Operational Plan for the eradication of Pacific Rats (*Rattus exulans*) from Late Island

Prepared for the
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Late Island, Photo by David Butler

EXECUTIVE SUMMARY

This plan sets out the operational detail, logistics and framework for a planned eradication of introduced Pacific rats from Late Island (1,731ha) in the Kingdom of Tonga. The method for the eradication is the delivery of grain-based bait containing the anticoagulant brodifacoum, into every potential rodent territory on the island. This will be done during the driest part of the year when rodents are potentially most vulnerable due to lower relative availability of natural food supplies. Because of the island's size and complex topography, the bait will be applied aerially using a helicopter with an underslung bait spreading bucket. Aerial application has been successful in eradicating rodents from many islands around the world, and the logistics and methodology are based upon similar successful operations. Mitigation measures will be required for key non-target species, especially the Friendly-ground dove. Monitoring of rodents and native species before and after the operation will be required to assess the success and effect of the operation.

Several key specifications necessary for operational planning have been omitted from this operational plan because trials necessary to inform project planning have not yet been completed and funding for project implementation has not yet been secured. On site trials will be required to determine final bait application rates, to complete the recommended non-target impact assessment, and to finalize the project's logistics. This operational plan was based on information gathered remotely, consultation with Tongan government agencies, community representatives and researchers familiar with the island. The authors did not visit the island and thus the recommended approach is limited by a lack of firsthand local knowledge of the island. The decision to proceed or not with an invasive rat eradication lies with the land managers and the government of Tonga. It is important that the decision makers fully understand the options and risks associated with those options before making a decision. This document is intended to provide the background to assist in making such a decision. It is recommended that additional meetings are held and further expert opinion is solicited before a decision to proceed is made.

Acknowledgements

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Malo 'aupito

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1. INTRODUCTION

The aim of this operational plan is to comprehensively outline the planning requirements, equipment, personnel, and logistics required for the proposed eradication of Pacific rats (*Rattus exulans)* from the island of Late in the Kingdom of Tonga. This will allow the ecology of Late to be restored, so that it is able to provide a secure home for populations of threatened and indigenous plants and animals that are currently present and those that could potentially recolonize.

The rat eradication feasibility study (Bonham & Griffiths 2014) recommended that aerial application of cereal bait pellets containing brodifacoum would be the most effective method to use; it would provide the greatest probability of eradication success and be the most logistically feasible. This document provides a framework to assist project management with the information and direction needed to conduct an eradication operation on Late. However, several key specifications necessary for operational planning have been omitted from this operational plan because trials necessary to inform project planning have not yet been completed and logistical details have yet to be determined.

2. OPERATION PLAN OBJECTIVE

The principal objective of the actions detailed in this operational plan is to eradicate Pacific rats from the island of Late. It is believed that this action will allow natural recovery of the ecosystem and protect the island's populations of native species. It will also create opportunities for the establishment of threatened species that currently do not exist on the island. Other objectives include the development of capacity and capability for future rodent eradications and biosecurity measures in the Kingdom of Tonga.

Supporting plans should be developed for:

- Friendly-ground dove (*Gallicolumba stairi*) mitigation
- Non-target species monitoring (pre- and post-project implementation)
- Pre- and post-monitoring of conservation objectives
- Safety plan
- Communications plan

3. ISLAND DESCRIPTION AND BIOTA

Late is an isolated and uninhabited island located about 55 km WSW of the island of Vava'u, in the Kingdom of Tonga. The 6-km wide circular island has historically been reported as having an area of 1,500 ha (e.g. Sykes 1981); however utilizing GPS points collected on island and digital aerial imagery, we recalculate the area to be about 1,731 ha, with a high point of 565 m. The island is characterized by a central crater, with the terrain sloping gradually away to the sea (Sykes 1981). Cliffs rising to approximately 20 m dominate the coastline (Sykes 1981).

The island is forested and provides a global stronghold for two species listed by the IUCN, the vulnerable Friendly ground-dove and the near threatened Tongan whistler (*Pachycephala jacquinoti*). Late is also home to seven central Polynesian Restricted Range Species, as well as

eleven species of seabird which are currently believed to breed on the island (Butler 2013). One native mammal, the Pacific flying-fox (*Pteropus tonganus*), and six species of reptile (*Emoia cyanura*, *Emoia impar*, *Cryptoblepharus boutonii*, *Lipinia noctua*, *Nactus pelagicus*, and *Gehyra oceanica*) have also been documented on Late (Rinke 1991; Butler 2013). Pacific rats are the only invasive vertebrate known to be present on Late.

Figure 1 Late, Kingdom of Tonga

4. THE PROJECT TEAM

The proposed eradication of rats from Late is within current levels of achievability, but it still poses a significant challenge and pushes the boundaries of existing rodent eradication experience and technology in tropical regions. To maximize the chance of operational success in such a costly and complicated project, the best available operational team members in terms of relevant skills and experience will be required.

Wherever possible local (i.e. Tongan) staff should be trained and utilized in the operation to build capacity in the region, but this should not be at the expense of the success of the project. It will be politically important for Tongan involvement in the project to gather local support and commitment to the project, on-going biosecurity and future island restoration opportunities within the Kingdom of Tonga.

Key staffing requirements for the operation include:

- Highly skilled helicopter pilots with previous experience in eradication operations and GPS-guided bait-sowing

- A Project Manager and key support staff with extensive experience in tropical rodent eradications (including aerial operations)
- At least one person in the key decision-making group should have some prior experience conducting projects in the tropical South Pacific
- Highly motivated staff with appropriate experience and a strong commitment to the task
- Staff able to work harmoniously for extended periods, under stressful conditions, in remote areas
- Involvement of key MLECCNR personnel (i.e. those with conservation, environment or biosecurity responsibilities).

The project team's sole focus should be on the operational detail and precision required to maximize the chance of success. Senior managers and funding agencies must be prepared to support and commit to the project for its entire duration – for eradication projects "the people and money must be available to carry out all tasks efficiently whilst not providing incentives for shortcuts" (Broome, Cromarty & Cox 2005).

4.1. Key Positions and Project Team Structure

Operational Project Team

Project Manager

The Project Manager will be responsible for the financial management, the ship and helicopter contracts, the permissions and liaison with the MLECCNR and will have the ultimate say in major decisions on the Project. The project manager will also be responsible for implementation, seeing the necessary trials are completed and will have oversight of all field operations. The Project Manager will liaise with international technical advisors and non-governmental stakeholders, and will be on site during implementation.

