2022/24 Mosquito Management Plan

GLADSTONE REGIONAL COUNCIL

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1 INTRODUCTION

Gladstone Regional Council (GRC) has developed a Mosquito Management Plan (MMP) in accordance with the Mosquito Management Code of Practice produced by the Local Government Association of Queensland (LGAQ).

GRC's MMP is an operational program that gives guidance to the region on the control and management of seasonal mosquitoes. The MMP presents an integrated approach, which examines various control measures that can be used to minimise the number of adult mosquitoes present in populated areas and to reduce the risk of mosquito-borne disease.

Mosquito management within the region is necessary for two reasons:

- Some species of mosquitoes can be vectors of disease; and
- Some mosquito species are aggressive biters, causing significant nuisance issues.

Mosquito management within the region will be active during all months of the year, however escalated during the wet season when mosquito numbers and disease risk are highest.

The primary focus of the MMP is to characterise the distribution and ecology of key mosquito species throughout the region to better understand the risk posed and accordingly, identify appropriate vector management activities to be implemented, where necessary. These activities will mitigate the risk to the community of contracting vector-transmitted diseases as well as reduce the nuisance value of the pests.

GRC is committed to the implementation of the MMP which has been developed with consideration for relevant best practice methods, legislation and the environmental amenity of the region.

1.1 Gladstone Regional Council

The Gladstone Region has a population of around 60,000 and includes the urban centres of Gladstone, Boyne Island, Tannum Sands and Calliope, plus the smaller towns of Agnes Water, Ambrose, Baffle Creek, Benaraby, Bororen, Builyan, Lowmead, Miriam Vale, Mount Larcom, Many Peaks, Nagoorin, Raglan, Rosedale, Seventeen Seventy, Turkey Beach, Ubobo and Yarwun.

The region is 40 kilometres south of the Tropic of Capricorn with a sub-tropical climate. Prevailing winds are predominately from the southeast with northerly breezes from time to time coinciding with the peak mosquito season. The average annual rainfall is around 1080mm.

The coastal environment in Gladstone and the surrounding region includes offshore islands and large coastal areas of intertidal wetland. Following key environmental events, large numbers of mosquitoes are able to breed and impact on residents in the area with a high prevalence around Gladstone City and the coastal townships.

GRC includes a number of remote communities and locations. Due to resource restraints and the inaccessibility of these remote locations during the peak mosquito season, this MMP focuses on the main population centres based in the Gladstone Regional Council area.

Figure 1: Geographical Map of the Gladstone Regional Council Local Government Area

1.2 Community Goal & Objectives

This MMP will result in a reduction of mosquitoes which achieves the following benefits:

- Reduction in disease,
- Low level of disturbance in the evenings,
- Being able to spend time outside without being annoyed,
- Young children and the elderly are protected from mosquitoes,
- Improved sleeping conditions,
- Improved living conditions,
- Improved outdoor working conditions,
- Improved possibilities for sport and leisure,
- Reduction in transmission of heartworm in dogs,
- Economic advantages for gastronomy and tourism,
- Potential increase in property values,
- Reduction in costs associated with vector borne disease such as medical and vet expenses and time off work.

1.3 Strategic Implications

In accordance with the GRC's Corporate Plan, the strategic direction is set against the landscape of our vision: 'Connect. Innovate. Diversify'. These three (3) intentions are woven throughout our strategic goals and community commitments to create a strong fabric of community connectedness; an organisation whose culture is proudly defined by innovation and a region that celebrates the diversification of opportunities and lifestyle.

The Mosquito Management Plan strives to address the following strategic goals and values:

- ***Connecting Communities*** - We work with you and for you, supporting the success of our communities. We care about each other, and our environment and we recognise that community is the core of our business.
- ***Delivering Value*** - We work efficiently to deliver value for your rates and the way we do business is continuously improving.
- ***Resilient Economy*** - Supporting the success of our region. Increased liveability and visitation to the region.
- ***Accountable Council*** - The environment is front of mind in what we do.
- ***Responsive*** - We respond by being present, proactive and solutions-focused, and we deliver on our commitments.
- ***Visionary*** - We plan as future-thinkers and opportunity- seekers and we have the courage to shape a better future for our community.
- ***Efficient*** – We deliver; we challenge the status quo, and we continually find better ways to reduce cost and improve services.

1.4 Environmentally Sustainable Mosquito Management

First and foremost, it is important to remember that mosquitoes are a natural part of the Australian environment. The ecological associations for some species result in large population abundances, triggered by favourable local climatic and environmental factors and for these species, there are no widespread biological controls to minimise their populations. In addition, the pathogens (i.e. arboviruses such as Ross River virus and Barmah Forest virus) that have the potential to cause human illness to circulate naturally between mosquitoes and native animals. To manage mosquito-borne disease risk, strategies are required that either disrupt these natural cycles or influence the activity of the community to minimise their exposure to mosquitoes. Strategies to reduce the risks of mosquito-borne disease and the impacts of nuisance-biting can include:

- Plan urban development to reduce exposure of the community to mosquitoes
- Educating the community on the most effective personal protection strategies
- Reducing the productivity of mosquito habitats through environmental modification
- Reducing mosquito populations through the judicious use of control agents

Environmentally sustainable mosquito management should follow the principles of Integrated Pest Management (IPM). Managing public health and/or pest risks requires a multidisciplinary approach informed by reliable scientific data on local mosquito fauna.

Before an effective strategy can be implemented, it is essential to understand the locally important mosquito species, their habitats, and associations with disease-causing pathogens. Monitoring mosquito populations and mosquito-borne disease activity is the keystone of effective mosquito management but monitoring alone will not reduce the risks of nuisance-biting or mosquito-borne disease.

It is important to inform and educate the community, not only on the risks of mosquito-borne disease but the measures individuals and households can make to protect themselves from exposure to mosquitoes. To enable dissemination of information to the community, effective monitoring programs are required. Legislation requires that local health authorities are notified of positively identified human cases of mosquito-borne disease. However, once this data is available, the periods of high risk of mosquito-borne disease have often passed. Monitoring programs that record relative changes in local mosquito population abundance, as well as the activity of arboviruses within mosquito populations, can provide a much more effective tool to enable public health warnings of elevated risks.

Personal protection strategies are available to individuals and households that can greatly reduce the risks of mosquito exposure. Such strategies may include:

- the removal of mosquito breeding sources within their properties
- the use of personal insect repellents
- the installation of screening on dwellings
- a change in behaviour to avoid mosquito habitats at time of greatest mosquito activity.

All of these can reduce the risks of disease. However, for these strategies to be effective there must be engagement with the community and communication informed by mosquito monitoring and research.

It would not be possible, or desirable, with methods currently available to eradicate mosquitoes entirely. However, broadscale mosquito control has been shown to significantly reduce the abundance of targeted species and may assist in reducing the risks of mosquito-borne disease. Broadscale mosquito control can be expensive and the effectiveness of the program can often be limited by the fact that control activities may not be possible in locally important mosquito habitats (e.g. national parks and nature reserves) beyond the control of local authorities. It is important to note, however, that even on a smaller scale, targeted mosquito control may be beneficial if 'hot spots' of mosquito activity are identified or if there is a disease outbreak. There is a range of products currently registered for use in Australia that, when used as recommended, can reduce mosquito populations without adversely impacting the environment.

A cost effective and sustainable approach to mosquito-borne disease management is to consider mosquito risk when planning future urban development, including both the location of developments and water sensitive urban design within them.

There is a range of options available for the design of both new residential and tourist developments that will assist in minimising mosquito risk. Similarly, the design and maintenance of constructed and rehabilitated wetlands, either for wildlife conservation or waste-water treatment, can incorporate strategies to minimise the risk of mosquitoes.

There is no single, easy to implement, strategy to managing mosquitoes and mosquito-borne disease risk. Effective management requires integrated strategies that target specific factors that can influence the risks of mosquito-borne disease now and into the future (Figure 1). It is these strategies that will be discussed throughout this document.

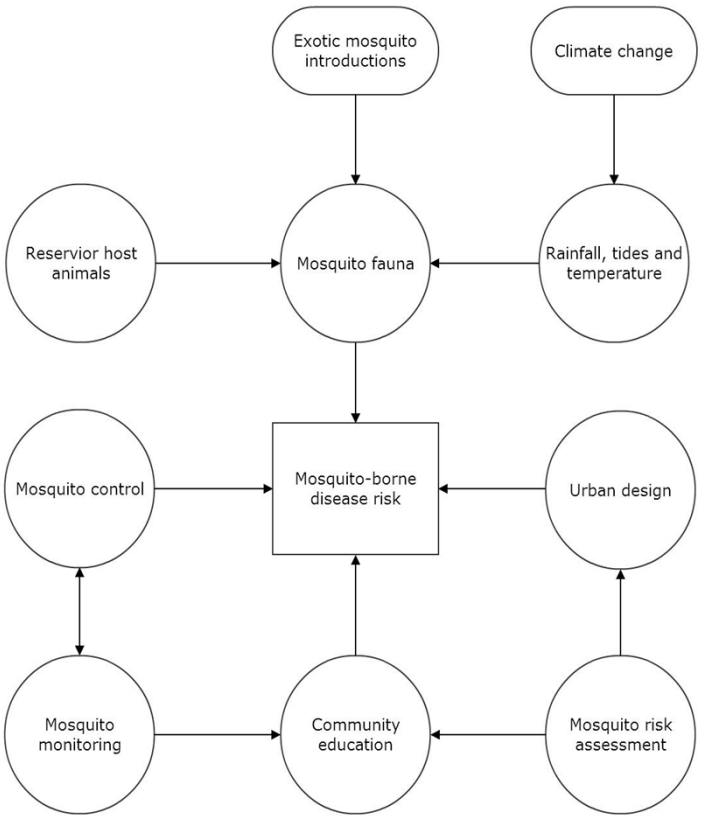

Figure 2: Illustration of direct and indirect factors influencing mosquito-borne disease risk in the local area that must be addressed by a mosquito management plan.

