over 90 taxa. The most common species are isopods, amphipods, gastropods and worms.

4.3.7 Mammals
There are no native terrestrial mammals present on the island. European rabbits, Ship rats and House mice represent the only terrestrial mammals on the island.

Three species of fur seal are present on the island. Subantarctic fur seals (Arctocephalus tropicalis) and Antarctic fur seals (Arctocephalus gazella) breed in small numbers (<200 pups annually) around North Head and occasionally in the south of the island near Hurd Point. New Zealand fur seals (Arctocephalus forsteri) are also present in large numbers around the coast during the summer months, although females are rarely seen. All three species are known to hybridise with each other to a varying degree. There are around 80 000 Southern elephant seals (Mirounga leonina) breeding around the coast with approximately 20 000 pups born each year (McMahon et al. 2005). Although breeding occurs mainly in the spring and summer, moulting animals are present on the island all year round.

4.4 Archaeological Sites
While artefacts of earlier settlements are found around much of the island, the main sites are found on the Isthmus, the Nuggets and Lusitania Bay on the east coast, Hurd Point in the southeast and Caroline Cove in the southwest. Other small sites with one or two artefacts are located on both coasts. Archaeological sites are not considered to be in any way impacted by the proposed activities of this operation.

4.5 Recreational and commercial interests
4.5.1 Recreational values and public access
Macquarie Island Nature Reserve is a restricted area and access is by permit only. Access authorities are issued by PWS to all members of the Australian Antarctic Division expeditions. Recently numbers based on the island have varied between 13 in winter and about 35 in summer, with the management plan restricting numbers on the island to a maximum of 40 (except for resupply periods). All staff use walking tracks and field huts on the island for recreational and scientific purposes. Generally between 500 and 1200 tourists per year visit Macquarie Island between November and March under permit from PWS (see Table 2), although the management plan caps tourist numbers at 750 (PWS 2006). Tourists
are only permitted to land at the main station and at Sandy Bay. No overnight stays by tourists on the island are permitted. Each tourist pays a landing fee that contributes towards funding the management of the island.

**TABLE 2.**
Tourist ship visits and passengers landed 1999-2009

<table>
<thead>
<tr>
<th>Year</th>
<th>Ship visits</th>
<th>Passengers landed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999/2000</td>
<td>4</td>
<td>329</td>
</tr>
<tr>
<td>2000/2001</td>
<td>7</td>
<td>556</td>
</tr>
<tr>
<td>2001/2002</td>
<td>7</td>
<td>371</td>
</tr>
<tr>
<td>2002/2003</td>
<td>4</td>
<td>202</td>
</tr>
<tr>
<td>2003/2004</td>
<td>5</td>
<td>433</td>
</tr>
<tr>
<td>2004/2005</td>
<td>5</td>
<td>303</td>
</tr>
<tr>
<td>2005/2006</td>
<td>10</td>
<td>735</td>
</tr>
<tr>
<td>2006/2007</td>
<td>9</td>
<td>595</td>
</tr>
<tr>
<td>2007/2008</td>
<td>9</td>
<td>617</td>
</tr>
<tr>
<td>2008/2009</td>
<td>14</td>
<td>886¹</td>
</tr>
</tbody>
</table>

¹ This figure does not include approx. 240 tourists who cruised offshore in zodiacs but did not land.

**4.5.2 Commercial values**

Vessels may be licensed by the Australian Government to fish for Patagonian toothfish (*Dissostichus eleginoides*) in the waters surrounding Macquarie Island (beyond the State waters). The eradication operation will not have any impact on commercial fisheries.
5. Environmental Effects and Proposed Management Actions

5.1 Introduction

This section is composed of the following parts:

1. Summary of the known risks of actual and/or potential effects of Phase One (aerial broadcast of brodifacoum using helicopters) and Phase Two (ground hunting rabbits using a range of methods) on:
   a) soil and water quality
   b) non-target native (and non-native) species
   c) human health and community well-being
   d) ecosystems

2. Assessment of the significance of the risks for each of the above at Macquarie Island

3. Discussion of options to manage the risks

4. Identification of proposed management actions to avoid, remedy or mitigate the risk of actual or potential adverse effects.

Brodifacoum is a second generation anticoagulant and is commonly used worldwide as a rodenticide. It works by inhibiting blood clotting mechanisms in the body. In this proposed operation the delivery of the toxin is in the form of a 2-gram bait pellet approximately 10mm in diameter, made from a compressed cereal grain with lure added, and dyed green. The active ingredient concentration is 20 parts per million (ppm). A permit to use this bait has been issued by the Australian Pesticides and Veterinary Medicines Authority (APVMA). Current and future developments in bait production (using the same active ingredient) will be monitored, especially baits designed to be more attractive to mice. Further applications to APVMA will be made if variation from the primary bait is considered to improve the likelihood of a successful eradication.

5.2 Soil and water quality

5.2.1 Potential effects of baits on soil and water quality

Bait will not be deliberately applied to water bodies during the operation. However, the necessity of ensuring comprehensive coverage, the manoeuvrability of helicopters and bait spreading buckets and the irregular nature of marine and freshwater shorelines means that some pellets will inevitably fall into water bodies.
Brodifacoum is almost insoluble in water (<10mg/litre of water at pH 7). Analysis of water samples from Red Mercury Island, New Zealand following the aerial application (See Section 5.3.1), showed no brodifacoum in any water samples, including those taken only one month after the operation (with a limit of detection of brodifacoum in water of 0.0001mg/ml) (Morgan 1993, Morgan and Wright 1996).

When baits are dropped directly into fresh or salt water, localised short-term contamination may occur (see Section 5.3.7), but the toxin will bind to organic matter in the sediment with negligible effects on water quality (Dell Acqua and Pronczuk 1990). Brodifacoum is most unlikely to be found in water even after aerial application of baits for rodent control on offshore islands. The low solubility of brodifacoum coupled with the small amount of bait being laid in the coastal area means the operation poses little risk of adversely affecting seawater quality. Due to low solubility of the toxin in water and the characteristic binding to soil particles, it is extremely unlikely to reach the station water supply by leaching through soil. Trials in New Zealand and the United Kingdom have shown no evidence of the toxin as a free agent in soils and no uptake by plants (Craddock 2004).

The cereal baits to be used in this operation are designed to break down following absorption of moisture from soil or rain. Baits will break down by swelling, cracking, and then crumbling, and are influenced by temperature, humidity, microbial processes and invertebrate activity. Mould and fungi can appear rapidly as breakdown proceeds. Tests have shown that the baits are usually broken down in exposed and grassy sites within about 60 days, as frequently found on Macquarie Island (PWS unpublished report 2005).

Although the cereal component of the bait disappears quickly, the toxin takes longer to break down. While nearly insoluble in water, brodifacoum binds strongly to soil particles, where it is slowly broken down by soil micro-organisms to its base components, including carbon dioxide and water, over a period of 3 to 6 months (Shirer 1992). Invertebrates that ingest soil are likely to have increased exposure to the toxin at this stage. Studies conducted by a chemical company that manufactured brodifacoum, Imperial Chemical Industries (ICI), indicated the half-life in soil varies from 12 to 25 weeks depending on the soil type and temperature.

There are a number of aerial baiting operations in New Zealand where soil and water has been extensively tested following the use of cereal-based brodifacoum baits. Analysis of bait and soil samples from Kapiti Island following an aerial application (14 kg/ha), showed only 10 to 30% of original levels of brodifacoum in bait samples taken 3 months after the
operation (Empson, pers. comm. in Brown et al. 2006). Analysis of soil samples from Red Mercury and Coppermine Islands (northern New Zealand) following rat eradication using brodifacoum showed no residue in any samples, including those taken only one month after the operation (Morgan 1993, Morgan and Wright 1996). Pellet breakdown and soil residues were measured at Tawharanui Regional Park (northern New Zealand) using the same baits as proposed for this project (Craddock 2004). In this study, caged bait pellets were found to completely disintegrate after 110 days in all habitat types. Soil samples from directly below the baits had residues on or below the minimum level of detection (0.02 µg/g) after a maximum of 110 days. However, microbial degradation is dependent on climatic factors such as temperature, and the presence of species that are able to degrade brodifacoum.

Bait trials on Macquarie Island in 2005 indicated that some non-toxic bait pellets weathered and disintegrated substantially over a 6 month period, but in some higher altitude regions, a few pellets were observed to remain in a semi-intact but degraded form for over eight months (see Appendix 3).

Since brodifacoum remains absorbed in soil when baits disintegrate, only the erosion of soil itself would see any brodifacoum reaching water, and even then brodifacoum would remain absorbed in organic material and settle out in the sediment. In studies conducted by ICI less than 2% of brodifacoum added to soil leached more than 2cm in a study where four soil types were tested (World Health Organization Report 1995).

### 5.2.2 Potential Effect of Human and Animal Waste on Soil and Water Quality

Faeces from birds and mammals are already widely spread across all island environments. Recent peaks in the rabbit population on Macquarie Island have resulted in increased incidence of rabbit faeces and carcasses washing into the water bodies, including the water supply dam for the station. Increased bacteria counts have been noted from AAD monitoring, and subsequent treatment of the water supply has been undertaken to ensure potability. Human and dog faeces are unlikely to significantly impact soil and water quality on Macquarie Island due to very low volumes and waste disposal management practices.

### 5.2.3 Management actions to avoid, remedy or mitigate adverse effects on soil or water quality

Spreading bait into either fresh water or seawater during this operation is undesirable on the grounds of operational efficiency and minimising environmental impacts. Bait taken to Macquarie Island will be finite and irreplaceable and thus it is important for the success of
the operation that this quantity is used as effectively as possible on target species. Consequently, there is a strong incentive not to waste any bait by dispersing it into water bodies where it is inaccessible to the target species. However, rat densities are known to be high in coastal areas where they have been frequently observed foraging at night in the inter-tidal zone. It is therefore critical to enhance eradication success by ensuring coastal areas and offshore rock stacks are treated with bait.

The accurate digital mapping of the island’s coastline and the use of experienced pilots will greatly assist in the precise deployment of the baits. This will be done using satellite imagery and cross-checked against known global positioning system (GPS) points on the coastline. A satellite-based GPS system will be used by pilots to ensure that bait is applied within the defined terrestrial area. This will minimise the number of baits dispersed into the sea. Where possible, baits will not be dropped into large freshwater bodies if avoiding them does not compromise the terrestrial coverage. Other techniques to minimise bait swathe and avoid dispersal of bait into water bodies may be utilised to reduce bait spread in unintended areas, including use of bait buckets fitted with ‘skirts’ similar to those used on Campbell Island (McClelland 2001); deflectors that allow baits to be spread in only one direction from the helicopter flight path; by slowing down the bucket spinner; or by using trickle buckets to reduce swathe width.

The very low solubility of brodifacoum in water indicates that the potential to affect any animal drinking sources is extremely low. Minimal quantities of bait pellets are expected to fall into fresh water bodies and those falling into streams will be quickly flushed out to sea.

Baiting of the area above Gadgets Gully Dam (the main catchment area for the station on Macquarie Island) will be undertaken, and although considered an extremely low risk to human health, precautions are proposed to ensure the supply of uncontaminated drinking water for station inhabitants, during and after the aerial baiting operation. The management of the station water supply and catchment will be based on a combination of prevention of bait egress and treatment. Initially the water supply dam will be disconnected and flushed (as part of an annual maintenance requirement). This will be undertaken immediately prior to the first bait drop over the catchment. Following baiting, staff will walk the creek bed from the source to dam and remove any bait pellets that are in the open bed or within 1 metre of the bank, or in areas of bare soil adjacent to the bank, distributing them back at least 1m from the banks of the stream. This action should prevent any pellets from reaching the dam. The water line will then be reconnected after being disconnected for a minimum of one day. This action (disconnect water supply and flush dam) will be repeated for subsequent bait drops.
within the catchment, with the overall goal of preventing pellets from reaching the dam and thus passing into the water supply. Daily checks will be made on the water catchment stream and dam following each bait drop and for a two-week period thereafter, with checks for bait pellets within 1m of the stream and to remove any carcasses that may be in the catchment area. A large enclosure was constructed around the dam and upstream catchment in 2008 to prevent rabbit contamination of the dam and to allow vegetation regrowth in riparian areas. This should have significantly reduced bacterial sources prior to aerial baiting.

Disconnection of the dam for 1-day periods should have a minimal impact on station water supplies as the water supply often freezes for longer periods than this during winter, and station life is adapted around this occurring.

As brodifacoum only attaches to particulate matter, filtration is an additional aspect to mitigate against contamination. The current filtration system for water from Gadget Gully Dam is as follows: water is drawn from the middle of the water column in the dam (so will not extract any floating or sinking material) and is then gravity-fed through a 100-micron screen into storage tanks (where it is batch chlorinated). It is then progressively sand filtered, and finally passes through a 1-micron Hayward bag filter, although mostly nominal rather than absolute bags are used. Absolute bags should be used for the duration of the aerial baiting and for at least three months afterwards. This filtration regime will virtually eliminate any risk of brodifacoum contamination of potable water, given the primary approach is to prevent any toxic material from reaching the water supply line in the first place.

Field hut water supplies on the island will also be managed. Downpipes feeding roof collection areas into rainwater tanks will be disconnected prior to bait-spreading in the area. Pellets that fall onto roof or guttering will be removed, and the roof washed down before downpipes are reconnected. Jerry cans will be supplied to each hut to provide washing down water and an additional water storage capacity. Additional jerry cans will be provided for Bauer Bay Hut, which primarily sources water from ground seepage although a rainwater tank is still present and could be filled before baiting occurs. As with the station water supply, the key management action is preventing pellets from entering the water supply.

The current policy regarding human waste disposal is that no solid human waste is deposited or left on the plateau regions of the island. At the sites planned for temporary field huts on the plateau, no toilet facilities will be provided other than folding toilet stools. All solid human waste will be carried down to the coast for disposal. The same technique was
adopted at the temporary field huts during the five years of the cat eradication project. At
temporary field huts on the plateau, burn drums will be used to incinerate burnable wastes,
primarily to cater for the disposal of bags having been used for human waste; which, for
hygiene reasons, should not be stored for 12 months to await annual waste removal during
resupply operations. Existing coastal field huts will maintain current waste management
practices.

Dog faeces will not be systematically removed from plateau or coastal areas during hunting
operations. Faeces around field huts or plateau areas will be collected when found and
buried locally.

Due to the requirement to cover all accessible parts of the island in the search for remaining
target individuals, cave systems will be covered by searching for signs of any pest species
(as they were during cat eradication, as cats favoured caves for breeding and shelter).
Disruption to soils and sediments on cave floors by rabbits is already extensive. Human
access is not expected to do further damage, however guidelines will be provided to field
staff to mitigate against possible impacts on cave structures, deposits and sediments.

5.3 Non-target species

Aerial baiting of islands to eradicate invasive species is a conservation management tool
increasing in frequency worldwide (Howald et al. 2007). A common feature of this type of
operation is the need to assess whether potential impacts of the operation on non-target
species are outweighed by the expected conservation benefits. In many projects a level of
non-target mortality must be accepted if the overall benefit to the ecosystem is expected to
be greater than the short-term impacts. Generally, eradication of invasive species has
resulted in far greater benefits to island ecosystems than the relatively low incidence of
impacts and risks to non-target species. However each island has specific characteristics
and indigenous species that need to be assessed. It is important to recognise that some
impacts on non-target bird species are anticipated. For each species however, there are
circumstances that suggest that no native species on Macquarie Island should suffer a
significant impact at a population level.

Mortality of vertebrate non-target species can potentially occur through direct ingestion of
baits (primary poisoning) or through ingestion of other animals containing the toxin, such as
dead rodents or rabbits (secondary poisoning). It is acknowledged that this operation will
result in some mortality of non-target native vertebrate species, based on experience from
other brodifacoum-based eradication operations, where numerous species were affected (Eason and Spurr 1995a, Dowding et al. 2006). It is possible that this may include some individuals of species listed as threatened under Australian legislation. Any mortality of non-target species in the short-term is expected to be far outweighed by the increased survival of most populations in the longer term once free of rodent predation and habitat modification by rabbits. Accordingly, Lovegrove and Ritchie (2005) reported that species suffering highest mortality after a bait drop increased to higher levels in the breeding seasons following the operation. In a recent example, in July 2009 it was reported that some Bald eagles and Glaucous-winged gulls were poisoned by brodifacoum during a rat eradication project in 2008 on Rat Island in the Aleutian Islands, but that some seabird species that had not successfully bred there in decades because of rat predation were already beginning to breed on the island (Borrell 2009).

In order to further assess the potential impact of the aerial baiting operation on vertebrate non-target species, bait trials (using dyed non-toxic baits) were conducted in 2005 and 2006 (Appendix 4 and Appendix 7). These trials investigated the response of elephant seals, fur seals, albatrosses, skua, gulls and penguins to baiting distribution. Further trials in 2007 assessed the likelihood of other bird species, such as terns, shags and ducks consuming baits and concluded that with the exception of gulls, none of these species were likely to consume bait. The seasonal cycles of some species of Macquarie Island wildlife are outlined in Appendix 8.

In addition to primary and secondary poisoning there are also potential risks of adverse disturbance to non-target species by helicopters, humans and hunting dogs.

The collection of all carcasses of target species in this operation is not feasible due to the large size of the island and the lack of staff to search for, collect, transport and process carcasses in an effective timeframe. However, where encountered by staff, dead target animals will be removed or buried on-site (as required in the conditions of the APVMA permit). Carcasses of non-target species will be collected wherever practicable.

See Table 1 (Section 4.3.3) for a summary of the assessed risks to non-target species, which are further discussed in the subsequent sections.
5.3.1 Potential for primary and secondary poisoning of birds

A wide variety of seabirds, including a number of threatened species, reside on Macquarie Island. These include burrowing seabirds such as shearwaters, prions and petrels, as well as albatrosses, shags, ducks, terns and penguins. With the exception of Kelp gulls and the opportunistic feeders, skua and Giant petrels, none of the other native species are known to feed on land and it is highly unlikely they will be negatively affected by the baiting operation. Most wildlife will not be present on the island during the proposed time that the aerial baiting will be conducted (May-August), further reducing the risk to non-target species. Secondary poisoning of some predatory or scavenging birds from eating dead or dying rabbits and rodents is probable (and has been reported elsewhere e.g. Eason and Spurr 1995a), but is likely to impact on only some individuals of a very small number of species, with little potential for significant impact to species at a population scale.

Those species considered most vulnerable to secondary poisoning on Macquarie Island include skua, Kelp gulls and Giant petrels.

**Burrowing Petrels**

The only burrowing petrel likely to be present on the island during the proposed baiting operation is the Grey petrel. Diet and feeding behaviour of grey petrels indicate that there is no likely pathway for primary or secondary poisoning of this species or any other Procellariformes that may be present on the island during aerial baiting.

**Kelp Gulls**

Some individual Kelp gulls (also known as Southern black-backed gulls in New Zealand and as Dominican gulls elsewhere) ate small quantities of non-toxic bait presented at gull congregation areas during the trials of 2005 (0-16 of 100 baits available), indicating there is some risk of mortality to this species through primary poisoning (see Appendix 7). Bait densities laid out during the trial (100/10m²) greatly exceeded the densities for the proposed operation (0.6/10m²), indicating a greater number of pellets available in the trial area where gulls congregated, and indicating that gulls would need to forage over a far greater area to consume a similar number of baits in the proposed operation, and a lower likelihood that they will encounter sufficient bait to consume a toxic dose. The trials were not able to determine how many individuals consumed baits – thus not all (if any) gulls that consumed pellets might have consumed a lethal dose. The LD50 (median lethal dose) of Kelp gulls from New Zealand is known to be 0.75 mg/kg (Eason and Spurr 1995a). This species has been affected in other rabbit and rat eradication operations (Rammel et al. 1984, Williams et al. 1986, McClelland 2001), possibly through a combination of primary and secondary
poisoning. The population of Kelp gulls on Macquarie Island is small (approximately 150 breeding pairs), although it is a very common and widely distributed species that breeds throughout sub-Antarctic and temperate latitudes, including the Southern Ocean, South Pacific, southern coastal Australia and New Zealand.

Kelp gulls will occasionally scavenge rabbit carcasses, although they are often out-competed by skua. Despite frequent availability of rabbit carcasses through myxomatosis and skua predation, gulls are not frequently observed as rabbit scavengers. While some individuals are likely to be affected, local population levels are not expected to be seriously impacted through primary or secondary poisoning and overall populations at species level will not be impacted. No mitigation is proposed for this species as any losses are likely to be small, localised and the population should naturally recover from any mortality. For example, Kelp gull populations on Campbell Island were estimated to have quickly recovered to pre-rat eradication levels following aerial baiting in 2001 (McClelland pers. comm.).

Subantarctic skua
Skua showed no inclination to directly consume baits during bait trials in 2005 (see Appendix 7) or subsequent observations in 2006 when skua were presented with bait (PWS video footage). Bait was presented to skua on a number of occasions at different locations around the island. In none of these cases were skua ever observed to pick up or ingest baits. Skua did not appear to associate the baits with anything of interest to them and only a cursory glance was given to any bait in their vicinity.

Skua numbers remained comparable before and after a brodifacoum poisoning operation on Hawea Island (Eason and Spurr 1995a & b). In contrast, some skua on Enderby Island died after directly consuming bait following an aerial broadcast of brodifacoum, although it was thought to be because they increased their interest in the bait over subsequent bait drops (Torr 2002). As skua from Macquarie Island were not observed to directly eat bait at any time during the 2005 trials (or further ad hoc trials in 2007), the risk to skua from primary poisoning in this operation is considered to be very low, especially as most skua will be absent from the island during the baiting period.

Eason and Spurr (1995a) considered skua to be among species that might be at risk from eating mammals that had ingested toxic baits. Mortality of skua has been known from consumption of anticoagulant toxins ingested by their prey, such as on Enderby Island (Torr 1999). Rabbits are primary prey species for skua on Macquarie Island. Skua have learnt that rabbits are much easier to catch and kill when infected with the myxoma virus and thus
move in very quickly on sick or slow-moving rabbits. Accordingly, the risk to skua from secondary poisoning is considered to be moderate to high for over-wintering individuals. A large proportion of the Macquarie Island skua population (estimated at > 98%) leave the island at the onset of winter and do not return until spring to breed (Jones and Skira 1979). Schulz and Gales (2004) estimated the overwintering skua population at fewer than 20 individuals, with maximum monthly winter congregations ranging from three birds in July to seven in August. It is believed that skua did not habitually over-winter on Macquarie Island before increasing rabbit populations provided a sufficient food source for some birds to do so.

As bait-dropping is scheduled to conclude by late August on Macquarie Island, the majority of rabbit or rodent carcasses will be quite decomposed by the time most skua return in September. Therefore the risk of skua scavenging and consequent secondary poisoning is reduced (considering that >95% mortality of rabbits and 100% mortality of rats is anticipated from the first bait drop in June). In an operation of comparable scale on Campbell Island targeting rats only, skua by-catch was avoided entirely by completing the aerial operation before the post-winter return of most birds (McClelland 2001). Due to the much higher biomass of dead animals, it is unlikely that this will also be the case on Macquarie Island, although the timing should significantly reduce the number of cases of secondary poisoning.

The risk to the overall skua population is considered to be low, because only the small number of over-wintering birds (<20) should be at risk of secondary poisoning (Schulz and Gales 2004). It should also be noted that the skua population on Macquarie Island is at a much higher level than if rabbits were not present as an additional food source (Jones and Skira 1979; Skira 1984). A 2004-2005 skua breeding survey found that increased rabbit numbers have allowed the island skua population to reach its highest recorded level with an estimated 580 pairs breeding around the island (Carmichael 2008). A 2008 survey indicated that the island skua population remains at a similarly 'inflated' level because of high rabbit numbers (McInnes et al 2009). The eradication of rabbits is likely to result in an immediate reduction in skua breeding success due to the greatly reduced prey-base, consequently skua numbers are expected to reduce naturally in the aftermath of a successful rabbit eradication project, although skua can be expected to place additional predation pressure on burrow-nesting seabirds in the first seasons following aerial baiting due to the lack of rabbits to feed offspring.

The symptoms of brodifacoum poisoning take some time to manifest, and rabbits (and rats) are likely to increasingly stay in their burrows with the onset of symptoms until death occurs.
This was observed in an operation in the Canterbury Province in New Zealand where rabbits that had died of brodifacoum poisoning were difficult to find as most died undercover or underground (Williams et al. 1986), a similar finding to Crosbie et al (1986); who found that the majority of brodifacoum-poisoned rabbits on Whale Island died under cover, reducing the risk of secondary poisoning to aerial predators. After bait application in the Bay of Islands (Alaska) in 2006, 88% of rodent carcasses recovered were found underground or in burrows (Alaska Maritime National Wildlife Refuge 2007), with a similar result found after a recent rat eradication in the Aleutian Islands in October 2008 (S. Buckelew pers. comm. 2008). If the majority of rabbits and rodents die in burrows, fewer poisoned carcasses are available for scavengers, significantly reducing the incidence of secondary poisoning. Rodents are also likely to die in their nests, although some can be expected to be found in the open.

The re-colonisation of the coastal slopes and large parts of the plateau by tussock grassland following rabbit eradication will benefit burrow nesting seabird species twofold, firstly through a reduction in skua predation effectiveness due to increased vegetation cover around burrows, and secondly through the recovery of degraded breeding habitat. The 'deflation' of the island skua population should benefit species such as Antarctic Prions (Pachyptila desolata), White headed petrels (Pterodroma lessonii), Blue Petrels (Halobaena caerulea), Sooty shearwaters (Puffinus griseus), Grey petrels (Procellaria cinerea), Fairy Prions (Pachyptila turtur), Soft-plumaged petrels (Pterodroma mollis) and Common Diving petrels (Pelecanoides urinatrix) (Carmichael 2008).

Wandering albatross
There was some evidence that Wandering albatross chicks moved baits that landed near nests, and possibly ingested pellets during preliminary bait trials in 2005 (see Appendix 7). During further trials in 2006 no evidence of chicks ingesting baits was found. Nevertheless, due to the extremely low breeding numbers on Macquarie Island and its Critically Endangered status, a precautionary approach will be taken with this species and comprehensive on-ground measures will be put in place to ensure that chicks do not have access to baits. Due to the winter timing of the aerial baiting there will be no other albatross species present on Macquarie Island during the aerial baiting operation.

Penguins
The only penguin species that will be present on Macquarie Island during the aerial baiting operation are King penguins and Gentoo penguins. During the 2005 bait trials, the response of King penguins to the bait was assessed by tossing baits at and near both adults and chicks during the winter months. Baits were placed directly at the feet of birds and also in the
path of birds walking around the beach. The responses of individual birds (adults and chicks) were then observed. On two occasions chicks leaned forward to look at the ground when the thrown baits landed at their feet, but took no further interest in them and appeared not to have noticed them once baits had settled; on all other occasions both adults and chicks completely ignored the baits. Where baits were placed in the path of wandering groups, no response to the baits was observed. Because King penguins feed exclusively at sea on euphasiids and fish, it can be expected that they would not associate bait pellets with food items. The risk to the King penguin population or individuals from primary poisoning has been consequently assessed as non-existent to very low (see Appendix 7).

Gentoo penguins are found around the island year-round in small groups. Unlike the other penguin species found on Macquarie Island, they do not breed in closely packed colonies, but occupy more sparsely populated and mobile breeding areas. Like King penguins, Gentoo penguins feed at sea on marine life and trials demonstrated that Gentoo penguins showed no interest in baits when presented with them. The risk to Gentoo penguins from primary poisoning has also been assessed as non-existent to very low.

**Macquarie Island shags**

The response of Macquarie shags was tested in a PWS trial on Macquarie Island in 2006 using non-toxic baits. Approximately two kg was spread around some roosting birds on the edge of a colony about 10m from nesting birds. Some of these birds were juveniles, while others were adults in full breeding plumage. The site was watched for about two hours after the bait had been spread. In the first 10 minutes, approximately 15 non-breeding birds closest to the site walked through the bait. Three of the birds picked up the bait before dropping it again, the others ignored it. None of the bait was consumed. After some initial curiosity, birds at the site ignored the bait. Over the two hour period, 28 new birds arrived at the site including juveniles and adults in breeding plumage. Most walked through the area and were not interested in the bait. However about six birds did pick bait pellets up, but again none were consumed. Some of the birds walking through the site picked up baits and attempted to incorporate them as nesting material. The risk to Macquarie Island shags from primary poisoning is assessed as non-existent to very low.

**Giant petrels**

Limited bait trials in 2007 were conducted to specifically assess the risk of primary poisoning to Giant petrels. Fifty baits were spread in clusters of five in a location that had high numbers of both Northern and Southern Giant petrels. The Giant petrels in the area dispersed when the baits were scattered and several returned soon afterwards, some sitting amongst the
baits. None of the Giant petrels showed any interest in the baits at any time during the 40 minutes of observation and the baits do not resemble any of a Giant petrels’ normal food items. The risk to Giant petrels from primary poisoning is assessed as non-existent to very low.

