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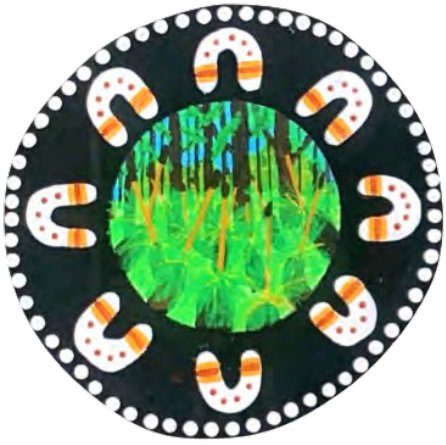
FLYING-FOX ROOST MANAGEMENT PLAN

October 2024

Livingstone
SHIRE COUNCIL

Acknowledgements



Ecosure acknowledge the Traditional Custodians of the lands and waters where we work. We pay deep respect to Elders past and present who hold the Songlines and Dreaming of this Country. We honour and support the continuation of educational, cultural and spiritual customs of First Nations peoples.

We would like to thank Livingstone Shire Council for their assistance during development of the flying-fox roost management plan, particularly John Wyland and Leise Childs. We gratefully acknowledge those that partook in the online survey and stakeholders and residents from nearby the roosts for participating in the community consultation meetings and providing feedback which has informed planned management actions.

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Acronyms and abbreviations

ABLV	Australian bat lyssavirus
ACP Act	*Animal Care and Protection Act 2001* (Queensland)
BFF	Black flying-fox (*Pteropus alecto*)
CMS	Canopy-mounted sprinklers
Council	Livingstone Shire Council
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAF	Department of Agriculture and Fisheries (Queensland)
DAWE	Department of Agriculture, Water, and the Environment (Commonwealth)
DCCEEW	Department of Climate Change, Energy, the Environment and Water (Commonwealth)
DES	Department of Environment and Science (Queensland)
DESI	Department of Environment, Science and Innovation (previously Department of Environment and Science) (Queensland)
DoE	Department of Environment (Commonwealth)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
EVNT	Endangered, vulnerable and near threatened
FFRMP	Flying-fox roost management permit
GBR	Great Barrier Reef
GHFF	Grey-headed flying-fox (*P. poliocephalus*)
the Guideline	Flying-fox Roost Management Guideline (Queensland)
HeV	Hendra virus
HSE	Heat stress event
LGA	Local government area
Low Impact COP	Code of Practice – Low impact activities affecting flying-fox roosts (Queensland)
LRFF	Little red flying-fox (*P. scapulatus*)
Management COP	Code of Practice – Ecologically sustainable management of flying-fox roosts (Queensland)
MNES	Matters of national environmental significance
MSES	Matters of state environmental significance
NC Act	*Nature Conservation Act 1992* (Queensland)
NFFMP	National Flying-Fox Monitoring Program
NSW	New South Wales
Planning Act	*Planning Act 2016* (Queensland)
the Planning Regulation	Planning Regulation 2017 (Queensland)

PPE	Personal protective equipment
Qld	Queensland
RE	Regional Ecosystem
the Referral Guideline	Referral Guideline for Management Actions in Grey-headed and Spectacled Flying-fox Camps (Commonwealth)
SEQ	South East Queensland
SoMI	Statement of Management Intent
UFFMA	Urban Flying-fox Management Area
VM Act	*Vegetation Management Act 1999* (Queensland)
WHA	Wildlife Health Australia

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1 Introduction

This Flying-fox Roost Management Plan (the Plan) provides Livingstone Shire Council (Council) with a framework to manage issues associated with the four major flying-fox roosts in the local government area (LGA) – Marlborough, Yeppoon, Emu Park and Keppel Sands. Three species of flying-fox have been recorded within the Livingstone Shire LGA: the grey-headed flying-fox (*Pteropus poliocephalus; GHFF*) black flying-fox (*P. alecto*; BFF) and little red flying-fox (*P. scapulatus*; LRFF) (seasonal visitor). BFF and LRFF have been recorded at all four roosts, whereas GHFF were only recorded at Emu Park and Keppel Sands in August 2019. The Plan includes a range of short- and long-term options to minimise conflict between humans and flying-foxes, improve awareness, and conserve flying-foxes and the critical ecosystem services they provide.

This Plan has been developed in accordance with relevant legislation and considers feedback received during stakeholder consultation. Council acknowledges the impact flying-foxes can have on nearby residents and is committed to implementing management actions that minimise impacts while also encouraging coexistence. Council intends to manage flying-fox roosts/camps on Council-owned or managed land but may also provide advice and assistance to residents and landowners affected by a flying-fox roost on privately-owned land. Where a roost spans Council-owned and private land, Council will work cooperatively with landowners to develop joint mitigation actions.

Roosts and camps have legislatively different definitions based on historical breeding activity and differing levels of protection, see also Appendix 1. Historical data on flying-fox breeding is not currently available to enable determination of each of the roosting sites in this Plan; as such all sites are collectively referred to as roosts herein, however noting some may actually be camps. It is important to note that new roosts may be established, and that roosting has temporarily or seasonally occurred at other sites across the LGA (e.g., Mount Chalmers; Iwasaki Road wetland; Todd Avenue, Yeppoon). This determination should be made by a flying-fox knowledgeable person prior to any management.

1.1 Stakeholders

Stakeholders with an interest in the Livingstone Shire roost sites and/or flying-foxes include:

- residents/businesses
- Traditional Custodians - the First Nations Darumbal, Woppaburra and Barada Kalbalbara Yetimarala peoples
- Livingstone Shire Council
- Department of Environment, Science, and Innovation (DESI)
- conservation groups, researchers, and community groups such as Batcare Capricornia
- community visitors and businesses in/around Livingstone Shire.

Feedback has been sought from many of these stakeholders through consultation over the past several years. Prior to the development of this Plan, Council initiated three community consultation meetings with key stakeholders including business owners and residents living and working close to roosts. An online survey was open to all members of the local government area between January and March 2024. Results from these consultations are included in Section 4 and were considered in the development of the Plan.

1.2 Legislation overview

Flying-foxes are protected native wildlife that provide a critical ecological role in long-distance seed dispersal and pollination. As such, there is a range of legislation and policy that governs how flying-foxes and their habitat can be managed in Queensland (Qld). As native animals, all flying-foxes and their roost habitat are protected under State legislation. GHFF are a threatened species and also protected under Commonwealth legislation. An overview of key legislation is provided below.

Commonwealth

The Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) provides protection for the environment, specifically matters of national environmental significance (MNES). A referral to the Commonwealth Department of Climate Change, Energy, the Environment and Water (DCCEEW) is required under the EPBC Act for any action that is likely to significantly impact on an MNES. GHFF are listed as a vulnerable species under the EPBC Act, meaning it is classified as an MNES and has previously been recorded within the LGA.

Nationally important GHFF roosts are afforded additional protection in line with the Referral Guideline for Management Actions in Grey-headed and Spectacled Flying-fox Camps (the Referral Guideline) (DoE 2015). To be considered a nationally important GHFF roost, a roost must have had more than one influx of ≥10,000 GHFF within the last ten years or have been occupied by more than 2,500 GHFF permanently or seasonally for the last ten years. The Livingstone Shire roosts have recorded infrequent, relatively low numbers of GHFF in the past ten years and therefore are not classified as nationally important flying-fox roosts.

State

All flying-foxes and their roost habitat are protected under the Qld *Nature Conservation Act 1992* (NC Act). Under this legislation, administered by the Department of Environment, Science and Innovation (DESI, formerly Department of Environment and Science (DES)), it is an offence to harm the animals, or disturb flying-foxes from daytime roosts without approval.

In Qld, local governments are authorised under the NC Act to manage roosts in areas subject to an urban zoning under a council planning scheme, inclusive of a one-kilometre buffer around such areas. This area of management is known as the Urban Flying-Fox Management Area (UFFMA).

Local governments have an ‘as-of-right’ authority under the NC Act to manage flying-fox roosts in mapped UFFMAs in accordance with *the Code of Practice – Ecologically sustainable management of flying-fox roosts* (Management COP) (DES 2020a). The Flying-fox Roost Management Guideline (the Guideline) (DES 2020b) has also been developed to provide local government with additional information that may assist decision making and management of flying-fox roosts. Councils are required to apply for a flying-fox roost management permit (FFRMP) to manage flying-fox roosts outside an UFFMA, or for management actions not specified in the Management COP. It must be noted that this ‘as-of-right’ authority does not oblige Council to manage flying-fox roosts and does not authorise management under other relevant sections of the NC Act or other legislation, such as the *Vegetation Management Act 1999* (VM Act).

Private land holders are required to apply for a FFRMP for any management directed at roosting flying-foxes, or likely to disturb roosting flying-foxes other than:

- certain low impact activities (e.g. mowing, minor tree trimming) if undertaken in accordance with the Code of Practice – Low impact activities affecting flying-fox roosts (Low Impact COP) (DES 2020c)
- instances where Council is enacting their as-of-right authority.

In addition, the Qld *Animal Care and Protection Act 2001* (ACP Act) applies to all living vertebrate animals, including wildlife. To comply with the ACP Act, flying-fox management actions must not cause mental or physical suffering, pain or distress.

Native vegetation is also protected under various legislation, including the NC Act and in some cases the VM Act and *Planning Act 2016* (Planning Act). Clearing of vegetation in core koala habitat and/or a koala priority area is prohibited, with few exemptions (see Schedule 21 and 24 of the Planning Regulation 2017 [the Planning Regulation] for exempted works). Permits/approval may be required for trimming or clearing protected habitat/plants.

Key Commonwealth and State legislation specific to flying-fox management is summarised in further detail in Appendix 1. Other legislatively significant ecological values of the roost sites that need to be considered in management are outlined in Section 3.

Local

Council endorsed a Statement of Management Intent (SoMI) in 2018 for Flying-fox Roost Management in Livingstone Shire for the purpose of providing a clear and ethical direction regarding the management of flying-foxes occurring in UFFMA within the LGA. Council recognises the ecological importance of flying-foxes and their valuable contribution to sustaining biodiversity through pollination and seed dispersal of native vegetation whilst considering the health and wellbeing of the community.

Council will consider appropriate non-lethal management actions, in accordance with the Management COP, to manage flying-foxes occurring on Council owned or controlled lands where their presence significantly impacts residents. Public educational resources will also be developed to assist the community in understanding human-wildlife coexistence. Council will support the community where flying-foxes occur on non-Council land however roost management requests will be referred to DESI.

2 Flying-fox ecology and impacts

2.1 Ecological role

Flying-foxes, along with some birds, make a unique contribution to ecosystem health through their ability to move seeds and pollen over long distances (Southerton et al. 2004, DES 2020d). This contributes directly to reproduction, regeneration, and viability of forest ecosystems (DAWE 2021). It is estimated that a single flying-fox can disperse up to 60,000 seeds in one night (DELWP 2015). Some plants, particularly *Corymbia* spp., have adaptations suggesting they rely more heavily on nocturnal visitors such as bats for pollination than daytime pollinators (Southerton et al. 2004). Intrinsically, flying-foxes are valuable as a key group of species that form part of Australia's biodiversity and evolutionary history.

Flying-foxes may travel 300 km in a single night with a foraging radius of up to 50 km from their roost (Welbergen et al. 2020) and have been recorded travelling over 500 km in two days between roosts (Roberts et al. 2012). In comparison, bees, another important pollinator, move much shorter foraging distances of generally less than one kilometre (Zurbuchen et al. 2010).

Long-distance seed dispersal and pollination make flying-foxes critical to the long-term persistence of many plant communities (Westcott et al. 2008, McConkey et al. 2012), including eucalypt forests, rainforests, woodlands, and wetlands (Roberts 2006). Seeds that can germinate away from their parent plant have a greater chance of growing into a mature plant (Ruxton & Schaefer 2012). Long-distance dispersal also allows genetic material to be spread between forest patches that would normally be geographically isolated (Parry-Jones & Augee 1992, Eby 1991, Roberts 2006). This genetic diversity allows species to adapt to environmental change and respond to disease pathogens. Transfer of genetic material between forest patches is particularly important in the context of contemporary fragmented landscapes.

Flying-foxes are considered 'keystone' species given their contribution to the health, longevity and diversity among and between vegetation communities. These ecological services ultimately protect the long-term health and biodiversity of Australia's bushland and wetlands. In turn, native forests act as carbon sinks (Roxburgh et al. 2006), provide habitat for other animals and plants, stabilise river systems and catchments, add value to the production of hardwood timber, honey, and fruit (NSW Wildlife Council 2010), and provide recreational and tourism opportunities worth millions of dollars each year (DES 2020d).

2.2 Flying-foxes in urban areas

Flying-foxes appear to be roosting and foraging in urban areas more frequently. In a recent study of 654 known national flying-fox roosts, 55.1% occurred in urban areas and a further 23.5% in agricultural areas (Timmiss et al. 2020). Furthermore, the number of roosts increased with increasing human population densities (up to ~4,000 people per km^2) (Timmiss 2017). There are many possible drivers for this urbanising trend, as summarised by Tait et al. (2014):

- loss of native habitat from urban expansion and agriculture
- opportunities presented by year-round food availability from native and exotic species found in expanding urban areas
- disturbance events such as drought, fires, cyclones
- human disturbance or culling at non-urban roosts or orchards
- urban effects on local climate

- refuge from predation
- movement advantages, e.g. ease of manoeuvring in flight due to the open nature of habitat or ease of navigation due to landmarks and lighting.

2.3 Roost preferences

Little is known about flying-fox roost preferences; however, research indicates that apart from being in close proximity to food sources, flying-foxes choose to roost in vegetation with at least some of the following general characteristics (SEQ Catchments 2012):

- closed canopy > 5 m high
- dense vegetation with complex structure (upper, mid and understorey layers)
- within 500 m of permanent water source
- within 50 km of the coastline or at an elevation < 65m above sea level
- level topography (< 5° incline)
- ideally greater than one hectare to accommodate and sustain large numbers of flying-foxes and allow the roost to shift its extent so vegetation can recover (note this does not appear to be a strong flying-fox preference, but more a consideration in roost habitat creation/improvement).

Recently, specific research into the roost habitat preferences of LRFF revealed that roosts were most often associated with the following attributes (MacDonald et al. 2021):

- marginally taller canopy; mean height of canopy trees was 19.9 m (± 8.9 m) and of subcanopy trees was 9.9 m ± 4.8 m
- greater canopy and subcanopy cover/complexity
- marginally taller shrub layer with greater cover
- shorter, less dense ground cover layer
- preference for ten tree species (accounting for 68% of roost habitats), including *Eucalyptus*, *Melaleuca*, *Rhizophora*, *Avicennia*, *Corymbia*, and *Tamarandus* species
- generally located within 200 m of watercourse (50% of roosts).

Proximity to water is a key attribute in roost location (Hall & Richards 2000, Roberts 2005, MacDonald et al. 2021) with one study suggesting that 94% of GHFF roosts in New South Wales (NSW) were (at that time) located adjacent to or on a waterway or waterbody (Eby & Lunney 2002).

These are general findings and flying-foxes have been known to roost in a variety of habitats outside the above criteria.

2.4 Flying-fox breeding cycle

Flying-foxes reach reproductive maturity in their second or third year of life. Reproductive cycles detailed below are indicative and can vary by several weeks between regions, are annually influenced by climatic variables, and births can occur at any time of the year. Expert assessment is required to accurately determine the phase in the breeding cycle to inform appropriate management timing.

Black and grey-headed flying-foxes

Mating begins in January with peak conception occurring around March to April/May (Table 1); this mating season represents the period of peak roost occupancy (Markus 2002). Young (usually a single pup) are born six months later from September to November depending on species (Churchill 2008). The birthing season becomes progressively earlier, albeit by a few weeks, in more northerly populations (McGuckin and Blackshaw 1991), however out of season breeding is not unusual and births may occur at any time of the year (Ecosure pers. obs. 2015-2023).

Young are highly dependent on their mother for food and thermoregulation. Young are suckled and carried by the mother until approximately four weeks of age (Markus & Blackshaw 2002). At this time, they are left at the roost during the night in a crèche until they begin foraging with their mother in January and February (Churchill 2008) and are usually weaned by six months of age around March. Sexual maturity is reached at two years of age with an average life expectancy of 5-7 years (Divljan et al. 2006, Fox et al. 2008). Individuals have been recorded to live to 18 years of age in the wild (Tidemann & Nelson 2011).

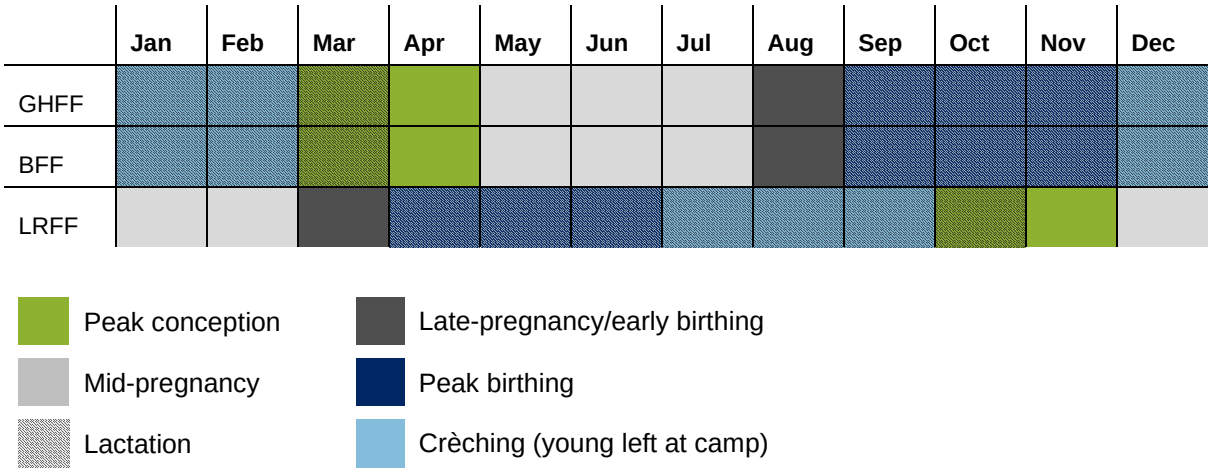
The critical reproductive period for BFF and GHFF is generally from August/September (when females are in late stages of pregnancy) to the end of peak conception around April/May. Dependent pups are usually present from September/October to February. See Appendix 2 for more information on flying-fox species ecology. Lastly, flying-foxes are susceptible to extreme heat (e.g., >43°C); see section 2.7.1 below.

Little red flying-fox

The LRFF breeding cycle is approximately six months out of phase with BFF and GHFF (Table 1). Conception occurs around October to November, with peak birthing in April-June (McGuckin & Blackshaw 1991, Churchill 2008). Young are carried by their mother for approximately one month then left at the roost while she forages (Churchill 2008). Suckling occurs for several months while young are learning how to forage.

LRFF pups are particularly vulnerable to cold weather and can suffer hypothermia and fall from their crèche trees. If LRFF pups are present, rescuers and carers should be on stand-by during cold weather. Equally, flying-foxes are susceptible to extreme heat (e.g., >43°C); see section 2.7.1.

Table 1 Indicative flying-fox reproductive cycle



2.5 Local and regional context

Flying-foxes are highly nomadic, moving across their east coast range between a network of roosts. Roosts may be occupied continuously, annually, irregularly or rarely (Vanderduys et al. 2024). The number of flying-foxes at a roost can fluctuate significantly each day, seasonally, and between years. An estimate based on satellite tracking found that up to 17% of a colony can turnover each day (Welbergen et al. 2020). A study by Welbergen et al. (2020) tracked individuals of all three species over a 60-month period and found that BFF and LRFF roosted in an average of 12 and 24 LGAs per year, respectively. The Livingstone Shire roosts form part of a network of roosts across the species' range (see Figure 1).

Typically, the abundance of resources within a 20–50 km radius of a roost site will be a key determinant of the size of a roost (SEQ Catchments 2012). As such, flying-fox roosts are generally temporary and seasonal, tightly tied to the flowering of their preferred food trees. However, understanding the availability of foraging resources is difficult because flowering and fruiting may not occur each year and vary between locations (SEQ Catchments 2012).