1.5 Statutory Requirements

- *Public Health Act 2005*
- *Public Health Regulation 2018*
- *Environmental Protection Act 1994*
- *Sustainable Planning Act 2009*
- *Fisheries Act 1994*
- *Fisheries (General) Regulation 2019*
- *Agriculture and Veterinary Chemicals (Queensland) Act 1994*
- *Chemical Usage (Agricultural and Veterinary) Control Act 1988*
- *Chemical Usage (Agricultural and Veterinary) Regulation 2017*
- *Biosecurity Act 2014*
- *Pest Management Act 2001*
- *Pest Management Regulation 2003*
- *Medicines and Poisons Act 2019*
- *Medicines and Poisons (Pest Management Activities) Regulation 2021*

2 MOSQUITO DISEASE RISK & NUISANCE

2.1 Mosquito – Borne Disease Risk

Over 220 species of mosquitoes have been identified in Queensland with more than 30 common species being identified in the Gladstone Region, several of which are capable of transmitting disease. Mosquitoes are the deadliest animal in the world with mosquito-borne diseases such as Malaria, Dengue Fever, Zika virus, Japanese encephalitis (JE), West Nile virus (WNV) infection and Chikungunya (CHIKV) causing major public health problems in many countries.

Increased international travel makes it easier for the introduction of these diseases into locations from which they have either been eradicated or in which they have never occurred. Australia and Queensland in particular, provide a suitable environment for incursions of these exotic diseases.

Dengue is endemic in many neighbouring countries with an estimated 2.5 billion people globally at risk and 22,000 people (mainly children), dying annually as a result of complications from Dengue infection. While Dengue is not endemic in Queensland, Dengue outbreaks have been occurring with increasing frequency and intensity over the last 10 years as a result of increased numbers of viraemic international travellers. Recent Dengue outbreaks have occurred in Townsville and Cairns. There are several different strains of Dengue. In past cases all strains have been experienced giving rise to the deadly Haemorrhagic Fever which occurs when a person who was previously infected with a Dengue strain and is then infected with a different strain.

Aedes aegypti is the main vector of Dengue and is present in the Central Queensland Region. Imported cases of Dengue fever have been diagnosed in our region. *Aedes aegypti* is also a vector of Zika virus. Between 2013 and 2015 there were large outbreaks of Zika virus infection in a number of Pacific countries. Local transmission is ongoing in this region. Since 2015 large outbreaks have been occurring in central and southern America and are continuing. Recent outbreaks in the Pacific and the Americas have raised concerns that Zika virus infection may cause birth defects such as microcephaly if a woman is infected while pregnant. An imported case of Zika virus was diagnosed in the Central Queensland Region in 2016.

Other mosquito-borne diseases such as Ross River virus (RRV) infection, Barmah Forest virus (BFV) infection, Kunjin virus infection and Murray Valley encephalitis (MVE) are also endemic in Australia. Mosquitoes that can transmit these diseases are present in the Gladstone Region.

RRV and BFV infection are the most common mosquito-borne diseases in Queensland. These infections are not life threatening, although symptoms such as polyarthritis and lethargy can be debilitating and last for prolonged periods of time. There is no specific treatment or vaccines to prevent RRV, BFV infection, Dengue and Zika despite continued research in this area.

Changing climatic conditions, higher temperatures and higher rainfall may have an impact on the breeding areas of other mosquitoes and may cause the southwards expansion of tropical mosquito-borne diseases such as Malaria, Dengue Fever, Zika virus, Australian encephalitis, Japanese encephalitis and epidemic polyarthritis.

Due to the level of existing endemic mosquito-borne diseases and recent history of outbreaks of exotic diseases such as Malaria, Dengue Fever, Zika virus and Japanese encephalitis, it is important to have effective and sustainable mosquito management plans in place.

2.2 Nuisance

As well as being a disease risk, mosquitoes can also be a considerable nuisance. Some mosquito species in the region are known to be aggressive biters, causing discomfort and pain to affected residents which can impact significantly on lifestyle.

Of particular concern are *Aedes notoscriptus* mosquitoes, which cause significant nuisance problems for the region. Adults readily attack humans by day in shaded areas but also feed during evening, night and early morning. This species is arguably the major domestic pest species in south-eastern Australia.

3 MOSQUITOES

3.1 Biology & Life Cycle

Mosquitoes are small blood sucking insects that belong to the family of flies called Culicidae (Order Diptera) and within Australia there are more than 300 different species. Each of these species is closely associated with particular habitats, and the nuisance and public health risks vary remarkedly between the species, but overall, they have similar biological requirements.

Mosquitoes differ in their biology and required larval habitat between species. Further, different species vary in their host feeding preferences and ability to transmit various pathogens. Accordingly, surveillance and control methodologies must be tailored to the biology and ecology of target species to maximize the impact of interventions. For the purposes of description of surveillance and control methodologies, two general classes of mosquitoes can be described:

- those that inhabit groundwater including flooded pools and saltmarshes; and
- those that inhabit small containers in urban environments.

An understanding of the general life cycle of mosquitoes is important for control. Where possible, the preferred method of control is to act upon the larvae, before they emerge into flying adults and disperse.

Eggs are laid by the adult mosquito and float on the surface of the water, soil or plants. Anopheles species lay their eggs as a single unit on the surface of a water body. Aedes deposit their eggs on a moist surface that will eventually be subject to water inundation. Aedes are generally associated with temporary water bodies and are desiccation resistant meaning they can last long periods out of the water. Culex species deposit their eggs in clusters that float on the surface of a water body.

Larvae hatch from the egg and live aquatically. The larvae grow through four (4) different stages (instars) before becoming a mature larva. This process can take between 4 – 10 days depending on the species and environmental conditions. The Culex and Aedes species of larvae have siphons that they breathe from and hang suspended from the surface of the water. The Anopheles species do not have a siphon and lie flat along the top surface of the water to breathe. The larvae feed on microorganisms and other organic matter within the water.

Following the final larval stage (4th instar) the larva moults into a pupa. Pupae are still mobile in the water but do not feed and are not affected by larvicides. This final stage can last for as little as 2 days before the adult emerges.

The newly emerged adult rests on the surface of the water for a short time to allow itself to dry before flying off to feed. Male mosquitoes do not bite and usually stay close to the breeding site feeding on plant and flower juices. Female mosquitoes travel further afield and firstly seek out a carbohydrate meal of plant juices to increase energy before mating with a male.

The females will seek blood after mating and then embark on a cycle of feeding, resting, developing and laying eggs. The average lifespan of an adult female is two-three weeks.

Currently the number of competent vectors within the GRC area is unknown, but this MMP aims to ensure the required information is gathered so that informed decisions on appropriate responses/actions can be made.

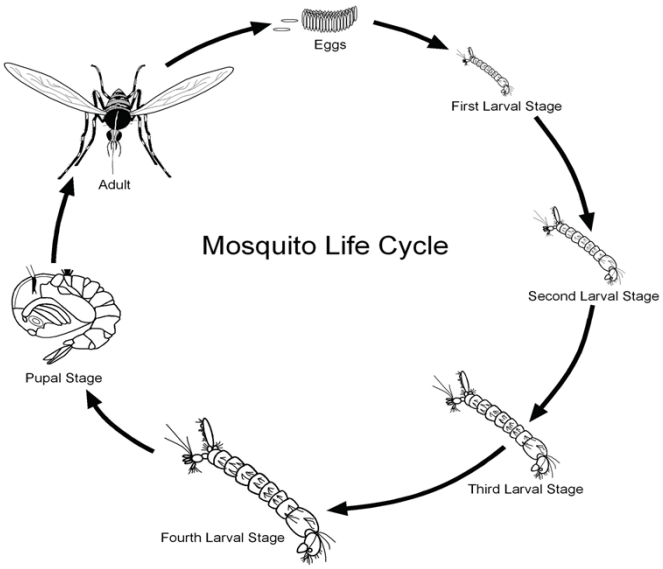

Figure 3: Mosquito Life Cycle

3.2 Species of Interest

An understanding of the different species of mosquitoes is crucial to implementing a MMP. Some species of mosquito can transmit diseases while others can cause significant pest nuisance issues due to their biting habits. Some species do not transmit diseases or cause pest issues and are a low priority for control.

Different species breed in different habitats and an understanding of the species present can allow for targeted larval investigations and control at the breeding site. Trapping of adult mosquitoes is therefore an important aspect of the management plan allowing for more targeted control actions. Given the geographic and climatic conditions of the region, there are a number of mosquitoes present. Over time Council has been developing mosquito management strategies aimed at reducing the incidence of arbovirus and nuisance within the community. Due to the extent and location of potential breeding sites it is not always possible to eliminate large adult mosquito populations from affecting residential areas.

