Mosquito Management Plan 2022

City of Karratha. Western Australia.

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ABBREVIATIONS

RRV- Ross River Virus

BFV- Barmah Forest Virus

MVE- Murray Valley Encephalitis

JEV- Japanese Encephalitis Virus

CofK- City of Karratha

DBCA- Department of Biodiversity, Conservation and Attractions

DoH- Western Australian Department of Health

DoP- Department of Planning

DOT- Department of Transport

EPA- Environmental Protection Authority

WAPC- Western Australian Planning Commission

WC- Water Corporation

MMP- Mosquito Management Plan

GIS- Geographic Information System

SOP- Standard Operating Procedures

CLAG- Contiguous Local Authorities Group

TPS- Town Planning Scheme

LGA- Local Government Authority

EVS/CO_2- Encephalitis Vector Survey/ Carbon Dioxide

POS- Public Open Space

MCAC- Mosquito Control Advisory Committee

MoU- Memorandum of Understanding

DEFINITIONS

Mosquito- A small flying insect of the family Culicidae. The females have a long proboscis adapted for piercing the skin of humans and animals to suck their blood.

Dipping- Sampling water with a standard dipping tool to estimate the number of mosquito larvae present.

EVS/CO_2- A mosquito trap outfitted with light and CO_2 to attract mosquitoes.

Nuisance- Used to describe a mosquito causing inconvenience or annoyance.

Threshold- The level or amount before a control strategy is implemented.

Larvicide- Biological or chemical agent to kill mosquitoes or midges in the innocuous larval stage before the adults develop and disperse.

Adulticide- Insecticide used to kill adult mosquitoes.

CLAG- Contiguous Local Authorities Group, comprised of one or more local governments that share a common mosquito problem.

Monitoring- The collection of data by various methods for the purpose of understanding natural systems and features, evaluating the impacts of development proposals on such systems, and assessing the performance of mitigation measures

1 INTRODUCTION

1.1 Summary

The City of Karratha covers an area of approximately fifteen thousand square kilometres and has a population of over twenty thousand. The City's population has been increasing and the number of people visiting the city has also been increasing. To realise the vision of being the most liveable regional city in Australia, the City of Karratha needs to be a place where people have a high level of amenities. One of the appealing features of the city is a climate conducive to outdoor living. Residents and visitors to the City of Karratha are fortunate that there is a low incidence of mosquito-borne diseases relative to other regions of Western Australia. However, the nuisance value of mosquitoes can impact the ability of residents and visitors to enjoy the outdoors. This Mosquito Management Plan (MMP) seeks to minimise the impact of mosquitoes on people's enjoyment of the outdoors.

Residents and visitors to the City of Karratha are fortunate that rainfall events are rare. However, when there are significant rainfall events, water pools in the landscape. Any event that results in ponding water creates potential mosquito breeding areas. If left unmanaged, this mosquito breeding can cause significant nuisance to communities. Figure 1 shows the geographic spread of the communities of the City of Karratha.

Population growth and expansion of the City's footprint have resulted in greater numbers of people living near areas known to breed mosquitos. This population growth also creates more potential for mosquito breeding in backyards, at community infrastructure sites and on commercial and industrial properties.

The City of Karratha actively pursues actions to reduce the impacts of mosquitos on the local community. This MMP aims to provide an integrated approach to mosquito management in the City of Karratha and Standard Operating Procedures that can be followed to minimise the risk of mosquito outbreaks.

Figure 1: Map showing the geographic spread of the CofK.

1.2 Objectives

The objectives of the Mosquito Management Plan are:

- Timely detection of mosquito breeding activity to guide intervention efforts.
- Monitor and record mosquito populations to increase local ecology knowledge-base and inform management efforts.
- Monitor and record virus occurrence to increase the local virus knowledge-base and inform the need for management efforts.
- Monitor the effectiveness of vector control efforts.
- Ensure funding is available for on-going mosquito management.
- Increase community awareness of the City's mosquito management strategies and educate the public on effective protection practices.
- Improve mosquito management in the region by partnering with the DoH to deliver healthy communities.
- Work with stakeholders within the CofK to reduce the potential for mosquito breeding.
- Continually review and refine mosquito management.