Giant petrels largely feed on carrion in the coastal environment, primarily dead seals and dead and injured penguins. Unlike skua, Giant petrels do not actively hunt rabbits; however individuals have been occasionally observed feeding on dead rabbits, placing them at potential risk from secondary poisoning. Giant petrels have had opportunities to encounter high numbers of dead rabbits over the years as myxomatosis has killed rabbits, but have not learned to rely on these as a food source in the same way that skua have. Both Southern and Northern Giant petrels are present on Macquarie Island throughout the year. While a proportion of the population disperse from the island during the winter months, significant numbers are likely to be present on the island during the proposed baiting operation. Giant petrels are large birds and would need to consume significant quantities of toxic tissue to receive a lethal dose. However some Giant petrels could be expected to consume poisoned rabbits, especially around coastal areas, suggesting a low to medium risk of secondary poisoning at a population level. The reduced number of Giant petrels at the time of year that baiting is proposed, together with their tendency to feed more on coastal carrion than search for food inland, make it unlikely that the impact of the baiting operation on the populations of these two species will be significant, although some impact at an individual level can be expected.

Ducks
Black ducks are found throughout the Pacific, New Zealand and Australia in three subspecies. Trials to comprehensively determine palatability of baits to Black ducks proved difficult due to their timid nature (no distinction was made in the trial between Black and Mallard ducks, or Grey teal which may occasionally be found on Macquarie Island). However, camera trials using remote sensing triggers recorded ducks by-passing or feeding adjacent to bait pellets and demonstrating no interest in them. Whilst acknowledging the limited nature of trials, there is nothing to suggest that ducks would consume baits directly and the risk of primary poisoning may be related to the potential for dabbling ducks to inadvertently consume disintegrated pellets in small water bodies. Under this scenario, the toxin would be in minute quantities and ducks would need to consume large amounts of matter to get a small exposure to poison. Given the known foraging behaviour of ducks (Norman 1987) and the relatively low susceptibility of ducks to brodifacoum (LD50 of mallards 4.6 mg/kg – Eason and Spurr 1995a), the risk of primary poisoning of these species
is assessed as low. One duck was known to have been killed during the Campbell Island rat eradication (P. McClelland *pers. comm.*).

*Redpolls, Starlings and vagrants*

Even though the risk is considered to be lower in smaller birds, there has been recorded mortality of passerines (including Redpolls) and other birds in other island eradication operations (Eason and Spurr 1995a, Lovegrove and Ritchie 2005). It is therefore possible that two of the most common non-native bird species - Starlings, and to a lesser extent Redpolls, may eat crumbs of bait and be affected by primary poisoning. However, these impacts are likely to be very small, and as these introduced species do not form a unique part of the islands’ fauna, it is extremely unlikely that there will be any net negative effect on the island ecosystems. Neither species were observed consuming bait during trials on Macquarie Island, and Lovegrove and Ritchie (2005) reported increased Starling numbers after an aerial poisoning operation using brodifacoum in New Zealand.

Some vagrant species have been identified at Macquarie Island, including Marsh harriers (*Circus approximans*) (Copson and Brothers 2008). The concern for vagrant species during the eradication project is low as recording sightings have been very sporadic and all vagrant species are common elsewhere. Due to the sporadic nature of vagrants, there is a strong likelihood that none will arrive on Macquarie Island during aerial baiting.

*Potential for secondary poisoning through invertebrate ingestion*

Kelp gulls and Starlings have both been observed eating terrestrial invertebrates. Secondary poisoning of these species through eating insects is considered unlikely. Soil invertebrates may be affected by the toxin but laboratory studies show that many invertebrates are unlikely to accumulate brodifacoum as it is eliminated quickly through metabolism and/or excretion (Morgan *et al.* 1996). In addition, the concentration of brodifacoum found in invertebrates collected after poison operations has been low, indicating that very large numbers of contaminated invertebrates would need to be consumed in a relatively short period to cause mortality (Morgan and Wright 1996). No invertebrates were found to have traces of brodifacoum following baiting operations on Stanley Island and Red Mercury Island (Towns *et al.* 1993, Morgan and Wright 1996). The chances of secondary poisoning are further reduced by the operation being carried out in winter when fewer invertebrate species are active. However, there is a documented case of birds in zoos being poisoned through ingestion of pavement ants that had fed on brodifacoum baits (albeit not in sub-Antarctic locales), so the possibility cannot be fully discounted. In addition, some New Zealand
dotterels died after consuming sandhoppers that had ingested bait on the shoreline at Tawharanui Regional Park, New Zealand (Dowding et al. 2006), although there are no shoreline-foraging bird species on Macquarie Island as are found in some New Zealand operations.

5.3.2 Potential effects of helicopter operations on birds
Interactions between penguins and aircraft, especially helicopters, have been the subject of studies in Antarctica and South Georgia (e.g. Giese and Riddle 1999, Hughes et al. 2008). Antarctic Treaty nations have developed guidelines to minimise disturbance to penguin breeding colonies. King penguins remain resident and breeding on Macquarie Island throughout the winter months and are considered susceptible to disturbance from low flying aircraft. King and Gentoo penguins are the main species present on the island during the proposed time of the operation that are likely to be potentially affected by helicopter operations. King penguins have an 18 month breeding cycle (Appendix 8). Giant petrels may also potentially be affected by helicopters, although their behaviour during annual resupply operations when in the vicinity of helicopter operations suggests that impacts will be minor and localised.

A study was conducted in April 2007 to determine the responses of King penguins to helicopter over-flights at various altitudes. The following paragraphs summarise the findings. The document “King Penguin Helicopter Over-Flight Disturbance Trials - Interim Report, Macquarie Island April 2007” (Giese et al.) is included in Appendix 5 and should be consulted for full details. The over-flight trial was repeated during March 2008 with controlled and observed over-flights at Green Gorge, Sandy Bay and Lusitania Bay King penguin colonies. The 2008 trials confirmed the results of the 2007 trials, with flights to 500 ft having a minor and transitory impact. King penguins are considered more likely to be at risk of harm from helicopter disturbance than Gentoo penguins, because they typically form in larger and denser colonies and may stampede, causing significantly greater impact compared to the more widely spread out and smaller Gentoo groups.

Part B - Operational Plan recommends a helicopter altitude for bait deployment between 300 and 500 ft. In April 2007, the behavioural responses of the birds to over-flights at altitudes from 1500 to 500 ft were filmed on four video cameras from vantage points at each of two King penguin colonies at Green Gorge and Sandy Bay. Based on these observations, significant behavioural responses by the King penguins were evident when helicopters flew at altitudes of 1200 ft and lower. Adult penguins that were not in close proximity to chicks
displayed the most marked responses. These birds, at the periphery of the colonies, showed marked displacement expressed by walking away from the direction of the helicopter approach. The 2008 trial confirmed the findings from 2007

Adult penguins within the colonies showed less marked responses to helicopter disturbance although both adults and large chicks moved in responses to helicopters flying overhead at altitudes of 900 ft and below. Over-flights at both 600 and 500 ft were observed to cause movement by birds within the colonies, although no adults that were brooding small chicks were observed to move when the helicopter flew overhead, even at 500 ft. No penguins were observed running or engaging in ‘stampede’ behaviour in response to helicopters. The responses that were observed, whilst significant, were not considered to cause long-term disruption to breeding adults or chicks, and their responses were considered to be minor and transitory in nature.

In the absence of any habituation that may occur, the responses by the penguins, whilst unacceptable if the aircraft operations were to be on-going and regular, are considered acceptable within the context of the eradication plan. To reduce impacts on King penguin colonies, helicopter pilots will be instructed to fly at a spreading altitude of 500 ft (160 m) when operating within 1000 metres of any King penguin colony perimeter, as long as this does not compromise the primary imperative of ensuring accurate bait distribution and coverage. The use of experienced pilots who understand how to turn their aircraft to minimise noise will also greatly assist in reducing disturbance to King penguins. A small number of over-flights at 1000 ft will be made over King penguin colonies to familiarise penguins with helicopter noise prior to baiting. Helicopters will not spread bait in windy conditions over king penguin colonies due to the risk of wind affecting the bait swathe from the greater altitude required to minimise king penguin disturbance.

There are expected to be 10 King penguin colonies present during the winter of 2010, all on the east coast of Macquarie Island. See Table 3 for number of chicks in these colonies in 2007 and 2008. All major King penguin colonies will be filmed by ground observers during aerial baiting operations around the colony, with observers in radio contact with pilots to advise on observed disturbance and request corrective action as required. Should there be significant adverse reactions by King penguins, mitigation strategies will be implemented including increasing the altitude of helicopters or increasing the duration between flights near the colony.
TABLE 3.
Estimated number of chicks and adults at King Penguin colonies in 2007 and 2008

<table>
<thead>
<tr>
<th>Colony Name</th>
<th>No. of chicks 2007</th>
<th>Estimated No. of adults 2007*</th>
<th>No. of chicks 2008</th>
<th>Estimated No. of adults 2008*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gadgets Gully</td>
<td>236</td>
<td>708</td>
<td>274</td>
<td>822</td>
</tr>
<tr>
<td>Sandy Bay</td>
<td>2661</td>
<td>7983</td>
<td>2618</td>
<td>7854</td>
</tr>
<tr>
<td>Green Gorge</td>
<td>936</td>
<td>2808</td>
<td>957</td>
<td>2871</td>
</tr>
<tr>
<td>South of Waterfall 1</td>
<td>2563</td>
<td>7689</td>
<td>2065</td>
<td>6195</td>
</tr>
<tr>
<td>South of Waterfall 2</td>
<td>999</td>
<td>2997</td>
<td>624</td>
<td>1872</td>
</tr>
<tr>
<td>Series of colonies to North of Lusitania Bay</td>
<td>6700</td>
<td>20100</td>
<td>8677</td>
<td>26031</td>
</tr>
<tr>
<td>Old Lusitania Hut</td>
<td>3086</td>
<td>9258</td>
<td>2451</td>
<td>7353</td>
</tr>
<tr>
<td>4 Waterfalls Bay</td>
<td>540</td>
<td>1620</td>
<td>522</td>
<td>1566</td>
</tr>
<tr>
<td>Below Mt Jeffries</td>
<td>2283</td>
<td>6849</td>
<td>1957</td>
<td>5871</td>
</tr>
<tr>
<td>Single chick near Gentooos</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Five chicks south of single chick</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>15</td>
</tr>
<tr>
<td>Lusitania Bay</td>
<td>58709</td>
<td>176127</td>
<td>42540</td>
<td>127620</td>
</tr>
<tr>
<td><strong>Total number counted</strong></td>
<td><strong>78714</strong></td>
<td><strong>236142</strong></td>
<td><strong>62691</strong></td>
<td><strong>188073</strong></td>
</tr>
</tbody>
</table>

* Estimated number of adults calculated by multiplying No. of chicks by 3. It has previously been estimated that each chick represents 3 adult birds, as breeding pairs have two chicks every 3 years (Achurch 2007). This causes an underestimate as eggs and chicks may have been lost before the chick counts were conducted (Achurch 2007).

Due to the more mobile and scattered nature of Gentoo penguins, no specific altitude requirements are proposed for flying over coastal areas that may contain Gentoo penguins.

There is potential for helicopter activity to disturb winter aggregations of Giant petrels. Although Giant petrel numbers decrease slightly between April and August, winter aggregations of both species do occur. Large numbers of Giant petrels (>200) remain along the coast in aggregations usually associated with King penguin colonies. Southern giant petrels may also remain in the vicinity of summer breeding colonies, including two plateau sites (Waterfall Lake and Amphitheatre). Given their proximity to King penguin colonies, the majority of Giant petrel aggregations will benefit from mitigation strategies outlined above for King penguins. These strategies may also be applied, if deemed appropriate, at Southern giant petrel colonies and other major winter aggregation areas. Mapping of winter Giant
petrel aggregations (coastal and plateau colonies) will be provided to helicopter pilots prior to baiting operations. The main form of disturbance is likely to be from helicopters flying overhead while spreading bait and causing Giant petrels to take flight. This impact is considered to be relatively minor because of the minimal time likely to be involved during the aerial baiting. Giant petrels are likely to circle and resettle quite promptly. A similar degree of disturbance is apparent during annual field hut resupply operations when helicopters are resupplying huts where there are nearby congregations of Giant petrels, such as at Green Gorge, Hurd Point and Bauer Bay. While the scale of aerial baiting operations is larger, the type of impact is likely to be less because bait-spreading helicopters are not reducing altitude to land as those resupplying huts are.

Helicopter disturbance of Grey petrels is not expected. The chicks are in burrows through the winter months and are unlikely to be exposed to either baits or helicopter disturbance. Adult birds generally depart and return to the island at dawn and dusk and are thus absent from the island during helicopter operating periods.

Helicopter disturbance of other Macquarie Island bird species is not expected to be significant due to the operating level of the helicopters and the sporadic occurrence of species such as terns and shags. Pilots will need to be aware of the location of wandering albatross nests and be observant to the possible presence of adult birds returning to feed their chicks.

5.3.3 Potential adverse effects on birds of hunting with dogs

Dogs have been under training from July 2008 for deployment to Macquarie Island in late winter of 2010. A significant part of the training, in terms of both duration and cost, is the training for aversion to non-target species. Dogs are trained to be absolutely obedient and to be averse to the scents of any animals other than rabbits. The dogs undergo two levels of assessment based on criteria developed specifically for this project, and are certified by the Project Dog Training Coordinator before they are considered to be at the standard required for use on the island.

The training standards for these dogs should ensure that impacts of dogs on native wildlife are minimal. Dogs trained to hunt cats were used on Macquarie Island from 2000 - 2003. These highly trained dogs were not responsible for any impacts on native birds, and their dog handlers considered that dogs did not interact with or have a disturbing effect on native wildlife (S. Robinson, S. King pers. comm. 2008). The need for hunters to travel through or
near penguin colonies may cause temporary disturbance, but these impacts are expected to be minimal, based on previous experience on Macquarie Island.

The standards for dog training developed for the current proposed operation are more stringent than those applied for the use of dogs from 2000, and include aversion to birds. With no observed impacts from the use of dogs during 2000 - 2003, these more stringent dog training standards are likewise anticipated to result in no disturbance to native wildlife.

Hunters and dogs will potentially put extra pressure on burrowing bird habitat with increased foot traffic through some areas and the potential for burrow collapse. The benefits arising from the eradication of rabbits and rodents are likely to far outweigh these potential negative impacts, which will be limited through education of hunting teams; identification of burrowing petrel colonies; adoption of appropriate techniques for working in those areas and briefings on sensitive wildlife areas. Hunters will be required to work their dogs in a manner that avoids undue disturbance to wildlife.

5.3.4 Potential adverse effects on non-target species of ground hunting techniques

In Phase Two of the project, a number of hunting techniques will be employed to complete rabbit eradication, following the initial reduction of the rabbit population through poisoning. These techniques include shooting, spotlighting, trapping, netting, burrow fumigation or burrow excavation.

In addition, other toxins may be considered for localised use to target rabbits. If used, only toxins already registered by APVMA for the purpose will be used (e.g. Pindone), with an assessment of the proposed bait delivery for the specific situation. Alternatives may be considered if the bait delivery method offers benefits that may attract rabbits to consume baits when they have not consumed brodifacoum pellets. An example would be the use of Pindone (a first generation anticoagulant widely used in Australasia for rabbit control) on irradiated carrot bait. Impacts on target species are considered to be consistent with those for brodifacoum. Any such use would be considered to be for localised and specific situations only and not for widespread use.

Fumigant tablets will be available for field staff to kill rabbits during Phase Two of the project. This technique is expected to have very little impact on non-target species. It involves the generation of phosphine gas from an aluminium phosphide tablet. The gas will only be used when a rabbit has been observed to go down a burrow and the hunter or dog handler
assesses fumigation as the best method to ensure the death of the rabbit. Accordingly, its use is expected to be very limited. A small risk is that rabbits are occasionally known to share burrows with burrowing petrel species (endoecism). While relatively rare, it is possible that a fumigated burrow may contain an individual of a native petrel species which is likely to die along with the targeted rabbit. To reduce the potential for unintended petrel mortality, this technique will not be used in burrows where signs of bird occupancy are apparent, such as feathers, down or faeces in the burrow entrance. Fumigant tablets were used in eradicating cats from Macquarie Island and no recorded instances occur of petrels suffering mortality from burrows fumigated for cats. Any instances of petrel mortality will be recorded.

Burrow fumigation will be used in situations where a rabbit has been observed to go underground and the burrow entrances can be clearly identified. Burrow entrances will be closed following insertion of an aluminium phosphide tablet, which releases toxic phosphine gas when moistened. This is a widely used technique for rabbit control throughout Australia and is considered a humane method. In some cases burrows may not be suitable for fumigation and hunters may decide to excavate the burrow instead, killing the rabbit by cervical dislocation once found. Where fumigated rabbit burrows have been excavated to retrieve rabbit carcasses, the soil will be replaced in the hole and turf layers placed on top, restoring the site as much as possible. The overall impacts of excavating burrows and refilling them are anticipated to be insignificant in the context of the large-scale damage done by burrowing rabbits across the island, especially as the use of this technique is anticipated to be very limited.

Care in the use and placement of leg-hold traps is expected to result in minimal impact on non-target species. Unlike the extensive trap lines utilised in the cat eradication project on Macquarie Island (which caught rabbits and skua as well as other non-target species), all trapping in this project is expected to be small in scale and will only target individual rabbits, usually by placing traps buried in burrow entrances. Roaming animals are therefore unlikely to be caught in traps. Because of the limited use of traps, the tight focus on trapping individual animals, and the known propensity for rabbits to escape from soft-jawed leg-hold traps, a permit will be sought to use steel-jawed traps for this project. If this cannot be obtained then permission to use soft-jawed traps will be sought, although these are less efficient and involve a higher risk of eradication failure. Traps will be checked within 24 hours of being set, although often more frequent checking will be feasible. Where possible a double-set will be used to minimise the risk of escape from the trap.
Spotlighting is expected to be a major component of the field work in both locating and eliminating surviving rabbits. Spotlighting is generally low-impact on non-target species although two areas of concern have been anticipated. Firstly, large numbers of burrow-nesting petrels and prions are active at night and may be drawn to light beams used for locating rabbits. Disorientation of some birds is possible in this circumstance and care will need to be exercised by field staff to keep light beams as horizontal as practical in searching for rabbits. Secondly, penguins may be disturbed by spotlight beams and in densely packed colonies over summer, a stampede reaction could have serious consequences. Field staff will be instructed to minimise the use of spotlights around penguin colonies.

Other techniques (or adaptations of existing techniques) may be utilised in this project as new products, techniques or methodology come to hand, for example rabbit long-nets can be used to encircle a warren or known habitat and net rabbits which are flushed from cover by hunters. Where such use is considered, prior permission to use alternative methods may be required from land management and animal welfare bodies, and best practice deployment methods will be followed. In addition, consideration of potential non-target species impacts will be required in each case.

Shooting is expected to be a valuable technique in hunting surviving rabbits. The primary rifle calibre to be used is the .17 HMR. A small number of .223 calibre rifles and 12 gauge shotguns will also be used. While shooting is expected to account for the majority of rabbits surviving baiting, the numbers are expected to be relatively low. For example, if the winter rabbit population is 50,000 and 95% are poisoned, about 2,500 rabbits may survive across the 12,800 ha island. On average, this is a density of approximately 1 rabbit per 5 hectares. This is far below the number of rabbits shot annually in the past during control operations, where several thousand have been shot annually within a relatively small part of the island.

Permission will be sought to use sound moderators on firearms used for hunting rabbits. The primary reason for this is to ensure that rabbits in groups are not alarmed by the sounds of a shot, and to allow other rabbits in the group to be targeted. A further advantage is that firearms can be used within closer range of wildlife colonies without disturbing wildlife by the sound of a shot.

A number of areas on Macquarie Island have been designated as Special Management Areas (SMAs), to reflect the concentrations of wildlife breeding there and to minimise disturbance during breeding seasons. While these areas will be accessed by field teams
hunting rabbits, additional briefings will be conducted to ensure that hunters conduct hunting operations to minimise disturbance in sensitive areas.

5.3.5 Potential for primary poisoning of terrestrial invertebrates
Most invertebrate species are not considered at risk from brodifacoum poisoning as invertebrates have a different blood clotting system to vertebrates (Shirer 1992). A number of recent studies in New Zealand have confirmed this to be the case (Eason and Spurr 1995b, Morgan et al. 1996, Spurr 1996), although some toxicity from brodifacoum poisoning has been observed. While the insolubility of brodifacoum makes the pathway for toxin exposure a relatively low risk for many invertebrate species, trials in New Zealand (Craddock 2004) and on Macquarie Island (PWS unpublished report) have shown invertebrates consuming bait. It is therefore likely that some surface invertebrates will ingest baits and excrete or retain a level of brodifacoum. In addition, soil-ingesting invertebrates may consume brodifacoum that has bound to soil particles in the 2-3 months period following aerial baiting.

5.3.6 Potential for primary poisoning and helicopter disturbance of marine mammals
Fur seals and elephant seals will be present on Macquarie Island in small numbers during the proposed baiting operation. The responses of elephant seals and fur seals were observed during non-toxic bait trials in 2005 (see Appendix 4). While fur seals were momentarily disturbed by the bait drops (the reaction was described as being the same response as when hail showers occurred), they did not ingest baits directly and, as none of their prey (primarily fish and squid) are likely to be poisoned, secondary poisoning is not considered possible. Southern elephant seals displayed even less interest in baits falling around them and they also showed no interest in directly consuming baits. Similarly, any New Zealand sea lions present on the island would be unlikely to be affected by primary or secondary poisoning. In trials on other islands prior to rat eradication operations, non-toxic baits presented to sea lions were almost totally ignored and no interest in eating them was displayed. Leopard seals are occasionally present on Macquarie Island in very small numbers and are likely to have a response similar to that of elephant seals. New Zealand sea lions and leopard seals are only occasionally visitors and do not breed on Macquarie Island.

The impact of helicopters on seals is likely to be transitory and minimal. Previous resupply operations on Macquarie Island suggest that while seals are momentarily disturbed by helicopters, there appear to be few, if any long term impacts, particularly during the winter
months. Macquarie Island has been resupplied by helicopters ferrying supplies from ship to shore for several decades, with nearly all helicopter flights occurring at a low level over concentrations of elephant seals, with no unacceptable adverse response recorded. Accordingly, disturbance or poisoning impact of marine mammals is anticipated to be non-existent to very low.

5.3.7 Potential adverse effect of baits on fish and other aquatic fauna

It is not the intention of this operation to place baits in the marine environment, but as baits are to be spread over the island to sea level, it is inevitable that some bait will enter this environment due to the irregular coastline of the island and the swathe width of bait buckets. Based on estimates drawn up for the Kapiti Island rat eradication, the amount of toxin deposited into the marine environment will be significantly lower than the lethal limits known to be toxic to some fish species (Empson 1996). It is possible, although unlikely, that some marine fish will consume whole baits before breakdown occurs. However, due to the amount of bait presented, no species is considered to be at risk at a population level. A study of marine fish undertaken during the Kapiti Island rat eradication found no evidence of reduced fish populations (Cole and Singleton 1996).

A single 2g Pestoff 20R bait pellet (the size planned to be used on Macquarie Island) contains on average approximately 0.00004mg of brodifacoum. At application rates of 16 kg/ha, the dispersal of the bait means, on average, a single pellet of bait will fall in every 2.3 m² of surface area of the island. To reach the Food Health Standards limits for safe human consumption, a theoretical 1 kg fish would have to consume 24 or more baits. At the rate that baits will be sown in this operation, it is unlikely that a single fish could physically encounter that many baits, or consume sufficient baits before water or wave action disintegrates the baits and disperses the toxin. Furthermore, testing of mussel samples from marine farms following an aerial baiting operation at Kaikoura Island (NZ) in October 2008 showed no traces of brodifacoum (Ritchie pers. comm.)

The rapid breakdown of the pellets should further reduce the risk to marine and freshwater fauna. As brodifacoum is nearly insoluble in water its direct effect is expected to be minimal. Heavier application rates in some steep areas are not considered likely to exacerbate this risk.

Further evidence of a minimal impact to the marine environment is provided by the sampling results following the crash of a truck carrying brodifacoum bait destined for an aerial baiting
operation. This large bait spill occurred at Kaikoura, New Zealand in May 2001 and consisted of 16 tonnes of Pestoff 20R (the same bait proposed for this operation) entering the sea at a single point (Meredith 2002 cited in Brown et al. 2006). At a concentration of 20 parts per million, a total of 0.36 kg of brodifacoum toxin is calculated to have entered the sea amongst the 16 tonnes of bait.

Sampling carried out by Environment Canterbury discovered significant concentrations of brodifacoum in the seawater at the site on the day of the crash, and detectable traces the day after the crash (Primus et al. 2005). Between 36 hours and 9 days after the crash, levels in seawater were below the level of detection. Samples were taken from crayfish, crab, sea urchins, starfish and two fish species offshore of the crash site. Brodifacoum was only detected in one butterfish and no positive samples were collected offshore a week after the crash. Brodifacoum was detected in mussels, limpets and paua (abalone) collected from the intertidal zone near the crash site, with the area of greatest contamination restricted to an area of approximately 100m$^2$ around the crash site. The levels detected were initially above Australia and New Zealand Food Health Standards limit (0.001mg/kg) for consumption of seafood. Brodifacoum at concentrations above this limit were detected in paua and mussels up to 12 months after the spill. The scientist who co-ordinated the monitoring carried out by Environment Canterbury considered it likely that the spill had caused some mortality among fish and invertebrates at the spill site (Primus et al. 2005). At Macquarie Island, no bait loads will be carried greater than a helicopter capacity (up to 750kg), therefore a large single-point dispersal of bait at this scale is extremely unlikely, unless caused by a shipwreck.

5.3.8 Management actions to avoid, remedy or mitigate the adverse effect on non-target species

General management actions

To date, over 332 successful rodent eradications have been undertaken on islands worldwide, with brodifacoum being used in over 70% of operations (Howald et al. 2007). About 15% of successful eradications used aerial broadcast of bait (reflecting developing technology as larger islands were attempted). The high number of similar operations now conducted around the world have allowed for the refinement of operational methodology and techniques. Learning from these operations, and utilising ‘best practice’ techniques will ensure that the impact on non-target species is minimised in this operation. Techniques developed for similar rabbit and/or rodent eradications in recent years will be important components. For example, green dyed bait (to be used in this operation) is unattractive to birds compared to other colours (Brown et al. 2006). Timing the operation to coincide with
the most inactive period for many non-target species is also an extremely important aspect of mitigating the impact on non-target species. A winter-based operation means many species of bird are largely absent from the island (e.g. some Giant petrels and most skua, burrowing seabirds, penguins and albatrosses) and will mean avoidance of disruptions to breeding activity in the spring-summer period.

In order to ensure the most accurate dispersal of baits, a location-enhanced navigational guidance system such as GPS will be used to ensure application is within the pre-defined terrestrial areas. In addition, techniques will be used on the bait spreading buckets (slowing bait spinners or using skirts or deflectors, similar to that utilised on Campbell Island (McClelland 2001) and Rat Island, Alaska) to minimise the spread of bait into the marine environment and the larger lakes. The technology used to guide the helicopters relies on flight paths being created on digitised maps, so the accuracy of lake and coastal margins can be plotted very accurately and flight paths designed accordingly. The use of experienced pilots is also a critical factor on minimising bait over-sow into areas where bait spread is not desirable.

During the period of the bait drop, mortality of non-target species will be recorded. Samples will be collected unless it is clear that death was from natural causes or brodifacoum poisoning. Samples will be stored for possible future analysis. Results of aerial baiting will be included in reports to all agencies issuing permits required to implement the eradication operation. To further reduce the likelihood of accidental poisoning of non-target species, Australian Pesticides and Veterinary Medicines Authority standards and brodifacoum label procedures for handling, transport, clean-up and disposal of pesticides will be followed.

A monthly count of birds along two separate routes in the northern part of the island has been undertaken since 2007 (see Appendix 10). These counts give an indication of species abundance during the year and provide some baseline information on the species observed. These monthly counts will be continued during and after the proposed operation as a means of assessing whether abundance changes over time following eradication of invasive species. Opportunistic biological observations are also part of current PWS work programs and these will continue during and after eradication operations.

Species specific management actions
The primary management approach to minimise the risk of poisoning skua, Kelp gulls and Giant petrels is to conduct baiting operations during winter when numbers of these species
present on the island are significantly reduced. Other actions to mitigate against the effects of primary and secondary poisoning of these species may be taken over the course of the operation, and will be done as thoroughly as possible without compromising the outcome of the eradication. For example, the use of green coloured bait (a colour less attractive to birds) should ensure that minimal primary poisoning of bird species occurs.

Field staff will be present at Wandering albatross nests at the time of bait deployment in those areas. Staff will manually remove all baits from the vicinity of the nests and ensure that none are within the reach of chicks. This will ensure that no accidental poisoning of Wandering albatross chicks occurs and will be easy to manage as there are only a small number of nests each winter at known locations (e.g. 2008: n=2; 2009: n=10).

Disturbance to seabird colonies by hunters and dogs will be minimised as will foot traffic around and through burrowing petrel colonies. Assistance will be enlisted from PWS staff to ensure that all hunting team members are aware of the location of vulnerable nesting areas and how to work in those areas to minimise impacts. Only dogs that have undergone rigorous training and have met assessment criteria will be used on Macquarie Island during this phase of the operation to ensure that impacts on other wildlife are minimised. Large areas of coastal strip are designated as Special Management Areas and while access is required to undertake rabbit hunting, staff will be briefed on the reasons for the Special Management Area designation and the requirement to work in a sensitive manner to minimise wildlife disturbance.