The most common mosquitoes found within the Gladstone Region are (refer to Appendix):

- *Aedes aegypti*
- *Aedes alternans*
- *Aedes notoscriptus / Ochlerotatus notoscriptus*
- *Aedes vigilax / Ochlerotatus vigilax*
- *Culex annulitostris*
- *Culex sitiens*
- *Mansonia uniformis*

3.3 Mosquito Dispersal

Another very variable aspect of mosquito behaviour which significantly effects the degree to which mosquitoes can impact human lifestyles is their ability to disperse away from breeding sites in search of bloodmeals. Many domestic mosquito species, such as *Ochlerotatus notoscriptus* only disperse tens, or at most hundreds of metres. Alternatively, *Ochlerotatus vigilax* (in Australia) and many other similar saltmarsh mosquito species elsewhere in the world which readily disperse up to fifty or more kilometres. This aspect of mosquito behaviour is critical to considerations of buffer zones between mosquito breeding areas and proposed residential or resort developments.

Mosquito dispersal distances also vary greatly according to the type of terrain to be traversed. Ginsberg (1986) showed that an American salt marsh mosquito (Ochlerotatus, sollicitans) dispersed many kilometres through wooded areas, but less widely across open, cleared areas and less widely again across open water. Whilst such detailed studies have not been carried out in Australia, observations by various mosquito workers suggest that similar patterns of behaviour by salt marsh mosquitoes also occur here.

4 MOSQUITOES AND THEIR HABITATS

Firstly, it is important to note that within the Gladstone region there are extensive areas of actual and potential mosquito habitat that are currently National Parks or Nature Reserves managed by Queensland Parks and Wildlife Service (QPWS) and The Department of Natural Resources, Mines and Energy. Although mosquitoes produced from these habitats have the potential to impact the community, surveys and mapping of habitats in these zones was beyond the scope of this investigation and local council will be unable to undertake any mosquito control in these habitats.

Mosquito control in saline wetlands (mangroves and saltmarshes) can be complex and is usually beyond the capacity of an individual. Notwithstanding the difficulties associated with persuading the various levels of government to undertake mosquito management in these sensitive habitats, the general principles for mosquito control in mangrove and saltmarsh areas can be listed as:

1. Tidal flushing within stands of mangroves should be maintained so that stagnant impounded water does not provide mosquito habitat.
2. Natural dewatering of the surface of the saltmarsh should be maintained so that water does not persist in depressions filled by the highest monthly tides.
3. Structural management (channelling/tunnelling) of water flow through the mangroves and onto and off the marsh, providing for natural flushing and dewatering, and access for predators, can be effective in reducing mosquito populations and can be environmentally acceptable.
4. Use of biorational control agents, such as bacterial products and growth regulators, to reduce mosquito populations can be effective and environmentally acceptable.

However, and in conclusion, the issue of mosquito production from saline wetlands must be considered on a case-by-case basis. Expert advice on the relative nuisance values and health risks, and the acceptable and effective options appropriate for particular sites should be sought from relevant experts and carefully considered.

4.1 Backyard Mosquitoes

Despite the potential for large mosquito populations to be produced from the saline wetlands of the Gladstone Region, mosquitoes associated with backyard habitats in residential, rural and industrial properties can have a substantial influence on local nuisance-biting and public health risks.

The larvae of *Aedes Notoscriptus* are usually associated with small water holding containers around dwellings such as tins, pots, ornamental ponds, roof guttering, water tanks and discarded tyres, as well as water holding plants (e.g. bromeliads) and tree holes. Essentially, any small to medium sized water holding container can be used by this species.

The most noteworthy result from analysis of the data is that while the abundance of mosquitoes was generally lower than estuarine and coastal swamp mosquitoes, they were generally common in all areas of GRC where collections were made.

5 BREEDING SITES – LAND OWNERSHIP AND RESPONSIBILITY

Identified breeding sites within the region contribute to mosquito populations. Some of these areas are monitored and treated by Council while other existing and potential breeding sites are the responsibility of external agencies. Council is responsible for management of breeding sites on regional properties including parks, gardens, Council facilities, roads and drainage systems.

The management of mosquitoes on private property is the responsibility of owners and residents. Backyard breeding of mosquitoes can contribute significantly to nuisance and disease risk in residential areas. Council conducts education campaigns to encourage residents to clean up and help them identify potential backyard breeding sites. If necessary, Council can undertake enforcement action to require residents or owners to remove backyard-breeding sites.

6 ENVIRONMENTAL CONSIDERATION

The region is 40 kilometres south of the Tropic of Capricorn with a sub-tropical climate. Prevailing winds are predominately from the southeast with northerly breezes from time to time coinciding with the peak mosquito season. The average annual rainfall is around 1080mm.

The environment in Gladstone and the surrounding region includes offshore islands and large coastal areas of intertidal wetland. Following key environmental events, large numbers of mosquitoes can breed and impact on residents in the area with a high prevalence around Gladstone and coastal townships. Some environmental variances that can greatly influence mosquito populations are:

- Tidal variations
- Rainfall
- Floods and cyclones
- Temperature
- Humidity

Mosquito management needs to consider environmental impacts, including but not limited to impacts from chemical control on the environment, flora and fauna. Council has an environmental duty to do no harm to the flora and fauna in the region and notes that excessive or widespread control of mosquito populations may disrupt established food chains in certain ecosystems. Adult mosquitoes have been identified as an important food source for natural predators such as birds, bats, dragonflies, lizards, frogs and spiders. Mosquito larvae also form an integral component of the wetland food chain, acting as a food source for damselfly nymphs, dragonfly nymphs, water striders, water fleas, beetle larvae and a range of fish species (Russell, 1993).

Mosquitoes feed on a variety of nectar producing flowers and are therefore important plant pollinators. Wildflowers and orchids are examples of plants that are pollinated by mosquitoes carrying pollen from flower to flower during feeding (Centres for Disease Control and Prevention, 2001).

While mosquitoes are recognised as an important food source and pollination tool, many species are only available to fulfil these roles on a seasonal basis. Mosquitoes are typically abundant in warmer months and remain dormant or in low numbers during colder weather. Predators are therefore not reliant on mosquitoes as a food source year-round, but rather as an opportunistic meal. When consumed, mosquitoes provide only small amounts of energy and certain predators such as bats are likely to seek alternative prey that will provide a higher energy source.

Over the years, the National Environment Agency (NEA) has gradually moved away from large-scale open area fogging and there are many arguments that support such decisions. Fogging is also toxic to other insects, such as butterflies and bees. The National Parks Board is planting more plants that host butterflies in an attempt to increase their population numbers, and these beautiful insects are particularly sensitive to pesticides. When bee populations are greatly affected by pesticides, global food production could be affected because of the lack of pollination.

Pesticides are also harmful to many other animals, including those that are natural predators of mosquitoes. Most pesticides used in fogging are toxic to fish, which are very important for the eradication of mosquito larvae. Frogs, geckos and birds, which also eat mosquitoes, could also be affected by pesticides.

The eradication of breeding grounds in personal living spaces are much more effective tools in the fight against Dengue and Zika than widespread fogging is.

6.1 Larval Survey

All identified breeding sites are monitored regularly during mosquito season or after large tides or floods to determine larval activity. Tidally influenced areas (many sites near Gladstone and surrounding areas) are surveyed 3-4 days after rain or tidal inundation events. Freshwater sites are surveyed 6 days after rain events.

Larval surveys are conducted at least monthly during the wet season. More extensive surveys are conducted twice per year, just after the first appreciable rains of the wet season and mid-way through the wet season in February. Larvae may be identified under a microscope or reared in emergence cages and identified as adults.

The findings of these surveys will determine if there is a need for the application of larvicide to prevent the emergence of adult mosquitoes. The threshold for larvicide treatment in freshwater sites is an average of two third or fourth instar larvae per dip.

Mosquito larvicides are not effective at the late fourth or pupal stage, therefore it is critical that if a mix of 3rd and 4th instars are observed that the larvicide is applied immediately. If 4th instars and pupae are observed, then it is too late to apply larvicide and the only chemical control option available at that point is to wait for the adults to emerge and conduct adult fogging. In tidal sites with thick vegetation, the presence of an average of two 3rd/4th instar larvae per dip will trigger treatment. In sites where, natural predators of larvae are evident dips resulting in early instars, but very few or no third and fourth instars, may indicate that biological control is sufficient. If practical, the site should be reinspected 1 or 2 days later to determine if the biological control is effective or if the cohort has progressed through to 3rd/4th instar and requires larvicide to be applied.

6.2 Adult Trapping

Adult mosquito traps are used to monitor populations of adult mosquitoes. The mosquitoes caught in the traps are counted and identified to species. Trapping is important to monitor mosquito abundance, as well as to identify problem species and allow targeted larval investigations and control actions.

Figure 4: CO2 Light Trap

Routine adult trapping will be undertaken monthly during the dry season and weekly during the wet season. Trap sites are positioned close to known breeding sites to capture the highest possible number of mosquitoes. Additional trapping may be undertaken in response to complaints and to evaluate the effectiveness of control activities.

6.3 Mosquito – borne Disease Notifications

Mosquito borne diseases (RRV, BFV, MVE and WNVKUN) are notifiable diseases in Queensland and are required to be reported to Queensland Health (QH). The Public Health Unit then notifies Council of cases reported within its jurisdiction. Where possible, Environmental Health Officers contact these cases to determine the location and timing of exposure as accurately as possible. The information remains completely confidential, used solely to inform mosquito management activities and to guide the Public Health Unit (QH) and Council to prevent the spread of mosquito borne disease.