A study compiled a range of data sources to rank LRFF diet trees in bioregions across Qld (Eyre et al. 2020). This followed the method developed by Eby and Law (2008) by assessing the relative importance of LRFF diet tree species, the abundance of nectar produced during peak flowering periods, and the frequency of substantial flowering by a species, to obtain an overall Diet Plant Nectar score. The static nectar score for remnant vegetation within Livingstone LGA indicates extensive foraging habitat to the north-east (Figure 2). While this analysis is based on LRFF diet, there is substantial overlap in dietary preferences between LRFF and BFF, and thus this mapping provides insight into flowering that will attract all species into the area. Importantly, this data does not assess urban and agricultural nectar (or fruit) resources, this is a knowledge gap that warrants assessment across the LGA and Qld.

Between 2019 and 2020, flying-foxes experienced significant population impacts across the east coast of Australia due to extreme weather events (predominantly South East Qld, NSW, and Victoria). Prolonged drought caused a mass food shortage from Gladstone (Qld) to Coffs Harbour (NSW), peaking around October 2019 (Mo et al. 2021), in which thousands of flying-foxes perished from starvation (Cox 2019, Huntsdale & Millington 2019). Following this, bushfires across the country resulted in the loss of large areas of native forest that provides natural foraging habitat for flying-fox populations. The total number of flying-foxes lost in these events is impossible to quantify but is likely to have been more than 100,000 individuals (M. Mo 2019, M. Mo 2022.).

Significant events including fires, cyclones, floods, and drought can severely impact foraging and roosting resources in natural areas. Consequently, foraging and roosting resources in and around urban areas become even more important for flying-fox conservation.

Figure 1 Regional context

Livingstone Shire Council

LSC Flying-fox Management Plan

LSC flying-fox roosts
- Emu Park
- Keppel Sands
- Marlborough
- Yeppoon

Flying-fox roosts (DESI data)

Livingstone LGA

Local Government Areas

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Job number: PR8019
Revision: 1
Author: MH
Date: 11/10/2024

0 10 20 30 km

GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Units: Meter

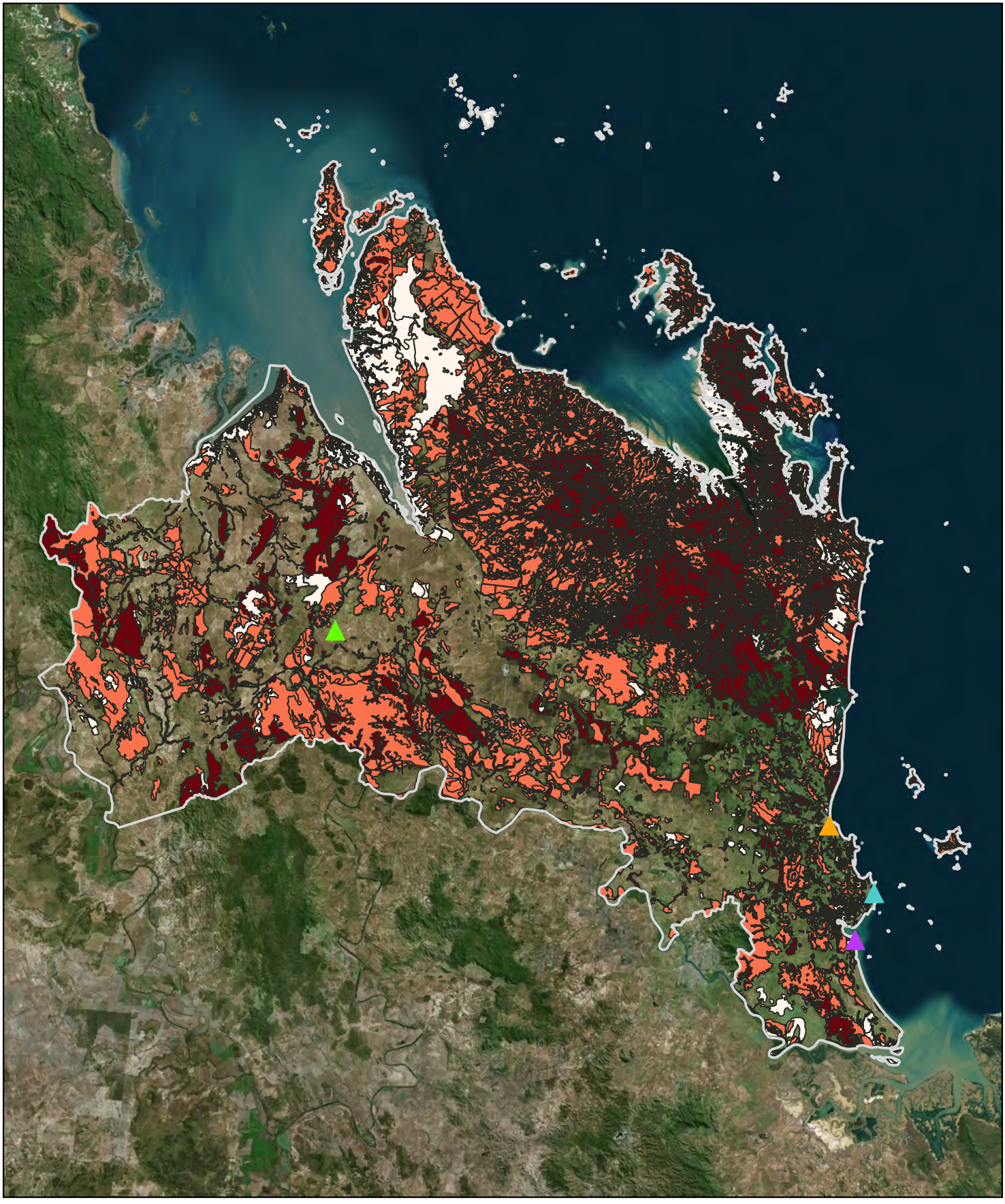

Figure 2 Distribution of the overall static nectar scores for remnant vegetation within Livingstone LGA

Livingstone Shire Council
LSC Flying-fox Management Plan

Data courtesy of QLD Herbarium/DESI/CSIRO

Livingstone LGA

Overall nectar scores*
- 0 - 7
- 7 - 16
- 16 - 24

*Eyre et al. 2020

LSC flying-fox roosts
- Emu Park
- Keppel Sands
- Marlborough
- Yeppoon

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Job number: PR8019
Revision: 0
Author: MH
Date: 07/06/2024

0 10 20 30 km

GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Units: Meter

2.6 Potential flying-fox impacts

2.6.1 Noise

A highly sociable and vocal animal, the activity heard from flying-foxes at roosts includes courting, parenting, and establishing social hierarchy. Noise is often most disturbing pre-dawn. This is often exacerbated during the breeding season (e.g. pup rearing in spring/summer, and during mating mid-March to mid-May; Table 1).

2.6.2 Odour

Flying-foxes use pheromones to communicate with each other, which is the source of the characteristic musky smell around their roosts and some foraging trees. There are several factors that affect odour detectability and intensity, such as the number of flying-foxes, time of year, weather conditions, wind direction, and site characteristics.

Odour may be more intense at roosts during the breeding and rearing season as female flying-foxes use scent to find their pups after foraging, and males regularly mark their territories (Wagner 2008). Likewise, odour is stronger after rain as males remark branches in their territories.

2.6.3 Human and animal health concerns

Flying-foxes, like all animals, may carry pathogens which can be harmful to humans. These risks can be effectively mitigated through education, protocols, personal protective equipment (PPE), and basic hygiene measures. The key human and animal health risks associated with flying-foxes are lyssavirus and Hendra virus; the latter being particularly important for flying-fox roosts located in close proximity to horse paddocks. Further information on flying-foxes and human/animal health is provided in Appendix 3.

2.6.4 Faecal drop

Flying-foxes have an extremely fast digestive process with only 15-20 minutes between eating and excreting (SEQ Catchments 2012). Given that flying-foxes regularly forage 20 km from their roost (Markus & Hall 2004) and establish new roosts within 600 m – 6 km when dispersed (Eby and Roberts 2013, Ecosure 2014), attempting to relocate a roost will not reduce this impact. As such, faecal drop impacts are best managed at an individual property level.

Faecal droppings can cause health concerns, reduced amenity, create a slip hazard, requires time and resources to clean, and can damage paint if not promptly removed. Appropriate PPE and hygiene measures are required when cleaning any animal excrement. High-pressure hoses and specific cleaning products are available to assist cleaning. Areas of concern, such as picnic tables and play equipment, could also be covered (e.g. with shade cloth).

2.6.5 Water quality concerns

Contamination of water supplies by any animal excreta (birds, amphibians and mammals such as flying-foxes) poses health risks to humans. This is particularly relevant for any residents who rely on rainwater tanks for drinking water. There is no known risk of contracting bat-related viruses from contact with faecal drop or urine (Qld Health 2020). Household water tanks can be designed to minimise potential contamination, such as using first flush diverters to divert contaminants before they enter water tanks.

Tanks should be appropriately maintained and flushed, and catchment areas regularly cleaned of potential contaminants. Trimming vegetation overhanging the catchment area for the tank (e.g. flying-fox foraging vegetation overhanging the roof of a house) will also reduce wildlife activity and associated potential contamination. Tanks in urban areas are not for domestic drinking water supply as these areas are supplied with reticulated town water.

Pool maintenance practices (e.g. filtration, chlorination, skimming, vacuuming) should remove general contamination associated with wildlife droppings. Public water supplies are regularly monitored for harmful bacteria and are filtered and disinfected before being distributed.

There have also been concerns about water quality in artificial or natural waterbodies near a flying-fox roost. In stagnant waterbodies there may be an increase in bacteria and nutrients associated with many animals, including flying-foxes and/or native birds. Water quality monitoring should be considered if this is of concern.

2.6.6 Damage to vegetation

Large numbers of roosting flying-foxes can damage vegetation. Most native vegetation is resilient and generally recovers well (e.g. casuarina and eucalypts) and flying-foxes naturally move within a roost site allowing vegetation to recover. However, damage can potentially be significant and permanent, particularly in small patches of vegetation and particularly if large numbers of LRFF are present. LRFF have different roosting behaviour to BFF, they aggregate in high densities which can cause branches to snap. Intervention may be required (as a last resort) to protect tree health if permanent damage is likely.

2.6.7 Flying-foxes and aircraft

The consequence of wildlife strikes with aircraft can be very serious. Worldwide, in civil and military aviation, fatal strike incidents have resulted in more than 532 human fatalities and 614 aircraft losses since the beginning of aviation (Shaw et al. 2019). Wildlife strikes cost the commercial civil aviation industry an estimated US$1.2 billion per annum (Allan 2002) and involve more than just the repair of damaged engines and airframes. Even apparently minor strikes which result in no damage can reduce engine performance, cause concern among aircrew and add to airline operating costs.

Flying-foxes are large (~800 g) animals that transit in large numbers at relatively low altitudes. Consequently, in terminal airspace, where aircraft are also operating at low altitudes, they may present a significant risk to air safety particularly prior to first light and post last light, daily. Between 2008 and 2017, flying-foxes and bats[1] were involved in 1,303 strikes in Australia and accounted for 10% of damaging strikes (ATSB 2019). Most notably, between 2016 and 2017 flying-foxes were the most struck flying animal.

2.7 Protecting flying-foxes and other fauna

2.7.1 Extreme weather impacts

Heat

Flying-foxes are especially susceptible to extreme heat. Temperatures above 38ºC, consecutive hot days, lactation, age and other weather variables such as high humidity

1 Due to inconsistent species reporting, species reported to the Australian Transport Safety Bureau (ATSB) include: flying-fox, bat, fruit bat, microbat species. ATSB reported that it is likely that many of the strikes involving animals reported as 'bats' actually involved flying-foxes.

contribute to the likelihood of a Heat Stress Event (HSE) (Bishop 2015, Welbergen et al. 2008). Flying-foxes may die of either heat stroke or dehydration, associated with saliva spreading used for evaporative cooling. Mass mortality can occur when temperatures exceed 42°C (Welbergen et al. 2008, Bishop et al. 2019). However, humidity is an important variable as the flying-foxes cool-down through evaporative cooling, therefore temperatures as low as 40.6ºC have caused HSEs in Queensland (Bishop 2015).

The Guideline (DES 2020b) provides information for decision makers during HSEs and should be adopted by Council if responding to HSEs in Livingstone Shire. A thorough HSE management strategy is outlined in Appendix 7.

A range of intervention methods are used by wildlife rescue and carers to reduce mortality in roosts, including directly spraying water on affected animals by hand, or using ground-based or canopy-mounted sprinklers/hoses to simulate a rain shower. These methods were reviewed by Mo and Roache (2020) who found that evaluation of the efficacy of heat stress interventions has been largely anecdotal rather than empirical. Intervention also has the potential to exacerbate HSEs through disturbance or increasing humidity with spraying water. To address this lack of empirical data, the NSW government approved a scientific trial of various methods in combination with flying-fox behaviour and temperature monitoring (currently underway).

Storms

Storm events can result in tree loss and damage to vegetation, which can lead to a reduction in roosting and, in particular, foraging resources for flying-foxes. The loss of tree crown can open the canopy, which may result in a hotter drier climate in areas with little canopy cover. Increased sunlight and drier soils often favour weed proliferation which can further degrade the habitat. Habitat restoration is critical to ensure sufficient recruitment over time to allow such canopy losses to be replaced as soon as possible.

Storms can result in injury and mortality in flying-fox roosts, particularly when flightless young are present (during summer, which coincides with storm season). (Council notes that wildlife rescue at a roost must only occur when it is safe for human access).

Drought

Drought and associated lack of natural food sources for flying-foxes can lead to mass mortality and pup abandonment events. Urban roosts with varied and consistent food sources provided by urban parks, street plantings and residential areas become more important during these times. Continued protection of urban roosts will be important to limit impacts of more frequent drought under climate change.

Bushfires

With the increasing impacts of climate change and more severe bushfire seasons in Australia, evident in the 2019-20 bushfire season, flying-foxes are extremely vulnerable to widescale habitat loss (Bat Conservation and Rescue Queensland 2019, Baranowski et al. 2021). With large areas of roosting and foraging habitat burnt during bushfires, flying-foxes are forced to relocate and find alternative suitable roosting and foraging habitat (Baranowski et al. 2021). This can disrupt flying-foxes breeding cycle and the ability to find adequate food for survival (Bat Conservation and Rescue Queensland 2019). Significant loss of habitat in areas affected by bushfire can lead to larger influxes of flying-foxes in urban habitats as they attempt to seek adequate roosting and foraging habitat (Baranowski et al. 2021). This may lead to increased community concern, therefore education regarding flying-foxes in general, and particularly during severe bushfire seasons, is key.

3 Roost assessments

Roost assessments were undertaken at Marlborough, Yeppoon, Emu Park and Keppel Sands on 17 April 2023 and 6 September 2023. All four roosts were included in the National Flying-fox Monitoring Program (NFFMP) and monitoring data is graphed in the below roost assessments.

3.1 Marlborough

3.1.1 Site description

Marlborough is a small township within the Livingstone LGA approximately 95 km north-west of Yeppoon. The Marlborough roost is located on Marlborough Creek, an ephemeral creek running through the township bordered by Glenprairie Road and Magog Road. The creek is infested by large leucaena (*Leucaena leucocephala*) shrubs, which have been partially defoliated due to flying-fox roosting. Large, healthy *Eucalyptus* spp. border the banks of the creek line.

The roost is generally considered low conflict, except for times of large influxes that have previously impacted the township community and inspired unauthorised attempts to drive the flying-foxes away.

During the development of the Plan, flying-foxes briefly returned to the Marlborough roost, however no monitoring efforts were undertaken (Council pers. comm.).

3.1.2 Land tenure

The Marlborough roost has historically been located on Lots 2 and 14 Glenprairie Road, (2RP604666 and 14RP602113), which are classified as Freehold and Township land respectively (Figure 4).

3.1.3 Ecological values

GHFF have not been recorded at the Marlborough roost and therefore it does not meet the criteria for a nationally important roost.

A WildNet search identified two threatened bird species and one insect species within 1 km of the Marlborough roost; squatter pigeon (*Geophaps scripta scripta*) (V), spectacled monarch (*Symposiachrus trivirgatus*) (SLC), and pale imperial hairstreak (*Jalmenus eubulus*) (V).

The Marlborough roost is mapped as Endangered - Dominant vegetation. The regional ecosystems (REs) present include:

- 11.3.38/11.3.38a/11.3.25c: Eucalypt open forests to woodlands on floodplains (16-16d)
- 11.12.2: Eucalypt dry woodlands on inland depositional plains (17-18d).

The majority of roost vegetation is mapped as regulated vegetation, which includes:

- Category R (Great Barrier Reef (GBR) riverine regrowth) regulated vegetation

- Matters of state environmental significance (MSES) wildlife
- Very High Aquatic conservation significance (riverine wetlands).

Marlborough Creek contains a good nesting site for the Fitzroy River turtle (*Rheodytes lukops*) with large numbers having been recorded there. This RE is a serpentinite ecosystem known to contain a number of rare and threatened species, including supporting a good population of crocodiles and a diversity of fish species.

Any management undertaken must consider these other values and relevant legislative requirements (see Section 1 and Appendix 1).

3.1.4 Flying-fox occupancy and roost extent

The Marlborough roost was vacant during Ecosure's site assessment on 6 September 2023. Anecdotal evidence suggests that the roost is more regularly occupied by BFF than LRFF and has previously overflowed into residents' properties impacting campers hosted by the Marlborough Hotel and the Marlborough Public Pool during large influxes.

NFFMP data recorded a large influx of BFF and LRFF in November 2020 at the Marlborough roost (Figure 3), otherwise, the roost has been intermittently occupied by BFF. The estimated maximum extent of the Marlborough roost is shown in Figure 4.