Following the recommendations of the report “King Penguin Helicopter Over-Flight Disturbance Trials - Interim Draft Report, Macquarie Island July 2009” (see Appendix 5) to minimise the effects of helicopters on King penguins, a minimum bait dispersal altitude of 500 ft (160 m) within 1000 m of a King penguin colony is recommended. This is expected to be the upper limit for accurate bait coverage as long as flights are undertaken in low wind conditions. These guidelines and other recommended flight operations will be followed, subject to the primary requirement to ensure comprehensive bait distribution. Observers will be on site to monitor King penguin behaviour and potential disturbance during baiting over King penguin colonies and will be in radio communication with pilots in order to cease operations if undue disturbance is evident. Baiting operations over the major King penguin colonies will be filmed.

When a rabbit is observed going down a burrow and fumigation is selected as the best technique to kill the rabbit, a check of the burrow entrance will be made to determine
whether a petrel is likely to be using the burrow. If bird faeces or feathers are present, alternative methods will be considered before fumigation. It is paramount that all known rabbits are killed upon location, and burrow fumigation will be used if no other technique appears suitable for the specific circumstance. The number of burrows that need to be fumigated (and subsequently excavated) is likely to be very low and have an inconsequential impact on slopes or soil compared to the current extensive burrowing from rabbits.

Outcomes of management actions will be recorded and included in a project report to project sponsors.
5.4 Vegetation and soil

5.4.1 Potential adverse effects on vegetation and soil

Hunters and dogs

The use of approximately 12 hunters and 11 dogs for several years following the aerial broadcasting may place pressure on vegetation in some untracked areas. The cause of recent dieback of the cushion plant *Azorella* is unknown (J. Whinam pers. comm. 2008) but may bring added requirements for management of foot traffic around the island. The extra impact may be heavy in localised areas where terrain funnels staff travelling from one catchment to another through passes and saddles and there is less room to disperse impacts. Staff moving across rabbit-burrowed areas and some steep slopes will inevitably cause a number of burrow collapses, resulting in localised soil slumping. Moving frequently around parts of the island that are not normally visited may also put pressure on some sensitive communities such as broad expanses of cushion plant.

While efforts will be made to minimise or disperse foot traffic through delicate areas, any damage caused by hunters is considered to be negligible and acceptable in the context of the wide scale damage caused by rabbits to vegetation and slope stability. Vegetation recovery and subsequent protection of soil through the cessation of rabbit grazing is anticipated to be far greater than localised degradation of vegetation through foot traffic caused by hunters, which itself is a short-term impact until rabbits are eradicated. Experience gained from similar field work during cat eradication showed no obvious lasting impact on soils or scree slopes from this type of field work and no major impacts on soils or slopes is anticipated during this eradication project.

The use of hunters and dogs for extensive hunting and monitoring of target species may be a vector for spreading seeds of introduced plants further around the island. While this did not appear to be a major influence during the five years of similar work with the cat eradication project, the current project will involve more staff and more dogs, thus increasing the possibility of inadvertent seed distribution. Field staff (including dog handlers) will be briefed on the need for checking and cleaning of clothing, equipment and dog coats on a regular basis.

Infrastructure

The proposed operation will require additional infrastructure in the form of temporary field huts, boardwalks, dog kennels and helicopter landing platforms. This is likely to have limited
localised impacts on native vegetation and soils. Of these, the installation of temporary field huts is expected to have the greatest impact due to the radial effect of staff working in different directions from these huts while undertaking hunting during Phase 2. In particular, some localised trampling of soils in the immediate area of new huts will occur. Again, experience following the cat eradication field work suggests that impacts will be relatively minor and transitory and impacted areas will recover rapidly. Sites where field huts were removed in 2003 following cat eradication have recovered well without remedial work. All infrastructure constructed for this project will be removed following project completion. Sites will be monitored following infrastructure removal and additional remediation will be considered if warranted, however based on previous examples on Macquarie Island, no artificial remediation is expected to be necessary.

5.4.2 Management actions to avoid, remedy or mitigate the adverse effects on vegetation and soil

Hunters will be thoroughly briefed on strategies for minimising damage to vegetation, soils and screes whilst hunting rabbits off tracks. It is possible to minimise impacts by adopting careful walking techniques. Where possible, while still effectively covering the entire island, staff will avoid fragile areas or densely burrowed areas to minimise burrow collapse. However it must be recognised that, ultimately, hunters have to focus on known or likely rabbit habitat as a clear priority.

Field huts and other temporary infrastructure will only be installed after the site condition is assessed and recorded. Boardwalk sections will be provided at each hut to minimise the impact of foot traffic causing localised trampling of soil and vegetation, although due to the wet nature of the ground some pugging is likely.

The installation of huts on the plateau is anticipated to be at the same locations as the temporary hut locations used during the cat eradication project. Alternate sites may be used if moving the hut to a new location would reduce impacts. For example, most of the Windy Ridge hut site was covered by a lake during 2005 and Caroline Cove hut was dismantled after being hit by two landslides during 2000. Alternative nearby locations have been identified. Once the operation is complete, these structures will be removed. Field huts have been built on Macquarie Island on a temporary basis during previous feral animal eradication operations and vegetation recovery occurred within 5 - 6 years following their removal in 2003. Monitoring of the vegetation recovery at four of these hut sites has been ongoing since their removal. A similar program is proposed following hut removal at the end of this
eradication project. All temporary field huts will be positioned, supplied and removed by helicopter.

The location of field huts from the cat eradication project and those proposed for the current project are shown in the following table.

**TABLE 4.**

**Location of proposed field huts**

<table>
<thead>
<tr>
<th>Location of hut</th>
<th>Proposed location of hut</th>
<th>Reason for change (if applicable)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1998-2003</strong></td>
<td><strong>2010-15</strong></td>
<td></td>
</tr>
<tr>
<td>Davis Point</td>
<td>Davis Point</td>
<td>n/a</td>
</tr>
<tr>
<td>Elephant Seal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Windy Ridge</td>
<td>Upper South Lusitania Creek or nearby in Lake Fletcher basin</td>
<td>Hut site covered by lake in 2005</td>
</tr>
<tr>
<td>Lake Tiobunga</td>
<td>Lake Tiobunga</td>
<td>May adjust slightly to seek drier ground</td>
</tr>
<tr>
<td>Mount Eitel</td>
<td>Mount Eitel</td>
<td>n/a</td>
</tr>
<tr>
<td>Caroline Cove</td>
<td>Windsor Saddle</td>
<td>Caroline Cove hut hit by landslides in 2000</td>
</tr>
<tr>
<td>Albatross</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5.5 Human health, community well-being and cultural heritage

5.5.1 Potential adverse effects on human health and community well-being

There is likely to be some concern amongst staff based on the island during the bait drop about the risk of poisoning from brodifacoum. This concern could have an impact on specific individuals or on the general community feeling on the station. Two areas of potential toxin intake are likely to be perceived by island staff; the water supply and through direct poisoning (through incorrect handling or not following simple precautions). The management actions proposed in Section 5.2.2 and the characteristics of the toxin suggest that the actual risk to humans is extremely low and is manageable; however the perception of risk does need to be managed.

Brodifacoum is toxic to humans, a lethal dose being approximately 15 mg of the toxin (Brown et al. 2006). Due to lack of test subjects, it is difficult to ascertain accurately and it could be as low as 7mg. There has been at least one documented human death from the deliberate consumption of brodifacoum, a 15 year old girl, however it is not known how much toxin was ingested (Palmer et al. 1999). Vitamin K (the antidote), has been successfully used to treat people with brodifacoum poisoning at doses up to 13 mg, 17.2 mg even up to 75 mg (Corke 1997, Bruno et al. 2000).

Based on the size (2 g) and toxin concentration (20 ppm brodifacoum) of the bait pellets to be used for this operation, an average adult would need to eat approximately 188 baits to receive a dose of 15mg. Brodifacoum can also be absorbed through the skin, but at levels far below (<200 times) those ingested orally (Brown et al. 2006). As bait-loading staff will use suitable personal protective equipment, it is considered an unlikely risk that exposure to skin would occur.

All staff stationed on the island during winter 2010 (expected to be about 35) will be there under authority. There will be no public access to Macquarie Island during the operation. No authorities will be issued for tourist or private vessels to visit the island during the period of the aerial baiting operation. All staff will be advised of the intended operation during the recruitment process by AAD, PWS and the Bureau of Meteorology. Prior to departure for Macquarie Island, all staff will be briefed on the aerial baiting operation, its goals and the precautions required to safeguard human health and welfare. Only trained staff will handle bait. Handling will be in accordance with the label requirements for personal protective equipment, handling and disposal.
Due to the requirement for all areas of the island to be baited, aerial baiting over-flights of the station will occur. These will be very brief due to the small land area of the station and are not expected to have any impact on staff at the station. All staff will be notified before baiting in the station area commences.

5.5.2 Proposed management actions to avoid, remedy or mitigate adverse effects on human health and community well-being

See Section 5.2.3 for measures proposed for ensuring drinking water quality.

The antidote for brodifacoum poisoning is Vitamin K. Although brodifacoum is slow acting and plenty of time is available for treatment, supplies of the antidote will be taken to the island and vested with the station doctor. Given the small number of staff at the station and the detailed information to be presented at compulsory staff briefings, ingestion of bait pellets is extremely improbable unless deliberate. If any person ingests bait, medical advice and aid will be sought immediately. Limited medical facilities and capacity are available at the main station (a qualified doctor with basic surgical and medical supplies) and adequate stocks of Vitamin K and appropriate clotting agents (such as Prothrombinex HT) will be available. Discussions will be held with the Australian Antarctic Division about additional training for the station doctor in anti-coagulant diagnosis and treatment. It is important to note that it would be extremely difficult if not impossible to inadvertently consume a quantity of bait that would result in illness. Screening staff for coagulopathy at monthly medicals is recommended from commencement of aerial baiting and for one month after conclusion of aerial operations.

A review of pesticide use in Australia by the Australian Academy of Technological Sciences and Engineering (Radcliffe 2002) suggested that safe pesticide operations that protect the health and safety of workers require the following:

- Safe systems of work
- Ongoing Occupational Health and Safety (OHS) risk assessment and control processes
- Operators with relevant knowledge and skills-training
- Access to adequate information regarding hazard and risk
- Ongoing compliance with safety requirements.
An extremely important component of the safe application of pesticides is that all those who are engaged in the application of pesticides have the necessary knowledge, skills and training to ensure that human exposure is limited to safe levels. Comprehensive training of this nature will be provided to all staff working on all aspects of the aerial baiting operation on Macquarie Island. Chemcert accreditation will be required for all personnel involved with the baiting operation and use of other toxins during subsequent rabbit hunting.

The Agricultural and Veterinary Chemicals Code Act 1994 makes provisions for the evaluation, registration and control of agricultural and veterinary chemicals. The registration process for pesticides in Australia includes assessment of the occupational health and safety (OHS) risk to workers involved at all stages in the production and use of each pesticide, including risks associated with re-entry and/or re-handling. The OHS package is generally assessed by the National Occupational Health and Safety Commission (NOHSC) for the National Registration Authority (NRA).

Part 6 of the NRA Guidelines Manual (1997) outlines the data requirements and indicates that assessment of the impact of the health and safety of workers handling or using the product, or exposed to product residues in the course of their work, follows a risk assessment methodology. This methodology includes evaluation of the hazard, the toxicology and physiochemical properties of the product; and assessment of exposure to the produce, based on measured and/or extrapolated data. Adherence to these protocols should ensure that the safest standards and procedures for handling, transport, clean-up and disposal of brodifacoum are undertaken.

Further information on the OHS requirements for registration and use of pesticides in Australia (including the legal framework under which registration is administered) can be found in National Registration Authority website (http://www.chemlink.com.au/nra.htm) and Radcliffe (2002).

In addition to the above, personnel involved in the operation will follow a detailed safety plan under the supervision of a nominated safety officer (Part D – Occupational Health and Safety Plan). The safety plan will take account of all the hazards identified for the operation and comply with Australian and Tasmanian Government regulations regarding the safe handling of pesticides.
**Safe Handling of Pesticides**

Assurance of protection of workers from adverse health effect of exposure to pesticides is achieved in the following ways (following Radcliffe 2002):

- Safe product – assessment of occupational health and safety risk of the product during production, formulation, packaging, and adequate safety guidance on e.g. labels and materials safety data sheets (MSDS)
- Safe operations - by workers engaged in transport, storage, mixing/loading, application, clean-up and first aid and emergency care in compliance with product label specifications with pilots and ground teams holding appropriate training and certification
- Monitoring of the effectiveness of risk control measures.

In addition, other factors that need to be addressed to ensure safe handling of pesticides and minimum risk to personnel are:
- Adherence to standards prescribed in Part D – Occupational Health and Safety Plan (e.g. label compliance, training and supervision, application and handling, storage)
- Adherence to “life cycle” standards and procedures covering transport, bait preparation, use, clean-up and disposal
- Compliance with specifications for personal protective equipment
- Establishment of procedures for managing and recording accidents, loss of pesticides and poisoning.

Disposal standards include:
- Redundant pesticide and used packaging is packaged safely for disposal when it has been ascertained that it is no longer required
- Label instructions regarding disposal of pesticide packaging and containers and contaminated equipment are followed
- All equipment that comes into contact with brodifacoum needs to be rinsed at a designated wash site following use.

**5.5.3 Proposed management actions to avoid, remedy or mitigate adverse effects on cultural heritage**

All PWS field staff will be briefed on the location of archaeological sites on the island, and the management prescriptions in place to safeguard and manage them. Their representation
in the planning of operational activities will ensure that such sites will be protected. The PWS Ranger-in-Charge will oversee briefings regarding cultural heritage management.
5.6 Ecosystems

5.6.1 Potential effects on ecosystems

Positive effects

On the basis of several previous rabbit and rat eradication campaigns on islands, short-term negative effects (usually related to non-target species issues) are far outweighed by longer-term positive responses (Micol and Jouventin 2002, McClelland 2001, Ambrose 2002, Merton et al. 2002, Torr 2002, Courchamp et al. 2003, Chapuis et al. 2004, Howald et al. 2007, Towns 2006). Rabbits and rodents are the only remaining introduced animal pests currently having significant negative impacts on the habitat values and quality of the communities on Macquarie Island. The proposed operation is likely to have significant beneficial and long-term effects for the health and function of the indigenous ecosystem and animal and plant species.

The most noticeable of these benefits will be the recovery of vegetation. This can be confidently predicted and has been demonstrated by exclosure plots built to exclude rabbit grazing (Copson and Whinam 1998, Bergstrom et al. 2006, Scott and Kirkpatrick 2008, PWS unpublished data) and by studies of vegetation regrowth after the introduction of myxomatosis substantially reduced the rabbit population (Copson and Whinam 1998, Scott and Kirkpatrick 2008).

Rodents on Macquarie Island eat seeds, seedlings, rhizomes, bulbs, fruit and flowers of a number of native plant species (Shaw et al. 2005). With the removal of these impacts, there will undoubtedly be changes in the regeneration patterns of a number of plant species. Endemic plant species currently threatened by rabbits are likely to recover and expand their range.

The rapidity of vegetation regrowth following pest eradication will eventually be determined by a suite of factors including soil, climate, altitude, availability of seed or propagule source, and the nature and severity of previous habitat alteration amongst others. At some sites, such as Sandy Bay, regrowth of Poa foliosa and the megaherbs Stilbocarpa polaris and Pleurophyllum hookeri has been significant within one growing season. Some tussock growth up to approximately one metre was evident after three years (PWS unpublished data). Native species associated with these dominant plants also show signs of recovery in the absence of grazing. The fern Polystichum vestitum has been selectively grazed and may take longer to recover or may not recover to former abundance, depending on the degree of
destruction of rhizomes in the soil. Decades of habitat alteration due to rabbit grazing (and possibly changes in local climate) have also affected the distribution of flora to a marked degree. For example, *Acaena magellanica* has expanded its range across the island and may inhibit the recovery or re-establishment of other native vegetation.

In general terms, the ability of the natural vegetation to recover is expected to negate the need for artificial rehabilitation (Scott and Kirkpatrick 2008). However, it must be recognised that the recovery of plant communities will take place over many years and due to changes to the island environment from two centuries of introduced plants and animals, may never be fully restored to pre-European condition.

Recovery of vegetation across the island is expected, in time, to increasingly protect soil and geological features, stabilise slopes, and decrease the extent and frequency of land slips and erosion.

Based on outcomes from other islands where rats (and other vertebrate pests) have been eradicated, significant changes in burrowing petrel populations can be predicted (Towns *et al.* 2006). Habitat destruction, competition for burrows by rabbits and direct predation by rats has slowed, or in some cases reversed, the positive population trend observed in several species after the eradication of feral cats. Eradication of rabbits and rodents will result in an increase in the abundance and distribution of most, if not all, species of burrowing petrel. This includes the re-colonisation of the main island by the Blue petrel, whose range has increasingly been restricted to rat-free offshore island stacks since rats became established on the island around 1900. Populations of Grey petrel, Soft-plumaged petrel, Cape petrel, White headed petrel and Sooty shearwater are also expected to directly benefit from the absence of rat predation and from habitat recovery. This anticipated population and distribution increase may be far more muted than expected if prey switching by skua results in higher mortality of petrels in the short to medium term. Prey switching can be anticipated after aerial baiting as skua seek to replace the food source previously available from rabbits (see Section 5.3.1).

Rodents are known to predate on invertebrates in environments such as Macquarie Island (Pye and Bonner 1980; Chown and Smith 1993; Smith *et al.* 2002). While it is impossible to predict the changes that will occur in the invertebrate community following the removal of rodents, it is likely that the abundance of certain species will increase to levels more closely aligned with pristine assemblages. Previous island rat eradications have shown that invertebrate species invariably benefit from the eradication of rodents, especially compared
with neighbouring islands still holding invasive rodents (such as Allen and Lee 1994, Chown and Smith 1993, Towns 2006). Invertebrates are also expected to benefit from a recovery in vegetation communities following rabbit eradication.

Information is insufficient for allowing accurate prediction of how successional trends will change, however, it is expected that regeneration and successional patterns will return to approximately those that existed prior to human colonisation (Copson and Whinam 1998, Scott and Kirkpatrick 2008). Changing climate conditions and recovery or amended distribution of vertebrate pest-influenced vegetation are likely to be primary variables.

Decomposition of rodent and rabbit carcasses is likely have a minimal effect on ecosystems. Not all carcasses of poisoned rodents and rabbits will be found and collected during this operation. Most animals are expected to die in their burrows or nests (about 90%), and a relatively small percentage are expected to die above ground. The decomposition of carcasses within the ground is expected to result in a short term increase in nutrient levels in the surrounding soil, possibly enhancing localised plant growth in the short term.

Adverse effects
Any adverse effect of the proposed operation on the ecosystems of Macquarie Island is anticipated to be of a minor and temporary nature, relative to the benefits that will accrue from removal of introduced vertebrate pests.

It is possible that eradicating rabbits will allow unknown alien plants to establish and proliferate. Currently some species may be present that are suppressed by rabbits to a point where they have not been detected. Cessation of grazing could allow them to germinate or spread. However, the likelihood of expansive spread of existing alien species is low, as native vegetation tends to out-compete them (Scott and Kirkpatrick 2008). During the late 1990s no such expansion was observed when vegetation flourished following myxomatosis-induced reduction of rabbit numbers.

Non-native invertebrate species may expand in both abundance and distribution in the absence of rodent predation. In this event, the potential impacts on native biota are difficult to establish.

It is possible that the introduction of dogs may also result in the introduction of non-native parasites or diseases. The likelihood of this is considered to be low given that Australian
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Quarantine and Inspection Service (AQIS) requirements for the international transfer of dogs will be implemented for all dogs, and dogs will be treated for parasites. Dogs also have a veterinary treatment regime and record for the period they are under training prior to departing for the island. Furthermore, it may be difficult to demonstrate that the use of dogs for this project is a definitive vector of alien diseases given a history of three previous periods of dogs on the island; packs of wild dogs from the 1820s; dogs and other domestic mammals during the period of industry of over 100 years; and the use of dogs during the cat eradication project (2000-2003). No adverse disease events have been demonstrated to have occurred from these periods.

It is also possible that Redpoll and Starling populations are predated at egg and chick stages by rats. If so, the release from predation of these two introduced bird species may lead to their expansion, with unknown consequences for other elements of the island's biota. Starlings have not been represented in species mortality lists from NZ eradications but as an insectivore they may be exposed to secondary poisoning through ingestion of invertebrates that have fed on toxic baits.

Another likely indirect effect of eradicating rabbits and rodents is related to the high skua population. The Macquarie Island skua population is higher than could be naturally supported in the absence of rabbits. The abundance of rabbits allows for their utilisation as a major prey item by skua (Jones and Skira 1979, Johnston 1973) and in some territories young rabbits form the predominant prey item during the breeding season. Many observations have been made of the predominance of rabbit carcasses around skua nests indicating they are a primary food source for chicks. If rabbits are eradicated it is likely that skua will need to switch prey and predate much more heavily on burrowing petrels, with potential for significant impacts on these populations, during their recovery stage in the absence of rats. Eventually the skua population can be expected to stabilise as the population reaches equilibrium, based on the availability of traditional prey items such as carrion, penguin eggs and chicks and burrowing petrels. Control of skua will only be considered on a site specific basis if significant predation of petrel species from offshore rock stacks by adult skua is observed. Eventual reduction in skua numbers from current and recent population levels may reduce predation on burrow nesting petrels and penguin colonies. This may contribute to a resultant increase in populations of those species, assuming other environmental factors are constant.

Some cave systems on Macquarie Island will require hand baiting as helicopter distribution will not penetrate the depths of caves. Both rats and rabbits utilise caves extensively and
although rabbits must leave the cave to feed, some rodents may remain within the cave system for extended periods. To minimise the risk of individuals not being exposed to baits, hand baiting will be conducted. Baits placed in caves are not anticipated to have a serious adverse effect on caves, but in the drier environment, bait pellets will take longer to degrade. No other animals are considered likely to consume baits within caves. Staff working on bait distribution to caves or subsequent rabbit hunting will be briefed on the need to avoid undue disturbance to cave environments and structures and the fragile nature of these systems.

While this eradication operation targets three pest species and there is a confidence that all target individuals will be put at risk, it is possible that the eradication may succeed for one or two species but not for all three. Mice are considered the most difficult species to eradicate from Macquarie Island, based on a number of failures of other mouse eradication attempts worldwide, and the known difficulty in targeting all individuals of this species. Anecdotal evidence suggests that mice are even more difficult to eradicate when rats are also present, as is the case on Macquarie Island. Various combinations of successful and failed eradication by species are possible and are briefly described in the following table.

**TABLE 5.**
 Brief assessment of likely future impacts from eradicating some but not all target species

<table>
<thead>
<tr>
<th>Species eradicated</th>
<th>Species remaining</th>
<th>Potential future impacts</th>
<th>Potential future management responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rabbits</td>
<td>Rats, mice</td>
<td>Extensive vegetation recovery, some remaining vegetation impacts due to loss of seeds and fruits, some recovery of burrowing petrel populations but continued rat predation on burrowing petrels, continued predation on invertebrates from rodents.</td>
<td>Identify potential causes of failure (short term). Localised control or eradication of localised populations (bait stations, hand-broadcast) (short-medium term). Assess densities and impacts during population recovery (long term). Identify management options in contemporary context (medium-long term).</td>
</tr>
<tr>
<td>Rabbits, rats</td>
<td>Mice</td>
<td>Extensive vegetation recovery, continued small scale vegetation impacts due to consumption of some seeds and fruits, significant recovery of burrowing petrel populations, continued predation on invertebrates, unknown population expansion in the absence of rats, unknown changes in mouse impacts in the absence of rats 1, similar densities expected on plateau environment (where rats currently absent).</td>
<td>As above.</td>
</tr>
</tbody>
</table>

1 Mice are known to cause mortality and significantly reduced breeding success of albatross and burrowing petrels on Gough Island where rats are not present; however there has been no evidence to date of mice predating seabirds on Macquarie Island, including in diet analyses.
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<table>
<thead>
<tr>
<th>Species eradicated</th>
<th>Species remaining</th>
<th>Potential future impacts</th>
<th>Potential future management responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rabbits, mice</td>
<td>Rats</td>
<td>Extensive vegetation recovery, some lower scale vegetation impacts through continued consumption of some seeds and fruits, continued predation of invertebrates, expanded rat population as preferred tall tussock grassland habitat recovers, continued predation of burrowing petrels.</td>
<td>As above.</td>
</tr>
<tr>
<td>Rats</td>
<td>Rabbits, mice</td>
<td>Eventual continued damage to vegetation communities (significant short-medium term vegetation improvement as failure may still occur with 99% rabbit removal), eventual continuation of accelerated erosion associated with vegetation loss, some ongoing predation of invertebrates by mice, unknown potential expansion of mice in the absence of rats.</td>
<td>As above. Assess introduction of RHVD as control mechanism for rabbits (long term).</td>
</tr>
<tr>
<td>Rats, mice</td>
<td>Rabbits</td>
<td>Long-term damage to vegetation communities after short-medium term improvement, reduced rate of recovery of burrowing petrels due to degraded environment and continued slope instability.</td>
<td>As above. Assess introduction of RHVD as control mechanism for rabbits (long term).</td>
</tr>
<tr>
<td>Mice</td>
<td>Rabbits, rats</td>
<td>Long-term damage to vegetation communities after short-medium term improvement, reduced rate of recovery of burrowing petrels due to degraded environment and continued slope instability.</td>
<td>As above. Assess introduction of RHVD as control mechanism for rabbits (long term).</td>
</tr>
<tr>
<td>No species eradicated</td>
<td>Rabbits, rats, mice</td>
<td>Medium to long term reversion to current impact levels after short-medium term improvement to ecosystem based on significantly reduced populations of all target species.</td>
<td>As above. Assess introduction of RHVD as control mechanism for rabbits (long term).</td>
</tr>
</tbody>
</table>

### Bait depots

Depots will be established at The Isthmus, Green Gorge and Hurd Point to store bait and fuel for the helicopter baiting operations on adjacent parts of the island.

The Isthmus bait depot will be in the general station area and whilst considerable space will be taken up, no new infrastructure is envisaged other than helicopter landing platforms. Existing equipment and machinery will be utilised. Accordingly, no additional impacts are likely beyond those typically involved in a station resupply. Wash-down of equipment is not expected to have any impacts and any bait spills on loading zones will be collected for redistribution or disposal.

The depot at Hurd Point will be established in the empty Royal penguin colony, which is vacated during April. The Hurd Point site is the largest Royal penguin colony on Macquarie Island. Infrastructure established to support this depot will include two fibreglass Apple huts...
for an operations centre and staff shelter. No sleeping or cooking facilities (other than a twin-ring burner) will be established at these huts – any staff remaining overnight will use the nearby Hurd Point Hut. The Apple huts will be removed after the completion of the aerial baiting phase, and before the return of Royal penguins in mid-September. Aerial operations are intended to conclude by the end of August. A pivot-steer loader may be considered for use at this site due to the solid open ground (gravel base), allowing mechanical loading of the bait-bucket. The placement of bait pods and fuel drums, the operation of loading bait buckets and the use of helicopters from this site are not expected to have significant impacts due to the hardened nature of this site, which covers several hectares and has a rock substrate. A likely impact is that the rudimentary pebble nest mounds of Royal penguins will be disturbed in the immediate area of bait loading operations, especially if a pivot-steer loader is used. This impact would be localised and involve only a small fraction of the overall area of the site. Damaged nest mounds would have pebbles locally scattered, rather than removed from the site, and as the first actions of returning male Royal penguins in September is to collect pebbles to rebuild nests (usually by stealing from adjacent piles or claiming any loose pebbles accumulated during the winter), this impact is considered to be minimal.

The central section of the island will be baited from a depot at Green Gorge. Due to the presence of a small King penguin colony, the beach area cannot be used for helicopter operations and a site in the general vicinity will be selected. The most likely site is a small ridge above Sawyer Creek where the ground is firm enough to support bait loading operations. Mechanised bait-loading is unsuitable for this site due to the likely impact on vegetation and soil disturbance.

5.6.2 Management actions to avoid, remedy or mitigate adverse effects on ecosystems
Monitoring of regenerating vegetation following the eradication operation will ensure that any increase in abundance or distribution of alien plants will be identified quickly. Either the plants will be removed or a management plan prepared. Vegetation monitoring will be further discussed in Part F – Monitoring Plan. After completion of the eradication operation, botanists from the Tasmanian Government Department of Primary Industries, Parks, Water and Environment or the Australian Antarctic Division will assess the threat of alien plants and develop contingencies.
The spring and summer of 2010-11 will be a period when rabbits that survived the aerial baiting breed. Field teams will attempt to reduce their numbers as fast as possible to keep the population in steep decline. Young rabbits can be expected to be present from the commencement of Phase Two and as they breed at a young age, the population could begin to expand rapidly without immediate hunting pressure. Female rabbits on Macquarie Island can have at least three litters in a breeding season with an average of 19.3 kittens per female per year (Skira 1978), with 100% of females either pregnant or lactating by December (Shipp et al. in Skira 1978).

The task of the hunters to swiftly reduce rabbit numbers after aerial baiting will be assisted by skua predation of rabbits in these first crucial months.