6.4 Complaints

Occasionally Council receives complaints from residents regarding mosquito nuisance. These complaints may provide information on areas where mosquito impacts are greatest. However, the tolerance of individuals to mosquitoes varies greatly and the number of complaints may not be directly related to actual mosquito populations.

6.5 Exotic Species Surveillance

There is potential for introduction of exotic species via either the Gladstone Port or travellers coming from Queensland. Species such as *Aedes aegypti* or *Aedes albopictus* are a particular threat as these species carry exotic mosquito borne diseases such as Dengue, Yellow Fever and Zika virus and are prevalent in Indonesia and many other parts of southeast Asia

The Australian Quarantine and Inspection Service (AQIS), a service of the Australian Department of Agriculture, Fisheries and Forestry undertake ongoing trapping and surveillance activities to detect incursions of exotic mosquitoes at international first air and seaports. AQIS performs these activities on behalf of the Australian Department of Health and Ageing (DoHA). AQIS also works in collaboration with Queensland Health and Local Government to assist in the control and eradication of exotic mosquitoes from these ports where necessary.

7 MOSQUITO CONTROL METHODS

In order to be effective this MMP uses an integrated approach incorporating four control methods:

1. Cultural control
2. Physical control
3. Biological control
4. Chemical control

7.1 Cultural Control

It is not possible, nor desirable to completely eradicate mosquitoes from the environment. Despite the control actions detailed in this plan there will always be some mosquitoes present and risk of mosquito-borne disease within the region. One of the most important aspects of this plan is public education. Due to the highly transient residential population in the region, it is important that educational programs are ongoing to ensure all residents receive information.

It is also essential to communicate this message to the large number of tourists that visit the region, as mosquito control activities are most active around the major town site of Gladstone and populated areas, however many residents and tourists will be exposed to mosquito bites in remote locations where mosquito control is not undertaken. This includes residents living in rural areas, as well as people taking part in recreational activities such as fishing and camping. For these groups the only way to reduce the risk of disease is to prevent mosquito bites by using personal protection measures.

Public education will begin towards the end of the dry season and will be active throughout the wet season. Activities will be intensified when surveillance indicates that disease risk is high, due to high mosquito numbers detected in adult traps. Education materials may include the following:

- Information displays at local events, particularly outdoor events
- Letter box drops
- Display information posters on local notice boards
- Promotion of the program through local radio stations and newspapers
- Dissemination of warnings through local media when surveillance indicates a risk of mosquito-borne disease is likely
- Public notification of planned chemical and physical mosquito control activities
- Displaying appropriate signage while in the field conducting monitoring or treatment.

Controlling Mosquitoes Around the Home

Residents can assist in the control of mosquitoes by taking these steps at home:

- Inspect your house and yard and remove any accumulations of water, for example: empty pot plant bases weekly or fill the base with sand to absorb water; Bromeliads and other water holding plants should be washed out weekly.
- Clean roof gutters out regularly and trim back trees which can block gutters.
- Ensure rainwater tanks are screened.
- Keep swimming pools maintained.
- Birdbaths, fishponds, and ornamental pools should be washed out weekly and where possible stock with suitable native fish.
- Stock dams with native fish and keep the edges clear of vegetation.

Mosquito Repellents

The use of personal insect repellents is the first line of defence against biting mosquitoes and consequently, mosquito-borne disease. These products are available in a wide range of formulations, including aerosols, creams, lotions, pump sprays and sticks. Regardless of the formulation, the most effective products contain at least 20% DEET (diethyl toluamide or N,N-diethyl-3-methylbenzamide) or Picaridin, two chemicals known to be effective insect repellents.

DEET was originally released to the public in 1957 and has been shown to be effective in repelling many species of mosquitoes in both laboratory and field trials worldwide. The chemical repels mosquitoes by confounding their sensory organs and inhibiting their host seeking stimuli. When applied according to manufacturer's recommendations there are no serious side effects to the use of DEET. Picaridin was developed more recently, and it also has shown similar effectiveness against a range of mosquitoes and other biting insects and is widely available in various formulations.

As well as DEET and picaridin, there is another product that may provide effective protection against biting insects. PMD (registered in Australia as 'extract of lemon eucalyptus being a modified acid of C*orymbia citriodora*') is not an essential oil product but rather a chemical derived from the distillation of the lemon eucalyptus plant. In Australia, it is currently only available in a 30% formulation. This product has been tested overseas and has been shown to be as effective as low dose DEET or picaridin products.

The decision of which formulation is most appropriate is probably best made by the individual but the key point to remember is, for complete protection, the entire surface of exposed skin must be covered. For this purpose, sprays are often effective for arms and legs while creams and towelettes are good for the face. Some repellents are available as patches or plastic wrist bands, but these only offer limited and localised protection (i.e. if any protection is provided, it is generally only immediately around the product). However, when used in combination with other repellents (or long-sleeved shirts), wrist bands may be worthy for those wanting to avoid getting repellent on their hands.

Increasingly, manufacturers are looking to combine insect repellents with other cosmetics including sunscreen and skin moisturizers. Studies have shown that the combination of sunscreen with repellents does not reduce effectiveness of repellents. However, there can often be confusion over the recommended use of these products with sunscreen requiring reapplication every two hours, a higher reapplication rate than would otherwise be recommended for some repellents with a high DEET concentration. In most circumstances, the reapplication of a low dose DEET based repellent combined with sunscreen every two hours will offer the best protection against both UV radiation and biting insects without unnecessary or excessive applications of repellent.

There is a large quantity of repellents available that contain 'natural' compounds derived from plants, including eucalyptus, tea-tree, catmint and citronella extracts. While such products are available for individuals wishing to avoid so-called 'chemical' repellents, it should be recognized that they are chemicals, and some will find they cause skin irritations. They generally offer substantially lower protection times when compared to those containing DEET and will need to be reapplied more frequently to provide protection.

A range of live plants (e.g. *Citronella geranium*, *Leptospermum* spp., *Chrysanthemum* spp.) are often marketed as mosquito repellents, with claims they are suitable for keeping mosquitoes away from areas where they are planted. The basis for these claims is that the plants contain strongly aromatic oils that

may have some mosquito repellent qualities, but studies have shown that these plants offer no useful protection from mosquitoes.

In addition to mosquito repellents that can be applied directly to the skin, there are a range of products including to coils, sticks and other 'burner' devices that purport to repel mosquitoes. These products are impregnated with an insecticide (usually a pyrethroid) that is released when heated, either by burning (coils and sticks) or heated by a small electrical unit (vaporising mat). These products are generally designed for indoor or sheltered outdoor areas and should be used as directed. Prolonged use in confined spaces should be avoided as some respiratory problems may result.

While there is demand from the community for repellents, particularly alternatives to topical creams and lotions, entrepreneurs will always be looking to make a quick dollar. While not always common in Australia, products often pop up that purport to use sound to repel mosquitoes. These gadgets can range from key ring sound emitters and plug in 'sonic' devices to mobile phone ring tones and wrist watches. There is no scientific basis to these claims and scientific trials have repeatedly shown that these units are not effective.

7.2 Physical Control

Physical control methods are measures taken to reduce the potential for mosquito breeding and harbourage by modifying the natural or built environment. Examples of physical control actions include:

- Maintenance of open stormwater drains to remove silt and weeds to ensure water not held for more than five days.
- Reduction of emergent vegetation in known breeding sites.
- The construction of weirs to prevent high tides from flooding upstream sections of creek beds.
- Filling in, or drainage of low-lying land to reduce pooling.
- Slashing of vegetation which provides harbourage for adult mosquitoes.
- Cleaning up yards to remove containers which will collect water; and
- Ensuring septic tanks are sealed and vents fitted with mosquito proof screens
- Ensuring that there is suitable and safe access for Mosquito Management to occur.

Some physical controls, such as maintenance of drains are undertaken routinely. Other actions such as construction of weirs require planning and allocation of resources and are long-term strategies. Yard clean-ups and sealing of septic tanks are the responsibility of residents and will be the subject of education campaigns

Vegetation Management

Council's Vector Control Officers regularly consult with the Parks and Roads to ensure that Council is adequately managing the drains and vegetation on Council land to ensure that there is no water pooling or overgrown vegetation which could provide additional breeding and nesting sites for mosquitoes.

7.3 Biological Control

Biological control refers to the natural predation of mosquito larvae, for example by fish. Biological control occurs naturally in many water bodies and when present will reduce the need for other control methods. The introduction of fish can also be an effective, long-term control for mosquito breeding in man-made situations such as backyard ponds. Introduction of fish to natural environments will not form part of this plan due to the large size and ephemeral nature of many breeding sites, as well as the potential environmental impact.

7.4 Chemical Control

Chemical control of adult and larval mosquitoes involves the application of minimal amounts of chemical substances that are toxic, physically damaging or hormonally disruptive to mosquitoes to kill them or slow/disrupt their development. Routine applications of these chemicals with the same mode of action or over application of these chemicals can result in resistance in the target mosquito population. Some of these chemicals can also have undesired impacts on non-target populations. It is important to understand that although insecticides have a place in mosquito control, these chemicals should be used sensibly to maximise their benefits while minimising any disadvantages.

There are two methods of chemical control considered in this plan: larvicides and adulticides. When possible, it is preferable to treat mosquito larvae while they are contained in an aquatic environment, rather than as flying adults.

Post treatment larval and adult mosquito monitoring is essential to assess the effectiveness of the application of insecticides against the target mosquito by comparing results with a pre-treatment survey. Any breeding site with pale looking larvae in comparison to untreated sites indicates the pellets or briquettes are still effective and re-treatment is not required.