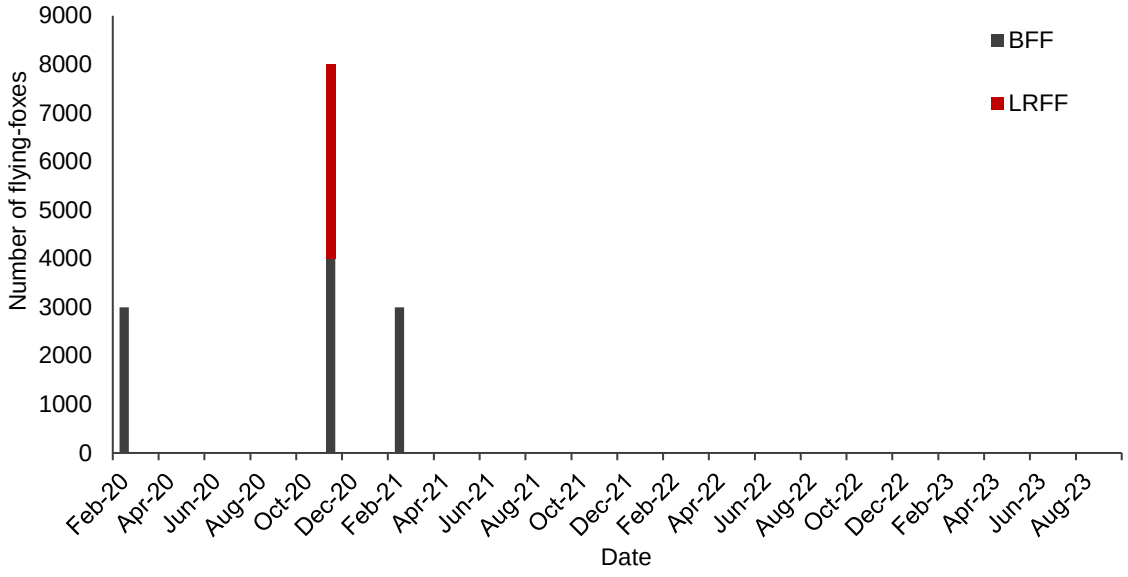


Figure 3 Historical flying-fox counts at the Marlborough roost (Source: DESI, Ecosure)

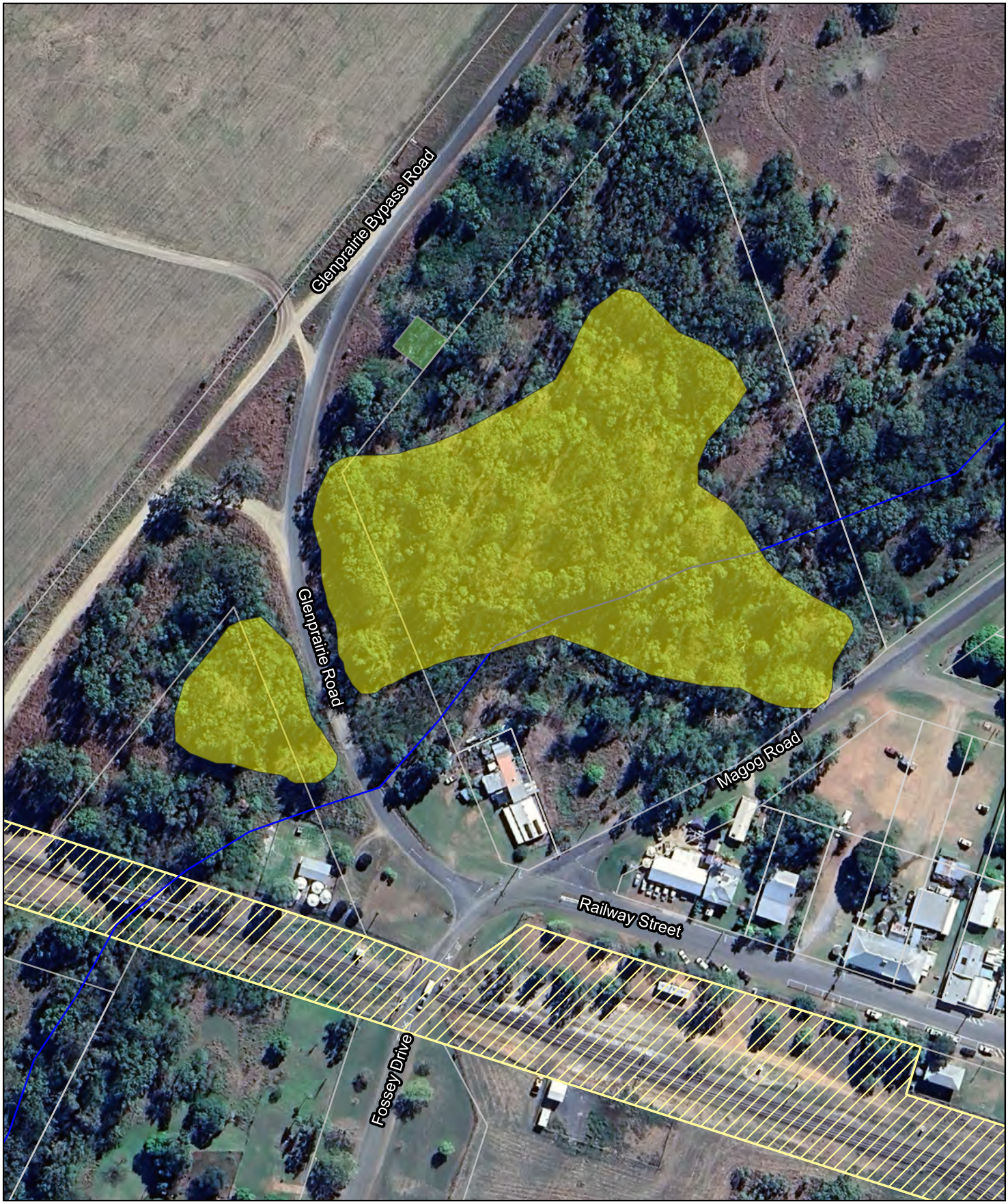


Figure 4 Marlborough estimated flying-fox roost extent

Livingstone Shire Council

LSC Flying-fox Management Plan

Estimated maximum roost extent
Watercourse
Freehold land
Leased land
Reserve

ecosure
improving ecosystems

Job number: PR8019
Revision: 2
Author: MH
Date: 11/10/2024

0 0.025 0.05 km

GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Units: Meter

3.1.5 Sensitive receptors

There are four sensitive receptors[2] located within 1 km of the Marlborough roost, including:

- Marlborough State School
- Marlborough Hotel
- Lions Park playground
- Marlborough Public Pool.

3.1.6 Management responses to date

Previously, Marlborough residents attempted to disperse the Marlborough roost. Unfortunately, the attempts splintered the roost throughout the township, amplifying concerns and impacts to the community, and specifically the Marlborough Public Pool and caravans residing behind the Marlborough Hotel.

Council has undertaken weed control, and community consultation and education, aiming to maintain the Marlborough flying-fox roost as a low conflict roost. This has been aided by reduced numbers of flying-foxes at this roost (Council pers. comm.).

[2] It is acknowledged that many land uses conflict with flying-fox roosts, such as some residences, public parks and businesses. Sensitive receptors, as used in this context, differ in that there are vulnerable cohorts of people and/or animals where managing risk may be more complex than awareness programs and property modification. These include schools, childcare centres, hospitals with helipads, airports, and equine facilities. Identifying sensitive receptors is necessary to any management actions that could inadvertently cause the roost to splinter to surrounding undesirable locations (e.g. other conflict locations close to residents) or sensitive receptors.

3.2 Yeppoon

3.2.1 Site description

Yeppoon is a large coastal town located approximately 35 km north-east of Rockhampton. The Yeppoon roost is currently located in the mangroves of Ross Creek between Maurie Webb Field and Remora Park, however it has previously been recorded further north in the mangroves surrounding Merv Anderson Park. The mangroves of Ross Creek are bordered by residential areas.

The Yeppoon roost is generally considered low conflict, the main concerns expressed by the community included the impacts to property from faecal droppings surrounding the roost.

3.2.2 Land tenure

The Yeppoon roost primarily occurs on Lot 3SP104438 which is mapped as Environment Reserve (Council pers. comm.). The roost occasional extends to Lot 11SP143269, also mapped as Reserve. The tenure surrounding the two lots is mapped as Freehold land.

3.2.3 Ecological values

GHFF have been recorded at the Yeppoon roost (Council pers. comm.), however limited data is available. Based on the limited data, this roost does not meet the criteria as a nationally important roost (see Appendix 1).

A WildNet search identified 30 conservation significant species that have been recorded within 1 km of the Yeppoon roost; one endangered, seven vulnerable, and 14 special least concern (SLC) fauna species, and eight SLC plants as listed under the NC Act.

The Regional Ecosystems present at the Yeppoon roost include:

- 11.1.2a: Samphire forbland on marine clay plains
- 11.1.4a: Mangrove low open forest and/or woodland on marine clay plains
- 11.14b: Mangrove low open forest and/or woodland on marine clay plains
- 11.11.15a: *Eucalyptus crebra* woodland to open woodland on deformed and metamorphosed sediments and interbedded volcanics
- 11.11.4a: *Eucalyptus crebra* woodland on old sedimentary rocks with carrying degrees of metamorphism and folding. Coastal ranges
- 11.3.9: *Eucalyptus platyphylla*, Corymbia spp. Woodland on alluvial plains.

The majority of roost vegetation is mapped as regulated vegetation, which includes:

- MSES wildlife
- State habitat for EVNT taxa
- Category R (GBR riverine regrowth) regulated vegetation
- Regulated vegetation – essential habitat
- Regulated vegetation – intersecting a watercourse
- Medium Aquatic conservation significance (riverine wetlands).

Any management undertaken must consider these other values and relevant legislative requirements (see Section 1 and Appendix 1).

3.2.4 Flying-fox occupancy and roost extent

BFF have been recorded occupying the Yeppoon roost by the NFFMP (Figure 5). Anecdotal evidence suggests that the roost has been occupied consistently for many years by BFF and occasionally LRFF, and the extent varies between Lot 3SP104438 and Lot 11SP143269. The roost extent observed during Ecosure's diurnal roost assessment is mapped in Figure 6, however due to restricted access, an accurate assessment of the population was not possible. Anecdotal records suggest LRFF also occasionally use the site (verified data not available). Drone surveys present the best option to confirm the species present and estimate the number of flying-foxes.

The Yeppoon roost is utilised as a 'soft-release' location for rehabilitated flying-foxes by the local wildlife carers. An aviary is maintained at the site for the purpose of soft-release of flying-foxes.

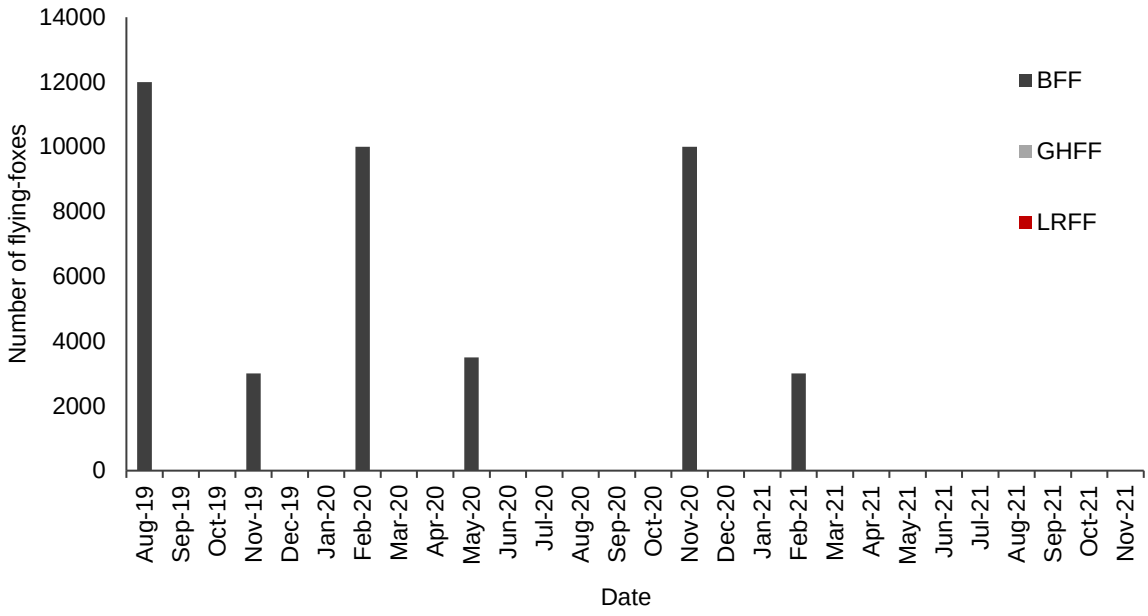


Figure 5 Historical flying-fox counts at the Yeppoon roost (Source: DES, Ecosure)

Figure 6 Yeppoon flying-fox roost

Livingstone Shire Council

LSC Flying-fox Management Plan

- Current roost extent
- Estimated maximum roost extent
- Freehold land
- Leased land
- Reserve

ecosure
improving ecosystems

Job number: PR8019
Revision: 1
Author: MH
Date: 03/10/2024

0 0.1 0.2 km

GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Units: Meter

3.2.5 Sensitive receptors

There are four sensitive receptors[2] located within 1 km of the Yeppoon roost, including:

- The Yeppoon Lagoon
- Appleton Park
- Merv Anderson Park
- Total Health Medical Centre.

We note that Yeppoon High School is located ~1.4 km west of the Yeppoon roost.

3.2.6 Management responses to date

Management actions at the Yeppoon roost have complied with the low-impact code of practice (e.g., trimming trees along paths, weed management). Interestingly, Council observed that the predominant roost extent shifted from Lot 11SP143269 to Lot 3SP104438 during the construction of Yeppoon Lagoon (circa 2018). This roost is in a low conflict location with a conservation priority; roost management is not anticipated to be required.

Council has noted flying-foxes regularly electrocuted on powerlines around Shaw Avenue. It is recommended to formally document these observations; as part of Council's community education program the community can be encouraged to submit photos using the iNaturalist app or website, adding to a national survey. It is also recommended that Council speak with the power company about upgrading sections of powerlines to aerial bundled cable, which does not electrocute wildlife.

3.3 Emu Park

3.3.1 Site description

Emu Park is a small coastal town within the Livingstone LGA approximately 16 km south-east of Yeppoon. The Emu Park roost is primarily located adjacent to Tasman Holiday Parks and within Bell Park, bordering Fishermans Beach. The roost site is dominated by rainforest scrub species including *Ficus* spp., and *Melaleuca* spp., as well as coastal vegetation types. Extensive growth of exotic coastal morning glory (*Ipomoea cairica*) covers the mid-story to upper canopy of the roost vegetation immediately bordering the Tasman Holiday Park. Partial defoliation of tree canopies was observed during the roost assessment.

3.3.2 Land tenure

The Emu Park roost is primarily located between Lot 100SP251104 and Lot 31LN801275 which are both mapped as Reserve (Open Space).

3.3.3 Ecological values

A WildNet search identified four threatened bird species and one plant species occurring within 1 km of the Emu Park roost; northern giant-petrel (*Macronectes halli*) (SLC), crested tern (*Thalasseus bergii*) (SLC), grey-tailed tattler (*Tringa brevipes*) (SLC), brown booby (*Sula leucogaster*) (SLC), and *Livistonia decora* (SLC).

The majority of the roost is mapped as Of Concern - Dominant vegetation. REs present include:

- 11.2.2/11.2.2b: Complex of *Ipomoea pes-caprae* subsp. *brasiliensis* and *Spinifex sericeus* and *Casuarina equisetifolia* low woodland and herbland on fore dunes
- 11.2.3: Microphyll vine forest ("beach scrub") on sandy beach ridges and dune swales
- Non-remnant.

The majority of roost vegetation is mapped as regulated vegetation, which includes:

- MSES Threatened wildlife
- Regulated vegetation – intersecting a watercourse
- Regulated vegetation – 100 m from a wetland
- Category B (endangered or of concern) regulated vegetation
- Medium Aquatic conservation significance (riverine wetlands).

Any management undertaken must consider these other values and relevant legislative requirements (see Section 1 and Appendix 1).

3.3.4 Flying-fox occupancy and roost extent

The Emu Park flying-fox roost has historically been occupied predominantly by BFF, however LRFF and GHFF were recorded during the NFFMP (Figure 7). During the site assessment, BFF and LRFF were present in the roost. Although GHFF have been recorded within the Emu Park roost, the numbers and frequency do not satisfy the criteria to be recognised as a

nationally important flying-fox roost (see Appendix 1).

The roost extent tends to vary between the coastal vegetation bordering Tasman Holiday Park and Bell Park (Figure 8). Generally, flying-foxes have shown preference to the coastal vegetation, occasionally utilising Bell Park during times of large LRFF influxes. Flying-foxes have been observed with pups at this roost; they have typically been observed in the main roosting area in the northern part of the roost.

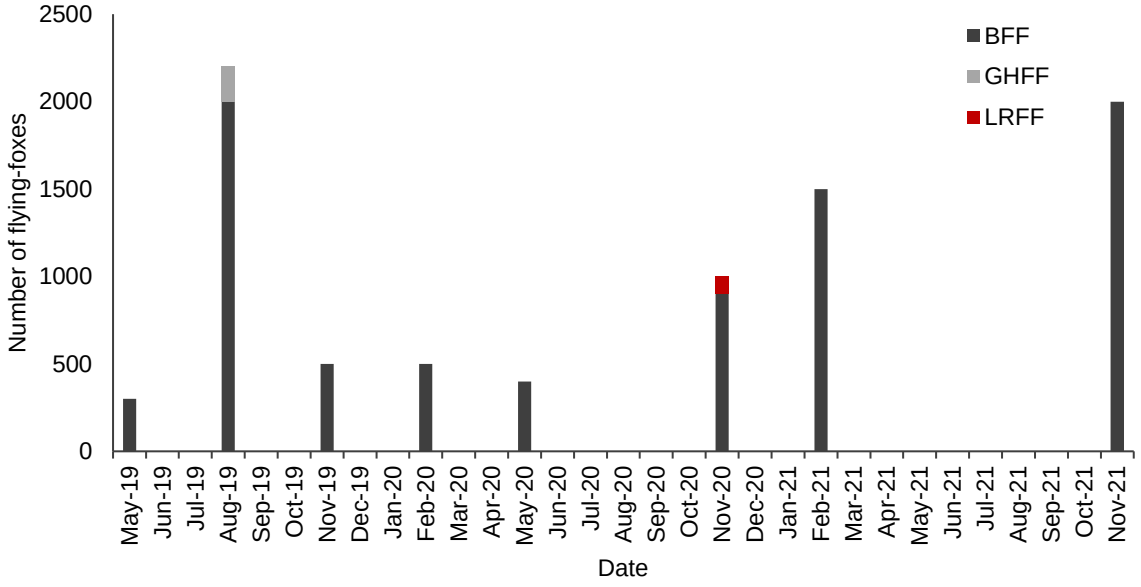


Figure 7 Historical flying-fox counts at the Emu Park roost (Source: DES, Ecosure)

Figure 8 Emu Park flying-fox roost

Livingstone Shire Council

LSC Flying-fox Management Plan

Current roost extent
Estimated maximum roost extent
Freehold land
Leased land
Reserve

ecosure
improving ecosystems

Job number: PR8019
Revision: 0
Author: MH
Date: 11/06/2024

0 0.025 0.05 km

GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Units: Meter

3.3.5 Sensitive receptors

There are nine sensitive receptors[2] located within 1 km of the Emu Park roost, including:

- Tasman Holiday Parks
- Coastal Kids Kindergarten
- QCWA Sunset Lodge Aged Care Facility
- Emu Park State School
- The Family Practice Emu Park
- Total Health at Emu Park
- Capricorn Health and Wellness
- Don Ireland Swimming Complex.

Emu Park airstrip is located marginally outside of the 1 km buffer and has been recognised due to the risk to aircraft, although anecdotal evidence suggests that aircraft do not utilise the airstrip at times that are likely to conflict with flying-fox departing or arriving at the Emu Park roost.

3.3.6 Management responses to date

Council has previously undertaken weed management of coastal morning glory within the vegetation bordering the Tasman Holiday Park in an attempt conserve the roost and maintain the aesthetic of the site. Vegetation trimming is periodically undertaken at night, under supervision, to maintain visitor safety and flying-fox roosting habitat.

3.4 Keppel Sands

3.4.1 Site description

Keppel Sands is a small coastal rural township within the Livingstone LGA approximately 22 km south-east of Yeppoon. The Keppel Sands roost is located on the corner bend of Limpus Avenue in the dense, fringing mangroves of Pumpkin Creek and the eucalypts of the vacant residence adjacent.

3.4.2 Land tenure

The main roost area on Pumkin Creek is mapped as a watercourse and the adjacent lot (16RP610627) that occasionally hosts the colony is mapped as Freehold land.

3.4.3 Ecological values

A WildNet search identified two SLC birds and four SLC plants occurring within 1 km of the Keppel Sands flying-fox roost; Australian tern (*Gelochelidon macrotarsa*), crested tern (*Thalasseus bergii*), *L. decora, Dendrobium discolor, Drynaria sparsisora*, and *Microsorum punctatum*.

The majority of the roost is mapped as No concern at present. The REs present include:

- 11.1.2a: Samphire forbland on marine clay plains
- 11.1.4a: Mangrove low open forest and/or woodland on marine clay plains.

The majority of roost vegetation is mapped as regulated vegetation, which includes:

- MSES Threatened wildlife
- Regulated vegetation – essential habitat
- High Aquatic conservation significance (riverine wetlands).

3.4.4 Flying-fox occupancy and roost extent

Historically, BFF have predominantly occupied the Keppel Sands roost with occasional, sizable influxes of LRFF (Figure 9). GHFF have been recorded at the Keppel Sands roost, however the numbers and frequency do not satisfy the criteria to be recognised as a nationally important flying-fox roost.

The roost extent primarily occurs within the mangroves of Pumkin Creek (Figure 10) however, during influxes, the roost has been observed to extend into the adjacent, vacant residential lot, occupying large eucalypts.