The possibility of prey switching by skua will be carefully monitored in the first summer after aerial baiting and if kills of burrowing petrel increase, action will be considered to manage skua numbers. Such action would likely be limited to the prevention of chicks hatching and only occur in skua territories adjacent to petrel colonies observed to be significantly impacted by skua predation. Monitoring of a number of skua territories adjacent to known Blue petrel colonies on off-shore rock stacks has been carried out since 2004, with continued monitoring proposed after aerial baiting. Prey switching will be monitored through petrel remains in skua territory, such as whether the number of petrel wing-sets is significantly greater than previously recorded. This monitoring will only be considered in skua territories that are adjacent to rock stacks with known burrowing petrel colonies. DPIPWE have proposed a program to assess the prevalence of prey-switching by skua which will be of assistance in determining appropriate action.

Portable boardwalk sections will be utilised at all bait-loading depots, except the Isthmus. This will minimise impacts on the immediate environment (thus reducing vegetation damage at Green Gorge and damage to royal penguin nest mounds at Hurd Point) and provide a safer working environment for bait-loading staff.

All materials will be removed from bait depots, including all huts and boardwalks, fuel drums, bait pods and empty bait bags. A permit is required from PWS for use of a vehicle off formed roads around The Isthmus and will be necessary should a loader be considered for use at the Hurd Point bait depot. Human waste disposal at bait loading sites will be the current standard for all field hut use on Macquarie Island.
The preferred disposal method for empty bait bags is incineration (as recommended on the product label). Empty bags will be burnt in the station incinerator during easterly or southerly winds. An alternative method is to return empty bags to Australia for disposal at an approved disposal facility in accordance with requirements listed on the bait registration label.
5.7 Biosecurity

5.7.1 Potential adverse affects on biosecurity

It is possible that an operation of this magnitude could introduce alien plant or animal species to the island. Alien species are any organisms introduced to the reserve by human activities. Due to the increased movement of ships, helicopters, equipment and personnel to the island during the eradication operation, stringent measures must be in place to ensure that this potential risk is managed. Trials have been undertaken that assist in identifying pathways of potential alien introductions for terrestrial organisms (Whinam, Chilcott and Bergstrom 2005). Management actions to prevent introduction of alien species will be prescribed in Part E – Project Biosecurity Plan.

Alien species pose the greatest threat to the integrity of natural ecosystems in the reserve. In the past, the presence of domestic animals, including dogs, horses, cattle, sheep, goats and poultry, may have left an unidentified and unquantified legacy of alien organisms. While fewer alien species have become established on Macquarie Island than on many other sub-Antarctic islands, the cumulative impacts of plants, rabbits, cats, weka, rats and mice have been severe. Other alien species such as Starlings, Redpolls and flatworms have had an unknown effect on the island’s ecosystems.

Some of these impacts are likely to be irreversible, and the removal or control of established alien species is expensive and difficult. Prevention of the establishment of further alien species is by far the most cost-effective means of managing this problem. Of the many species introduced to Macquarie Island in the past, only two plant species and two vertebrate species have been eradicated, while others have died out or been removed from the island. Warmer temperatures due to global climate change are likely to increase the risk and impact of introductions due to more favourable survival conditions. From both ecological and management points of view it is imperative that every effort is made to prevent any further alien introductions.

5.7.2 Management actions to avoid, remedy or mitigate potential adverse effects on biosecurity

The aim of biosecurity management for Macquarie Island is to minimise the risk of accidental introductions of alien species. The management actions prescribed to achieve this are described in Part E – Project Biosecurity Plan (under preparation).
Dogs used on the project will be required to meet Australian biosecurity requirements before deployment to Macquarie Island. Dogs were used on Macquarie Island for two years during cat eradication operations and are not considered a significant biosecurity issue.

If the successful helicopter contractor for the aerial baiting operation is New Zealand-based, or if shipping departs directly to Macquarie Island from New Zealand, AQIS and Biosecurity New Zealand guidelines to prevent the potential for biological introduction/s into or from Macquarie Island will be followed. This is particularly important for any aircraft undertaking a transoceanic passage. NZ pilots and crew will be fully briefed on biosecurity obligations and methods of minimising biological introductions prior to departing NZ, and will implement the prescriptive actions outlined in Part E – Project Biosecurity Plan. Briefings by the Project Manager will emphasise the requirement for the removal of any vegetative and soil material from all clothing and equipment prior to departure. Particular attention to shoes, socks and garments with Velcro will be required. Inspections will be carried out by NZ Dept of Conservation or Biosecurity NZ staff experienced in biosecurity inspection and cleaning.

The Australian Antarctic Division (AAD) has implemented a range of initiatives and procedures at the AAD store and at their wharf facility for minimising the risk of introductions via shipping. In an eradication operation these stores and wharf facilities will most likely be utilised, unless shipping departs directly from New Zealand. The AAD, PWS and DPIPWE are working together with Quarantine Tasmania to establish clear biosecurity protocols for all shipping to and from Macquarie Island. The Macquarie Island Biosecurity Plan (in preparation) provides an overall biosecurity strategy for Macquarie Island and will guide the preparation of Part E - Project Biosecurity Plan to specifically manage biosecurity risks for the eradication project.

The potential arrival of alien species at Macquarie Island in shoes, clothing, equipment and/or cargo of personnel, particularly those who have visited other sub-Antarctic islands or other places with similar climatic conditions, poses a significant risk to the reserve. The use of tourist ships, charter and/or fishing vessels to transport personnel to the reserve is also an area of risk, however vessels of this nature are frequently used to transport staff to and from Macquarie Island and protocols are in place to ensure that these ships comply with all applicable biosecurity measures.
The main objectives of biosecurity management are to:

- prevent the introduction of alien plant and animal species (and pathogens) into the reserve
- protect the reserve from the adverse impacts of alien introductions.

These objectives will be achieved by adhering to the following protocols:

- All materials, equipment, transport (vehicles, vessels and helicopters) and foodstuffs, will be suitably cleaned and/or fumigated before entering the reserve
- Compliance with provisions of the Macquarie Island Biosecurity Plan (in draft) and Part E - Project Biosecurity Plan
- Any vessel visiting Macquarie Island must be certified free of rodents since its last major port of call, and demonstrate that stringent precautions have been taken to ensure that no re-infestation has occurred since certification
- No wharves or mooring facilities will be constructed in the reserve. Direct mooring to the land is prohibited except for authorised purposes
- Vessels must be anchored at least 200m (at point of closest swing at anchor) from the coast except where written permission is given by the Director of DEPHA to anchor closer for scientific, management or safety reasons. Such authorisation will be only considered for daylight hours
- All staff and visitors must thoroughly clean all belongings and equipment before arrival at Macquarie Island. Particular care should be taken to clean seeds and propagules from equipment and camera tripod feet, equipment cases, carry bags, Velcro fastenings, gloves, socks, gaiters and footwear
- Ensure that induction and education programs for all visitors to the reserve continue to emphasise the risks and impacts of alien introductions and the precautions that must be taken to minimise these risks
- Ensure that educational material regarding biosecurity gets to staff before they pack to go to the reserve and to family and friends who may send items to staff on the reserve.
5.8 Effects on target species

5.8.1 Adverse effects of brodifacoum on target species

In an eradication operation of this magnitude, where the death of hundreds of thousands of animals is required in a short space of time, there are no entirely humane options. Brodifacoum causes death by internal haemorrhaging and the time that it takes rabbits and rodents to die following the onset of symptoms can be up to several days (Godfrey 1985, Littin et al. 2000). However, rabbits and rodents are extremely susceptible to poisoning by brodifacoum (as shown by low LD50 rates: see Fisher and Fairweather 2006) and at the proposed application rate any animals consuming baits are likely to ingest far more than the lethal dose, with death occurring more rapidly. Staff at a recent rat eradication operation in Alaska (Rat Island, October 2008) noted dead rats within three days of baits first being spread, which reflects experience of other rodent eradications from islands. In addition, rats are generally considered to succumb to brodifacoum poisoning more quickly at higher latitudes such as Macquarie Island, probably as a result of lower temperatures exacerbating the effects of blood loss (Buckelew pers. comm.). Brodifacoum has been used for almost three-quarters of successful rodent eradications on islands to 2007 and its selection has largely been made on the basis of its effectiveness and efficiency (Howald et al. 2007).

Brodifacoum can be considered significantly more humane than myxomatosis which has been continually been spread among the Macquarie Island rabbit population from 1978 to 2007 as a control measure. The time from the onset of myxomatosis symptoms to death is often longer than two weeks. Rabbits were often eaten alive by skua as the virus caused blindness and thus rabbits had no way of detecting or avoiding skua.

The hunting phase will use dogs to identify the location of rabbits, following which they will be killed using the most suitable method for the circumstances. This may involve using a firearm, fumigating or excavating burrows, or trapping. If death is not instantaneous from the selected technique the rabbit will be killed as quickly as possible using approved techniques.

5.8.2 Management actions taken to avoid, remedy or mitigate the adverse effects on target species

All available options were carefully considered and discussed by a range of experts in relevant fields before the decision was made to adopt the current methodology. Brodifacoum represents the best option for a variety of reasons, and its effectiveness with these target species, combined with its low potential to cause non-target or human mortality make it by
far the best option. It is effective after a single dose, avoiding the need for repeated treatments that are necessary with some other toxins. In an island pest eradication situation, this allows a one-off operation which prevents accumulation of toxin in the ecosystem. For further reasons behind the rationale and justification for the proposed methodology see Part A – Overview.

Hunters with extensive experience with firearms are preferred for employment on the island, helping to ensure that rabbits shot will die instantaneously. An important consideration in the need to ensure a quick kill by hunters using firearms is the imperative that rabbits do not become ‘educated’ and thus prolong the hunting period by learning to avoid hunters.

The dogs trained for the project are being trained to not kill rabbits. Their task is to locate the presence of rabbits and indicate that to their handler, who will then determine the appropriate method to kill the rabbit.

A priority for field staff is to focus on using the most humane techniques for killing rabbits according to the situations in which they find them. In many cases this will be by shooting, however there will be some situations (such as trapped or netted rabbits and rabbits in burrows that are excavated) where other approved methods are more appropriate. Minimising stress and suffering to animals are the required standards for carrying out this task.

All traps that are set will be checked every 24 hours until the trap is closed. Trapped rabbits will be killed by cervical dislocation or shooting.

5.9 Summary of potential effects and management actions

This section has identified and assessed the potential and likely effects of the techniques used in the proposed eradication operation. Particular areas of concern have included the risk to human health, non-target wildlife and the potential for the introduction of non-native species.

The assessment has considered ways in which the risks of the operation can be minimised and how any actual or potential adverse effects can be avoided, remedied or mitigated. The performance standards and management actions identified and prescribed in this section are appropriate ways of achieving this outcome. On balance, the positive effects that will result from the eradication of rabbits and rodents from Macquarie Islands are much greater than
any potential negative effects, particularly in the context of the proposed management and risk mitigation actions.
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6. Consultation and Approvals

6.1 Introduction
Consultation is necessary to inform the public and other interested parties or stakeholders of the proposed operation, in order to identify significant issues and constructively discuss the means by which any concerns may be addressed. In the case of Macquarie Island, where there is no unregulated public access, public stakeholders are not directly affected by the on-ground operation. The tourist industry that operates on Macquarie Island during late spring and summer is unlikely to be negatively impacted due to the winter timing of the aerial baiting.

This section outlines:
- Information made available to the public and other interested parties about the proposed operation
- Parties consulted about the proposed operation
- Formal approvals necessary for the proposed operation.

6.2 Consultative processes

6.2.1 Inter-governmental consultation
The funding agreement between the Australian and Tasmanian Governments is contingent on the process being managed by a joint government Steering Committee that is supported by a Scientific and Technical Advisory Committee. Ongoing liaison between the relevant agencies within each government will continue throughout the duration of the project. The relevant agencies are the Australian Government Department of the Environment, Water, Heritage and the Arts (Natural and Indigenous Heritage Branch) and the Tasmanian Department of Primary Industries, Parks, Water and Environment (DPIPWE), within which PWS sits. The PWS was within the Department of Environment, Parks, Heritage and the Arts, until the Department was disbanded by the Tasmanian Government on 1 July 2009.

6.2.2 Australian Antarctic Division (AAD)
Another aspect of inter-governmental consultation is the discussions between the PWS and the Australian Antarctic Division. Ongoing communication and mutual support between these two organisations is fundamental to the success of the operation and constant liaison will continue throughout the preparatory and operational phases. The AAD are recognised as the primary provider of expertise in the provision of sub-Antarctic logistics and are a vital
partner in implementing the eradication project. The AAD capacity to support some research or management programs on Macquarie Island may be constrained during the eradication project, given the cap on station numbers designated in the Management Plan.

6.2.3 Inter-departmental consultation
The Resource Conservation Branch of the Tasmanian Department of Primary Industries, Parks, Water and Environment offers scientific advice on natural processes, landforms and species biology and management to PWS. In addition, Quarantine Tasmania, Australian Quarantine and Inspection Service, Australian Customs and the Civil Aviation Safety Authority have been consulted on aspects within their areas of expertise and responsibility.

6.2.4 Scientific Research Institutions
A large number of Australian and overseas universities are involved in scientific research projects on Macquarie Island. All scientific research on the island requires both support by the Australian Antarctic Division and a permit under the *Nature Conservation Act 2002*. The Macquarie Island Research Advisory Group (MIRAG) is the Tasmanian government body that assesses all scientific research applications for the island. Given the large number of research organisations involved on Macquarie, MIRAG is the appropriate avenue for consulting those scientific research institutions interested in conducting research during the period of the eradication project.

6.2.5 New Zealand Department of Conservation - Island Eradication Advisory Group (IEAG)
The New Zealand Department of Conservation’s Island Eradication Advisory Group has been consulted throughout the preparation of *Part A – Overview* and *Part B - Operational Plan* of the Macquarie Island Pest Eradication Plan. Their experience in all facets of island eradication principles and practice is extremely valuable. The IEAG will continue to be consulted throughout the preparatory and operational phases of the project. The collective knowledge of this group proved invaluable in the formulation of the detailed methodology outlined in *Part B - Operational Plan*. An agreement between PWS and the Department of Conservation allows continued access to DOC expertise in this area.
6.2.6 World Wide Fund for Nature – Australia (WWF)

WWF Australia has engaged with PWS and the Department of the Environment, Water, Heritage and the Arts (DEWHA) and has indicated strong support for the proposed eradication of the target species from Macquarie Island.

6.2.7 Public consultation

The Macquarie Island Pest Eradication Project Part A – Overview was posted onto both Australian and Tasmanian Government websites in early 2007. During 2007 there was significant media coverage that also helped to inform the public of the intention for an eradication project to be carried out on Macquarie Island. Since the availability of Part A – Overview in the public domain, the eventual funding agreement between the Australian and Tasmanian Governments and the associated media coverage, numerous letters have been received by both the Australian and Tasmanian Governments regarding the proposed eradication operation. These letters have provided a range of opinions, comments and suggestions from interested members of the public. The majority of letters were strongly supportive of the need to manage impacts on Macquarie Island by eradicating feral pests. All of these letters have received a personal and detailed response. No letters, however, have prompted any major change to the overall operational plan as outlined in Part B – Operational Plan.

Once an EPBC referral has been submitted it will published on the DEWHA website for public comment. It is probable that the proposed action will be assessed as significant and will thus need approval from the Australian Government Minister for the Environment. In this case, there will be a further public assessment procedure prior to the proposal being assessed by the Minister, with this EIS providing further information.

6.2.8 Tourist ship operators

All companies that operate or intend to operate tourist ships to Macquarie Island have been notified of the PWS intention to conduct the eradication operation. Due to the winter timing of the helicopter operations and the limited access that tourists have to the island it is very unlikely that either the aerial baiting or ground hunting phases of the eradication operation will have any adverse impact on this industry. Likely positive impacts may result from improved biodiversity and abundance of wildlife over time, making the island more attractive to tourists. All vessels require prior permits to land passengers on the island. In the event that this is not obtained radio contact can be expected on arrival and information on
eradication operations passed on as required, however in general permits for private landings will not be issued during the period of aerial baiting.

6.2.9 Animal ethics and animal welfare groups
The operation has attracted interest from the Tasmanian Government Animal Ethics Committee, the Australian and NZ Federation of Animal Societies (ANZFAS) and the RSPCA. Dialogue will be maintained with these organisations in the lead up to the operation.

The project has agreement for the Tasmanian Government Animal Ethics Committee to consider animal ethics issues associated with the eradication operation. PWS holds an Animal Research License administered by the Department of Primary Industries and Water.

The RSPCA has been involved in early discussions about the eradication and a representative attended the helicopter bait trial on Macquarie Island in 2005.

6.2.10 Non-governmental conservation organisations (NGOs)
The following NGOs have been identified as potentially having an interest in the proposed eradication operation on Macquarie Island:

- Tasmanian Conservation Trust
- The Wilderness Society
- Australian Conservation Foundation
- World Wide Fund for Nature
- Tasmanian National Parks Association (TNPA).

These organisations will be kept informed of any major developments that occur throughout the lead up to the operation. To date, feedback that has been received has been positive in nature and supportive of the concept of the eradication operation.

6.2.11 Other interest groups
Several other organisations have also been identified as being interested in the eradication operation:

- Commonwealth Scientific and Industrial Research Organisation (CSIRO)
- Animal and Plant Control Group – South Australian Department of Water, Land and Biodiversity
- National Parks and Wildlife Advisory Council
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- National Consultative Committee of Animal Welfare
- Invasive Animals Cooperative Research Centre
- New South Wales National Parks and Wildlife Service
- Australian Veterinary Association
- Agreement on the Conservation of Albatrosses and Petrels (ACAP).

Again, these organisations will be kept informed of developments and progress. Officers from both the CSIRO and the Animal and Plant Control group were consulted during the formulation of the operational plan.

Part G – Communications Plan outlines communication methods and strategies for stakeholders and interested parties.
6.3 Formal approvals required

6.3.1 Referral under the EPBC Act
Under the conditions of the Environment Protection and Biodiversity Conservation Act 1999, any action having a Significant Impact requires approval from the Minister before it can commence. Significant impact has been defined as:

… an impact which is important, notable, or of consequence, having regard to its context or intensity. Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment which is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts. You should consider all of these factors when determining whether an action is likely to have a significant impact on the environment.

Due to the World Heritage listing of Macquarie Island and the presence of threatened species, the eradication project needs to be referred to the Minister for the Environment. This EIS forms the basis for most of the information contained in the referral. Further information regarding the EPBC Act and the referral process can be found at [http://www.environment.gov.au/epbc/index.html](http://www.environment.gov.au/epbc/index.html).

6.3.2 APVMA Approval
Before veterinary or agricultural chemical products can be supplied, sold or used in Australia, they must be registered by the Australian Pesticides and Veterinary Medicines Authority (APVMA). While brodifacoum it is registered as a rodenticide in Australia, a permit is required to aerially disperse the baits using a helicopter and also to target rabbits. The APVMA website should be consulted for further information about the application process: [http://www.apvma.gov.au/minor_use/general.shtml](http://www.apvma.gov.au/minor_use/general.shtml). A Minor Use Permit has been received from APVMA to implement the Macquarie Island Pest Eradication Project using the described methodology, with conditions including the collection of target animal carcasses and the use of GPS to ensure accurate bait coverage.

6.3.3 Tasmanian Government approvals
The proposed eradication operation will be conducted within a Nature Reserve administered by PWS. Under applicable legislation, a Reserve Activity Assessment (RAA) is required to assess the potential impacts of the proposed activity. The RAA is distributed to other Tasmanian Government departments that have jurisdiction over particular aspects assessed
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by the RAA, such as landscape processes and threatened species. The RAA for this project has been approved by the General Manager of PWS in July 2009. Tasmanian Government approval is also required for the broadcast of brodifacoum and the use of a vehicle off formed roads in Zone B, staff access to the Nature Reserve and within Special Management Areas, and the use of firearms, dogs and traps.
7. Environmental Monitoring

7.1 Introduction

Monitoring is important to:

- Determine the achievement of the conservation goals and operational objectives
- Establish whether adverse environmental effects have been avoided, remedied or mitigated
- Provide information for making post-operational management decisions, for example, allocating hunting resources into hunting blocks
- Fulfil reporting requirements to Project Sponsors.

Full details of the proposed monitoring to be undertaken before, during and after the eradication operation will be included in Part F - Monitoring Plan.

7.2 Monitoring the success of the operation

Existing rabbit count areas across the island will continue to be monitored after aerial baiting. Monitoring for rabbit presence is closely linked to follow-up rabbit hunting, as rabbit hunters (some with dogs) will be searching for grazing, scats, prints or digging in the course of hunting activities.

In the event of a failed operation against rodents, mice and rat numbers may take up to two years to recover to a level where they can be detected. For this reason comprehensive monitoring to confirm the success of the first operational objective will be carried out two years after the completion of the aerial baiting operation, through the deployment of rodent detection dogs. Monitoring will also involve the use of tracking tunnels or traps for a set number of nights across a representative range of habitat types and geographic ranges. In addition, field staff will be covering the island thoroughly during rabbit hunting operations and will be able to search for rodent signs. If rodents are detected within two years, there may be no need for the deployment of dogs to the island to check for presence or absence of rodents.

Long-term monitoring of the pest-free status of the island following the eradication project will be achieved by establishing bait station and tracking tunnel systems. This will be established as part of the islands permanent rodent detection and prevention system, which is to be initiated as part of this program.
Samples have been taken from 21 rats and 28 mice for DNA fingerprinting purposes. Should rodents be found on the island subsequent to the eradication operation, this data can determine whether they are survivors from the original population or the result of a post-eradication invasion. Samples were taken from various sites covering the length and breadth of the island.

Before the eradication project is declared successful, monitoring for rabbits and rodents will be conducted until there has been a minimum of two years with no sign of any pest mammals.

The Health and Safety Officer for the operation will monitor for the second operational objective (‘conduct the operation without accident or serious incident’, see Section 3.4.4) throughout the operation (aerial baiting and ground hunting) by observation and on-going communication with operation personnel. The Health and Safety Officer for the aerial baiting and initial ground hunting operation is the Assistant Project Manager. For subsequent ground-hunting phases the Health and Safety Officer will be the Eradication Team Leader. Results from this monitoring will be discussed at the scheduled debriefing at the conclusion of the aerial baiting phase and then the overall operation.

7.3 Outcome monitoring
The impact of rabbits and rodents is so far reaching that it impacts on almost every aspect of the ecology of Macquarie Island. The most likely benefits from the eradication of rabbits and rodents are likely to be observed in:

- Geomorphological recovery (including and erosion reduction and protection of geoheritage sites)
- Vegetation recovery
- Recovery of invertebrate, burrowing petrel and albatross species.

While there is little doubt that these aspects will benefit from the proposed eradication operation, it is important to quantify the responses. While there is good baseline information for vegetation (for example An Annotated Atlas of the Vascular Flora of Macquarie Island – Copson 1984), soil dwelling invertebrates (primarily Collembola), albatrosses and petrels, there are few published studies on the abundance and distribution of above-ground invertebrates. The primary document that describes the monitoring regime to record and measure the effects of the eradication operation is Part F – Monitoring Plan.
7.3.1 Vegetation

Vegetation changes can be measured on a variety of scales. A number of studies have established monitoring plots and/or methodology for monitoring vegetation and geomorphology processes on Macquarie Island (see Table 6). Whilst this table does not list all relevant research that has been conducted on the island it includes data that is most relevant to identifying vegetation change following the eradication of rabbits and rodents. While much of this existing research will be useful in monitoring vegetation change following pest eradication, it may not be necessary to utilise all of these studies to effectively monitor changes.

### TABLE 6.

**Vegetation monitoring already underway on Macquarie Island**

<table>
<thead>
<tr>
<th>Scale</th>
<th>Method</th>
<th>Affiliation</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Island</td>
<td>Quickbird Imagery</td>
<td>UTAS, AAD</td>
<td>Bergstrom <em>et al.</em> (2009)</td>
</tr>
<tr>
<td>Island/community</td>
<td>Photomonitoring/quantitative assessment</td>
<td>PWS</td>
<td>Unpub.</td>
</tr>
<tr>
<td>Community/species</td>
<td>Photomonitoring, Exclusion plots/monitoring plots</td>
<td>DPIW</td>
<td>Copson and Whinam 1998</td>
</tr>
<tr>
<td>Community/species</td>
<td>Monitoring plots</td>
<td>AAD</td>
<td>Bergstrom <em>et al.</em> (2009)</td>
</tr>
<tr>
<td>Species</td>
<td>Exclusion Plots</td>
<td>PWS</td>
<td>Unpub.</td>
</tr>
<tr>
<td>Species</td>
<td>Seed bank data</td>
<td>AAD</td>
<td>Unpub. Hons Thesis</td>
</tr>
<tr>
<td>Erosion</td>
<td>Monitoring Plots</td>
<td>MRT</td>
<td>Selkirk and Saffigna 1999; Selkirk-Bell 2000</td>
</tr>
</tbody>
</table>

Extensive research is already being conducted on the vegetation of Macquarie Island at a range of scales. Some of this research will prove extremely useful in investigating the responses of vegetation following the eradication of rabbits and rodents. In addition a multi-
year Australian Antarctic Science proposal has obtained funding and approvals to, in part, investigate the impact of human-induced perturbations (e.g. rabbits and rodents) before and after management actions. Recent studies have also assessed geomorphological aspects.

### 7.3.2 Geomorphology, soils and geoconservation values

A broad range of descriptive material is available on the bedrock geology, geomorphology and soils of Macquarie Island (e.g. Banks and Smith 1988, Selkirk et al. 1990, Taylor 1955). The most widespread systems that induce change on Macquarie Island are erosion and deposition by water, wind, coastal and lake waves; and slope movement induced by saturation and periglacial activity, such as freezing and thawing (I. Houshold, *pers. comm.*). Additionally, the island is tectonically active, which drives changes to slopes and river systems. As yet only one quantitative study has looked at these systems, and it was based on a very limited dataset (Selkirk-Bell 2000). Regarding geomorphological change induced by the impacts of rabbits and rodents, long-term photographic data is available covering the extent of bare versus vegetated soil in landslip or sheet-erosion prone areas (Scott and Kirkpatrick 2008). Very little work has been undertaken to quantify rates and magnitudes of change in key soil or other geomorphic processes.

### 7.3.3 Invertebrates

The terrestrial invertebrate fauna of Macquarie Island has been well documented in recent publications (Greenslade 2006, van Klinken and Greenslade 2006). However, much less is known about invertebrate abundance and distribution. In a study conducted in the 1990s, Davies and Melbourne (1999) described some invertebrate assemblages associated with different vegetation types and provided some baseline data that might be useful in examining the response of invertebrates to the eradication of rabbits and rodents. Freshwater aquatic invertebrate communities have also been studied by Marchant and Lilywhite (1994), who provide some baseline data. Further work is required to establish some pre-eradication baseline data.

### 7.3.4 Burrowing petrels and albatrosses

There is good baseline data on burrowing petrel numbers and change from surveys conducted in 1999 (Brothers and Bone 2008) and from 2001-2006 (DPIW/PWS unpublished data). In 2005-06 a review of the current monitoring methodology was conducted. The subsequent report provided recommendations for future monitoring on burrowing petrels on Macquarie Island (Hedley and Terauds 2006). A database was developed to record the monitoring information. This database is currently held by DPPIPWE. Since 2005-06
monitoring of burrowing petrels has been refined and continued by PWS staff (PWS unpublished data) and by 2009 a comprehensive set of baseline data has been obtained. As the burrowing petrel response to rodent eradication is likely to be dramatic, it is critical that monitoring of burrowing petrels continues in conjunction with the start of the rabbit and eradication operation on Macquarie Island, to record the effects of the eradication. Monitoring is also undertaken for evidence of pest species interaction with burrowing petrels (e.g. burrow sharing with rabbits, evidence of rodent predation on eggs or chicks) and on some skua territories for petrel remains.

There has been increasing concern over recent years about the increase and extent of rabbit grazing on the slopes of Petrel Peak and the potential impact this could have on albatross breeding success and ultimately albatross breeding numbers. DPIPWE manage an ongoing albatross and Giant petrel monitoring program that assesses breeding numbers and breeding success each year on Macquarie Island. The monitoring program has produced a data set spanning multiple years of albatross and Giant petrel population numbers and trends. It forms an important role in measuring any population changes in these species that may occur following the eradication of rabbits and rodents.

7.3.5 The confounding effect of climate change
There is little doubt that the climate on Macquarie Island is changing (Tweedie and Bergstrom 2000, Pendlebury and Barnes-Keoghan 2007). Studies of Macquarie Island climate data have indicated that there has been increased precipitation since record collection began; an increase in wind speed, especially in winter; changes in precipitation, mainly occurring in autumn and winter; a significant decrease in the number of calm days; more cyclonic activity since 1990; and, a shift in predominant wind direction from westerly to north westerly (N. Adams, pers. comm.).

It is likely that these changes will affect the geomorphology, vegetation, invertebrates and burrowing petrels in a variety of ways. The extent to which climate change exacerbates the impact of rabbits and rodents is not known, but it seems possible that cumulatively these factors may result in more severe impacts (partially due to a potential increase in kitten survival and thus an expanding rabbit population). The recovery of vegetation, invertebrates and burrowing petrels after rabbit eradication may not be as pronounced as predicted if the effects of climate change continue.
7.4 Bait monitoring

Monitoring bait quality, bait spread and bait degradation throughout the eradication program is vitally important for the success of the operation and for the on-going management of the island. Monitoring of baits will also increase our knowledge base of bait characteristics and contribute extremely useful data for future operations.