7.4.1.1 Larvicides

Larvicides kill mosquito larvae and/or prevent the emergence of adult mosquitoes. Materials known as larvicide are placed in known mosquito breeding water sources in the region. These larvicides stop the breeding cycle of mosquitoes at the larval stage, so they are not able to transition into an adult mosquito and therefore are not able to bite and cause the spread of diseases. Larvicides are species specific, so do not kill any other species that ingests them.

Larvicides are both in pellet and briquettes forms and can last up to three (3) months, meaning they can be used for areas in which water is held for longer periods of time. Larvicides are used to treat known breeding sites in close proximity to residential areas.

Advantages:

- Mosquitoes are killed before they pose any health risk
- Products can be very target specific making it easier to manage any environmental impact
- Controlled release formulations allow for residual control
- Reducing populations at the larval stage limits ongoing breeding, making ongoing control easier

Disadvantages:

- Treatment can be limited by site access and the size of the area requiring treatment
- Pupae and late 4th instar larvae are not affected, making the timing of treatment crucial.

In small breeding sites, larvicides can be applied by hand without any specialist equipment. Council has backpack sprayers that can be used to apply pellets to larger breeding sites.

The following larvicides are currently part of Council's MMP:

1. Bacterial
2. Insect Growth Regulators
3. Organophosphates

Bacterial – Mosquitoes

Three bacterial formulations are available as larvicides:

- Bacillus thuringiensis israelensis (Bti),
- Bacillus sphaericus (BS)
- Larvicide derived from the bacterium saacharopolyspora spinosa.

These bacteria affect larval mosquitoes and some midges by causing cellular breakdown in the midgut resulting in rapid death, usually within eight (8) to twelve (12) hours. It is important to note that these formulations must be ingested by actively feeding mosquitoes, so they have no effect on late fourth (4th) instar larvae or pupae.

These products are generally available in liquid, briquet and granular formulation from commercial sources under trade names such as Vectobac®, Aquabac® and Teknar®.

Bti works well in a variety of freshwater habitats. Granular formulations are particularly effective against mosquitoes when the larvae are in their second and third stage. Bacillus sphaericus does not have the Bti‟s broad spectrum of activity but has a longer period of larvicidal activity. In addition, Bacillus sphaericus works well in highly organic habitats. Because of its extended control and effectiveness in organic water, Bacillus sphaericus is effective in treating catch basins.

These larvicides last only a few weeks in water and pose no danger to humans, non-targeted animal species, or the environment when used according to directions on the label. Therefore, calibration of application equipment is important to ensure product is being applied as close as possible to target rates. Regular calibration and maintenance of application equipment will be undertaken in accordance with manufactures instructions and chemical labels and materials safety data sheets (MSDS). If further advice is required, the Department of Health will be contacted to provide advice.

Insect Growth Regulators

Methoprene is an insect growth regulator. This product disrupts the mosquito larvae's normal growth pattern by artificially limiting its development, making it impossible to reach the adult stage. It may be used to control second (2nd), third (3rd) and fourth (4th) instar larvae. Treated larvae will pupate but adults will not emerge from the pupal stage; it is not toxic to existing pupal or adult stages. The mode of delivery includes liquid, charcoal pellet and briquet. This product can be applied to larger bodies of water in the form of time-release briquets which can last from one to five months. Use of this larvicide does not pose an unreasonable health risk to humans or other wildlife and it will not leach into the ground water supply. There is a small acute and chronic risk to some fish and freshwater invertebrate species.

Organophosphate

Temephos, marketed as Abate and ProVect, is an organophosphate which prevents mosquito larvae from developing resistance to bacterial larvicides which can be delivered as a plaster pellet, liquid or sand granule. Due to the small amount needed and the fast rate that temephos breaks down in water, this type of larvicide does not pose an unreasonable health risk to humans, but large doses can cause nausea or dizziness. This insecticide has been used by the World Health Organization to treat stored drinking water. However, careless handling or ingestion of any organophosphate increases health risks.

As with any insecticide special attention to the label is necessary relative to site use, mixing, and application of material. Similarly, there is not a large risk to terrestrial species, but there is a toxic

concern for non-targeted aquatic species. Therefore, temephos should be limited only to sites where less hazardous larvicides are ineffective and with intervals between applications.

7.4.1.2 Adulticides

Adulticides are those chemicals that kill mosquitoes at the adult stage. Pesticides kill or alter an organism by disrupting some vital physiological function. The method by which this occurs is called the pesticide's mode of action. The most typical mode of action involves disruption of the insect's nervous system. They are the only chemical control option once flying adults have emerged.

Advantages:

- Fast knockdown of biting adults in times of high disease risk
- Residual surface sprays are available which can be used as barrier sprays with longer lasting effects

Disadvantages

- Only temporary control is achieved by fogging – mosquitoes are likely to re-enter treated areas from adjacent untreated areas, meaning treatments must be repeated regularly
- No target specific formulations are available. Adulticides work like a large-scale insect spray, killing all flying insects, including natural predators of mosquitoes and beneficial insects such as bees.
- Mosquitoes can develop insecticide resistance through the overuse of adulticides.
- Highly toxic to fish and other aquatic organisms and cannot be used near wetlands.
- Labour and chemical costs associated with ongoing fogging treatments can be very high.

Application of adulticides will only occur during times of high disease risk when the risk to public health outweighs the risk to the environment.

The most common compounds used for adult mosquito control in Australia are the Pyrethroids, a synthetic chemical whose structures mimic the natural insecticide pyrethrum. Pyrethrin's are found in the flower heads of some plants belonging to the family Asteraceae (e.g. chrysanthemums). These insecticides can knockdown insects quickly and can be degraded very easily by ultraviolet light which oxidizes the compounds. In general, this phenomenon leads to lower environmental risk.

Pyrethroids can pose significant hazards to aquatic organisms and the potential for bioaccumulation within sediment is a concern as it is highly toxic to insect pests at very low rates. Synthetic pyrethroids have been chemically altered to make them more stable and safer to mammals. Pyrethroids are axonic poisons; attacking the nerve fibre by binding to a protein in nerves called the voltage-gated sodium channel. Normally, this protein opens causing stimulation of the nerve and closes to terminate the nerve signal. Pyrethroids bind to this gate and prevent it from closing normally which results in continuous nerve stimulation. Control of the nervous system is lost, producing uncoordinated movement and ultimately mortality.

Fogging

Council can also undertake fogging. However, unlike larvicides, the chemicals required to be used for fogging are not species specific, so any flying insect that encounters the product will die. The chemicals used for fogging do not linger in the air, therefore, it only has an impact on the mosquitoes that come into direct contact with the spray. Given the distance mosquitoes will travel, this will not kill the majority of mosquitoes within a region and is therefore not deemed a very effective treatment method. This does not align with Council's mission/objective, as it is not considered an environmentally appropriate treatment method. Therefore, is not a standard part of Council's mosquito control program. However,

there are instances, such as following significant weather and rain events when there are a prevalent number of adult mosquitoes that fogging will be used as an additional tool to reduce mosquito numbers.

It is generally regarded that mosquitoes are considered a 'nuisance' when the number of mosquitoes caught at a single location in a single carbon dioxide (CO_2) baited trap exceeds 300 of a specific species over a normal sampling period (i.e. 12 – 18 hours). Where the species caught are ones that are known or suspected of being vectors of mosquito-borne disease and the mosquito population is in close proximity to a heavily populated area, then the mosquitoes may present a health risk and there is a public health imperative that management be undertaken.

The threshold of 300 has been adopted for this report but it should be noted that there are several other salient factors that need to be taken into consideration. These factors include:

a) The species present: the main vector species *Aedes camptorhynchus* and *Aedes vigilax* are particularly aggressive and where residential areas are close to breeding sites the threshold should be reduced accordingly.
b) The proximity of known breeding sites to residential areas.
c) The presence and extent of any buffer zones that are to be created around known breeding sites.

In addition to this general threshold level, there are some additional reference numbers when using CO_2 baited light traps that can also be used. Trap collections of more than 300 *Aedes vigilax* or 500 *Culex annulirostris* within 500 metres of residential areas indicates a pest problem and potential disease risk, triggering increased public awareness activities. Trap collections of over 500 *Culex annulirostris* within 500 metres of residential areas would be regarded as a severe pest problem and potentially a significant disease risk. This will trigger discussions with QH regarding the appropriate control response.

Priority Areas

Council does acknowledge that there are a number of areas and events that are considered to be high risk such as day-care and aged care facilities, additionally, there are events held whereby a significant number of the public will be in attendance. Instances such as these will be subject to the above process then reviewed as per the risk to determine if fogging or additional treatments are an option. Ideally, larvicide and barrier treatments are to be undertaken first to provide long term protection, where this is not possible fogging may be considered.

Residual or Barrier Treatments

Barrier treatments involve the use of a residual sprayer to spray specific areas of vegetation or other matter with a chemical that remains present on these items for approximately two (2) months. As mosquitoes land on the items, they absorb the chemical in their feet and die. This treatment can be used on small trees and shrubs. This method is predominantly used in two different areas:

- Sand/pellets in tidal areas to project the treatment and/or use as a pre-treatment, where conditions don't allow general treatment i.e. too windy.
- Liquid treatment i.e. in toilets, parks,

A relatively new strategy for protection against adult mosquito populations is through the treatment of mosquito harbourage sites with a residual insecticide. These treated areas then create a 'barrier' between residential and/or recreational areas and mosquito habitats.