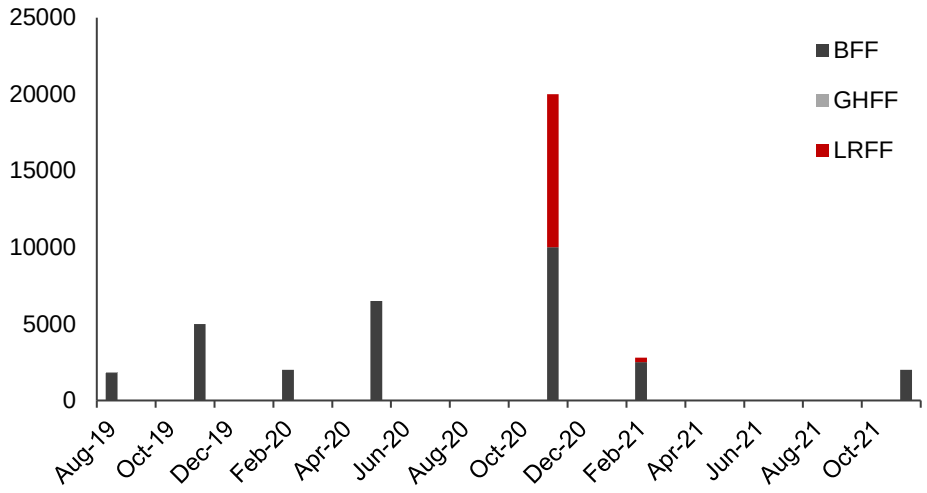


Figure 9 Historical flying-fox roost counts at the Keppel Sands roost (Source: DES, Ecosure)

Figure 10 Keppel Sands flying-fox roost

Current roost extent
Estimated maximum roost extent
Freehold land

Livingstone Shire Council

LSC Flying-fox Management Plan

ecosure
improving ecosystems

Job number: PR8019
Revision: 1
Author: MH
Date: 03/10/2024

0 10 20 30 m

GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Units: Meter

3.4.5 Sensitive receptors

There are two sensitive receptors[2] located within 1 km of the Keppel Sands roost, including:

- Keppel Sands State School
- Keppel Sands Caravan Park.

3.4.6 Management responses to date

Management has not been and is currently not required at the Keppel Sands flying-fox roost.

4 Community Engagement

Early and effective community engagement and education has benefits for both the community and land managers. These benefits include increasing community understanding and awareness of flying-foxes, their critical ecological role, and factors that need to be considered in developing a management approach. Engaging with the community is equally important to ensure land managers understand impacts associated with a roost to effectively manage community concerns.

Ecosure has developed this Plan following a site assessment (September 2023) and meetings with Council, stakeholders, and affected residents. The general public was also given an opportunity to complete an online survey (see survey results in Section 4).

Council sought to consult with all stakeholders with an interest in the flying-fox roosts during the development of the Plan. The results of the engagement are detailed below.

4.1 Community consultation sessions

Council and Ecosure representatives hosted three separate stakeholder engagement sessions at Marlborough (Lions Park), Yeppoon (Merv Anderson Park), and Emu Park (Bell Park) in February 2024. Council directly engaged residents and businesses in close proximity to the flying-fox roost sites to attend and also invited the Wildlife Operations team from DESI and local wildlife carers BatCare Capricornia. The purpose of this meeting was to understand the issues experienced by the community to assist with development of suitable management options. There was good attendance at each session and a range of positive comments were received and concerns were raised. Concerns included common misconceptions about disease transmission, impacts of noise, smell and faecal drop to properties in proximity to roost sites, the financial impacts to businesses such as the Tasman Holiday Park, fruit loss in orchards and backyards, and Council's approach to roost conservation.

4.2 Online survey results

Council hosted a community survey from January to March 2024 on their community engagement website, Get Involved. The online survey was intended for feedback from the broader community pertaining to flying-foxes within the LGA.

A total of 184 community members contributed to the survey. Some respondents skipped survey questions, varying the sample size per question. Of the respondents, 59% (n=184) reported that they live near a flying-fox roost, 7% were unsure and 23% reported that they did not. Seven percent of respondents reported that they owned a business near a flying-fox roost. Based on these data it can be assumed that results are representative of a wide range of the Livingstone community.

The primary concerns of residents (n=184) were flying-fox habitat protection (51%), misinformation about flying-foxes (51%), flying-fox conservation (47%), flying-fox welfare (41%), mess from droppings (36%), smell (35%), fear of disease (30%), and noise (24%).

The community was asked to assess their experience or interaction with flying-foxes. Of the 184 responses, 62% reported positive experience or interaction, 25% negative, and 13% neutral.

Reviewing qualitative data suggested that many of the negative experiences or interactions with flying-foxes (n=46) were associated with impacts of smell, noise and faecal drop, fear of disease, fruit loss in orchards and backyards, damage to roost vegetation, financial impacts to businesses, and contamination of tank water.

When asked how strongly participants (n=184) agreed or disagreed with statements about flying-foxes, 62% strongly agreed that flying-foxes are important to the environment and should be protected. Similarly, 49% of respondents strongly agreed that flying-foxes and humans should be able to share the urban environment and 45% strongly agreed that they like when flying-foxes visit their garden. Respondents reported that living next to bushland presents some challenges in relation to wildlife (48%) and 36% agreed that Council should seek to balance conservation and resident amenity.

Qualitative data was reviewed for the time of day that respondents (n=46) are impacted. The majority of responses were ‘evening’, ‘dusk’ or ‘night’, suggesting that they experience impacts of fly-outs and foraging behaviour.

When asked how important, on a scale of 1 (not important) to 10 (very important), it is to them that Council assists in the management of flying-foxes, 34% (n=168) responded with ‘10’. Similarly, the majority of respondents reported that it was ‘very important’ when asked how important it is that Council roost management actions protect flying-fox roosts (50%, n=170) and Council protects vegetation and other environmental values in parklands and bushland areas (58%, n=178).

Management options that were most highly supported by participants (n=184) were education and research (61%), protecting and enhancing flying-fox habitat in low conflict areas (61%), land use planning including zoning of flying-foxes (59%) and buffers using plants unsuitable for roosting (40%).

All educational options were highly supported by participants (n=184) including educational signage (58%), fact sheets with up-to-date information regarding flying-foxes and roosts (58%), promoting flying-fox roosts as a natural asset to future residents (57%), school engagement programs (54%), annual engagement with flying-fox specialists, community and local government (54%), website with links to up-to-date information (48%), educational talks by Traditional Owners, wildlife carers and rangers (46%) and opportunities to meet a flying fox (38%).

5 Management approach

Management actions are outlined for the Livingstone Shire roosts (Table 2) based on site-specific analysis of available flying-fox impact management options (Appendix 4). An overview of the approach in the short-term is to reduce impacts on residents through:

- maintaining buffers between residential dwellings/businesses and flying-fox roosts through vegetation modification
- potential buffer enhancement and/or habitat management through the installation of canopy mounted sprinklers or lighting.

An overview of the long-term approach for roosts in the LGA is to:

- regularly maintain the edges of roost sites to improve amenity and reduce weed invasion
- increase community engagement and education, particularly during larger influxes
- undertake regular monitoring of roost dynamics to better inform management actions
- identify and improve low conflict roost options in the townships to encourage roosting away from conflict areas
- avoid habitat disturbance at roosts to encourage flying-foxes to remain there.

Education and community engagement will form an important part of the ongoing management of urban flying-fox roosts. Misinformation and fear of disease were identified as primary concerns to residents. Educational material should aim to cover key messages in a way that educates and informs, rather than causing alarm, e.g. emphasising that there is very little risk associated with living or playing near a flying-fox roost (Qld Health 2021) – 'no touch, no risk' (Bat Conservation and Rescue Queensland 2019). Council should aim to provide regular and easily accessible information, through educational signs, informational sheets, updates on Council's website/social media and school engagement programs. Community engagement will be particularly important during larger influxes of flying-foxes.

Active management, including nudging and/or dispersal activities, should only be considered for very high conflict sites where other management techniques have been effectively implemented and proven unsuccessful in alleviating impacts. Where necessary, nudging attempts should be as passive as possible (e.g. lighting as opposed to noise). No form of nudging is appropriate in areas where young are present as it will likely result in harm and breach legislation. Further, it will not be effective when flightless young are present.

Table 2 Management actions to be implemented at Livingstone Shire roosts. Note costs are indicative only for external assistance (i.e. estimates not provided for Council time).

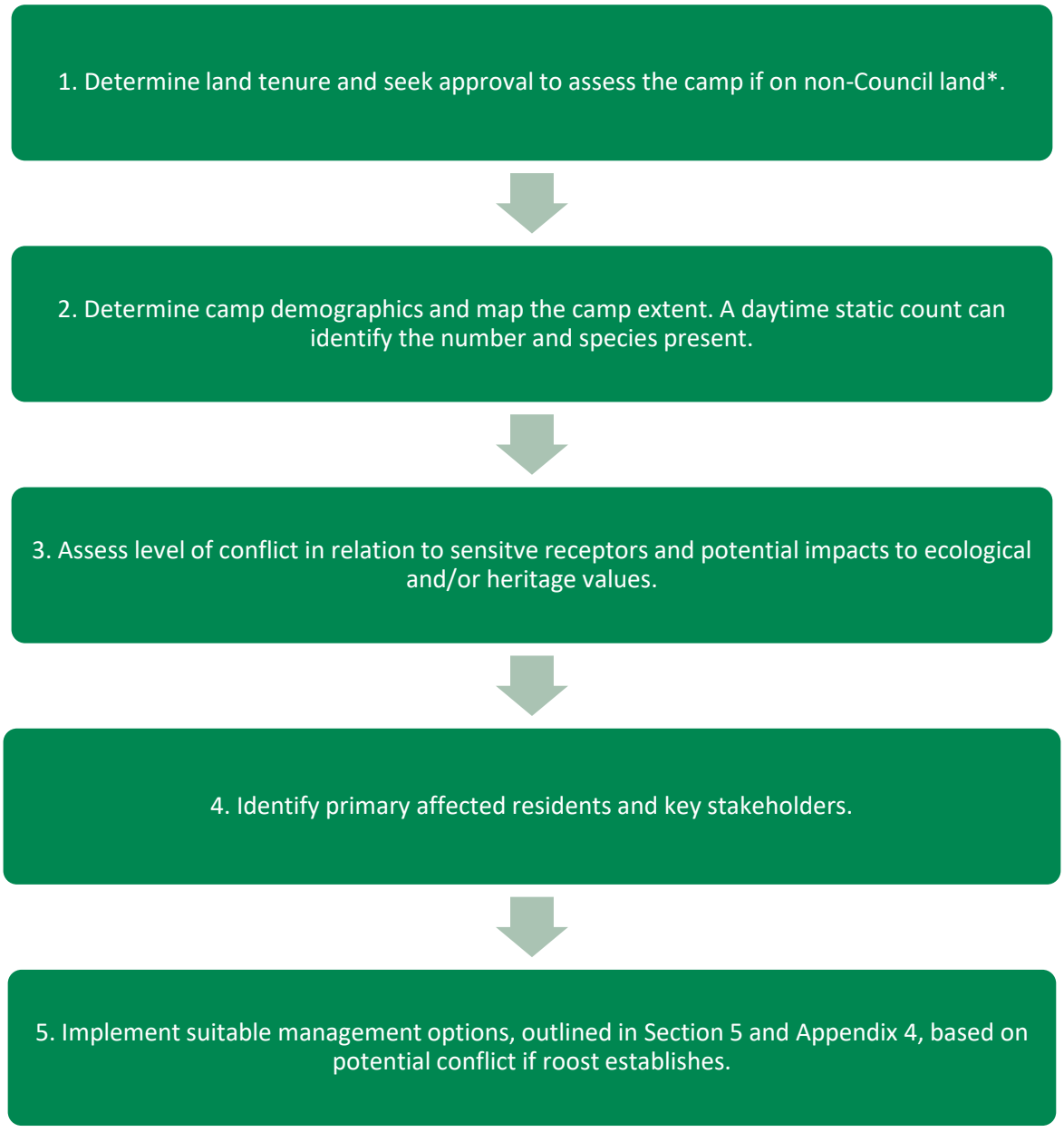
Management type	Management action	Indicative costs (ex GST)	Approvals required	Timeframe
Education	Increase education within the community to ensure access to up-to-date health information is available, and residents are aware of impact mitigation options available at a property level (e.g. methods to prevent water tank contamination, odour-neutralising gel pots, noise attenuation fencing, vegetation management on private land) and legislative responsibilities. Educational tools should include flyers, regularly updating Council's website, and installing interpretive signage roost sites. Direct, one-on-one engagement may be required for primary-affect residents.	Council time.	No	ASAP
	Facilitate community information sessions, targeting primary-affected residents. Information sessions should be offered prior to the predicted influx of LRFF in summer months and continue during large influxes.		No	ASAP
Buffer	Trial lighting (e.g., PROVolitans) at Emu Park (Tasman Holiday Park) roost, and at Keppel Sands roost as required, to deter flying-foxes from high-conflict areas and create a buffer where possible. If unsuccessful, CMS and/or vegetation removal can be considered.	≈ $80,000	Dependent on vegetation removal, refer to Appendix 4	ASAP
	Investigate opportunities and likely outcomes of expanding or creating buffers (where possible) between residential properties or conflict areas and flying-fox habitat through weed removal and vegetation trimming and/or removal. Buffers should be created between vegetation bordering Tasman Holiday Park. During influxes at Marlborough and Keppel Sands, residents should be directed to the Low Impact COP for information on how they can maintain vegetation on their properties.	≈ $30,000 (including labour, environmental assessments, offset)	Yes, refer to Appendix 4	ASAP - prior to next anticipated flying-fox influx
Subsidy program	Investigate a targeted, responsive subsidy program. If supported by Council, in response to an exceptional influx of flying-foxes, subsidies may be offered to affected residents. Subsidies could be provided for items (e.g. vehicle covers, carports, clothesline covers, clothes dryers, pool/spa covers, shade cloths, rainwater first-flush diverters, high-pressure water cleaners, air conditioners, fragrance dispensers or deodorisers, double-glazing of windows, door seals, screen planting, tree netting, and lighting) or services (e.g. clothes washing, cleaning outside areas and property, solar panel cleaning, car washing, removing exotic trees, or contributing to water/electricity bills). Alternatively, a nominal amount of money could be offered to residents based on their proximity to the flying-fox roost, on the basis they can prove the relevance of expenditure to mitigating flying-fox impacts. Further information regarding subsidy programs (e.g. subsidy options, means of delivery, and potential outcomes) is provided in Appendix 5. Council should aim to engage one-on-one with affected residents to establish how their concerns could be addressed through a subsidy program.	Variable as budget allows.	No	ASAP

Management type	Management action	Indicative costs (ex GST)	Approvals required	Timeframe
Habitat improvement	Avoid disturbance to low conflict roost habitat such as Marlborough, Yeppoon, and Emu Park (Bell Park) roosts to encourage flying-foxes to roost at these sites. Undertake weed management and, where possible, revegetate areas within or adjoining existing roosts; this is particularly relevant for Emu Park.	Council time (e.g. liaising with Council contractors and educating the public)	No	ASAP and ongoing
	Identify suitable roost habitat in low conflict locations and restore and/or enhance habitat to encourage flying-fox roosting. Habitat enhancement should aim to maintain good canopy health through weed and vine removal, and maintain good canopy succession (i.e. lower, mid and upper storey) to prevent complete forest deterioration during large flying-fox influxes and provide refuge habitat during HSEs.	Costs will depend on extent of restoration efforts.	No	By the end of 2024
Research	Investigate local native flowering events to develop understanding of the value of foraging habitat within the LGA and assist in predicting potential flying-fox influxes. Examine applications new technologies through trials at high conflict sites.	Variable as budget allows.	Depending on project, refer to Appendix 4	ASAP and ongoing
Incident management	Adopt and implement HSE management and response plan for each roost site within LGA. Continue engaging with wildlife carers and stakeholders to ensure plans and policies are kept up-to-date. Investigate flying-foxes handling training and Australian bat lyssavirus (ABLV) vaccination for staff.	Council time (e.g., plan administration and. engaging/liaising with stakeholders)	No	ASAP
Planning	Incorporate human/wildlife management principles into land use planning to proactively reduce conflict between community and flying-foxes.	Variable with land use planning/development, however likely to be offset by long term savings.	No	ASAP
Active management (nudging and/or dispersal)	Active management will only be considered for very high conflict sites where other management techniques have been effectively implemented and proven unsuccessful in alleviating impacts.	Costs will depend on the size of the roost, location, resources, and personnel required to undertake initial works, and ongoing costs to maintain nudging/dispersal outcomes	Yes, refer to Appendix 4	Only when required

Management type	Management action	Indicative costs (ex GST)	Approvals required	Timeframe
Regular monitoring	Undertake regular monitoring of all Livingstone Shire roosts, utilising appropriate methods (e.g. diurnal static or fly-out, crèching or drone surveys) to detect any changes in population numbers or distribution in the area. Monthly monitoring is recommended, quarterly monitoring at a minimum aligns with the NFFMP. It is recommended to undertake monitoring at a roost prior to implementing management actions (e.g. vegetation trimming). Moreover, monitoring should increase to daily in the three days prior to, during, and following active management as determined by the level of disturbance associated with the management.	Approximately one day (depending on methods) suitably qualified contractor or staff to monitor the key roosts.		ASAP and ongoing

5.1 Management framework for emerging roosts

Emerging roosts will be assessed and managed in accordance management options detailed in Appendix 4. The following flow chart outlines a general procedure to assess and manage emerging flying-fox roosts in the Livingstone Shire.



*Early management intervention at an emerging roost may be possible, before it meets the criteria for a flying-fox roost (see DES 2021). In this case, it is important to note that the NC Act still applies, meaning any actions to kill, injure or harm flying-foxes are prohibited, and native vegetation is protected. Planning required to properly coordinate management actions to avoid community and flying-fox impacts should always be prioritised over the speed of management actions implemented.

5.2 Reducing risk to flying foxes

Council can further reduce the risk of negative impacts to flying-foxes by considering the following:

- reducing or eliminating the amount of barbed wire on Council projects, by
  - shifting to non-barbed alternatives for new projects
  - using non-barbed alternatives when conducting maintenance that required wire replacement
  - replacing out barbed wire in areas with recorded flying-fox mortalities
- the installation of underground power cabling instead of new overhead power lines where possible
- maintaining records of wildlife injury and deaths to monitor potential hotspot areas that may require further intervention, e.g., existing aboveground powerlines could be upgraded to aerial bundled cable to prevent electrocution mortalities, such as Shaw Avenue, Yeppoon
- implementing heat stress event emergency response actions detailed in Appendix 7.

Scheduled works at or near roosts sites should adhere to the below:

Table 3 Planned actions for potential impacts during any works under or near a flying-fox roost

Welfare trigger	Signs	Action
Unacceptable levels of stress	If any individual is observed: · panting · saliva spreading · located on or within two metres of the ground	· Works to cease for the day
Fatigue	In situ management · more than 30% of the roost takes flight · individuals are in flight for more than five minutes · flying-foxes appear to be leaving the roost	· In situ management · Works to cease and recommence only when flying-foxes have settled* / move to alternative locations at least 50 m from roosting animals
Injury/death	· a flying-fox appears to have been injured/killed on-site (including aborted foetuses) · any flying-fox death is reported within one kilometre of the site · loss of condition evident	· Works to cease immediately and DESI notified · Rescheduled or stopped indefinitely and alternative management options investigated. · Adapted sufficiently so that significant impacts (e.g. death/injury) are highly unlikely to occur, as confirmed by an independent expert.
Reproductive condition	· females in final trimester · dependent/crèching young present	· Works rescheduled · Stopped indefinitely and alternative management options investigated.

*maximum of two unsuccessful attempts to recommence work before ceasing for the day.

6 Plan administration

6.1 Evaluation and review

A review of the Plan, including community consultation and expert input, should be scheduled annually. The Plan shall remain in place until a revised version is adopted by Council; a 5-year review is recommended.

The following may trigger an earlier Plan update:

- changes to relevant policy/legislation
- new management techniques becoming available
- outcomes of research that may influence the Plan
- incidents associated with the roost.