1.3 Guiding Documents

- Mosquito and midge management Manual (Department of Health Western Australia, 2017)
- Western Australian Department of Health Australian Mosquito Control Manual (Whelan, 2011)
- A guide to developing a mosquito management plan for Local Government (Department of Health)
- Department of Health website

1.4 Strategic Implications

Mosquito management has been identified as an important component of the City's key corporate planning documents. Guidance for mosquito management is included in the Corporate Business Plan 2020-2025, the Operational Plan 21-22 and the Long-term Financial Plan 2019-20 to 2028-29.

Planning Document	Goal	Objective	Statement
Corporate Business Plan 20-25	To reduce the number of public complaints	To have no more than 15 public complaints per financial year	Number of complaints received from residents reporting nuisance mosquitos
Operational Plan (2021-2022)	Healthy residents	To activate safe, healthy and liveable communities	Review and implement the Mosquito Management Plan
Long Term Financial Plan 2019-20 to 2028-29	Deliver a long-term financial plan for the CofK	To provide an operational framework for environmental and community health.	Mosquito control and various health promotions and pest control expenses mainly relating to mosquito control.

Note: a limit of 15 complaints per financial year may not be achievable during high rainfall years. Mosquito numbers tend to spike after major rainfall events, and it is likely the public complaint objective will be unachievable until water levels recede.

2 Statutory management and legislation

There is currently no State-level legislation for the control of mosquitoes in Western Australia. The continued expansion of towns and communities in the absence of legislation and land-use planning measures to control mosquito breeding, combined with increasing expectations from constituents to improve local mosquito management places pressure on local governments to manage mosquito breeding. (Neville 2018)

2.1 Public Health Act 2016

The State Government (Western Australia DoH) has a state-wide charter to ensure the protection of public health, including the threat of mosquito-borne disease. Consequently, DoH engages in mosquito control in WA to protect the public from illnesses arising from diseases transmitted by mosquitoes (DoH, 2017). Currently, this involvement extends to:

- partial funding of mosquito control programs for Local Governments (LGs) that have met requirements for the formation of a Contiguous Local Authorities Group (CLAG) as determined by the Mosquito Control Advisory Committee (MCAC)
- provision of advice, expertise, training and warnings on mosquito-borne disease and control to all LGAs, other State Government departments and the private sector throughout WA; and
- assisting LGAs with emergency mosquito control during severe outbreaks of mosquito-borne disease.

2.2 Planning and Development Act 2005

The Planning and Development Act 2005 provides for the following measures that are often required as part of the planning process:

A Mosquito Management Strategy can be required by the WAPC as part of a Local Structure Plan. In addition, a condition can be imposed on a subdivision approval by the WAPC requiring notification to be placed on the title of newly created lots notifying prospective purchasers of the potential mosquito hazard.

The local government can impose further conditions ahead of development approval.

3 Demographics

The City of Karratha supports a rapidly growing community. Karratha itself is just over 50 years old as a settlement and has grown to become a major regional centre with a population of nearly 20 000. The future for the City of Karratha looks bright, with large projects being developed by the resources sector, an enviable lifestyle and plenty of employment opportunities.

According to the 2016 census:

- 65.7% of people in Karratha were born in Australia. The next most common countries of birth were New Zealand 5.3%, Philippines 3.0%, England 2.9%, South Africa 1.5%, and India 1.3%.
- 76.2% of people in Karratha spoke only English at home. Other languages spoken at home included Tagalog 1.7%, Filipino 1.1%, Afrikaans 0.8% and Mandarin 0.7%.

The most common responses for religion were No Religion 35.3% and Catholic 22.0%. Karratha's vision is to become Australia's most liveable regional city, with a diversified economy, high-quality infrastructure and amenities, and a healthy local community. It is set to be a place of choice, to work, visit, grow up, raise families and age in comfort.

The Karratha City of the North Plan (KCN) provides a robust planning framework that aims to:

• Enhance the quality of life for existing residents and attract and retain future residents;
• Respond to the environment and achieve a sense of place;
• Achieve sustainable growth and development over the long term;
• Support economic activity and promote diversification;
• Deliver a vibrant and activated town centre; and
• Identify and establish a partnership approach to deliver the projects.

(Source: Development WA 2021)

3.1 Cultural Heritage

The land, rivers and sea of the City of Karratha have been occupied by the ancestors of the Ngarluma, Yindjibarndi, Martuthunia and Yaburara peoples for more than 30,000 years. The

towns of Dampier, Roebourne, Point Samson, Cossack, Wickham and Karratha are located within these traditional lands.