The product most commonly used for this purpose is the synthetic pyrethroid bifenthrin. The product provides a residual layer of pesticide that kills resting mosquitoes and is currently registered for treating

mosquito resting places (internal and external areas of domestic, commercial, public and industrial buildings). However, there are some environmental concerns surrounding the widespread use of this product, in particular for non-target insects and aquatic organisms. The manufacturer advises that the product is toxic to bees, fish and aquatic organisms and that mud, sand, mangroves and other aquatic habitats should not be directly treated or exposed to spray drift.

As with all adulticides, targeting adult populations rather than larval (immature) populations will be less effective, particularly for pest mosquitoes such as the saltmarsh mosquito that can disperse widely from breeding habitats. While barrier treatments may provide protection in the immediate surrounds of a treated dwelling, they will not reduce mosquito impacts beyond the treated area.

8 MOSQUITO CONTROL PROCESS

Our process for control is predominately through scheduled inspections and routine work of known mosquito breeding sites in addition to trapping numbers and species identified.

The first control measure will be larvicide treatment of the water breeding area. Trap monitoring will be utilised to ensure the success and determine species numbers. Where the mosquito problem continues barrier treatment may occur, as this barrier treatment is new to Council this control needs to be measured through traps to ensure it is successful. Where the issue continues, Council may refer to the fogging parameters in the previous section prior to fogging.

9 EMERGENCY RESPONSE

Mosquitoes can be a major problem during or following a major event such as flooding caused by rainfall, major runoff or storm surge. Should a State of Disaster be declared for such an event under the *Disaster Management Act 2003* (DMA 2003), then the matters being addressed by the State of Disaster may no longer be subject to the provisions of the EP Act.

However, the *Disaster Management Act 2003* prevails when there is an inconsistency with the provisions of any other Act, environmental protection will therefore only be compromised when there is inconsistency between the provisions of these two Acts. There is a trend for disaster situations to be handled at the local level without the need for declaring a State of Disaster. This will place increasing importance on planning procedures to mitigate against the effects of particular events and to allow effective remedial and recovery responses. There is also potential for an emergency situation to arise if there is a major accidental or natural introduction of exotic mosquitoes or there is an outbreak of mosquito borne disease in Queensland.

The *Public Health Act 2005* makes provision to address public health emergencies (chapter 8) and when a public health emergency is declared under the *Public Health Act 2005* allows for the exercise of considerable powers to meet the emergency, the provisions of the EP Act still apply. This is also the case with the *Exotic Diseases in Animals Act 1981* that could require the control of mosquitoes as part of a program to control exotic disease in animals.

Council is prepared to respond to emergencies such as flooding and other disasters that can increase community exposure to mosquitoes. All emergency response to mosquitoes is undertaken in alignment with State emergency plans and GRC's Disaster Management Plan.

10 STAKEHOLDERS

10.1 Internal Stakeholders

Local Government

Local government has responsibility for the public health risks related to breeding grounds for designated pests and harbourages of designated pests. Mosquitoes are defined as a designated pest.

Ideally, residential developments should be located well away from extensive mosquito breeding sites to minimise mosquito management requirements. However, this is often not achievable in the Gladstone region due to the magnitude of the natural environment and potential breeding areas in comparison to the size of town sites. Nevertheless, Council's Development Services Team considers the appropriateness of proposed land for development applications. Likewise, Council's Strategic Asset Performance Group also have a responsibility for a number of areas that affect mosquito management including stormwater drains and vegetation management. Effective delivery of this plan, particularly physical control methods, will require close liaison with infrastructure.

10.2 External Stakeholders

To ensure the most successful surveillance, management and where possible prevention of mosquitos occurs within the region, Council works with key stakeholders, this includes community, State and Federal Governments and industry. GRC's Biosecurity and Environmental Health Team chairs annual meetings with relevant stakeholders to discuss the different agencies current strategies, emerging issues and upcoming works.

Queensland Health

Queensland Health seeks to protect the health of Queenslanders and is responsible for the coordination and support of initiatives to reduce the risk of transmission of mosquito-borne diseases to human and managing the response to outbreaks of mosquito borne disease.

Queensland Health achieves this through:

- Identification of and mechanisms to prevent or minimise adverse health impacts from notifiable conditions such as RRV and BFV under the *Public Health Act 2005*.
- Working with or supporting local government to prevent or control outbreaks of mosquito-borne diseases such as Dengue, Japanese encephalitis and Malaria.
- Preventive Dengue control programs in high-risk areas.
- Health promotion activities focusing on the prevention of mosquito bites and reduction of household mosquito breeding.
- Facilitation of education and training for health workers covering mosquito management, prevention, surveillance, and control.
- Taxonomic reference service to identify mosquitoes.
- Leading and supporting eradication campaigns, in collaboration with AQIS and local government, against the exotic mosquito *Aedes albopictus* in north Queensland.
- Contributing to research on mosquito biology and control.
- Surveillance of mosquito-borne diseases.
- Providing an expert advisory resource on mosquito control issues for local governments and other agencies.

- Collaboration with government, research institutions and industry towards the development of new mosquito control products and methods through research and development programs, revision of products and contributing research funds.
- Distribution of annual applied research funds for the control of mosquito-borne diseases in humans and mosquito management programs.
- Provision of advice, interpretation of, guidance notes and operational procedures on legislation relevant to mosquito control i.e. *Public Health Act 2005, Public Health Regulation 2018, Medicines and Poisons Act 2019* and assistance to local government to develop and implement integrated mosquito management programs.

Other state government departments administer legislation that has an impact on mosquito management and control in Queensland, including the Department of Environment and Science and the Department of Employment, Economic Development and Innovation.

Department of Environment and Science

The Department of Environment and Science (DES) is responsible for ensuring that state land is managed for the benefit of the people of Queensland by having regard to the principles of:

- **Sustainability**: sustainable resource use and development to ensure existing needs are met and the State's resources are conserved for the benefit of future generations
- **Development**: allocating land for development in the context of the state's planning framework and applying contemporary best practice in design and land management
- **Community purpose**: if land is needed for community purposes, the retention of the land for the community in a way that protects and facilitates the community purpose
- **Protection**: protection of environmentally and culturally valuable and sensitive areas and features.

DES may be involved in approval of works required for habitat modification for saltmarsh mosquito control in accordance with relevant provisions of the *Sustainable Planning Act 2009*. DES has designed a wetland management profile to provide information about the distribution, ecology, cultural values, conservation status, threats and management on saltmarsh wetlands and its relationship with saltmarsh mosquitoes within Queensland.

Department of Agriculture and Fisheries

Department of Agriculture and Fisheries (DAF) has statutory interests in fish habitat protection and management of the impacts from habitat modification (e.g. saltmarsh runnels) and chemical application programs for saltmarsh mosquito control in declared fish habitat areas. Legislative provisions for fish habitat protection and management are in accordance with the requirements under the *Fisheries Act 1994* (and Regulation 2019) and *Sustainable Planning Act 2009* (and Regulation 2009).

Stocking of native fish for mosquito control and control of exotic and noxious fish are also managed under the *Fisheries Act 1994*. A Fish Habitat Area Code of Practice has been developed to include the compliance requirements for chemical and biological insect control in declared Fish Habitat Areas (*Fisheries Act 1994* and *Fisheries (General) Regulation 2019*).

Fisheries Queensland has prepared Integrated Development Assessment System (IDAS) self-assessable development codes which apply to new runnels (Code Number MP06) and runnel maintenance (Code Number MP02). Fisheries Queensland administers fish stocking restrictions in Queensland waters (stocked fish species must be native to drainage basin locations) under the *Fisheries Act 1994*, *Fisheries*

(General) Regulation 2019, and the *Fisheries (Freshwater) Management Plan 1999*. Fish stocking approvals are required for dams, streams and other waterways that are publicly owned.

Biosecurity Queensland, another service of DAF, administers legislation on application and use of agricultural and veterinary chemicals including those used for mosquito control. Infestations of certain aquatic plants can provide havens for mosquito breeding. Aquatic plants such as *Salvinia molesta* and *Hymenachne amplexicaulis*, are declared pest plants under the *Biosecurity Act 2014.*

The Australian Government

The Australian government's role in mosquito management is primarily focused within a 400-metre radius of entry points to international aircraft and vessels. Management activities performed by AQIS include:

- Vector monitoring (mosquito trapping and surveillance) at international first ports on behalf of the DoHA as part of Australia's commitment to World Health Organization's International Health Regulations 2005
- Notification of reportable mosquito species and breeding sites detected in the international first port zone to DoHA and other stakeholders (control activities for mosquitoes and breeding sites identified are not physically performed by AQIS)
- Ensuring all aircraft cabins and holds disinfection is complete for all arriving international aircraft
- Complete vector deck inspections of all international vessels arriving from high-risk seaports
- Ensuring import conditions are met for imported cargo posing a vector risk (e.g. tyres) including mitigation activities such as mandatory treatments and inspections.

The DoHA also administers the National Arbovirus and Malaria Advisory Committee (NAMAC) that provides advice (via a website and disease response plans), advocates policy and negotiates funding for elimination campaigns for exotic mosquitoes.