The Project Manager is responsible for helicopter operations and manages the Helicopter Operations Team. The Helicopter Operations Team will consist of two pilots, and one mechanic. This position also supervises the GIS Manager and Mitigation Manager.

Implementation Advisor

The Implementation Advisor will provide advice and guidance to the Project Manager. The Implementation Advisor will act as the replacement Project Manager if the primary Project Manager is unable to fulfill the duties of the position.

Logistics Manager

The Logistics Manager will be responsible for permissions and logistics regarding the importation of bait and coordinating bait, ships, boats, field supplies (including water and food) and helicopter logistics. The Logistics Manager will also serve in an operational role during bait application (e.g. Loading Manager).

Baiting Pilots and Mechanic

The Baiting Pilots will be responsible for the aerial broadcast of the bait, and data transfer of bait flight lines from the onboard GPS to the GIS Manager. The Baiting Pilots will provide advice on baiting strategies. The Baiting Pilots will liaise with the Project Manager on flight conditions.

The pilots will adhere to the relevant Tonga Civil Aviation flying regulations and safety requirements.

The mechanic will ensure that all required maintenance is carried out and spare parts are readily available in case of any reasonably expected breakdown.

GIS Manager

The GIS Manager will set up the GPS points to fix the island's position for the operation, create flight lines, upload those to the helicopter's GPS unit, download the baiting flight tracks for the Project Manager to review during the eradication operation and manage the bait application spreadsheet. The GIS Manager will be experienced in the use of the GIS hardware and software. The GIS Manager will coordinate the bait bucket calibrations. A backup GIS Manager will be identified and onsite during the entire baiting operation.

Loading Manager

The Loading Manager is responsible for managing the team that loads the bait buckets, recording bait bucket configuration (disk size, presence of deflector) and quantity of bait sent on each flight. Bait bucket configuration for each flight will be coordinated by the Loading Manager in conjunction with the GIS Manager and Pilots.

The loading team will be made up of personnel familiar with helicopter operations. All will be trained and/or refreshed in bait bucket loading during bucket calibration exercises.

Bucket Technician

The Bucket Technician will be responsible for the preparation, maintenance and servicing of the buckets before and during the baiting operations. Initial setup of the buckets and helicopter GPS will be led by the Bucket Technician and Pilots, in conjunction with the mechanic and GIS Manager. Adjustment to bait bucket configuration and refueling will be conducted by the Bucket Technician.

Mitigation Manager

Mitigation Manager is responsible for planning and coordinating the implementation of the Friendly-ground dove mitigation strategy, including capture, holding, release, and post-release monitoring. This position will liaise with experts on aspects related to dove health. The Mitigation Manager will be charged with the care of captive doves on Late Island.

Conservation Measures Manager

The Conservation Measures Manager is responsible for designing and implementing the pre- and post-monitoring of native and endemic species (conservation measures).

Off-island Support

Project & Financial Administration

The project's administration and finances may of necessity be overseen by a steering committee or a specific agency. The Project Manager should have authority to authorize purchase of items

identified as necessary for the operation, but the process for purchasing and the subsequent payments should be controlled by the designated agency or steering committee.

The Project Manager and field team should be freed up from as much administrative burden as possible to focus on the operational demands. The financial system should be designed to recognize this, and be as streamlined as possible to ensure rapid payment of providers, which will foster goodwill, as this may be important in the long run. Day-to-day activities will largely be the Project Manager's responsibilities.

Support and Advisory Committee

The Support and Advisory Committee (SAC) incorporates representatives from key stakeholder groups. Its role will be advice and support in 'emergency' matters or situations arising that are not adequately addressed in the operational plan. The SAC will have the role to discuss, seek advice and approve any departures from the operational prescription forced on the operational team by any change in circumstances or unforeseen events.

Membership of the SAC is based on representation for the key organizations with an interest or stake in the eradication project, and inclusion of technical expertise in island eradications.

The SAC should be comprised of:

- MLECCNR representative (Chair)
- Ministry of Agriculture, Food, Forest, and Fisheries (MAFFF) representative
- An independent eradication expert
- The Project Manager will be an ex officio member of the SAC.

By accessing their expertise and the resources of their parent organizations, members of the SAC will:

1. Provide advice on specific operational matters as referred to them by the Project Manager.
2. Act as the primary conduit for communication between each of the participating organizations and the Project Manager.
3. Monitor the implementation of the eradication plan and advise the Project Manager of the implications of any serious issues that arise during implementation.

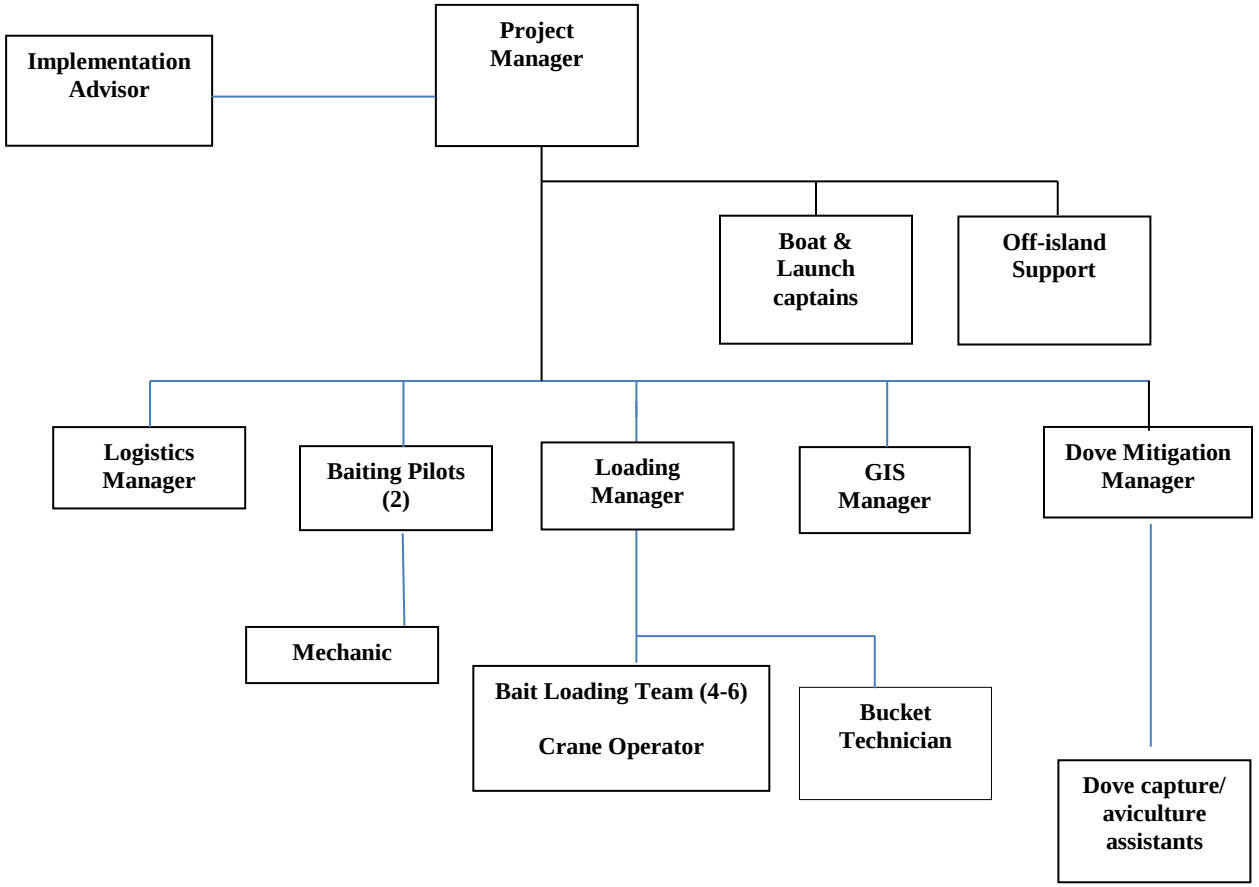
Technical Advisory Group (TAG)

