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AGENCIA DE REGULACIÓN Y  
CONTROL DE LA BIOSEGURIDAD Y  
CUARENTENA PARA GALÁPAGOS



# Floreana Island Ecological Restoration: *Rodent and Cat Eradication Operational Plan*



## Version History:

VERSION	DATE	AUTHOR	REASON FOR CHANGE
V1	May 2010	Karl Campbell	Initial production
V2	Sept 2011	Chad Hanson w/review by Karl Campbell	Revisions for multispecies eradication (Rat and Cat). Template revision to PII
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V5	June 2015	Chad Hanson	Review by Pete McClelland, Erin Hagen, Karl Campbell.
V6	Jan 2016	Chad Hanson	Review by IEAG / Revisions incorporated from memo: DoC-2716900
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**Authors:** Chad Hanson, Karl Campbell

**Reviewed by:** Island Conservation Eradication Advisory Team (ICEAT - USA), Island Eradication Advisory Group (IEAG - New Zealand), Pete McClelland (independent consultant)

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# Table of Contents

Table of Contents.....	3
1. EXECUTIVE SUMMARY.....	5
2. OPERATIONAL SUMMARY .....	6
3. INTRODUCTION.....	8
4. PEER REVIEW .....	8
5. GOAL, OBJECTIVES and OUTCOMES .....	9
5.1 Goal .....	9
5.2 Objectives and Outcomes .....	9
5.3 Outcomes Anticipated due to Implementation .....	11
6. PROJECT SITE & TARGET SPECIES .....	13
6.1 Floreana Island .....	13
6.2 The Target Species .....	15
7. RISK ASSESSMENT and MANAGEMENT .....	16
7.1 Human Health and Safety .....	16
7.2 Non-Target Species .....	19
8. COMPLIANCE AND OPERATIONAL CONTRACT .....	21
8.1.1 Compliance and status (incomplete) .....	21
8.1.2 Contracts and status (incomplete) .....	22
9. OPERATIONAL PREPARATION AND PLANNING .....	22
9.1 Pre-eradication preparations and trial results.....	22
9.1.1 Rodent bait availability trial .....	22
9.1.2 Rodent bait weathering trial.....	23
9.1.3 Rodent bait color trial .....	24
9.1.4 Vegetation index evaluation .....	25
9.1.5 Conservation 25D lethality trial .....	25
9.1.6 Genetic testing .....	26
9.1.1 Baiting Survey.....	26
10. OPERATION DETAILS: RODENT ERADICATION .....	28
10.1 Strategy overview for rodents .....	28
10.2 Rodenticides and bait products .....	28
10.3 Bait application overview and rates .....	30
10.4 Bait ordering, testing, packaging, transport, and storage. ....	31
10.5 Aerial baiting equipment .....	32
10.6 General timeline and commencement process for rodents.....	33
10.6.1 Baiting Operation Target Date .....	33
10.6.2 Commencement of Daily Baiting Operations .....	34
10.6.3 Bait application timeline .....	35
10.7 Aerial bait application: preparation, strategy, and logistics .....	37
10.7.1 UAV and Bait Bucket Calibration.....	37
10.7.2 Fixing position of islands and flight safety management.....	38
10.7.3 Flight plan.....	39
10.7.4 Aerial baiting Pilot to UAV communications.....	43
10.7.5 Loading and fueling.....	44
10.7.6 Aerial application - Interior .....	45
10.7.7 Aerial application - Coastal perimeter .....	47
10.7.8 Aerial exclusion zone treatment .....	47
10.7.9 Aerial application monitoring .....	48

<b>10.7.10</b>	Contingency and Spot Treatment Bait .....	50
10.8	Hand broadcast application: preparation, strategy, and logistics .....	50
<b>10.8.1</b>	Hand baiting in utility structures and abandoned or condemned structures .....	52
<b>10.8.2</b>	Hand baiting exclusion zone treatment .....	53
<b>10.8.3</b>	Hand application monitoring .....	53
10.9	Rodent station application: preparation, strategy, and logistics .....	54
10.10	Special baiting considerations and related strategies .....	55
<b>10.10.1</b>	Addressing Bait Shyness .....	55
<b>10.10.2</b>	Bait application in commensal areas .....	55
<b>10.10.3</b>	Bait application in agricultural/farmland area .....	56
<b>10.10.4</b>	Bait application in the tortoise holding pen .....	57
<b>10.10.5</b>	Bait application over fresh water sources and standing water .....	58
<b>10.10.1</b>	Alternative Food Sources .....	58
10.11	Post application activities .....	60
<b>10.11.1</b>	Bait Availability monitoring .....	60
<b>10.11.2</b>	Carcass searching .....	61
<b>10.11.1</b>	Monitoring to confirm rodent eradication .....	61
<b>10.11.2</b>	Evaluation of rodent reports .....	62
<b>10.11.3</b>	Rapid response plan .....	62
11.	OPERATIONAL DETAILS: CAT ERADICATION .....	63
11.1	Strategy overview for Cats .....	63
11.2	Bait product and toxicant .....	63
<b>11.2.1</b>	Manufacturing of sausage baits .....	63
<b>11.2.2</b>	Sourcing of PAPP .....	64
11.3	General timeline and commencement process for cats .....	64
<b>11.3.1</b>	Operation Target Date .....	64
<b>11.3.2</b>	Development of trail network .....	64
<b>11.3.3</b>	Initial population monitoring .....	65
11.4	Aerial bait application: preparation, strategy, and logistics .....	65
<b>11.4.1</b>	Detection probability analysis .....	65
<b>11.4.2</b>	Efficacy Monitoring .....	66
<b>11.4.3</b>	Population reduction during rat eradication .....	66
<b>11.4.4</b>	Transition from rodent to cat aerial operations .....	67
<b>11.4.5</b>	PAPP bait delivery and preparation .....	67
<b>11.4.6</b>	Transition from rodent to cat aerial operations .....	68
<b>11.4.7</b>	Broadcast, spot, and exclusion baiting .....	68
<b>11.4.8</b>	Loading and Fueling .....	69
<b>11.4.9</b>	Contingency bait and bait disposal .....	70
11.5	Remnant cat removal methods .....	70
<b>11.5.1</b>	Trapping .....	70
<b>11.5.2</b>	Hunting with dogs .....	72
<b>11.5.3</b>	Fumigants .....	72
<b>11.5.4</b>	Spotlight hunting .....	72
11.6	Monitoring techniques to confirm eradication .....	73
12.	Operational safety .....	73
13.	Logistics and Timing .....	74
13.1	Pre-implementation / Mobilization .....	74

13.1.1	Regulatory Compliance .....	74
13.1.2	Operational Contracts and Agreements .....	74
13.1.3	Project Reviews and Meetings .....	74
13.1.4	Community meetings .....	75
13.1.5	Steering committee meetings .....	75
13.1.6	Partner meetings .....	75
13.1.7	Personnel (arrival, lodging, communications) .....	75
13.1.8	Bait .....	75
13.1.9	Operational Communications .....	75
13.2	Post-implementation / Demobilization .....	75
13.2.1	Debrief .....	76
13.2.2	Personnel .....	76
13.2.3	Bait .....	76
13.2.4	Equipment and Supplies .....	76
13.2.5	Finalizing Reports .....	76
14.	EQUIPMENT LIST .....	76
15.	OPERATIONAL TEAM .....	77
16.	TASK SCHEDULE .....	81
	REFERENCES .....	82
	Appendix A - Rodent Station Task Sheet .....	85
	Appendix B – Bait Availability Protocols / Hand Broadcast Monitoring .....	88
	<i>Monitoring plot pellet quantities representing prescribed application rate.</i> .....	88
	Appendix C – Change Notice / Justification Form .....	91
	Appendix D – Product Labels .....	92

## 1. EXECUTIVE SUMMARY

The eradication of introduced vertebrates has become a widely accepted strategy for restoring island ecosystems. In a formal assessment, eradication of black rats, house mice and cats from Floreana Island, Galápagos was considered feasible using current techniques. These same techniques have been used to safely remove rodents and feral cats from islands worldwide, including recent eradication projects within the Galápagos archipelago. Presented here is the operational plan to remove black rats, house mice and cats from Floreana. The strategy, methods, timeline, and necessary stakeholder involvement are described in detail.

The goal of this project is to restore ecosystem function and enhance community well-being on Floreana Island. This would be achieved through ecosystem recovery post- eradication of black rats, house mice and cats, by reducing impacts to crops and households, and by implementing effective biosecurity measures (e.g. preventing reintroductions of rodents and cats, and sterilization of all domestic cats so they cannot act as a source population). This project is a partnership between the Galápagos National Park Directorate (GNPD), Galápagos Biosecurity Agency, the Ecuadorian Ministry of Environment, Junta Parroquial Isla Santa Maria, San Cristobal Municipal government, and Island

Conservation and contributes to the overarching goal of developing a sustainable life on Floreana: “Floreana Sostenible”.

Methods recommended for this multi-species eradication take into consideration that Floreana is a dry-tropical island<sup>1</sup> with a higher associated risk of failure than temperate islands (Keitt et al. 2015). The combination of methods will include aerial and ground dispersed toxic rodent and cat baits (resulting in primary and secondary poisoning), trapping, and hunting with and without dogs. Detection tools including remote cameras will be used before, during and post implementation to assist in confirmation. To complement these actions domestic cats will be sterilized and registered, euthanized or removed from the island. Regulations will be implemented prior to the eradication to ensure that these actions can be applied to all domestic cats on the island, and that no cats can be imported to the island after the operation. Agreements are in place manage domestic livestock, crops, and allow access to all buildings and areas of the island, regardless of tenure. Regulations to ensure these actions can occur are also necessary. Additional guidelines are described regarding options for interisland biosecurity, enhanced ongoing biosecurity on island, as well as legislation to regulate or prohibit importations of certain animals.

This plan should be read in conjunction with plans related to protecting non-target species during the campaign. Background information and context is provided within the Floreana Island rodent and cat eradication feasibility study (Island Conservation 2013).

Supplemental planning documents to be read in conjunction with this plan include:

- Operational safety plan
- Risk management plans (x8)
- Project communications plan
- Biosecurity plan
- Non-target mitigation plan

## 2. OPERATIONAL SUMMARY

- **Site:** Galapagos Archipelago, Floreana Island, Ecuador
- **Target Species:** Black rats (*Rattus rattus*), house mice (*Mus musculus*) and feral cats (*Felis silvestris catus*)
- **Treatment area:** Floreana Island (17,253ha)
- **Target application date:** October 2023
- **Bait type:**
  - Rodents: Conservation 25D Formula 2, 3/8” (9.5mm) diameter pellet, intermediate sorbitol, blue dye, no pyranine; FINAL all-weather BLOX, 25ppm Brodifacoum, 20g cereal block, tamper-resistant when installed correctly in bait station (Bell Laboratories, Inc.).

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<sup>1</sup> This is based on the parameters established by a tropical rodent eradication review (Keitt et al. 2015). Although lying between the tropics of Capricorn and cancer, Floreana has clear, delineated seasons within studies indicating that rodent breeding is not present over the bait application dates (Clark 1980). As a conservative measure, this plan has taken into account that a higher failure rate is associated with tropical rodent eradications. Suggestions made during the tropical rodent eradication conference have been incorporated into the operational plan.

- Cats: 20-24g Sausage bait based off of Curiosity® bait formula containing 78mg of Para-aminopropiophenone (PAPP) at the concentration of 310g/kg. PAPP will be encapsulated in a hard-shell deliver system (HSDV).
- Biosecurity: FINAL all-weather BLOX 25ppm Brodifacoum, 28g cereal block, tamper-resistant when installed correctly in bait station (Bell Laboratories, Inc.)
- **Application volume / rate:**
  - Rodents: 363,781 kg<sup>2</sup>. Highland area broadcast at 10kg/ha. Lowland area broadcast at 6 kg/ha. Coast perimeter broadcast at 9kg/ha. Two identical applications. 21 days between applications. A third application 15 days after the second including highland area, coastal perimeter, and areas of higher risk including historic dump site, vegetated gullies, etc. Broadcast will provide thorough coverage across all potential rodent home ranges.
  - Cats: 52,000 individual baits over three applications (= 1 bait / ha / application). Applications scheduled to occur 10 days, 25 days, and 40 days post the final rodent bait application. Broadcast will occur across a 300m grid with additional spot treatment occurring along likely travel routes and in response to detections.
- **Application method:**
  - Rodents: Aerial broadcast by unmanned aerial vehicle (UAV); Structures targeted by hand broadcast/bait station/trays; Exclusions to aerial broadcast targeted with hand broadcast and/or bait trays.
  - Cats: Aerial broadcast by unmanned aerial vehicle (UAV); Exclusions to aerial broadcast targeted with hand broadcast and/or bait trays.
- **UAV rodent bait application protocol:** Baiting conducted across blocks to accommodate multi-day baiting period.
  - Interior – sown by parallel lines ending at the coastal high tide mark.
  - Coast – bait sown with a directional broadcast along the coastal perimeter (i.e. high tide mark or cliff edge) to minimize chance of gaps where interior stopped. Bait lines will be digitally mapped in advanced to support accurate flight management.
  - Vertical cliff faces – sown by vertically spaced parallel flight lines.
- **Hand application protocol:** Hand baiting staff, guided by a line boss, will align in a linear fashion at 20m spacing to distribute bait from individually identified baiting points. Each baiting point will be marked on a GPS when complete and digitally assessed for thorough coverage. Bait stations and/or trays will be utilized to strategically treat structures. Hand baiting and/or the use of bait stations/trays will be utilized in all areas excluded from aerial broadcast).
- **Supplemental/contingency bait:** 13% of application volume (including 3% or unplanned overlap). Supplemental bait may be used as contingency if spoilage occurs. All excess bait will be used by the Galapagos National Park for conservation purposes or disposed of in accordance to label guidelines.
- **Spot treatment bait:** 10% of application volume. Spot treatment bait will be used to provide coverage over standard aerial application rate to address high risk sites and supplement bait stations if required.
- **Biosecurity:** Departure and arrival protocols managed by the Galapagos Biosecurity Agency will remain in place. Bait stations and remote cameras will be strategically placed near the wharf and

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<sup>2</sup> See Excel document titled "Floreana Bait Calculation Guide 29\_Mar\_2017" for detailed breakdown of calculation.

supply depots on Floreana Island. Bait stations will have rodent traps and chew blocks installed continuously with the option to activate with toxic bait. Additional protocols will be added as biosecurity efforts develop over time.

### 3. INTRODUCTION

This document lays out a detailed description of the site and target species, project approach, scope, and stakeholder involvement designed to carry out a successful multispecies eradication of rats (*Rattus rattus*), mice (*Mus musculus*), and cats (*Felis silvestris catus*) on Floreana Island.

#### Key points:

- The Galápagos National Park Directorate (GNPD) is the lead agency supporting the restoration of Floreana.
- The Galápagos Biosecurity Agency (GBA) has jurisdiction for regulating and implementing management actions involving invasive and domestic animals in urban and agricultural areas.
- Island Conservation will provide technical assistance to partners.
- The community on Floreana must be involved early in the planning process and throughout the operation including ongoing biosecurity to facilitate a successful eradication campaign.
- Basic biosecurity measures are already in place, awareness of aspects in need of further development is growing, and interest is high to restore and maintain a natural ecosystem on Floreana.
- Funding sources are currently being identified to fund the eradication of rats, mice, and cats. Only after all components of the eradication are financed will critical actions be initiated (i.e. bait order, secure vendor contracts, etc.).

Background information was primarily obtained from an initial cat eradication plan (earlier draft) prepared in 2009 and a feasibility analysis prepared in early 2013 (Island Conservation 2013). Multiple site visits, frequent stakeholder community engagement, field trials (Jolley 2012, Hall 2016, Espinosa 2016, Castaño et al. *in prep*, Digby et al. 2019) and background research occurred to develop the details presented within this eradication plan.

Hyperlinked text within the document is incorporated to simplify the navigation to figures including tables, images, or appendixes. Footnotes are utilized where necessary to explain various topics or concepts that the authors felt would benefit from further justification.

### 4. PEER REVIEW

Peer reviewers have reviewed the eradication plan and provided additional advice to the Project Team. A draft version of this plan was reviewed by Island Conservation's Eradication Advisory Team (ICEAT), along with other staff of Island Conservation (IC). Additional review of this plan has included two independent external reviews by Pete McClelland, and a subsequent draft has been reviewed by the New Zealand Department of Conservation's Island Eradication Advisory Group (IEAG). Prior to submitting a bait order and finalizing the aerial broadcast contract, ICEAT will assess any relevant updates to project planning as well as evaluate project readiness.



## 5. GOAL, OBJECTIVES and OUTCOMES

### 5.1 Goal

The goal of the proposed project is:

Contribute to the restoration of natural ecosystem function, native species recovery and community well-being on Floreana Island by eradicating introduced invasive cats, rats and mice.

### 5.2 Objectives and Outcomes

The objectives that this project will achieve and the outcomes that will be seen as a result of achieving these objectives are:

Objectives	Outcomes
1. Contribute to the ecological restoration of Floreana Island through the eradication of cats, rats, mice and the control of feral chickens.	1.1 Planning documents are prepared detailing the eradication of rodents and cats including, but not limited to: feasibility plan; human health risk assessment and mitigation plan; non-target risk assessment; operational plan, etc.
	1.2 Three damaging invasive species are removed permanently from Floreana Island.
	1.3 Produce management plans for the community related to water, children, pets, tourism, and the commensal environment and mitigate unacceptable impacts.
	1.4 Produce management plans for non-target native species, domestic animals (livestock), agriculture, and mitigate unacceptable impacts.
	1.5 The feral chicken population is reduced or removed altogether.
	1.6 The recovery of native species, including the medium tree finch, Galápagos petrel, marine iguana, lava lizard, Galápagos martin, endemic snails and <i>Opuntia</i> cactus.
	1.7 On-island conditions exist to support successful reintroductions of extirpated species such as the Floreana mockingbird, Floreana giant tortoise, and lava gull.

	1.8 Biosecurity measures are functional and effective. No livestock or pets are brought on-island without GBA permits and having undergone quarantine procedures, including disease checks for livestock and sterilization of pets.
	1.9 Detection measures continue in perpetuity and response measures are in place for dealing with any 'rodent spills' post eradication confirmation regardless of jurisdiction.
2. Participatory decision-making process developed and is led by a steering committee, including Galápagos Biosecurity Agency (GBA), Galápagos National Park Directorate, Ministry of Agriculture (MAGAP), Floreana Island Parish Council (FIPC), community members and Island Conservation representatives.	2.1 Charter for steering committee approved by members.
	2.2 Partners have a regular forum in which to share information (i.e. plans, census information, etc.), collaborate on planning, and coordinate future project components.
	2.3 Eradication methods and other project components including Individual Property Management Agreements are developed and implemented with the community's awareness and support.
	2.4 All domestic cats on Floreana Island are sterilized and registered. Regulations are in place and are being enforced for directing the management of pets.
	2.5 The Floreana community supports biosecurity.
3. Improve livelihoods on Floreana Island.	3.1 The Floreana community is supportive of the project.
	3.2 Reduced risk of disease, bacteria and parasites for which cats and rodents are vectors, including toxoplasmosis, leptospirosis, cat scratch disease, cutaneous larva migrans, lymphocytic clorio-meningitis, plague, hantavirus and salmonellosis.
	3.3 Improved quality and quantity of horticultural production.
	3.4 Reduced damage to infrastructure, unprotected materials/supplies and food for people and livestock.

	<p>3.5 Improved quality and quantity of livestock products.</p> <p>3.5.1 Regulations regarding domestic livestock management requirements are in-effect.</p> <p>3.5.2 Island is destocked of the majority of livestock prior to eradication. Actions for eradicating livestock diseases occur.</p> <p>3.5.3 Livestock management avoids farmer-conservation conflicts.</p>
	3.6 Costs associated with rodent control are eliminated
	3.7 Aesthetic values and visitor experience improved. Tourism-based economic benefits increase due to ecosystem recovery, presence of endemic species, and the type of visitors attracted to the island.
4. Each partner leverages existing capacities and builds new ones in-line with their missions.	4.1 Each partner in the partnership has a role and contributes to the project's larger goals leading to success of the overall project.
	4.2 Each partner develops additional capacities that facilitate implementation of their mission in the future.
5. Prepare for reintroductions of extirpated species	5.1 Plans developed for reintroductions of Floreana giant tortoise, Floreana mockingbird, Galápagos hawk, Galápagos racer, and lava gull.
	5.2 Knowledge gaps relating to conducting reintroductions are filled prior to completion of eradications. Researchers/re-introduction practitioners bring funding not available for eradication activities.

### 5.3 Outcomes Anticipated due to Implementation

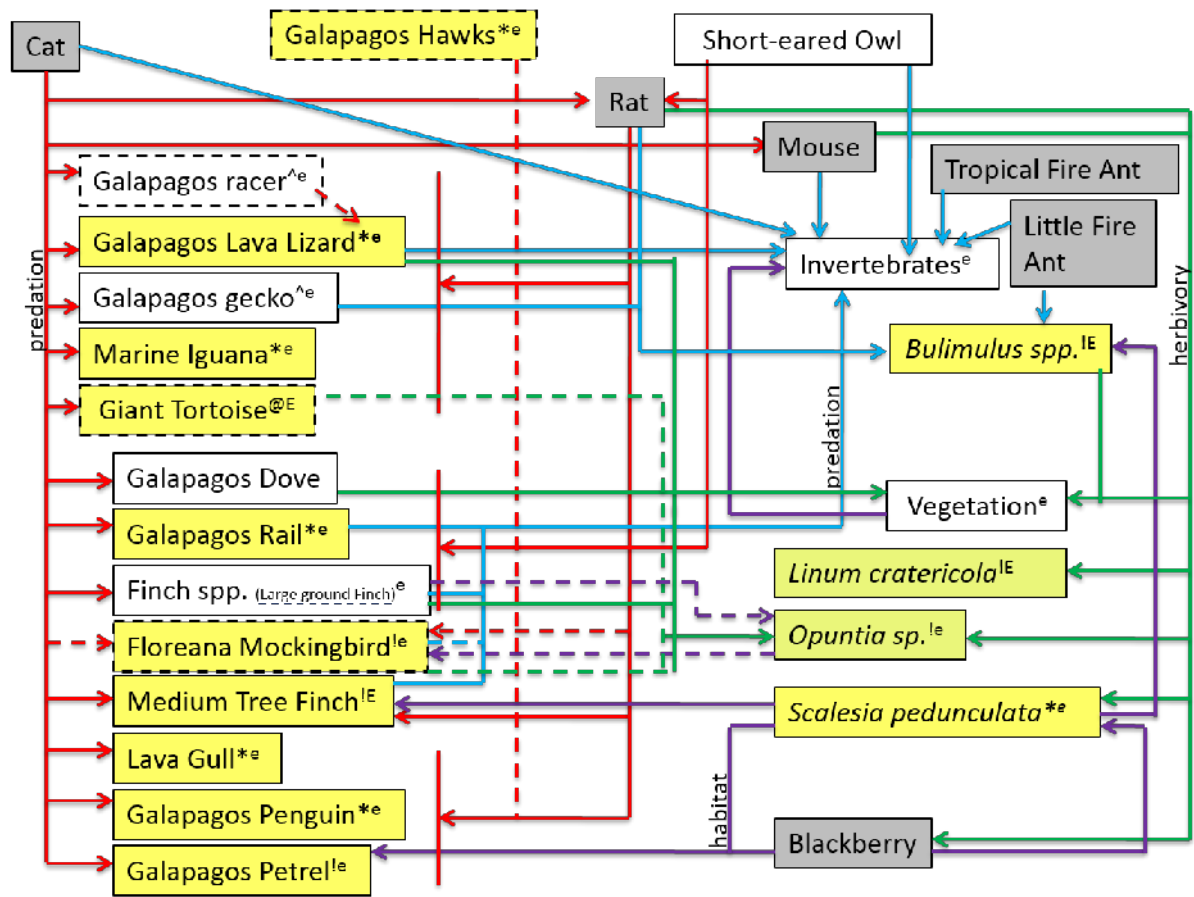
It is anticipated that the campaign to remove rodents and feral cats from Floreana Island will have both short and long-term impacts on the island. The overall anticipated effect is a net benefit to the community and island ecosystem. Predictions are based upon the numerous studies, which have documented human health risks and the widespread damage caused by introduced rats, mice, and cats on islands as well as the studies that document the recovery of island species after these species are removed. These benefits will mostly be realized after the project is completed allowing for the removal of various human health and wellbeing risks and the island's fauna and flora has time to recover in the absence of rodents and cats.

Short-term impacts will be realized during the campaign. These can be both positive and negative. The positive impacts will primarily be that farmers and households can immediately forego the control of rodents and an immediate reduction in mortality of cat and rodent prey items will be seen such as the island endemic lava lizard, finches, nesting seabirds, seeds, seedlings and other species. The expected negative impacts are primarily short-term and are associated directly with the effort and activities during and related to the removal of rodents and cats from Floreana Island. Examples include an inconvenience to the island community as a change in routine to accommodate an effective operation will be necessary; farmers will experience a temporary reduction in their production of produce, meat, eggs and milk and the local market may need to be subsidized from off-island sources; the mortality of non-target species from toxicants used to achieve rodent and cat eradication; and construction and maintenance of trails and aerial operation's loading zone that require vegetation to be cut.

Long-term positive impacts, a result of the absence of cats and rodents, are expected. Increased rates of harvest of farmed crops are expected to occur without rodent predation. By eradicating rodents, the need for and use of rodenticides will cease, creating opportunities for the production of organic products. Additional health and wellbeing benefits gained by the removal of cats and rodents is a reduction in zoonotic diseases, bacteria, and parasites that are carried, or transmitted by these species.

The diet of feral cats on islands is largely made up of seabirds, small mammals and reptiles (Konecny 1987a, Biro et al. 2005, Harper 2005). However, cat diet changes with food availability and cats are known to take the most abundant available food source (Van Aarde 1980, Veitch 1985). On islands with seabirds, this means cats can consume seabirds when seasonally present and maintain their population level by taking alternative prey items at other times of the year. By simultaneously removing cats along with rats and mice, the likelihood of prey switching or meso-predator release that could place further pressure on endangered species populations will be reduced (Griffiths 2011).

Contributors to this report believe we have considered the ecosystem responses that can be anticipated with our current knowledge of the ecosystem, which is typically limited to bi-trophic responses (e.g. cats eat birds, removing cats will cause an increase in bird numbers) and some tri-trophic responses. There may be some unexpected responses that we are currently unable to predict (Zavaleta et al. 2001), which are most likely 3<sup>rd</sup>, and  $\geq 4^{\text{th}}$  level trophic responses (*Figure 1*). Responses at these levels may be partly a result of complex interactions involving rainfall events, nutrient cycles, and other factors.