11 CLIMATE CHANGE & FUTURE RISKS

Mosquitoes and mosquito-borne disease are often discussed as a major concern should climate change result in global warming and/or sea level rise. The greatest concern is that, with increased temperatures, the geographic range of pest and vector species will increase and with it the risk of human disease, particularly 'tropical' diseases such as Malaria and Dengue. However, there are many factors besides temperature, including the availability of suitable habitats, short term changes in rainfall and tidal heights, urbanisation and mosquito control programs, that influence the distribution and abundance of mosquitoes as well as the incidence of human disease.

While the risks of mosquito-borne diseases such as Dengue or Malaria are unlikely to change with predicted climate change, there may be local increases in the risk of RRV and BFV. With overall warmer temperatures, there may be a decrease in the incubation period (the time between when a mosquito ingests a virus and when it is capable of transmitting the virus to humans) of the viruses in local vector species. This will mean that a potentially greater proportion of mosquitoes can transmit RRV or BFV in the local area. In addition, the warmer weather may not increase the magnitude of population increases but it may extend the period of mosquito activity, increasing nuisance-biting and potential public health risks into the spring and late autumn.

While there is no specific prediction of rainfall change in the Gladstone region associated with climate change, there is the prediction that there may be a greater frequency of extreme weather events and

increases in rainfall intensity. These factors may contribute to increased mosquito productivity from the coastal swamp habitats in the Gladstone region. Currently, the abundance and distribution of these coastal swamp mosquitoes are strongly influenced by rainfall patterns between November and April each year with years recording above average rainfall generally resulting in more abundant mosquito populations. While major outbreaks of mosquito-borne disease do not necessarily follow increased mosquito populations, abundant mosquito populations are typically associated with a rise in local disease cases.

It is important to remember that the risks of mosquito-borne disease are influenced by a range of factors, not only mosquito populations. The activity of vertebrate reservoir hosts (e.g. birds, macropods) is an important factor and how these populations are influenced by changes in rainfall, temperature and sea level rise (as well as urban development) will influence mosquito borne disease risks into the future.

The magnitude of temperature, rainfall and sea level change varies by model and study, but the pest and public health impacts of mosquitoes in the future may be determined as much by urbanisation, wetland management strategies and mosquito control programs as much as any change to the climate in the Gladstone region.

12 TRAINING

It is essential that personnel involved in the operational aspects of the MMP are suitably qualified, trained and/or supervised. More than one staff member should be trained in mosquito management. Skills required to carry out the requirements of the MMP safely and effectively are:

- Basic mosquito ecology
- Principles of integrated mosquito management
- Surveillance/monitoring techniques
- Collection, recording and identification of mosquito samples
- Standard operating procedures for equipment
- Safe storage, handling and application of chemicals/larvicides in accordance with product labelling and MSDA.
- Use of appropriate PPE in accordance with product labelling, MSDS and environmental conditions
- Calibration techniques
- Information technologies/geographical information systems
- Budget management

Mosquito management courses are conducted by Environmental Health Australia (EHA) which teaches most skills and competencies required.

13 RESOURCE REQUIREMENTS

Operating and implementing an effective mosquito management program is dependent on ongoing human and operational resources. Resource requirements will fluctuate significantly depending on the severity of the mosquito-breeding season, which is largely dependent on environmental variables. Environmental Health staff are primarily responsible for implementing this MMP. However, mosquito management is only a small part of Council's Environmental Health responsibilities and assistance is required from other staff. This can include assistance with monitoring activities, physical control activities or application of chemicals. A 4WD vehicle is also required for mosquito management work.

Contributions toward chemicals is dependent upon Council's own budget allocation. This money can be utilised in years when mosquito-borne disease risk/nuisance is greater than normal.

14 STRATEGY

The following key strategies have been identified as paramount to the program:

1. Plan Principles and Management
2. Mapping and Identification of Mosquito Breeding Areas
3. Public Education, Promotion, Collaboration
4. Treatment Strategies

14.1 Plan Principles and Management

Mission

To maintain, develop and implement effective and efficient strategies to minimize the incidence of arboviruses and mosquito nuisance within the community in an environmentally responsible manner.

Objective

The Mosquito Management Plan seeks to demonstrate how Council proposes to manage mosquitoes within the Gladstone region.

14.2 Mapping and Identification of Mosquito Breeding Areas

To ensure Council is adequately treating and managing mosquitoes Council must have the most up to date data regarding where mosquitoes are breeding and what species of mosquitoes are breeding in these sites.

Council obtains this data through a range of different methods including:

a. Surveillance

Council undertakes a diverse range of surveillance activities to ensure that council has the most up to date information and data on the current numbers and types of mosquitoes present in the region. These activities include:

Mosquito Traps

Traps are put up in areas known to have a presence of mosquitoes. From the numbers and types of mosquitoes identified in these traps, the appropriate response and treatment is determined.

Arbovirus Surveillance Program

Council participates in an additional survey program run by Queensland's Population Health Unit (QPHU), which uses QPHU traps. QPHU use the samples obtained to identify what types of mosquitoes are present within the different regions of Queensland and what diseases are being carried by these diseases. QPHU also use this data to establish different mosquito management plans and strategies for applicable regions of Queensland.

b. Mapping

Council has recently developed a mapping layer specific to mosquito management. This map layer identifies water bodies within the region along with the complaints received by Council and trap locations and the species within these traps.

This layer will allow Council's Vector Control Team to ensure they are targeting the appropriate areas and will also assist in officers ensuring they are selecting the most appropriate treatment method for a site. By being able to identify where complaints are received it will also assist officers in determining which sites should be prioritised for treatment and further surveillance.

c. Customer Complaints

As part of the Vector Control operations of Council, the Vector Control Officers undertake initial investigations from the community regarding properties that may be unknowingly increasing the breeding sites in the region. Dependant on the nature and severity of the complaint the Environmental Health Team may undertake further enforcement actions if compliance is not met.

14.3 Public Education/Promotion/Collaboration

Ensuring that people within the Gladstone region are adequately informed about mosquitoes and how best to reduce the impact they have on people's day to day life is a very important mechanism for reducing their effect on individuals and the community as a whole. The below outline a couple of ways in which Council provide awareness to the community.

Stakeholders and agreements

To ensure the most successful surveillance, management and where possible prevention of mosquitoes occurs within the region, Council works with a number of stakeholders including the community, State Government and industry. Council chairs an annual meeting with relevant stakeholders to discuss the different agencies current strategies, emerging issues and upcoming works.

Public Awareness

Council undertakes public awareness regarding mosquitoes throughout the region. This awareness is in many forms including media releases and factsheets being sent out to the community at relevant times of the year. Additionally, educational stalls are set up at applicable events such as Ecofest and other locations and education sessions are undertaken in schools, preschools and community centres.

Door knocks

Door knocks can also be undertaken within the region to ensure that members of the public are not unknowingly providing additionally breeding sites.

Dealing with the media

The local media regularly include mosquito stories during the summer months, often instigated by action groups within the community lobbying for greater levels of mosquito control or in response to health warnings by local authorities (or sometimes just because it is that time of the year). Dealing with the media is an important component of community education because it provides an opportunity for the dissemination of accurate information on mosquitoes and personal protection strategies, as well as opportunities to publicise the local mosquito management program.

It is crucial that representatives of local authorities dealing with media have appropriate training and/or resources to answer questions regarding general mosquito biology, locally important pest mosquitoes, personal protection strategies and background on the local mosquito surveillance and any mosquito management programs.

While the majority of mosquito related articles in the media relate to pest and/or public health issues, opportunities to promote mosquitoes as an important component of the local environment should be pursued. There are many interesting aspects to mosquito biology and ecology that will provide the basis of radio, newspaper or television segments that have a wide appeal to audiences.

14.4 Treatment Strategies

Like any pest species, there is no single treatment method that is appropriate for reducing the presence and impact of mosquitoes on the region. Council officers utilise a number of different methods dependent on the site, type and stage of life cycle of a mosquito. The treatment methods officers use include:

- Larvicide Treatments
- Barrier Treatment
- Vegetation Management
- Fogging

Strategic Goal		Actions	Performance Outcomes
1. Plan Principles and Management			
To ensure that the Mosquito Management Plan (MMP) continues to be based upon sound principles including extending & establishing the rural regional areas into the MMP.	1.1	Ensure that the MMP embrace the principles of Integrated Pest Management (IPM).	The principles of Integrated Pest Management have been adopted.
	1.2	Ensure that the MMP operates in an environmentally sound, effective and cost-efficient manner.	Operating within budget.
	1.3	To participate and operate the MMP in a cooperative and partnership arrangement with key stakeholder organizations.	Interagency Pest/Vector Management Group Forum held prior to main breeding season or following a significant mosquito event.
To provide an efficient and effective framework to manage the MMP	1.4	Ensure only environmentally safe bio-rational agents are used for larval control.	Review of larvicides used in response to change in legislation or industry best management practices.
	1.5	Provide and maintain ongoing reporting of operational activities.	Provide reports for operational activities upon request.
	1.6	Review the complaints monitoring system for all mosquito complaints.	Complaints are logged into 'Pathway' and managed in accordance with procedures.
2. Mapping and Identification of Mosquito Breeding Areas			
Identify and record key mosquito breeding areas	2.1	Maintain data recording systems identifying all key mosquito breeding areas utilising Council's mapping system.	Document breeding areas in Council's mapping system.
3. Surveillance of Mosquito Breeding Areas			
To establish a surveillance system to facilitate implementation of management strategies	3.1	Monitor known mosquito breeding sites.	Monitoring and identification of species.
	3.2	Maintain arbovirus disease surveillance data.	Review notifiable disease report from Queensland Health.
4. Public Awareness and Education			
To educate the community on mosquitoes and effective preventative measures	4.1	Ensure relevant information is provided to the community.	Provide relevant information to the community through communication platforms.
	4.2	Council Officers engage with the community to ensure public awareness and education.	Council Officers to participate in communication education programs (for example Ecofest). Promote GRC's Mosquito Management video.
5. Treatment Strategies			
To implement best practice treatment strategies.	5.1	Review treatment strategies and threshold for key mosquito breeding area.	Review completed.
	5.2	Implement, where possible, source reduction strategies to eliminate breeding areas.	Where practicable, breeding areas have been eliminated.