This group will act as a review and technical advisory team for the eradication project such as trials, design, and implementation. TAG members will have considerable practical eradication and/or eradication planning experience, and have wide networks with other experts.

If necessary, the TAG could also be consulted as required on any operational issues that cannot be resolved on the island. If the Project Manager, after consulting with the support team and other team members, believes that there is an issue that requires the input of the TAG, they will contact the TAG chair or nominated alternative and inform them of the issue and what guidance is required. Depending upon the urgency and nature of the issue, this will be via radio/phone/fax or e-mail. The TAG chair would then responsible for obtaining a consensus

from the group members and then communicating this to the Project Manager by the appropriate system.

Example Operational command structure



5. OPERATIONAL PHASES AND TIMING

The operation will be divided into three major phases:

1. Pre-operation preparation
2. Field operations
3. Post operation completion

Timing

Eradications are likely to have a higher probability of success when target animals are food-stressed, at lower densities, are non-reproductive, and experiencing a period of high population mortality. In the tropics, rodent population cycles are often aligned with the rainy season. Rainfall drives up resource abundance such as fruit production which in turn elevates rodent abundance which progressively declines in the dry season as resources become scarce (Madsen & Shine 1996). Fruit was found to be relatively abundant during a September site visit, though its relative availability to wetter months is unknown (Butler 2013). Although there is no information on the population cycles of rodents on Late, it is recommended to conduct the eradication during the drier months.

Climate information recorded at the Lupepau'u Airport in Vava'u suggests that August is the month with the second lowest average number of days without measurable rainfall (n=14) combined with the lowest mean total rainfall (100 mm) (Tonga Meteorological Service 2006). It is recommended that the rodent eradication be implemented between July and August, coinciding with the drier season and avoiding the cyclone season (November to April).

6. PRE-OPERATION PREPARATION

This phase comprises the planning for the eradication operation and includes:

- Trials
- Permitting and compliance
- Project reviews and meetings
- Operation contracts and agreements
- Purchasing equipment
- Bait ordering and transport
- Bait storage
- Ships & helicopters
- Monitoring

6.1. Non-target Impacts Trial

(SECTION TO BE COMPLETED WITH DATA AND FINDINGS FROM RECOMMENDED ON SITE TRIAL)

6.2. Baiting Trial

(SECTION TO BE COMPLETED WITH DATA AND FINDINGS FROM RECOMMENDED ON SITE TRIAL)

A non-toxic baiting trial was conducted on Late in XXXX. Bait was hand-applied in two applications, X days apart, over an XXha study area at an overall rate of XXkg/ha.

6.3. Permitting and compliance

Permitting and compliance for the importation and application of the bait falls under the jurisdiction of MAFFF. Therefore, all the activities laid out in the Operational Plan will need to be reviewed and approved by MAFFF, in addition to MLECCNR. Permits for the importation and application of the bait will need approval by the MLECCNR.

There are specific aspects of the operation that will require scrutiny and approval.

1. Application of rodenticide bait containing a rodenticide onto the islands (this plan)
2. Non-target risk analysis and decision by MLECCNR on acceptable risks
3. Mitigation plan for Friendly-ground dove
4. Monitoring activities for native and endemic species

6.4. Project reviews and meetings

External reviewers will provide review of the eradication plan, while providing additional advice to the Project Manager as required. The operational plan should be reviewed by international eradication experts.

During field operations involving bait application, meetings shall be held daily between the Project Manager, Implementation Advisor, Baiting Pilots, GIS Manager and Loading Manager.

6.5. Operation contracts and agreements

The aerial baiting portion of the operation should be conducted by a helicopter company experienced in remote operations, preferably with prior rodent eradication experience. Besides the helicopter, all equipment to apply the bait, GPS systems, bait buckets and all spares for the operation will need to be sourced.

6.6. Services and equipment

Ship

As identified in the feasibility assessment (Bonham & Griffiths 2014), the baiting operation may be ship based. A large ship, capable of transporting all of the required equipment, bait, and

supplies as well as serving as a platform to conduct the baiting from will need to be secured. Ships of this nature will likely need to be sourced from outside Tonga, from locations such as New Zealand.

The ship for the transportation of the bulk of the equipment for this project will need:

- Helicopter storage (for 2 helicopters)
- Helicopter fuel storage capacity
- Covered, dry and secure holds, or space for shipping containers, for c.52 tons of bait plus other dry goods (food, etc.).
- 2 x helicopter landing pads (can be temporary, i.e. constructed for the project)
- Accommodation for a field team of at least 10 people, in addition to normal ship's crew
- All modern communications and navigation systems
- Food, fuel, water, etc. for the expected maximum duration of the operation and associated travel.
- Guaranteed availability for maximum potential duration of charter (and ideally an emergency substitute also to be identified).
- Undergone biosecurity measures as prescribed by the project (outlined in Section 6.6) to reduce the risks of accidental introduction of invasive species to Late.