- \*Listed as vulnerable (yellow box)
- ! - Listed as endangered or critically endangered (yellow box)
- E - Endemic to Floreana
- e - Endemic to the Galápagos
- ^ - Not evaluated
- Dashes = past breeder
- @ - Extinct in the wild

**Figure 1.** Conservation measures Floreana food web (Wolf 2011)

## 6. PROJECT SITE & TARGET SPECIES

### 6.1 Floreana Island

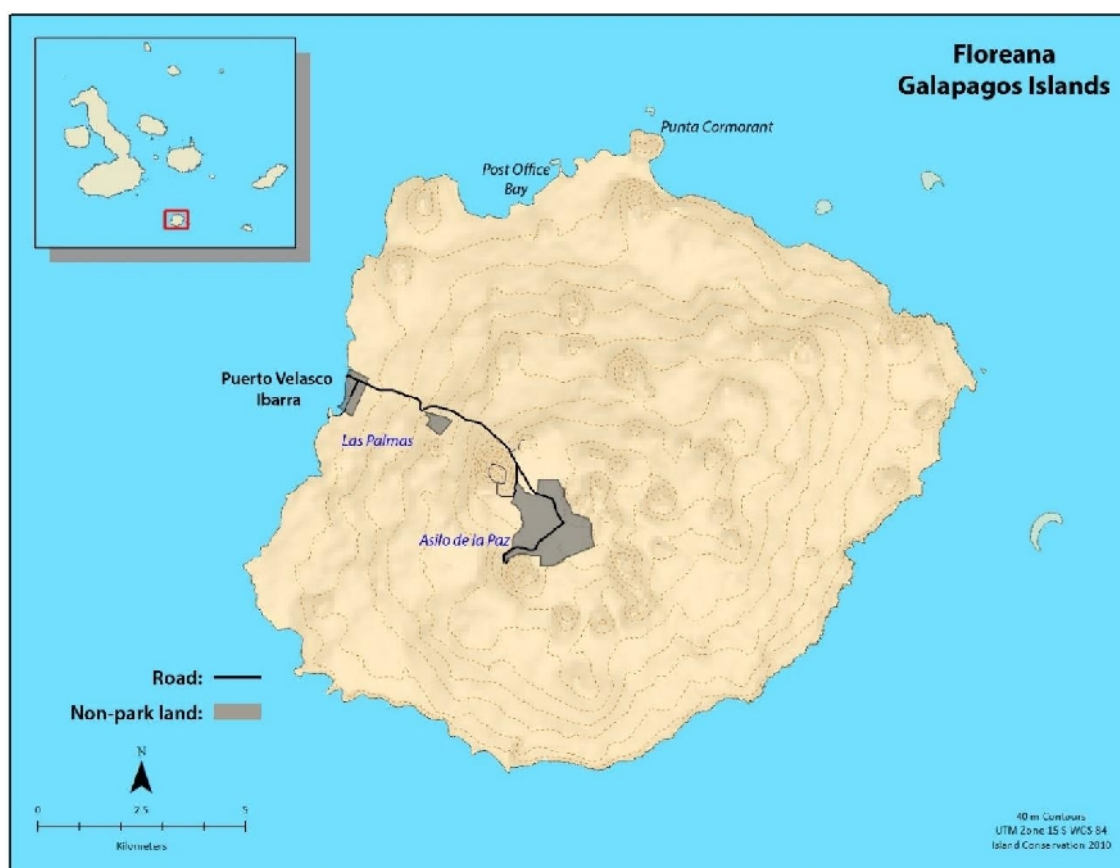
Floreana Island is situated within the Galápagos archipelago lying roughly 1,000 km off the coast of Ecuador. All 128 islands and islets are within the Galápagos province of Ecuador. Floreana Island is the fourth largest of five inhabited islands and the sixth largest island within the Galápagos archipelago. It covers 17,253 ha, with a maximum elevation of 640 m at Cerro Pajas. Like all of the Galápagos Islands, Floreana is of recent volcanic origins. Two general habitat types make up the island; a dry arid lowland (12,654 ha), and a lush highland (4,599 ha), (Figure 2). The island has multiple ponds and lagoons, two drinking-water sources derived from springs (La Baronesa and Asilo de la Paz) that are present in the

highlands, one spring (Las Palmas) in the lowlands, and an array of subterranean lava tubes lying underground. Sea cliffs of up to 30 m are present on the southern and eastern coastline.

Lying at 1.2 degrees south of the equator, Floreana Island is considered a dry-tropical island. It experiences slight climatic variation; a dry season from Oct – mid-January delivering blue skies and little to no rain (and a declining or crashed rodent population); a wet (warm) season from mid-January – June with a more humid climate that includes daily precipitation and more consistent cloud cover; and a Garua season from July – September with dense marine air, routine fog presence, and precipitation in the form of fog (particularly heavy in the highlands). Air temperatures range from 21º - 30º Celsius while sea temperature remains between 21º – 25º Celsius and sea conditions are suitable for transit year-round. A climate shift to heavy and frequent rain can be expected during El Niño events while more arid drought conditions are present during La Niña events.

Floreana Island was previously known by several other names, the most common being Santa María and Charles (Woram 1989). The Galápagos National Park manages over 98% of the island, with an agricultural zone of 230 ha and the town of Puerto Velasco Ibarra (42 ha) filling the remaining 2%. The island was first settled in 1832 and has a well recorded history.

The primary use of Floreana Island includes agriculture, tourism, conservation and fishing. Today, a community of roughly 140 people reside on island while tourism, primarily day-trips, results in dramatic, temporary increases in the number of people on the island. Infrastructure exists on island to accommodate tourists while safe moorage for tour cruises and recreational activities are found at two other places on Floreana beside the port; punta cormorant and post office bay. In the surrounding waters Champion Island, Devil's crown, and Enderby Island provide snorkeling or diving opportunities for tourists. Multiple farms, several divided amongst lessees make up the agricultural zone in the highlands.



**Figure 2.** Floreana Island is round in shape, approximately 16 km in diameter, with roughly 68km of coastline. The town of Puerto Velasco Ibarra is located on the western side of the island. A single road leads to the highland agricultural zone.

Access to Floreana Island from other ports in the archipelago is generally achieved by boat. Puerto Velasco Ibarra is 62km (34 nautical miles) from Puerto Ayora on Santa Cruz Island (~1.5 - 3 hours by boat). The port can support small watercraft and skiffs while offshore waters have no limiting factors that would restrict larger vessels. Airspace above Floreana Island is not restricted and potential helicopter landing zones are present across the landscape. No runway exists on island to accommodate fixed-wing aircraft. San Cristobal, Isabela, and Baltra Island each have a runway while Baltra (airport code GPS) supports regular commercial flights daily and acts as the primary air conduit to the archipelago.

## 6.2 The Target Species

Invasive rats (*Rattus rattus*), house mice (*Mus musculus*), and feral cats (*Felis silvestris catus*) are all targeted for removal from Floreana. All three species are listed within the Invasive Species Specialist Group's (ISSG) 100 world's worst invasive alien species (ISSG 2015); none of which are native to Floreana's ecosystem.

## 7. RISK ASSESSMENT and MANAGEMENT

### 7.1 Human Health and Safety

Risk assessments regarding the application of Brodifacoum and Para-aminopropiophenone (PAPP) were developed for Floreana. Documents include:

- A priori assessment of the potential for human inhabitants, domestic animals, and other species harvested for food on Floreana to be exposed to Brodifacoum as the result of the propose aerial application of rodenticide bait and risks likely to be associated with this (Fisher and Campbell 2017a).
- A report providing information to enable decision makers to determine which toxicant (or combination of toxicants for different areas) should be used for the removal of feral cats from Floreana following the application of rodenticide bait for the eradication of invasive rodents (Fisher and Campbell 2015).

Specific action to address human health and safety can be found in the following management plans developed by the partnership and in consultation with stakeholders. Plan summaries are included below:

- **Risk management related fresh water** - the population of Floreana Island is supplied from three natural sources of water: Asilo de la Paz, Finca Witmer and Las Palmas. In addition to natural springs, a sea water desalination and purification plant operates on island which supplies 40% of the demand of the island.

Although brodifacoum is not soluble in water, together with the community of Floreana Island, it has been decided to carry out mitigation actions to prevent both baits and dying rodents from coming into contact with fresh water sources. A series of measures were developed that includes the isolation of spring water sources, isolation of rainwater harvesting systems, protection of lagoons with geomembranes used for agriculture, as well as the protection of natural and artificial lagoons.

The isolation measures for the protection of water sources for human consumption consist of placing a fine anti-rodent metal mesh anchored to the ground and on this a impermeable tarpaulin to prevent pellet fragments from falling onto the water outlet.

No aerial application of the bait will be carried out around the water source. Bait will be placed manually and supplemented by the installation of mechanical traps and bait stations.

In addition to all these security measures, water from potable water sources will not be used during the rodent eradication stage. Only drinking water from the desalination system will be supplied for drinking with volume being increased by the Municipality and the Parish Board to ensure no shortage occurs. Furthermore, water reserve capacity will be expanded through a provision of 4 plastic cisterns providing a total capacity of 5000 gallons.

Management of natural and artificial lagoons will occur through by either excluding the site from aerial broadcast or covering the site with an impermeable tarpaulin. Areas excluded from aerial broadcast will have a hand broadcast conducted around perimeter out to the aerielly baited area to ensure all rodents are at risk of removal. Covered lagoons will be included in the aerial broadcast. Bait residing on lagoon covers will be retrieved when covers are removed.



Management of rainwater harvesting systems will consist of covering the roofs and cistern with an impermeable tarpaulin and disconnecting the plumbing system until all bait applications have been conducted.

Specific management will be guided by a digital data collection system and will adhere to individual property management agreements.

- **Risk management related to agricultural plots** - the agricultural area of Floreana island is very suitable for the development of agricultural activities including short-cycle, annual, biannual and perennial crops. The main objective of managing agricultural production is to remove alternative food sources which may be more attractive than bait required to eradicate rodents. Measures developed in consultation with farmers include:
  - a) The harvesting of agricultural products prior to the application of bait.
  - b) Delayed planning of crops typically harvested over the period of the planned eradication.
  - c) Monitoring of sites posing high risk to rodent eradication.
  - d) Conduct a third application of bait to sites with high productivity.

Additional management include harvested crops being stored in rodent-proof containers. Rodent management efforts specific to these sites will include mechanical traps within, and bait stations immediately outside all storage locations.

Agriculture outside of farms is limited to fruit trees residing within the park boundary. Orange and guava trees will have fruits harvested and closely managed by dedicated caretakers. Trees without caretakers will be removed prior to implementation.

Specific management will be guided by a digital data collection system and will adhere to individual property management agreements.

- **Risk management related to residents** – measures are proposed for the entire population of Floreana Island with special emphasis on children and people whose ability to interpret management action may be impaired. In cases where risk may be present, management action will be in place to prevent the accidental handling and consumption of bait. Actions include:
  - a) Prevention campaign which includes a detailed socialization of all phases of the project, the risks of exposure, and how to prevent exposure. Information brochures will be freely available to all and presented during visits to each home.
  - b) A record of children and people benefiting from additional care will be developed. A map of the location of each management strategy will be incorporated into individual property management agreements. In each house where there are children, a safe play area will be defined and maintained.
  - c) At the Amazonas School, the areas most frequented by children will be isolated and bait will not be openly broadcasted. Bait will be applied only within tamper-proof bait stations. Additional rodent removal methods including mechanical traps will be utilized to achieve eradication success.

Other options are also being considered, such as organizing expeditions to other islands with all the school children while the bait is being applied at each stage. These activities will be coordinated with the Directorate of the Ministry of Education.

- **Risk management related to near-shore fishing** – although the bait application strategy will strive to limit bait entering the marine environment, it is necessary to manage the coastal fishery of Floreana Island to prevent toxicant exposure. Stakeholders have agreed on the management action to close any type of near-shore fishing during and after the bait application. On after toxicological analysis indicate toxicant residue is not present will fishing be re-opened. Management of local fishing will occur by an issuance of an Administrative Resolution of the GNPD.

During the closing time of the coastal fishery, the supply of these products from another island will be coordinated.

Deep-sea fishing will require no action other than the normal control that the GNPD performs at the dock of Floreana Island.

- **Risk management related to tourism** - to minimize the risks involved in the use of toxicant (brodifacoum and PAPP), visitation to Floreana Island will be managed over the period of time during and immediately after bait application periods.

During the preliminary phase, a broad information campaign will be carried out with all naturalist guides who lead groups on Floreana Island, tourism operators of the different modalities that visit Floreana, all crew of tourist boats that visit Floreana, shipowners and crew of coastal vessels who frequently travel to Floreana Island, as well as owners and staff of island services (e.g. lodging, restaurants). The objective of the information campaign is to ensure all people engaging with tourists have the same level of information about what the project entails, the risks, and how they are being managed, so that they in turn have a basis to inform visitors.

The Directorate of the Galapagos National Park will analyze the possibility of temporarily closing visitor sites, however, at the entrance of each tourist visit site there will be a Park Ranger controlling visitor access and informing details in such a way as to avoid any risk.

- **Risk management related to rodents within inhabited spaces (commensal rodents)** – rodents living in conjunction with human habitation represent one of the greatest risks for the success of eradication. Specific measures to mitigate risk of failure is the management of human food sources in terms and the availability of rodents as an alternative food to bait. Human food includes both what is produced locally and what is imported from other islands or from the mainland.

The greatest emphasis is on the storage of food of all kinds, but especially those that attract rodents. All food products will be contained/stored in rodent proof containers. Preparation of food will continue to employ sanitary procedures which limit potential access by rodents. Organic waste will be collected throughout preparation and secured within rodent proof containers until fed to livestock or destroyed. Non-organic waste will be washed and managed within an updated recycling system that does not present risk related to alternative food sources.

Other risks will be managed by evaluating septic tanks, inspection boxes, and sewage pipes resulting in any necessary repairs to prevent rodent access. Construction material will be organized to limit safe harbor of rodents. Garbage accumulated on the grounds of Puerto Velasco Ibarra will be thoroughly destroyed before implementation.

Rodent management tools will be prescribed to each property in consultation with residents. Management will be guided by a digital data collection system and will adhere to individual property management agreements.

- **Risk management related to livestock** - the bait used to eradicate rodents utilizes a compressed cereal matrix which can be attractive to livestock, especially pigs and chickens. As a result, livestock owners, in conjunction with the project partnership, have determined the best management action is to institute captive holding in conjunction with an effort to reduce overall numbers so that their management is more feasible.

In the case of cattle, animals will be corralled for 6 months. Pigs, due to their foraging habits, will be held in piggeries until bimonthly toxicological analysis indicates residual residues are no longer present. In the case of chickens, flocks will be maintained within coops indefinitely to remove wildlife/livestock conflicts associated with predation (i.e. owl and hawk predation on chicks). State of the art enclosures including 15 chicken coops, 7 piggeries, and 5 corrals have been designed and built for each producer to enable long-term holding. Livestock will be fed with products processed to optimize nutrition and stored in rodent-proof containers. Actions prior to initiating the eradication campaign will include the removal of livestock not managed within a dedicated space.

The area of the confinements will be excluded from the open broadcast of bait. Eradication success will be achieved by placing bait stations strategically around and within enclosures. Particular attention will be given to feeding areas so livestock are not exposed to bait, yet all rodents have access to removal methods. Rodent removal methods will be guided by a digital data collection system which will adhere to individual property management agreements.

The feeding of livestock will be closely managed so remains of food is available to serve as an alternative food source for rodents.

Action necessary to address operational safety can be found elsewhere within this document (Operational safety).

## 7.2 Non-Target Species

Risk assessments regarding the application of Brodifacoum and Para-aminopropiophenone (PAPP) were developed for Floreana. Documents include:

- A priori assessment of the potential of endemic, native, and introduced wildlife present on Floreana to be exposed to Brodifacoum as the result of the proposed aerial application of rodenticide bait, and the risks likely to be associated with this (Fisher and Campbell 2017b).
- A report providing information to enable decision makers to determine which toxicant (or combination of toxicants for different areas) should be used for the removal of feral cats from Floreana following the application of rodenticide bait for the eradication of invasive rodents (Fisher and Campbell 2017c).

Specific action to address non-target species can be found in the following management plans developed by the partnership and in consultation with stakeholders and within a comprehensive native species mitigation plan shaped by a consortium of species experts and stakeholders. Plan summaries are included below:

- **Risk management related to domestic pets** - pets could be affected by consuming rodents or other animals that have ingested the baits prescribed for the eradication of rodents and cats. As a result, management measures have been defined in order to prevent unwanted effects on pets. For the care of pets during the eradication campaign, several management options have been developed in conjunction with the community so that each owner can decide what is best for their circumstance. Options available include:
  - a) Temporary translocation outside of Floreana to an inhabited island of the Archipelago. This action will comply with the necessary biosafety and quarantine procedures specified by the Galapagos Biosecurity Agency (ABG).
  - b) Permanent translocation outside of Galapagos. This action also required the completion of the necessary biosafety and quarantine procedures specified by the Galapagos Biosecurity Agency (ABG).
  - c) Captive holding on Floreana. This action will result in pets remaining inside their owners' homes or within adequate confinements on the owner's property, prior to which they must comply with the registration and sterilization requirements of their pet.
  - d) Euthanasia. This action will comply with approved veterinary procedures and applicable ABG requirements. Community members preferring this options must sign a document expressly stating their consent.

Rodent removal methods near domestic pet enclosures will be guided by a digital data collection system will adhere to individual property management agreements.

- **Risk management related to livestock** – *see summary within Human Health and Safety*
- **Risk management related to near-shore fishing** – *see summary within Human Health and Safety*
- **Risk management through native species mitigation** (Durrell, plan in prep) - it is critical that potential impacts of eradication methods on at-risk native species (five species of Darwin finches including a hybrid population, Galapagos short-eared owl, Floreana gecko, Floreana lava lizard, and American flamingo, the latter identified as at risk from the social perspective) is effectively managed. Captive holding has been determined as the most appropriate management action for all five species of Darwin finches (including a hybrid population) and Galapagos short-eared owl. Reintroduction from nearby Champion island has been determined as the most appropriate mitigation action for Floreana geckos and lava lizards if populations are extirpated from Floreana. For flamingos, bait application by hand around nesting areas utilizing one of two people was determined the most appropriate to minimize the disturbance to the species during the rodent eradication operation.

Populations of wildlife maintained in captive holding will be treated as safeguard populations receiving the most appropriate care in case mortality is above what has been identified for each of the species (e.g. medium and small tree-finch low to medium risk (island population may be reduced by <10% to 10-50%), ground-finches (including cactus-finch) medium to high risk (island population may be reduced by 10-50% or >50%), and for short-eared owls high risk) and can be safely returned to the wild and supplement wild populations after the eradication.

In addition to captive holding, additional recommendations were identified to manage the risk to the remaining wild populations of the five finch species and hybrid population during the eradication campaign. This includes the treatment of a feasible number of finch nests with insecticide to reduce the impact of *Philornis downsi* on these wild populations during the breeding period after the rodent and feral cat eradication has been implemented. The aim of this is to increase the chances of nestling survival and therefore natural recruitment of juveniles into the adult population following the rodent and feral cat eradication.

Detailed information on each species mitigation actions can be found within the parent document: 'Floreana non-target wildlife mitigation Plan for managing toxicant exposure risk during the Floreana Rodent and feral cat eradication'.

General impacts such as physical disturbances (e.g. trail cutting, UAV helicopter noise), collision of individual birds with aircraft, and non-target captures did not trigger an exhaustive evaluation as previous efforts and similar eradication actions within the Galápagos have shown positive net benefits with no long-term negative impacts. Although this is the case, it is recognized the Floreana is a unique site and data will be recorded and utilized for adaptive management or mitigation if necessary. If a solution cannot be managed in the field it will be brought to the Incident Advisory Group and project steering committee for further evaluation.

## 8. COMPLIANCE AND OPERATIONAL CONTRACT

### 8.1.1 Compliance and status (incomplete)

Permit / Authorization Type	Status / Date secured
Environmental Impact Assessment	In progress
Ministry of Environment project approval	
Bait application authorization (Rodent)	
Bait application authorization (Cat)	

### 8.1.2 Contracts and status (incomplete)

Service	Status
UAV contract	Proposal received
Rodent bait procurement and delivery	
Cat bait procurement and delivery	

## 9. OPERATIONAL PREPARATION AND PLANNING

### 9.1 Pre-eradication preparations and trial results

#### 9.1.1 Rodent bait availability trial

Bait availability trials were conducted in 2012 (Jolley 2012), to assess the bait availability rates through time after an aerial broadcast of cereal baits. Additional activities included, but were not limited to, confirming the present of rats and mice within the study area, monitoring of bait piles with cameras to assist in identifying non-target consumers, and monitoring degradation rates within exclusion plots. Two applications of bait were applied to a single plot within the highland and two separate lowland plots. The first application was an active (toxic) 12.7mm diameter, 2.3g pellet with a follow-up broadcast of 9.5mm diameter, 1g pellet. The two bait applications were spaced 15 days apart.

Application rates for the highland and lowland zones were calculated by using the lower 99% confidence interval<sup>3</sup> of the bait disappearance rate (Keitt et al. 2015).

**Figure 3.** 2012 bait trial bait availability results summary.

Baiting Block	Pellet size (g)	Initial Application Rate	Days until first plot zeroed out	Days until all plots zeroed out
Lowland A Application 1	2.3	10.3	27	> 63
Lowland A Application 2	1.1	8	21-28	>49

<sup>3</sup> This measure is considered more conservative as it attempts to address unsampled areas where bait loss may be more rapid as described by Keitt et al. (2015).

<b>Lowland B Application 1</b>	2.3	17	14	> 63
<b>Lowland B Application 2</b>	1.1	12.4	21-28	>49
<b>Highland A Application 1</b>	2.3	16.5	8	15
<b>Highland A Application 2</b>	1.1	12.9	9	14-21

### 9.1.2 Rodent bait weathering trial

Rodent bait weathering trials were conducted from October through November 2016 to determine the effects of weather on three different types of bait formulations to assess what is the most durable, and presumably palatable, bait formulation to eradicate black rats (*Rattus rattus*) and house mice (*Mus musculus*) from Floreana.

Bait was excluded from vertebrate consumers within mesh cages and left for a total of twenty-five days. Results indicated that all bait type formulas remained intact for at least six days in all habitat zones monitored. Zones monitored encompassed the highland, lowland, within transitional habitat between high- and lowlands, and coastal fringe (Espinosa 2017).

Aside from minor signs of discoloration on exposed surfaces of some pellets located on the coastal plots, all pellets within 16 weathering cages across all habitat types remained intact for the first seven nights; sufficient signs of weathering to deserve a Craddock score of 2 did not start to appear in some of the pellets in the highland zone till day eight of monitoring.

In general, bait pellets inside the weathering cages located in the highland zone started degrading, and degraded at a faster rate, than in all other locations; likely due to a higher moisture content in the air and to a richer soil compared to other habitat zones. An effort was made to place the cages underneath trees and on areas where there was vegetation in order to capture higher moisture scenarios. Consumption by ants took place in both the highland and the transition zone **Error! Reference source not found.** and various invertebrates were seen on the pellets presumably eating them (unidentified beetles, isopods and other minuscule invertebrates). It is important to note that the island seemed to have been undergoing a very dry spell while the trial took place, with minimal fog, dew or precipitation recorded and this slowed down the breaking apart of the pellets and the appearance of mold which would have accelerated pellet degradation. Where there is lack of humidity and the soil is poor, terrestrial invertebrates play a big role in bait degradation. If these invertebrates are absent, bait will likely persist and remain accessible in the environment for several months, especially if the bait matrix is made to withstand wet surroundings.

**Figure 4.** Time to key events in the bait weathering trial. Pellets were monitored for 25 days.

	<b>Highland zone</b>	<b>Transition zone</b>	<b>Lowland zone</b>	<b>Coastal zone</b>
<b>Discoloration</b>	Day 4: first signs of discoloration on Less Dry and Dry formulas	Day 4: first signs of discoloration on Less dry and Dry formulas	Day 4: first signs of discoloration on all formulas	Day 3: first signs of discoloration on Less Dry and Dry formulas

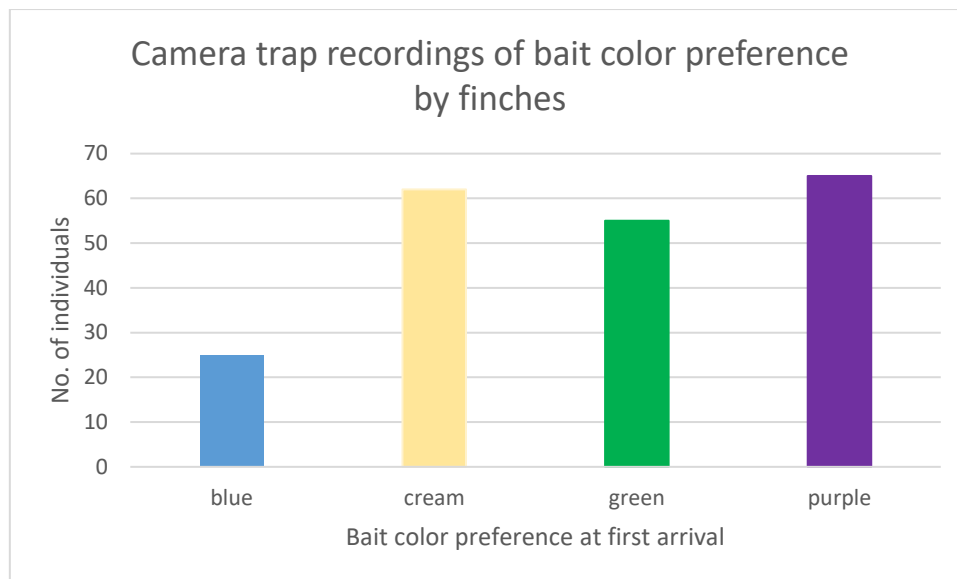
<b>Cracking</b>	Day 4: minor cracks appear on all formulas	Day 4: minor cracks appear on all formulas	Day 5: minor cracks appear on Less Dry and Dry formulas	Day 6: minor cracks appear on Less Dry and Dry formulas
<b>Molding</b>	Day 18: pellets of all formulas are covered in mold	Day 21: patches of mold start to appear on pellets of all formulas	N/A	N/A
<b>Crumbling</b>	Day 8: pellets of the Less Dry and Dry formulas start to look granular	Day 8: pellets of the Less Dry and Dry formulas start to look granular	N/A	N/A
<b>Completely degraded</b>	N/A	N/A	N/A	N/A
<b>Consumed by ants/invertebrates</b>	Day 8: first time invertebrates are seen on pellets. Day 6: ants have entirely consumed 4 pellets.  Day 10: pellets are actively being consumed by ants.	Day 4: ants are seen on pellets.  Day 18: ants have completely removed the pellets from one weathering cage	Day 12: small beetles are seen on pellets  Day 15: ants are seen on pellets.	N/A

### 9.1.3 Rodent bait color trial

Rodent bait color trials were conducted during October and November of 2016 to determine if specific colors of bait demonstrate reduced bait consumption by non-target species, specifically finches. Data collected in the field was used to evaluate if among the colors tested there is a specific color that finches avoid or prefer over other colors, particularly colors used on other eradication projects.

General results indicated that finches were more likely to avoid eating blue bait than the other colors (Espinosa 2017).





**Figure 5.** Camera trap recordings of finches foraging on four different colored bait piles. The results show the bait color preferred first at arrival at the feeding station.

#### 9.1.4 Vegetation index evaluation

Vegetation comparisons using remote sensing (photographs) were compiled in 2012 and 2016 to develop a basis of understanding regarding how vegetation changes across years depending on climatic conditions (Hall 2016; Espinosa 2017). A notable difference in the “greenness” between 2014 and 2016 is present; vegetation appeared to be drier during October-November 2016 than during the same months in 2014 (Espinosa 2017).

This variation in vegetation condition, coupled with a satellite imagery and the evaluation of enhanced vegetation index (EVI) modeling, suggests that inconsistency in annual conditions is likely and the implementation window must take into consider factors like El Nino and La Nina which correlate with higher rainfall and greater productivity.

#### 9.1.5 Conservation 25D lethality trial

Floreana has a >35-year history of Brodifacoum use to protect Galápagos petrels and crops from rodent predation. Although resistance to Brodifacoum has not been confirmed in any rodent population, tolerance has been suggested in at least one population of mice (Priddel et al. unpub. report). As a result, a choice trial was conducted using non-toxic food and Conservation 25D bait pellets which were offered to individually housed rats and mice, followed by a no-choice trial for any survivors.