Progress and priority of management actions in the Plan will be evaluated annually by Council.

6.2 Reporting

Council will complete the DESI evaluation form for actions under its as-of-right authority (excluding activities listed under the Low Impact COP), returned within six weeks of the date of actions being completed. Council will comply with any reporting obligations under the Code of Practice or approvals obtained to implement the Plan.

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Appendix 1 Legislation

Commonwealth

Environment Protection and Biodiversity Conservation Act 1999

The Commonwealth's EPBC Act provides protection for the environment, specifically MNES. A referral to the Department of Climate Change, Energy, the Environment and Water (DCCEEW) is required under the EPBC Act for any action that is likely to significantly impact on an MNES. The GHFF is listed as a vulnerable species under the EPBC Act, meaning it is an MNES.

State

Nature Conservation Act 1992

As native species, all flying-foxes and their roosting habitat are protected in Qld under the NC Act. State approval is required to:

a) destroy a flying-fox roost;

b) drive away, or attempt to drive away, a flying-fox from a flying-fox roost ('drive away' is defined to mean "cause the flying-fox to move away from the roost; or if the flying-fox has moved away from the roost, deter the flying-fox from returning to the roost"); and/or

c) disturb a flying-fox in a flying-fox roost.

Note that the definition under Qld law means that once a flying-fox roost is established, it remains as such even when it is unoccupied. The *Interim policy for determining when a flying-fox congregation is regarded as a flying-fox roost under section 88C of the NC Act* (DES 2021b) has recently been released and is currently in consultation. It is our understanding that this Plan aligns with this roost policy, however amendments can be made to this Plan in consultation with DESI if required.

A 'flying-fox roost' is defined under the NC Act as 'a tree or other place where flying-foxes congregate from time to time for breeding or rearing their young'.

<u>Council 'as-of-right' management</u>

Under the NC Act, local governments have an 'as-of-right' authority under the NC Act to manage flying-fox roosts in mapped UFFMAs, without the requirement for a permit, in accordance with the *Code of Practice – Ecologically sustainable management of flying-fox roosts* (Management COP) (DES 2020a).

Councils must however still notify DESI of the planned management. Notification is by means of a completed 'flying-fox management notification form' from the DESI website submitted at least two business days prior to commencing any management actions, unless an authorised person from DESI provides written advice that these actions can commence earlier. Local governments may also choose to, with the relevant landholder's permission, exercise their 'as-of-right' authority on private land. Notification is valid for all notified management actions within a four-week timeframe.

The *Flying-fox Roost Management Guideline* (DES 2020b) has also been developed to provide local government with additional information that may assist decision making and management of flying-fox roosts. Councils are required to apply for a FFRMP to manage flying-fox roosts outside an UFFMA, or for management actions not specified in the Management COP. It must be noted that this 'as-of-right' authority does not oblige a council to manage flying-fox roosts and does not authorise management under other relevant sections of the NC Act or other legislation (such as the VM Act).

Anyone other than local government is required to apply to DESI for a FFRMP for any management directed at roosting flying-foxes, or likely to disturb roosting flying-foxes. Certain low impact activities (e.g. mowing, minor tree trimming) do not require approval if undertaken in accordance with the *Code of Practice – Low impact activities affecting flying-fox roosts* (Low Impact Code) (DES 2020c).

Flying-fox roost management permits

Councils wishing to manage flying-fox roosts located outside an UFFMA or to conduct flying-fox management activities that are not Code-compliant, must apply to DESI for a FFRMP. Under the Nature Conservation (Animals) Regulation 2020 (the Animals Regulation), a FFRMP may only be approved for management of a flying-fox roost where its resident flying-foxes are causing or may cause damage to property; or represent a threat or potential threat to human health or wellbeing. The Management COP may generally also apply where such a requirement is stated on the FFRMP. Such a permit is valid for a period of one year, or up to three with a DESI-approved flying-fox management plan (e.g. this Plan).

Anyone other than local government is required to apply for a FFRMP for any management directed at roosting flying-foxes, or likely to disturb roosting flying-foxes other than:

- certain low impact activities (e.g. mowing, minor tree trimming) if undertaken in accordance with the Code of Practice – Low impact activities affecting flying-fox roosts (Low Impact COP) (DES 2020c)
- instances where Council is enacting their as-of-right authority.

Low impact roost management

All landholders – private or public – can undertake low impact activities such as mulching, mowing and weeding near flying-fox roosts, as well as allowing trimming of up to 10% of the total canopy of the roost without a FFRMP if it is done in accordance with the Low Impact Code (DES 2020c). This authorisation is provided these activities not being undertaken with the intention of destroying the roost, or disturbing or driving away the flying-foxes.

Flying-fox management statements and planning

The *Flying-fox roost management guideline* (DES 2020b) was developed to provide local councils and other entities wishing to manage flying-fox roosts with additional information that may assist their decision-making, including developing SOMIs and flying-fox roost management plans.

Vegetation under the *NC Act 1992*

All plants native to Australia are protected under the NC Act. Prior to any clearing of protected plants, a person must refer to the flora survey trigger map to determine if the clearing is within a high-risk area.

- in a high-risk area, a flora survey must be undertaken and a clearing permit may be required for clearing endangered, vulnerable and near threatened (EVNT) plants and their supporting habitat.
- if a flora survey identifies that EVNT plants are not present or can be avoided by 100 m, the clearing activity may be exempt from a permit. An exempt clearing notification form is required.
- in an area other than a high-risk area, a clearing permit is only required where a person is, or becomes, aware that EVNT plants are present.
- clearing of least concern plants will be exempt from requiring a clearing permit within a low-risk area.

Vegetation under the *Fisheries Act 1994*

All marine plants, including mangroves, seagrass, saltcouch, algae, samphire vegetation and adjacent plants (e.g. melaleuca and casuarina), are protected under Qld law through provisions of the *Fisheries Act 1994*. Approval must be gained from Fisheries Qld to destroy, damage, or disturb any marine plant. Under the Fisheries Act, a 'marine plant' includes:

a) a plant (a 'tidal plant') that usually grows on, or adjacent to, tidal land, whether it is living or dead, standing or fallen;
    - The *Fisheries Act* does not define 'adjacent' as it relates to marine plants. In the absence of a definition, the Fish Habitat Management Operational Policy describes the application of 'adjacent' in terms of when a marine plant development permit application would be required for disturbance of plants in or adjacent to the tidal zone.

b) the material of a tidal plant, or other plant material on tidal land;

c) a plant, or material of a plant, prescribed under a regulation or management plan to be a marine plant.

Vegetation Management Act 1999

The clearing of native vegetation in Qld is regulated by the VM Act, the *Sustainable Planning Act 2009* and associated policies and codes.

The type of clearing activity allowed, and how it is regulated, depends on:

- the type of vegetation (as indicated on the regulated vegetation management map and supporting maps)
- the tenure of the land (e.g. freehold or Indigenous land)
- the location, extent and purpose of the proposed clearing
- the applicant proposing to do the clearing (e.g. state government body, landholder).

Depending on these factors, clearing activities will either:

- be exempt from any approval or notification process
- require notification and adherence to a self-assessable code
- require notification and adherence to an area management plan
- require a development approval.

VM Act exemptions allow native vegetation to be cleared for a range of routine property management activities without the need for a development approval or notification. A number of VM Act exemptions may apply to clearing vegetation that is flying-fox roosting or foraging habitat. However, specific advice should be obtained from Department of Natural Resources and Mines for each proposed vegetation clearing activity.

No explicit VM Act exemptions for clearing flying-fox roosting or foraging vegetation were in place as of June 2023.

Animal Care and Protection Act 2001

The ACP Act provides for animal welfare. The ACP Act is administered by Biosecurity Qld within the Department of Agriculture and Fisheries. The ACP Act applies to all living vertebrate animals, including wildlife. To comply with the ACP Act flying-fox management actions must not cause mental or physical suffering, pain or distress.

Civil Aviation Act 1998

The Civil Aviation Act establishes Australia's Civil Aviation Safety Authority functions in relation to civil aviation, with particular emphasis on safety. Civil Aviation Safety Regulations 1998 Part 139 contains specific requirements for wildlife hazard management.

Appendix 2 Species profile

Black flying-fox (*Pteropus alecto*)

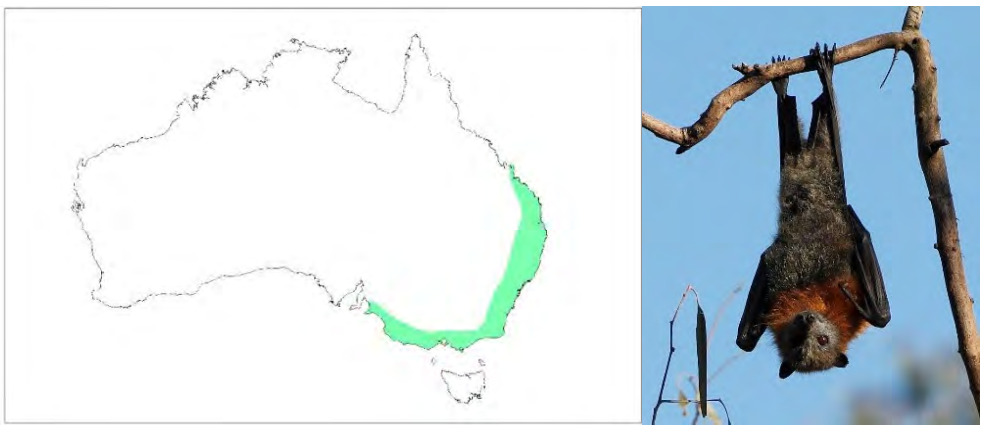
Black flying-fox indicative species distribution (Department of Planning and Environment [DPE] 2023)

The BFF has traditionally occurred throughout coastal areas from Shark Bay in Western Australia, across Northern Australia, down through Qld and into NSW (Churchill 2008). Since it was first described there has been a substantial southerly shift by the BFF (Webb & Tidemann 1995). This shift has consequently led to an increase in indirect competition with the threatened GHFF, which appears to be favouring the BFF (DAWE 2021).

They forage on the fruit and blossoms of native and introduced plants (Churchill 2008), including orchard species at times. BFF are largely nomadic animals with movement and local distribution influenced by climatic variability and the flowering and fruiting patterns of their preferred food plants. Feeding commonly occurs within 20 km of the roost site (Markus and Hall 2004).

BFF usually roost beside a creek or river in a wide range of warm and moist habitats, including lowland rainforest gullies, coastal stringybark forests and mangroves. Roost sizes can change significantly in response to the availability of food and the arrival of animals from other areas.

Grey-headed flying-fox (*Pteropus poliocephalus*)



Grey-headed flying-fox indicative species distribution (DPE 2023)

The GHFF is found throughout eastern Australia, generally within 200 kilometres of the coast, from Finch Hatton in Qld to the north to Melbourne, Victoria (Office of Environment and Heritage [OEH] 2020). This species now ranges into South Australia and individual flying-foxes have been reported on the Bass Islands and mainland Tasmania (Driessen et al. 2011). It requires foraging resources and roost sites within rainforests, open forests, closed and open woodlands (including melaleuca swamps and banksia woodlands). This species is also found throughout urban and agricultural areas where food trees exist and will feed in orchards at times, especially when other food is scarce (OEH 2020).

All the GHFF in Australia are regarded as one population that moves around freely within its entire national range (Webb and Tidemann 1996, DAWE 2021). GHFF may travel up to 100 kilometres in a single night with a foraging radius of up to 50 kilometres from their roost (McConkey et al. 2012). They have been recorded travelling over 500 kilometres over 48 hours when moving from one roost to another (Roberts et al. 2012). GHFF generally show a high level of fidelity to roost sites, returning year after year to the same site, and have been recorded returning to the same branch of a particular tree (SEQ Catchments 2012). This may be one of the reasons flying-foxes continue to return to small urban bushland blocks that may be remnants of historically used larger tracts of vegetation.

The GHFF population has a generally annual southerly movement in spring and summer, with their return to the coastal forests of north-east NSW and South East Qld in winter (Ratcliffe 1932, Eby 1991, Parry-Jones & Augee 1992, Roberts et al. 2012). This results in large fluctuations in the number of GHFF in New South Wales, ranging from as few as 20% of the total population in winter up to around 75% of the total population in summer (Eby 2000). They are widespread throughout their range during summer, but in spring and winter are uncommon in the south. In autumn they occupy primarily coastal lowland roosts and are uncommon inland and on the south coast of New South Wales (OEH 2020).

There is evidence the GHFF population declined by up to 30% between 1989 and 2000 (Birt 2000, Richards 2000). There is a wide range of ongoing threats to the survival of the GHFF, including habitat loss and degradation, culling in orchards, conflict with humans, infrastructure-related mortality (e.g. entanglement in barbed wire fencing and fruit netting, and power line electrocution) and competition and hybridisation with the BFF (DCCEEW 2021). For these reasons it is listed as vulnerable to extinction under NSW and federal legislation.

Little red flying-fox (*Pteropus scapulatus*)

Little red flying-fox indicative species distribution (DPE 2023)

The LRFF is widely distributed throughout northern and eastern Australia, with populations occurring across northern Australia and down the east coast into Victoria.

The LRFF forages almost exclusively on nectar and pollen, although will eat fruit at times and occasionally raids orchards (Australian Museum 2020). LRFF often move sub-continental distances in search of sporadic food supplies. The LRFF has the most nomadic distribution, strongly influenced by availability of food resources (predominantly the flowering of eucalypt species) (Churchill 2008), which means the duration of their stay in any one place is generally very short.

Habitat preferences of this species are quite diverse and range from semi-arid areas to tropical and temperate areas, and can include sclerophyll woodland, melaleuca swamplands, bamboo, mangroves and occasionally orchards (Australian Museum 2020). LRFF are frequently associated with other *Pteropus* species. In some colonies, LRFF individuals can number many hundreds of thousands and they are unique among *Pteropus* species in their habit of clustering in dense bunches on a single branch. As a result, the weight of roosting individuals can break large branches and cause significant structural damage to roost trees, in addition to elevating soil nutrient levels through faecal material (SEQ Catchments 2012).

Throughout its range, populations within an area or occupying a roost can fluctuate widely. There is a general migration pattern in LRFF, whereby large congregations of over one million individuals can be found in northern roost sites (e.g. Northern Territory, North Qld) during key breeding periods (Vardon & Tidemann 1999). LRFF travel south to visit the coastal areas of South East Qld and NSW during the summer months. Outside these periods LRFF undertake regular movements from north to south during winter–spring (July–October) (Milne & Pavey 2011).

Appendix 3 Human and animal health

All animals can carry pathogens that may pose human health risks. In Australian bats, the most well-defined of these include ABLV and Hendra virus HeV. Specific information on these viruses is provided below.

Excluding those people whose occupations require contact with bats, such as wildlife carers and vets, human exposure to ABLV and HeV, their transmission, and frequency of infection is extremely rare. These diseases are also easily prevented through vaccination, PPE, safe flying-fox handling (by trained and vaccinated personnel only) and appropriate horse husbandry. Therefore, despite the fact that human infection with these agents can be fatal, the probability of infection is extremely low, and the overall public health risk is also judged to be low (Qld Health 2022).

Below is current information at the time of writing. Please refer regularly to Qld Health for up-to-date information on bats and health.

Australian bat lyssavirus

ABLV is a rabies-like virus that may be found in all flying-fox species on mainland Australia. It has also been identified in yellow-bellied sheathtail baits (*Saccolaimus flaviventris*), an insectivorous microbat, and seroconversion (development of virus-specific antibodies) has been found in seven microbat genera (WHA 2019). It is assumed that all bats may be capable of hosting ABLV (WHA 2019). The probability of human infection with ABLV is very low with less than 1% of the flying-fox population being affected (WHA 2019) and transmission requiring direct contact with an infected animal that is secreting the virus. In Australia, three people have died from ABLV infection since the virus was identified in 1996 (WHA 2019).

Transmission of the virus from bats to humans is through a bite or scratch but may have potential to be transferred if bat saliva directly contacts the eyes, nose, mouth or broken skin (WHA 2019, Merritt et al. 2018). ABLV is unlikely to survive in the environment for more than a few hours, especially in dry environments that are exposed to sunlight (Department of Agriculture and Fisheries; DAF 2020). Transmission of closely related viruses suggests that contact or exposure to bat faeces, urine or blood does not pose a risk of exposure to ABLV, nor does living, playing or walking near bat roosting areas (DAF 2020).

The incubation period in humans is assumed to be similar to rabies, generally around three to eight weeks (Merritt et al. 2018). However, in few cases, the incubation period has ranged from a few days to several years (Merritt et al. 2018). The disease in humans presents essentially the same clinical picture as classical rabies. Once clinical signs have developed, the infection is invariably fatal. However, infection can easily be prevented by avoiding direct contact with bats (i.e. handling). Pre-exposure vaccination provides reliable protection from the disease for people who are likely to have direct contact with bats, and it is generally a mandatory workplace health and safety requirement that all persons working with bats receive pre-vaccination and have their level of protection regularly assessed. Like classical rabies, ABLV infection in humans also appears to be effectively treated using post-exposure vaccination and so any person who suspects they have been exposed should seek immediate medical treatment. Post-exposure vaccination is usually ineffective once clinical manifestations of the disease have commenced.

Domestic animals are also at risk if exposed to ABLV. In 2013, ABLV infections were identified in two horses (Shinwari et al. 2014). A dog that caught and consumed a flying-fox also tested positive for ABLV antibodies in 2013 (Wright 2013). According to the Qld Government's ABLV

factsheet for veterinarians, clinical symptoms are most likely to appear in animals within 1 – 6 months following exposure (DAF 2020). Given the incubation period variability, animals that are bitten or scratch by a flying-fox should monitor for clinical symptoms for months to years following potential exposure (DAF 2020). Consultation with a veterinarian should be sought if exposure is suspected.

If a person or pet is bitten or scratched by a bat they should:

- wash the wound with soap and water for at least five minutes (do not scrub)
- contact their doctor immediately to arrange for post-exposure vaccinations.

If bat saliva contacts the eyes, nose, mouth or an open wound, flush thoroughly with water and seek immediate medical advice.

Please refer to WHA's Australian bat lyssavirus fact sheet for further information.

Hendra virus

Flying-foxes are the natural host for HeV, which can be transmitted from flying-foxes to horses. Infected horses sometimes amplify the virus and can then transmit it to other horses, humans and on two occasions, dogs (WHA 2021). There is no evidence that the virus can be passed directly from flying-foxes to humans or to dogs (WHA 2021). Clinical studies have shown cats, pigs, ferrets and guinea pigs (as well as hamsters and African green monkeys – not applicable to Australia) can carry the infection, though there is no evidence of direct HeV transmission from flying-foxes to any species other than horses (WHA 2021). As of 2021, over 106 HeV infections in horses (confirmed or possible cases) have been reported (WHA 2021). These infections occurred across over 60 disease outbreak events, three of which also involved human infections. Although the virus is periodically present in flying-fox populations across Australia, the likelihood of horses becoming infected is low and consequently human infection is extremely rare.

The transmission of HeV from flying-foxes to horses is thought to be complex and involve several host and environmental factors (WHA 2021). The most likely route of transmission is through exposure of horse mucous membranes to infected flying-fox urine, body fluids, or excretion (WHA 2021). This may occur directly (direct contact of infected fluids with mucous membranes) or indirectly (e.g. ingestion of contaminated forage or water). The incubation period of HeV in horses is estimated to be 5 – 16 days (WHA 2021). The mortality rate of HeV in horses is approximately 80% (Qld Government 2023).

While considered very rare, humans may contract the disease after close contact with respiratory secretions (e.g. mucous) and/or blood of an infected horse (WHA 2021, Qld Government 2023). Similarly, the dogs may become infected following close contact with infectious bodily fluids of infected horses (Qld Government 2023). HeV infection in humans presents as a serious and often fatal respiratory and/or neurological disease and there is currently no effective post-exposure treatment or vaccine available for people. The mortality rate of HeV in humans is approximately 70% (Qld Government 2023).