Other baiting operations have been successfully conducted from barges, which may provide an alternative option if a suitable ship cannot be sourced. In addition, ground-truthing of the island by an experience aerial eradication practitioner may result in the identification of an area on Late from which the operation could be based, removing the requirement for a ship/barge based operation.

Helicopter and Crew

For the bait-spreading operations, it is strongly preferable to have two helicopters, for operational efficiency and security – if one is damaged or breaks down, then the other can continue to complete the project. Two helicopters with external lift capacity of >400kg will be contracted for the operation.

As the project is dependent upon the skills and experience of the pilots, two highly experienced pilots with >300 hours of aerial bait/fertilizer spreading work and direct experience on ≥3 island rodent eradications involving aerial baiting should be specified as a requirement of the successful bidder. Once selected, the pilots will be provided with a copy of this plan to ensure that they are aware of what is required of them.

A certified aircraft mechanic will also be required to be on site during the operation.

Helicopter GPS

The helicopter will be fitted with a GPS flight unit which consists of a light bar, receiver, field computer display, and a GPS antenna mounted on the helicopter. Before the operation commences all GPS equipment will be installed and tested in the helicopter. One additional GPS receiver and cable package will be available in Tonga as a spare.

Eradication operations using aerial techniques sometimes use Differential GPS systems (involving the use of a base station set up on a high point or a satellite based correction service) because these systems can minimize the potential errors inherent in the standard GPS technology (i.e. the use of a standard GPS system can introduce a greater degree of risk of failing to complete the planned bait coverage). Standard GPS technology has a variety of error rates depending of the quality of satellite signal coverage. When compounded with the inaccuracies caused by weather conditions, flight speed, and the pilot's ability to follow a flight line it is possible for flight paths and bait spread to be at an unacceptable level of accuracy at the full realization of all error rates. However, the risk of all potential errors being realized simultaneously is slim, and GPS signal strength, especially along the equator, is considered more than sufficient.

We plan to use non-differential GPS in this operation. GPS technology and accuracy is considered sufficient for accurate generation and flying of the designated flight paths, and even if all potential cumulative errors were realized, the 50% overlap between swaths will ensure that all areas receive some bait coverage, bearing in mind that the full application rate is achieved with numerous passes over the same area.

Helicopter parts installation

Installation of the operation's equipment for the helicopter will be required prior to the operation, and it is vital that all fittings, hardware and software between the helicopter, bait buckets and GPS system are compatible and tested prior to the operation.

This includes wiring and mounting of the GPS unit and antenna, and wiring of the gate activation switch to the GPS unit. This can be signed off in-house by a certified aviation engineer, who will be onsite the helicopter crew. The installation of GPS and switching system will be the responsibility of the helicopter crew's engineer, assisted by the GIS Manager and Bucket Technician.

Bait spreader buckets

The spreader buckets used will be designed specifically for the broadcast of pelletized baits and three buckets will be on site. Two buckets will be used for the operation, one configured with an internal bait deflector, one without. If either bucket is damaged the spare bucket can be configured to replace the function of the damaged unit.

Spare parts on site will include a complete spinner assembly, agitator motor and gear box, air ram, switching system and other small parts such as belts, spark plugs, etc.

Spreader bucket calibration

Every bait type operates differently out of spreader buckets and different spreader buckets also spread bait at different rates. Bait flow is controlled by using various sized aperture disks on the bait bucket, while helicopter flight speed determines the distribution of that flow. These factors need to be calibrated to provide the specific amount of kg/ha required.

Any further calibrations need to be tested on a flat open area before the application day, using all the same equipment that will be used. Calibration of buckets with the deflector is also

required. The calibration will be done at least two days before the operation. This can also be a check of the interoperability of the helicopter GPS, GIS computer program and spreader bucket.

Methodologies for bait bucket calibration, calculating effective swath width and flow rate have been outlined in detail within Island Conservation's bait bucket calibration best practice document (Island Conservation 2012). In addition to protocols outlined there, throw-forward will be determined for the bait. This data will be compared with coverage as recorded by the helicopter GPS without this factor being considered during the operation.

In summary, prior to the baiting operation, the following needs will have been determined:
For ½" diameter bait:
Calibration of bucket #1 **with deflector** to XXkg/ha
Calibration of bucket #2 **without deflector** to XXkg/ha
Determination of effective swath width for each bucket configured as detailed above
The 'throw forward' of baits from each bucket at 40-45 knots and altitude from which baiting would occur

Ground truthing island area and the coastline

Prior to the operation, the helicopter will overfly the island to 'log' the perimeter (fix the outline of the islands with the GPS). It is highly desirable to do this as it gives the GIS Manager a shape file for geo-location of the more accurate coastline GIS shape file. This will be used to generate the shape file to overlay with the flight-lines for the operation (see timeline, Appendix 2). The GIS Manager has shape files of the islands' coastlines, and this process will allow for correction of the reference location and highlight any inconsistencies that can then be checked. This can be conducted as an orientation flight for the Baiting Pilots, Implementation Advisor, GIS Manager, and Project Manager.

During the time between the orientation flight and the first bait drop the GIS Manager will revise shape files. Shape files will be loaded into the GPS unit in the helicopter (and the spare GPS unit) and will enable flight paths to be set to the intervals required to achieve coverage of the island at the specified application rate by overlapping swathes by 50%. The interval is half of the expected swath width from the bait buckets.

6.7. Biosecurity

Shipping containers will be fumigated once on the ship and then sealed. The shipping lugs on the container and fork holes will be sprayed with an insecticide. Upon arrival to Tonga inspectors from the MAFFF will inspect the cargo and the outsides of the containers.

The quarantine procedures for island visits, as outlined in the Biosecurity Plan, would remain in force for the operation with respect to checking clothing for weeds and seeds, bringing food and water on to the island and disposal of human waste.

6.8. Bait

Bait Quantities

Table 6. Bucket calibration rates, amount of bait on ground and overlap

Application	Site	Bucket sowing rate (kg/ha)	Type of bucket and overlap of swathes	On ground (kg/ha)

(TABLE TO BE COMPLETED WITH DATA AND FINDINGS FROM RECOMMENDED ON SITE TRIAL)

Table 7. Areas to be treated, showing breakdown by application and total bait needs

Note: interior of Late is calculated as total island area minus areas occupied by coastal swath and the lake exclusion area.
Actual island size: 1,731ha

Island	Approximate Area to be Treated (ha)	Intended on-ground rate, 1st Application	First Bait Application (kg bait)	Intended on-ground rate, 2nd Application	Second Application (kg bait)	Total Bait Needed (kg)
Late interior	1733.7					
Late cliff section	67.1					
Coastal buffer	57.2					
Subtotal						
Contingency 10%						
TOTAL						

(TABLE TO BE COMPLETED WITH DATA AND FINDINGS FROM RECOMMENDED ON SITE TRIAL)

Table 8. Quantities Ordered

Bait type	Late (kg)	Calibration (kg)	Total kg	Converted to lbs.	Total lbs. (rounded up to nearest 50lbs)	# bags (50 lbs. each)	KGs of bait to order

(TABLE TO BE COMPLETED WITH DATA AND FINDINGS FROM RECOMMENDED ON SITE TRIAL)

Table 9. Total bait application amounts from the two bait applications taking into account overlaps between interior and coastal flight lines.