Trials used a four-night exposure period with estimates made of the total amount of each food type consumed, followed by 20-days observation. In black rats, a total median intake equivalent to 0.30 mg/kg (0.01 - 0.53 mg/kg) of brodifacoum caused 100% mortality (80% mortality in initial choice trial, 20% in subsequent no-choice trial). In house mice a relatively higher oral exposure of up to 1.63 mg/kg brodifacoum resulted in 100% mortality (87% in choice, 8% in a first no-choice, 5% in a second no-choice).

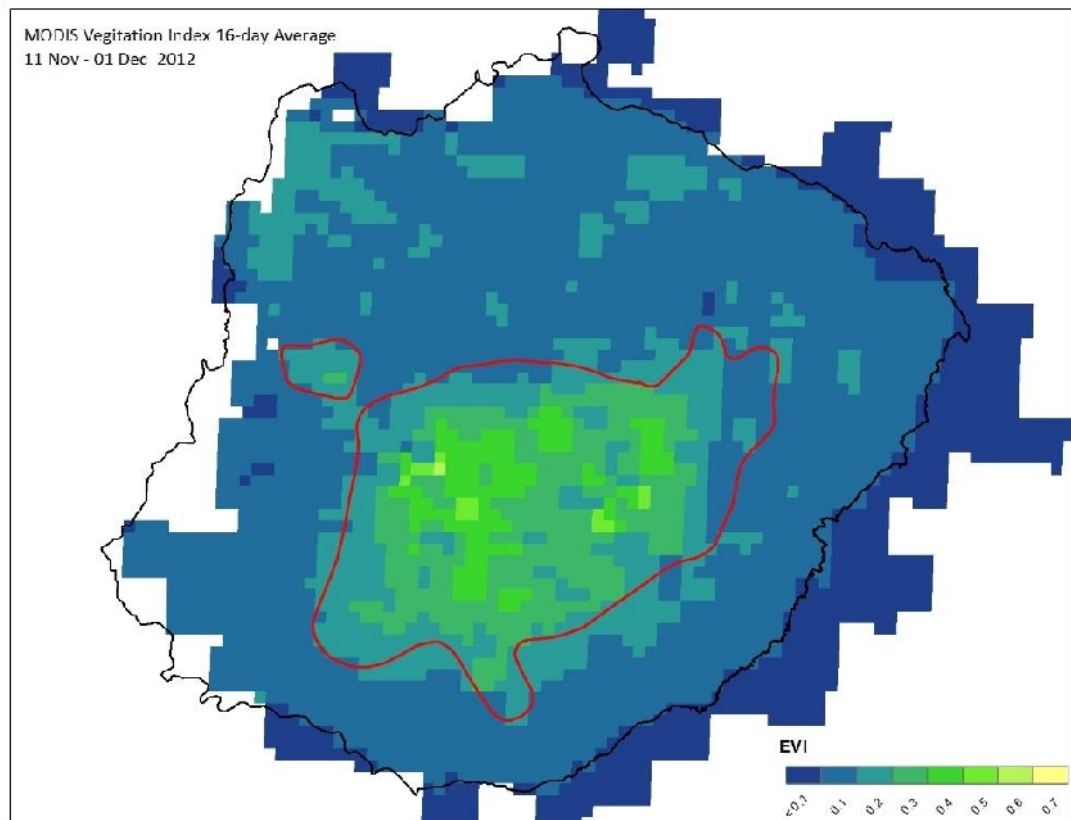
General results indicate that both rats and mice present on Floreana are susceptible to brodifacoum poisoning. The operational strategy has taken intake results and timing until death into account and extended the window between applications as well as added a third application of bait to sites supporting higher productivity.

#### **9.1.6 Genetic testing**

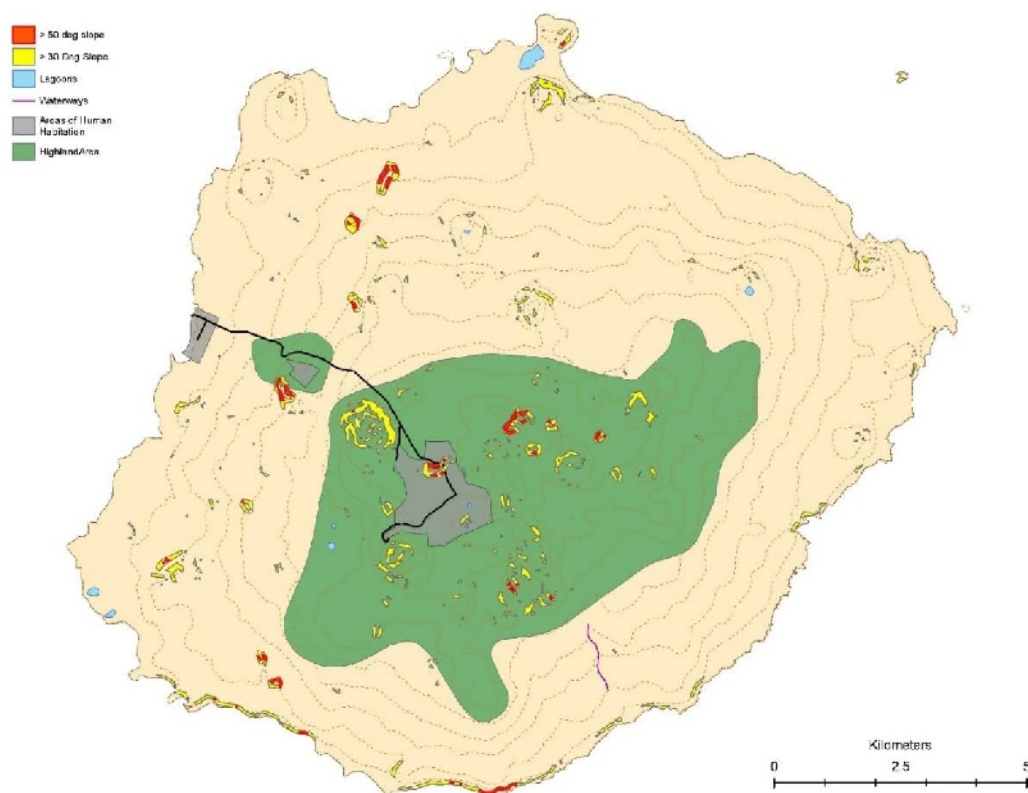
Rat and mice genetic samples were collected on island (2012) to serve as a genetic baseline. DNA has been extracted and are archived at the University of North Carolina for mice and Ecogene New Zealand for rats. Additional samples may be required to effectively sample the mouse and rat populations across the island. Sampling methodology has followed IC protocols (Ross 2009). If rodents are found on Floreana post eradication, samples will 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 *et al.* 2007).

#### **9.1.1 Baiting Survey**

Survey results using remote sensing and local knowledge have documented specific landscape features and the highland vegetation line (Figure 6). Static features including: caves, standing water (to be confirmed present one month before the operation), craters, steep faces, deep ravines, and cliffs have been mapped (Figure 7). A GIS layer will be created from data within the broadcast database which will guide UAV baiting. Features that do not remain static over the course of time including: standing water and agricultural zones (i.e. fruit trees and crops) will be mapped within one month prior to the first application. The quantity of bait necessary (including supplemental reserves) to carry out the entire project as planned has been generated by estimating the area of dynamic features combined with the early survey results of static features. Baiting rates are based on the prescribed bait application rate found in Figure 8.



**Figure 6.** Highland estimate based on a 16 day average of vegetation index (EVI).



**Figure 7.** Static features including slope, lagoons, significant waterways, human habitation, and highland terrain to be uniquely addressed during the bait application.

## 10. OPERATION DETAILS: RODENT ERADICATION

### 10.1 Strategy overview for rodents

- ☐ Conduct bait application trials to inform the baiting strategy
- ☐ Institute a public awareness program about the eradication project and community involvement
- ☐ Conduct detailed non-target risk assessments
- ☐ Develop mitigation plans for species facing unacceptable risks
- ☐ Develop pre-eradication commensal rodent control guidelines, management plans, and Individual Property Management Agreements
- ☐ Assess ongoing biosecurity measures and collaborate with biosecurity agency to refine procedures as necessary
- ☐ Implement Individual Property Management Agreements including all relevant management actions
- ☐ Conduct audits to assess community adherence to protocols
- ☐ Collect and harbor non-target species deemed to be at unacceptable risk, as described in mitigation plans
- ☐ Implement aerial baiting with cereal bait and activate bait stations (rodent traps will be activated after the first aerial application)
- ☐ Assess bait availability and bait persistence after each bait application
- ☐ Deploy proven rodent detection tools for monitoring towards confirmation
- ☐ Conduct early rodent detection efforts in high risk areas with the use of detection dogs, camera traps and other tools - Respond as appropriate if required.
- ☐ Confirm the eradication outcome after at least two breeding cycles have passed

### 10.2 Rodenticides and bait products

The use of the second generation anticoagulant toxicant Brodifacoum is the only known toxicant capable of achieving successful eradication on an island the size of Floreana. Previous rat and mouse eradications in the archipelago that employed aerial baiting techniques (e.g. Rabida, Pinzon, Plaza Sur, Plaza Norte, Seymour Norte) utilized Conservation 25D, Conservation 25D (Formula 2), or Conservation 50D<sup>4</sup> (Island Conservation unpub. data). On Floreana, the product Conservation 25D (Formula 2) from Bell Laboratories (Madison, WI) will be utilized. When in a pellet form, bait can be distributed by hand, within a bait station, or from a mechanical spreader bucket that can be calibrated for specific application rates and suspended below a helicopter. The bait pellet formulation chosen, if not consumed, will naturally degrade over time. The duration bait takes to degrade is related to environmental conditions (e.g. rainfall, sun exposure, etc.), and bacterial and invertebrate activity. It is important to note that bait degradation is not an appropriate metric to gauge the disappearance of toxin in the environment. Toxin residues may remain in a habitat or within certain non-target consumers creating a pathway of exposure that is not well understood (Howald 2015). Effort to monitor residue persistence in lava lizards had occurred on Pinzon and Rabida Islands and the analysis

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<sup>4</sup> Increasing the part per million level of Brodifacoum to 50 ppm was initially considered but dismissed due to the added risk to non-target species and precedence of 25ppm baits having shown to be sufficient in prior rat and mouse eradications.

of this monitoring is being utilized to estimate the persistence of toxin residues in various environments on Floreana.

Assumptions made regarding implementation:

- Although data from Clark (1980) suggests rats will not be breeding on Floreana during the baiting window (October – December), planning takes into consideration that rodent reproduction may be occurring in highly productive areas on the island.
- Rodents will demonstrate a preference to consume readily available food items (including bait) within their foraging range.

One bait product<sup>5</sup> manufactured by Bell Laboratories (Madison, Wisconsin) is selected for use on Floreana Island for all broadcast applications:

Aerial Application —

- Conservation 25D Formula 2, 9.5mm (3/8 in) diameter pellets, 25ppm Brodifacoum, dyed blue, without pyranine. Pellets average ~1g

Hand Application —

- Conservation 25D Formula 2, 9.5mm (3/8 in) diameter pellets, 25ppm Brodifacoum, dyed blue, without pyranine. Pellets average ~1g

Bait Trays —

- Conservation 25D Formula 2, 9.5mm (3/8 in) diameter pellets, 25ppm Brodifacoum, dyed blue, without pyranine. Pellets average ~1g

Bait Stations —

- FINAL all-weather BLOX, 50ppm Brodifacoum, 28g cereal block, tamper-resistant when installed correctly in a bait station.

While several other products meet some of the conditions listed, only the proposed product, Conservation 25D (Formula 2) currently meet all criteria for general broadcast. FINAL all-weather BLOX were selected for limited use within bait stations due to compressed crushed grain matrix and a form allowing for tamper resistant installation. When installed correctly within a bait station the use of FINAL BLOX will reduce the risk of unintentional bait brodifacoum exposure to humans, particularly children, and domestic animals. Sections criteria for rodenticide bait for eradication rodents from Floreana Island:

- Has a base matrix of compressed crushed grain

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<sup>5</sup> A single size of bait pellet has been chosen to reduce the logistical complexity of the operation. Key considerations are that mice are characterized as having smaller homeranges, submissive behavior to rats, and a higher tolerance to brodifacoum. By utilizing a smaller ~1 gram pellet, the density of baits will be roughly double that of the larger alternative ~2 gram pellet if applied at the same application rate. It is expected that this will improve the frequency at which mice will encounter baits within their natural foraging range as well as allow small individuals to transport and consume pellets with greater ease. The size of pellets prescribed (9.5mm diameter) has shown to successfully eradicate both rats and mice from islands (e.g. Plaza Sur, Anacapa) and has precedent on other rodent eradications including Seymour Norte.

- Does not contain bitrex, a bait additive believed to have caused eradication failure (Cromarty et al. 2002; McClelland 2002)
- Does not contain pyranine, a fluorescent bait biomarker considered to decrease palatability of bait to *Mus musculus* (Pitt et al. 2013)
- Has demonstrated it can be applied consistently and at the intended density by a helicopter suspended bait spreader bucket
- Has demonstrated efficacy at eradicating the target species (*Rattus rattus*, *Mus musculus*) in the Galápagos when deployed by helicopter
- Has been trialed on Floreana Island (Jolley 2012; Epinosa 2017)
- Has been demonstrated to arrive in good condition and capable of eradicating rodent populations after months of transit/storage with the packaging type proposed
- Can be packaged in bulk bags
- Is capable of remaining available to rodents for at least four nights in both wet and dry environments as experienced in the Floreana highlands and lowlands
- Is biodegradable in both wet and dry environments (Jolley 2012)

The application of Conservation 25D and FINAL BLOX will be authorized under a single use permit granted by the Galapagos National Park.

### 10.3 Bait application overview and rates

The eradication of rats and mice from Floreana will occur through three successive bait applications of a rodenticide containing the toxicant Brodifacoum. Two separate island-wide applications initiated no less than 21 days apart will aim to apply sufficient bait to every potential rodent territory ( $\leq 0.0035$ ha for mice (Clapperton 2006)) on the island. A third application conducted 14 days after the second broadcast will target the highland zone, coastal zone, and areas considered a high risk of harboring surviving rodents. Bait will be applied to the emergent land area via three delivery methods: aerial broadcast, hand broadcast, and rodent bait stations (enclosed and open bait trays). Due to the size of Floreana, rugged terrain, and inaccessible areas, the majority of bait will be applied aurally using a spreader bucket attached to a heavy-lift UAV.

Hand broadcast will be used to treat areas physically protected (i.e. covered by an impermeable structure) from an aerial broadcast and sensitive areas (exclusion zones<sup>6</sup>) that require a targeted bait placement. The broadcast of bait by hand will be utilized at specific locations including within the town exclusion, around large freshwater ponds, within abandoned structures, under awnings and lean-tos, within known caves, supplement high-risk commensal sites, and other areas where precise bait placement is critical. Some small sensitive areas, such as ponds, livestock holding pens, the two freshwater springs and enclosures holding captive non-targets will be covered by an impermeable barrier (if not already under a roof) and baited aurally to reduce baiting complexity. Follow-up inspections at springs, livestock pens, and non-target holding enclosures will occur immediately to assess coverage and remove any bait pellets within the exclusion site. All other sites will be inspected within 24 hours after the broadcast. Supplemental hand broadcasting will occur if gaps in coverage are identified.

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<sup>6</sup> Exclusion zones have been considered very carefully before having been incorporated into the operational plan. Each suggested exclusion zone has been critically examined and will only be used as necessary to protect highly sensitive areas such as fresh water sources for the community and water sources that serve as feeding sites for native bird species. Each site on island will be inspected prior to the aerial broadcast to determine if the exclusion of the area is required.

The use of rodent bait stations and traps, although labour intensive, will be critical to target rodents residing within inhabited structures, mitigation enclosures, and livestock holding pens while not compromising human health and safety or risk to the health and safety of captive animals.

A database and map of hand broadcast sites and associated baiting prescriptions are held by the GPS Specialist lead. The Baiting Chief is responsible for management and tracking to ensure thorough and effective bait coverage. Target bait application rate is shown in Figure 8 while bait application density on the ground is shown in Figure 9.

**Figure 8.** Target bait application rate minimums to provide 4 nights of bait availability.

	First Application	Second Application	Third Application
<b>Highland Rate (kg/ha)</b>	10	10	10
<b>Lowland Rate (kg/ha)</b>	6	6	0
<b>Coastal Rate (kg/ha)</b>	9	9	9

**Figure 9.** Bait density on the ground per application.

		Kg/ha	Baits/ha	Baits/4m <sup>2</sup>	Number of baits / mouse homerange <sup>7</sup>
<b>1st Application</b>					
	Highland Est.	10	9091	3.64	32
	Lowland Est.	6	5455	2.18	19
	Coast Est.	9	8182	3.27	29
<b>2nd Application</b>					
	Highland Est.	10	9091	3.64	32
	Lowland Est.	6	5455	2.18	19
	Coast Est.	9	8182	3.27	29
<b>3rd Application</b>					
	Highland Est.	10	9091	3.64	32
	Lowland Est.	0	0	0.00	0
	Coast Est.	9	8182	3.27	29

## 10.4 Bait ordering, testing, packaging, transport, and storage.

As described in detail within the Floreana Bait Ordering, Packaging, and Testing Plan (Island Conservation and Galapagos National Park Directorate (In prep a)), bait packaging and testing will occur by the manufacturer Bell Laboratories (Madison, Wisconsin). A Sampling of each batch of bait will be taken and tested prior to delivery to ensure chemical properties, particularly the level of

<sup>7</sup> Based on a .0035 ha minimum homerange (3.3m radius) as described within Clapperton 2006



Brodifacoum, are within the product's specified range. Only bait that meets the specific product label parameters will be packaged and shipped for use on Floreana.

Bait will be packaged in a plastic bag liner topped with desiccant packs. Bags will then be placed into industrial strength collapsible/recyclable bulk boxes (Ox Box, Addison, Illinois). Bulk boxes are intended to preserve bait freshness and minimize bait attrition while in transit. Container bait volume is correlated with the 180kg maximum payload capacity of a single UAV helicopter. Bulk box containers used in conjunction with pallets will be stackable to maximize the weight limit capacity of a standard 20-foot shipping container.

Containers will be sea-worthy to manage biosecurity risks and will ship directly from the manufacturer to Guayaquil, Ecuador via land and sea freight. Upon arrival to Guayaquil, shipping will follow a logistics plan to transfer cargo to Floreana (Island Conservation and Galapagos National Park Directorate (In prep c)). Storage will occur on Floreana at a designated site designated for storage and bait loading to support the aerial operation (Figure 20). Site location (adjacent to the road providing access to the community water storage tank) and preparation details are outlined within the Floreana Bulk Bait Loading Plan (Island Conservation and Galapagos National Park Directorate (In prep b))

## 10.5 Aerial baiting equipment

The Floreana project will utilize three heavy-lift unmanned Mosquito helicopters for all aerial operations. The Mosquito platform uses a piston powered, water cooled, oil injected, fuel injected, electronic programmable ignition, 800cc engine.



**Figure 10.** *Mosquito heavy-lift UAV helicopter.*

Mission planning will be fully programmable including the incorporation of flight polygons with start/stop waypoints, no go zones with buffers, speed and altitude setting. The autopilot will be able to program flight speeds either on air or ground speed. In case of communication failure, the autopilot system has a number of redundancies and can be programmed to either continue on mission, hover for a set time or return to the landing zone.

Units can be stored in a 20' standard shipping container. With just the front rotor blade removed, each unit measures 4.3m length x 1.5m width x 2.1m height.



Every 25 hours there is a requirement for a brief service, including filters and lubrication. This will be timed correctly during the operation to minimize downtime whilst the service is being completed. Every 100 flight hours there is a more thorough service which will be conducted between applications.

Spare parts will be brought to site to replace all key components on both the drone platforms as well as brodifacoum and PAPP sausage spreaders. Parts will be accompanied by all necessary tools.

Each UAV pilot will use a ground control station which will incorporate a manual controller, computer with programmed flight mission for autonomous flight and screen monitor for real-time camera footage and additional data display.

Operations will run day and night. To support night operations, three tower lights running on inbuilt gasoline generators will be supplied with UAV as additional freight. Tower lights will also provide running power for the ground control stations. 2000-watt lighting will be supplied by each tower to provide ample light for safe working during night shift. Having the generators inbuilt ensures sufficient power supply is available without requiring additional equipment to be on site.



**Figure 11.** *Mobile generator and flood light necessary to operate safely at night.*

The equipment for bait application including UAV, spreaders, spare parts, and all associated flight management equipment will be brought to site by sea freight in 3 x 20' standard shipping containers.

## **10.6 General timeline and commencement process for rodents**

### **10.6.1 Baiting Operation Target Date**

At the macro-scale, a dry season is experienced on Floreana from late September – mid-January delivering blue skies and little to no rain (and a declining or crashed rodent population). Outside of this window a more humid climate that includes daily precipitation and more consistent cloud cover or Garua (dense marine air and mist) can result in routine fog presence and precipitation in the form of fog; particularly in the highlands.

At a micro-scale, rodent homerange is likely to fluctuate in relation to the severity of tides; extreme low or high tides reduce or expand available foraging opportunity. Neap tide conditions which offer

the least amount of variation in tidal swings are associated with quarter and three-quarter moon phases. The first waning third quarter moon will occur 6 October 2023.

As a result, early October will be targeted as the ideal month to initiate the aerial application of rodent bait.

### **10.6.2 Commencement of Daily Baiting Operations**

A risk to the operation on Floreana is the potential for inclement weather to halt baiting operations, particularly in the highlands. Excessive rain, or prolonged periods of dense water-laden fog will disrupt the timing of a bait application. Heavy or prolonged rain may cause early breakdown of bait or submerge and bury bait pellets in contact with the ground, possibly reducing the spatial and temporal availability of bait pellets to their intended target. Rain during an application will cause spreader bucket malfunctions and increase wear on aircraft components. Unmanned craft can continue to bait with GPS guidance through fog although bait and mechanical impacts related to dense fog will need to be routinely assessed.

The baiting window, beginning in October, has taken likelihood of precipitation into account to maximize the number and duration of optimal baiting days. On the evening before and again at dawn on each aerial application day, the Baiting Chief and Aviation Manager will study local weather conditions and forecasts to assess whether they are suitable for baiting. If conditions are deemed suitable, the team will proceed with any final preparations for baiting. If weather forecasts are not suitable then bait operations will not commence until the appropriate conditions exist.

Initial baiting operations will begin on a day where a storm or heavy rain is not predicted for at least the next seven days. Once baiting starts it will continue as weather permits until that drop is completed.

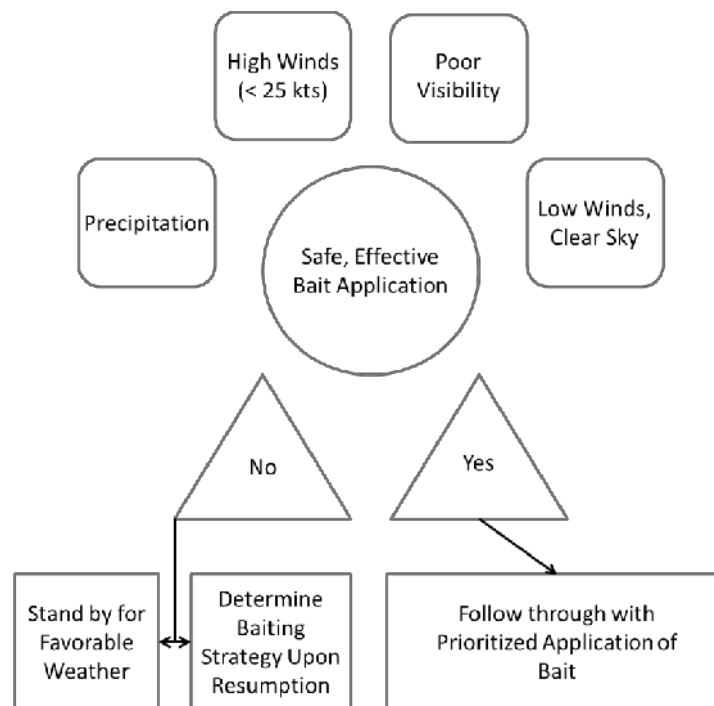
Poor weather conditions that occur during baiting may cause operations to be halted, altered, or otherwise delayed. Daily baiting of specific zones will be delayed (or discontinued if flying has already commenced) if: a. the presence of precipitation renders the island overall, or a specific zone unsuitable for bait application as determined by the Baiting Chief, b. the Aviation Manager feels it is no longer possible to conduct flights in a safe manner (e.g. high winds). Weather conditions in which baiting may be halted or postponed are:

- Conditions with rain or dense water-laden fog at the loading site, in transit, or where bait will be applied<sup>8</sup>
- Wind conditions average to 25 knots or gusts to over 30 knots

The Baiting Chief together with the Aviation Manager will have authority to cease baiting operations if current weather conditions or forecasts are not suitable or if the UAV's ability to safely operate is jeopardized. [Figure 5](#) provides a schematic of the daily decision process that will be followed to decide whether to commence bait operations.

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<sup>8</sup> Previous eradication trials on Palmyra Atoll have demonstrated that loading bait buckets while raining may cause "gumming" of bait and potentially cause bait bucket to jam or clog.



**Figure 12.** The decision process used daily by Baiting Chief and Aviation Manager to assess whether to commence aerial bait operations for the day.

### 10.6.3 Bait application timeline

The process and approximate timeline for bait application is summarized in Figure 13. Beginning 90 days prior<sup>9</sup> to the aerial broadcast for rodents, tamper-proof enclosed Protecta (Bell Laboratories, Madison Wisconsin) bait stations will be established within buildings regularly accessed or inhabited and open-tray bait stations will be established within uninhabited structures and spaces on Floreana that do not pose a risk to human health or safety. The decision of what type of bait station will be used will take human health and safety into account and will be included within Individual Property Management Agreements. Rodent traps<sup>10</sup>, including, but not limited to, GoodNature resetting traps (model #A24, GoodNature, Wellington, NZ) Sherman traps (model LFA or 3310, H. B. Sherman Traps Inc., Tallahassee, Florida), snap-traps (model T-rex/Mini-rex, Bell Laboratories, Madison, Wisconsin, and model #M205, Woodstream Corp., Lititz, Pennsylvania), and glue traps (model TRAPPER, Bell Laboratories, Madison, Wisconsin) will be activated one day following<sup>11</sup> localized aerial bait application to target commensal rodents where the open broadcast of bait is restricted and further safeguard the islands two fresh water springs. Trap status-checks and refreshing will be occur along with refreshment of bait in stations. The selection and location for the placement of bait stations and

<sup>9</sup> It was decided that enclosed bait stations and open-tray bait stations would be seasoned for 90 days as opposed to 180 days which has been used in the past for enclosed bait stations. Additional fresh bait stations will be deployed during each bait broadcast to cater to sub-dominant animals who may be averse to using stations seasoned by dominant rodents.

<sup>10</sup> Sherman rodent traps are being recommended for use as they are not species specific. Victor snap traps and GoodNature A24 would have been preferred although a single model may not consistently kill both rats and mice if they are small in size. Glue traps are placed in rodent "runs" and do not require the use of bait. This type of device will provide an alternative trap targeting rodents that may be averse to bait or attractants.

<sup>11</sup> This delay is based on the theory that rodent traps (if baiting or accompanied by a lure) may serve as an attractant and bring rodents into buildings as well as serve as an alternative to toxic bait if placed prior to the aerial application.

traps will be identified in advance and included within Individual Property Management Agreements and in accordance to risk management planning.