Previous studies have shown that HeV spillover events have been associated with foraging flying-foxes rather than roost locations. Therefore, risk is considered similar at any location within the range of flying-fox species and all horse owners should be vigilant. Vaccination of horses can protect horses and subsequently humans from infection (Qld Government 2023), as can appropriate horse husbandry (e.g. covering food and water troughs, fencing flying-fox foraging trees in paddocks, etc.).

Although all human cases of HeV to date have been contracted from infected horses and

direct transmission from bats to humans has not yet been reported, particular care should be taken by select occupational groups that could be uniquely exposed. For example, persons who may be exposed to high levels of HeV via aerosol of heavily contaminated substrate should consider additional PPE (e.g. respiratory filters), and potentially dampening down dry dusty substrate.

Please refer to WHA's Hendra virus and Australian wildlife fact sheet for further information.

General health considerations

All animals, including flying-foxes, can carry bacteria and other microorganisms in their guts, some of which are potentially pathogenic to other species. Bat urine and faeces should be treated like any other animal excrement. As with any accumulation of animal faeces (bird, bat, domestic animals), fungi or bacteria may be present and care should be taken when cleaning faeces. This includes wetting dried faeces before cleaning or mowing, wearing appropriate PPE and maintaining appropriate hygiene. If disturbing dried bird or bat droppings, particulate respirators should be worn to prevent inhalation of dust and aerosols. See 'Work with bird and bat droppings' for detail.

Contamination of water supplies by any animal excreta (birds, amphibians and mammals such as flying-foxes) poses a health risk to humans. Household tanks should be designed to minimise potential contamination, such as using first-flush diverters to divert contaminants before they enter water tanks. Trimming vegetation overhanging the catchment area (e.g. the roof of a house) will also reduce wildlife activity and associated potential contamination. Tanks should also be appropriately maintained and flushed, and catchment areas regularly cleaned to remove potential contaminants. Public water supplies are regularly monitored for harmful microorganisms and are filtered and disinfected before being distributed. Management plans for community supplies should consider whether any large congregation of animals, including flying-foxes, occurs near the supply or catchment area. Where they do occur, increased frequency of monitoring should be considered to ensure early detection and management of contaminants.

Appendix 4 Management options analysis

Table 4 outlines a site-specific assessment of flying-fox management options commonly used across Australia, and their suitability for the Livingstone Shire roosts, as well as emerging roosts. Descriptions and examples of management options are provided in Appendix 5.

Table 4 Management options analysis (see Appendix 6 for option descriptions).

Management options	Advantages & disadvantages	Suitability for Livingstone Shire flying-fox roosts	Suitability for emerging roost	Approvals required	Appraisal
Education and awareness programs	**Advantages:** Low cost, promotes conservation of flying-foxes, contributes to attitude change which may reduce general need for roost intervention and reduce anxiety, increasing awareness and providing options for landholders to reduce impacts can be an effective long-term solution, can be undertaken quickly, will not impact on ecological or amenity value of the site. **Disadvantages:** Education and advice itself will not mitigate all issues, and in isolation would not be acceptable to the community.	Collecting and providing information should always be the first response to community concerns in an attempt to alleviate issues without the need to actively manage flying-foxes or their habitat. Council has engaged with affected residents to provide information on human health, legislation, and the importance of flying-foxes. Continued education and ensuring all residents have access to the latest health information is required. High overall interest expressed for education in community engagement and online survey.	Proactive engagement with surrounding landholders and sensitive site occupants/attendees (e.g. schools, hospitals) is vital to address impacts and concerns before they arise.	No	Continue and increase at all four roost sites.
Subsidy program	**Advantages:** Property-level impact mitigation (e.g. double-glazing, indoor odour-neutralising pots, noise attenuating insulation, car covers, boundary barriers such as dense plantings with fragrant flowers) is one of the most effective ways to reduce amenity impacts. It provides more certain outcomes compared with attempting to manage flying-foxes or their habitat. It is relatively low	Property modification may be supported if costs were able to be assisted by a Council-funded subsidy program. Generally, costs are likely to be more expensive than roost management due to the number of residents in close proximity to roosts, particularly in Yeppoon, although management costs are hard to predict. Property modification to residences in immediate proximity to the Keppel Sands roosts may be well received. Council	Suitable for emerging roosts in high conflict areas, particularly if residents are experiencing impacts related to noise and smell, or other issues that could be alleviated through an item/property-based	No	Council to investigate potential for a Council-funded subsidy program which may include service subsidies, and opportunities to apply for grants to supplement such a program.

Management options	Advantages & disadvantages	Suitability for Livingstone Shire flying-fox roosts	Suitability for emerging roost	Approvals required	Appraisal
	cost, can be included in building design and materials, will not impact on the roost and may add value to the property. Service subsidies (e.g. assistance with cleaning faecal drop) may encourage tolerance of living near a roost; promotes conservation of flying-foxes; can be undertaken quickly; will not impact on the site; would reduce the need for property modification. **Disadvantages:** Property modification may be cost-prohibitive for private landholders, unlikely to fully mitigate community concerns. Services may be costly over a large scale which must be considered if proposed development intends to increase dwelling density around roost.	should investigate potential for a Council-funded subsidy program, and opportunities to apply for grants to supplement such a program. Services can be costly over a large scale, it is suitable for smaller sites with fewer impacted residents than larger townships. Service subsidies for cleaning are likely to be well regarded given the substantial response to impacts caused by faecal drop.	subsidy program		
Routine roost management	**Advantages:** Can improve amenity at the site as well as impacts to biodiversity such as weeds on the site and in downstream areas. **Disadvantages:** Will not generally mitigate amenity impacts for nearby landholders. Weed removal and bushfire management has the potential to reduce roost availability and reduce numbers of roosting flying-foxes. Removing weeds also changes	Vegetation at low conflict sites, such as Yeppoon and Keppel Sands, should be maintained and improved without deterring flying-foxes from roosting in an effort to attract flying-foxes from close high conflict sites. Residents at Marlborough and Keppel Sands are able to maintain properties in accordance with the Low Impact COP.	Avoid undertaking roost management activities that are likely to discourage flying-fox roosting at low conflict sites (e.g. weed removal). Encourage roosting at low conflict sites through habitat improvement activities. For an emerging roost in a high conflict area, roost vegetation should be	No permit required for weed management or habitat improvement.	Required at Emu Park where roost has financial impact on businesses. Must be undertaken in suitable areas and at appropriate times (ideally in the non-breeding season or adapted during the breeding season to be less disruptive)

Management options	Advantages & disadvantages	Suitability for Livingstone Shire flying-fox roosts	Suitability for emerging roost	Approvals required	Appraisal
	the microclimate which can increase roost temperature and therefore susceptibility to HSEs.		managed to discourage roosting (e.g. vegetation thinning, weed removal).		
Alternative habitat creation	**Advantages:** If successful in attracting flying-foxes away from high conflict areas, dedicated habitat in low conflict areas will mitigate all impacts and helps flying-fox conservation. Rehabilitation of degraded habitat that is likely to be suitable for flying-fox use could be a more practical and faster approach than habitat creation. **Disadvantages:** Generally costly, long-term approach so cannot be undertaken quickly, previous attempts to attract flying-foxes to a new site have not been known to succeed.	Most roosts in the Livingstone LGA are considered low conflict. Council could investigate potential alternative sites for habitat enhancement as a long-term management solution. Bell Park is considered a lower conflict roost site than the vegetation bordering Tasman Holiday Parks in Emu Park. Disturbance to the roost at Bell Park should be avoided in an effort to prevent flying-foxes moving into the Tasman Holiday Park roost. Council should aim to identify suitable roost habitat in low conflict locations and restore and/or enhance habitat to encourage flying-fox roosting. Habitat enhancement should aim to maintain good canopy health through weed and vine removal, and maintain good canopy succession (i.e. lower, mid and upper storey) to prevent complete forest deterioration during large flying-fox influxes and provide refuge habitat during HSEs. This is likely to be well received by the community, as on eof the most supported management options from the community survey was protecting and enhancing flying-fox habitat in low conflict areas.	If emerging roost is in high conflict location, Council should aim to identify suitable roost habitat in low conflict locations and restore and/or enhance habitat to encourage flying-fox roosting there. At low conflict sites, habitat should be improved to encourage roosting (as row above).	No	Avoid disturbance at low conflict roosts. Pre-emptively identify alternative, low-conflict sites for habitat restoration/enhancement
Provision of artificial roosting habitat	**Advantages:** Artificial roosting habitat (e.g. suspended ropes) could be considered to supplement the canopy if weed removal or roost management	To date artificial habitat structures have not been effective. Further trials could be considered with the aim of reducing pressure on roosting vegetation where this is a main concern.	Potentially suitable to enhance a low-conflict emerging roost where the pressure on roosting	No	Investigate for sites where vegetation damage is a main concern

Management options	Advantages & disadvantages	Suitability for Livingstone Shire flying-fox roosts	Suitability for emerging roost	Approvals required	Appraisal
	affects available roosting space. **Disadvantages:** No guarantee that flying-foxes would use artificial habitat but collaborating with a researcher on varying design options would increase the likelihood of success.		vegetation where this is a main concern.		
Protocols to manage incidents	**Advantages:** Protocols for managing incidents (e.g. HSEs, unauthorised disturbances) can reduce the risk of negative human/pet-flying-fox interactions. Low cost, promotes conservation of flying-foxes, can be undertaken quickly. In some cases, infrastructure problems such as power black-outs from flying-foxes being electrocuted on powerlines may be avoided by proactive management (e.g. adding spacers on powerlines). **Disadvantages:** Will not mitigate amenity impacts.	Council should respond to HSEs as per Appendix 7. Council should continue to engage with wildlife carers and nearby residents, particularly during potential mass mortality events such as HSEs and post-storm recovery. Flying-fox conservation was identified as one of the major concerns to the community in the online survey.	Protocols for managing incidents should be established at both low and high conflict emerging roosts.	No	Continue to manage incidents in close communication with local carers
Research	**Advantages:** Support research that improves understanding and more effectively mitigates impacts. For example, outdoor odour-neutralising technology could be used to mitigate odour impacts to residents. **Disadvantages:** Generally, cannot be undertaken quickly, management trials may require cost input.	Smell was identified as a great concern associated with flying-foxes amongst the community. An odour-neutralising trial could be conducted at affected sites – focusing on high trafficked areas. Develop understanding of native flowering events in LGA to understand and predict potential influxes of flying-foxes. New research should be reviewed at least annually and incorporated into management where appropriate.	Odour-neutralising trial could be considered at high conflict sites where odour is regarded as the major impact. Research should be ongoing for both low and high conflict sites.	Research permit and Animal Ethics Committee (AEC) approval required for outdoor odour-neutralising trial	Investigate outdoor odour-neutralising trial and native flowering events within LGA.
Appropriate land-	**Advantages:** Planning for future	Incorporate planning controls where	Incorporate planning	No	Investigate

Management options	Advantages & disadvantages	Suitability for Livingstone Shire flying-fox roosts	Suitability for emerging roost	Approvals required	Appraisal
use planning	land use where possible, will reduce potential for future conflict between community and flying-fox roosts. **Disadvantages:** Will not generally mitigate current impacts.	possible. Likely to be well regarded by the community as third most supported management option.	controls where possible.		
Property acquisition	**Advantages:** Allows affected landholders to move away from a roost, mitigating all impacts. Supports flying-fox conservation. **Disadvantages:** Costly; property owners may not want to sell.	This option is considered cost-prohibitive and unlikely to be accepted by affected residents.	This option is considered cost-prohibitive and unlikely to be accepted by affected residents.	No	Not suitable
Buffers through vegetation removal	**Advantages:** Can provide a buffer between the community and flying-fox roosts which can reduce concerns in some instances. **Disadvantages:** Removing vegetation can reduce buffering benefits of the vegetation to noise, odour and visual impacts, with potential to create additional conflict. Vegetation removed may exacerbate the impacts of HSEs.	Vegetation in high conflict areas, such as the perimeter of Tasman Holiday Park, Emu Park, may be thinned, lopped, or removed so it is less attractive for roosting in future. Likely to be an effective management option at Emu Park (Tasman Holiday Park) and potentially Keppel Sands roosts, although the greatest concern identified by the online survey was flying-fox habitat protection and is unlikely to be well regarded by the community. Where there is a high infestation of weeds or a dense mid/understorey (particularly below a low canopy), weed and understorey management may sufficiently alter buffer habitat, making it unfavourable for roosting flying-foxes. If weeds and/or understorey are not present, trees may require trimming to create a buffer.	Suitable at high conflict sites where residents are in close proximity to flying-fox roosting habitat. Vegetation removal should be avoided/limited at low conflict sites to avoid inadvertent dispersal of flying-foxes.	Approval likely required to remove native vegetation (Appendix 1). Weed removal can occur as a general maintenance program and is permitted under the DESI Low Impact COP. If undertaking vegetation works outside of the Low Impact COP, DESI notification will be required.	Consider at Emu Park and Keppel Sands if other methods (below) are unsuccessful.
Buffers without vegetation	**Advantages:** Can provide effective buffers with maximum	CMS may be feasible as a buffering method for Emu Park (Tasman Holiday	Suitable at high conflict sites where	Notification to DESI and possible	Trial D-ter and PROVolitans lighting at

Management options	Advantages & disadvantages	Suitability for Livingstone Shire flying-fox roosts	Suitability for emerging roost	Approvals required	Appraisal
removal – visual deterrents, olfactory deterrent, noise emitters, canopy mounted sprinklers (CMS)	retention of vegetation. **Disadvantages:** Can be logistically difficult (installation and water sourcing) and may be cost-prohibitive. Misting may increase humidity and exacerbate HSEs, and overuse may impact other environmental values of the site. Water restriction consideration required. The type and placement of visual deterrents would need to be varied regularly to avoid habituation. May appear an eye-sore and lead to increase in rubbish in the natural environment.	Park) and residents bordering the Keppel Sands roost. Other methods, such as PROVolitans, could be trialled to create a buffer between residential dwellings directly adjacent to flying-fox roost habitat. While D-ter has previously had a very localised effect, it could be used to deter flying-foxes from individual trees.	residents are in proximity to flying-fox roosting habitat. Buffering method (e.g. CMS) should be determined on a site-specific basis.	approval under the VM Act* (if removing vegetation to install sprinklers).	Emu Park (Tasman Holiday Park) roost. As required for other roosts.
Noise attenuation fencing	**Advantages:** Standard noise attenuation fencing is intended to alleviate amenity issues for residents. Advice from an acoustic consultant may provide site-specific alternatives. **Disadvantages:** Noise attenuation fencing is costly and can be considered unsightly if not cleaned of faecal drop.	Noise was identified as one of the major issues to residents who experienced negative interactions with flying-foxes. To avoid the high costs associated with permanent acoustic fencing, and where flying-fox presence is transient, temporary fencing could be erected in property backyards. This may be a viable management option at Yeppoon during large influxes. Residents/businesses could have the ability to fold down the acoustic fence when there are no flying-foxes present and erect it when flying-foxes return to the site. Given the limited number or residents impacted at Keppel Sands and Marlborough, and the proximity to the roost at Emu Park (Tasman Holiday Park) currently, noise-attenuation fencing is not justified at this stage.	Potentially suitable at high conflict sites where noise is identified as the main concern for residents. Not suitable for low conflict sites due to cost.	No	Consider and liaise with residents at Yeppoon.

Management options	Advantages & disadvantages	Suitability for Livingstone Shire flying-fox roosts	Suitability for emerging roost	Approvals required	Appraisal
Nudging using low intensity disturbance	**Advantages:** Can encourage flying-foxes to shift away from high conflict areas next to residential areas. **Disadvantages:** May lead to inadvertent dispersal if not done at the correct time, frequency or duration. Resource intensive with flying-foxes quickly returning to their favoured roost trees.	Unnecessary at Marlborough and Yeppoon considering the locations are low conflict. It is unlikely that nudging will be effective at Keppel Sands and will shift flying-foxes closer to other residents or cause the roost to splinter into private residential yards (as has done before at Marlborough during large influxes). May be a suitable option for Emu Park (Tasman Holiday Park), given that other management techniques should be attempted and unsuccessful. Bell Park would be a low conflict nudging destination but attempts may also shift flying-foxes closer to nearby sensitive receptors If other management techniques (e.g. buffers through vegetation removal, PROVolitans, D-Ter, lighting etc.) to shift flying-foxes away from high conflict areas are unsuccessful, and negative impacts increase, nudging only in very high conflict areas may be considered in future.	Early intervention nudging may be suitable for new roosts in high conflict areas to prevent the roost from establishing in high conflict locations (e.g. directly adjacent to residents or sensitive sites).	Nudging may be done at certain times under the Management COP and Council's as-of-right but should be during the day to avoid inadvertent dispersal/splintering of the roost which would require a FFRMP. If attached young are present, nudging activities should be as passive as possible. Nudging is not appropriate if creching young are present.	Only suitable where other management techniques have been effectively implemented and proven unsuccessful in alleviating impacts.
Passive dispersal through vegetation removal	**Advantages:** If successful can mitigate all flying-fox impacts at that site. **Disadvantages:** Likely less stressful on flying-foxes if done in a staged way than active dispersal, but risks as per active dispersal with additional impacts of losing native vegetation.	Protection of vegetation was highly regarded in multiple sections of the online survey suggesting that this management option is unlikely to be supported by the community. Emu Park (Tasman Holiday Park) and Keppel Sands roosts are the only sites where this option may be feasible. Given the size of the sites and number of potential roosting trees, flying-foxes are unlikely to vacate the roosts completely even if some trees are removed (i.e. nudging effect rather than dispersal). Removal of vegetation from Council-	Early intervention dispersal through tree removal may be suitable for new roosts in high conflict areas to prevent the roost from establishing in high conflict locations (e.g. directly adjacent to residents or sensitive sites). Suitability for vegetation removal	Removal of vegetation would require approval.	Only suitable where other management techniques have been effectively implemented and proven unsuccessful in alleviating impacts.

Management options	Advantages & disadvantages	Suitability for Livingstone Shire flying-fox roosts	Suitability for emerging roost	Approvals required	Appraisal
		managed land is likely to push flying-foxes onto private land and private residents are unlikely to be receptive to removing trees from yards.	will need to be determine on a site-specific bases.		
Active dispersal through disturbance	**Advantages:** If successful can mitigate all flying-fox impacts at that site. **Disadvantages:** Multiple studies show that dispersal is rarely successful, especially without significant vegetation removal (not suitable for this site) or high levels of ongoing effort and significant expenditure (e.g. several years of daily works and over $1M for Sydney Botanic Gardens). Flying-foxes will almost always continue to roost in the area (generally within 600 m, Roberts and Eby 2013), and often splinter into several locations which may result in more widespread impacts. Appendix 6 provides a summary of research conducted on flying-fox dispersals in Australia.	Active dispersal is very costly with highly unpredictable outcomes and can often worsen human-wildlife conflict. As such, it is not currently recommended for any Livingstone Shire roosts. While previous dispersal and nudging attempts at Marlborough roost have had temporary success, none have provided a long-term solution for the conflict at the site and resulted in splintering the roost into higher conflict areas. If conflict increases and/or alternative management strategies are deemed ineffective following effective implementation, dispersal may be considered at high conflict sites. However, with the above management strategies implemented, the potential need for dispersal is considered very low.	Early intervention dispersal may be suitable for new roosts in high conflict areas to prevent the roost from establishing at the site. Once a roost has established, the suitability of dispersal significantly decreases.	Dispersal in accordance with the Management COP is permitted under Council's as-of-right authority with notification to DESI.	Only suitable where other management techniques have been effectively implemented and proven unsuccessful in alleviating impacts

Appendix 5 Management options

Below is an overview of management options commonly used across Qld and Australia which were considered in the development of the Plan.

Low impact options

Education and awareness programs

This management option involves undertaking a comprehensive and targeted flying-fox education and awareness program to provide accurate information to the local community about flying-foxes.

Such a program would include information about managing risk and alleviating concern about health and safety issues associated with flying-foxes, options available to reduce impacts from roosting and foraging flying-foxes, an up-to-date program of works being undertaken at the roost, and information about flying-fox numbers and flying-fox behaviour at the roost.