7.4.1 Bait quality

The range and average toxic loading and size of a sample of baits will be monitored via standard laboratory assay techniques prior to the operation commencing. Aspects of bait quality such as bait hardness, fragmentation and any presence of mould will also be checked prior to the operation. Any bait of dubious quality will be disposed of as per the label instructions.

7.4.2 Aerial bait spread

Satellite positioning technology will be used as an aid to mapping the distribution of bait. Blocks will be designed in conjunction with the helicopter contractor to be as efficient for flying and bait spreading as possible. Flight paths will be plotted onto block maps and guide the helicopter pilot in the accurate sowing of bait. Block boundaries will be flown and checked before bait application commences. Data will be recorded on GPS software in the helicopters used in the operation, and maps of flight lines flown versus those plotted can be downloaded during refuelling stops and printed. Data will be reviewed to ensure bait spread is accurate and comprehensive within the operational boundaries. Any areas where gaps are detected between recorded bait runs will be re-sown as soon as possible (preferably the same day). Monitoring of bait application rates will be carried out during application to allow for adjustments where necessary, especially if bait uptake suggests a lower application rate may be desirable and still be within project parameters.

There are no exclusion zones for the spreading of bait except for the larger lakes on the island where the lake size is sufficient for the pilot to judge where to stop and restart bait flow without leaving gaps in coverage. Islands in lakes and off-shore rock stacks will also be baited, using trickle buckets to minimise bait swath and focus bait spread onto the target area.
7.4.3 Bait breakdown

Bait weathering trials were conducted in 2005. These trials showed that baits could persist in an edible form for rabbits and rodents for up to 9 months (see Appendix 3) although in the eradication operation the vast majority of baits are expected to be consumed by target species or to weather and break down into fragments.

Monitoring of toxin breakdown is considered unnecessary as extensive previous experience and research has shown that if any bait still exists, toxins will still be present, albeit in reduced concentrations.

7.5 Soil and water quality monitoring

Drinking water issues will be managed by the measures addressed in Section 5.2.1.

No monitoring of soil and water is proposed, unless a major site-specific spill occurs in a stream or the sea. Existing knowledge of the proposed methods and toxin characteristics on soil and water is considered sufficient to negate the need for specific monitoring (see Section 5.2). Brodifacoum has been used extensively in eradication operations elsewhere and the active pathways of the chemical are well known and documented. The one-off nature of this operation will ensure that toxins do not accumulate in the environment. Brodifacoum is not readily soluble in water so it cannot be expected to be detected in water bodies unless at high concentrations, such as the result of a spill. Previous operations have provided data on the likely effects of small quantities of brodifacoum entering the sea (see Section 5.3). For this operation the effects are expected to be negligible.

Baits spread in caves will be occasionally monitored for breakdown rates during hunting operations and any remaining six months after aerial baiting may be removed and buried.

7.6 Monitoring the effect on non-target species

It is important to quantify the level of non-target species mortality in order to gauge the success of the third of the operational objectives of the eradication; to understand the impacts of this operation; and, to increase the knowledge base for future eradication operations. Due to the timing of the operation and the absence of any other terrestrial mammals, the risk of non-target mortality is low and is restricted to a small number of species. A level of mortality of non-target species is expected, however the benefits of the eradication operation are expected to far outweigh any negative consequences, and impacted species are expected to recover quickly in the absence of mammal pests. Non-
target impacts are considered to be sustainable at an individual level and no significant or irreversible impacts are expected at a population level for any species. Any mortality or significant disturbance to non-target species resulting from helicopter or hunting activities will also be recorded and reported.

The main species that are likely to be affected by primary poisoning are Kelp gulls and possibly skua, should they become habituated to bait during successive bait drops and consume it. Any bird carcasses that are found incidentally that are not obviously from death by natural causes or brodifacoum poisoning will be recorded and a liver sample collected, should subsequent necropsy be required. If required, liver samples can be taken from individuals to test for the presence of brodifacoum.

Skua, Kelp gulls and to a lesser extent Giant petrels are thought to be the main species at risk from secondary poisoning. Carcasses will be recorded and collected with any obvious signs of death recorded. Not all carcasses found will be caused by brodifacoum poisoning and some liver samples will be taken to check for the presence of the toxin. Any other species will be autopsied and/or samples taken to enable the cause of death to be established. In cases of animal mortality from brodifacoum poisoning, autopsy is often sufficient to establish whether symptoms of haemorrhaging are evident. Sample collection will cease four weeks after the final bait drop, unless monitoring of bait uptake and target species mortality suggests that an extended period may be required. However, most bait pellets are expected to have been consumed by target animals or have begun to disintegrate after this time frame. Records of all detected non-target species mortality will be included in a report on the project to Project Sponsors (PWS and DEWHA).

Non-native bird species also potentially at risk include Starlings and Redpolls. Carcasses of these species will be recorded and collected where found. These species are, however, exotic to the island and if they are poisoned during the eradication program this is not considered to be a negative outcome.
8. References


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9. Acknowledgements

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Rosemary Gales
Sandra Potter
Stacey Buckelew
Tim Rudman
Appendix 1  Maps

Map 1  Location of Macquarie Island
Map 2  Macquarie Island - historic sites, huts and tracks

Historic Sites Table

<table>
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<tr>
<td>1</td>
<td>Wireless Hill Station</td>
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<td>2</td>
<td>The Lieutenant Processing Works</td>
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Spatial data provided by Australian Antarctic Data Centre
Map 3  Macquarie Island – vegetation (north)

Spatial data provided by Australian Antarctic Data Centre
Map 4  Macquarie Island – vegetation (south)

Spatial data provided by Australian Antarctic Data Centre
Map 5  Macquarie Island – Special Management Areas

Spatial data provided by Australian Antarctic Data Centre
Appendix 2 – Vascular Flora of Macquarie Island

From: Macquarie Island Nature Reserve and World Heritage Area Management Plan 2006

BLECHNACEAE
  Blechnum penna-marina

DRYOPTERIDACEAE
  Polystichum vestitum

GRAMMITIDACEAE
  Grammitis poeppigiana

HYMENOPHYLLACEAE
  Hymenophyllum falklandicum

LYCOPODIACEAE
  Huperzia australiana

APIACEAE
  Azorella macquariensis ............... e
  Hydrocotyle novae-zeelandiae

ARALIACEAE
  Stilbocarpa polaris

ASTERACEAE
  Leptinella plumosa
  Pleurophyllum hookeri

BRASSICACEAE
  Cardamine corymbosa

CALLITRICHACEAE
  Callitriche antarctica

CAROPHYLLACEAE
  Cerastium fontanum .................. i
  Colobanthus affinis
  Colobanthus apetalus
  Colobanthus muscoides
  Stellaria media ........................ i
  Stellaria parviflora

CRASSULACEAE
  Crassula moschata

HALORAGACEAE
  Myriophyllum triphyllum

Legend:

  e – endemic species
  i – introduced species
ONAGRACEAE
   *Epilobium brunnescens*
   *Epilobium pendunculare*

POLYGONACEAE
   *Rumex crispus* ................................ i

PORTULACACEAE
   *Montia fontana*

RANUNCULACEAE
   *Ranunculus crassipes*

ROSACEAE
   *Acaena magellanica*
   *Acaena minor*

RUBIACEAE
   *Coprosma perpusilla*
   *Galliumantarcticum*

JUNCACEAE
   *Juncus scheuchzerioides*
   *Luzula crinita*

CYPERACEAE
   *Carex trifida*
   *Isolepis aucklandica*
   *Uncinia divaricata*
   *Uncinia hookeri*

POACEAE
   *Agrostis magellanica*
   *Anthoxanthum odoratum* ................ i
   *Deschampsia caespitosa*
   *Deschampsia chapmanii*
   *Festuca contracta*
   *Poa annua* ................................... i
   *Poa cookii*
   *Poa foliosa*
   *Poa litorosa*
   *Puccinellia macquariensis* ........... e

ORCHIDACEAE
   *Nematoceras (Corybas) dienema* e
   *Nematoceras sulcatum* ............... e
Appendix 3  Bait Weathering Trials

To:  Noel Carmichael, Macquarie Island Executive Officer, Tasmanian Parks and Wildlife Service, Hobart.

From: Keith Springer, Parks & Wildlife Service, Macquarie Island.

Date: April 25th 2006.

Bait Trials Report #2.  Bait Weathering Trials – Macquarie Island

Introduction.

Rabbits were introduced to Macquarie Island by 1880 and rodents arrived at various times, but were probably established soon after European discovery by sealing ships in 1810.

Historically rabbit populations have followed both increasing and decreasing trends on the island, with the largest decrease following the introduction of the myxoma virus in the late 1970’s. Following the eradication of the rabbits’ main predator – cats – by 2000, numbers have steadily increased and the resulting impact on vegetation of overgrazing is well documented by photomonitoring programmes. Removal of vegetation has also lead to serious slope instability, bank erosion on gullies and coastal areas, and removed protective habitat from burrow-nesting seabird breeding areas.

Rats are known to predate eggs and chicks of burrowing seabirds and to consume large proportions of the seed crops of native plants, including megaherbs. Rats are also thought to impact on invertebrate populations but the degree of this impact is difficult to quantify. Rats are mostly restricted to the coastal fringe and escarpment slopes, although individuals have been seen and trapped on the plateau.

Mice are also known to predate on invertebrates and seeds of native vegetation.

Planning for eradication of rodents and rabbits from Macquarie Island Nature Reserve was undertaken during 2005, with two main components – an aerial application of brodifacoum baits and a follow-up operation utilising ground hunting teams and dogs.

Previous experience in island eradications had stressed the importance of using bait that was as fresh as possible, but the logistical constraints of the proposed Macquarie Island operation mean that baits are likely to be at least 6 months old when spread.

A trial was conducted on Macquarie Island from June to October 2005 to assess weathering rates and resultant palatability of cereal baits for the proposed rodent and rabbit eradication project on the island.

Report.

The complete report comprises this current report, a spreadsheet detailing results from each site visit over the duration of the trial, a folder of site photos of bait condition and site location at each site, and a copy of the bait weathering trials conducted by Kerri-anne Edge in 2000. The full report will be burnt to disc and provided to Noel Carmichael, Parks and Wildlife
Goal.

The goal of the trial was to assess the palatability of pellet bait in relation to weathering rates in Macquarie Island winter conditions. The trial dates were chosen to replicate the months during which poison baits would be spread in an aerial application. The two key elements of interest were:

1. at what rate would baits physically deteriorate under conditions experienced at different altitudes and in different vegetation associations
2. as baits deteriorated what effect – if any – would this have on palatability to target species (rats, mice, rabbits).

Area.

The area selected for the trial was north of Bauer Bay. Six bait cages were located in increasing altitudinal sequence and representing three different vegetation associations. All sites were adjacent to the Island Lake Track.

Dates.

The trial was commenced on June 10th and the last stage concluded on November 3rd 2005.

Bait.

Bait used was non-toxic cereal pellet bait, supplied by Animal Control Products, Wanganui, New Zealand. The baits were 10mm diameter, 2-gram baits dyed green, thus being a visual replica of the toxic baits proposed for the eradication project. The bait was produced in January 2005 and was thus 6 months old when deployed to the trial sites. Interim storage since arrival on Macquarie Island in March 2005 was in zip lock plastic bags stored inside a screw top plastic barrel.
Location of cages.

The locations selected to place the cages were chosen to represent different vegetation associations that are common on Macquarie Island (in order to assess what level of weathering could be expected to affect baits sown in different vegetation types) and at increasing altitude (to reflect two things – firstly that rodent and rabbit populations varied by vegetation type which themselves vary with increasing altitude, and secondly to reflect that weather conditions, especially precipitation and sunlight, both vary with increasing altitude, with increasing rainfall and decreasing direct sunlight as altitude increases.)

The cages were all located near to the Island Lake Track (ILT) for easy access. In order of increasing altitude, the cages were placed in the following vegetation types:

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<tr>
<th>Site</th>
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<td>492084 955088</td>
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<td>Pleurophyllum</td>
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<td>Adjacent to ILT by Emerald Lake</td>
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<tr>
<td>P2</td>
<td>plateau short tussock grassland &amp; Pleurophyllum</td>
<td>492320 956272</td>
<td>500m NE from Emerald Lake, near ILT track</td>
<td>194</td>
</tr>
</tbody>
</table>

At the time of commencing the trial all site locations were heavily grazed by rabbits, to the point where much of the “dominant” vegetation was dead or severely impacted. This remained the case until about mid-summer, after which the surrounding vegetation growth began to outpace the rate of grazing. However for the duration of the trial vegetation was heavily grazed around the cages.

1. Methods.

1.1 Cages

Due to insufficient materials being supplied (5 metres vs. 25 metres mesh as specified in the methodology); the specified number of cages for the trial (12) was not achievable. Cages were made from plywood sides carried around from VJM (the Australian Antarctic Division station) and used a 5m roll of rodent-proof netting to make the top cover (5mm mesh). Sufficient netting had been supplied to make six cages each 800 x 800mm. The ply sides were of a size (and thus weight) suitable for two people to carry over to Bauer Bay Hut. Ply sides were used purely to extend the amount of mesh to enable the six cages to be constructed.
1.2 Field deployment
Cages were set out in the field by using a spade to make slots into the ground for the plywood sides to fit into. Each cage was pegged down using four steel pegs. Due to the height of the sides and of the vegetation contained within the enclosure, the sides were embedded approximately 100mm into the soil. Within each cage 165 bait pellets were placed.

After two weeks rats gained access to three of the six cages by tunnelling underneath the ply sides and into the cage – eating some, or in one case all, of the baits inside. Following this, wider sections of ply were carried over from station, screwed to the cage sides, and seated into the ground in deeper slots. The extended cages had sides embedded approximately 250-300mm into the ground, and no further rat access to within the cages occurred. Cord handles were attached to two sides of each cage to enable removal of the cage to access the baits – until these were fitted a spade had to be used to dig them out which damaged the sides. At the three sites where baits had been eaten by rats (T1, S2 and P1) a new set of 164 baits were placed at the end of June and the trial re-commenced from that date.

1.3 Bait removal and monitoring
The procedure was to visit each site at approximately weekly intervals and remove 12 baits per cage on each visit. The baits were placed outside the cage at a known or marked site and on the subsequent visit checked to see if any had been eaten. The week-interval visits were mostly maintained over five months although occasionally other work priorities prevented this. Snow cover sometimes prevented access to the cages, especially Site P2, which held snowbanks longer than the immediate surrounding area.

2. Results
The results for the duration of the trial are shown in the attached spreadsheet (electronic version). The following points summarise the main findings.

- In all sites except P2 – the highest site on the plateau – baits that were removed from each cage were gone by the next check – and in most cases where the next check was the following day – almost all were consumed overnight. This pattern was consistent throughout the trial, and indicates that for at least one species eating the baits, weathering of the baits over the duration of the trial did not affect palatability.
- An anomaly in the above results was at the highest (plateau) site – P2, where no baits were taken over the course of 18 weeks, and thus a number of piles each of 12 baits built up around the cage – these were all untouched until 2 weeks before the
end of the trial when they all disappeared during the interval between subsequent checks.

- Weathering over the duration of the trial caused progressive deterioration of the physical appearance of the bait, however this did not affect rate of consumption once placed outside the cage. I am unsure of the rate of breakdown of toxin in the pellets in these conditions (in relation to the toxic pellets being used for the eradication rather than the non-toxic baits used for this trial).

- The weathering characteristics included a loss of colour on the outside of the bait (when broken apart the inside remained green) and a change in consistency – putty-like when wet or damp; but hardening again when it dried out. When damp or wet the pellet did not disintegrate, even by the end of four months. When dried out again the pellet was a more crumbly inconsistency if rubbed by hand, but showed no inclination to disintegrate if left to weather naturally.

- Significant breakdown of the pellets was noted in the latter two months of the trial due to invertebrate consumption.

- There was no significant or obvious difference in weathering rates across the different sites reflecting different vegetation associations or increased altitude, other than an apparently higher rate of weathering at the highest site (P2), although this was not at a significant rate. Note however, that in the area specified for the trial, there was no vegetation in healthy enough condition to replicate the few places on the island where healthy vegetation associations remain. For example there was no tall standing tussock or dominant stands of Stilbocarpa in the Bauer Bay basin that would allow trials to be undertaken in healthy examples of these vegetation types. Instead all trial sites selected were a more homogenous mix of mostly open vegetation (dominated by *Poa annua*) with areas of bare ground. Bait spread into tall tussock or dense Stilbocarpa stands could be expected to weather at different rates, characterised by higher moisture (once baits are on the ground) and with lower light and airflow affecting the baits.

**Figure 2** - bait condition at Site T1 on September 21st (left) and October 28th (right) after 11 and 17 weeks exposure. The black dot in middle of bait on the right is a beetle. Physical deterioration is mostly due to a combination of weathering and invertebrate consumption.

### 3. Discussion

The results from this trial generate a number of factors to note that are pertinent to a future eradication operation, and are discussed in this section.

1. While the trial aimed to replicate field conditions that the baits would be subjected to following a winter aerial poisoning drop – the cages did create a micro-climate that...
was damper than the area surrounding each cage. This was due to the necessity of using solid (plywood) sides rather than mesh (due to insufficient mesh being supplied). Mesh was attached to the top. The solid sides and small mesh size meant that airflow over the cage was reduced and so the area within the cage tended to remain damper than outside the cage. This was evidenced when removing baits on some occasions and vegetation within the cage was covered in droplets of moisture, when no moisture could be found on vegetation immediately outside the cage. This indicates that to an extent, the baits were subject to damper periods for longer than they would have been had the cage been absent. Note though, that even damper ground conditions would prevail for bait falling into the few remaining stands of tussock and dense Stilbocarpa found in some parts of the island.

2. The fact that apart from Site P2 most bait pellets were consumed overnight after removal from cages suggests that bait palatability was not affected by weathering for the four months of the trial. As noted elsewhere in this report the baits removed from P2 remained untouched for 18 weeks before all being consumed in the interval between visits. Because these baits were not being consumed on site for four months several were periodically collected from those already placed outside the cage and taken down to Bauer Bay hut. They were placed outside the hut in the evening and in all cases were gone by the following morning, indicating that the non-take from the P2 site was not due to palatability issues but more likely that no animal likely to be attracted to them had found them until late in the trial (i.e. into spring, when more animals were likely to be roaming further afield after winter conditions on the plateau eased.) On another occasion, when travelling to VJM instead of to Bauer Bay on a rainy day, half a dozen of these baits were placed in a plastic bag and I forgot to retrieve them for 4 days. As a result, they were wet, squashed to a paste, and had gone mouldy. However the baits were placed in a saucer and set outside (on station) after dark, and were eaten within 3 hours. This would possibly be the worst condition these baits could have attained and yet they still proved palatable.

3. There is no indication of whether all three target species were consuming baits placed outside the cages. It is certain that rats were, as rat faeces would often be found on the mesh tops of the cages, plus the burrowing into the cages and faeces within indicated rats actively pursuing the baits. There was no indication of whether rats were taking baits and caching them – behaviour not unknown in black rats on Macquarie Island. Despite obvious rabbit grazing all around the lower five cages, and occasional rabbit faeces and rabbit prints in snow on top of the cage mesh, rabbit consumption of baits cannot be ascertained. Consumption of baits by mice is likewise not confirmed by definite presence of faeces or tracks in snow.

4. No sign of skua, gulls or any other non-target species were ever seen at or near any of the cages.

5. Invertebrate activity was noticed from late August on, coinciding with the onset of spring. Invertebrates managed to gradually consume entire bait pellets and significantly dismantled most remaining baits by the end of September. The only time specific invertebrates were observed on baits was a number of worms in one bait at Site P1 and beetles crawling over some pellets at other sites.
6. The timing of the trial was consistent with that planned for the aerial poisoning operation, although it continued for a period after which the bait drop can be expected to have concluded (November cf. July).

7. The cages provided a de facto site for protecting invertebrates from predation by rodents, and despite the tiny area of these mini-refuges (the area of each cage was $0.6m^2$) there was a noticeably greater level of invertebrate activity within the cages than in the area immediately adjacent. Another factor that may have contributed to this is that with rabbits excluded from the cages the vegetation was able to grow un-grazed, and thus a much richer plant community existed within the cage, possibly enhancing invertebrate habitat. Given the size of the mesh it is likely that the increased number of invertebrates (which were not specifically recorded) was a reflection of individuals and eggs existing within the ground under each cage that were able to forage and develop without predation from rodents.

8. The fact that so many of the baits were consumed by invertebrates is a potential concern for risk to invertebrate populations as a result of an aerial toxic bait drop. Some factors may ameliorate these concerns though. In the practical application, baits will be broadcast over the island and affect invertebrate populations that are already subject to rodent predation; thus there may be a lower density of invertebrates over the island as a whole compared to those found in these cages which excluded rodents. Secondly the proposed eradication drop will spread baits with a density of around 2200 baits to 4400 per hectare (depending on which drop), and is thus far more sparse than the situation in these cages where the bait density is 273 per m² or 273,000 per ha (based on 165 per cage of 0.6m²). In addition the invertebrate activity was noticed most from late August on, whereas the bait spreading should be completed by August and the majority of baits consumed by vertebrate pests, leaving less for eating by invertebrates, and at an earlier time of year.

9. The cages also provided a micro-scale exclosure plot to gauge the response in vegetation from the exclusion of grazing animals – especially rabbits. Once the spring growing season commenced (late August) the difference was quite marked, with a 100% ground cover of native and introduced species (especially Poa annua) quickly developing, compared to the highly grazed environment outside the cages.
Figure 4 – Grazing impacts at Site S1 in September.

10). Upon removal of the trial cages in February 2006, two remaining pellets were found from Site P2 (the highest) that had been missed when the trial concluded in early November. The pellets were severely weathered, having been in the field for about 8.5 months. These two baits were taken back to station and put outside with 3 fresh baits. All five were gone overnight, indicating that even after nearly 9 months of weathering, the baits were still palatable, even when placed next to fresh baits. This augurs well for bait take by any remaining animals surviving a poison drop, although the species taking these last baits can’t be absolutely determined. Rats are the most likely species to have consumed them.

4. Conclusion.

The trial results indicate that weathering rates over the period of proposed bait spreading (June-July and possibly into August) do not affect palatability of the baits in Macquarie Island winter conditions for at least one target species – probably rats; and also that baits in particularly poor condition will still be consumed.

Give the methodology of this trial it is not conclusive that all three target species were consuming the baits or whether they were more palatable to one species than to the others. My supposition is that rats were more keenly pursuing the baits than either rabbits or mice; however the Palatability Trial (#1) showed that all species were taking the bait when offered, although a lower proportion of rabbits consumed baits. Experience on Enderby Island and Saint-Paul Island suggests that not all rabbits will consume baits even when they are available.²

Invertebrates did consume the baits but only after spring commenced. With the proposed baiting operation concluded by July this should be less of a problem in terms of poisoning of invertebrates, although the final impact will also depend how many baits are remaining after all target species have consumed all that they are going to. Even with poisoning of some invertebrates, populations should recover rapidly once predation from rodents is removed across the island.

² Micol, T and Jouventin, P: Eradication of rats and rabbits from Saint-Paul Island, Turning the Tide: Proceedings of the 2001 International Conference on Eradication of Island Invasives. Torr, N: Eradication of rabbits and mice from subantarctic Enderby and Rose Islands; ibid
Figure 5 - Condition of baits at Site S2 at setup on June 10th (top) on June 20th (centre) and October 11th (bottom).

Figure 6 – Condition of baits at Site T2 on June 28th (top left), July 18th (top right) and October 14th (bottom).
Appendix 1. – Macquarie Island Rainfall Records, June-October 2005

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<td>0.2</td>
<td>10.4</td>
<td>6.0</td>
<td>0.2</td>
</tr>
<tr>
<td>31</td>
<td>2.4</td>
<td>14.0</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
</tr>
</tbody>
</table>

| Total Rain | 90.4 | 119.0 | 140.6 | 114.0 | 38.2 |
| No. of Days of Rain | 29 | 28 | 30 | 27 | 24 |
| Total Since Jan.1 | 587.8 | 706.8 | 847.4 | 961.4 | 999.6 |
| Averages all year | 75.9 | 70.9 | 69.7 | 71.2 | 75.5 |
| Total days since Jan.1 | 164 | 192 | 222 | 249 | 273 |
Appendix 2. – Specifications given for conducting weathering trial and responses.

**Bait Longevity Trial**

- Trial to be undertaken between June and August. Trial was conducted between June and the final check in October, once all baits had been removed.
- Trial to be undertaken at Bauer Bay in three (tussock, *Stilbocarpa* and *Pleurophyllum*) vegetation communities between the field hut and the plateau but including the plateau *Pleurophyllum* communities adjacent to Emerald Lake environs and eastward along Island Lake track for 500 metres. Sites reflected these criteria. Six to eight bait testing sites will suffice. Six sites were established.
- Fine mesh cages (mesh size small enough to exclude mice) and large enough to place a quantity of baits (1kg) in each. 1 kg of baits equals nearly 600 baits, yet only 12 were required to be removed weekly for 12 weeks (June – August) – a huge cage would have been required to cover 1 kg of baits so the required number of baits was calculated and a cage of 800x800mm built to contain these.
- Small quantities of baits (twelve) will be removed at weekly periods to test their condition, and their relative palatability to rodents in that condition. Baits can be laid immediately outside the wire enclosures. Care will be required as the baits age and become susceptible to disintegration. In fact – they don’t become very susceptible to disintegration and can be handled carefully with no problems, even after 5 months (lift into position using cover plastic of notebook). This method was not required as the baits were robust enough to handle manually.
- Note and record rainfall through period - Bureau of Met records. See Appendix 1.
- Trial will continue until there is no obvious interest by rodents in bait trial continued until all baits had been removed from cages, approximately four months. Rodent interest in baits was maintained throughout.
- Baits will be checked and noted for mould appearance and invertebrate activity on baits throughout the trial. No mould was observed on baits apart from the situation noted where wet baits went mouldy after having been left in a plastic bag for a few days.
- Note skua take or interest. No skua were ever seen in the vicinity of the baits or cages.

**NB:** Particular note of bait acceptance to mice over a period in plateau environs is required. Mice eradication on islands has met with patchy success and may be linked to unpalatability of this particular bait type. Impossible to determine which species was eating baits.

**Needs**

- 25 metres of galvanised fine mesh wire (gauge small enough to exclude mice). Only 5 metres was supplied.
- Construction of 12 X galvanised rodent proof cages capable of holding 500g - 1 kg of bait only sufficient mesh for 6 cages, not 12.
- 25 litre plastic bin with screw top lid for storage of bait.
- Delivery of container and 10-25kg of non-toxic, non pyranine impregnated “green” bait to Bauer Bay field hut during 2005 resupply just over 1 kg was sufficient for the entire trial.
- Flagging tape Old trap-marking flags were used to mark the sites.
Appendix 3: Results of weathering site visits and actions taken and observations at each visit.

These results are included in the accompanying Excel spreadsheet (electronic) – not attached in this version.

Appendix 4: Sequential photos of trial sites and bait conditions are attached in the accompanying folder (electronic) – not attached in this version.
Appendix 4  Bait Palatability Trials

To:  Peter Cusick, Macquarie Island Executive Officer, Tasmanian Parks and Wildlife Service, Hobart.

From:  Keith Springer, Parks & Wildlife Service, Macquarie Island.

Date:  21st April 2005.

Introduction.

A trial was conducted in March-April 2005 on Macquarie Island to assess palatability of cereal baits for a proposed rodent and rabbit eradication project on the island.

Area.

The area chosen for the trial was North Head, a distinct and geographically isolated headland at the northern end of the island. North Head is separated from the main part of the island by a narrow isthmus, upon which the Australian Antarctic Division station is located.

North Head comprises about 50 hectares of land, and represents most vegetation and landform types found on the island.

Dates.

Bait was spread on Monday March 28th 2005. The spreading operation was undertaken using an AS350BA helicopter from Helicopter Resources, during the annual resupply visit to Macquarie Island.

Trapping and shooting of target animals commenced on 1st April 2005 and concluded on April 8th.

It should be noted that the timing does not replicate that of the proposed eradication project, which would involve spreading bait in suitable weather conditions between May and August.

Bait.

Bait used was non-toxic cereal pellet bait with pyranine dye, supplied by Animal Control Products, Wanganui, New Zealand. Six hundred kilograms of 10mm diameter bait was supplied and spread. The baits were dyed green as well as containing the pyranine, thus being a visual replica of the toxic baits to be used in the eradication project.
Staff.

Helicopter Resources pilot Leigh Hornsby spread the bait by helicopter, assisted by AAD and Helicopter Resources staff on the helipad. Georgie Hedley and Keith Springer (Tas PWS) completed the follow-up trapping and shooting, and assessment of bait take.

Bait spreading details.

1. Spreader. The spreader supplied was usually used for aerial spreading of fertilizer. It was calibrated by trial and error to try and achieve the desired spreading rate (6kg/ha). 50 kg lots were put through the spreader and timed to gauge dispersal rate from the spinner. This process was repeated four times with adjustments made accordingly. Bait was collected in a tarpaulin held around the spreader and then re-used. Once a dispersal rate was calculated a flying speed was worked out based on the desired sowing rate (12kg/ha total).

2. Spreading lines. The helicopter GPS was not sufficiently accurate for programming lines to fly so this was essentially done by eye.

3. A trial run across the top of North Head was measured and the area calculated. Based on this the flying speed was increased for the remainder of the drop.

4. Estimated spreading speed was 45-60 knots, taking into account a 20-25 knot southerly wind. Estimated spreading height was 50 - 70 metres above ground level.