The first aerial application will target 3 October 2023. The date of the first bait application is scheduled around seasonal dryness and to allow coastal applications to coincide as closely as possible with a neap tide<sup>12</sup> (6 Oct, 21 Oct, 5 Nov, 2023). All applications will utilize Conservation 25D intermediate 9.5mm diameter (1g) bait. The 1<sup>st</sup> aerial application component is expected to take 7 to 11 full flying days to complete. In coordination with the 1<sup>st</sup> aerial broadcast, hand application of bait will occur within all land areas excluded from the aerial broadcast or selected for supplemental baiting by the Baiting Chief and outlined within the broadcast database. Bait stations will be activated with toxic bait one day following the aerial application of bait to that area. Bait stations will be activated with Conservation 25D intermediate 9.5mm diameter (1g) bait or 28g CONTRAC All-Weather BLOX<sup>13</sup> where freely accessible bait presents a risk to island inhabitants or pets. Bait stations will be checked on the third, sixth, ninth, and 15<sup>th</sup> day after each broadcast or more frequently if bait is being taken.

In line with Keitt et al. (2015) recommendations, the 2nd aerial bait application will begin roughly 21 days after the initiation of the 1<sup>st</sup> aerial broadcast. The second aerial broadcast will be followed immediately by a second-hand broadcast. Bait stations will be checked on the third, sixth, ninth, and 15<sup>th</sup> day after each broadcast or more frequently if bait is being taken. The second application will attempt to target similar neap tide conditions.

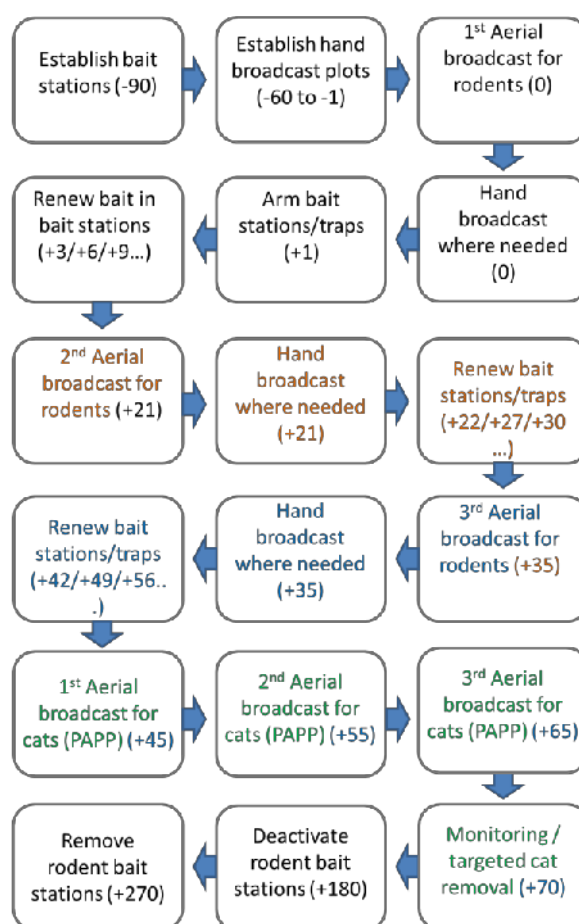
A third aerial application will be conducted 14 days after the 2<sup>nd</sup> bait application in humid highlands, valleys, craters, coastal perimeter and high-risk commensal sites listed within Figure 27. After the third aerial application, bait stations will transition to a seven-day check routine until stations are deactivated. If bait consumption produces empty stations during this period, the Baiting Chief in consultation with the Commensal Manager may increase the frequency of bait station checks.

Traps and bait in stations will be assessed on the same schedule (Figure 13). Refilling of enclosed and open-tray bait stations will weekly as necessary to ensure bait levels remain at capacity and in good condition. Glue traps will be replaced once a capture occurs or their efficacy is reduced by non-target captures (e.g. geckos or insects reduce usable surface area). Sherman and snap traps will rotate attractants as per manufacture's product guidelines. GoodNature traps will utilize a 0.2ml long-life lure product designed for rats which will remain effective throughout the duration of the project. Rodent control devices associated with mitigation at fresh-water springs will be deactivated and removed in accordance to management plan guidelines. Rodent traps and bait stations around the wharf and where indicated within the long-term biosecurity plan will remain in place until confirmation or later for biosecurity purposes. All other bait stations and trays will be deactivated 180 days after the 1<sup>st</sup> broadcast if rodent sign has not been detected for  $\geq 60$  days. If rodent sign is detected, devices will remain in place until  $\geq 60$  days have passed without a subsequent detection. All devices not intended for biosecurity will be removed three months after deactivation.

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<sup>12</sup> Bait application would ideally occur on or near a quarter or three-quarter moon to take advantage of less extreme tidal fluctuations.

<sup>13</sup> CONTRAC BLOX are designed as a block with a hollow core allowing a steel rod to secure the block within a station. This reduces the likelihood of bait becoming accessible if the station is tampered with.



**Figure 13.** Bait application process and timeline. Numbers in parenthesis indicate the number of days pre (-) or post (+) each activity. Activities coincide with colors.

## 10.7 Aerial bait application: preparation, strategy, and logistics

### 10.7.1 UAV and Bait Bucket Calibration

Prior to departing New Zealand, each UAV platform will be flight examined ensuring programming and flight protocols are responsive within the flight controller and the airframes are airworthy, prior to departure. Flight testing will verify:

- Accuracy of GPS positioning using ground truthing with a known coordinate. Testing the unit's ability to maintain flight line spacing, accurate action of spreaders and respond to increment weather and programmed adjustments.
- Relative altitude consistency based on the DSM.
- Speed consistency during flight of a grid pattern.
- Pre-programmed flight patterns and manoeuvres simulative of Floreana coastal and terrestrial environments and conditions.
- Sufficient parts available to maintain the units over the duration of the task.

Initial calibration of spreader buckets will also be performed in New Zealand. Full swath, half swath (a.k.a. directional with 120 to 150-degree arc), and narrow swath (a.k.a. trickle) spreader units on all UAV helicopters will be calibrated and confirmed operational. Trials will utilize Bell Laboratories inert 9.5mm Conservation D pellets and will generate calibration figures below, on target, and above to allow predictable field adjustments. Island Conservation staff will be present to support data analysis and validate swath width and target sow rates are met. Additional quality control assessments will take place once baiting begins on Floreana.

Methodologies for traditional bait bucket calibration, calculating effective swath width and flow rate are outlined in detail within IC's bait bucket calibration best practice document (Island Conservation 2015). In addition to protocols outlined there, throw-forward and throw-back will be reassessed for 9.5mm bait. If necessary, adjustments to exclusion zone buffers and digital baiting maps prior to implementation to minimize risk of bait entering these sites.

The following data has been determined for 9.5mm diameter bait prescribed for Floreana:

<b>Bucket Type</b>	<b>Application Sow Rate</b>	<b>Effective Swath Width</b>	<b>Flight Speed</b>	<b>Flow rate aperture</b>
<b>Full swath</b>	5 kg/ha	80 - 100m	110 km/h	TBD
<b>Full swath</b>	3 kg/ha	80 - 100m	110 km/h	TBD
<b>Directional half swath</b>	10 kg/ha	40 - 50m	55 km/h	TBD
<b>Directional half swath</b>	6 kg/ha	40 - 50m	55 km/h	TBD
<b>Narrow swath</b>	10 kg/ha	10 - 20m	55 km/h	TBD
<b>Narrow swath</b>	6 kg/ha	10 - 20m	55 km/h	TBD

### 10.7.2 Fixing position of islands and flight safety management

Aerial imagery of Floreana island will use google earth satellite imagery. This imagery plus Digital Elevation Model (DEM) data will be input into the baiting drone's flight mission software for accurate start/stop points as well as altitude variations. This removes the requirement of drone imagery and associated cost, logistics and timeframe.

The satellite imagery and DEM will be checked for accuracy by ground truthing using points of interest immediately after the aerial baiting contract has been initiated and in consultation with the GIS Specialist Lead. This is an important step to ensure that both XY coordinates are accurate for start/stop points so areas are not left unbaited. Elevation data is also important for safety measures, as well as baiting coverage on cliff and coastlines. Furthermore, the GIS Specialist Lead will compare a previously collected shape file of the islands' perimeter with satellite imagery and DEM. This process will allow for correction of the reference location and highlight any inconsistencies that can then be checked.

If it is determined that the DSM from satellite imagery is not accurate enough for the coast and cliff line baiting applications, aerial imagery of the perimeter of Floreana Island will be acquired, capturing just the coast and area for directional swath baiting. This will be completed by fixed wing drone prior to implementation with ground control points at set locations around the island for absolute accuracy.

As an additional safety measure, to account for the use of satellite imagery, the baiting drones will use laser/radio altimeters as well as GPS and barometer altimeters for safe ground and cliff distances.

All known offshore islets and any other outlying rock stacks subject to treatment will be identified and mapped to ensure they receive bait. The Baiting Chief in consultation with the GIS Specialist Lead will confirm prescription and subsequent treatment of each site and include these within the Broadcast Database and Map.

During the time between generating the flight plan and the first bait drop the GIS Specialist Lead will review shape files. Shape files will be loaded into the flight tracking software in the UAV helicopters (and the spare tracking unit) and will enable flight paths to be set to the appropriate meter intervals required to achieve coverage of the island at the specified application rate by overlapping swathes by 50%. The meter interval is half of the expected swath width from the bait buckets and will be verified during calibration trials. This data will be transferred to the tracking units in all operational UAV helicopters.

### **10.7.3 Flight plan**

Three UAV helicopters equipped to lift 130-180kg will be used to apply bait from specialized under-slung baiting buckets. In the event that mechanical problems with a UAV helicopter occur that are beyond the scope of an on-site repair, the Project Manager advised by the advisory team, will decide the course of action. Possible solutions to such an incident include: 1) parts may be shipped in, or 2) the machine is reserved for its parts and baiting continues at a reduced pace with the remaining machines. The remaining machines will keep working regardless.

The distribution of bait being aurally applied to the island will be guided by a TracMap or similar system onboard each UAV helicopter. Tracking systems will be interchangeable between helicopters if the need arises. A spare set of associated hardware will be available for all buckets on site as will spare parts to ensure continued operation of baiting machinery.

The island will be divided up into blocks, each block having a designated UAV to cover. These blocks also designed to minimize any risk of aircraft crossing during transit and dispersing.

These blocks are named, Northern, Western, Southern and Central. Northern, Central and Southern will be applied first, and Western at the end. All flight paths will be parallel to ensure consistency of swath widths and reduce risk of accidents.



**Figure 14.** Map of block division for bait applications and loading site location (circle within Western block).

UAV 1; will conduct application on Northern Block starting from the southern side.

UAV 2; will conduct application on Central Block, starting from the northern side (alongside Northern Block)

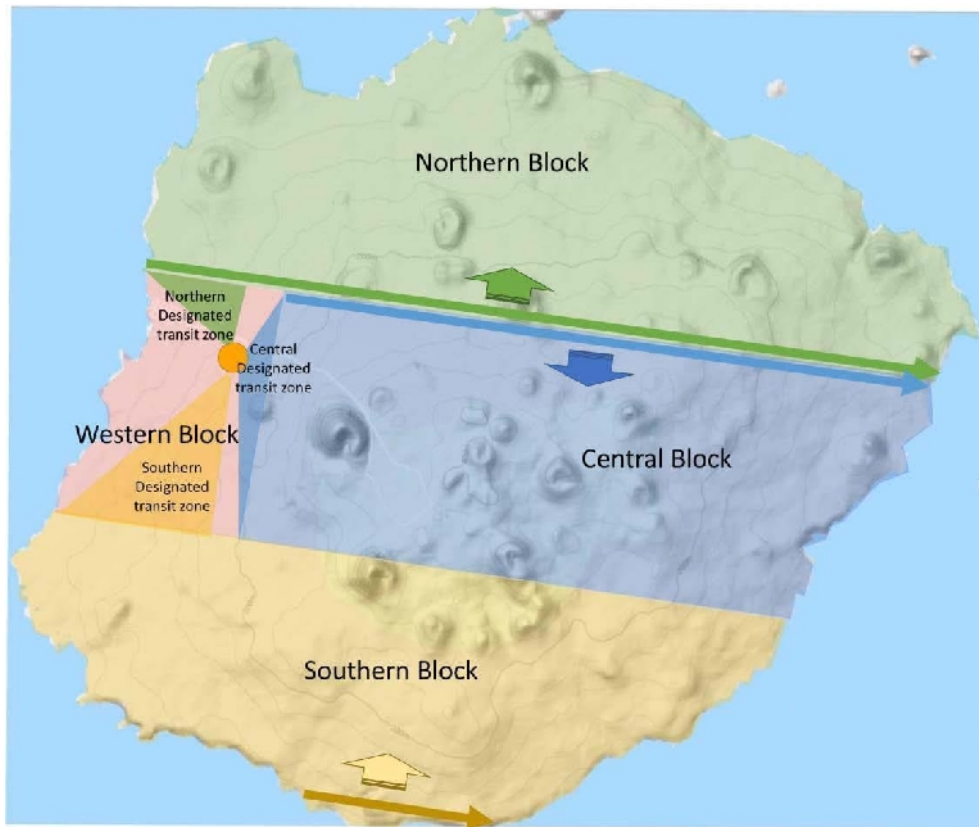
UAV 3; will conduct application on Southern Block, starting from the southern coastal perimeter.

Once these blocks are nearing completion, the Western Block will be targeted, with similar flight plan using 2 or 3 UAVs.

The UAVs will be programmed to fly at a ground speed according to the calibrated application rate (lowlands 6kg/ha, highlands 10kg/ha). Therefore, the flight speed will change to automatically adjust to the calibrated rate when flying over the lowland/highland boundary.

Using a combination of software and the Digital Surface Model, the UAVs will be accurately terrain following, therefore in steep terrain it is not required to calculate different application rates depending on the terrain angle. The UAVs will travel across the ground surface at a constant speed rather than a constant XY speed. For example, it will take longer for the UAV to fly cross undulating terrain than flat ground.





**Figure 15.** Map of flight plan with designated blocks and starting flight lines.

To add additional layers of safety:

- Each UAV will follow a designated flight corridor for transiting to and from its block. This ensures that the UAVs will not be required to cross paths.
- UAV will return at designated heights to avoid other aircraft.
- In the event of a unit needing to transit over another block, a safe set height will be adhered to avoid contact.
- UAV Pilots will be in constant communication with one another and with the groundcrew. Radio communication links will be established when/where required.

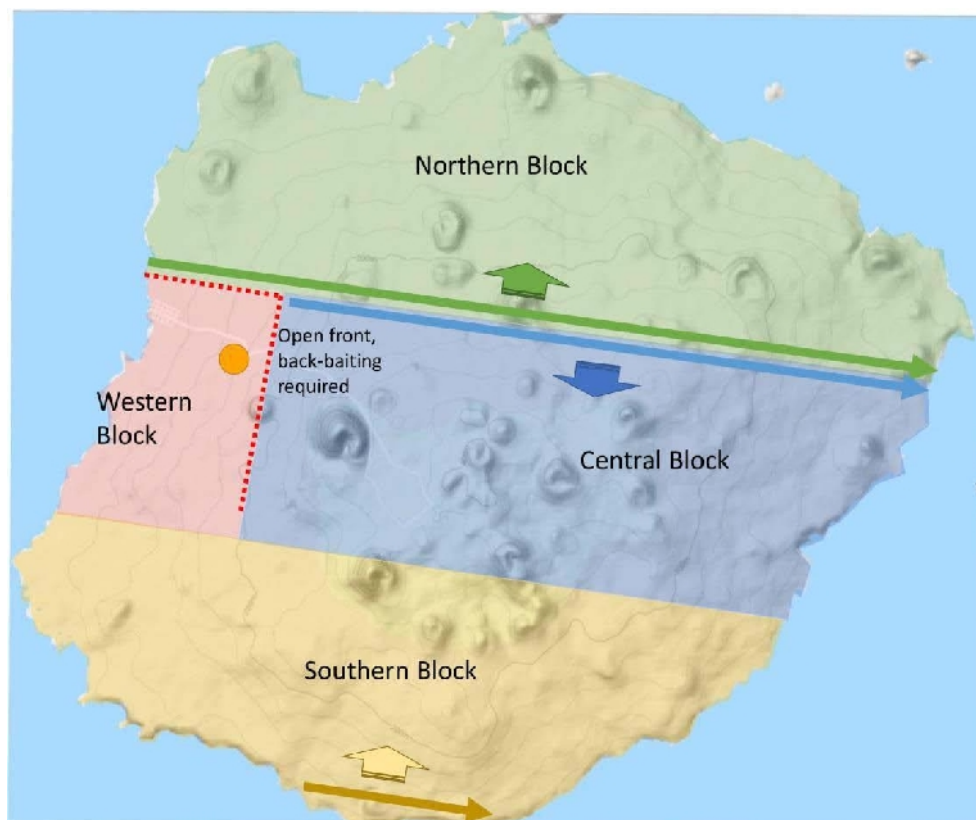
This flight plan, with baiting activities running 24 hours a day, ensures that most bait fronts are rolling which minimizes back baiting. However, there is a 6km baiting front which is left exposed due to the remaining Western Block application. It is expected that this baiting front will be exposed for 1-6 days with the southern section having shorter exposure time. Back baiting over 6km with a full 80m swath covers 48ha, which at the lowland application rate of 6kg/ha will require an additional 288kg of bait.

Any delay in baiting will trigger discussion with the Incident Advisory Group to confirm back baiting coverage. Coverage prescriptions can be found in Figure 16.

**Figure 16.** *Back baiting coverage guide.*

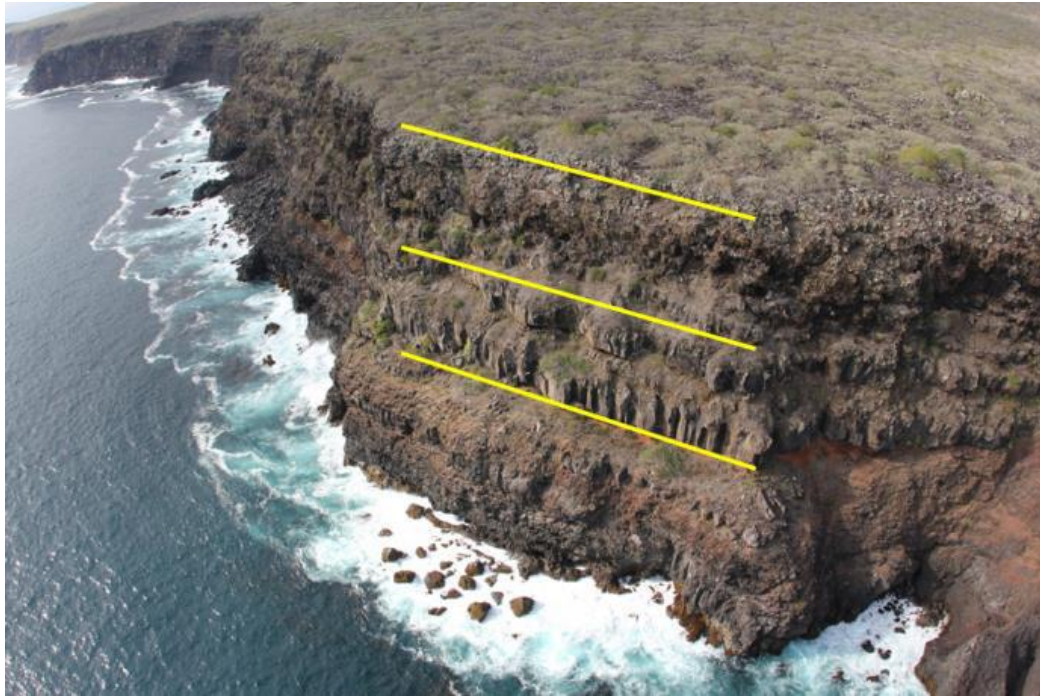
Back-baiting coverage		
Baiting Delay	0 – 72 hours	50% (Standard overlap)
	>72 – 144 hours	100% (1 full line / 50% overlap)
	>144 – 216 hours	200% (2 full lines / 50% overlap)
	>216 (9+ days)	300% (3 full lines / 50% overlap)

To reduce the need for this back baiting, it maybe possible to coordinate UAV 2 (central block) to continue to carry out application runs on Western Block, inline with advancements on the Central Block. This possibility will have to be discussed prior to application. In this case, All UAV will have designated holding zones within their respective blocks to ensure appropriate air traffic control procedures are followed during return. With timings allocated for take-off and landings depending on proximity to landing area and pathway clearance. Co-ordination and pilot control will be under the Aviation Manager.



**Figure 17.** *Map of potential back baiting if Western Block remains until the end.*

For coastal application, a directional swath will be used with approximately 120° sideways application. The coastal perimeter will be completed at timely stages during the inland application, again ensuring no baiting fronts remain exposed.



**Figure 18.** *Representation of vertical swaths prescribed to treat cliff faces.*

With the DSM from satellite imagery, it will be possible to accurately apply bait to the coastal cliffs by a programmed flight path along the cliff perimeter. This will reduce risk of bait into the water yet will ensure sufficient coverage of bait along the coastal cliffs.

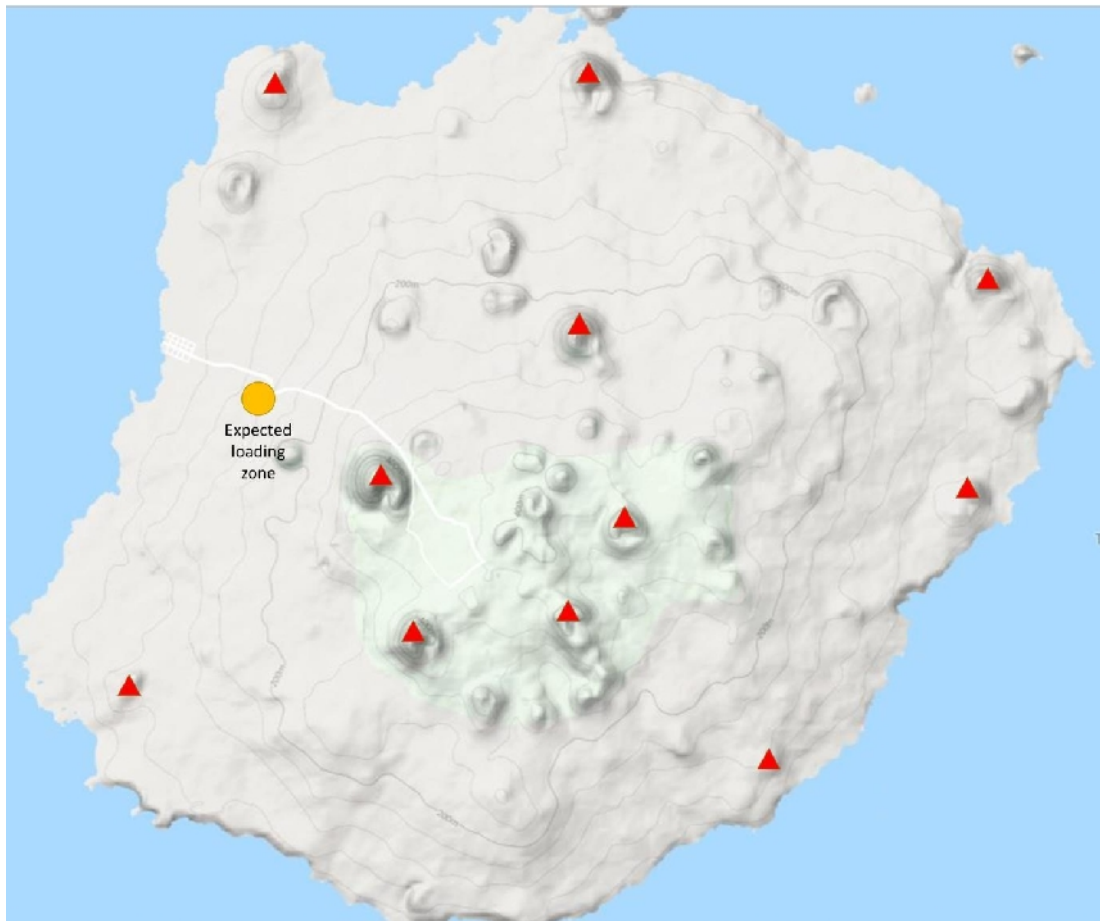
The DSM will provide cliff heights which will enable accurate planning for the number of vertical steps of application on a cliff. Just as the inland flight paths are, the different vertical steps on cliffs will also be programmed with precise GPS coordinates but with different altitudes to match the steps.

#### **10.7.4 Aerial baiting Pilot to UAV communications**

Mission control repeaters will be at set locations around the island to ensure communication with UAV at all times. Repeaters will be situated on elevated areas to maximize line-of-sight transmission.

11 transmit and receive repeaters are estimated for Floreana. Coverage will offer overlapping signal to reduce the risk of broken communication throughout each flight.

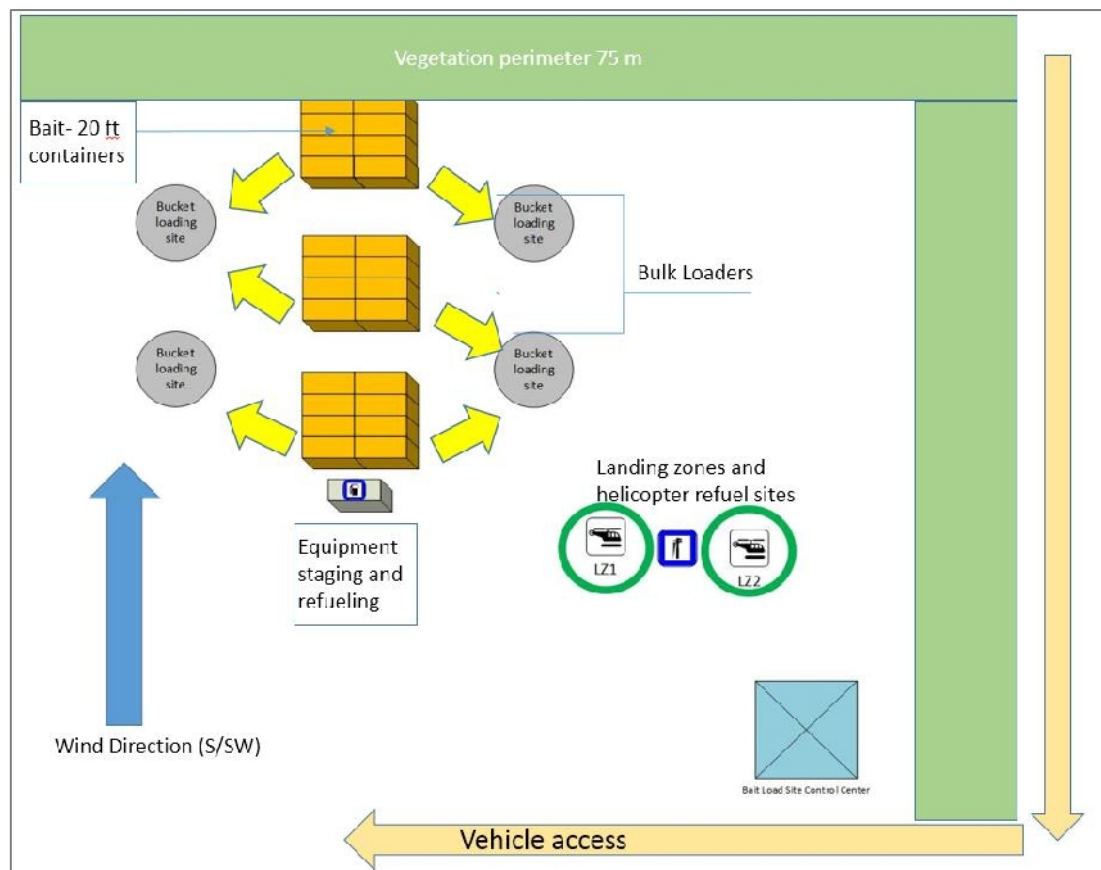
Transceivers will be mounted upon portable antenna telescopic masts to clear the surrounding vegetation and provide a clear signal. To avoid collisions, the maximum height of all portable antennas will be significantly less than the flight height which a UAV operate. Due to the remote locations of these areas, the units will be self-sustainable throughout the operating period. Repeaters are compact and lightweight allowing personnel to transport to repeater sites as necessary.