Residents should also be made aware that faecal drop and noise at night is mainly associated with plants that provide food, independent of roost location. Staged removal of foraging species such as fruit trees and palms from residential yards, or management of fruit (e.g. bagging, pruning) will greatly assist in mitigating this issue.

Collecting and providing information should always be the first response to community concerns in an attempt to alleviate issues without the need to actively manage flying-foxes or their habitat. Where it is determined that management is required, education should similarly be a key component of any approach.

The likelihood of improving community understanding of flying-fox issues is high. However, the extent to which that understanding will help alleviate conflict issues is probably less so. Extensive education for decision-makers, the media and the broader community may be required to overcome negative attitudes towards flying-foxes.

It should be stressed that a long-term solution to the issue resides with better understanding flying-fox ecology and applying that understanding to careful urban planning and development.

An education program may include components shown below.

Possible components of an awareness-raising program

Property modification

The managers of land on which a flying-fox roost is located would promote or encourage the adoption of certain actions on properties adjacent to or near the roost to minimise impacts from roosting and foraging flying-foxes:

- Create visual/sound/smell barriers with fencing or hedges. To avoid attracting flying-foxes, species selected for hedging should not produce edible fruit or nectar-exuding flowers, should grow in dense formation between two and five metres (Roberts 2006) (or be maintained at less than 5 metres). Vegetation that produces fragrant flowers can assist in masking roost odour where this is of concern.
- Manage foraging trees (i.e. plants that produce fruit/nectar-exuding flowers) within properties through pruning/covering with bags or wildlife friendly netting, early removal of fruit, or tree replacement.
- Cover vehicles, pools/spas, and clothes lines (e.g. with carports or tarp covers) where faecal contamination is an issue, or remove washing from the line before dawn/dusk (e.g. use clothes dryers)
- Move or cover eating areas (e.g. BBQs and tables) within close proximity to a roost or foraging tree to avoid contamination by flying-foxes.

- Install double-glazed windows, door seals, insulation, and sound-proof curtains, and use air-conditioners when needed to reduce noise disturbance and smell associated with a nearby roost.
- Use white noise machines and fragrance dispensers or deodorisers within the home to reduce noise and odour impacts.
- Include suitable buffers and other provisions (e.g. covered car parks) in planning of new developments.
- Install rainwater first-flush diverters on rainwater tanks to remove potentially harmful bacteria and microbes from flying-fox faecal drop
- Turn off lighting at night which may assist flying-fox navigation and increase fly-over impacts.
- Consider removable covers for swimming pools and ensure working filter and regular chlorine treatment.
- Appropriately manage rainwater tanks, including installing first-flush systems.
- Avoid disturbing flying-foxes during the day as this will increase roost noise.

The cost would be borne by the person or organisation who modifies the property; however, opportunities for funding assistance (e.g. environment grants) may be available for management activities that reduce the need to actively manage a roost.

Odour neutralising trial

Odour neutralising systems (which modify odour-causing chemicals at the molecular level rather than just masking them) are commonly used in contexts such as waste management, food processing, and water treatment. They have the potential to be a powerful tool for managing odour impacts associated with flying-foxes. Two trials have been undertaken that utilised two different odour-neutralising systems. The indoor system uses a Hostogel™ pot containing a gel-based formula for neutralising indoor odour. These are inexpensive, only require replacement every few months, and may be sufficient to mitigate odour impacts in houses affected by flying-fox roosts. Initial results suggest there may be a positive localised effect in reducing flying-fox odour within homes. This option may be useful for affected residents (particularly those directly adjacent to the roost), as residents could choose whether or not they wish to have a gel-pot in their living space and can simply put the lid back on the pot when the odour is not impacting on them.

The outdoor system consists of a Vapourgard™ unit that dispenses an odour-neutralising vapour through diffuser pipes that are installed on boundary fences. A world-first trial was undertaken in April – June 2021 with the participation of residents living near a flying-fox roost at Porter Park, Sunshine Coast. The system followed a predetermined schedule (alternating on / off cycles) for 9 weeks and residents were asked to rate the flying-fox odour every day throughout the trial.

Objective results were difficult to obtain due to the significant negative experience of residents as a consequence of the large influxes of flying-fox numbers during the trial, however initial results indicated both the indoor and outdoor systems were beneficial. If future trials confirm this technique is effective, the odour-neutralising system could be installed along the boundary of residential properties bordering the flying-fox roost.

Subsidy programs

Subsidy programs provide councils with an opportunity to support impacted residents living near flying-fox roosts. There are a number of factors to consider when establishing a subsidy

program, including who to offer subsidies to (i.e. who is eligible, generally based on proximity to roost), what subsidies to offer (e.g. service-based or property-based), how subsidies should be offered (e.g. reimbursements for purchases or upfront funding), and how the program will be evaluated to determine effectiveness for reducing flying-fox impacts to residents. A recent report published by the NSW Department of Planning, Industry & Environment (Mo & Roache 2019) summarised the implementation and efficacy of subsidy programs across six councils in NSW: Eurobodalla, Ku-ring-gai, Cessnock, Tamworth, and Sutherland councils. This report provides insight into the aforementioned factors for council's consideration, if a subsidy program is to be adopted.

Government initiatives that provide financial assistance commonly assess residents' eligibility based on a number of variables, including property distance from a roost, and deliver subsidies as partial or full reimbursements for purchases. It is important to consider that the popularity of certain subsidies likely varies across different communities, so affected residents should be consulted in the process of establishing an effective subsidy program. The NSW subsidy study (Mo & Roache 2019) found managers who design programs that best meet community needs have an increased probability of alleviating human-wildlife conflicts. Critical thresholds of flying-fox numbers at a roost and distance to a roost may also be used to determine when subsidies would apply.

While subsidies have the potential to alleviate flying-fox impacts within a community, they can be negatively received if residents believe there are broader issues associated with flying-foxes that are not being addressed (Mo & Roache 2019; Mo et al. 2020). As such, it is important (as with any community-based program) to assess the needs of residents and have open, ongoing communication throughout the program to ensure the subsidies are effectively reducing impacts, and if not, how the program can be adapted to address these needs.

A brief description and examples of property and service-based subsidies is provided below.

Property modification/item subsidies

Fully funding or providing subsidies to property owners for property modifications may be considered to manage the impacts of the flying-foxes. Providing subsidies to install infrastructure may improve the value of the property, which may also offset concerns regarding perceived or actual property value or rental return losses. Focusing funds towards manipulating the existing built environment also reduces the need for modification and removal of vegetation. Property modifications/items listed under 'Property modifications' above may be included in a subsidy program. Of these, vehicle and clothesline covers and high-pressure water cleaners were the most common subsidies taken by residents (Mo & Roache 2019).

When offered, double-glazing windows was popular amongst residents and was able to achieve a 65% reduction in flying-fox noise (Mo & Roache 2019). Furthermore, in a study by Pearson & Cheng (2018), it was found using infrastructure such as double-glazing windows significantly reduced the external noise level measured inside a house adjacent to a roost. This finding was supported by post-subsidy surveys undertaken by Port Macquarie Hastings Council that showed that double-glazed windows were rated as being more effective in mitigating impacts than any other subsidised option (e.g., high pressure cleaners, clothesline covers, shade cloths etc.) (Reynolds 2021).

Sunshine Coast Council undertook Round 1 of a private property grant trial in July 2021. The trial was used to facilitate property improvement or impact reduction infrastructure on eligible private properties. Feedback from this round confirmed that residents that have lived nearby a roost long-term are more likely to participate in the trial and experience more positive outcomes. It is acknowledged that residents that have only experienced short-term impacts may not be ready yet for this intervention. Council is currently implementing Round 2 of the

grant trial where a one-off grant would be provided to eligible residents, which would be supported by ongoing roost management, education, research and monitoring.

Service subsidies

This management option involves providing property owners with a subsidy to help manage impacts on the property and lifestyle of residents. The types of services that could be subsidised include clothes washing, cleaning outside areas and property, solar panel cleaning, car washing, removing exotic trees, or contributing to water/electricity bills. The NSW subsidy study showed that while many property modification subsidies proved popular amongst residents (e.g. high-pressure cleaners, air conditioners), many raised concerns over the increase in water/electricity bills. Increases in bills can be difficult to quantify and justify, and has not yet been effectively offered by a council in a subsidy program.

Routine roost maintenance and operational activities

All persons are authorised to undertake low impact activities at roosts in accordance with the Code of practice—Low impact activities affecting flying-fox roosts. Low impact activities include weeding, mulching, mowing or minor tree trimming (not in a tree where flying-foxes are roosting).

Protocols should be developed for carrying out operations that may disturb flying-foxes, which can result in excess roost noise. Such protocols could include limiting the use of disturbing activities to certain days or certain times of day in the areas adjacent to the roost and advising adjacent residents of activity days. Such activities could include lawn-mowing, using chainsaws, whipper-snippers, using generators and testing alarms or sirens.

Revegetation and land management to create alternative habitat

This management option involves revegetating and managing land to create alternative flying-fox roosting habitat through improving and extending existing low-conflict roosts or developing new roosting habitat in areas away from human settlement.

Selecting new sites and attempting to attract flying-foxes to them has had limited success in the past, and ideally habitat at known roost sites would be dedicated as a flying-fox reserve. However, if a staged and long-term approach is used to make unsuitable current roosts less attractive, whilst concurrently improving appropriate sites, it is a viable option (particularly for the transient and less selective LRFF). Supporting further research into flying-fox roost preferences may improve the potential to create new flying-fox habitat.

Foraging trees planted amongst and surrounding roost trees (excluding in/near horse paddocks) may help to attract flying-foxes to a desired site. They will also assist with reducing foraging impacts in residential areas. Consideration should be given to tree species that will provide year-round food, increasing the attractiveness of the designated site. Depending on the site, the potential negative impacts to a natural area will need to be considered if introducing non-indigenous plant species.

The presence of a water source is likely to increase the attractiveness of an alternative roost location. Supply of an artificial water source should be considered if unavailable naturally, however this may be cost-prohibitive.

Potential habitat mapping using roost preferences and suitable land tenure can assist in initial alternative site selection. A feasibility study would then be required prior to site designation to assess likelihood of success and determine the warranted level of resource allocated to habitat improvement.

Provision of artificial roosting habitat

This management option involves constructing artificial structures to augment roosting habitat in current roost sites or to provide new roosting habitat. Trials using suspended ropes have been of limited success as flying-foxes only used the structures that were very close to the available natural roosting habitat. It is thought that the structure of the vegetation below and around the ropes is important.

Protocols to manage incidents

This management option involves implementing protocols for managing incidents or situations specific to particular roosts. Such protocols may include monitoring at sites within the vicinity of aged care or child care facilities, management of compatible uses such as dog walking or sites susceptible to heat stress incidents (when the roost is subjected to extremely high temperatures leading to flying-foxes changing their behaviour and/or dying).

Participation in research

This management option involves participating in research to improve knowledge of flying-fox ecology to address the large gaps in our knowledge about flying-fox habits and behaviours and why they choose certain sites for roosting. Further research and knowledge sharing at local, regional and national levels will enhance our understanding and management of flying-fox roosts.

Appropriate land-use planning

Land-use planning instruments may be able to be used to ensure adequate distances are maintained between future residential developments and existing or historical flying-fox roosts. While this management option will not assist in the resolution of existing land-use conflict, it may prevent issues for future residents.

Property acquisition

Property acquisition may be considered if negative impacts cannot be sufficiently mitigated using other measures. This option will clearly be extremely expensive, however is likely to be more effective than dispersal and in the long-term may be less costly.

Do nothing

The management option to ‘do nothing’ involves not undertaking any management actions in relation to the flying-fox roost and leaving the situation and site in its current state.

Buffers

Buffers can be created through vegetation removal, revegetation of non-flying-fox attractant vegetation and/or the installation of permanent/semi-permanent deterrents.

Creating buffers may involve planting low-growing, spiky, non-flowering plants between residents or other conflict areas and the flying-fox roost. Such plantings can create a physical and/or visual buffer between the roost and residences or make areas of the roost inaccessible to humans.

Previous studies have recommended that vegetation buffers consisting of habitat not used by flying-foxes, should be 300 m or as wide as the site allows to mitigate amenity impacts for a community (SEQ Catchments 2012). Buffers need to take into consideration the variability of

use of a roost site by flying-foxes within and across years, including large, seasonal influxes of flying-foxes. The usefulness of a buffer declines if the flying-fox roost is within 50 m of human habitation.

Buffers through vegetation removal

Vegetation removal aims to alter the area of the buffer habitat sufficiently so that it is no longer suitable as a roost. The amount required to be removed varies between sites and roosts, ranging from some weed removal to removal of most of the canopy vegetation.

Any vegetation removal should be done using a staged approach, with the aim of removing as little native vegetation as possible. This is of particular importance at sites with other values (e.g. ecological or amenity), and in some instances the removal of any native vegetation will not be appropriate. Thorough site assessment will inform whether vegetation management is suitable (e.g. can impacts to other wildlife and/or the community be avoided?).

Removing vegetation can also increase visibility into the roost and noise issues for neighbouring residents which may create further conflict.

Suitable experts should be consulted to assist selective vegetation trimming/removal to minimise vegetation loss and associated impacts.

The importance of under- and mid-storey vegetation in the buffer area for flying-foxes during heat stress events also requires consideration.

Buffers without vegetation removal

Permanent or semi-permanent deterrents can be used to make buffer areas unattractive to flying-foxes for roosting, without the need for vegetation removal. This is often an attractive option where vegetation has high ecological or amenity value.

While many deterrents have been trialled in the past with limited success, there are some options worthy of further investigation:

- Visual deterrents – Visual deterrents such as fluoro vests (GeoLINK 2012) and balloons (Ecosure, pers. comm.) in roost trees have shown to have localised effects, with flying-foxes deterred from roosting within 1–10 metres of the deterrents. Lights tend to have limited effectiveness in deterring roosting. For example, a high-intensity strobe light was trialled in the Sydney Botanic Gardens to deter roosting; flying-foxes demonstrated only a slight reaction and lights did not deter flying-foxes from roosting (van der Ree & North 2009). However, a recent study identified a light that flying-foxes perceive as abnormal (Olkkola 2019), which PROVolitans trialled above the canopy of a roost tree, reporting an 80% decrease in the number of flying-foxes roosting in the tree. PROVolitans lights may offer a non- harmful method of flying-fox deterrence for future trials. Ultimately, the type and placement of visual deterrents would need to be varied regularly to avoid habituation. Potential for litter pollution should be considered and managed when selecting the type and placement of visual deterrents. In the absence of effective maintenance, this option could potentially lead to an increase in rubbish in the natural environment.
- Noise emitters on timers – Noise needs to be random, varied and unexpected to avoid flying-foxes habituating. As such these emitters would need to be portable, on varying timers and a diverse array of noises would be required. It is likely to require some level of additional disturbance to maintain its effectiveness, and ways to avoid disturbing flying-foxes from desirable areas would need to be identified. This is also likely to be disruptive to nearby residents.

- Smell deterrents – For example, bagged python excrement hung in trees has previously had a short-term localised effect (GeoLINK 2012). The smell of certain deterrents may also impact nearby residents, and there is potential for flying-foxes to habituate.
- Canopy-mounted water sprinklers – This method has been effective in deterring flying-foxes during dispersals (Ecosure personal experience), and current use in Qld are showing promise for keeping flying-foxes out of designated buffer zones. This option can be logistically difficult (installation and water sourcing) and may be cost-prohibitive. Design and use of sprinklers need to be considerate of animal welfare and features of the site. For example, misting may increase humidity and exacerbate heat stress events, and overuse may impact other environmental values of the site. Further information regarding canopy-mounted sprinklers is detailed below.
- Screening plants – A 'screen' can be created by planting a row of trees along the edge of a roost, with the aim of reducing visual impacts associated with flying-foxes. This technique can be particularly useful in cases where residents can suffer extreme reactions triggered by the mere sight of flying-foxes.

Canopy-mounted sprinklers

CMS can be used to deter flying-foxes from a buffer either:

- without any roost tree trimming/removal or
- accompanied by selective roost tree trimming/removal.

Canopy mounted sprinklers installed by Sunshine Coast Council (source: National Flying-fox Forum 2016, Ecosure).

To date CMS have been successful at other locations at discouraging flying-foxes from roosting in the buffer zone and enabling residents to have more control over flying-foxes near their properties.

CMS can be installed and effectively operated without the need for any vegetation removal, as long as the vegetation is not so thick as to restrict the extent of water spray. If vegetation thinning is required to allow sprinklers to operate effectively in some areas, approval will be required under the VM Act as exemptions do not exist for this. CMS can reach a radius of 15

m but due to vegetation cover this reach may be less.

Water pressure must be firm so it is sufficient to deter flying-foxes, however, must not risk injuring flying-foxes (or other fauna) or knocking an animal from the tree. Water misting should be minimised as this is unlikely to deter flying-foxes and could exacerbate heat stress event effects. Flying-fox heat stroke generally occurs when the temperature reaches 42°C, however, can occur at lower temperatures in more humid conditions (Bishop 2015). Given that humidity is likely to increase with water in the environment, sprinklers may need to be turned off in higher temperatures (e.g. >30°C) to avoid exacerbating heat stress (N.B. A NSW government-funded trial through Western Sydney University is currently underway to determine if sprinklers increase humidity and potential heat stress impacts; results should be considered for sprinkler usage).

Sprinklers should release a jet of air prior to water, as an additional deterrent and to cue animals to move prior to water being released. The intention of the sprinklers is to make the buffer unattractive, and effectively 'train' individuals to stay out of the buffer area.

If installed, sprinklers should be programmed to operate on a random schedule and in a staggered manner (i.e. not all sprinklers operating at the same time, to avoid excessive disturbance). Each activation should be for approximately 30-45 seconds per sprinkler. Each sprinkler should be activated up to five times between 0630 and 1600 avoiding critical fly-in or fly-out periods. To avoid flying-foxes habituating to the stimuli, sprinklers should only be operated by residents when flying-foxes are within range. Sprinkler settings would also need to account for seasonal changes (e.g. not in the heat of the day during summer when they may be an attractant, and/or could increase humidity and exacerbate heat events). Individual sprinklers may also need to be temporarily turned off depending on location of creching young, or if it appears likely that animals will be displaced to undesirable locations.

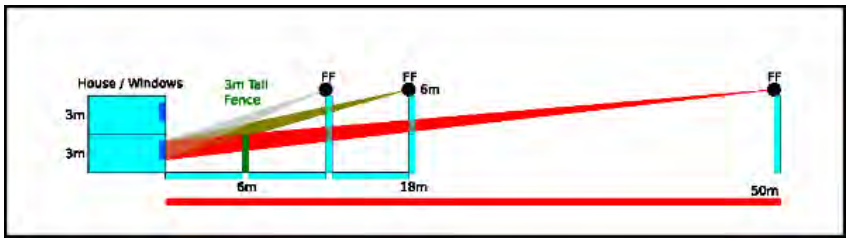
Infrastructure should ideally be designed to accommodate additional sprinklers should they be required in the future. Sprinklers should be designed and attached in a way that allows for future maintenance, replacement, and sprinkler head adjustments, with consideration given to vandalism if located in a publicly accessible area.

Noise attenuation fencing

Noise attenuation fencing aims to reduce noise and potentially odour where the roost is close to residents.

Example of noise attenuation fencing (source: http://www.slimwall.com.au/gallery)

This may also assist with odour reduction, and perspex fencing could be investigated to assist fence amenity. Although expensive to install, this option could negate the need for habitat modification, maintaining the ecological values of the site, and may be more cost-effective than ongoing management.



Indicative scaled distances to achieve shielding for bats approximately 6 m elevated, to a typical window height

(Air Noise Environment 2019). Image is indicative only with further investigation required.

Sound Block Acoustic Barrier (source: https://fortressfencing.com.au/sound-block-acoustic-barrier-noise-barrier)

Disturbance or dispersal

Nudging

Noise and other low intensity active disturbance restricted to certain areas of the roost can be used to encourage flying-foxes away from high conflict areas. This technique aims to actively 'nudge' flying-foxes from one area to another, while allowing them to remain at the roost site.