Site	Av. (kg/ha)	Range (kg/ha)
Late **Interior**		
Late **Coast**		
Late **Cliff**		
Late Coast w/ interior overlap		
Late Cliff w/interior overlap		

(TABLE TO BE COMPLETED WITH DATA AND FINDINGS FROM RECOMMENDED ON SITE TRIAL)

Bait ordering and transport

Physical damage or contamination of the bait before application could compromise the success of the project. Precautions will be taken to ensure the bait arrives in optimum condition for the operation.

Bait

A cereal grain pellet containing brodifacoum will be used for the operation. This toxicant is the most common second generation anticoagulant used for rat eradications worldwide (Howald *et al.* 2007). The bait, called (INSERT BAIT NAME) was developed for conditions such as those found on Late by (INSERT BAIT MANUFACTURER NAME). The standard (INSERT BAIT NAME) bait is a nominal (INSERT PELLET WEIGHT) gram pellet (compacted crushed grain) of (INSERT PELLET DIAMETER) mm diameter, with XXX mg (XXX ppm) of brodifacoum per kg of bait. The baits are dyed (INSERT BAIT COLOR) to reduce their attractiveness to non-target species. The bait will be packaged in (INSERT WEIGHT/SIZE) plastic-lined bags, which will protect it from moisture during transport and storage.

Bait should be ordered in (INSERT MONTH TO ORDER BAIT), and will be manufactured approximately (INSERT MONTH OF PRODUCTION), placed within shipping containers for sea freight to Tonga. Bait will travel in three 20-foot shipping containers between the (INSERT ORIGINATING PORT/COUNTRY) and Tongatapu.

The primary aims are to protect bait from physical damage and moisture during all stages of transport and storage. Characteristics of the packaging are that they are of a durable material, easy to clean, and relatively secure against invertebrate infestation.

Based on the total quantity of bait, including contingency amounts, and a small amount of inert bait for trials and calibration, (INSERT AMOUNT OF BAIT) will be used. Each 20ft shipping container can hold up to (INSERT NUMBER OF BAIT PODS) per container. Each bait package will be clearly marked as to its contents, and packed in containers in such a way as to be able to be removed in order with the intended sequence of use. Inert bait will be used for bucket calibrations. Further work may also be desirable on effective swath width determination.

During manufacturing, one 50-gram sample of brodifacoum bait will be removed from each batch manufactured. As per standard, samples from the bait produced will be analyzed to validate the concentration of brodifacoum and the firmness and moisture levels at the time of manufacture. No testing is required for inert bait. These results will be recorded for reference. No toxicity sampling will be conducted from bait once it arrives to Tonga. However, reference samples will be kept to confirm toxicity after the operation if necessary.

Bait transport

Upon arrival of containers at the Port of Nuku'alofa, bait pods will remain within the containers. Customs clearance will occur. This process will be overseen by the Logistics Manager.

Once the bait has arrived in Tongatapu and cleared customs procedures, the containers will be stored in Nuku'alofa at the shipping agent's storage facility until ready to be loaded onto the project ship. The ship will then travel to Late, after being loaded with the bait and taking on the project crew at the Port of Nuku'alofa. Other locally-held equipment and provisions may also be loaded onto the ship at this time.

Table 5. Summary of timeline for each major component of bait transport

Task	Weeks	Start Date	End date

(TABLE TO BE COMPLETED ONCE FINANCE HAS BEEN SECURED FOR PROJECT IMPLEMENTATION)

Bait storage

From shortly after manufacture until soon before being used on the island, bait will be stored in bait pods, and until arrival at the island these will be within shipping containers. Bait pods will provide protection to bait from physical damage, sea spray or splash, rain and as they are fully enclosed with additional plastic bag liners there is some protection from large invertebrates. Bait pods should also assist in maintaining a relatively constant humidity around sacks of bait, which are plastic lined. Each pod will have one bag of desiccant placed between bags. The bait will be protected within the containers which will have sea worthiness certificates, and the pallet-style base of the pods will further allow any water or moisture finding its way into containers to pass under the pods.

During transport between the point of manufacture and the customs warehouse bait pods will be in 20-foot containers. Upon arrival to the customs warehouse the containers will be stored, with the bait pods still within them. Once customs is cleared, the containers will be transported to a facility for temporary storage until loading onto the project ship. After being placed on the project ship, containers will be fumigated. Shipping lugs and fork holes on the containers will be sprayed with an insecticide.

After the operation, any unused bait will be moved to Vava'u for storage. Bait pods and bait sacks will be burnt at the refuse site.

7. FIELD OPERATIONS

The field operation comprises two stages:

1. Positioning of bait, staff and equipment to the island
2. Aerial baiting commencement

7.1. Positioning

The positioning of bait, equipment and staff to Late will involve the use of a ship, which will be used as an operating base for bait application.

Weather forecasting

A weather forecasting service will be used to provide specific forecast information to the project team. The Project Manager or delegated team member will obtain daily synoptic weather charts and a forecast for the following day and a long-term weather outlook. The forecast will cover the chances of rain, predicted wind strengths and directions, with information on position and movement of depressions and anticyclones in the South Pacific.

Some possible options include:

- The Tonga Meteorological Service, who may be able to provide local forecasts and interpretations of weather maps
- Weather Underground website
- NOAA satellite imagery
- New Zealand Meteorological Service
- MetVUW website (www.metvuw.com)

Weather conditions

Wind conditions are typically 10-15 knots and are not expected to have a significant impact on flying. High swell conditions are unlikely, but if they did occur the boats supporting the project will position themselves in the lee of Late.

If unusual or unfavorable weather conditions are predicted for the scheduled days of bait application a decision to delay will be made by the Project Manager, Implementation Advisor, and Baiting Pilots.