5. Despite intending to not spill bait on station, a malfunction with the spreader when the helicopter was lifting off from the pad (the electric cable disconnected with the gate on open) meant that bait was effectively spread in a 40 metre radius of the helicopter pads. The cable disconnected on several other occasions, caused by the spinning of the bucket winding up the cable until it shortened and pulled out.

6. Video footage was taken of the spreading operation. The tape is still here on Macquarie Island and will be returned later in 2005.

Coverage.

Bait coverage was assessed by searching for baits on the ground. In essence the plateau area of Wireless Hill was well covered; and parts of the eastern slopes and Secluded Beach were well covered. Other than a swathe across the western slope of North Head proper, little bait was found on the flat behind Aerial Cove or on the northern end of North Head. Some areas of bait were found on the beach at Aerial Cove. The bait found was mostly intact and little seemed to have broken up by the spreader or by impact with the ground. Scree slopes had accumulations of bait at the bottom of the scree – often quite a considerable quantity.

Trapping and spotlighting.

Traps were set and spotlighting concentrated in areas where there was known to be bait present. No traps were set in Aerial Cove (there were fur seals around the small areas of bait on the beach). Traps were also set around the station to assess whether rodents were travelling far in their foraging for food. Results indicated that some rodents were travelling through tussock and eating baits that were not present around the trap sets, whereas in other cases at least one rodent trapped around the helipad spill had not eaten bait. Weather restricted spotlighting opportunities to three nights.
Techniques.

Trapping commenced on April 1st – four days after the aerial bait drop. Traps were set the previous day. Rat snap-traps were used to catch all rodents. Rabbits were obtained by a combination of day hunting or spotlighting at night. Snap traps were covered with a chicken wire cover to exclude birds and rabbits. A 50:50 mix of raw linseed oil and peanut oil was used as bait on snap traps, dribbled onto cotton wool tied to the trigger.

Animals trapped and shot were examined with a UV light to establish bait take. Initially the mouth, paws and anus were checked. If nothing was observed the abdominal cavity was opened and the stomach/intestines examined under the UV light. In most cases this was unnecessary as the dye was visible on fur, faeces and/or urine. On mice it glowed through the stomach fur without needing to open the stomach.

Results.

1. Non-target species.

Fur seals
Fur seal response to the helicopter over-flight was assessed by a team of four working on fur seals in Secluded Beach at the time of the drop. Sue Robinson and Kristian Peters observed that the seals reacted minimally to the helicopter noise as it flew overhead, but that they responded quite vigorously when the bait pellets came down around them. They observed that this behaviour was consistent with behaviour displayed by fur seals when hailstorms occur. Overall the impact of the bait drop on the fur seals was assessed as low.

Light mantled sooty albatross
Georgie Hedley and Graeme Lewis were in position to observe Light Mantled Sooty Albatross nests as the helicopter flew over (note that these birds would all be expected to have departed the island at the time of the eradication project bait drop). No apparent response was observed to the helicopter flying overhead. One bird looked up at the aircraft but appeared undisturbed. Graeme filmed the albatross nests during the flyover.

Skuas
Rangers on the island constructed three cages to capture skua and kelp gulls, in order to monitor these species for bait uptake. The cages were set out the day of the drop and the following day dead rabbits were placed in them to allow the birds to associate the traps with food. As it turned out the skuas stayed around the traps waiting for more rabbits and enough faeces were produced around the traps that they were able to be looked at under UV light without the necessity of trapping the birds. No faeces thus examined showed any signs of bait take. The skua traps on Wireless Hill were in areas where there was significant bait lying visible in the open, and skua were never observed showing any interest in the bait lying on the ground all around them. When bait pellets were tossed near the skuas they still showed no interest in them.

Kelp gull
At no stage were kelp gulls seen around the bird traps or baits on Wireless Hill, however a flock of gulls were present on the helicopter pad for several days after the drop. As there had been significant bait spilt on the pad during the drop (bucket malfunction) there was abundant bait in the area. After a week the pad area was checked and numerous green pellets were observed in gull faeces, so it is clear that they will eat the baits.
Environmental Impact Statement

2. Target Species.

Rodents

Rodents were trapped over 8 days. Initially few rats were caught – none the first or second days, one on the third. No rodents were trapped nor any traps sprung following the first night of set traps. Cotton wool was chewed off triggers on several occasions.

Difficulty was experiencing distinguishing between mice and juvenile rats, as they fall into the same weight range and have other similarities. Cunningham and Poors\(^1\) was the identification reference used. For the purposes of this report, all rodents falling into the size range of <30 grams are considered mice, but it is acknowledged that this will probably include some juvenile rats.

Gender mix amongst trapped mice can be considered unreliable as our identification improved over the course of the trial and we are sure that we initially sexed some female mice as males. However most rodents were kept frozen, so if gender mix is considered relevant to the eradication project then they can be thawed and re-sexed.

The results of the bait take need to be considered carefully as not all traps were within the zone of bait spread. Some traps were placed outside the zone of spread bait to assess whether rodents were foraging far and eating baits. A number of baits were placed around the station buildings for the same reason. Details on trap location can be found in the accompanying spreadsheet.

In total 68 rodents were caught – comprising about 20% of trapnights set. Of these 20 were rats and the other 48 mice. In overall terms (ignoring trap location relative to bait spread) 56 had eaten bait (including carcasses that had been eaten but sufficient remained to distinguish bait take), eight had not, and four were indeterminate (due to the carcass being eaten), leaving a valid sample size of 64. Of the eight that had not eaten bait:
- Two were trapped in locations with no bait spread in the immediate area or nearby (i.e. >30 metres)
- Four were in locations with no immediate access but with bait nearby (<30 metres)
- Two were in areas where bait had been spread, but were caught on the last day of trapping, and in searching for remaining bait in the area I couldn’t find any (rabbit bait-take was significantly down on the same day).
- From that assessment, if it is accepted that variation is attributable to lack of access to bait, then 100% of the remaining rodents had eaten bait.

Trap locations are available as a .map file if required.

Rabbits

A total of 52 rabbits were taken by both day and night shooting, commencing on the fourth day after the bait drop. Rain and snow conditions in early April meant that only three nights of the trial proved suitable for spotlighting. Rabbit shooting was concentrated on areas where bait was known to have been spread, although in some places it seemed to be spread quite sparsely. This essentially meant that all rabbits were taken from the North Head, Wireless Hill (plateau) and Lambing Gully areas. Beach areas were not covered to avoid disturbing seals and penguins with lights and shooting. GPS locations were recorded for all rabbits shot. Locations are available as a .map file is required.

No fleas were collected from rabbits shot, as there was no demonstrated relevance of this to bait take in rabbits. However fleas were incidentally observed on nearly all rabbits shot on North Head.

Of the 51 rabbits shot, 32 had eaten bait. There was a noticeable increase in rabbits that had taken bait after night shooting commenced. However a possible reason for this is that 10 of 11 rabbits shot during the daytime were on North Head (north of the saddle between Aerial Cove and Goat Bay) and this seemed to be an area where bait spread was a bit sparse, so it may reflect quantity of bait available rather than the fact they were shot during the daytime. By the final night of spotlighting (8th April) virtually no bait was able to be located on the ground (other than occasional very wet ones) and the rabbits taken on that last night showed a marked drop off in bait take (down 60% from three nights previously). This was 11 days after the bait drop, and would seem to indicate that in the conditions at the time bait was ineffective or gone after 9-10 days. Due to the absence of bait found I would attribute this to most of the bait being eaten by then, rather than the bait not lasting.

<table>
<thead>
<tr>
<th>Date</th>
<th>Number shot</th>
<th>Bait take</th>
<th>Shooting</th>
<th>Av. weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4.05</td>
<td>5</td>
<td>2 (40%)</td>
<td>day</td>
<td>1.9 kg</td>
</tr>
<tr>
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<td>6</td>
<td>2 (33%)</td>
<td>day</td>
<td>1.9 kg</td>
</tr>
<tr>
<td>3.4.05</td>
<td>14</td>
<td>12 (86%)</td>
<td>night</td>
<td>2.3 kg</td>
</tr>
<tr>
<td>5.4.05</td>
<td>14</td>
<td>12 (86%)</td>
<td>night</td>
<td>2.4 kg</td>
</tr>
<tr>
<td>8.4.05</td>
<td>12</td>
<td>3 (25%)</td>
<td>night</td>
<td>2.1 kg</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>51</strong></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Details of rabbit shot are on the accompanying spreadsheet. Interestingly the average weight of rabbits shot during the day was lower than the average weights of rabbits taken at night. While the sample size is small it may just be a reflection of younger rabbits staying still in daylight long enough to get a shot at them.

In addition to rabbits shot, four piles of rabbit faeces were found which glowed under UV.

### Bait weathering.

The day following the drop, bait pellets that had dropped in puddles or boggy areas were quite mushy but still maintained their shape. Pellets on open ground and in vegetation gradually absorbed moisture over the next few days and became more putty-like in consistency. It maintained this state until no more bait could be found, by about April 7th (10 days after the drop). A search on Friday 8th in areas where bait had fallen at a high density (including at the bottom of screes where bait had accumulated) revealed no bait other than that on boggy ground, indicating that all palatable bait had been consumed after 10 days, and that the small amount of remaining wet bait was unpalatable. This seems to be supported by the fact that evidence of bait take in both rodents and rabbits was lowest on the final day of the trial (8th April). Further bait longevity trials will be conducted between June and August.

### Points to note.

The trial as conducted had some important differences to the actual eradication project as proposed:

- The spreader used was not designed for spreading pellet bait
- The GPS aboard the aircraft was not able to be used for flying accurate lines
- The pilot had not been able to do any trials with this type of work or equipment due to the logistical challenges of the hopper and bait arriving on the ship while the pilots had spent the season in Antarctica.
- Calibration was "rough and ready" and there was no excess bait to use for calibration, so it had to be collected each time and put through the spreader again after further
adjustments. Because of the speed of the pellets coming out of the spinner and hitting the tarpaulin held around the spinner to contain the baits, many of the pellets broke, meaning a much reduced piece size was used in the calibrating exercise over the course of three or four adjustments. This may have had an effect on subsequent bait flow from the spreader during the drop (in that those pellets in subsequent loads were whole and only went out of the spinner once).

- As a result of all of the above the rate of spread and overlap percentage were inaccurate, leading to uneven and somewhat sporadic coverage of bait over the target area.

- Damian Love (AAD) was loading bait at the helipad and noted that the bait was not always running freely (although this had improved by the last adjustment prior to commencing spreading) and that pellets seemed to run through at different rates with each load. He also noted that the bucket was spinning at slower speeds (not enough airspeed to have an effect on the fin).

- Timing of the operation was different by up to 2-3 months, and it is likely that food sources for rabbits and rodents are more abundant in late March/early April than they will be during May-August. This may influence rabbit bait take upwards during those months, and result in a higher percentage taking baits than the highest in this trial (86%).

- Several of the non-target species will be absent or in lower numbers during the eradication project.
Appendix 1 – Photos.

Figure 1: Bait spreader
Figure 2: Mice under UV light showing pyranine dye in stomach. Note that in the right hand photo the tissue up the inner leg is glowing through the skin too. This animal has not been cut open.

Figure 3: Trap under mesh cover
Figure 4: Example of trap location – Lambing Gully (cover removed)

Figure 5: Cotton wool tied to trigger was sometimes removed by rodents
Figure 6: Gulls around helipad where bait was spilt – they stayed several days in this spot.

Figure 7: Gull-pecked bait pellet fragments from helipad
Figure 8: Bait pellets in kelp gull faeces/vomitus
Figure 9: Bait pellets retrieved 9 and 11 days after the drop. Both samples are from boggy areas and had flattened while carrying. No other baits were to be found by this time.
Appendix 2. – Proposed outline for conducting palatability trial and responses.

1 Bait Palatability

1a) Target species bait uptake trials methodologies

- Non toxic trial conducted to identify uptake of baits by target species
- Helicopter drop of 600 kg of non-toxic baits impregnated with pyranine tracer dye
- Conducted on North Head during annual station resupply and including coastal and headland areas, (total 50 ha @ 12 kg/ha). Bucket will be calibrated at 6kg/ha with helicopter undertaking 40m swaths (bait should be applied by bucket to a width of 80m giving a 50% overlap) therefore giving on ground rate @ 12kg/ha. Calibration and sowing rate both fairly variable due to operating considerations. Limited overlap and some parts of the trial area not well covered.
- Potential disturbances to fur seals, LMSA’s and penguins, but no long-term effects are expected. Personnel on site at Secluded Bay to take note degree of disturbance to fur seals. Yes, and also in position to observe LMSA’s.
- Take of target species to begin 3 days after initial helicopter drop (therefore best to undertake operation as late as possible into resupply if possible). Traps set out on the third day, so the first trapnight was the fourth night after bait was spread. As resupply had to be concluded and then the traps prepared (cotton tied on triggers) and set, this was the earliest that could be achieved.
- Up to 100 species each of Black Rat, House Mouse and European Rabbit will be taken. 20 rats, 48 mice and 51 rabbits taken in 8 days of trapping and shooting
- Rodent target spp to be taken by snap back traps placed inside a chicken wire compound which excludes birds and rabbits. Yes
- Attractant will consist of a 50/50 mix of peanut and raw linseed oil syringed onto a hard bound cotton wrapped around trap trigger Yes
- Traps will be checked every 24 hours. Yes
- Rabbits will be taken through shooting. All animals will be sexed and weighed. Yes
- All animals where there is no obvious sign of pyranine uptake will be returned to the station laboratory for a more detailed analysis of stomach content No – it was very obvious if they had or had not taken the bait and any rabbits that did not show glowing around the fur or anus had the stomach cavity opened on the spot to see if intestines glowed in the UV light. Rats and mice often were taken to the lab because they were lighter to carry and easier to weigh in the lab.
- 5 genetic samples of rat and mice ears and tail tips will be retained as part of a round island DNA analysis study. Other collection sites will include Green Gorge and Bauer, Lusitania and Caroline Bays. Samples will be placed in a 90% Ethanol solution and returned to Australia for analysis. See trial 5 for details. No samples were taken from this trial, as it would have made the collection date different to that requested in trial 5. Will do this separately as part of trial 5.
- Carcasses will be left for birds to scavenge Yes. Note this would have meant that scavenging birds would have then had glowing faeces without necessarily ingesting bait directly.
- Care will be taken not to spill bait on station so as the uptake by rodents on the southern end of the station may be analysed, i.e.; distance outside drop area rodents will travel to access baits While care WAS taken, unfortunately a malfunction on the spreader bucket meant that a considerable quantity of bait was spread around the helipad area. Some rodents trapped in this area showed a positive bait take.
- Collections of fleas off rodents and rabbits will be made noting a GPS location, date, habitat description (eg, tussock upper slope, lower slope, coastal tussock, etc) and which personnel Fleas were observed on most rabbits shot.
- Station trapping around buildings to be included to attain movement of rats into North Head tussock areas from station. Traps were placed around station buildings
including Cumpston's, main store, gym, Post Office, plumbers' workshop, field store, comms and cat shed.

1 b) Non target uptake trials methodologies
- Non toxic trial conducted to identify uptake of baits by non target species
- Live trapping of a maximum of twenty individuals of Subantarctic Skuas and Kelp Gulls around station environs. No skuas or gulls were trapped. Skua scats were available from outside set traps as they tended to hang around them waiting for more rabbits to be brought to the traps. Gull scats were collected from the helicopter pad a week after the drop. Three gulls were seen a day after the drop on Wireless Hill, no other gulls were observed in the higher areas of the bait zone. Gull scats/vomitus contained bait but skua did not.
- Other species (exotic) which may be taken if the opportunity arises to analyse bait uptake include,
  - Redpolls
  - Starlings  No redpolls or starlings were observed during the trials.
- Trapping will be undertaken using observed cage traps which have been pre-fed
- Traps will be baited with meat scraps other than poultry Rabbits were used.
- Individuals caught will be held in a quiet area until a scat is produced for analysis, then, marked with Niazonol marker and released. None caught
- Birds checked hourly for production of scats None caught.
Appendix 5  King Penguin Helicopter Trials

King Penguin Helicopter Over-Flight Disturbance Trials

Interim Draft Report

Macquarie Island
April 2007 & March 2008

Helicopter operating at 600ft above Lusitania Bay, Mach 2008. Photo: M. Giese

Melissa Giese & Rosemary Gales
NSW PWS
NSW

DPIWE
Tasmania
EXECUTIVE SUMMARY

Rabbits and rodents are known to be significantly impacting on the ecological integrity of Macquarie Island and a plan to eradicate these feral species has been developed. An integral component of the eradication plan involves the use of helicopters to deploy baits during winter. The altitudes that are recommended for bait deployment from helicopters range between 300 and 500 ft.

King penguins (Aptenodytes patagonicus), remain resident and breeding on Macquarie Island throughout the winter months and are known to be susceptible to disturbance from low flying aircraft, including helicopters. In order to investigate the tolerance of king penguins to over flights by helicopters, trials were conducted on the island during April 2007 and March 2008, in which the behavioural responses of king penguins were recorded as a helicopter passed overhead at altitudes ranging from 1,500 to 500 ft. Three king penguin colonies, all located on the east coast of the island, were used; Sandy Bay, Green Gorge and Lusitania Bay.

This interim report documents preliminary results which reflect the immediate behavioural responses of king penguins that were observed from the ground during over flights. Additional results, based on thorough quantification and analysis of filmed behaviour, will be published at a later date in the refereed literature.

Based on our observations, significant behavioural responses were evident among king penguins when a helicopter flew overhead at altitudes of 900 ft and lower. The most marked responses were displayed by adult penguins that were not in close proximity to chicks. These birds, at the periphery of the colonies, showed marked displacement, walking distances of up to 70 m away from the direction of the helicopter. Adult penguins within the colonies showed less marked responses although both adults and large chicks were nevertheless displaced when the helicopters flew overhead at altitudes of 900 ft and below. Over flights at both 600 and 500 ft were observed to cause movement by birds within the colonies – although no adults that were brooding small chicks were observed to move when the helicopter flew overhead, even at 500 ft. Flights in an east-west flight direction (i.e. from the sea toward the plateau) generated a stronger observable response than flights along the coast, in a north-south direction. At no time were penguins observed running in response to any over flights, and we did not observe behaviour approximating a stampede, as has been described for king penguins by others.
At Lusitania Bay, we also examined the responses of penguins to three over flights in quick succession; all at an altitude of 500ft. King penguins appeared to respond more strongly following the third flight, compared to their responses to single over-pass flights. Repeated flights seemed to cause many hundreds of king penguins to depart the colony for the sea, remaining roughly 1 km off-shore for at least 20 minutes after the last over flight was completed.

During the bait-spreading phase of the eradication program, it is anticipated that a major bait depot will be located 300 m from the Green Gorge hut site and 400 m from the Green Gorge king penguin colony. This placement will result in relatively frequent helicopter access during the period of bait deployment (approximately 250 flights over a period of up to three months). During our study, we made additional opportunistic observations of the behavioural responses of king penguins to helicopters that were undertaking resupply operations at Green Gorge hut. These operations involved helicopters delivering and retrieving loads via slings, requiring flying at extremely low altitudes (ca 50 ft). The behavioural responses of penguins to these helicopter approaches appeared to be significantly stronger than those observed during single passage over flights, particularly in terms of the displacement of adult king penguins at the periphery of the colony. A large number of birds departed the colony precinct, travelling distances of several hundred meters before settling. Initial observations however, did not show any sustained adverse behaviour of birds within the colonies, including those adults brooding small chicks.

The king penguin responses we observed, whilst significant, were not considered likely to cause long term disruption to breeding adults or chicks. Rather, responses of these birds were minor and transitory in nature and consequently, in the absence of any habituation that may occur, responses are regarded as acceptable within the context of the eradication plan; which is a short term and one-off operation. However, we do not recommend over flights lower than the current prescription (1,000 m as prescribed in Macquarie Island Management Plan 2006), for more general aircraft operations, particularly those involving the on-going and regular movement of helicopters around breeding birds.

Specific recommendations for the operation of helicopters with respect to disturbance of king penguins during the eradication program include:
Flight Management Planning

- Sufficient difference was detected in the responses of king penguins from each of the colonies to justify site-specific flight management plans for each king penguin colony on Macquarie Island.
- Flight plans should take into account the size and shape of the colony and any geographic characteristics that will influence aircraft sound attenuation. Flight plans should therefore be developed in consultation with pilots familiar with ways of reducing helicopter flight noise.
- Flight plans may need some inherent flexibility to accommodate local weather conditions (for example how to minimise blade-slap during certain wind conditions).
- As part of the planning/preparation for bait deployment, develop of a short training/instructional video, demonstrating the various types and intensities of king penguin behavioural responses to helicopters, with particular emphasis on responses likely to be observed during low level flights.

Operational Procedures

- Helicopter should not be operated below 500 ft within 1 km radius of king penguin colonies.
- When spreading bait over king penguin colonies a 1 km distance should be maintained from the coast when banking to return (most relevant to east-west flight paths).
- For breeding areas that require multiple over-passes, successive over flights should be separated by at least 10 minutes;
- The behavioural responses of king penguins during helicopter bait deployment should be filmed and observed in a manner that does not contribute any on-ground disturbance. Observers should be trained so they are familiar with the responses of king penguins to helicopter activity.
- Observers on the ground should be in constant radio contact with helicopter pilots during all flights over penguin colonies. In the event that responses stronger than those reported here are observed during bait deployment, aircraft should be instructed to immediately increase altitude.

Future research and monitoring

- Consider undertaking non toxic bait spreading operation to ascertain the response of the penguins to falling baits (as this may influence ingestion of baits).
- Consider further documentation of the responses of king penguins to helicopter activities associated with hut resupply and bait pod access/delivery at sites adjacent to a breeding colonies.
- Undertake on-going and regular census of king penguins across Macquarie Island to ascertain any gross impacts of bait spreading on population size.

The authors are aware of only one other attempt to document the responses of king penguins to helicopter activity. The results of our trials, when fully analysed, will therefore contribute greatly to mitigating against inappropriate flight altitudes for the eradication program at Macquarie Island and should also have broader application in the development of other eradication programs planned for islands where king penguins are resident.
1. INTRODUCTION

Macquarie Island lies in the Southern Ocean (54° 30'S, 158° 54'E), approximately 1500 km SSE of Tasmania. It is 34 km long and 5 km at its widest point, its steep coastal slopes rise, in most part to a 250 m plateau. Macquarie Island is part of the state of Tasmania, and is managed by the Tasmanian Parks and Wildlife Service (TASPAWS) of the Department of Tourism, Arts and the Environment (DTAE). The island is listed as a World Heritage Area and is a restricted area under the National Parks and Reserves Management Act 2002. The island contains numerous species of unique fauna, many of which are recognised as threatened under both Tasmanian and Commonwealth legislation. Four species of penguin breed on the island: king (Aptenodytes patagonicus), gentoo (Pygoscelis papua), royal (Eudyptes schlegeli) and rockhopper (Eudyptes chrysocome).

Rabbits, rats and mice are significantly altering the natural environment of Macquarie Island and are having a significant negative impact on breeding habitat for many seabird species, including threatened albatross and petrel species. An eradication plan to eliminate the three feral mammal species has been prepared and additional supportive planning is underway. This includes preparation of an Environmental Impact Statement (EIS) which will provide information for a referral of the project to the Commonwealth Minister for the Environment, Water, Heritage and the Arts (DEWHA) for consideration under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).

The eradication plan is based on an initial bait spreading operation across the entire island. To ensure the best chance of success, every rodent and rabbit must have the opportunity to encounter and consume baits (Parks and Wildlife Service 2007). Because penguin colonies provide a food source for rodents, especially in winter; bait coverage at the specified rate is essential within and around these colonies. For an island of the size and topography of Macquarie Island, aerial spreading using helicopters is the only viable way to ensure accurate and comprehensive bait coverage across the island. Helicopter bait-spreadings across most of the island must occur at low altitudes (300-500 ft optimal altitude: above ground level, IEAG 2005), to ensure coverage at the specified application rate. However, in the vicinity of penguin colonies, flights at low altitudes have the potential to cause wildlife disturbance.

The use of aircraft around penguin colonies has been the subject of various management protocols by nations working in Antarctica and those administering islands where penguin
colonies are located. A small number of experimental studies have measured the responses of some penguin species to aircraft (Sladen and Le Resche 1970, Culik et al. 1990, Giese and Riddle 1999). Available evidence suggests that aircraft activity can, in some circumstances, be highly stressful and disruptive to breeding penguins, and that a key parameter in determining the impact of aircraft is over flight altitude (Sladen and Le Resche 1970, Giese and Riddle 1999).

Little is known of the responses of king penguins to aircraft and limited experimental work has been published on the effects of controlled helicopter over flights on the species (but see Stone et al. 2002). Available reports suggest that the responses of king penguins to aircraft may include increased vigilance and territorial behaviour, walking away from approaching aircraft (Stone et al 2002), to panic and fleeing when aircraft pass overhead at low altitudes (Rounsevell and Binns 1991, Cooper et al. 1994). Previously at Macquarie Island, for example, 7000 king penguins at Lusitania Bay were reportedly killed during a stampede thought to have been triggered by a single, low level flight of a Royal Australian Air Force C130 Hercules (Rounsevell and Binns 1991).

The bait deployment phase of the Macquarie Island eradication plan is scheduled to occur during winter months (May-July) in order to maximise chances of success and minimise disturbance to wildlife. However, unlike other wildlife on the island, king penguins remain resident and breeding on Macquarie Island during winter and may therefore be vulnerable to disturbance during bait deployment. Minimising disturbance to this species during bait deployment flights has therefore been identified as an important objective of eradication planning.

Opportunities arose during the 2007 and 2008 resupply of Macquarie Island to conduct helicopter flights over king penguin colonies so as to inform planning for the rabbit and rodent eradication program. The purpose of the trials was to provide a quantitative basis for identifying which over flight altitudes best met the required balance between maximising the efficacy of bait drops while minimising disruption to king penguins.

Specifically, the project aimed to:
1. collect quantitative information on the behavioural responses of king penguins to helicopters operating at various altitudes;
2. identify the minimum altitude at which a helicopter may operate above a king penguin colony without causing unacceptable disturbance;
3. identify any potential site-specific differences in the responses of king penguins to helicopters; and
4. collect information on the possible cumulative responses of king penguins to repeated flights conducted in relatively quick succession (i.e. simulation of an aerial bait drop over a large area where multiple flights may be required).

The purpose of this interim report is to provide descriptive results of the visible, behavioural responses of adult king penguins and chicks to helicopter over flights. Comprehensive behavioural analysis of video footage is required before a more rigorous, quantitative analysis of the effects of the over flights on king penguin behaviour can be made.

2. METHODS

2.1 Study Colonies

Helicopter over flights were conducted during April 2007 and March 2008 at three king penguin colonies on the east coast of Macquarie Island: Sandy Bay (54° 33.74' S° 158° 55.2' E°), Green Gorge (54° 37.9' S°, 158° 53.9' E) and the main colony at Lusitania Bay (54° 42.834' S° 158° 51.182' E°). These colonies constitute almost 80% of the king penguin population on the Island although they differ markedly in size. In August 2007, a total of 2,660 chicks were counted from the Sandy Bay colony, while 940 chicks were counted from Green Gorge (Achurch 2007, Figure 1). By contrast, the main Lusitania Bay colony forms part of an extended extent of king penguin breeding sites on the east coast of the island (Figure 2). The smallest colony in this area has recently been estimated to contain 540 chicks, while 58,709 chicks have been counted from the main Lusitania Bay colony used in our study (Achurch 2007).

The three colonies also differ in topography. The Sandy Bay colony is situated on a relatively small beach that rises steeply to the plateau, such that the birds occupy a natural amphitheatre (Figure 3). By contrast, the beach at Green Gorge is relatively open and the topography behind the colony slopes gently to the plateau. At Green Gorge, king penguins largely occupy an area to the north of a permanent creek running from the plateau to the sea (Figure 4). The main Lusitania Bay colony is located on a beach, which also rises abruptly to the plateau. Unlike either Sandy Bay or Green Gorge, there can be little available space at the main Lusitania Bay colony due to the sheer number of birds that often occupy the site (Figure 5).
Figure 1: Northern half of Macquarie Island showing location and size of the king penguin colonies Sandy Bay and Green Gorge. Image and colony size figures reproduced from Achurch 2007.
Figure 2: Southern half of Macquarie Island showing location and size of the king penguin colonies in the Lusitania Bay area. Image and colony size figures reproduced from Achurch 2007.
Figure 3: Sandy Bay king penguin colony. Photo by N. Holmes, March 2003.

Figure 4: Green Gorge king penguin colony. Photo by M. Giese, April 2007
2.2 Helicopter Trials

The reactions of king penguins to helicopters were recorded from Sandy Bay during both the 2007 and 2008 seasons. The Green Gorge and Lusitania Bay colonies were used during 2007 and 2008 respectively.

A single-engine AS350BA ‘Squirrel’ helicopter was used for all flights, and was operated by the same pilot during both seasons. Prior to flights, we selected observation sites and took GPS positions of a northern and a southern point that would mark the start and finish of the flight path for each colony. The same flight paths were used for all flights at each colony. Due to the opportunistic nature of the trials and the other tasks helicopters were scheduled to complete during the island resupply, the helicopter sometimes carried a sling-load of cargo. While we could not control for this, all flights with loads were noted.