**Figure 19.** *Contour map with repeater installation sites.*

#### **10.7.5 Loading and fueling**

Utilizing multiple bait loading zones was assessed in an effort to minimize ferry times and maximize efficiency while aerial baiting (Will 2014). It was determined that a single loading zone in the lowlands that was comprised of multiple loading sites could effectively service the entire island once baiting swaths and return routes are strategized as loops. One site will serve as the bait loading site with multiple loading zones, bait staging, and an air operations and control base. A separate zone capable of refueling and maintenance operations will be established within the premises of this zone. Bait loading and fueling activities will be separated to reduce any potential risks to safety and delays from multiple UAV helicopters attempting to occupy a single site. The loading zone and site setup is described in detail within the Floreana Bulk Bait Loading Plan (Island Conservation, In prep b).



**Figure 20.** Map of loading site and fueling site.

Loading and fueling procedures will be unique to the use of UAV helicopters and associated bait bucket apparatus. Design and development of UAV aircraft and buckets is underway. Once complete, Standard Operating Procedures (SOP) will be developed for loading and fueling procedures. The SOPs will be available in English and Spanish and all operating crew on site are required to read, sign and adhere to. There will be zero tolerance for any crew member not following the appropriate SOP.

Equipment required for fueling and loading is outlined in the Floreana Bulk Bait Loading Plan.

All UAV helicopters will operate on unleaded petrol. The estimated fuel required on site is 11,400 liters: 3,900 litres for each of the first two aerial applications, a 3rd application requiring approximately 1,600 litres, and 2000 liters of contingency fuel. Daily assessments will be conducted to monitor the quantity of fuel available.

### 10.7.6 Aerial application - Interior

Specific application rates will differ across two interior treatment zones; highland and lowland (Figure 21). A detailed description of how lowland and highland zone was determined can be found in section 8.1.1 – ‘Baiting Survey.’ The highland and lowland blocks will receive 10kg/ha and 6kg/ha respectively with UAV flight speeds and spreader bucket speed programmed to automatically adjust at the treatment zone’s transition line. This automation supports higher or lower application rates to be sown without conducting manual changes to the budget apparatus. Flight lines beginning or ending a



swath near the coast will start or stop sowing at the median high-tide mark<sup>14</sup>. Physical breaks between application blocks will be inspected closely to ensure that sufficient overlap has occurred, especially if a time-lag occurred between baiting.

Aerial exclusion buffers will be imported as shapefiles to each UAV helicopter's flight planning software to manage flight paths across the island. A map will then be generated with a grid of baiting swath lines laid over an island map. The orientation of the lines will be identified by the Baiting Chief and Aviation Manager based on a combination of application efficiency, expected weather patterns, and ease of application around exclusion buffers. The processing of flight line data is time intensive and must be done at least one week in advance to ensure adequate time remains if changes are required.

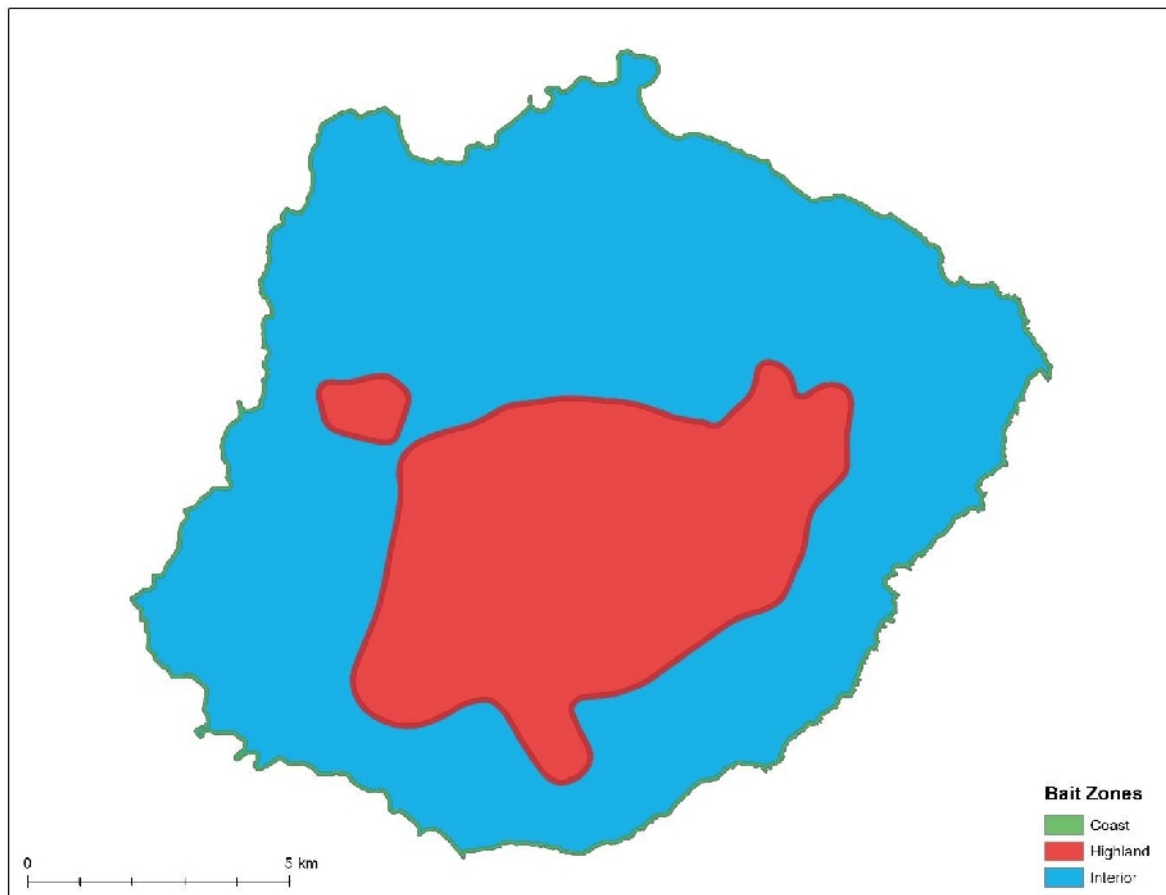
Flight swaths will be defined by the uniform distance of bait broadcast from the hopper. An effective swath will be confirmed during calibration trials and used to generate spacing for all programmed flight lines. Flight swaths will be flown in parallel, with subsequent flight swaths overlapping the previous by 50% to reduce the possibility of gaps in bait coverage.

Pilots will attempt to maintain a flight speed no greater than 110 km/h for gross line sowing. An optimal application speed for coastal and exclusion zones will target a slower speed of 55-65 km/h to improve accuracy of application rates and bait placement across convoluted flight lines. Baiting areas that are less than 40m wide will be treated with a directional bucket or a narrow-swath bucket calibrated to apply bait at the target application rate. This includes fingers of terrain that extend into the ocean, rock stacks near shore, and to fill buffer areas around exclusion zones.

Locations that may support higher densities of rodents or terrain features that result in a reduced baiting density (from the target rate) are considered special treatment areas (Figure 27). These areas are assigned specific treatment protocols which are listed in detail within the Broadcast Database and Map. Treatment methods will include supplementary bait application using the full swath, directional swath, narrow swath, or hand broadcast to ensure adequate bait density exists on the ground.

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<sup>14</sup> Due to the conservative nature of this approach to reduce the potential of gaps in the bait application to effectively target mice, some bait may inadvertently enter the near-shore environment.



**Figure 21.** Example of interior zone and coastal perimeter treatment polygons.

#### 10.7.7 Aerial application - Coastal perimeter

Flight lines beginning or ending a swath near the coast will start or stop sowing at the median high-tide mark. This prescription will leave a narrow perimeter along the coastline which is susceptible to gaps in bait coverage. This perimeter section will be flown with a directional bait bucket calibrated to apply bait at 3 kg/ha. This application swath will overlap with interior end points to result in the prescribed 9kg/ha on the ground. Coastal perimeter baiting will occur in succession with adjoining inland blocks to allow the island to be completed in sections due to the island's size.

Coast sections which present cliff faces or steep slopes with a vertical distance greater than  $\frac{1}{2}$  swath width will require multiple flights. Cliff/slope perimeter flights will be stepped vertically  $\frac{1}{2}$  swath width to address the three dimensional environment (Figure 18).

#### 10.7.8 Aerial exclusion zone treatment

While baiting across the island, UAV will cease line broadcasting bait at a minimum of 60 meters from each of the aerial application exclusion zones and at the mean high tide line along the coastal perimeter to account for throw forward and throw back (Will 2012). This strategy will reduce the potential of directly applying bait into exclusion areas and limit the risk of gaps in coverage being generated along critical habitat at the coastline. Follow-up broadcast by a more precise aerial method (directional or narrow swath application) and/or hand broadcast will be conducted at the immediate

perimeter of exclusion areas to ensure gaps in baited coverage are not present around the excluded site. Treatment response will be determined by the Baiting Chief at least one month prior to the first bait application and indicated within the broadcast database for reference and tracking. If daylight is lost, all remaining follow-up baiting will be completed the following morning when baiting activities are restored.

An audit comprised of visual inspection and spot sampling will occur at exclusion zones by an experienced rodent eradication (see Hand Broadcast Monitoring – Appendix B). Results will be reported to the Baiting Chief. If the thoroughness or target rate of the bait application is in question, a supplemental baiting will be prescribed by the Baiting Chief. Follow-up baiting methods will adhere to site specific methods outlined within the Broadcast Database.

Exclusion areas are outlined within management plans and include large ponds, lagoons, and town.

Public drinking sources including the two springs on island and catchment systems will be protected from bait. Both springs on island will receive an impermeable cover prior to implementation. This will prevent bait from inadvertently entering the system. Additional visual inspections will occur to verify that no bait exists under each cover. One month prior to the bait application a perimeter of mechanical traps will be placed around Asilo de la Paz and Las Palmas to reduce the local rodent population and minimize the potential of moribund rodents entering the communities drinking source. Any home with a water catchment will have the plumbing disconnected during implementation if not excluded from the aerial broadcast. These systems will not be placed back into service until after the final broadcast has occurred and the roof and gutters can be swept clean and rinsed of remaining bait pellets and pellet dust. More detail regarding management actions associated with the broadcast can be found within their related management plans.

#### **10.7.9 Aerial application monitoring**

Given the size and areas with dense vegetation on Floreana it would be impractical to physically validate the bait application distribution and rate on the ground; therefore, the monitoring of bait application will occur through frequent downloads of the data collected by UAV helicopter (e.g. onboard GPS), and by calculating the amount of bait applied with each bucket load to the island area treated. Visual audits with spot-sampling will be employed at sites where mixed application methods occurred (e.g. a mix of baiting swath widths or methods used in exclusion buffers). A report on each site's status as either "complete" or "bait insufficient", will be communicated (i.e. radioed) to the Baiting Chief and recorded. If the baiting is insufficient, the site will be re-baited by the most efficient means until reaching the prescribed bait density on the ground.

Flight data will be downloaded from UAV to communicate the amount of area (measured in ha and provided by the tracking software) that was treated with bait. Live-stream monitoring will confirm false sowing of bait due to blockages, mechanical failure, etc. does not occur. These data will be recorded into a monitoring spreadsheet. The spreadsheet template will automatically calculate the average bait application rate per hectare for each bucket load, and compare the expected vs. observed application rates. This will enable the Baiting Chief to ensure the bait application is meeting the desired rates across the island. Changes to flight speed or modifications to the spreader bucket will occur as necessary to achieve the optimal application rate. Once the bucket is refilled, the bait loader's assistant will record the UAV helicopter ID, quantity of bait loaded, and bucket configuration within a



tablet-based application. All data will be uploaded via an intranet to the primary database managed by the GIS Specialist Lead. This connection will provide a real-time link from the loading site to the GIS management office.

During the operation, UAV pilots will use flight tracking software monitor flight paths, application start and stop points, and assess application is occurring as expected. Precise GPS and pre-programmed flight lines will guide autonomous baiting and reduce the change of human error when distributing bait in a uniform fashion targeting prescribed rates. A cumulative baiting map will be monitored by the GIS Specialist Lead and the Baiting Chief in near-real time to determine application rates across the island and identify potential holes or gaps in application. Necessary adjustments to application rates and holes in coverage can be communicated directly to the Aviation Manager who will instruct UAV pilots to adjust accordingly.

During the first aerial bait application, GPS information will be downloaded and reviewed after the first bucket load of each separate application rate. Subsequent downloads will occur during each refueling stop and once the UAV helicopter discontinues baiting. This mandatory review will allow for early corrections to be made to any possible errors in flight lines, GPS logging, or bait application rates. Additional downloads may be requested at any time by the Aviation Manager, GIS specialist Lead, or Baiting Chief. Once baiting is initiated for each application, flights will continue around the clock to complete the broadcast in a timely fashion. If data review is unable to review progress for gaps, a hard stop will be required to allow enough time to review, clean-up of gaps, and to close exposed baiting fronts. Any gaps identified in the bait application not immediately re-flown will be prioritized and filled before proceeding onto another baiting block.

The GIS specialist lead will be responsible for the download, back-up, and monitoring of flight path information. Information will be transferred to the GIS Specialist Lead's computer by USB drive, hardline, or wirelessly from the UAV helicopter's onboard computer. The information will be downloaded and a copy of the raw data file will be made prior to any file manipulation. The data files will be viewed and processed using ArcGIS ArcInfo. Data files can be converted to a shapefile for viewing of flight paths overlaid on geo-referenced maps of Floreana. Flight lines will be viewed without buffers for greater visibility. The monitoring of the bait application will occur by visually identifying gaps in flight lines displayed in the shapefiles or subsequent printouts. Gaps will be considered as any location, real or perceived, presenting an untreated area  $\geq 400$  square meters. Swath width flight lines displayed on computer will be a contrasting color to the background map of island (e.g., the map of island is red and flight lines yellow).

During each application of bait, an island map will be overlaid with colors representing baiting rates. Each color will represent a range of application (e.g. 6 - 8 kg/ha). As the baiting operation progresses, the map will be updated to identify how each block has been sowed across the island. The Baiting Chief must inspect and approve the map prior to the aerial application of a block being declared complete.

Throughout baiting operations, the Baiting Chief will consult regularly with the GIS specialist lead to review bait flight lines and identify any potential problems or gaps in application. Any potential issues with the baiting operations arising through the monitoring of bait tracking information will be communicated from the Baiting Chief to the Aviation Manager directly. If problems persist or are

irresolvable, the Baiting Chief may request for the Aviation Manager to halt baiting until the issue can be resolved.

Procedures described in this section will be the standard requirement for all applications. Any changes or additions to the aerial baiting strategy must have a change notice and justification recorded if circumstance result in change (see Change Notice / Justification Form - Appendix C).

#### **10.7.10 Contingency and Spot Treatment Bait**

A contingency of bait equaling 10% of the consigned total of each bait type will be brought to the island in the event that bait is damaged or becomes rancid during transport and storage and to allow for unplanned overlap of flight lines during the baiting operation. An additional 5% of the consigned total of bait will be added to the order and reserved for spot treatment (see Monitoring to Confirm Rodent Eradication). Prior to implementation, if greater than 10% of either bait types no longer appears suitable for use, the Incident Advisory Group will need to assess enough bait remains to complete an entire island-wide application. If an acceptable amount of bait (determined by the Incident Advisory Group) does not exist to achieve at least two complete island-wide applications, then the project must be delayed until the prescribed amount of suitable bait available.

Bait (not reserved for spot treatment) that remains after all applications have been completed may be strategically applied to areas determined to have received insufficient bait coverage during the operation or over high-risk areas. Priority areas that may receive a supplemental broadcast of remaining contingency bait can be found in Figure 27. The Baiting Chief in consultation with the Incident Advisory Group will direct the Aviation Manager to the priority of areas that have been reviewed and determined appropriate to receive supplement coverage. After supplemental coverage has occurred, any remaining bait that is not stored at GNP as a contingency for rodent invasions will be disposed of following label regulations (Appendix D), which include incineration and disposal at an approved waste disposal facility. It is recommended by the manufacturer that rodent bait stored longer than a year should be disposed of as its palatability to rodents will be in question.

### **10.8 Hand broadcast application: preparation, strategy, and logistics**

Rodenticide will be applied by hand around freshwater ponds, mitigation holding pens, within abandoned structures, under awnings and lean-tos, within known caves, at high-risk commensal sites, and other areas deemed appropriate in-situ by the Baiting Chief. Known sites will be documented within the Broadcast Database and mapped in advance. In-situ sites will be added as necessary to be addressed immediately as well as during subsequent applications.

Bait will not be broadcast inside of any inhabited structure. Personnel involved in hand application operations will undergo on-site training to ensure that the target application rate is achieved. The hand-baiting application rate will target the same on-the-ground bait density as that for the aerial application (Figure 8). Higher risk areas will receive a third application (see Figure 27). For areas larger than ½ ha in size, a 20m x 20m GIS grid layer will be created for that treatment area. Areas that are smaller than ½ ha in size will be baited by eye and have each bait point logged into a GPS so the site can be reviewed by the Baiting Chief and GIS Specialist Lead for adequate coverage. Each grid intersection will carry a unique baiting point identifier, and the baiting points will be uploaded into hand-held GPS units to guide baiting staff.

In each hand baiting areas where a grid has been prepared, a baiting point will be located with the GPS unit and marked with wire pin-flags in areas with sandy soil while flagged nails, inverted marking paint (short-term weather resistant e.g. Rustoleum # 2554838) or flagging tape wrapped around a stone will be used in areas with compressed soil and/or volcanic rock (i.e. lava beds). The marking of hand broadcast grids in preparation for implementation will occur one to two months in advance of implementation. Some areas with tall or dense vegetation may not accommodate the marking of a grid and will have to be conducted without the use of a pre-marked grid. Under these circumstances a dedicated line boss must ensure line spacing and distances of hand baiting staff accommodate for the necessary application rate.

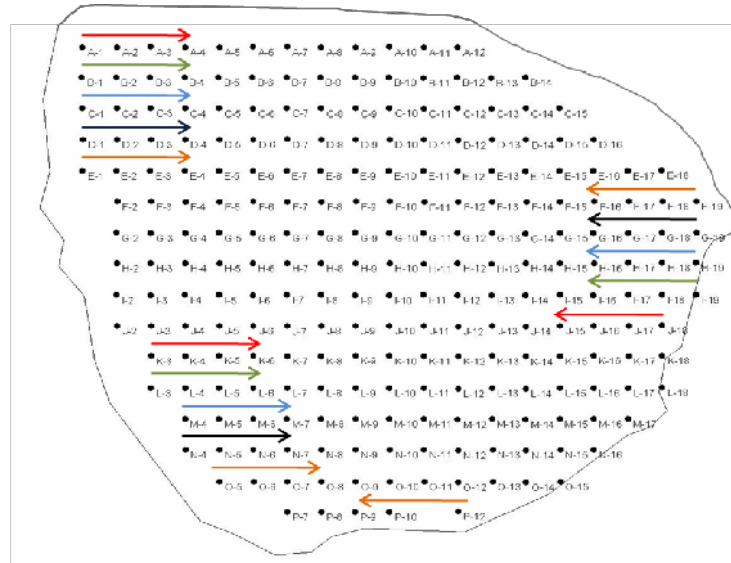
Hand baiting will be accomplished with people walking adjacent baiting point lines. Each person will distribute bait to the back, front, directly below, and to both sides in a sweeping fashion for consistent and thorough coverage (Figure 23 / Figure 24). After distributing bait from a specific point, the point will be logged into the baiter's hand-held GPS unit signifying that the area had been baited.

Plastic cups pre-sized or marked for the volume of bait that equals the target application rate will be used to ensure that the proper amount of bait is applied at each baiting point (Figure 22). Bait applicators will start with 10kg of bait carried in JIM-GEM double tree planting bags (#69093) with adjustable shoulder harnesses (#69100) and will restock bait as needed at bait depots preplaced in the treatment areas. Bait depots with sufficient bait for that area will be established at all hand baiting sites prior to each application. Bait will be stored in commercial ox-boxes to prevent exposure to inclement conditions.

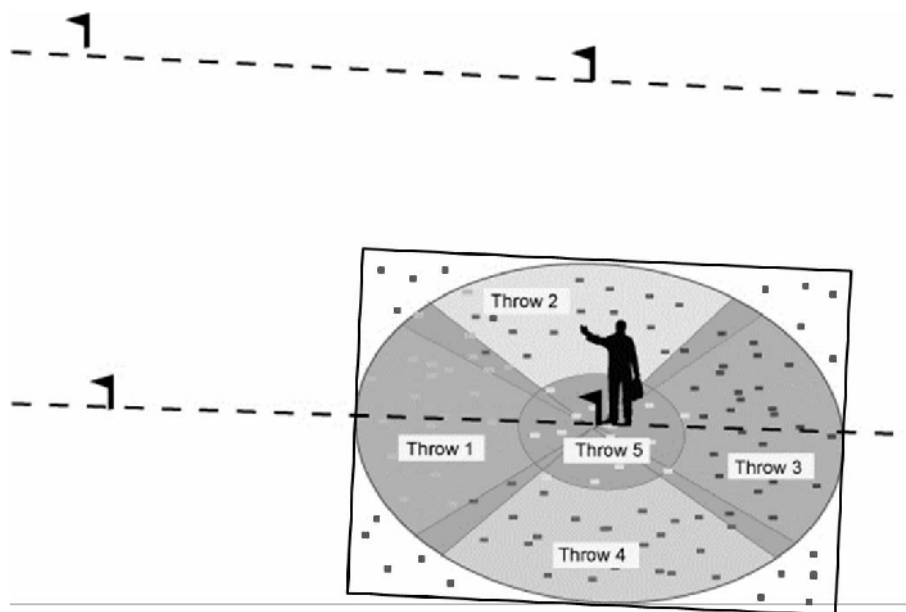
Remaining bait at the end of each application will be inventoried then repackaged within ox-boxes to resist moisture and possible non-target consumption. After the last application, all bait remaining at bait depots will be removed directly after the entire treatment area has been baited and taken to the primary bait storage site adjacent to the UAV helicopter loading zone. All ox-boxes will have associative bait warnings and the bait product label posted in both English and Spanish. Bait handlers will wear appropriate PPE at all times while participating in hand baiting activities (see label for more information, Appendix D).

**Figure 22.** Hand broadcast quantities for a 20m baiting grid.

Broadcast Rate	Quantity of bait dispersed at each 20m baiting point
10 kg/ha	400g
9 kg/ha	360g
6 kg/ha	240g



**Figure 23.** Hypothetical hand baiting area with 20m x 20m grid overlay or 20m equidistant points with unique identifiers. This scenario has 5 people traversing the treatment area to achieve an even, timely bait application.



**Figure 24.** Hand application of bait on an established grid (Cromarty 2009). Flags are 20m apart and the applicator throws bait at least 10m from their position in 5 throws to apply bait evenly. A square pattern is the goal to eliminate gaps.

### 10.8.1 Hand baiting in utility structures and abandoned or condemned structures

Floreana will be surveyed for utility and abandoned structures in advance of bait being ordered. Structures found may range from electrical conduit boxes or sewage and water culverts to unused dwellings or boats. Each structure will receive a unique GPS ID and its location will be catalogued in the Broadcast Database. Because the aerial bait application will not effectively deliver bait into most of the abandoned structures, all catalogued structures will be treated by hand and will, at a minimum, match the prescribed baiting rates for each application. Areas that are unsuitable for open baiting (i.e.

areas too moist for bait to persist) will receive one or more open-tray bait stations with at least 120g of bait per tray.

### 10.8.2 Hand baiting exclusion zone treatment

The school playground and residential yards designated as children play areas will be excluded from any open distribution of bait (i.e. neither aerial nor hand broadcast will occur). Bait stations will be used to treat these areas which may harbor rodents. The approach to limit bait access within these areas is intended to minimize reduce risk to human health and safety; particularly for children who may not be strictly monitored while at play. More detail can be found within the Risk Management Plan regarding residents.

### 10.8.3 Hand application monitoring

During the initial treatment of the hand application zones one to two people will spot-sample the real-time application rate by following the bating line and counting pellets within randomly placed 1m hoop plots. Each 1m hoop plot will be sampled by throwing a hoop out into the baiting zone. All bait pellets within the hoop or larger circle will be counted while vegetation and leaf-litter will be moved to decrease detection error. Every 10 hoops assessed will be averaged to provide an index. Major deviations ( $\pm 25\%$ ) below or above the target application rate (see Figure 25) will be reported to the Hand Application Manager, who will then instruct the baiting line on what is required to achieve an even bait spread at each baiting point. Major deviations below the target application will trigger a re-application of the site. Spot-sampling for baiting accuracy will occur during all hand applications to ensure accuracy throughout the project.

**Figure 25.** Monitoring plot (1m hoop and 1m radius plot) broadcast quantities.

Broadcast Rate	Average quantity of pellets (9.5mm / 1g) per 10 monitoring sites (1m hoop)
10 kg/ha	0.7854 pellet
9kg/ha	0.7068 pellet
6 kg/ha	0.4712 pellet

A GIS assistant will manage the incorporation of all hand applied bait coverage including hand baited grids, spot treatment, structure broadcast, bait stations, as well as traps. Throughout the baiting operation the GIS assistant will be guided by the GIS Specialist Lead. The GIS Specialist Lead will consult regularly with the Baiting Chief to identify any potential problems or gaps in the hand-application component of the project.

Procedures described in this section will be the standard requirement for all applications. Any changes or additions to the hand baiting strategy must have a change notice and justification recorded if circumstance result in change (see Change Notice / Justification Form - Appendix C).

## 10.9 Rodent station application: preparation, strategy, and logistics

Rats and/or mouse sign has been observed in many of the buildings on Floreana (Hanson and Campbell pers. observation, 2012). Inhabited buildings are not considered appropriate for an open broadcast of rodenticide. Tamper-proof bait stations and traps, each considered as a single rodent station, will be used to target commensal rodents inside inhabited structures while providing options to reduce interspecies competition between rats and mice. Open tray bait stations similar to those used on Rangitoto (Griffiths et al. 2012) will be deployed in uninhabited structures and in spaces that do not pose a risk to human health and safety.

At a minimum, one station will be placed per every 25m<sup>2</sup> (5m x 5m) of floor space on each level. At least one bait station and trap type will eventually be placed in every structure. Rodent stations will be baited with up to four CONTRAC All-Weather blocks one day after the immediate area receives the first aerial application and will be restocked until 180 days after the final application for that zone. Mechanical (snap and glue) traps will be installed between the 2<sup>nd</sup> and third aerial bait application to limit early aversion to stations if unsuccessfully trapped and subsequently educated. Traps used in rodent stations will be baited with a commercial rodent lure and checked alongside bait for condition and quantity. Glue traps will be installed external to rodent station within compatible tunnel devices. Rodent stations and glue traps will initially be checked and restocked on a three-day rotation to maintain an uninterrupted supply of fresh bait. This routine will reduce to a seven-day frequency after the 3<sup>rd</sup> aerial bait application or as needed if residents indicate activity or trap success.