7.2. Logistics

The Field Team

Team transport to Late

It is planned that key project staff will be transported onboard the ship. Otherwise, or as a fallback option, day trips will be conducted by charter boats departing and returning daily from/to Vava'u. The on-island field team will be taken to Late via charter boats and returned in the same way.

Team accommodation

The operational team for the baiting operations will sleep aboard the ship. A camp will also be established for the mitigation team at a site on Late. The staff engaged in this part of the operation will be required to remain on-site until all captive birds are released. Staff rotations will be detailed in the non-target mitigation plan.

Cooking

Sourcing supplies and cooking for the bait operation team will be the responsibility of the Logistics Manager. A dedicated cook will be onboard the ship. Meals will be available on the ship during the operation. The mitigation team will be self-sufficient from a catering perspective.

Mitigation Team Camp Protocols

As the dove mitigation team may be based on the island for several weeks before, during and after the bait applications, it will be critical they do not create a potential alternative food resource for rodents, especially once the bait is on the ground. To reduce potential food availability for rodents, the mitigation team (and all overnighters in the wider operational team) will endeavor to:

- With the exception of sealed (unopened) tins, keep all food inside rodent-proof containers
- Use a covered toilet with ecologically suitable chemicals to render wastes unattractive to rodents.
- Securely wrap or contain all food waste and place inside sealed containers inaccessible to rats.
- Place all food scraps (uneaten portions, peelings, etc.) immediately into sealed rubbish containers. Food wastes in dishwashing water should be strained from the waste water and placed in secure rubbish storage.
- Ensure no food is left in personal bags or in areas accessible to rodents
- Maintain vigilance for any rodent interference with any foodstuffs through regular checks of food stores and condition of the storage containers.
- Trap rats around the campsite and aviaries with live traps and euthanize.
- All the above also applies to all food materials used for dove feeding.

GIS and Operations Command Post

The GIS and Operations Command Post (OCP) will be onboard the ship, where bait loading will take place. The office will include a large computer screen attached to the GIS computer, to review tracks of the bait application to identify potential baiting gaps. A spare second computer with all programs installed and a printer will also be available.

Equipment breakdown

In most cases there will be at least one spare for virtually all critical components of the operation readily available, so if one component of the operation fails an identical spare can be put into service almost immediately.

Helicopter storage

The helicopter will be stored on the ship during the baiting operation. The helicopter may be stored at the Lupepau'u Airport in Vava'u between baiting applications.

Fuel storage

Sufficient fuel for the entire operation will be transported and stored onboard the ship.

Refueling

Refueling will be carried out on the ship during the baiting operation. Refueling will be the responsibility of the helicopter mechanic. Refueling may also be carried out at the Lupepau'u Airport in Vava'u between baiting applications.

Refuse

All empty bait sacks will be collected and stored on the ship. They will be marked that they contain contaminated refuse. These will be disposed of by incineration (the recommended method). Bait pods and bait sacks will be returned at the conclusion of the operation to Vava'u where they will be incinerated at the island's waste disposal facility.

Refuse from field camps, lunches and any food scraps will be stored in rodent proof containers on island until transfer to the ship is possible. Refuse from the ship and field camps will be stored in secure containers and taken back to Vava'u for disposal as possible or where possible burnt with bait bags. Care will be taken not to leave any edible refuse (food scraps, food containers, etc.) on the island as such items can distract rodents from consuming bait pellets.

7.3. Communications

External Communication

A temporary radio repeater will be installed on Late to ensure clear communications between the helicopter, ship, and project personnel during the operation. A satellite phone will be available for emergencies. The ship and support vessels will have radio capabilities. The helicopter will be required by contract to have VHF and aviation frequencies on its radio.

Internal Communications

Communications between pilots, ground crew and the vessels will be by VHF radios. All managers and the Implementation Advisor will have handheld radios.

Communication will be structured to reduce radio traffic to pilots and the Project Manager. Handheld radios will be programmed to operate on at least three channels excluding the marine channels. Channels will be assigned for aerial to managers and between managers. An additional channel will be assigned for small boat and island operations. Emergency frequencies will also be assigned. All the operational crew will be briefed on the radio use and schedule of operations prior to the start of the operations and the communication schedule will be tested during the calibration 'dry run' prior to the operation commencing.

1st application debrief

In order to improve the efficacy of the second bait drop, a debriefing will be held immediately after the 1st bait application. This will include all team members and discuss any portions of the operation that personnel think could be improved or worked well. Daily debriefs between the Project Manager, Implementation Advisor, GIS Manager, Baiting Pilot and Loading Manager will also occur at the end of days when bait has been applied

Public Relations

The MLECCNR will be responsible for leading communications to the public. Project partners will support the MLECCNR in drafting press releases, and advising on communications strategy. A pro-active local approach is to be taken. It is suggested that national and local press will be invited to observe one day of the second bait application.

Tourist or fishing boats that are at the island during baiting will receive a visit from a MLECCNR and project representative to interpret the activity correctly to both crew and passengers, and answer any questions they may have.

7.4. Bait Application

Bait broadcast by helicopter will be the primary application technique used. Bait will be broadcast from a bait spreader bucket slung below a helicopter (Fig. 2). Bait spread will be tracked using GPS and GIS analysis tools to ensure even coverage. Bait will be applied in two applications, separated by at least 21 days. The helicopters will fly parallel flight lines across the interior of the island, with a 50% overlap of the effective

baiting swaths to reduce the potential for gaps in bait coverage. The flight lines of the second application will be offset by 3-5 degrees from the first application lines, as an additional measure to avoid gaps in bait coverage (Fig 3). A flight line will be flown following the perimeter of the island to ensure coverage of potential gaps at the end of the interior flight lines. Cliff faces will be treated with an additional targeted application as well.

Fig. 2. Aerial broadcast with helicopter and spreader bucket

Fig. 3. Potential baiting flight lines for two applications of rodent bait to Late

Loading bait buckets

Bait loading will be carried out from the bait loading site on the ship. One team of five (four loaders and a site controller) will conduct the loading. Extra people (a minimum of two) will be available to rotate in and out of the loading team to allow individuals to rest (e.g. MLECCNR

staff potentially could be present to gain first-hand experience in the baiting operations and loading in particular). Mechanical loading (e.g. ship crane) of the bait buckets could be utilized in lieu of manual loading by personnel.

A shaded area (i.e. inside the ship) will be nearby for the bait loading team to get out of the sun and keep them fresh and rested between loads in the hot conditions. Food and water will be available at all times for the resting team members.