A number of over flight altitudes were tested at each site, ranging from 1500 to 500 ft (500 to 170 m, see Appendix 1). The timing and frequency of over flights, by necessity, was arranged on an opportunistic basis around the operational requirements of station resupply. As far as possible, over flights were separated by an interval of 20-40 minutes, during which
time there was no aircraft activity in the vicinity of the penguin colonies. In order to replicate the activity of the helicopter during planned bait drops, all flights were conducted at a speed of 60 knots.

During the eradication program, helicopters are scheduled to sow bait by flying along a series of north/south and east/west flight paths, spaced at roughly 40 m intervals along and across the island. As a result, while most of our trials were conducted using a north/south flight path (i.e. along the length of the island), some east/west flights were also conducted. At Lusitania Bay, due to the size of the area occupied by the main colony, several overpasses are envisaged during bait broadcasting, to ensure the entire colony area receives sufficient bait. To examine the possible cumulative responses of king penguins to repeated over flights, the birds at Lusitania Bay were also exposed to three flights in close succession, all operating at 500ft.

In addition to examining the effects of altitude and flight frequency, an opportunity arose to record the behavioural responses of king penguins to helicopter flights that occurred during the 2007 resupply of the Green Gorge hut, situated approximately 300 m from the king penguin colony and roughly 70 m from the beach (see Figure 4).

Throughout the study, behavioural responses of king penguins were monitored before, during and after helicopter flights. Behaviour was recorded on video cameras that were mounted on tripods and operated by observers at the periphery, or above each colony. When recording the responses of king penguins to the hut resupply at Green Gorge, one camera focused on the colony area, and the other on the adult penguins along the beach that were not attending chicks. The use of video cameras enabled a relatively large amount of data to be collected on the responses of individual penguins from various age and breeding classes and will allow for detailed quantification of responses at a later date.

On each day of flights, penguin behaviour was recorded for approximately 20 minutes prior to any helicopter activity, to provide a measure of pre-flight ('control') behaviour. Behaviour was then filmed immediately before (for 10 minutes), during and after (10 minutes) helicopter activity. Two observers (RG and MG), were on the ground operating video equipment and observing the immediate reactions of the birds. Observers were in constant contact with the helicopter pilots, ensuring that flights would be abandoned if extreme adverse reactions from the penguins were observed. As the helicopter approached the colony, the pilot indicated when the aircraft was 1 km in front of, over head of and 1 km past the colony. This
information was relayed by observers onto the sound track of video cameras for later analysis.

Local meteorological information was collected in situ before and after each flight. Wind speed (knots), wind direction, ambient temperature (°C), cloud cover (%) and the type/intensity of precipitation were all recorded.

3. RESULTS

This interim report provides descriptive results only of the visible, behavioural responses of adult king penguins and chicks to helicopter over flights. Detailed quantification of penguin behaviour will be completed at a later date. It is anticipated that these quantitative results will be peer reviewed and published, so they are available for other Sub-antarctic Island programs.

The date, time, altitude and direction of each flight conducted is given in Appendix 1. For each colony we attempted to trial all altitudes within the one day, however competing demands on the use of aircraft and deteriorating local weather conditions meant that this was not always possible. The locations of filming points, along with northern and southern fly-over positions for each colony are given in Appendix 2.

At Sandy Bay, roughly 30 adults with small chicks and 60 older chicks were filmed during 2007, along with more than 200 adult penguins that were not attending chicks. During 2008, we recorded the responses of roughly 20 adults with small chicks, 40 older chicks and 80 adults not attending chicks. At Green Gorge, information on the behavioural response of roughly 80 adult king penguins with small chicks (2-3 weeks of age), and 50 older chicks (6 months of age), was collected. At Lusitania Bay, behavioural responses were collected from approximately 40 adults with small chicks, 40 older chicks and in excess of 200 adults not attending young.

3.1 Behavioural responses during single over flights
King penguins showed only very limited visual behavioural responses to over flights at 1500 ft and 1200 ft. However, at all colonies, penguins showed clear behavioural responses when the helicopter was operating at or below 900 ft. As the helicopter approached and passed overhead, penguin behavioural responses included changes in orientation (i.e. the birds were ‘looking’ to locate the source of the sound), a decrease in vocalizations, particularly of
adults, an increase in flipper movement and physical displacement, which was generally manifested as walking a few metres away. At Sandy Bay and Green Gorge, adults in the middle of the colonies had a tendency to walk inland, while birds on the north and south perimeters turned and traveled ‘away’ from the colony. At Lusitania Bay, birds tended to walk in land in response to lower altitude flights before returning to their original positions. No penguins were observed running in response to the helicopter and we did not observe behaviour approximating a stampede.

Large chicks that were usually in small crèches were generally displaced distances of 5-10 m. No adults with chicks appeared to be displaced. Adults not attending chicks moved the greatest distances in response to the over flights; sometimes up to an estimated 30 m away. After most flights, even those conducted at low altitudes, penguin behaviour appeared to resemble pre-flight behaviour within 5 min of the helicopter departing.

At all colonies, the immediate behavioural responses of the birds were stronger with decreasing altitude, and flight direction also appeared to influence behaviour. Generally, flights in an east/west (i.e. seaward to inland) direction elicited a stronger response than did north/south flights. This effect was particularly noticeable for flights at Sandy Bay conducted during 2008, where a north-easterly approach (i.e. from the sea toward the eastern slope of the escarpment) resulted in blade-slap; the sudden occurrence of which corresponded with an increase in the number of birds moving quickly toward the back of the colony. A more detailed description of the behavioural responses of king penguins to flights of different altitudes is given in Table 1.

3.2 Behavioural responses during repeated over flights

At Lusitania Bay, king penguins were also exposed to three helicopter flights, conducted in quick succession (5 min apart) at an altitude of 500 ft. On the day of the flights the colony appeared very full, with few available spaces visible from the back of the colony to the shoreline. Birds reacted to the first flight with a cessation of vocalisations, increased flipper-flapping and displacement, generally in the direction of the sea. Larger, unattended chicks were displaced up to 5 m from their original locations. No adults with smaller chicks appeared to be displaced.

From our observations, king penguins had not resumed their pre-flight behaviour before the second flight occurred. By the third flight, the responses of the birds had intensified, and many hundreds of penguins were seen slowly walking toward the sea and departing the
colony. While some birds were observed returning to shore soon after the last flight, many more king penguins were observed off-shore (estimated at 1km), bathing and swimming. Giant petrels at Lusitania Bay were also noticeably more active at this time. King penguins continued to depart the colony for up to 20 minutes after the last over flight was conducted, suggesting that these flights had a more lasting effect on king penguins than did single over passes.
**Table 1.** Summary of behavioural responses of king penguin adults and chicks to helicopter over flights of varying altitudes.

<table>
<thead>
<tr>
<th>Altitude (ft)</th>
<th>Behavioural responses</th>
<th>Large chicks/Adults brooding small chicks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1500</td>
<td>Limited reorientation and looking up, some flipper-flapping. No overt displacements.</td>
<td>No discernible effect</td>
</tr>
<tr>
<td>1200</td>
<td>Responses similar to 1500 ft. At Sandy Bay, adults not associated with chicks walked en masse south – away from helicopter during approach. Returned after helicopter had departed.</td>
<td>No significant effect, some increase in flipper flapping.</td>
</tr>
<tr>
<td>900</td>
<td>Ca. 50 % of adults on N and S perimeters of colonies walked away from colony, some towards the water, distance moved ca. 20-30 m. None entered water. Increase in flipper-flapping. Some movement of adults within colony, displacement being inland. Settled after helicopter ca 1 km distant.</td>
<td>Some large chicks displaced, walking ca 5 m away from original position. No significant effect to adults brooding small chicks.</td>
</tr>
<tr>
<td>750</td>
<td>Adults not attending chicks outside the colony walked quickly either towards water or towards the colony. Greater proportion of adults showed displacement than at higher altitude. After helicopter had passed, the penguins settled less quickly than after higher altitudes (indicated by flipper flapping and agonistic encounters between adults).</td>
<td>Large chicks and adults within colony that were not brooding small chicks moved up beach and inland, displacement much stronger than at 900'</td>
</tr>
<tr>
<td>600</td>
<td>Nature of response similar to 750 ft, but intensity of response increased with greater proportion of birds moving and greater distances moved either away from noise, or inland. Giant petrels departed colony as helicopter approached. Noticeable increase in flipper flapping and decrease in vocal</td>
<td>Large chicks showed significant movement with the colony, displacement approximately 10 m from original position, towards back of colony. No</td>
</tr>
<tr>
<td>Altitude (ft)</td>
<td>Behavioural responses</td>
<td>Large chicks/Adults brooding small chicks</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------------</td>
<td>------------------------------------------</td>
</tr>
<tr>
<td>Adults</td>
<td>communication between birds as helicopter approached followed by significant increase in vocalisations after helicopter had passed. Much movement in the colony after the helicopter had passed</td>
<td>displacement of adults brooding small chicks observed.</td>
</tr>
<tr>
<td>500</td>
<td>Adults displaced by quick walking, all vacant spaces within colony filled as density of birds in colonies significantly increased. Giant petrels departed colony as helicopter approached. Noticeable decrease in vocal communication between birds as helicopter approached followed by significant increase in vocalizations after helicopter had passed.</td>
<td>Large chicks displaced, walking quickly from helicopter approach. Smaller chicks not displaced.</td>
</tr>
</tbody>
</table>
3.3 Behavioural responses during hut resupply

The resupply of Green Gorge hut involved four helicopter visits within a period of 2.5 hours to a site 100 m west of the hut (Figure 4). During this time, the helicopter usually approached from an easterly direction (i.e. from the sea) and was invariably carrying and retrieving loads via slings. Resupply involved flights at extremely low altitudes (ca 50 ft above ground level).

King penguins at Green Gorge appeared to respond more strongly to this activity than to over flights, particularly in terms of the displacement of adult king penguins situated at the periphery of the colony and on the beach. As the helicopter approached the hut, a large number of birds departed the colony, travelling several hundred meters before settling. Birds that were on the beach closest to the helicopter landing area moved quickly along the beach (travelling north, ‘away’ from the aircraft) in response to the first helicopter flight and landing. Although the movement of these birds appeared to slow with successive flights, king penguins only began returning to their original positions roughly 2.5 hrs after helicopter resupply had commenced.

4. DISCUSSION

4.1 Restatement of operational design

This project was designed to opportunistically measure the behavioural responses of king penguins to helicopter over flights so that operational guidelines could be refined prior to any planned aerial bait deployments on Macquarie Island. The prevailing weather and opportunistic nature of the project meant that certain aspects of the field program could not be controlled, including the timing, frequency and number of helicopter over flights. Similarly, there was limited opportunity to replicate flights over king penguin colonies of different sizes, or to thoroughly examine the effect of key meteorological variables, such as wind speed, wind direction and cloud cover, on the responses of the birds to helicopters.

During this study, penguins were incrementally exposed to flights of lower altitudes on the basis of their immediate behavioural response to higher altitude flights. Additional rigour may have been achieved by randomising the order in which birds were exposed to flights of different altitudes. However, given that king penguins could be expected to respond to aircraft in a moderate to extreme manner (Rounsevell and Binns 1991 and Cooper et. al. 1994), our deliberately conservative approach was considered warranted.
4.2 Assessment of responses during single over flights

King penguins at all colonies examined responded to a single helicopter over pass in a broadly similar manner. At higher altitudes (i.e. 1,500 and 1,200ft), there was little discernable change in penguin behaviour as the helicopter passed, although birds appeared to be aware that the aircraft was in the vicinity. At lower altitudes (below 900ft), adults not on nests and older chicks, decreased vocalisations, increased their flipper movements and became physically displaced, generally walking ‘away’ from the aircraft as it flew overhead. Stronger responses were observed with lower altitudes, until, at 500 ft (170 m), the majority of adults and older chicks in all colonies walked quickly in response to the aircraft. No birds were seen to run in response to single over flights, and no birds tending young chicks were displaced.

Our observations align well with those of Stone et al (2005), who reported that king penguins observed at South Georgia (54.1°S, 36.96°E) became quiet and walked toward the back of the colony when a Westland Mark 3 ‘Lynx’ helicopter passed overhead at altitudes of now lower than 750ft. Similarly, Stone et al (2005) also reported that the behavioural responses they observed among king penguins were of relatively short duration, lasting only as long as the helicopter was in the immediate vicinity of the colony.

Where the opportunity arose to test the effect of flight direction on penguin response (i.e. for flights at 600 ft), flights in an east/west (i.e. seaward to inland) direction elicited a stronger response among the birds than did north/south flights, with the occurrence of blade-slap having an immediate and relatively strong effect on penguin behaviour.

Generally, the responses that were observed from single over passes, whilst significant, were not considered to cause long term disruption to breeding adults or chicks; their responses assessed as being minor and transitory in nature. In the context of the eradication plan, which will involve a short term and one-off operation, the responses we observed are considered acceptable.

4.3 Assessment of responses during repeated over flights

The strongest responses we measured were associated with low altitude (500 ft) flights, repeated in quick succession over Lusitania Bay. Here, we observed significant numbers of birds departing the colony by the time the helicopter had completed its third passage, and the reaction was still evident 20 minutes after the helicopter had left the area. On the day before these flights, the Lusitania Bay colony was exposed to five single over flights, and this
may have influenced the magnitude of the responses we observed. If so, it is interesting to note that birds appeared to become more, rather than less sensitive to disturbance.

Probably of greater influence, however, was the size and situation of the Lusitania Bay colony. At the time of our trials, the colony contained many thousands of king penguins, with little available space evident from the back of the colony, near the escarpment, to the beach. In this situation, retreating to the ocean possibly represented the only feasible ‘escape’ for birds that were displaced.

The significance of the displacement we observed is difficult to ascertain, as even though we did not observe any movement of adults attending young chicks it was not possible to determine the status of all displaced penguins; such was the scale of the response. Nevertheless, although the reaction we observe to successive flights was strong, the birds were not considered to be close to panic or stampeding, as has been described elsewhere for king penguins on Macquarie Island (Rounsevell and Binns 1991).

The planned bait drops for Macquarie Island are scheduled for May-July, at a time when fewer penguins are likely to be occupying Lusitania Bay compared to March, when our trial was conducted. Later in the year only older chicks and non-breeding adults are expected to be present, so the strength of the responses we observed may therefore not be repeated during actual bait deployments. Flights conducted over Lusitania Bay during our study were separated by only 5 min, which apparently gave the birds no time to recover and resume ‘normal’ behaviour before the next flight was occurring. While there may be potential efficiencies in conducting successive flights in quick succession, the level of disruption we observed would likely be reduced if flights were separated by greater time intervals possibly of 10 min or more.

4.4 Assessment of responses to hut resupply

Our study provided only one opportunity to observe and film the responses of king penguins at Green Gorge to the reapply of the nearby hut. However, this location will be subject to a relatively high frequency of flights during the bait sowing stage of the eradication program, because a bait station (depot) will be located above the hut.

The observations of king penguin responses at Lusitania Bay, when the birds were subjected to repeated flights, should be used to inform planning for helicopter operations around bait stations that are in close proximity to penguins colonies, such as at Green Gorge. Although Green Gorge contains far fewer penguins than Lusitania Bay, the flights
into and around the hut/bait station at this site will be very low, potentially causing significant displacement of king penguins. Although king penguins are likely to habituate to repeated flights at some stage, preliminary results from Lusitania Bay suggest that, at least initially, king penguins may become more, rather than less sensitive the more they are exposed to helicopters. Additional monitoring of penguins during hut resupply at Green Gorge is therefore strongly recommended.

4.5 Caveats for broader application

During the time of our study, various breeding stages were evident within the king penguin colonies. The majority of birds present were adults not attending chicks, however large numbers of older, unattended chicks (6 months) and smaller, guard-phase chicks with adults were also observed. Only small numbers of moulting adults were present in the colonies (<5 birds) and we observed no birds incubating eggs.

Breeding phase is known to influence the nature and intensity of seabird response to human activity, with birds being particularly sensitive during nest establishment, and during the periods immediately after egg laying and chick hatching. Additional analyses of the footage we collected of behavioural responses may reveal differences in the reactions of adult king penguins that were not attending chicks, compared to older chicks and adults guarding smaller chicks.

In relation to the planned bait spreading phase of the eradication project, the timing is such (late May- July) that only older chicks and non-breeding adults are expected to be present and therefore exposed to over flights. Whilst these birds are likely to elicit responses to low altitude over flights that include short term and short distance displacement, the consequences of these responses are likely to be relatively minor and transient.

Macquarie Island is estimated to have an expanding king penguin population, which was in 2000 was estimated at approximately 400-500,000 birds (PWS 2006). At present, less than ten colonies have been identified, which range in size from 100 to 250,000 birds. Colony size and location can be an important variable influencing the sensitivity of breeding seabirds to disturbance and results from our study suggest the effects of helicopters on king penguin behaviour may vary with different colonies. For example, the number of birds at Lusitania Bay may have influenced the reactions we observed to repeated flights, while the setting at Sandy Bay probably contributed greatly to the occurrence of blade slap at that site, with its associated disturbance.
There were several other key factors that may influence the reaction of penguins to the broadcasting of bait during the eradication program that, for logistic reasons, could not be incorporated into these trials. These include the additional influence of the actual delivery of the bait pellets (2 g, 10 mm diameter pellets). The helicopter type to be used during the eradication program has also not yet been determined. As sound propagation properties differ between the different helicopter models anything other than a ‘Squirrel’ helicopter may elicit different responses.

Finally, the responses of predators to helicopter disturbance are not well documented, though we anecdotally observed increased flight behaviour among giant petrels and skuas when helicopters were present. The responses of predators could have a bearing on the overall impact of disturbance – could be considered in light of increased numbers and residency of GPs and skuas observed at Macca since rabbit numbers have increased.

5. RECOMMENDATIONS

The penguin over flight trials conducted at Macquarie Island during the 2007 and 2008 resupply represent one of only two known attempts to document responses by king penguins to helicopter disturbance. The results of these trials, when fully analysed, shall be critical to successfully mitigate against inappropriate flight altitudes for the eradication program at Macquarie island, shall have broader application for eradication programs planned for other islands where king penguins are resident and will provide valuable information for the development of operational guidelines for more general helicopter activities in and around king penguin breeding sites.

Based upon our preliminary analyses in this interim report we suggest that recommendations for the operational helicopter plans with respect to disturbance of king penguins during the eradication program include:
Flight Management Planning

- Sufficient difference was detected in the responses of king penguins from each of the colonies to justify site-specific flight management plans for each king penguin colony on Macquarie Island.
- Flight plans should take into account the size and shape of the colony and any geographic characteristics that will influence aircraft sound attenuation. Flight plans should therefore be developed in consultation with pilots familiar with ways of reducing helicopter flight noise.
- Flight plans may need some inherent flexibility to accommodate local weather conditions (for example how to minimise blade-slap during certain wind conditions).
- As part of the planning/preparation for bait deployment, develop a short training/instructional video, demonstrating the various types and intensities of king penguin behavioural responses to helicopters, with particular emphasis on responses likely to be observed during low level flights.

Operational Procedures

- Helicopter should not be operated below 500 ft within 1 km radius of king penguin colonies.
- When spreading bait over king penguin colonies a 1 km distance should be maintained from the coast when banking to return (most relevant to east-west flight paths).
- For breeding areas that require multiple over-passes, successive over flights should be separated by at least 10 minutes;
- The behavioural responses of king penguins during helicopter bait deployment should be filmed and observed in a manner that does not contribute any on-ground disturbance. Observers should be trained so they are familiar with the responses of king penguins to helicopter activity.
- Observers on the ground should be in constant radio contact with helicopter pilots during all flights over penguin colonies. In the event that responses stronger than those reported here are observed during bait deployment, aircraft should be instructed to immediately increase altitude.

Future research and monitoring

- Consider undertaking non toxic bait spreading operation to ascertain the response of the penguins to falling baits.
- Consider further documentation of the responses of king penguins to helicopter activities associated with hut resupply and bait pod access/delivery at sites adjacent to a breeding colonies.
- Undertake on-going and regular census of king penguins across Macquarie Island to ascertain any gross impacts of bait spreading on population size.
6. ACKNOWLEDGEMENTS

This program could not have been undertaken without the generous support of the Australian Antarctic Division. In particular, we are indebted to the 2007 and 2008 Voyage Management, particularly Voyage Leaders Don Hudspeth and Robb Clifton, Macquarie Island 2006-07 station leader, David Gillies and 2007-08 station leader Matt Dahlberg, communications operator Jenny Paton and the Helicopter Resources pilots and engineers who supported the program. We are grateful to the support of the host organisations that enabled us to undertake this work, namely the Biodiversity Conservation Branch of the Tasmanian Department of Primary Industries, Parks, Water and Environment (DPIPWE), the Parks and Wildlife Service (TASPAWS), the Marine and Biodiversity Division of the Australian Government Department of the Environment and Water Resources (DEW) and the NSW National Parks and Wildlife Service.

7. APPROVALS

This program was conducted under the conditions approved in the Scientific Permit # TFA 07067 issued by the Department of Primary Industries and Water, and in accordance with the Animal Ethics Committee Approval (# 31/2006-07; expiry 8/3/2008).

8. REFERENCES


### APPENDIX 1

Number, altitude, direction of flights and presence of sling-load during flights at king penguin colonies on Macquarie Island, 2007 and 2008. Flight times are UTC +10h.

<table>
<thead>
<tr>
<th>Location</th>
<th>Flight times (h)</th>
<th>Flight altitudes (ft)</th>
<th>Flight Direction</th>
<th>Sling-loaded</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green Gorge</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>0940 - 1000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-flight 0940</td>
<td>1006</td>
<td>1500 - 1700</td>
<td>N/S</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1020</td>
<td>1500</td>
<td>N/S</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1235</td>
<td>1200</td>
<td>N/S</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1329</td>
<td>900</td>
<td>N/S</td>
<td></td>
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<td>0940 - 0955</td>
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APPENDIX 2

Location of filming points and fly-over points for king penguin colonies.

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<tr>
<th>Location</th>
<th>Filming Position(s)</th>
<th>Northern fly-over position</th>
<th>Southern fly-over position</th>
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<td>54° 37.733' S°</td>
<td>54° 37.865' S°</td>
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<td>158° 53.896' E°</td>
<td>158° 52.926' E°</td>
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<td>54° 33.744' S°</td>
<td>54° 33.659' S°</td>
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<td>158° 55.218' E°</td>
<td>158° 55.221' E°</td>
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<td>Lusitania Bay</td>
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<td></td>
<td>158° 51.182' E°</td>
<td>158° 51.182' E°</td>
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</table>
Appendix 6 Burrowing Petrel Breeding Locations, Macquarie Island 2007

Note: Numerous White-headed Petrel and Antarctic Prion breeding colonies are located around the island but these have not yet been systematically mapped.
Appendix 7  Bait Trials 2005

To:  Noel Carmichael, Macquarie Island Executive Officer, Tasmanian Parks and Wildlife Service, Hobart.

From: Keith Springer, Parks & Wildlife Service, Macquarie Island.

Date: April 25th 2006.

Bait Trials Report #4. Non-target Species Trials – Macquarie Island

Introduction.
Planning for eradication of rodents and rabbits from Macquarie Island Nature Reserve was undertaken during 2005, with the plan having two main components – an aerial application of brodifacoum baits and a follow-up operation utilising ground hunting teams and dogs.

Previous experience in island eradications has highlighted the need to consider what impact any eradication programme has on indigenous species that are not species targeted by the eradication attempt and yet may be at risk from the operation.

Various trials were conducted on Macquarie Island from April to October 2005 to assess the effect of the proposed rodent and rabbit eradication project on non-target species. The trial methodology focused on the use of different coloured baits (blue and green), however as there are wider issues regarding non-target species effects the opportunity was taken to adopt a broader strategy to consider likely impacts of a poison bait drop non-target species in a wider context, and assessing a wider range of species than the proposed trial would have provided alone.

Report
The complete report comprises this current report and a spreadsheet detailing results from each trial conducted using specific quantities of different coloured bait. Video footage of king penguins at Green Gorge during helicopter operations and of wandering albatross chicks with baits is also included. The full report will be burnt to disc and provided to Noel Carmichael, Parks and Wildlife Service, Hobart; and a copy kept on the TASPAWS server on Macquarie Island under Feral Animals/Bait Trials/2005 Bait Trials.

This report is particularly aimed at providing information relevant to the section of Part C of the Eradication Plan – the Environmental Impact Report or Assessment, and should be passed on to the person writing that part of the plan.

Goal
The goal of the trial was to assess the effect on non-target species in relation to eradication operation spreading techniques and baits used, preferably in Macquarie Island winter conditions. Some trial dates were chosen to replicate the months during which poison baits would be spread in an aerial application, while others were conducted during and after a helicopter baiting trial in late March.

A further goal was assessment of the likely impacts on individuals and populations of native species present on Macquarie Island.
Bait

Bait used for the trials was non-toxic cereal pellet bait, supplied by Animal Control Products, Wanganui, New Zealand. For trials where baits were left out for several hours two bait colours were used - 10mm diameter, 2-gram baits dyed green and blue, to determine whether there was any colour distinction made between non-target species in potential bait uptake. Bait used for direct observations were all dyed green. Quantities of the bait were held at Bauer Bay, Green Gorge and Hurd Point Huts to allow trials to be conducted when in these widely spaced areas and also to ensure that variation in results was not due to repeating the trials at the same area.

Methods.

Methods used to assess impact on non-target species varied according to the type of risks assessed for each species.

The main methods used were:

1. Observation of species (including video taping) during helicopter operations in an area where non-target species were present.
2. Setting out of specific numbers of both green and blue baits and leaving for four hours, then re-counting baits at the conclusion of the trial. This method was always used during the day, so that nocturnal foraging by rodents would not skew the results. This was the original trial requested.
3. Direct exposure of non-target species to the baits – by placing baits adjacent to individuals (as they would be after a helicopter had passed overhead spreading baits) and observing to assess whether any interest was displayed toward the baits in any form.

Results of different coloured bait trials.

Six trials were conducted involving the method described in 2.) above. Of these, four were conducted on the isthmus and one each on the beach at Bauer Bay and Hurd Point. The comparison of the consumption of different coloured baits was inconclusive: of the six trials two had no baits touched, two had more green baits missing at trial end than blue baits, and two had more blue baits missing than green baits. The biggest distinction between coloured baits was from the first (heli-pad) trial, where 34/50 blue baits remained after four hours, compared to 45/50 green baits. At the other trials where some baits were missing, the gap was never greater than five baits between the two colours.

If the data is summarised across the six trials, with 50 each of green and blue baits left out for four hours making 300 baits of each colour, then at the conclusion of the trials there were 280/300 green baits remaining and 276/300 blue baits remaining.

With no clear pattern emerging, there was no conclusive difference between the two bait colours.

After the bait trial at Bauer Beach all 100 baits retrieved were placed in a pile outside the hut. By morning 99 were gone and the remaining one had been carried a short distance and dropped in grass.

After one trial, most pellets were covered with a layer of kelp flies.
Results by species.

**Fur seals** (*Arctocephalus sp.*)

Antarctic (*Arctocephalus gazella*), Sub-antarctic (*Arctocephalus tropicalis*) and New Zealand Fur Seals (*Arctocephalus forsteri*) are found on Macquarie Island during the spring to autumn months (the breeding season). Most individuals have left the island by winter.

The bait spreading trial conducted on March 28th 2005 provided an opportunity to assess the response of fur seals in Secluded Bay to helicopter spreading bait. Fur seal research programme staff were on hand in Secluded Bay and observed the response of the seals to the helicopter passing overhead and to the bait pellets falling around them.

The reported response was that the fur seals (all species are found in the bay) showed no reaction to the helicopter passing overhead, and that the seals responded immediately to the pellets falling around them by showing momentary minor alarm or confusion. The comment from the observers was that the fur seals responded in exactly the same way to hailstones falling around them during hail squalls. The helicopter passed overhead at an approximate altitude of 60 metres.

Because the fur seal population will have left the island by the months scheduled for bait spreading (June-July) the effect of the bait drop on these three species is expected to be non-existent, or very minor for any remnant individuals wintering on the island. There is no risk of prey species being poisoned by the bait drop and thus secondary poisoning is not considered to be a risk.

**Elephant seals** (*Mirounga leonina*)

A small number of elephant seals were also in Secluded Bay during the aerial bait drop trial, and the fur seal programme researchers observed no reaction from them to either helicopters passing overhead or to bait falling on the beach around them.

As most elephant seals leave the island for the winter there is considered to be no risk to the elephant seal population or individuals that remain over winter. There is likewise no risk of secondary poisoning as the elephant seals’ prey species will not be affected by any baits entering the water.

**Hookers (New Zealand) Sea Lion** (*Phocarctos hookeri*)

No sea lions were observed during the bait spreading trial on North Head. A very small number (<5) of Hookers Sea Lions can usually be found on Macquarie Island during the winter. While none were directly observed for a response – there is likely to be a similar response to either elephant seals or fur seals – i.e. no risk to the population (which in any case is transitory) or individuals.

**Skua** (*Stercorarius skua lonnbergi*)

Skua were a species which bait was “fed to” to see what the response was. This was carried out on a number of occasions in different locations around the island. In no case were skua ever observed to pick up, let alone ingest the baits directly. Nor was any more than a cursory look displayed when the baits landed near them, and they obviously did not associate the baits with anything of interest to them either food or otherwise. The risk to skua from direct poisoning is thus considered to be low.