Bait stations and traps will be installed in areas likely to experience rodent activity (i.e. placed along rodent runways, against a wall or on roof beams, and between points where rodents would seek refuge or enter a building). Areas that are not regularly disturbed by human activity will be preferred. The spacing between bait stations and traps will be no greater than 5m to accommodate for the minimum mouse homorange. Attics, cellars, and other similar spaces must be assessed and will require rodents station/s receiving at least one alternative trap type if separated from other deployed devices.

A suite of rodent stations and subsequent use of traps will be deployed to each structure on the island that cannot receive a hand broadcast. The number of bait stations and traps used per structure will be variable depending on the buildings use and size. If a room is large enough to contain multiple mouse homeranges, additional stations will be required. Structures used to prepare or store consumables and large dwellings will require a greater number of bait stations and traps. The schoolyard and areas designated as children's play areas will receive a 10m x 10m network of rodent stations. Specific details of station placement, number, and additional treatment specifications will be outlined within each Individual Property Management Agreement that is developed in cooperation with the property owner and/or tenant. Additional details can be found within associated management plans.

Trap types including A24 traps are prescribed to protect the area surrounding the island's two fresh-water springs as well as being considered for long-term biosecurity. These traps will utilize a slow release fluid lure provided by the manufacturer. The manufactures recommendations must be followed closely to ensure proper installing and efficacy of the trap design.

The Commensal Manager will supervise the placement, monitoring, and maintenance of the rodent station operation. The design and implementation of the rodent station operation will be audited by the Baiting Chief and will be reviewed by the Project Director, Project manager, Baiting Chief, and Commensal Manager.

Procedures described in this section will be the standard requirement for all applications. Any changes or additions to the aerial baiting strategy must have a change notice and justification recorded if circumstance result in change (see Change Notice / Justification Form - Appendix C).

## **10.10 Special baiting considerations and related strategies**

### **10.10.1 Addressing Bait Shyness**

Bait shyness can develop in rodents as a response to a negative experience with a toxicant, bait matrix, or both (Clapperton 2006). On Floreana the rodenticide that will be utilized consists of a grain-based pellet impregnated with the toxicant Brodifacoum. To reduce the risk of rodents avoiding bait, any use of bait products utilizing a grain bait matrix must be discontinued at least two years prior to the bait application<sup>15</sup>. If rodent control is necessary, the early employment of rodent proofing tactics and mechanical control (i.e. snap traps, GoodNature A24 traps) will be strongly encouraged as the preferred alternative to rodenticide. Any chemical control of rodents still required must switch to an approved rodenticide (e.g. cholecalciferol, brodifacoum<sup>16</sup>) that does not utilize a similar bait matrix to what is prescribed for eradication or has been documented to develop bait shyness in rodents. Due to product availability being variable, any proposed bait product must be reviewed and approved by an experience project staff member. One month prior to the first aerial bait drop, all rodenticide use for control must be discontinued.

### **10.10.2 Bait application in commensal areas**

A mixed-method approach using aerial broadcast, hand broadcast, bait stations, and traps will be utilized to target each homerange within town and on farmland where covered structures exist. Extra attention will be given to areas of higher risk where alternative food sources may exist. High risk sites will be assessed on an individual basis by the Baiting Chief and Commensal Manager and additional aerial baiting swaths, supplemental hand baiting, or a high density of bait stations and traps will be prescribed (see Figure 27) and added to the broadcast database and associated map.

Details associated with each property are compiled with the use of a digital application and uploaded into a master spreadsheet. Details include: property identification number and location, map

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<sup>15</sup> The lifespan of a rat can reach 24 months. By discontinuing the use of similar bait types the risk of potential bait shyness will have died out over the course of 24 months.

<sup>16</sup> The continued use of brodifacoum may continue as a control measure. There is no reliable data suggesting that a tolerance for brodifacoum has ever developed or that bait shyness has developed with an associated to the toxicant. Ongoing control up until implementation will be underway around the perimeter of crops and within private residences. Discontinuing baiting on island is not preferred as it will promote the use of non-registered, unsupported toxins (likely including acute toxins) to be utilized by farmers and households to minimize the presence of rodents. At present, rodent control has shown to be effective on multiple farms (e.g. Claudio Cruz, Cecelia Salgado) and around the petrel colony. A notable exception includes ripened maize crops which continue to experience damage from rodents even with control (maize crops are considered highly palatable due to existing rodent techniques have not been able to stop predation). These crops will be harvested if fruiting will occur during implementation. Prior to implementation, a reduction in the rodent populations near these high-risk areas is expected to reduce the pressure on individual rodents to forage beyond readily available bait once a broadcast occurs. Furthermore, expansive crops will be reduced as far as possible to facilitate monitoring by detection tools including dogs. The final decision regarding action on agricultural land and within private residences will be made by the community while practitioners promote crop reduction to be as close to a full harvest as possible (see Agriculture Action Plan).

overview, property point of contact, number and age of children, details regarding any residents with special needs, open water sources, catchments, primary dwellings and features (e.g. kitchen, bodega, catering, tourism site), outbuildings, utility boxes, debris piles, subterranean structures, agriculture (e.g. crop type and size, artisanal garden), pets, and the presence of livestock. These details guide rodent station allocation and placement, water source management, and bait broadcast methods and rates which are adapted to each individual property. Available options to address each property's specific circumstances can be found within any one of eight risk management plans developed in collaboration with stakeholders.

Preferred management options are developed through discussion between permanent project staff and the property point of contact. Details are composed into an Individual Property Management Agreement which serves as a contractual agreement once formally signed by both the point of contact and Galapagos National Park representative – all private properties have an associated Individual Property Management Agreement which serves as the foundation of the bait application process on privately owned property.

Any areas that require hand broadcast will be evaluated by the Baiting Chief in advance of the operation to determine if management is required to provide reliable and safe access by the hand broadcast team. Management action will require the removal and subsequent mulching of vegetation, particularly dense spiny thickets (e.g. genus *parkensonia*), that may serve as a barrier to effectively applying bait in a consistent and reliable fashion. Sites will be identified within Individual Property Management Agreements and management actions will be completed during the months of June through August to ensure sufficient time is available to complete the task before implementation while reducing the risk of vegetation regenerating if completed too early in the year.

### **10.10.3 Bait application in agricultural/farmland area**

The majority of domesticated livestock designated for human consumption will be harvested or removed from the island prior to implementation. Animals that remain on island will be maintained within a designated space where bait is tightly managed in accordance to livestock risk management plan guidelines. Livestock spaces will be limited to corrals, piggeries, and chicken coups; each designed and constructed in a fashion that minimizes risk of toxicant exposure to livestock while eliminating safe harbour to rodents.

Large feral livestock and unclaimed free-range animals such as cattle will be removed from park lands through park-sanctioned actions. A valid attempt to detect and remove any smaller feral livestock (i.e. poultry) known to remain on island will occur through pre-baiting and trapping<sup>17</sup>, as well as hunting with air rifles. All livestock removal will be conducted amongst the partnership and will occur at least two full months prior<sup>18</sup> to the anticipated date of the first bait application to ensure bait or carcasses do not remain on site once baiting occurs.

Crops and fruiting trees will provide a potential source of natural food to rats and mice during the operation. Fruit trees will have designated caretakers to remove fallen fruit. Caretakers are indicated

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<sup>17</sup> The use of avicides such as DRC-1339 was considered as the preferred alternative to trapping, then rejected as the exposure risks to non-target species was considered unnecessary by external reviewers.

<sup>18</sup> Livestock, including chickens, will be removed at least one month before the first bait application. This decision was made to ensure that carcasses were not present acting as an alternative food source. Due to the humidity and presence of maggots, the full decomposition of flesh occurs within days to a few weeks in the Galápagos.



within individual property management agreements. In certain cases, heavy pruning will take place prior to the bait application. Fruit trees discovered on GNP land that do not have an identified caretaker will be removed altogether at least three months prior to implementation. The bait application rate used on areas with crops or fruit trees (stands and individuals) that remain on private land will receive an additional bait application to increase bait density to 1.5x the standard rate. This effort is intended to improve access to rodents by reducing search time for pellets. These areas will be estimated and mapped in detail prior to ordering bait. Fallen fruit under fruit trees will be collected at a minimum each day prior to an application and disposed of in accordance with protocols for organic waste. Supplemental baiting to increase the baiting rate to 1.5x will occur by spreading an additional non-overlapped aerial bait broadcast, utilizing trickle bucket swaths, or by hand baiting initially at the prescribed increased rate. All baiting details will be summarized within Individual Property Management Agreements.

Having crops remain on island is noted as a risk to the success of eradication. In particular, maize crops, once ripened, experience rodent damage even in the presence of bait station control efforts. Other crops, such as yucca, do not appear to be preferred over bait (Klerat, 50ppm Brodifacoum blue wax block with bitrex) that is used within bait stations on Floreana. The decision regarding how to respond to agricultural areas has been made with the community while developing the Agriculture Management Plan. Complete crop reduction or as close to a “full harvest” as possible of high-risk products listed within the Agriculture Management Plan will occur to minimize the risk that alternative food sources poses to project success. Noted exceptions are that all maize and other cereal crops must be fully harvested prior to implementation. If necessary, the project will be delayed until a suitable resolution to agricultural risks exists.

#### **10.10.4 Bait application in the tortoise holding pen**

Galápagos tortoises have a low susceptibility to Brodifacoum and pose a low non-target risk, in part because of their large mass (Fisher 2011). Observations on Isla Pinzon suggest that uptake of bait from tortoises as non-target consumers may be higher than expected, yet no mortality was observed, supporting the low risk assessment (K. Campbell pers. comm.). All tortoises on Floreana are captive and housed in a 1ha corral at a density that may impact the availability of bait to rodents if consumption by tortoises is high. In an effort to maximize bait availability to rodents cohabitating with captive tortoises, special attention will be given to the captive holding pen on Floreana. Prior to implementation, a smaller pre-existing interior pen will be refurbished to safely and effectively harbour tortoises (Figure 26). The day prior to each bait application, all captive tortoises will be moved to the smaller holding pen. Bait will be applied aerially over the entire site as if it were a part of the regular landscape and a handful of bait will be spread along each side of the temporary holding pen. Tortoises will then be released into the larger enclosure seven days after each application. Immediately upon release, the smaller holding pen will be closed and hand baited at the current applications’ prescribed rate.

For two days before and for two weeks after each bait application, tortoise feedings will be postponed<sup>19</sup>.

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<sup>19</sup> Tortoises are capable of surviving for long durations without feeding. As a result, for a short period of time, tortoise feedings will be postponed two days before and for an additional two weeks after each bait application.



**Figure 26.** *Pre-existing tortoise enclosure scheduled to be refurbished as a temporary holding pen.*

#### **10.10.5** Bait application over fresh water sources and standing water

Due to seasonal variation, fresh water sources and standing water will each be visually assessed within one month prior to the first bait application. Based on the condition of the site, mitigation measures outlined within the Water Supply and Water Body Management Plan will be chosen to protect these sites from exposure to rodenticide. Mitigation measures include covering the site by a non-permeable shield that prevents bait from entering the water or mapping the site as an exclusion zone to prevent it from being included in the aerial broadcast. For sites mapped as an exclusion zone, a hand-broadcast or trickle bucket broadcast of the buffer zone around the excluded site's perimeter will be conducted to ensure thorough bait coverage. Each exclusion and associated prescription will be included in the broadcast database and map. Follow-up inspections on these sites will occur within 24 hours after the broadcast to assess coverage. Additional hand broadcasting of bait will occur if gaps in coverage are identified. During these inspections, any bait found to have unintentionally entered fresh or standing water will be removed to the degree possible (i.e. that degradation allows) and redistributed to the surrounding non-excluded area.

#### **10.10.1** Alternative Food Sources

Alternative food sources will be identified on all private and park lands. Areas including home kitchens, dining areas, tourist sites, dump sites, trash receptacles, and pantries will follow commensal guidelines outlined in the Commensal Rodent Management Plan and included within Individual Property Management Agreements. Multiple seminars will be held on island, providing rodent proof receptacles and guidance on how to prevent the availability of alternative food sources.

Tourism on Floreana is limited to certain landing sites. Tour services with guided groups will be held responsible for ensuring tourists remain within authorized sites and comply with commensal guidelines. All tourists visiting the island during implementation must be accompanied by a guide and will be instructed to read posted guidelines upon arrive which provide a background on the eradication

and details the commensal guidelines. At locations where active broadcast can be closely observed, project staff will be onsite to serve as an interpreter for the project.

All animal feed must be either removed from the island, destroyed or cached in rodent proof containers. Rodent proof containers will be supplied if necessary and the feeding of livestock remaining on island will adhere to the livestock risk management plan. Prior to implementation, inspections will occur to certify each container as being rodent proof. Spontaneous audits of compliance will be undertaken throughout the project.

Pets remaining on island will need to be managed according to the guidelines outlined within the domestic pet risk management plan.

Solid food waste from kitchens (i.e. cooking scraps, meal remnants, etc.) will be collected throughout the day and stored in rodent proof bins. Following collection, bins will be placed along the street for pickup. A daily collection will occur and deliver the solid food waste to highland farms where supervised feeding to domestic pigs within specially designed piggeries<sup>20</sup> will occur. A rodent proof storage unit will serve as a redundant measure to prevent rodents from accessing solid waste in the event that delivery to pig farms is temporarily out of service or volume exceeds capacity. Plates, cutlery, cooking/dining utensils and other items that have come into contact with food should be washed thoroughly while screening dishwater to collect any food particles. All grey water plumbing must either have a subterranean drain or be finely filtered to collect all food particles if drained above ground. If food-contaminated material is to be disposed of, it must be placed into a rodent proof solid-waste bin designated for either trash or recycling. All trash must be burnt immediately after collection or stored in a larger rodent proof bin until it can be burnt later or transferred off island. More detail regarding the management of solid food waste can be found in the commensal rodent risk management plan.

**Figure 27.** Areas requiring special attention when applying bait.

Special Treatment Areas	Treatment necessary
<b>Lowland town within GNP perimeter</b>	<ul style="list-style-type: none"> <li>• These areas will be treated during the third application of bait.</li> <li>• All sites will be pre-recorded in the Broadcast Database and tracked as they are baited.</li> <li>• A visual check will occur three days post each application. If insufficient bait is present, additional bait will be applied by hand.</li> </ul>
<b>Garbage dump / recycling center</b>	
<b>Springs and covered bodies of water</b>	
<b>Agricultural plots and natural alternative food sources (planted crops, fruit trees, petrel nesting areas)</b>	

<sup>20</sup> Piggeries have been designed then constructed which limit access to rodents, permit perimeter baiting to occur as an open broadcast and support the use of bait stations, and allow thorough clean-up of feed once feeding has been completed.

<b>Commensal environment</b>	
<b>Inland cliff faces and slopes<sup>21</sup> (areas identified as 'in excess of 50° slope')</b>	<ul style="list-style-type: none"> <li>The application rate will be increased to maintain targeted sow rates which align with adjusted surface area. Flight speeds will be automated (slowed) to treat slope in excess of 50° without requiring an extra pass.</li> </ul>
<b>Highland blocks</b>	<ul style="list-style-type: none"> <li>The entire highland area will be treated with a third application of bait.</li> </ul>
<b>Baiting block perimeter</b>	<ul style="list-style-type: none"> <li>Back bait will occur as necessary into the perimeter according to guidelines found in Figure 16.</li> </ul>
<b>Standing water</b>	<ul style="list-style-type: none"> <li>Large, uncovered, water bodies will be treated as exclusion zones.</li> <li>All sites will be pre-recorded and tracked as they are baited.</li> </ul>
<b>Watercourse drainages</b>	<ul style="list-style-type: none"> <li>In addition to being treated as a regular part of a block a supplemental full swath on either side or just one directly down the line of the drainage (assessed on &gt;/= effective swath width vs drainage width) will be sown.</li> <li>Drainages will be treated with a third application of bait.</li> </ul>
<b>Sink holes, caves, and bottom of craters</b>	<ul style="list-style-type: none"> <li>These areas will be treated with a third application of bait.</li> <li>Craters treated by 'plunging' with full-swath bucket.</li> </ul>

## 10.11 Post application activities

### 10.11.1 Bait Availability monitoring

Tracking bait pellet disappearance rates will provide an indication of the efficacy of the operation and will inform baiting decisions. If, for instance, pellets remain available longer than expected, or disappear more rapidly in certain habitats the Baiting chief, with input from the Incident Advisory Group, could decide to adjust the bait application rate for the subsequent broadcast.

Forty bait availability transects will be developed one week prior to the first bait application with 12 transects placed in natural lowland habitat, 12 to be placed in natural highland habitat, 5 to be placed in agricultural plots, 5 to be placed in the township, and 6 transects to be established along the coastal perimeter. Each transect will be 25m x 1m. Coinciding with when bait is broadcast in the area, the appropriate number of baits (Figure 28) will be established in each transect according to local broadcast rate. Each pellet will be flagged and transects will be checked at 2, 3, 4, 5, 6, 9, 12, 15, and 18 days post application. Daily timing of checks will strive to maintain consistency. Flags will be removed when baits are no longer present. The number of flags removed and number of pellets remaining will be recorded

<sup>21</sup> Slope presents a larger surface area which reduces bait density/volume if prescribed bait application rates are not increased.

at each check. Additional detail regarding bait availability monitoring protocols are listed within Appendix B.

**Figure 28.** Monitoring plot pellet quantities representing prescribed application rate.

Broadcast Rate	Average quantity of pellets within each 25m <sup>2</sup> transect (9.5mm / 1g)
10 kg/ha	25 pellets
9 kg/ha	22 pellets
6 kg/ha	15 pellets

### 10.11.2 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. medium tree finch) or is a species that was not forecasted to be impacted within non-target risk assessments. If carcasses are collected, necropsies will be conducted in an attempt to ascertain the cause of death. The Incident Advisory Group will be notified immediately upon the death of an unexpected species that was determined to have succumbed from Brodifacoum poisoning. Carcasses found in a condition that can be preserved will be offered to the Charles Darwin Foundation museum or other collections, as determined by the GNP.

### 10.11.1 Monitoring to confirm rodent eradication

Rodent eradication campaigns wait until two breeding seasons have elapsed before an effort is made to detect a remnant rodent population (Broome et al. 2011). On Floreana, field surveys to detect rodent presence will be conducted after all aerial applications have occurred and again in September 2025 after two rodent breeding seasons (2 years<sup>22</sup>) have elapsed. If no rodents are detected after two breeding seasons, confirmation of successful eradication will be declared.

A range of tools will be utilized to detect rodents include rodent detection dogs, traps (live traps and snap-traps), chew-tabs, rodent hotels, and remote trail cameras. Detection tools will focus on, but will not be limited to, higher-risk areas including kitchens, food storage facilities, the dump, productive agricultural areas, non-target species enclosures, and the marina.

Field surveys will begin two weeks after the third aerial bait broadcast and continue for two months. Detection dog/s will assess high-risk sites weekly<sup>23</sup>. Rodent stations with bait and traps previously installed for the eradication will remain in place and will continue to be serviced weekly throughout this period. Rodent hotels, chew tabs, and remote trail cameras will be installed in accordance with the biosecurity plan and will be monitored weekly over the field survey period. After the initial field

<sup>22</sup> Two years will accommodate the potential of one single breeding season for rats as indicated by (Clark 1980).

<sup>23</sup> Dog use (strategies, time spent, success rate, etc.) will be documented throughout the project in an effort to assess the tools effectiveness and to identify potential areas in need of improvement during the project and for future use. Refresher-training for dogs will occur on Santa Cruz Island at regular intervals. Dogs will undergo aversion training with rodent and cat bait or be muzzled to discourage bait consumption.

surveys are complete, efforts will transition into long-term biosecurity (see Floreana Biosecurity plan). Final confirmation will rely on a close evaluation of biosecurity tools.

If a rodent is collected after baiting operations have ceased, it will initiate an assessment by the partnership to determine the source of the sample. DNA analysis against archived samples will seek to determine if the individual survived eradication or if biosecurity was breached. Additional analysis may identify the source leading to a breach. In the event that biosecurity is breached, the biosecurity plan must be reevaluated and amended to prevent future incursions.

#### **10.11.2 Evaluation of rodent reports**

Reported sightings or sign found by staff, residents or visiting tourists will be investigated immediately. A search for rodent sign including den sites, food storage and husking sites, fecal deposits, footprints and active runways will be conducted in the local area by experienced staff. Additional detection methods including rodent detection dogs, traps (live traps and snap-traps), chew-tabs, rodent hotels, and/or remote trail cameras will be utilized to further evaluate a report if necessary.

Rapid response guidelines below outline a series of steps which address suspected presence or detected individuals.

#### **10.11.3 Rapid response plan**

If rodent sign is detected, or presence considered possible, detection dogs and other passive detection methods including mechanical traps, bait blocks, remote cameras, chew tabs, and/or tracking plates must be utilized to delineate the area occupied. Ideally, detection devices are also capable of removing the rodent.

Devices must be established no greater than 20m x 20m apart surrounding the sign or sighting. The grid should be at least 200m on each side with the location of the sighting, or presumed presence, at the center; a larger grid should be established if resources are available to do so. An immediate response is critical. The grid should be checked daily and left in place for at least one week, ideally longer.

Concurrently, a visual inspection of the area will be conducted by personnel experienced in detecting rodent sign. If a detection is confirmed and considered localized (i.e. not considered evidence of an island-wide recolonization), a broadcast of bait should be considered immediately across the dimensions of the detection grid while additional response planning takes place. Bait should be applied in two applications and in accordance with treatment prescriptions outlined elsewhere in this plan. Management of alternative food sources should also be considered if present in the localized area.

If possible, rodents should be identified to species to assist in tailoring a response plan. If rodent species cannot be determined, then planning must default to planning for mice. Included within bait quantities calculated for implementation is an additional 5% of the total which is intended for potential spot treatment. The response plan should consider the reapplication of rodent bait over the infested area including a buffer of up to one kilometer surrounding the site. All baiting activities must take into consideration individual property management agreements where applicable. Detection devices placed in and beyond the treatment area must be monitored as frequently as possible during the response period, and until the point at which rodents have not been detected for 90 consecutive days.

Prior to any baiting activity, human health and safety, non-target risk, and the probability of removing all target individuals should be taken into consideration. If a detected population/s of rodents spans an area significantly greater than what can be targeted with available bait, it must be acknowledged that the probability to expose all remaining rodents to rodenticide is greatly reduced. At this point it is recommended that funding be allocated towards a review that determines the probable cause/s of eradication or biosecurity failure.

## **11. OPERATIONAL DETAILS: CAT ERADICATION**

### **11.1 Strategy overview for Cats**

- ☐ Preparation of a trail network across the island
- ☐ Placement of motion sensor IR trail cameras to provide baseline of cat abundance and activity (place inactive trap sites for later use if necessary)
- ☐ Survey island, select trap sites, document latrine sites
- ☐ Capture 30 cats in total. Collar 20 cats to establish home-range data and utilize as an efficacy monitoring tool. Hold 10 cats in captivity
- ☐ Link data into Detection Probability Analysis
- ☐ Implement aerial baiting applications of cereal baits for rodent eradication
- ☐ Implement aerial baiting of sausage baits for cat eradication
- ☐ Survey island and assess knockdown due to bait applications
- ☐ Activate select traps in key locations
- ☐ Release 10 captive held cats with GPS collars
- ☐ Monitor remote cameras and respond to detections with sausage bait spot treatment and targeted trapping and/or dog hunting efforts
- ☐ Conduct supplemental monitoring (sign search, dogs)
- ☐ Confirm eradication based on Detection Probability Analysis

### **11.2 Bait product and toxicant**

Western Australia Department of Parks and Wildlife (WA DPaW), formally Western Australia Department of Environment and Conservation sausage baits are preferred for use, though regionally manufactured bait will be used to simplify logistics. WA DPaW sausage baits are patented and an off-site manufacture approval has already been granted for sausages developed in Ecuador to conduct non-target risk assessment and degradation trials in 2015 (Hall 2016). All local manufacturing of sausages have and will occur under a strict confidentiality agreement with WA DPaW. The final product will be a 20-24g skinless sausage once cured.

The active ingredient used will be the toxicant PAPP at 310g/kg concentration. 78mg of PAPP will be encapsulated in a hard-shelled pellet (HSDV) with one pellet being inserted into a single sausage bait.

The application of PAPP sausage baits will be authorized under a single use permit granted by the Galapagos National Park.

#### **11.2.1 Manufacturing of sausage baits**

Meat based attractants will be manufactured in Ecuador by a commercial food producer following protocols from the developers of the WA DPaW's Curiosity bait. Baits will utilize ground beef rather



than Kangaroo to reduce importation needs. Remaining ingredients will be sourced locally in Ecuador. Ingredient sourcing will begin in January 2023 to ensure all components are available and present in the volume required.

Bait will be comprised of 70% fresh ground beef, 20% minced chicken fat, 10% digest, flavor enhancers and sodium nitrite as a preservative. The meat emulsion will be buffered to a pH of 7.5 using sodium carbonate to ensure the integrity of the HSDV is maintained and premature breakdown PAPP is avoided. Baits will be dried in a climate-controlled room with constant airflow to generate a 20-24g skinless sausage-like product.

### **11.2.2 Sourcing of PAPP**

PAPP pre-loaded into HSDV<sup>24</sup> will be sourced in 2000 pellet quantities from the Department of the Environment and Energy, Kind Edward Terrace, Parkes, ACT 2601, Australia. HSDV pellets will be ordered in April 2023.

## **11.3 General timeline and commencement process for cats**

### **11.3.1 Operation Target Date**

Preparations including trail cutting, placement of remote cameras, and the capture of cats to monitor efficacy will occur in the months leading up to the rodent bait application (July – September). Aerial baiting to remove cats will begin in mid-November - 1.5 months after the first bait broadcast for rodents is scheduled to occur. Broadcast baiting will continue over the span of one month and be completed in mid-December 2023.

Monitoring efforts and removal efforts in the event of a detection will continue until the eradication of cats is considered complete based on a probability of detection analysis (section 10.4).

### **11.3.2 Development of trail network**

Park staff supplemented by contracted laborers will cut rudimentary trails across the island. Trails will serve to expedite access and enable remote camera installation, trap installation where appropriate, and support routine sign search. The trail networks will be installed June – August 2023 to ensure paths remain clear throughout implementation before regrowth occurs. Trail location will be developed in consultation with GNP, will improve access an overlay of 500ha monitoring blocks (Figure 29), and will utilize pre-existing accessways where available. Time required to cut trails will be determined based on vegetation density in 2023.

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<sup>24</sup> A hard-shell delivery system (HSDV) will be used to encapsulate the PAPP to minimize risk to non-target species (Fisher and Campbell 2017c). The use of HSDV also serves to provide a stable pH; a condition necessary to maintain toxicity (Hall 2016).