The bait bucket will be maneuvered by the pilot onto the platform, guided by one person if necessary. Once in place the bucket will be filled with bait; the pilot will then depart with the bucket.

It is anticipated that baiting will occur over 2 days for each application, so demands will not be severe, and for this reason just a single team of 4 bait loaders is sufficient, but additional people should be available to relieve fatigued staff. In situations where a further replacement is required, this could be temporarily found among other project staff on site (e.g. Loading Manager, Implementation Advisor).

Hand baiting

Hand-baiting may be conducted on Late around the dove aviaries and dove team's camp, but only as required. It is proposed that aerial baiting will occur over the entire island, including the areas where the aviaries will be sited. Dove aviaries will be protected from bait falling within them by a shade-cloth cover that will be part of the standard aviary design. Nevertheless, dove mitigation staff will inspect all aviaries immediately after (and each time) the bait-sowing helicopter has passed over, and will remove any bait that has found its way into the aviaries.

Aerial baiting commencement

Commencement of operations

Daily decisions to begin baiting will be made depending on conditions. This decision will be made after discussion by the Project Manager, Implementation Advisor, and Pilots.

1st application

Staff will travel to Late on the ship the day before, stay overnight and be ready on the bait day by first light. Once all equipment and personnel are on site, safety equipment (coveralls, dust mask, goggles, ear muffs/plugs and hard hat for working under a helicopter) will be issued for the loading teams.

The Loading Manager will be designated site controller for loading the bait into the spreader bucket, the person responsible for ensuring that everything during loading runs smoothly (see: 'Bait application command structure').

Bait spills at the loading site will be cleaned up and placed in empty bags for disposal. No spilled bait will be put into the bait bucket because of the risk of this bait being contaminated with fuels or oils or chemicals used to clean the deck. Disposal of this bait can be by incineration with empty bait bags.

Download of flight lines from the GPS to the GIS computer will be with a flashdrive. This will occur after the first bucket is applied, and after then each time the helicopter returns for refueling (c. every hour of flying). At the completion of the first bucket-load, the helicopter will land on the ship and the GIS Manager will check the flight-line on a large computer screen and confirm with the project manager and pilot that the bait is going out at the appropriate rate.

This check will be repeated by the GIS Manager throughout the operation and observations relayed to the Project Manager. If all is going to plan, the next inspection of track logs by the Project Manager, Baiting Pilots, Implementation Advisor and GIS Manager will occur when the day is over or the application is complete.

Tracking the amount of bait that goes out in each bucket load, the area covered (reported by pilots from the GPS readout) and comparing that with GPS track log allows the GIS Manager to track the bait application rate. At the same time, the flight-lines will be checked to identify any gaps in bait coverage. All identified gaps will be re-sown prior to departing the island.

The Baiting Pilots will be instructed to return with approximately 1kg of bait in the bucket. This amount should be as consistent as possible, to avoid problems with calculating actual bait/ha coverage. If no bait is present, this signifies that GPS track log has not been logged as 'baited' when in fact the bucket's gate has been open but no bait has been dispersed. Failure to return with bait in the bucket will initiate a re-application of the final 10-15% of the anticipated track that could have been baited and any other area that was 'reportedly covered' with that bucket load.

2nd application

The same procedures will be repeated for the second application (preferably with the flight lines going at different angles to those of the first drop – exact orientation will be determined by the Baiting Pilots), to be carried out at least 21 days after the first drop and then as soon as the weather/sea conditions allow.

Baiting commencement following delays

It is possible that there will be delays during bait applications that will entail restarting the operation at a later date. Potential delays can result in reinvasion of rodents into areas already treated with bait. Recommencement of baiting will probably require re-baiting of areas that could have been reinvaded. Following an incomplete application to any island, the area to be re-baited will need to be identified by the Project Manager on a case by case basis. Decisions will be made based on the time period elapsed since the last application, which area that had been treated and the area remaining that requires treatment. For example, 3 swath widths at the normal application rate for the block will be required after a pause in the operation of 1-3 days. If the shut-down period is longer than 3 days then a wider re-application area will be considered. Advice would be sought from the Implementation Advisor, Baiting Pilots, and from external experts as required.

Bait application monitoring

Validation of the bait application will be carried out by monitoring of the application swaths recorded on the TracMap GPS downloads on the computer, coupled with known bait quantities that went out in each load. In addition the GPS will calculate the area of ground previously covered with each bucket of bait. It is essential, therefore, that the initial calibration of the application rates and swath widths is carried out accurately.

The area covered will be relayed at each bait refill to the GIS Manager via radio from the Baiting Pilots. The Loading Manager will record number of sacks/bucket on a paper sheet, which shall be collected by or relayed by radio to the GIS Manager as required. The GIS Manager will record the area covered from the Baiting Pilots and amount of bait per bucket from the Loading Manager on the monitoring spreadsheet which automatically calculates the bait application rate per bucket load, and compare the observed vs expected application rates in an effort to identify areas where bait application was higher or lower than expected. In areas with large discrepancies, appropriate measures can be taken to rectify any problems, be they extra applications or reducing the application rates. This can be done by adjusting the baffle aperture size, helicopter speed or flight lines as necessary.

The Loading Manager will regularly check the spreadsheet with the GIS Manager to ensure the actual application rates are not excessively above or below the target application rates and that bait spread over the island is as even as possible.

Supplemental bait broadcast

If it is suspected that any area received less than the desired bait application rate it will be re-treated at the prescribed rate.

Completion

Once bait has been applied to the islands as per this plan and the operation is declared complete by the Project Manager, the ship and support vessels will return to Vava'u for demobilization.

7.5. Safety

Helicopter Safety

Operating with a helicopter brings potential risks and these risks will have to be minimized. The majority of the crew that will be involved with the bait loading should be very familiar with helicopter operations, but some may not be familiar with loading a spreader bucket. The bait loading procedure will be practiced before the operation commences (mock ups and during calibration) to allow any inexperienced crew to become familiar with the procedure and to know what is required of them.

The Implementation Advisor will conduct bait loading training and a bilingual staff person will be on hand to assist with translation. Another good practice for reducing risk is to allow enough breaks for the crews to be well rested as tiredness will lead to accidents. Safety briefings for working around the helicopter will occur in English and Tongan prior to operations initiating.

Pesticide Safety

<u>Personal Protective clothing</u>

Coveralls with hoods, dust masks with valves or half-face respirators, goggles, ear muffs/plugs, leather gloves and hard hat will be provided for the crews working under the helicopter loading bait. This equipment will have to be worn at all times when loading. Dust from the bait is considered hazardous and should not be inhaled or ingested. When the team takes long breaks they will need to remove protective clothing and wash their hands and faces in soapy water before eating or at the end of the day. A wash station will be established for this purpose on the ship.