However rabbits form a primary prey species for the majority of skua – especially those over-wintering, and are used to scavenging carcasses as well as actively hunting rabbits. They also know that some rabbits are easy pickings when infected with the myxoma virus and thus focus very quickly on sick or slow-moving rabbits. Accordingly, the risk to skua from
secondary poisoning is considered to be moderate to high for over-wintering individuals. A large proportion of the Macquarie Island skua population leave the island during the winter, returning in the spring to breed, and as the bait-dropping operation is scheduled to conclude by July, the majority of any rabbits in the open will be quite decomposed by the time skua return during September. The symptoms of brodifacoum poisoning take some time to manifest so rabbits may increasingly stay in their burrows with the onset of symptoms, until death occurs. If the majority of rabbits die in their burrows (the likely proportion is unknown) then this will make fewer poisoned carcasses available for scavenging by skua (and giant petrels) and this would certainly reduce the degree of secondary poisoning risk to over-wintering skua. The risk to the overall skua population is considered to be low, because only over-wintering birds should be at risk of secondary poisoning. It is noted that the skua population is at a higher level than would be supported by the island if rabbits were not present.

Kelp Gull (*Larus dominicanus*)
The trials using different coloured baits were all conducted on beach areas where kelp gulls were observed to be present, although skua were also present and this was not a specific way of targeting only gulls.

The results from trials where baits were left out often showed that some baits were often gone at the conclusion of the trial. There did not appear to be a specific pattern to whether more green or more blue baits were missing and this aspect was inconclusive. While no birds were directly seen to ingest the baits during these trials (the baits were left for a minimum of four hours and were not observed during the trial) kelp gulls are the most likely species to have eaten them. The reason for this is that no other species present on the beaches had shown any interest in the baits when directly exposed to the baits, and gulls were usually observed in the immediate area prior to setting the baits out. One of these trials was conducted on one of the station helipads, which is a favoured resting spot for flocks of kelp gulls, and bait pellets were found in bird faeces or vomitus on the helicopter pads at the conclusion of the trial. Gulls are the species most likely to have ingested them, and so the risk to individuals from direct poisoning is considered moderate to high. However the baits were put out at the rate of 100 per 10m x 10m trial area (50 blue and 50 green) equalling 1 bait per square metre or 10,000 per hectare. This is a far higher rate than can be expected to occur after an aerially spread bait drop, and thus the trial provided a bulk feeding opportunity that would not be replicated by the aerial spreading operation, where bait densities closer to 4400 per ha can be expected at the highest sowing level, and half that for the lower sowing rate.

Gulls are rarely (if ever) observed scavenging rabbit carcasses, and do not directly predate rabbits, so the risk to individuals or the population from secondary poisoning is low.
Gulls are widespread through the island and throughout the southern ocean, and the risk to the population as a whole is considered to be low.

**Black Duck** (*Anas superciliosa superciliosa*)

Black duck are one of the most timid species found on Macquarie Island, and are extremely difficult to approach without them taking flight. Due to this, direct exposure to baits was not practical, and nor was leaving baits out in their favoured habitat (tarns and pools on the coastal fringe), as they are widely dispersed and rarely return to an area from where they have been disturbed. Accordingly, no direct evidence is available on the risk of primary poisoning to black (or mallard) ducks. There appears to be no reason why ducks should ingest the baits as they do not resemble any of their natural food sources, nor have they had any exposure to situations where they would associate them as food (e.g. feeding on grain crops). However due to lack of information the risk of primary poisoning must be categorised as unknown. The risk of secondary poisoning would appear to be low. The toxin to be used in the baits is not readily soluble in water and nor do the pellets tend to disintegrate quickly when lying in water.

Black ducks on Macquarie Island are the same species as Grey ducks in New Zealand, and they have also hybridised with mallards on Macquarie. Even if some individuals were to consume baits, the risk to the population is considered low.

**King Penguin** (*Aptenodytes patagonica*)

1. Helicopter disturbance

Helicopter disturbance to king penguins has long been considered as a very high risk, as penguins are thought to be highly disturbed by helicopter overflights. This was the reason (not specific to kings) for the United Kingdom and Australian Antarctic agencies to introduce (in 2004) more conservative separation distances for aircraft overflying penguin colonies in Antarctica, by Antarctic Treaty nations (Working Paper on Guidelines for the Operation of Aircraft Near Concentrations of Birds in Antarctica - WP010 Agenda Item CEP 4d Cape Town 2004). Note that these guidelines are for voluntary compliance by Antarctic Treaty nations and are not directly applicable to Macquarie Island which is a part of Tasmania.

Personal observations of helicopter overflights during November resupplies on Macquarie Island have also shown that a degree of mass panic is evident when landing helicopters in or near colonies of both royal and king penguins. Green Gorge is a key site for assessing penguin disturbance because it is the site of a proposed bait and fuel depot for the eradication operation, and helicopters would be operating out of there spreading bait during the winter months. The 2005 hut resupply provided an opportunity to video the king penguins on the beach at Green Gorge whilst helicopters were overflying the beach to resupply the hut – which involved working on the terrace behind the hut. The distance from the king penguin colony crèche at Green Gorge to the terrace where helicopters were depositing cage pallets is about 197 metres; and the distance from the beach in front of the hut to the terrace is 100 metres - there being penguins all over the beach during helicopter operations. The video was kept trained on the penguins to gauge their reaction to the noise of helicopters flying overhead and to about 100 metres away. The helicopters can be heard in the video but not seen (as the video is kept trained on the penguins). A minimal reaction can be discerned from the birds to the helicopters operating nearby. There is an increased rate of alertness and flipper-shaking, and there is slightly more movement amongst the birds on the beach than prior to the helicopters’ arrival. However there is no evidence of significant agitation or alarm to the point where the birds actively remove themselves from the area. One possible explanation for the marked difference in apparent disturbance between November and April is that in November the penguins are just returning for the island after a winter away from the island, and are just starting to engage in pair formation and bonding for the imminent breeding season – a period when they may be vulnerable to disturbance. In
April the moult is concluding and birds are beginning to leave the island, plus more adult birds are away during the day feeding to support their chick, and thus may be less vulnerable to disturbance. In May to August – the period of the proposed helicopter bait drops – there are even less king penguins left on the island, with only the parents of surviving chicks left on the island. Green Gorge is the site of a planned bait and helicopter fuel depot for the eradication operation, and as such needs to be carefully considered as to the effect (on penguins and grey petrels) of helicopters operating out of there during the winter. There is a terrace above and to the south of the terrace where the cage pallets are currently placed – this upper terrace is 390 metres from the crèche and 300 metres from the beach and thus further away from the penguins. It may prove a suitable site for the storage of baits and fuel and as an operating area for helicopters spreading bait.

The 2006 resupply also provided an opportunity to assess penguin disturbance from helicopters operating at Green Gorge, and I observed the colony whilst flying into Green Gorge on a familiarisation flight for a new pilot. On the standard approach line to the hut operating area and returning back to the sea on three passes, no significant movement, reaction or disturbance was discernable amongst the birds on the beach or in the colony. From these observations it seems that king penguins may be less susceptible to disturbance by helicopters in autumn months than in the spring, with the implication that a similar behavioural response is likely in the winter months. However direct overflights of the colony at different altitudes were not conducted, and further trials to replicate the spreading of bait over the colonies should be conducted in the 2007 resupply. This would aim to gauge the vertical separation distance required above colonies to minimise disturbance to the birds without compromising bait swathe width and sowing rate. The risk to the king penguin colonies on the island from trials conducted thus far would seem to be low to moderate as far as helicopters operating in close proximity is concerned (moderate because although no response to the helicopters was observed, the response may be variable between colonies and a significant adverse response could have a moderate effect on a colony) – however the risk to the overall population would appear to be low. As noted above risks to the colonies and island population as a whole from direct overflights needs further assessment and none is offered in the context of this report.

2. Bait responses
The response of king penguins to the bait was assessed by tossing baits at and near to both adults and chicks during the winter months. Baits were placed both directly at the feet of the birds and also in the path of birds walking around the beach where they would encounter them. Individual birds (adults and chicks) were then observed to assess their response to the baits. On two occasions chicks leaned forward to look at the ground when the thrown baits landed at their feet, but took no further interest in them and appeared not to have noticed them once they had landed; on all other occasions both adults and chicks completely ignored the baits. Where baits were placed in the path of wandering groups no response to the baits was observed. The risk to the king penguin population from direct or secondary poisoning is thus assessed as nil to low.

Gentoo penguin (*Pygoscelis papua*)
Gentoo penguins also had baits tossed at and near them, with the same result as the king penguins - no interest was displayed toward the baits at all. It would appear that the major consideration of risk to gentoo penguins also lies in helicopter disturbance. I would note that for many years helicopter flying during November resupplies was carried out within 50 metres of gentoo penguin colonies (an example is the 1999 resupply when there was a gentoo colony around the satellite dome, with Sikorski S76 helicopters working the helipads all day for several days). The disturbance is likely to be transitory in nature as the birds have demonstrated the ability to acclimatise in past resupply flying situations. While the exact degree of impact of these past resupplies is now impossible to gauge accurately, the fact
that Gentoo still nest all around the station environs and that current census numbers are comparable with recent censuses suggests that no colony failures resulted from their previous exposure to adjacent working helicopters. In the 1999 example the Gentooos were seen abandoning their nests and stampeding away from the noise when helicopters were on approach for the first day or two, but after a couple of days their reaction was far more muted. The eradication plan timeframe means that while gentoo penguins will be present on the island they will not be breeding.

**Royal Penguin** (*Eudyptes schlegeli*) and **Rockhopper Penguin** (*Eudyptes chrysocome*)

Royal penguins have all left the island by mid-late April and do not return until mid-September. This means that for the proposed duration of the helicopter baiting operation no royal penguins will be present on the island and thus the risk to colonies and populations from either helicopter disturbance or poisoning is nil. Rockhopper penguins have a similar timeframe cycle delayed by a few weeks but again the operation should be conducted while there are no rockhoppers on the island and again the risk to them is considered to be nil.

**Wandering Albatross** (*Diomedea exulans exulans*)

Wandering albatross are a critically endangered bird breeding in very small numbers on Macquarie Island. Risk aspects pertinent to wandering albatross include potential helicopter disturbance and bait ingestion. Note that only chicks are present on the island during the helicopter operation timeframe, with parent birds returning infrequently to feed the chick.

1. **Helicopter responses.**

No helicopter activity was conducted near albatross during the 2005 or 2006 resupply, so no trial-based assessment can be offered in this report. However helicopter activity is strictly controlled on Macquarie Island to avoid disturbing breeding birds during the usual resupply period (March or April) it would seem to be unavoidable that the wintering chicks are overlown during the course of the bait spreading operation. With an 80 metre sowing swath this would probably involve around two passes near each nest, and there would probably be no direct impact on the chick, as long as an adult was not present on a feeding visit and the feeding disrupted as a result. In the event of an adult bird being seen during bait spreading operations, the area should be deferred until the adult bird has departed.

2. **Bait responses.**

Baits were placed on or near the nest pedestals of two chicks during the 2005 winter: the chick on the summit of Petrel Peak and the chick closest to Boiler Rocks on the north-western featherbed. Baits were placed by crawling to within a few metres and tossing a couple of handfuls of baits and then crawling away to a vantage point. The chicks were then observed either directly or with binoculars for about 20-25 minutes.

The Petrel Peak chick showed no reaction to the baits for the first 10 minutes or so. Following this I moved out of sight of the nest for 5 minutes. I then approached the nest from a different angle and noted the chick picking up a bait pellet and raising its head and swallowing. Photographs of the nest pedestal taken at first distribution and again about 20 minutes later show that most baits lying directly under the chicks front had gone. As the chick rotates on the nest and grooms the area within reach of the pedestal it can be assumed that all baits within reach of the chick will be moved in the course of grooming and that some baits will be ingested.
The chick near Boiler Rocks on the featherbed was observed through binoculars and was also observed moving the baits in the course of grooming the nest area, and was also observed ingesting some. During the period of observation most bait pellets were picked up with the beak and rearranged around the nest (usually picking up from the base of the pedestal with the beak and placing them on top of the pedestal or underneath the chicks' body). Only a small number appeared to have been eaten during the period of observation. However it is possible that baits may have been eaten subsequent to the chick rearranging them around the nest pedestal and after observation ceased.

While I am unsure of the toxicity of the baits to be used in the context of a bird the size of a Wandering albatross chick the fact remains that the risk to individuals must be assumed to be high. The risk to the Macquarie Island population, given its critically endangered status, may be moderate, but would be dependant on the number of chicks present in the winter of aerial bait spreading operations.

That Wandering albatross chicks will eat baits means a baiting strategy will have to be adopted during the aerial application to avoid ingestion of baits that may fall around the nest, whilst still ensuring the availability of baits to rodents foraging in the vicinity of each nest. One such strategy might be to have a person on the ground at each nest site, who is tasked with observing whether any baits land near the pedestal and immediately removing any that fall within say a 5-metre radius of the nest. Although foraging rodents should cover a wider area than that with baits removed from around the nest, a couple of Philproof bait stations can be placed near to the nest to ensure that baits are available to rodents.

**Light-mantled Sooty Albatross** (*Phoebetria palpebrata*)

With the bait spreading trial in late March 2005 the opportunity was taken to observe light mantled sooty albatross on the North Head slopes to gauge potential helicopter disturbance. During the bait drop observers were stationed on eastern slopes where these albatross breed and are commonly seen soaring, but no albatross showed any signs of alarm, distress or indeed any response whatsoever to the helicopter flying overhead and spreading baits. Combined with the fact that all light-mantled sooty chicks should have fledged and adults departed by the commencement of bait spreading in late May or early June, then risk of disturbance to these birds is assessed as nil to low.

**Giant Petrels**

Two species of giant petrel are present on Macquarie Island throughout the year; the Southern giant petrel (*Macronectes giganteus*) and the Northern giant petrel (*Macronectes halli*). Giant petrels are also timid around humans and thus were not approached to directly expose them to baits, nor were giant petrels ever observed in the area of the different coloured bait trials. Consequently no information is available on the likelihood of direct
consumption of baits, although from their observed behaviour there is no reason to think that they would consume baits directly. While on the island giant petrels are primarily scavengers of the coastal area, they have been observed scavenging dead rabbits - but only infrequently and never far from the shore. The risk to individuals from secondary poisoning is likely to be low, and the risk to the population also as low.

**Antarctic tern** (*Sterna vittata bethunei*)
Antarctic terns are present on Macquarie Island in small numbers throughout the winter. Predominantly inshore feeders, they are not thought to be at risk from either helicopter disturbance or secondary poisoning at either individual or population levels.

**King cormorant** (*Phalocrocorax albibenter purpurascens*)
As for Antarctic terns.

**Burrowing petrels and prions**
A number of burrowing seabird species breed on Macquarie Island and adjacent offshore rock stacks, with varying population abundance. These include Cape Petrel (*Daption capense*), Grey petrel (*Procellaria cinerea*), Blue petrel (*Halobaena caerulea*), White-headed petrel (*Pterodroma lessoni*), Soft-plumaged petrel (*Pterodroma mollis*), Fulmar prion (*Pachyptila crassirostris*), Antarctic prion (*Pachyptila desolata*), Fairy prion (*Pachyptila turtur*), and Sooty shearwater (*Puffinus griseus*). Of these, only grey petrels are likely to be present in the period of aerial baiting. With the adult birds largely departing and returning to the island at dawn and dusk, helicopter disturbance to grey petrels is assessed as minimal. The chicks are in burrows through the winter months and are unlikely to be exposed to either baits are helicopter disturbance, thus the risks to grey petrels are likely to be nil to low.

**Conclusion.**
Amelioration of the effects of the eradication operation on non-target species will form an important part of the overall eradication plan.

This report has assessed observed or surmised effects on non-target species in relation to poisoning – both primary and secondary – and as a result of helicopter disturbance. No assessment has been made of the likely impacts of the follow-up operations after the baiting has been completed i.e. the ground teams covering the island (including coastal areas) and following up with shooting, trapping, gassing burrows and the use of dogs.

The main impacts on non-target species can be summarised as the potential for poison baits to be ingested by kelp gulls and wandering albatross chicks; secondary poisoning by skua and possibly giant petrels; and potential for helicopter disturbance of king and gentoo penguin colonies, although observed behaviour of king penguins showed a response to nearby aircraft that was discernable but apparently not significant.

The skua population is “artificially” high as a result of an abundant year-round food source (rabbits) and with rabbits gone (or hugely reduced) after a poisoning drop careful consideration is needed of the likely prey-switching behaviour of skua and the impact on alternative prey species populations (especially blue petrels and white-headed petrels) in the following breeding season.

Further work is required to assess behaviour of king and gentoo penguins with helicopters passing directly overhead. Management of individual wandering albatross nests will be required during baiting operations. Overall impacts are likely to be minimal to native species on a population basis.
Environmental Impact Statement

The effect of baiting operations on introduced species (such as mallard ducks, starlings and redpolls) was not assessed.

Appendix 1. – Specifications given for conducting non-target species trial and responses.

Non-target Uptake of Differing Coloured Baits

- Trial to test preference of non-target bird species with green or blue dyed baits through consumption counts. This was done but the trial expanded to use the opportunity of being on the island with non-toxic baits to assess impacts on a wider range of species. The report was also expanded to include observations of helicopter disturbance and direct bait responses in addition to the trial methodology noted below.
- Non-toxic, non pyranine inserted blue and green dyed baits to be used
- 100 non-toxic baits, consisting of 50 green and 50 blue dyed baits to be laid out randomly within a 10 metre square grid through the day. After four hours, a count of baits remaining will be made. Completed
- Repeated in different locations/habitats around island where gulls and/or skuas are present. Completed

Needs

- 15 kg non-toxic, non pyranine “green” baits.
- 15 kg non-toxic, non pyranine “blue” baits
- GPS
Appendix 2: Results of different coloured bait trials.

<table>
<thead>
<tr>
<th>Date</th>
<th>Location</th>
<th>GPS reference</th>
<th># of green baits</th>
<th># of blue baits</th>
<th># of green remaining after 4 hrs</th>
<th># of blue remaining after 4 hrs</th>
<th>Weather conditions</th>
<th>Observations</th>
<th>Observer</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-Jun-05</td>
<td>helipad on isthmus</td>
<td>496008 961012</td>
<td>50</td>
<td>50</td>
<td>45</td>
<td>34</td>
<td>about 3°C, showers, 25 knots W</td>
<td>1 gull observed on pad at start and end of period. Many baits softened and sand covered - possibly some regurgitated? Also elephant seals in area may have moved some baits.</td>
<td>K. Springer</td>
</tr>
<tr>
<td>11-Jun-05</td>
<td>behind Cat Shed</td>
<td>495909 960935</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>6.7°C, 13 Knots NW</td>
<td>Too few birds around. After the trial the 100 baits were placed overnight outside SAD. 82 remained the next morning - although 7 had been cached 500mm away.</td>
<td>K. Springer</td>
</tr>
<tr>
<td>17-Jun-05</td>
<td>Bauer Bay beach</td>
<td>491833 954784</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>cool, overcast, light winds</td>
<td>King penguin walked through trial area. Collected baits after trial and put them on the grass outside the Bauer Bay hut porch that night. 99 had gone by morning. Remaining 1 had been shifted and dropped in grass.</td>
<td>K. Springer</td>
</tr>
<tr>
<td>8-Jul-05</td>
<td>helipad on isthmus</td>
<td>496008 961012</td>
<td>50</td>
<td>50</td>
<td>45</td>
<td>50</td>
<td>3°C, 25 knots W, snow showers</td>
<td>No birds observed.</td>
<td>K. Springer</td>
</tr>
<tr>
<td>22-Aug-05</td>
<td>helipad on isthmus</td>
<td>496008 961013</td>
<td>50</td>
<td>50</td>
<td>46</td>
<td>43</td>
<td>4°C. Fine, sunny, 15 knots W</td>
<td>No birds observed. Interestingly, nearly all baits covered with kelp flies, or had kelp flies on the baits.</td>
<td>K. Springer</td>
</tr>
<tr>
<td>29-Sep-05</td>
<td>Hurd Point</td>
<td>488848 930520</td>
<td>50</td>
<td>50</td>
<td>44</td>
<td>49</td>
<td>fine afternoon, little wind.</td>
<td>Non conclusive as king penguins moved onto site and some baits had sand scuffed over and buried.</td>
<td>K. Springer</td>
</tr>
</tbody>
</table>
Appendix 8  Seasonal cycle of some Macquarie Island wildlife
Appendix 9  APVMA permit

Australian Government
Australian Pesticides and
Veterinary Medicines Authority

PERMIT TO ALLOW MINOR USE AND SUPPLY
OF AN AGVET CHEMICAL PRODUCT
FOR THE CONTROL OF EUROPEAN RABBITS, BLACK RATS AND HOUSE MICE
ON MACQUARIE ISLAND

PERMIT NUMBER -PER10895

This permit is issued to the Permit Holder in response to an application granted by the APVMA under section 112 of the Agvet Codes of the jurisdictions set out below. This permit allows a Supplier (as indicated) to possess the product for the purposes of supply and to supply the product to a person who can use the product under permit. This permit also allows a person, as stipulated below, to use the product in the manner specified in this permit in the designated jurisdictions. This permit also allows the Permit Holder, the Supplier (if not one and the same) and any person stipulated below to claim that the product can be used in the manner specified in this permit.

THIS PERMIT IS IN FORCE FROM 1 MAY 2009 TO 30 SEPTEMBER 2011.

Permit Holder:
TASMANIA PARKS AND WILDLIFE SERVICE
124a Tolosa Street
GLENORCHY TAS 7010

Supplier:
Animal Control Products,
408, Heads Rd.,
Wanganui,
New Zealand

Persons who can use the product under this permit:
Employees of or persons under the direct supervision of Tasmanian Parks and Wildlife, who are trained or experienced in the preparation and use of agricultural chemical products.
## CONDITIONS OF USE

**Product to be used:**
PESTOFF RODENT BAIT 20R
Containing: 0.02 g/kg BRODIFACOUM as its only active constituent.

**Directions for Use:**

<table>
<thead>
<tr>
<th>Situation</th>
<th>Pest</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macquarie Island</td>
<td>European rabbits</td>
<td>5kg - 35kg per hectare depending on rabbit densities.</td>
</tr>
<tr>
<td></td>
<td><em>Oryctolagus cuniculus</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Black rats</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Rattus rattus</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td>and</td>
<td></td>
</tr>
<tr>
<td></td>
<td>House mice</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Mus musculus</em></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SO NOT apply more than 4 applications per season with a minimum re-treatment interval of 14 days.</td>
<td></td>
</tr>
</tbody>
</table>

**Jurisdiction:**
TAS only.

**Supply:**
1. The supplier must supply the product in a container that complies with the requirements of section 18(1) of the Agricultural and Veterinary Chemicals Code Regulations. Attached to this container must be a label which is identical in content and format to the label in Attachment 1.

**Additional Conditions:**
2. Persons who wish to prepare for use and/or use products for the purposes specified in this permit must read, or have read to them, the details and conditions of this permit. Unless otherwise stated in this permit, the use of the product must be in accordance with instructions on its label as contained in Attachment 1.

3. Either a Global Positioning System (GPS) or its enhancement Differential Global Positioning System (DGPS) must be used for logging of bait placement during the baiting program to ensure high efficiency and minimise unnecessary overlap of baiting runs during distribution.

4. Collection and disposal of carcasses. Retrieve any visible carcasses of target animals (Rats, Mice and Rabbits) in accessible areas and dispose them in a manner that would reduce the risk of secondary poisoning.

5. Target and non-target species monitoring and reporting
   a. Monitoring must be undertaken for all non-target species at risk of primary and secondary poisoning, specifically the Great Skua and Kelp Gull. Data collated must include mortality rates and behavioural changes. Any significant and/or unexpected non-target species effects must be reported to the APVMA within 7 days.
   b. Monitoring must be undertaken on target species (Rats, Mice and Rabbits) following each round of baiting. Data collated must include behavioral changes (effects from the poison) and situations where they die.
   c. A report on the above monitoring and efficacy of the program once completed, including any unexpected impacts, must be provided to the APVMA.

Issued by

Delegated Officer

PER10895

Permit Version 1

Page 2 of 3
Environmental Impact Statement

ATTACHMENT I

For the control of rodents on non-stocked off-shore islands or for rodent control carried out in accordance with the Code of Practice approved for this product. Contains 0.02 g/kg of brodifacoum in the form of the bait.

PRECAUTIONS

Harmful substance. Repeated oral exposure may cause toxin to accumulate in intake organs and may affect the clotting activity of the blood. Wear gloves when handling. Do not breathe dust. Toxics to terrestrial vertebrates. Take measures to prevent domestic mups and pets being exposed to the bait either through eating baits or through eating the carcasses of poisoned animals.

Storage: Store in original container. Keep closed and away from food, feedstuff or household. Weeds out of reach of children and domestic animals. Do not store in direct or diffuse sunlight. Avoid direct heating and cooling.

Handling: Wear rubber gloves and rubber or PVC gloves when handling pellets. When handling the product in open bags, carefully remove baits, avoid inhalation of dust, which may cause an allergic dust rash. Avoid contact by mouth and do not smoke, drink or eat while using. Wash hands and exposed skin areas before meals, smoking and after any contact. Prevent access to baits by children and domestic animals. Avoid spillage of any water supply with chemical or bait container. Any one recently found should be buried.

Emergency处理: Brodifacoum is an anticoagulant poison. In the event of this product being swallowed, seek medical advice. Do not induce vomiting. The symptoms of anticoagulant poisoning may take several days to appear. Symptoms may include pale gums, palpation of blood in veins and arteries, and appearance of bruising. Always seek medical advice in the event of suspected human poisoning.

Treatment of domestic animals accidentally poisoned: Warfarin N, is an effective anticoagulant against accidental poisoning of domestic animals by Pestoff Rodent Bait 20R. Treatment and care are similar to the normal for Warfarin N, therapy and should be continued.

Exposure: In the event of a spill, involve the spill area and take all practical steps to manage any harmful effects of the large quantity of pellets by preventing pellets from entering streams of waterways. Remove all spills into secure containers. Recover any unintended spill for further use by placing in a suitable container and discarding it as directed below. Use a thorough to collect the pellet and spill from the spill area with caution. Only after all spilled bait has been removed.

Disposal: Product which is surplus or remains should be disposed of by mixing with other organic materials on the property. A small amount of this material may be placed within the sediments of waterways or other covered surface areas. Ensure that a good covering of soil is applied over the area to prevent access to scavenging birds. Alternately, the material can be mixed into and composted within an approved waste container. Use an accredited waste container, otherwise it is not an approved waste container. Do not use empty container for any other purpose.

DIRECTIONS FOR USE

Apply baits where by hand broadcasting or by using a aircraft fitted with a bait spreading equipment. Apply bait at a rate of approximately 1.2 kg to 16 kg per hectare. Spreading is not required when using Pestoff Rodent Bait 20R.

LEGAL OBLIGATIONS

Sale: This product may be supplied only to the Department of Conservation or to authorised persons appointed in accordance with the Code of Practice approved for this product. Authority is not to be exercised in any other manner.

Limitations on Use: A Code of Practice entitled “Use and Handling of Pesticides” published by the New Zealand Department of Conservation may be obtained by anyone wishing to use this product. Any person who wishes to use this product, knowingly or negligently, may be liable to prosecution.

Suppose that a bait is applied in an area where the public has access to the area, it is a legal requirement that signs must be posted to notify the public that this product has been applied in the area. Signs must be placed that will indicate that the baits are used at the risk of the public. Signs must remain for a period of 12 months after the last application of the bait. The product must only be used as specified in the Code of Practice.

GENERAL INSTRUCTIONS

Shelf Life: The shelf life of this product may vary according to the availability of storage conditions. As a guide, it is recommended that the product be used within 3 months of manufacture. This product must be used within 3 months of manufacture. If the product is conditioned for storage in cold rooms or refrigerators, the product must be stored in a dry place, away from any other product, and must be protected from direct sunlight or heat.

Conditioning: The conditioning of the product must be carried out in accordance with the Code of Practice. The conditioning of the product must be carried out in accordance with the Code of Practice. The conditioning of the product must be carried out in accordance with the Code of Practice. The conditioning of the product must be carried out in accordance with the Code of Practice.

Storage: This product must not be stored in a building, on the floor, or in any other place. The product must be stored in a dry place, away from any other product, and must be protected from direct sunlight or heat.

Use: This product must be used for the purpose for which it is intended. Any person who wishes to use this product, knowingly or negligently, may be liable to prosecution.

Conditioning: This product must be used within 3 months of manufacture. This product must be used within 3 months of manufacture. This product must be used within 3 months of manufacture. This product must be used within 3 months of manufacture. This product must be used within 3 months of manufacture.

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Department of Primary Industries, Parks, Water and Environment – Parks and Wildlife Service
Macquarie Island Pest Eradication Project. Part C – Environmental Impact Statement
Appendix 10  Monthly bird counts on standard routes – Macquarie Island

Duck numbers during bird surveys May 2007 - June 2009

Kelp Gull numbers during bird surveys May 2007 - June 2009
Giant Petrel numbers during bird surveys May 2007 - June 2009

Antarctic Tern numbers during bird surveys May 2007 - June 2009
King Penguin numbers during bird surveys May 2007– June 2009
(NB: Dec 07 chicks counted as adults)

Skua numbers during bird surveys May 2007– June 2009
Imperial Shag numbers during bird surveys May 2007 - June 2009