**Floreana  
Galapagos Islands**

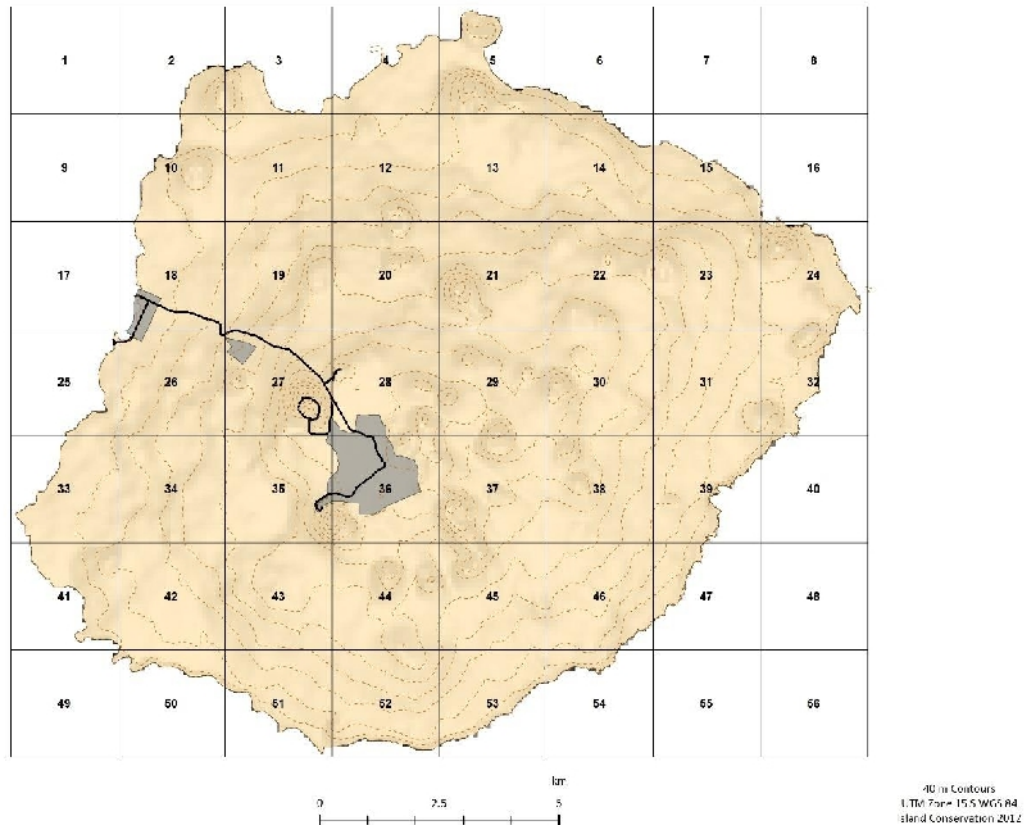


Figure 29. **500ha monitoring block overlay to support fieldwork activities and planning.**

### 11.3.3 Initial population monitoring

Two months prior to the implementation of a rodent bait broadcast, the placement of at least 250 remote camera traps (*specific model still under review*) will occur across the island to acquire a baseline of cat abundance. Locations will be determined by experienced cat trappers capable of identifying cat sign and heavy use sites. During this effort, any locations deemed appropriate to receive a cat trap will be marked and recorded by a GPS. Sites marked with having a significant amount of cat activity will have trap equipment immediately staged at the site to season *in situ*. Sign including scat, latrine sites, and travel routes will be surveyed and cataloged. Any cat scat catalogued will be buried or ground up under boot to prevent future detection. This data will be utilized where appropriate in a probability of detection model as well as function as a guide for trap placement.

## 11.4 Aerial bait application: preparation, strategy, and logistics

### 11.4.1 Detection probability analysis

A detection probability analysis will be conducted, and a model produced, prior to removal efforts. The model will provide stopping rules for cat monitoring efforts and for determining the timing for declaring the success of cat eradication. Stopping rules will be designed to reduce the probability of falsely declaring eradication success or incurring expenses associated with unnecessarily continuing eradication efforts once cats have already been successfully removed (Ramsey et al. 2010). Monitoring

data including, but not limited to trapping results, the frequency and volume of camera images acquired, effort and results from sign searching, detections and captures of marked cats, and dog team effort and success will be incorporated and used to assess the probability that a cat (or cats) remain on Floreana. Modeling will also be used to estimate population numbers throughout the campaign, how much additional monitoring is required to declare success, and guide the selection of tools and methods employed to maximize probability of detection as well as removals.

Eradication confirmation will be declared only after 99.5% confidence towards success has been achieved by the model.

#### **11.4.2 Efficacy Monitoring**

One and a half months prior to the implementation of a rodent bait broadcast, 30 cats will be captured with the use of leg-hold traps in blind sets<sup>25</sup>. Cats will have their capture locations noted for later release at the same site. All cats will be fitted with a passive integrated transponder (PIT) tag and sterilized via tubal ligation for females and vasectomy for males. Ten cats will be held in captivity until just prior to the first aerial broadcast of meat-based sausages containing PAPP. Twenty cats will be fitted with GPS collars and released at their original capture locations immediately after recovery from sterilization. Data from GPS collars from the initial twenty cats will be remotely uploaded and used to develop homerange estimates as well as evaluated the efficacy of secondary poisoning on cats from the aerial broadcast of rodenticide (Brodifacoum bait pellets).

After the estimated survival window from secondary poisoning has passed (7-40 days after the first application, (Griffiths 2011, P. Fisher pers comm), GPS collars will be recovered from cats which succumb from brodifacoum. One week prior to the first aerial broadcast of PAPP, remaining cats will be released with refitted GPS collars to serve as an efficacy measure for aerial PAPP broadcasts as well as follow-up spot baiting and trapping if deemed necessary based on camera detections. Hunting efforts, if required, will utilize any extant collared animals as Judas cats.

The specific model of GPS collar will be determined 9 months prior to implementation to ensure current technology is being utilized. Collars will be selected that can demonstrate long battery life, low collar-to-animal weight ratio, and can clearly be identified within photos taken by remote cameras. Additional features that may be incorporated include an RFID transponder and mortality signal. Animals chosen to receive GPS collars will represent juvenile and adult cats, of both sexes.

#### **11.4.3 Population reduction during rat eradication**

Fecal analyses suggest that cats will prey or scavenge rodents which will contain brodifacoum from the broadcast of Conservation 25 bait. It is also anticipated that cats will predate species such as lava lizards and locust which have been shown to contain sub-lethal but relatively high levels of Brodifacoum for months after an aerial broadcast (Island Conservation unpublished data). Although cats have a relatively high tolerance to brodifacoum (LD50 25 mg/kg) compared to black rats (LD50 0.46 - 0.77 mg/kg) and mice (LD50 0.4 - 0.52 mg/kg), they remain at risk to secondary brodifacoum poisoning and bioaccumulation (Dowding et al., 1999; Fisher 2005). As a result, rodent eradication

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<sup>25</sup> Set type selection is critical to limit the education of animals that may need to be captured later in the campaign.

efforts causing secondary poisoning of cats will be utilized as cost effective method to initiate feral cat removal.

Predicting the effectiveness of secondary poisoning on Floreana is difficult, but reductions of 80% or more in cat populations have been observed when rodents are targeted simultaneously with cats (Campbell et al. 2011). Aerial baiting with PAPP and direct methods to remove cats will be conducted only after aerial baiting for rodents has been completed and the immediate window for secondary poisoning has passed. Efficacy will be assessed based on the percentage of collared cats that succumb to Brodifacoum poisoning.

#### **11.4.4 Transition from rodent to cat aerial operations**

It is expected that a number of the UAV support personnel will depart after the end of the brodifacoum applications. Remaining staff will include sufficient personnel to pilot 2x UAV platforms as well as engineering and management personnel.

Due to the lighter nature of the PAPP applications, night operations will be dropped in favor of maintaining continuous daytime operations.

2 UAV platforms will be utilized with a specially designed PAPP sausage dispenser, programmed to drop sausages along the flight line. The 2 UAVs will be piloted by the Chief UAV pilot and one additional UAV Pilot.

The Groundcrew Supervisor will lead a small crew of (minimum) 2 groundcrew to assist in loading and fueling the UAVs. Groundcrew will be staffed by local personnel.

Any other UAV and support equipment not required for the PAPP application will be prepared for departure from the island.

#### **11.4.5 PAPP bait delivery and preparation**

Sausage bait developed on mainland Ecuador will be delivered to large chilling units already present on Santa Cruz Island or directly to Floreana where they will be stored in chest freezers or a refrigerated shipping container until required. Freight method and storage placement will be confirmed when bait manufacturing begins. If not already on Floreana, baits will be transferred to Floreana after the third aerial application for rodents occurs.

Preparation of bait will occur in stages and follow recommendations from the developers in Australia (Johnston et al. 2014; M O'Donoghue and Johnston M. pers comm 2015):

- All sausages will be defrosted enough to load<sup>26</sup> with HSDV containing PAPP and returned to a freezer as until needed.
- A subset of sausages will be selected for the following day's broadcast. Estimates will be based on the prescribed broadcast area and ferry time. Preparation will occur within 24 hours to maximize bait quality.
- Each sausage will be fully defrosted on elevated drying racks set out to receive full sun exposure.

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<sup>26</sup> The insertion of a toxin is currently a manual process and will seek a commercial applicator to expedite the process.

- Bait will be rotated regularly until all sides have received equal sun exposure, display a firm quality, and have a slight sheen on the surface (i.e. sweated fats which have leeching out).
- All baits will receive a solution of Permethrin diluted with water to reduce ant activity (Hall 2017).
- Baits will be sorted into groups of three and prepared for loading into the aerial broadcast device or reserved for exclusion baiting.

#### **11.4.6 Transition from rodent to cat aerial operations**

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Any other UAV and support equipment not required for the PAPP application will be prepared for departure from the island.

#### **11.4.7 Broadcast, spot, and exclusion baiting**

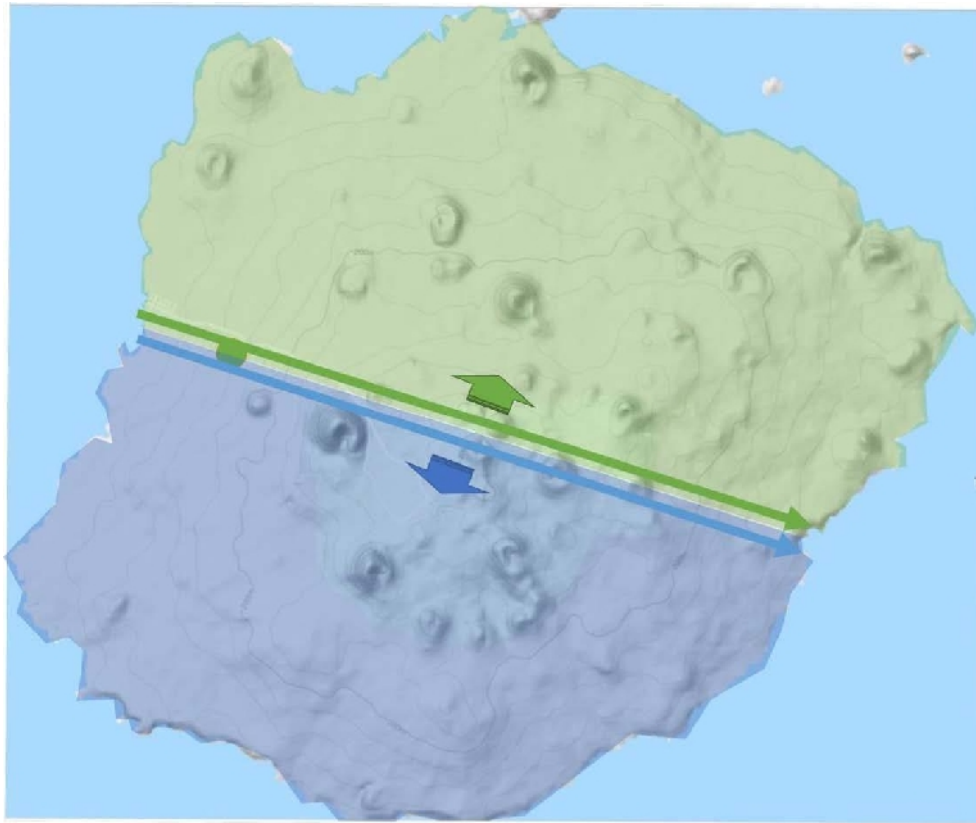
Two UAV helicopters and support equipment used for rodent baiting operations will conduct the aerial dispersal of PAPP baits.

Three aerial broadcasts of meat sausage baits containing 80mg each of para-aminopropiophenone (PAPP) will be distributed for feral cats. Distribution of bait will be conducted at 10-day intervals beginning 10 days after the final rodent broadcast is complete. Broadcasts will take approximately 3-4 days. Baiting transects will be flown at 80km/h with the use of an automated flight management system guided by GPS. A dispersal system designed to distribute sausage baits will be pre-programmed and calibrated to broadcast 3 sausages every 300m<sup>27</sup>. Flight speed and height will be automated to produce parallel grid lines over varying terrain features. Supplemental baiting during each broadcast will target an overlay of prominent landscape features including ridgelines, gullies, trails, coastline, cliff edges, and bird colonies which serve as high-use sites cats.

All flights will be observed by the UAV pilot via live video feed. The Aviation Manager will provide the GIS Specialist Lead with flight path export data at each fueling stop or upon request to support near-real-time monitoring. This will enable efficient quality control and pinpoint any gaps that will need to be treated before the broadcast is considered complete.

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<sup>27</sup> This spacing should provide coverage for any potential cat home range, based on a known minimum of a 21 ha home range for an adult female cat in the Galápagos (Konecny 1987b). A circular 21 ha home range would have a diameter of 364m. A baiting density of at least one bait/ha is recommended for this general coverage.



**Figure 30.** Map of PAPP broadcast blocks containing 300m baiting grids. Division and loading site present to support two UAV helicopter.

Watersheds around the island's two highland and single lowland spring will be excluded from the general aerial broadcast. Each exclusion will receive hand placed baits as outlined within applicable management plans.

Remote camera detections and sign search will be used to guide additional spot baiting to remove remnant cats if necessary. Size and shape of areas treated with spot baiting will be determined ad-hoc by the Baiting Chief based upon the detection site and landscape features. Spot baiting may be conducted by UAV helicopter or by hand if UAV have been demobilized.

Approximately 17,500 will be required to conduct grid baiting. An additional 6,500 baits will be used for supplemental baiting, spot baiting, and to treat exclusion perimeters. A total of 24,000 PAPP sausage baits will be distributed across three broadcasts.

#### **11.4.8 Loading and Fueling**

Different dispersal system prototypes are in development and will be tested prior to selection. A working model is anticipated to be completed in 2021. Once a model is selected, loading SOPs will be created for all operational crew members to adhere to regarding aerial PAPP loading operations.

Equipment required for fueling and loading is outlined in the Floreana Bulk Bait Loading Plan.

All UAV helicopters will operate on unleaded petrol. The estimated fuel required for the PAPP broadcast is 1,500 liters. Daily assessments will be conducted to monitor the quantity of fuel available.

#### **11.4.9 Contingency bait and bait disposal**

The entire lot of cat baits will be stored together in one refrigerated container or split across several smaller refrigerators utilizing a shared power source. It is probable that if bait is damaged (i.e. becomes rancid), the entire shipment will be compromised. As a result, no contingency of sausage baits will be brought to the island and alternative methods will be used to target remnant animals while awaiting another shipment of bait from manufacturer.

Bait remaining after the completion of all applications and supplemental spot treatments will be used for cat control by the GNP on Santa Cruz, San Cristobal or Isabela Islands or disposed of in an appropriate fashion.

### **11.5 Remnant cat removal methods**

#### **11.5.1 Trapping**

Trapping is the most frequently used method for feral cat removal and will serve as an important operational tool on Floreana.

Cage traps and blind-set padded leg-hold traps will be used to capture cats intended for efficacy monitoring (11.4.2). Trapping effort will seek to capture cats at multiple locations across the island beginning 1.5 months prior to the first aerial bait broadcast for rodents. Site selection for trap placement will occur at this time as well before removal efforts reduce the volume of sign.

General site location will be selected with aerial imagery and outlined within a GIS trap layer. The selection of specific trap sites will be guided by visual sign search based on cat's micro-habitat preferences and typical trail-routes and camera trap detection results. Areas found with dense sign will have padded leg-hold traps strategically staged and seasoned for rapid activation later in the campaign.

Spot trapping to remove remnant animals will occur once rodent and cat bait applications have taken place. If detections are made in a general area, experienced trappers will investigate the area on foot to determine the specific site/s for trap placement. The presence of cat sign and camera detections collected prior to baiting operations will further aid in trapper's evaluation of trap sites.

A total of 250 Bridger #2 leg-hold, 150 Conibear #160 body grip, 500 Snare-one snares, and 30 Tomahawk cage traps will be available to incorporate into the network. Leg-hold traps have consistently shown a high level of efficacy, and will be the primary trap type used on Floreana (Figure 31). Leg-hold trap functionality will be improved by utilizing four springs and square padded jaws. Walk-through, cubby, blind, and dirt-hole sets will be employed. Body grip traps will be set as primarily as cubby sets. Snares sets will be used along clear travel routes. Cage traps will be utilized primarily to capture animals intended to receive a GPS collar. Modifications to set types may deviate from standard practice if needed to capture educated animals. Skilled trappers will be used to reduce the risk of animals becoming trap-shy and to ensure that traps operate efficiently and effectively. Inexperienced trappers will be trained off-site, such as on Santa Cruz Island, until they have proven they can consistently demonstrate the skills required to trap cats consistently and are approved by the Project Manager to trap on Floreana.



**Figure 31.** *Soft-jaw leg-hold live trap set for feral cats. A trail/walk-through set is pictured.*

Lures and attractants will be used with traps to increase effectiveness. Possible attractants may include chicken flesh, cured fish, commercial cat food, commercial (e.g. catnip oil (*Nepeta cataria*)) or home-made olfactory lures (i.e. 'pongo' which consists a mixture of scat, urine, scent gland extraction, and glycerin), audio lures, and visual lures. Initially, pongo and visual lures including feathers will be used as they can remain in the field for a longer duration without having to be maintained.

Trapping feral cats will follow standard codes of practice and guidelines (Sharp and Saunders 2005a and 2005b, IAFWA 2006, Wood et al. 2002). Details concerning specific leg-hold trap sets will be based on Wood et al. 2002 and Hanson et al. 2010 with the allowance for deviations to improve trapping success rates and non-target avoidance on Floreana. Cats captured will be dispatched on site through blunt force trauma to the skull or an accurately placed air rifle shot through the brain.

A trap monitoring system based on the system developed for feral cat eradication from San Nicolas Island (California) will be used to increase trap-checking efficiency (Will et al. 2010, Hanson et al. 2010). The system will be comprised of transmitter units connected to live-capture style traps and will be supported by an existing digital receiver network. Signal coverage across the island will be achieved by incorporating additional repeaters if a centralized system cannot provide the necessary coverage. A total of 300 trap monitoring devices will be available for use on live traps. Body grip and snare traps will not require a monitor as captures will be lethal.

Trap transmitters will behave like standard wildlife radio collars, each one emitting a unique radio signal. When a trap is sprung the signal will change pace. A computer-based program that converts trap signals into a user-friendly, easy-to-interpret interface will monitor trap status and alert staff of the need to visually check a specific set. Traps will be checked as necessary under the following circumstances: a. the trap monitoring system reports a trap has been sprung, b. a trap monitor is no longer reporting a signal, c. a trap has not been visually inspected within two weeks.

Live traps that do not receive a trap monitor will be visually inspected daily.

Transmitter installation guidelines:

1. Secure at least 30cm of monofilament line to the outer jaw of a leg-hold, door of a box trap, side wire of a body-grip trap, or neck of a snare and connect the trigger-magnet to the loose end of the line.
2. Anchor the monitor's puck to the ground at a distance that ensures the monofilament line is semi-taught when the trigger-magnet is placed within the puck.
3. Mount the transmitter box upright, elevated, and in a linear path of the receiving station.
4. Plug the puck cord into the transmitter box.
5. Assess the LED light to verify the trap monitor is operating.
6. Radio in to confirm that a signal is being received. If no signal exists, readdress step 3 and continue following the guideline.

### **11.5.2 Hunting with dogs**

Up to six hunting dogs and two dog handlers will be contracted if probably of detection analysis indicates baiting and trapping are no longer effective. Support will be sought from professional dog handlers based in Olancho, California, USA.

Dogs destined to hunt cats on Floreana will be trained to focus exclusively on feral cats and to disregard other species including rodents, birds, marine mammals and reptiles. Dogs will be trained to find feral cats by following ground and/or wind-borne scents. Hunting with dogs will occur most often during daylight hours, preferably early morning when target identification is easier. However, if hunting with dogs occurs at night, care will be exercised to ensure that the safety of the hunter, the dog and others is not jeopardized.

Cats trapped by dogs in a hole, rocks, or trees will be dispatched by an accurately placed shot to the head. A high-powered air rifle of .25 caliber or greater will be used. Shooting will occur only after the dog/s have been called away and when the shooter is 100% certain of the identity of the target and that a safe backdrop is present. It is expected that dogs will dispatch any cats that do not take refuge.

### **11.5.3 Fumigants**

Cats are extremely susceptible to phosphine gas, which is produced by aluminum phosphide tablets upon contact with water (Campbell et al. 2011). Aluminum phosphide fumigant (Appendix D) will be used to target cats seeking refuge within sealable holes and dens where a hunter cannot confidently place a gunshot. Holes and dens showing signs of recent cat activity (scat, tracks, detected with dogs) will be marked, determined free of non-target species (e.g. Galapagos petrel), and then fumigated. All known entrances will be covered with the surrounding sediment and left in place allowing returning staff to assess if any excavation occurred post fumigation. Areas of refuge that are not suitable for fumigation (e.g. cannot be sealed) will have traps strategically placed within the immediate vicinity.

### **11.5.4 Spotlight hunting**

Spotlight hunting can be very effective in the removal of cats due to the distinct reflection a felid's eyes provides. Night hunting with spotlights is routinely utilized in cat control and eradication projects and has been utilized to remove the remaining cats when other methods were no longer effective (Hanson 2011). Although this method can be very effective, it is labor intensive and specific circumstances (i.e. clear and accessible terrain) must exist before success can be achieved.



On Floreana, spotlight hunting may prove to be an important technique in special circumstances but would most often be combined with the use of dogs. Hat mounted LED spotlights (Nite Lite model #NL6812) and large caliber air rifle or GNP owned centerfire rifle with variable zoom optics will be used.

## **11.6 Monitoring techniques to confirm eradication**

Detection methods for feral cats will primarily include trail cameras (including use of olfactory or audio lures to attract cats) and searching for cat sign (e.g. scat, paw prints). Supplementary search effort will rely on traps, and detection dogs. Once animals are no longer detected on the island, the operation will move into the confirmation monitoring phase.

All activities during the eradication operation will be recorded, including GPS location data for trap placement, date of cat capture, age and sex of animal, details of cat sign (e.g. type and age of sign, time of day), GPS location and photograph of cat sign, unintended mortality in traps, and verified sprung-no-capture events (trap escapes). Small, rugged hand-held field computers with GPS capabilities (e.g. Archer PDA Juniper Systems, Logan, UT) will be used in the field to record all relevant data via drop-down menus. This system allows for standardized data collection and when utilized with GIS, and allows for near real time data analyses (Hanson et al. 2010, Will et al. 2010). Managers will use these data to monitor real-time progress of the eradication operation, and to assist with critical adaptive management decisions (Lavoie et al. 2007).

A probability of detection model using data collected during the eradication operation will estimate the number of animals that may persist, as well as to predict the amount of continued surveillance required to declare the eradication complete (Ramsey et al. 2011). For the detection probability model, managers will utilize a 99.5% level of certainty (i.e. confidence) that if a cat existed, it would have been detected. After no further animals can be detected, and all animals believed removed, the project will be declared a success.

## **12. Operational safety**

During Project Isabela, and for the Pinzon, Rabida, and Seymour Norte rodent eradications, extensive safety protocols were established and followed. This project will build on those protocols to minimize risk to personnel throughout the project. A safety plan is available for specific protocols and greater detail. The following guidelines will be implemented to ensure the safety of personnel and other persons:

- All project staff, contractors, and other personnel directly involved in baiting will have adequate training in all aspects of the work that they are expected to perform. All personnel will have suitable oversight and guidance present from staff with an extensive background in the tasks being performed.
- Provide appropriate training and personal protective equipment for all staff (PNG, ABG, IC, Floreana residents, contractors, etc.).
- An emergency, search and rescue, and evacuation protocols will be in place and all components prepared to go into effect if necessary. Key GNP staff supporting procedures will be well trained and capable of following plan.

- All protocols and procedures are developed with safety in mind. Safety will remain a priority at all times with a dedicated safety officer and operations personnel providing routine audit of activities taking place.

## 13. Logistics and Timing

### 13.1 Pre-implementation / Mobilization

#### 13.1.1 Regulatory Compliance

Permitting and compliance for the operation falls under the jurisdiction of the GNP and ABG, as all the activities, excluding toxic bait importation will take place within the National Park or within the community on Floreana. Therefore, all the activities laid out in the Operational Plan will be reviewed by the GNP Technical Committee and ABG officials, then approved. Risk related to human health and safety will need to undergo review and approval by the Ministry of Health, Municipality of San Cristobal, GNP, and GBA. Non-target species will need to undergo review and approval by the Galápagos National Park Directorate. Operational Safety

Aspects of the operation which will receive review and approval<sup>28</sup>:

1. Application of rodenticide bait with Brodifacoum and cat bait with PAPP onto the islands (*this plan*)
2. Non-target risk analysis, and decision by GNP on acceptable risks (Fisher and Campbell 2015a; Fisher and Campbell 2015b; Fisher and Campbell 2015c)
3. Species mitigation plans (as indicated through the Wildlife Non-target Risk Processes).
4. Monitoring activities for native and endemic species using standard monitoring protocols established for the Galápagos Islands (CCAL 2010).
5. Importation of toxic bait to Ecuador and Galápagos and special use permits.
6. Human health and safety plan.

#### 13.1.2 Operational Contracts and Agreements

All large contracts associated with the operation are being managed by the GNP.

An agreement with IC and the GNP as to respective roles and responsibilities will be required prior to implantation.

#### 13.1.3 Project Reviews and Meetings

Monthly meetings will occur from March-August of the implementation year. From 1 September, meetings will be every week until the operation commences. The Project Coordination Team: Project Director, Project Manager, Logistics Manager, Baiting Chief and Commensal Manager and Mitigation

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<sup>28</sup> Very similar or identical aspects to points 1-5 have been scrutinized, approved and successfully undertaken for previous baiting operations preparing for the eradication of rodents within the Galápagos. Point 6 has been addressed for operational staff on previous projects, but will need to be adapted to function for a community and in compliance with GBA and Ministry of Health standards.

Manager will attend the meetings until 1 September, after which all staff concerned will be involved in more general meetings to inform everyone of progress and identify tasks required.

During field operations involving bait application, meetings shall be daily with at least the Project Manager, Implementation Advisor, Baiting Chief and Managers, GIS Manager, Logistics Manager, and Community Liaison. Conservation Measures Manager and Mitigation Manager will attend as necessary.

During all meetings team member input will be encouraged. This will aim to build ownership, comradery and create opportunity to improve the project process.

#### **13.1.4 Community meetings**

Frequency and structure to be determined from additional stakeholder involvement.

#### **13.1.5 Steering committee meetings**

To be determined from additional stakeholder involvement.

#### **13.1.6 Partner meetings**

To be determined from additional stakeholder involvement.

#### **13.1.7 Personnel (arrival, lodging, communications)**

All off-island personnel will arrive via commercial airline to Baltra Airport. Routine boat charters and GNP boats will provide transportation as needed between Santa Cruz Island and Floreana. Drone pilots and support staff will accompany the UAV helicopters that arrive to the island. Lodging will be supported by local accommodations. Communication will occur by means of the following items: radio, wifi communication apps, satellite phone.