Hand baiting team members will be provided with coveralls, nitrile gloves, and nose and mouth dust masks. When the team takes breaks from baiting they will need to remove protective clothing and wash their hands in soapy water before eating or at the end of the day.

8. MONITORING & MITIGATION

Native and endemic species

Monitoring is required to determine both positive and negative impacts on non-target species, and whether the condition of the ecosystem responds favorably or not to the eradication. The monitoring program should be designed and conducted by those who specialize in monitoring native and endemic species pre and post vertebrate eradications. The methodologies for this work will be presented in a separate plan.

1. Conducting a BACI (Before-After, Control-Impact) designed monitoring program to determine population level impacts to native and endemic species on Late.

2. Establish a baseline for measuring impacts on populations over a few years after the rodent eradication attempt.

Non-target risk assessment

A formal non-target risk assessment has been conducted and is presented separately. The risk and/or potential sensitivity of the Friendly-ground dove is considered sufficiently high to warrant specific mitigation.

See the Mitigation Plan for more information.

Dove mitigation

(INSERT SUMMARY OF MITIGATION PLAN TO BE FORMULATED BASED ON DATA AND FINDINGS FROM RECOMMENDED ON SITE TRIAL)

Bait availability transects

Bait availability transects will be established during the first bait application on Late in baited areas. Baits will be flagged and checked every day between bait applications and for 10 days post the second application. Flags will be removed when baits are no longer present. Data will be analyzed prior to the second application and may provide data upon which to base changes in bait application strategy.

Carcass searching

Carcass searching will be conducted opportunistically during other activities. Carcasses will not be collected unless fresh and from species of significant concern (e.g. Tongan Whistler). If carcasses are collected, necropsies and assays if necessary will be conducted in an attempt to ascertain the cause of death.

Reinvasion risk

The risk of re-invasion of Late by rats is moderate. It has no visitor sites and is relatively infrequently visited. However, standard and established biosecurity protocols will be advocated and enforced for all visits to the island. Visitors (fisherman/yachters), who do not follow biosecurity protocols, may occasionally camp overnight and pose the most significant risk to a reintroduction of rodents to Late. This risk has been highlighted to the MLECCNR. Enforcement of no camping is required to begin immediately and continue indefinitely, and this has been brought to the attention of the MLECCNR.

Rodent genetics baseline information

Genetic samples of the rat population on Late were taken in 2013. Additional samples will also be collected from rats on each island and sent to (INSERT LAB NAME) for archiving.

After 2 years, unless otherwise requested, samples will be destroyed. If rats are found on Late post eradication, samples can be taken and compared with archived material. Using molecular analysis techniques geneticists can identify if animals are from the same population (eradication failure), a different population (introduction), or a combination (eradication failure and introduction) (Abdelkrim, Pascal & Samadi 2007).

Bait weathering

(INSERT SUMMARY OF BAIT WEATHERING TRIAL RESULTS FROM RECOMMENDED ON SITE TRIAL)

Assessment of operation success

The success of tropical rat eradication projects can be determined 12 months after the project has been completed, due to year-round breeding. This time lag will allow for any population recovery to be at a detectable level if the eradication is unsuccessful. Sampling for rats will occur in April/May when rodent numbers are likely to be at their highest. Sampling will include live traps and chew blocks.

Coastal areas and forested areas will be the principal sites for monitoring as this is where rat numbers are likely to be the highest. Any rats trapped will have tissue samples taken for genetics analysis.

9. POST OPERATIONS

Post-operation procedures begin once the crew and vessels have returned to Vava'u after the second bait drop is completed. Post operations include:

- Debrief
- Equipment/excess bait storage
- Finalizing reports
- Monitoring

9.1. Debrief

After the operation, debriefs will occur with the management team and the entire eradication team. All components of the operation will be discussed, recorded and disseminated in order to improve systems for future eradication operations. Additionally, debrief sessions will occur with partner agencies to improve any required aspects of the project to optimize success in future operations.

9.2. Excess bait storage

Excess toxic bait may remain after baiting the islands if no contingency bait is required to be applied. The exact amount will depend on needs for contingency bait for filling gaps in coverage, re-sowing areas or other contingencies. After the operation, bait will be stored for any detected rat invasion of an island.

9.3. Bait disposal

As the bait is cereal based it will go rancid and become unpalatable to rodents after a period of storage. If bait has not been used after 6 months it will be disposed of by incineration.

9.4. Finalizing reports

It is the responsibility of the Project Manager to complete the final report on a timely basis following the operation. A final report will be submitted to the project stakeholders. Reports for mitigation activities will be produced separately and are the responsibility of the Mitigation Manager.

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Appendix 1. Chronology of Late operation

(TABLE TO BE COMPLETED ONCE FINANCE HAS BEEN SECURED FOR PROJECT IMPLEMENTATION)

Month	Activity	Status
	MOU developed between parties	
	Operational plan reviewed and amended	
	Agreement for funds transfer between parties	
	Bait ordered and shipment date specified	
	Bait produced	
	Bait containerized and shipped from NZ to TO	
	Internal review of draft OP	
	Geo-reference map of Late (by GIS Manager)	
	Bait shipment arrives at TO	
	Customs clearance of bait	
	Non-target risk assessment trials conducted and risk assessment report written	
	Mitigation plan completed, presented to MLECCNER.	
	Operational Plan completed, presented to MLECCNR and other project partners.	
	Helicopter tenders sought	
	Helicopter contract finalized	
	Dove cage materials taken to Late	
	Dove facilities constructed	
	Ship loads in (INSERT NAME OF PORT), departs for Tongatapu	
	Bait, helicopter and fuel loaded onto ship in (INSERT NAME OF PORT) and transported to Tongatapu.	
	Ships call into Vava'u, to receive clearance of Port Captain. Loads bait buckets plus any other equipment	
	Dove capture	
	Bait bucket calibrations (flow rates)	
	Arrival of outside contractors in Tonga	
	Ship travels to Late	
	Log island boundaries and have GIS shape files created	
	First bait application	
	Ship returns to Vava'u	
	Debrief after first bait applications	
	Second bait application	
	Ship returns to Vava'u	
	Debrief after 2nd baiting application	
	Monitoring of bait decay, non-target species monitoring	
	Departure of outside contractors	
	Doves released (as determined by Mitigation Manager)	
	Helicopter contract concludes	