Unless the area of the roost is very large, nudging should not be done early in the morning as this may lead to inadvertent dispersal of flying-foxes from the entire roost site. Disturbance during the day should be limited in frequency and duration (e.g. up to four times per day for up to 10 minutes each) to avoid welfare impacts. As with dispersal, it is also critical to avoid periods when dependent young are present (as identified by a flying-fox expert).

Dispersal

Dispersal aims to encourage a roost to move to another location. Dispersing flying-foxes may be achieved in two ways:

- actively disturbing the roost pre-dawn as flying-foxes attempt to return from nightly foraging
- passively, by removal of all roosting habitat.

There is a plethora of research that demonstrates flying-foxes dispersals are not effective long-term, and often have unpredictable outcomes. A review of dispersal attempts between 1990 and 2013 found that flying-foxes only moved within 600 m of the original site in 63% of cases (Roberts & Eby 2013). Similarly, another review of 69 dispersal attempts undertaken

between 1992 and 2020 found that in 88% of dispersals, new roosts established within 1 km and resulted in new conflict sites (Roberts et al. 2021). In addition, a review of 25 dispersal attempts in Qld between November 2013 and November 2014 found that when flying-foxes were dispersed, they did not move further than 6 km away from the original roost site (Ecosure 2014). Ultimately, these results indicate that, when dispersed, flying-foxes generally relocate within 600 m – 1 km of the original roost site, and do not travel further than 6 km away.

Driving flying-foxes away from an established roost is challenging and resource intensive. There are also a range of risks associated with roost dispersal. These include:

- shifting or splintering the roost into other locations that are equally or more problematic
- impacts on animal welfare and flying-fox conservation
- impacts on the flying-fox population including disease status and associated public health risk
- impacts to the community associated with ongoing dispersal attempts
- increased aircraft strike risk associated with changed flying-fox movement patterns
- high initial and/or ongoing resource requirement and financial investment
- negative public perception from some community members and conservationists opposed to dispersal.

Despite these risks, there are some situations where roost dispersal may be considered. ‘Passive’ or ‘active’ is described further below. See Appendix 6 for further information regarding dispersal attempts across Australia.

Passive dispersal

Removing vegetation in a staged manner can be used to passively disperse a roost, by gradually making the habitat unattractive so that flying-foxes will disperse of their own accord over time with little stress (rather than being more forcefully moved with noise, smoke, etc.). This is less stressful to flying-foxes, and greatly reduces the risk of splinter colonies forming in other locations (as flying-foxes are more likely to move to other known sites within their roost network when not being forced to move immediately, as in active dispersal).

Generally, a significant proportion of vegetation needs to be removed in order to achieve dispersal of flying-foxes from a roost or to prevent roost re-establishment. For example, flying-foxes abandoned a roost in Bundall, Qld once 70% of the canopy/mid-storey and 90% of the understorey had been removed (Ecosure 2011). Ongoing maintenance of the site is required to prevent vegetation structure returning to levels favourable for colonisation by flying-foxes. Importantly, at nationally important roosts, sufficient vegetation must be retained to accommodate the maximum number of flying-foxes recorded at the site.

This option may be preferable in situations where the vegetation is of relatively low ecological and amenity value, and alternative known permanent roosts are located nearby with capacity to absorb the additional flying-foxes. While the likelihood of splinter colonies forming is lower than with active dispersal, if they do form following vegetation modification there will no longer be an option to encourage flying-foxes back to the original site. This must be carefully considered before modifying habitat.

There is also potential to make a roost site unattractive by removing access to water sources. However, at the time of writing this method had not been trialled so the likelihood of this causing a roost to be abandoned is unknown. It would also likely only be effective where there

are no alternative water sources in the vicinity of the roost.

Active dispersal through disturbance

Dispersal is more effective when a wide range of tools are used on a randomised schedule with animals less likely to habituate (Ecosure, pers. obs. 1997–2015). Each dispersal team member should have at least one visual and one aural tool that can be used at different locations on different days (and preferably swapped regularly for alternate tools). Exact location of these and positioning of personnel will need to be determined on a daily basis in response to flying-fox movement and behaviour, as well as prevailing weather conditions (e.g. wind direction for smoke drums).

Active dispersal will be disruptive for nearby residents given the timing and nature of activities, and this needs to be considered during planning and community consultation.

This method does not explicitly use habitat modification as a means to disperse the roost, however if dispersal is successful, some level of habitat modification should be considered. This will reduce the likelihood of flying-foxes attempting to re-establish the roost and the need for follow-up dispersal as a result. Ecological and aesthetic values will need to be considered for the site, with options for modifying habitat the same as those detailed for buffers above.

Early dispersal before a roost is established at a new location

This management option involves monitoring local vegetation for signs of flying-foxes roosting in the daylight hours and then undertaking active or passive dispersal options to discourage the animals from establishing a new roost. Even though there may only be a few animals initially using the site, this option is still treated as a dispersal activity, however it may be simpler to achieve dispersal at these new sites than it would in an established roost. It may also avoid considerable issues and management effort required should the roost be allowed to establish in an inappropriate location.

It is important that flying-foxes feeding overnight in vegetation are not mistaken for animals establishing a roost.

Maintenance dispersal

Maintenance dispersal refers to active disturbance following a successful dispersal to prevent the roost from re-establishing. It differs from initial dispersal by aiming to discourage occasional over-flying individuals from returning, rather than attempting to actively disperse animals that have been recently roosting at the site. As such, maintenance dispersal may have fewer timing restrictions than initial dispersal, provided that appropriate mitigation measures are in place.

Unlawful activities

Culling

Culling is addressed here as it is often raised by community members as a preferred management method; however, culling is illegal under local, State, and Federal legislation and is not permitted as a method to manage flying-fox roosts.

Appendix 6 Dispersal summary results

Multiple studies have clearly demonstrated the long-term ineffectiveness of flying-fox roosts dispersals. Dispersal via disturbance has been shown to reduce concerns and improve amenity in the short-term, however, roosts are usually recolonised, and the conflict remains (Roberts & Eby 2013, Currey et al. 2018).

Roberts and Eby (2013) summarised 17 known flying-fox dispersals between 1990 and 2013, and made the following conclusions:

- In all cases, dispersed animals did not abandon the local area[3].
- In 16 of the 17 cases, dispersals did not reduce the number of flying-foxes in the local area.
- Dispersed animals did not move far (in approx. 63% of cases the animals only moved < 600 metres from the original site, contingent on the distribution of available vegetation). In 85% of cases, new roosts were established nearby.
- In all cases, it was not possible to predict where replacement roosts would form.
- Conflict was often not resolved. In 71% of cases, conflict was still being reported either at the original site or within the local area years after the initial dispersal actions.
- Repeat dispersal actions were generally required (all cases except where extensive vegetation removal occurred).
- The financial costs of all dispersal attempts were high, ranging from tens of thousands of dollars for vegetation removal to hundreds of thousands for active dispersals (e.g. using noise, smoke, etc.).

Ecosure, in collaboration with a Griffith University Industry Affiliates Program student, researched outcomes of management in Qld between November 2013 and November 2014 (the first year since the current Qld state flying-fox management framework was adopted on 29 November 2013).

An overview of findings[4] is summarised below.

- There were attempts to disperse 25 separate roosts in Qld (compared with nine roosts between 1990 and June 2013 analysed in Roberts and Eby [2013]). Compared with the historical average (less than 0.4 roosts/year) the number of roosts dispersed in the year since the framework was introduced has increased by 6250%.
- Dispersal methods included fog[5], birdfrite, lights, noise, physical deterrents, smoke, extensive vegetation modification, water (including cannons), paintball guns and helicopters.
- The most common dispersal methods were extensive vegetation modification alone and extensive vegetation modification combined with other methods.

[3] Local area is defined as the area within a 20-kilometre radius of the original site = typical feeding area of a flying-fox.
[4] This was based on responses to questionnaires sent to councils; some did not respond and some omitted responses to some questions.
[5] Fog refers to artificial smoke or vapours generated by smoke/fog machines. Many chemical substances used to generate smoke/fog in these machines are considered toxic.

- In nine of the 24 roosts dispersed, dispersal actions did not reduce the number of flying-foxes in the LGA.
- In all cases, it was not possible to predict where new roosts would form.
- When flying-foxes were dispersed, they did not move further than six kilometres away.
- As at November 2014 repeat actions had already been required in 18 cases.
- Conflict for council and community was resolved in 60% of cases, but with many councils stating they feel this resolution is only temporary.
- The financial costs of all dispersal attempts were considerable, regardless of methods used, ranging from $7500 to more than $400,000 (with costs ongoing).

Newly published research investigating the effectiveness of dispersal attempts (Roberts et al. 2021) has shown similar findings which are summarised below:

- In 95% of cases, dispersal did not reduce the number of flying-foxes from the local area.
- Of the 48 roost dispersals attempted, only 23% were deemed a success at reducing conflict with communities, and this generally only occurred after extensive destruction of roost habitat.
- No project with a budget less than A$250,000 was deemed successful.
- Repeat actions were required in 58% of cases, some for months and years following the initial activities.

In 88% of cases, replacement roosts were established within one kilometre of the original roost, transferring conflict to neighbouring communities.

Appendix 7 Heat Stress Management

Heat stress events (HSEs) can cause mass flying-fox mortality during summer. At least 40 HSEs have occurred in Australia since 1994 (Lab of Animal Ecology 2024) including the largest on record, 45,500 deaths across 52 South East Queensland (SEQ) camps in the summer of 2014 (Welbergen et al. 2014). The second largest mass die-off occurred in Cairns in November 2018 where 23,000 spectacled flying-foxes (*P. conspicillatus*), or one third of the Australian population, died when temperatures reached over 42ºC for two days (Kim & Stephen 2018).

A range of intervention methods are used by wildlife rescue and carers to reduce mortality in roosts, including directly spraying water on affected animals by hand, or using ground-based or canopy-mounted sprinklers/hoses to simulate a rain shower. These methods were reviewed by Mo and Roache (2020) who found that evaluation of the efficacy of heat stress interventions has been largely anecdotal rather than empirical. Intervention also has the potential to exacerbate HSEs through disturbance or increasing humidity with spraying water. To address this lack of empirical data, the NSW government approved a scientific trial of various methods in combination with flying-fox behaviour and temperature monitoring (currently underway).

The Queensland Flying-fox Heat Stress Guideline (DES 2023) provides a structure for enhancement, preparation, response and recovery of flying-foxes and roosts affected by heat stress events based on current knowledge. The Heat Stress Guideline should be adopted by Council to prepare for and manage the effects of HSEs that that may occur within the LGA. Council's heat stress response should be reviewed as results of current research becomes available.

A chain of communication specific to HSE response in Livingstone LGA is illustrated in Figure 11. Only ABLV-vaccinated and trained personnel should be permitted to rescue flying-foxes, and only under the direction of the Site Coordinator. Appendix 3 details human health risks associated with interacting with flying-foxes. Clear demarcation must be made for what actions vaccinated and non-vaccinated respondents can complete (Table 5).

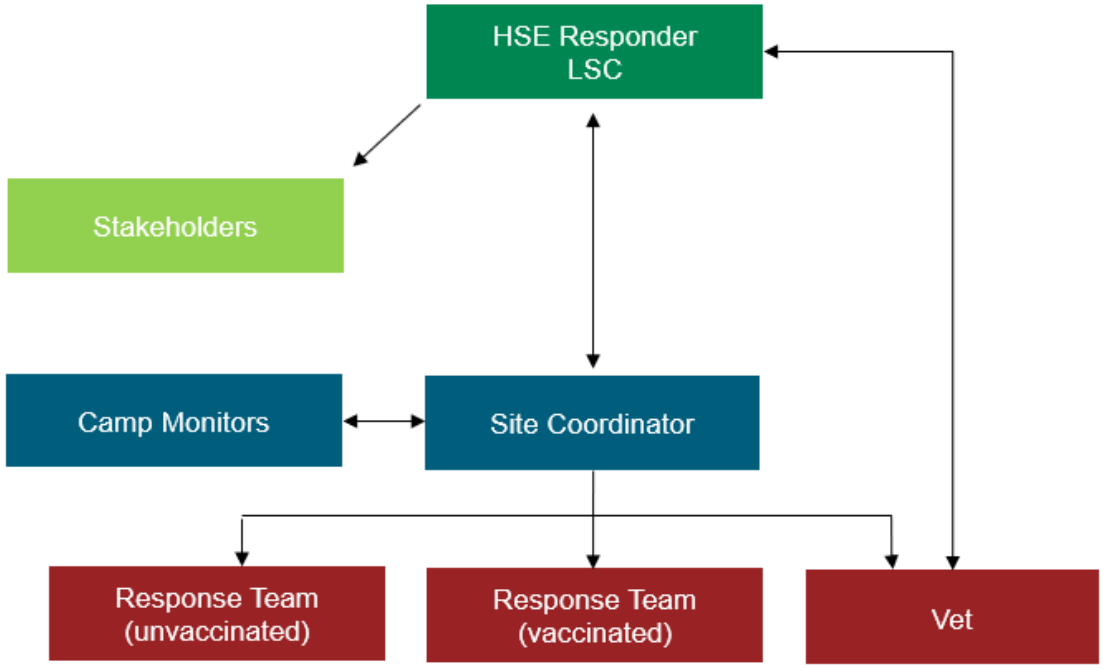


Figure 11 Chain of communication

Table 5 Personnel and responsibilities

Role	Who	Responsibilities	Reporting lines
HSE Responder	LSC	· Provide HSE plan to Site Coordinator · Initiate HSE plan with Site Coordinator · Notify Event Organisers of potential HSE · Notify LSC veterinarian – standby/mobilise · Supply equipment · Set up debrief if necessary	Reports from: Site Coordinator LSC vet
Site Coordinator	Flying-fox knowledgeable person	· First point of contact for Camp Monitors (see below) · Initiate response plan and enforce safety protocols including personnel inductions · Delegate roles and position in and around the colony according to (ABLV) vaccination status · Collect data records · Identify triage area or HQ · Support all team members · Debrief team	Reports to: HSE Responder Reports from: Camp monitors Response team
Camp Monitors (Rostered)	Volunteers	· Monitor temperature at weather sites (Bureau of Meteorology, [BOM] or Flying-fox HSE Forecaster tool) between November and February · Monitor flying-fox behaviour · Notify Site Coordinator if HSE is likely · Set up sprinklers under the colony if requested by Site Coordinator · Participate as required in heat stress response	Reports to: Site Coordinator

Role	Who	Responsibilities	Reporting lines
Response team (ABLV vaccinated)	Volunteers	· Monitor and observe flying-fox behaviour and report to Site Coordinator · Spray water as advised by Site Coordinator /Veterinarian · If trained, rescue flying-foxes where safe and appropriate to do so · Collect deceased flying-foxes, checking for attached young.	Reports to: Site Coordinator
Response team (Can be unvaccinated)	LSC staff	· Must not handle flying-foxes in any circumstances · Record weather / flying-fox behaviour · Register triaged animals and scribe for Vet · Sign-in/sign-out participants · Maintain human (e.g. water) and flying-fox supplies.	Reports to: Site Coordinator
Vet / Qualified Carer	LSC vet / carers	· Flying-fox triage, rehydration, treatment and care · Euthanasia if necessary	Reports to: HSE Responder

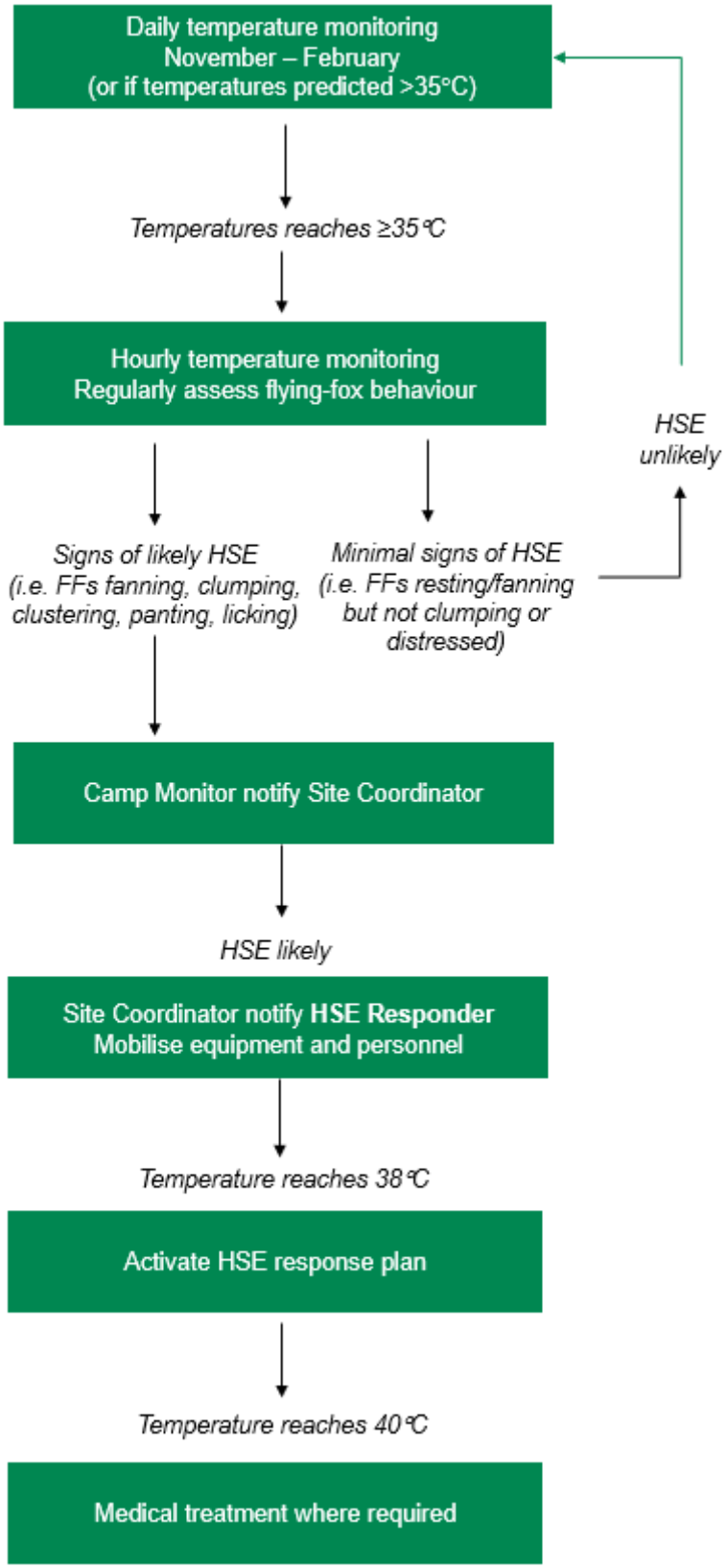


Figure 12 Heat stress event process - camp monitoring to treatment

A list of vaccinated rescuers, veterinarians, carers and other contacts is provided in Table 6.

Table 6 Contacts

Organisation	Contact
Livingstone Shire Council	1300 790 919
BatCare Capricornia	Permissions required
Yeppoon Veterinary Surgery	07 49 398 300
Quality Veterinary Care Centre Yeppoon	07 48 082 808
Department of Environment, Science and Innovation	1300 130 372
Queensland Health	13 43 25 84

Revision History

Revision No.	Revision date	Details	Prepared by	Reviewed and approved by
00	12/06/2024	Livingstone Shire Council Flying-fox Roost Management Plan	Mitch Horan, Senior Fauna Ecologist	Jess Bracks, Principal Wildlife Biologist
01	11/10/2024	Livingstone Shire Council Flying-fox Roost Management Plan.R1	Mitch Horan, Senior Fauna Ecologist	Dr John Martin, Senior Ecologist

Distribution List

Copy #	Date	Type	Issued to	Name
1	11/10/2024	Electronic	Livingstone Shire Council	John Wyland
2	11/10/2024	Electronic	Livingstone Shire Council	Leise Childs
3	11/10/2024	Electronic	Ecosure	Administration

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