15 REVIEW & REPORT

Good record keeping practices are crucial for the continuation of this plan and retention of knowledge within the organisation. The following list includes the minimum required records to be kept on the Council's record management system:

- Records of complaints
- RRV/BFV/MVE notifications and follow-up documentation
- Adult trapping results
- Larval survey results
- Chemical treatments
- Vector Control maps
- Chemical product labels and MSDS
- Media releases

This plan will be reviewed every two (2) years by 31 December with information included in the GRC's annual report. It is important to assess effectiveness of the surveillance program and the overall control program to allow for continuous improvement. An ongoing surveillance program will assess whether the mosquito populations are being reduced and if the control program is achieving reductions in pest problems or mosquito borne disease. Council will also continue to liaise with relevant stakeholders and research the most up to date treatment and prevention methods for mosquito management within the Gladstone region.

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17 APPENDIX A

Aedes aegypti:

The *Aedes aegypti*, mosquito (known as the dengue mosquito in north Queensland) is found in many tropical countries around the world including parts of Queensland, and only live where there are people. They live inside homes and hide in dark areas—under beds, tables and other furniture, behind curtains or under the house.

Figure 5: Aedes aegypti Image courtesy of CDC.gov

Characteristic Features

Female: A smallish, dark mosquito with conspicuous white markings and banded legs; the proboscis is all black although the palps are white tipped; the scutum has a dorsal pattern of white scales in the form of a 'lyre' with curved lateral and 2 central stripes contrasting with the general covering of narrow dark scales; wings are dark scaled; hind legs with femur pale scaled for basal three-quarters with dark scales dorsally on apical two-thirds and ventrally on apical third, tibia dark but tarsi with pale basal bands on 1-4 and 5 all pale; abdominal tergites with median and lateral white scale patches or bands (possibly some white scales on apical margins), sternites predominantly pale scaled with subapical bands on distal segments.

Breeding Habitats: Adults are found within or close-by human environments. This species commonly breeds in artificial and natural containers. For example, pot plants, saucers and tyres; natural containers would include bromeliads, tree axils and discarded palm fronds.

Active Season: The mosquito is most active during daylight year-round, for approximately two hours after sunrise and several hours before sunset.

Biting Habits: Often biting indoors or in sheltered areas near the house; biting is predominantly by day in shaded areas but may also occur early in the night.

Disease Vector: Major vector of Dengue, zika, chikungunya and yellow fever; potential vector of dog heartworm, RRV, MVEV and BFV.

If *Aedes aegypti* is identified on private property Gladstone Regional Council has the ability to instruct the property owner/tenant to undertake control.

Aedes alternans:

The *Aedes alternans* prefers to bite humans and has several techniques in which to find a host, including detection through body odour, increases in carbon dioxide and air pressure, as well as heat.

They breed in saline/brackish ponds of water and the larvae have been found to be cannibalistic.

Figure 6 Aedes alternans. Image by Wendy Moore.

Characteristic Features
Large in size, and shaggy striped appearance. Has specialised mouth parts and is predatory on other mosquito larvae and various aquatic macroinvertebrates.

Breeding Habitat: Tidally influenced saltmarsh but can also be found in freshwater habitats. Larvae are predatory and feed on other mosquito larvae.

Active Season: Year-round / wet months.

Dispersal Capabilities: can travel 5-8km from breeding site in search of a blood meal.

Biting Habits: very aggressive biters, will attack throughout the day and night. This species may continue to be a pest up to three weeks after breeding areas are inundated.

Disease Vector: Potential nuisance-biting pest but is not considered an important vector of RRV or BFV.

Aedes Notoscriptus/Ochlerotatus notoscriptus:

This species is arguably the major domestic pest species in south-eastern Australia.

Figure 7: Aedes Notoscriptus/ Ochlerotatus notoscriptus

Characteristic Features

Female: A smallish to mid-sized dark species with conspicuous pale markings and banded legs; proboscis with median white band; scutum with narrow dark scales and with silvery (sometimes golden) scales forming conspicuous 'lyre' shaped pattern of curved laterals, a long central and short sub-lateral lines; wings all dark scaled; hind leg femur and tibia with pale stripe, tarsi banded and last segment may be all white; abdominal tergites dark with basal patches or constricted bands separated from lateral patches, sternites mostly pale scaled from base but terminal segments may be predominantly dark.

Breeding Habitat: Clean water within domestic environment: artificial containers (buckets, tins and tyres).

Active Season: Year-round / wet months.

Dispersal Capabilities: 0.4km.

Biting Habits: Vicious, active dawn and dusk; occasionally at night and day, prefers shade.

Disease Vector: RRV Important vector of dog heartworm and has also been shown to carry Murray Valley Encephalitis.

Culex Annulitostris:

Figure 8: Culex Annulitostris

Characteristic Features

Female: A medium sized mosquito of brownish to dark appearance with banded legs; proboscis dark scaled with a pale band in middle third; scutum with dark bronze and golden narrow scales (a few pale narrow scales at the 'shoulders' and towards the rear); wings dark scaled; hind femur mottled with pale scales and scattered pale scales on tibia, tarsi 1-4 with pale basal bands, 5 all dark; tergites dark scaled with basal pale bands typically extended medially, sternites with pale scaling from base typically interrupting an apical dark band.

Breeding Habitat:
Permanent/semipermanent freshwater bodies. Prefers heavily vegetated sites

Active Season: Year-round esp. mid wet season to early dry season
Dispersal Capabilities: Up to 10km
Biting Habits: Active dawn, dusk and night
Disease Vector: MVEV, WNVKUN, RRV, BFV as well as being a vector for myxomatosis and an effective carrier of dog heartworm.

Culex sitiens:

Culex sitiens can become a major pest during summer months. This specie is found along most coast lines of Australia and has the ability to travel large distances in order to seek a blood meal.

Characteristic Features

Culex sitiens is primarily dark brown in colour, with a large median white band on the proboscis, and pale stripes across the abdominal segments and leg joints, giving an almost wasp-like appearance.

Breeding Habitats*:* The major breeding site of the sitiens is the same as *Aedes vigilax* – temporary brackish pools and marshes filled as a result of tidal inundation. Eggs of this species are deposited in rafts on the surface of the water Larvae of *Culex sitiens* are often found in the same habitat with *Aedes vigilax* but *Culex sitiens* also has the ability to adapt to freshwater habits.

Active Season: This species usually reaches population peaks during late summer when rainfall has diluted salinity in tidal salt marsh pools and flooded lowland agricultural flats.
Dispersal Capabilities up to 35 km.

Biting Habits: Feeds mainly at night and may disperse widely from its coastal breeding areas.
Disease Vector: Current research indicates that this species is a competent vector of Ross River Virus within the laboratory setting, with further research continuing to determine transmission efficiency as a possible field vector.

Mansonia uniformis:

Characteristic Features

Female: A mid-sized mosquito of mottled brownish appearance; proboscis mottled but mostly pale on basal three-quarters and predominantly dark apically; scutum with narrow golden scales but with paler scaled lines medially, broader stripes laterally and patches towards the rear; wings mottled with broad dark and pale scales on all veins; hind legs with femur mostly pale scaled on basal half but otherwise dark scaled with mottling and patches of pale scales. Tibia, likewise, tarsi all with basal pale bands and tarsus 1 with medial pale band as well; abdominal tergites mostly dark scaled with some mottling and pale lateral patches, sternites mostly pale scaled.

Figure 10: Mansonia uniformis

Breeding Habitat: Heavily vegetated freshwater especially with Typha/water lilies
Active Season: Jul-Nov

Dispersal Capabilities: 1-3km
Biting Habits: Vicious, all times in shade
Disease Vector: MVEV, RRV, WNVKUN

Figure 9: Culex sitiens

Ochlerotatus Vigilax:

Figure 11: Ochlerotatus Vigilax. Image by Stephen L. Doggett

Characteristic Features

Female: A mid-sized mosquito of dark appearance with banded legs; proboscis with pale scaling on basal two-thirds underside; scutum with dark bronze and some golden scales; wings dark scaled with sparse mottling of narrow white scales mainly along front veins; hind legs with femur and tibia mottled tarsi with basal bands; tergites dark with pale basal bands; sternites pale scaled with dark lateral apical or sub-apical patches (occasionally bands).

Breeding Habitat: Essentially coastal and associated with saline habitats including estuaries, mangrove zones and mudflats.

Active Season: Oct-Dec and Mar-May **-** Hatching of eggs, dormant in dried salt marsh, is in response to inundation of mudflats through extremely high tides and/or through rainfall.

Dispersal Capabilities: Up to 100km.

Disease Vector: Murray Valley encephalitis (MVEV), Ross River Virus (RRV), Barmah Forest Virus (BFV) and Dog Heartworm.

Our Region. Our Future.

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Document Set ID: 4287410
Version: 3, Version Date: 04/05/2023