#### **13.1.8 Bait**

Bait will be packaged and loaded into shipping containers at Bell Labs in Madison, Wisconsin, USA. The shipment will then go via truck and ship to Ecuador. A logistics plan describes in detail how bait will find its way to the Floreana loading site. The development of this plan is awaiting the development of improved dock infrastructure on Floreana.

#### **13.1.9 Operational Communications**

The local GNP communications network will be utilized to support the project. This network is already in place and functional. Multiple channels will be necessary to accommodate ground, and commensal activities. Once acquired, specific information about the radio network, frequencies, repeaters, etc. will be included within a communications plan. If possible, the trap monitor system and camera uploads will be integrated into the existing system.

### **13.2 Post-implementation / Demobilization**

All equipment, field gear, and supplies delivered to Floreana will be removed from the island upon project completion. Equipment leaving the island will be packaged in a manner that meets all biosecurity requirements and allows for inspections to occur.

### **13.2.1 Debrief**

After the operation, debriefs will occur with the entire eradication team, then the management team. During periods where both rodent and cat operations are ongoing, separate debriefs will occur before the management team debrief. 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 operation to optimize success in future operations. If available, a translator that is not part of the project's management staff will be used to allow management staff to fully engage in each debrief. Outside of designated meeting times, feedback will be encouraged to occur independently at an individual's discretion to accommodate for differing personality types or sensitive subject matter.

### **13.2.2 Personnel**

All personnel will depart the island by boat.

### **13.2.3 Bait**

After supplemental coverage has occurred, any remaining bait that is not stored at GNP as a contingency for rodent invasions will be disposed of following label regulations, which include incineration and disposal at an approved waste disposal facility. It is recommended by the manufacturer that rodent bait stored longer than a year should be disposed of as its palatability to rodents will be in question.

Packaging material associated with bait (liners, bulk bags, ox boxes, and pallets) will be burned in compliance with the bait label. Any cardboard products that have not come into contact with bait may be recycled if possible. Although this is the case, corrugated cardboard is a significant risk to biosecurity and extra precautions must be taken for safe transport including "bug-bombing" within an enclosed container and empty shipping containers can be used for this purpose.

### **13.2.4 Equipment and Supplies**

Equipment and supplies pertinent to biosecurity on Floreana will remain in place or available for use. All other equipment and supplies will be redistributed and exported from Ecuador if necessary. Equipment staying in the Galápagos but not on Floreana will be stored at the GNP warehouses and in the empty shipping containers which are housed at GNP headquarters near the dog kennels.

### **13.2.5 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 partners including Island Conservation. Reports for mitigation activities will be produced separately and are the responsibility of mitigation managers. Supplemental operational reports will be requested from the UAV operations staff.

## **14. EQUIPMENT LIST**

A detailed list of equipment necessary for the eradication of rodents and cats from Floreana can be located on the IC server within the most up-to-date Floreana Master Blue Budget. Specific details concerning each product or service type, quantity, and time of purchase can be found within the purchase detail tab.

## 15. OPERATIONAL TEAM

Successful implementation of the eradication on Floreana will require a cohesive team effort to attain the objectives of the project. The team will be led by a Project Manager, who has the technical knowledge for managing an invasive species eradication operation and who is supported by appropriately skilled staff. The operational command chart demonstrates the chain of communication and level of responsibility of project staff (*in prep, to be included once available*).

Role	Name	Responsibilities
Project Director	GNP employee	The Project Director is responsible for government authorizations, ship contracts, local permissions and liaison with Galápagos National Park personnel. The Project Director is responsible, overall, for the Project. The Project Director will have the ultimate say in major decisions on the Project. The Project Director is employed by the Galápagos National Park (PNG) and based in regional offices in Puerto Ayora.
Incident Advisory Group	Includes members of GNP, ABG, Junta Parroquial, and IC and the Project Director, Project Manager, Baiting Chief, Commensal Manager	The Advisory Team, composed of 3 personnel with extensive eradication experience, will provide the Project Manager with real-time review of and advice on operational situations.
Project Manager	Victor Carrion	The Project Manager is responsible for overview of the implementation, ensuring that project staff have been supplied safety information and has oversight of all field operations and partner communications. The Project Manager will liaise with Island Conservation's Technical Advisory Group and non-governmental stakeholders, and will be on site during the entire aerial baiting operation. The Project Manager will be fluent in Spanish and have capacity to operate in English.
Implementation Advisor Back up Project Manager	Chad Hanson	The Implementation Advisor will have experience in lead roles on both rodent and cat eradications. The Implementation Advisor will provide advice and guidance to the Project Manager. The Implementation Advisor will act as replacement Project Manager if they become unavailable to fulfill the duties as the PM for any reason. The implementation manager will be based full-time in the Galápagos throughout implementation. The Implementation Advisor will be bi-lingual.

Baiting Chief	Jose Luis Cabello	<p>The Baiting Chief will oversee the Commensal Manager, GIS Manager, and Aviation Manager. Bait bucket configuration for each flight will be coordinated by the Baiting Chief in conjunction with the GIS Manager and Aviation Manager. The Baiting Chief is responsible for coordinating all baiting teams to ensuring a thorough broadcast of bait has been achieved according to this plan. The Baiting chief is responsible for proposing suitable baiting alternatives and completing change notice / justification forms if changes to the plan are necessary. The baiting chief will maintain up-to-date weather forecast information. The Baiting Chief will be bi-lingual</p>
Commensal Manager	Juan Pablo Mayorga	<p>The Commensal Manager will establish a working relationship with the Floreana community and ensure that Floreana's environment is conducive to a successful eradication, e.g., the waste management system is effective, the risk posed by crops has been mitigated, and the risk to non-target domestic animals has been mitigated. The Commensal Manager will work directly with the community liaison to manage on-island questions and concerns. The Commensal Manager will organize, implement, and follow-up on all manual bait station application, and trapping within residences. The Commensal Manager will also be responsible for providing guidelines to establish sufficient rodent station coverage, and to communicate the progress of work to the Baiting Chief.</p> <p>This position will be responsible for the safety of the rodent station team.</p>
Rodent Station Team	Local partner/community staff	<p>The Rodent Station Team will establish, activate, maintain, and deactivate all bait stations and traps. The Rodent Station Team will be a mix of partnership staff and will report to the Commensal Manager.</p>
Hand Broadcast Manager	Freddy Villamar	<p>The Hand Broadcast Manager will implement all manual bait application, including plot establishment, bait application to plots and uninhabited structures, and plot cleanup. The Hand Broadcast Manager is also responsible for providing guidelines on how to identify buffers, uninhabited structures, and communicating the progress of work to the Baiting Chief.</p> <p>This position will be responsible for the safety of the hand broadcast team.</p>

Hand Broadcast Team	TBD	The Hand Broadcast Team will establish the hand baiting plots, bait within the plots, cleaning up the plots after baiting is finished, and bait uninhabited structures. The Hand Broadcast Team will report to the Hand Broadcast Manager.
Community liaison	Carolina Torres	<p>The Community liaison will serve as the point of contact for Floreana residents. The Community liaison will arrange community meetings, distribute project information (i.e. pamphlets, newsletters, etc.), and will be responsible for insuring residents are aware of project goals and intended outcomes. The Community liaison will regularly assess buy-in and monitor the general feeling of residents throughout the planning and implementation phases of the project.</p> <p>This position will replace the Commensal Manager if necessary.</p>
Logistics Manager	Freddy Villamar	The Logistics Manager is responsible for permissions and logistics regarding the importation of bait and coordinating bait, ships, boats (fibras), field supplies (including water and food) and helicopter logistics. The Logistics Manager must be based in Puerto Ayora or on Floreana.
Aviation Manager	Samual Vye	<p>The Aviation Manager is responsible for UAV helicopter operations and coordination. The Helicopter operations team will consist of 6 pilots, an operations manager, a maintenance controller, and a loading team to support bait loading. All staff aside from the ground crew will be contracted with the UAV. Ground crew personnel will be a mix of partnership staff.</p> <p>The Aviation Manager will be responsible for the aerial broadcast of the bait and data transfer of bait flight lines from the onboard tracking 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. All pilots will adhere to the relevant Ecuadorian Civil Aviation (DGAC) flying regulations and safety requirements. The operational manager will ensure that all required maintenance and servicing is carried out and spare parts are readily available in case of any reasonably expected breakdown.</p>
Operations Manager	TBD (UAV crew)	The Operations Manager is responsible for managing the Maintenance Controller and UAV Loading Team. The Operations manager will product and present recommended baiting lines across bait blocks, record bait

		<p>bucket configuration (disk size, presence of deflector), direct and record quantity of bait sent on each flight, and ensure bait was available for distribution throughout each flight.</p> <p>This position will be responsible for the safety of the load site and associated staff.</p>
Maintenance Controller	TBD (UAV crew)	<p>The Maintenance Controller will be responsible for maintain all UAV and associated equipment, initial setup of UAV and baiting apparatus, and insuring functionality of flight management software and tracking systems. Adjustment to bait bucket configuration and refueling will be conducted by the bucket technician. Monitoring of the bucket function will occur with cameras. This data will be reviewed in real-time by UAV pilots.</p>
UAV Pilot (x6)	TBD (UAV crew)	<p>UAV Pilots are responsible for conducting safe and effective flights of UAV helicopters throughout the operation. Pilots will conduct takeoff, landing, monitor automated flight, and monitor live video feed to ensure bait application is occurs as required.</p>
UAV Loading Team	Local partner staff	<p>The UAV Loading Team is responsible for conducting bait bucket filling operations, managing bait transport from containers to the landing zone, and policing debris and materials associated with the bait loading operation.</p>
GIS specialist lead	David Will	<p>The GIS Manager will support all spatial operations as well as evaluate proposed UAV bait application flight lines to ensure no gaps in coverage. The GIS Manager will record and process rodent and cat flight data and produce bait density maps for the Project Manager and Baiting Chief to approve. The GIS Manager will also create and manage the probability of detection database. The GIS Manager is experienced in the use of the GIS hardware and software (e.g. TracMap). The GIS Manager will coordinate the bait bucket calibrations and oversee the GIS assistant.</p>
GIS assistant	TBD	<p>The GIS assistant will set up and manage data associated with the hand broadcast, structure broadcast, bait stations and traps, and the camera and trap network. The GIS assistant will provide support on tasks as needed by the GIS specialist lead.</p>
Mitigation Manager	Paula Castano	<p>The Mitigation Manager is responsible for planning and coordinating a team to implement a multispecies mitigation strategy including capture, holding, release,</p>



		and post-release monitoring. The Mitigation Manager will liaise with species experts on aspects related to health and captive holding. The mitigation manager will be charged with the care of captive animals on and off Island. The Mitigation Manager is also responsible for planning and if needed implementing additional mitigation plans if deemed necessary.
Mitigation team	TBD	The mitigation team will perform all duties necessary to implement actions described within the non-target mitigation plan. All team members will report to the Mitigation Manager.
Safety Officer	TBD	The Safety Officer will be responsible for overseeing the safety plan, ensuring safety related materials are distributed to staff and the community, and for facilitating safety briefings. This position is also responsible for the project team's adherence to safety protocols and regulations. The Safety Manager will report directly to the Project Manager and must be bilingual.
Conservation Measures Manager	TBD	The Conservation Measures Manager is responsible for designing and implementing the monitoring of native and endemic species (conservation measures).

## 16. TASK SCHEDULE

A detailed list of tasks necessary for the eradication of rodents and cats from Floreana can be located on IC's SharePoint site. Specific details concerning each phase, general activity, specific activity, the status of completion, initiation and completion dates. This schedule remains as a living document, indicates what has to be done, when, and by whom, and continues to develop throughout the lifecycle of this project.

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## Appendix A - Rodent Station Task Sheet

### - Floreana Rodent/Cat Eradication Task Sheet -

**Task Title:** Hand Baiting – Commensal Area

**Reports to:** Baiting Chief, Jose Luis Cabello

**Team Leader:** Juan Pablo Mayorga

**Staff Involved:** TBD

**Location:** Inhabited areas across Floreana

#### Task Description

The commensal hand baiting team's responsibility is to place a sufficient number of Conservation 25D (Formula 2) pellets and or Contrac BLOX into every structure on Floreana so that every mouse or rat present at that location is exposed to a lethal quantity of bait. Supplemental traps will be installed if necessary. Bait quantity will target 120g of bait per station

Open trays, to be used as bait stations, will be filled with bait and then placed into every enclosed space on the island. 120g of baits will be placed into each tray which will then be positioned so that rodents can freely access the bait.

A recommended number of bait stations to be deployed at each site as per the relevant individual property management plan is based on the size of the structure but individual judgement will be required. As a general rule there should be at least one bait station per room. If there is any doubt place additional bait stations. Bait stations or trays must also be placed in all attics and subfloor spaces.

Hand baiting team members will be divided between highland and lowland commensal sites. Up to 4 hand baiting teams will each be allocated to the lowland town area and up to 4 teams will be allocated to the highland farms. Team members will be required to complete the work in less than two days. Each team will be equipped with a means of transport and the materials to do the job. It is the team leader's responsibility to ensure that all teams are appropriately equipped.

All teams will be provided with a handheld GPS pre-loaded with the waypoints for all structures on the islands. Aerial photos with all structures marked will also be supplied. Team members will record on the digital checklist the location of all bait stations within each structure to facilitate their location by subsequent teams. Unless the bait station is readily visible, a short description or a diagram of where the bait station is located is required.

If access to a structure cannot be gained, contact must first be made with the team leader who will discuss the issue with the Baiting Chief prior to providing direction on what to do. All attempts to gain permission must be made before resorting to other means. If the keys cannot be located and entry must be forced a before and after photo must be taken and damage kept to a minimum. Before leaving the site a letter must be left for the owner and a note made on the checklist of the action taken and the damage incurred.

Regular progress updates and any problems should be relayed via radio to the team leader. Empty plastic bags should be kept for reuse as bait stations will be refilled. Bait stations will be refilled by team members according to the project timeline (Figure 13) and then again during the second and third aerial drops.

#### Included in scope

- Hand baiting all structures within team's designated sectors
- Recording the number and location of all bait, bait stations, and traps deployed
- Recording the fate of all bait put out with the use of a standardized spreadsheet.
- Storing empty plastic bags for reuse
- Cleaning up any spills immediately
- Advising any members of the public (town members or tourists) that the island is being baited and relaying this information to the community liaison
- Replacement of consumed/unsuitable bait

#### Standards:

- ☐ The team leader is responsible for the team's health and safety and welfare.
- ☐ The hand baiting team will follow the "Safe handling of Pesticides SOP" at all times.
- ☐ All staff will put on the correct safety gear before commencing work and will remove it prior to entering staff accommodations. A storage site for safety gear will be established prior to the operation. Gloves should also be removed and hands washed prior to eating food.
- ☐ Ziplock plastic bags will be used to transport bait unless advised otherwise.
- ☐ Bait deployed in bait stations must be in good condition and not crushed, damp or mouldy.
- ☐ Any bait spilled within a structure should be picked up immediately.
- ☐ Any bait collected to be disposed of appropriately as per protocols
- ☐ Sufficient bait stations will be placed in all structures across the team's sector of responsibility that all rodents within those structures have access to a lethal dose of bait.

#### Equipment Required:

- ☐ Safety gear – rubber boots or leather boots, white overalls or a long sleeved shirt, Nitrile gloves
- ☐ First Aid kit for each sector (highland and lowland areas)
- ☐ 1 VHF radio and cell phone for the team leader
- ☐ Radio per team of two people
- ☐ Hand held GPS unit with pre-programmed waypoints per two people
- ☐ Group folder containing aerial photos, map, check lists
- ☐ Flashlight or headlamp per team of two

- ☐ Open tray bait station materials
- ☐ Sharpie for marking tins
- ☐ Rodent bait
- ☐ Pencils
- ☐ Eraser
- ☐ Water supply for washing hands (1.5 l bottles) and soap
- ☐ Letters to be left if forced entry is required
- ☐ Digital camera per team of two
- ☐ Storage area for safety gear

**Further information:** Reference Product Labels (Brodifacoum, Para-aminopropiophenone, Aluminum Phosphide Fumigant)

## Appendix B – Bait Availability Protocols / Hand Broadcast Monitoring

### Transect Monitoring

**Personnel requirements:** 2 personnel to establish plots, 2 personnel to flag bait pellets, 1-2 personnel to monitor daily uptake.

**Equipment requirements:** GPS units, notebooks, pin flags (3 colors, 1 for each application), 30 m transect tapes, bait availability reference table, nitrile gloves.

**Form:** Bait availability.

#### Methods:

##### Transect establishment

Prior to baiting operations, 40 bait availability transects will be established.

12 transects will be established in the highlands, 12 in the lowlands, 6 along the coastal perimeter, 5 in the highland agricultural environment, 5 in town.

Transect area will measure 25 m x 1 m.

The perimeters of transects will be delineated using doubled pin flags set at each corner outlining the transect.

##### Transect deployment

##### *1<sup>st</sup> aerial broadcast*

1-2 personnel will be deployed to each site during aerial baiting.

Once the area has been aerially baited, personnel will travel the length of the transect, marking each pellet within the 25 x 1 meter transect with a consistent color of pin flag (pin flag color to be determined immediately prior to transect deployment based on color availability)

The target bait density on-the-ground will vary according to site with 10kg/ha in the highland and agricultural environment, 9kg/ha along the coastal perimeter, and 6kg/ha in the lowland habitat and town. The bait availability reference table will be used to determine the appropriate number of pellets for the area of the transect.

*Monitoring plot pellet quantities representing prescribed application rate.*

Broadcast Rate	Average quantity of pellets within each 25m <sup>2</sup> transect (9.5mm / 1g)
10 kg/ha	25 pellets
9 kg/ha	22 pellets
6 kg/ha	15 pellets



Any pellets occurring within the transect above the appropriate number will be removed from the transect and relocated to outside the transect; associated flags will also be removed.

If too few pellets are found within the transect, the appropriate number of pellets should be located within the surrounding area and added to the transect and marked with a flag.

### *2<sup>nd</sup> aerial broadcast*

1 - 2 personnel will be deployed to each site during aerial baiting.

Once the area has been aerially baited, personnel will travel the length of the transect, marking each new pellet with a pin flag.

Should pellets remain in the transect from the 1<sup>st</sup> aerial broadcast, these pellets and corresponding flags must be left in situ and a different color pin flag must be used to mark pellets applied during the 2<sup>nd</sup> aerial broadcast.

The target bait density on-the-ground will be identical to the first bait application. Pellet numbers will vary according to site with 10kg/ha in the highland and agricultural environment, 9kg/ha along the coastal perimeter, and 6kg/ha in the lowland habitat and town.

Any pellets occurring within the transect above the appropriate number will be removed from the transect and relocated to outside the transect; associated flags will also be removed.

If too few pellets are found within the transect, the appropriate number of pellets should be located within the surrounding area and added to the transect and marked with a flag.

### *3<sup>rd</sup> aerial broadcast*

1 - 2 personnel will be deployed to each site during aerial baiting.

Once the area has been aerially baited, personnel will travel the length of the transect, marking each new pellet with a pin flag.

Should pellets remain in the transect from the 1<sup>st</sup> or 2<sup>nd</sup> aerial broadcast, these pellets and corresponding flags must be left in situ and a different color pin flag must be used to mark pellets applied during the 2<sup>nd</sup> aerial broadcast.

Only the highland, coastal perimeter, and certain high-risk sites will receive a 3<sup>rd</sup> bait broadcast. Pellet numbers will vary according to site with 10kg/ha in the highland and agricultural environment, 9kg/ha along the coastal perimeter.

Any pellets occurring within the transect above the appropriate number will be removed from the transect and relocated to outside the transect; associated flags will also be removed.

If too few pellets are found within the transect, the appropriate number of pellets should be located within the surrounding area and added to the transect and marked with a flag.

#### *Transect monitoring*

Each transect will be monitored daily at approximately the same time until all pellets have disappeared.

Any flags found without pellets below them will be removed and this number recorded.

Additionally, the number of pellets remaining in each transect will be recorded on data sheets.

*Recording both numbers will avoid misunderstanding as to what data was collected.*

#### **Hand broadcast monitoring**

**Personnel requirements:** 1-2 personnel measure and assessment hand broadcast rates.

**Equipment requirements:** GPS units, notebooks, calculator, 1m diameter hoops, bait application reference table, nitrile gloves.

**Form:** Bait availability.

#### **Methods:**

During the initial treatment of the hand application zones, one to two people will spot-sample the real-time application rate by following the baiting line, repeatedly tossing a 1m hoop out into the landscape, and counting pellets that are within the 1m circle plot. Tossing the 1m hoop will result in a random sampling of the local area. If vegetation is present and the hoop does not land flush with the ground, some interpretation of the hoop's perimeter will be necessary. Additionally, vegetation and leaf-litter may need to be moved to ensure thorough assessment can occur and detection error is minimized. Major deviations ( $\pm 25\%$ ) below or above the target application rate will be reported to the Hand Application Manager, who will then instruct the baiting line on what is required to achieve an even bait spread at each baiting point. Major deviations below the target application will trigger a re-application of the site. Spot-sampling for baiting accuracy will occur during all hand applications to ensure accuracy throughout the project.

## Appendix C – Change Notice / Justification Form

### ***Change Notice / Justification form***

***Purpose:*** Describe and capture changes to original plan and reasoning for plan deviation.

***Need:*** Facilitate risk management, post-operational review, and influence future operations.

***Trigger:*** Any change to original planning which requires a re-evaluation of risk.

***Change description:***

*Planned action:*

*New action:*

***Justification:***

***Submitted by:***

***Date:***

*Signature:*

***Approved by:***

***Date:***

*Signature:*

*\*Update with final bait labels once available*

**CONTENIDO NETO: 22.6 kg (50 lbs)**  
**NET WEIGHT: 22.6 kg (50 lbs)**

Lot No.: XXXXX  
DOM: XX-XX-XX



GEN313850

2282

# PESTICIDA DE USO RESTRINGIDO

For use exclusively in conjunction with Parque Nacional Galápagos, Ecuador

## FINAL®

ALL-WEATHER BLOX™

KILLS RATS & MICE

**Mata a ratas noruegas resistentes a warfarina y ratones caseros Resistentes a la humedad • Resistente al moho**

Ratas noruegas, ratas negras y ratones domésticos pueden consumir una dosis fatal en la alimentación de una noche, apareciendo los primeros roedores muertos cuatro o cinco días después del primer consumo.

INGREDIENTE ACTIVO:  
Brodifacoum (CAS #56073-10-0) ..... 0.0095%  
OTROS INGREDIENTES: ..... 99.9905%  
Contains Denatonium Benzole TOTAL 100.000%

## MANTÉNGASE FUERA DEL ALCANCE DE LOS NIÑOS CUIDADO

PRIMEROS AUXILIOS  
MANTENGA LA ETIQUETA CON USTED CUANDO RECIBA TRATAMIENTO

En señale a:	<ul style="list-style-type: none"> <li>• Una persona que esté en mal estado de salud.</li> <li>• Una persona que esté en mal estado de salud.</li> <li>• Una persona que esté en mal estado de salud.</li> </ul>
En señale a:	<ul style="list-style-type: none"> <li>• Una persona que esté en mal estado de salud.</li> <li>• Una persona que esté en mal estado de salud.</li> <li>• Una persona que esté en mal estado de salud.</li> </ul>
En señale a:	<ul style="list-style-type: none"> <li>• Una persona que esté en mal estado de salud.</li> <li>• Una persona que esté en mal estado de salud.</li> <li>• Una persona que esté en mal estado de salud.</li> </ul>

## PRECAUCIÓN NO CIVO PARA HUMANOS Y ANIMALES DOMÉSTICOS

Evite el contacto directo con el producto. Evite el contacto con el agua. Evite el contacto con el agua. Evite el contacto con el agua.

## RIESGOS AMBIENTALES

Este producto es tóxico para los peces y los animales acuáticos. Evite el contacto con el agua. Evite el contacto con el agua. Evite el contacto con el agua.

## EQUIPO PROTECTOR PERSONAL

- Pantalones largos y mangas largas
- Guantes
- Zapatos cerrados
- Lentes protectores contra el viento

## RESTRICCIONES DE USO

Este producto debe usarse únicamente en las áreas designadas en las etiquetas y en las instrucciones de uso. Evite el contacto con el agua. Evite el contacto con el agua. Evite el contacto con el agua.

## ALMACENAMIENTO Y DISPOSICIÓN DE DESECHOS

Almacenamiento: Almacene en un lugar seco y fresco, lejos de la humedad y de la luz solar. Evite el contacto con el agua. Evite el contacto con el agua. Evite el contacto con el agua.

## USO DEL PRODUCTO

El uso de este producto debe seguirse de acuerdo con las instrucciones de uso. Evite el contacto con el agua. Evite el contacto con el agua. Evite el contacto con el agua.

PROHIBIDA SU VENTA

CONTENIDO NETO: **8.2 kg (18 lbs)**  
NET WEIGHT:



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Knoxville, TN 37604-1800  
N.C. www.vmc.com

GEN332018

Trim Line - Final trim size 8.5" x 9"

# RESTRICTED USE PESTICIDE

For use only in conjunction with Galápagos National Park, Ecuador

## FINAL®

ALL-WEATHER BLOX™

KILLS RATS & MICE

**Kills Warfarin Resistant Norway Rats And House Mice Moisture Resistant • Mold Resistant**

Norway rats, roof rats, and house mice may consume a lethal dose in one night's feeding with first dead rodents appearing four or five days after feeding begins.

ACTIVE INGREDIENT:  
Brodifacoum (CAS #56073-10-0) ..... 0.0095%  
OTHER INGREDIENTS: ..... 99.9905%  
Contains Denatonium Benzole TOTAL 100.000%

## KEEP OUT OF REACH OF CHILDREN CAUTION

FIRST AID  
HAVE LABEL WITH YOU WHEN OBTAINING TREATMENT ADVICE

Inhalation:	<ul style="list-style-type: none"> <li>• Call a doctor for advice.</li> <li>• Give person 1 cup of water to drink.</li> <li>• Do not induce vomiting.</li> </ul>
On skin:	<ul style="list-style-type: none"> <li>• Take off contaminated clothing. Take skin immediately with water for 15-20 minutes. If rat or mouse, take to medical assistance.</li> </ul>
Ingestion:	<ul style="list-style-type: none"> <li>• Give person 1 cup of water to drink for 15-20 minutes. Remove contaminated clothing. Do not induce vomiting. If rat or mouse, take to medical assistance.</li> </ul>

NOTICE: PHYSICIANS: Consult the product label for first aid instructions. If ingested, victim should be kept hydrated with water. If inhaled, victim should be kept hydrated with water.

## PRECAUTIONARY STATEMENTS HAZARD TO HUMANS AND DOMESTIC ANIMALS

May be harmful if swallowed. Causes moderate eye irritation. Avoid contact with skin, eyes or clothing. Wash thoroughly with soap and water after handling.

## PERSONAL PROTECTIVE EQUIPMENT (PPE)

- Long pants and long sleeves shirt
- Gloves
- Shoe coverings
- Safety glasses for eye protection

## USE RESTRICTIONS

This product is for use only in the areas designated on the label and in the instructions of use. Avoid contact with water. Avoid contact with water. Avoid contact with water.

## STORAGE AND DISPOSAL

Storage: Store in a cool, dry place, away from moisture and light. Avoid contact with water. Avoid contact with water. Avoid contact with water.

## DIRECTIONS FOR USE

The use of this product for purposes other than those stated on the label is void. Always use label and follow directions of use. Always use label and follow directions of use. Always use label and follow directions of use.

NOT FOR SALE

Lot No.: **K37916**  
DOM: 10-23-18

1325 2