4 Geography

The City of Karratha covers an area of over 1500km².

4.1 Karratha

Karratha is the largest and most populated centre in the City of Karratha and is also the administrative centre. Karratha has 9 main suburbs: Karratha City Centre, Bulgarra, Pegs Creek, Millars Well, Nickol, Nickol West, Baynton, Baynton West, Madigan Estate, Tambrey; and two industrial areas, known as KIE (Karratha Industrial Estate) and Gap Ridge Industrial Estate. Mulataga is a large new residential development area planned to the east of Bulgarra.

4.2 Dampier

Dampier is located approximately 20km northwest of Karratha. Dampier was originally developed as a Hamersley Iron port town with port activities still important to Dampier, but the town has also transformed into a highly desirable place to live and a popular place for residents and tourists to visit. Dampier is the gateway to the Dampier Archipelago.

4.3 Roebourne

Roebourne was established as a gold rush town in the late 1800s and served as the administrative centre of the area until it was moved to its current location in Karratha. The town lies approximately 30km east of Karratha and still retains some of the original buildings that have been restored and provide an insight into the architecture of the day.

4.4 Point Samson

Point Samson is a small coastal settlement 1,579 km north of Perth and 18 km north of Roebourne in the Pilbara region of Western Australia. The town is a popular holiday location for the nearby mining towns, including Wickham, Karratha and Dampier. Fishing is the main industry.

4.5 Wickham

Wickham was established in the 1970s by Cliffs Robe River Iron Associates. The aim was to create a processing plant for the iron ore mined at nearby Pannawonica, a port (at Cape Lambert) from which to ship the product, and a town to house the associated employees. Wickham is 13km north of Roebourne and 40km east of Karratha. The town is low lying, being approximately 7m above sea level.

4.6 Cossack

Cossack is a historic ghost town located approximately 50km from Karratha and 15 km from Roebourne. The nearest town to Cossack is Wickham. Cossack is located on Butchers Inlet at the mouth of the Harding River. Accessed by a single, sealed road that follows the original causeway across a series of tidal salt flats. The overall landform of the region around Cossack is low and flat with occasional rocky hills and ranges.

5 Mosquitoes

5.1 Distribution

Mosquitoes are bloodsucking insects that cause nuisance and transmit disease to humans and other warm-blooded animals. Over 90 species of mosquito have been recorded in Western Australia. A contributing factor to the number of species in Western Australia is the range of environments from the tropical north to the temperate south, from lush rainforest through the wet and dry bushland to the scrub plains and desert. Mosquitoes utilise water bodies for breeding habitats and have colonised a vast array of natural and man-made environments, including tree-holes, flood plains, sewage ponds, salt marshes, water-filled debris, leaf axils, coastal rock pools, gutters, irrigation ditches, billabongs, wheel ruts, septic tanks, stormwater drains and many more. Most female mosquitoes are restricted to particular parts of an ecosystem to deposit eggs and utilise specific water bodies to initiate the larval component of their life cycle (DoH, 2009).

Within any habitat, other factors such as sunlight or shade, the presence or absence of emergent vegetation and prevailing winds may affect mosquito breeding. Mosquitoes tend to prefer habitats with slow-moving water and an abundance of aquatic vegetation. Slow flowing water allows eggs to settle on the surface and aquatic vegetation provides a source of food as well as protection and stability in which to breed. Water bodies with high organic pollution levels, such as sewage treatment works are often a prolific source of mosquitoes (DoH 2009).

5.2 Biology

Mosquitoes have the potential to be transmitters or vectors of pathogenic diseases. Carbon dioxide exhaled by humans and animals attracts mosquitoes. Mosquitoes mostly feed at dawn and dusk and can become greater nuisances around these times of the day although many species will bite at any time of the day, especially in shaded areas (DoH 2009).

The life cycle of mosquitoes consists of four distinct stages: eggs, larvae, pupae and adults (figure 2). Adults can lay hundreds of eggs on or around water bodies, depending on the species, and all require water for their complete development (Le Messurier, 1987). The Aedes mosquito species lay eggs on moist substrates, the Anopheles and Culex species deposit eggs on the water surface and the Mansonia species lays a submerged egg mass attached to aquatic plants (DoH 2009).

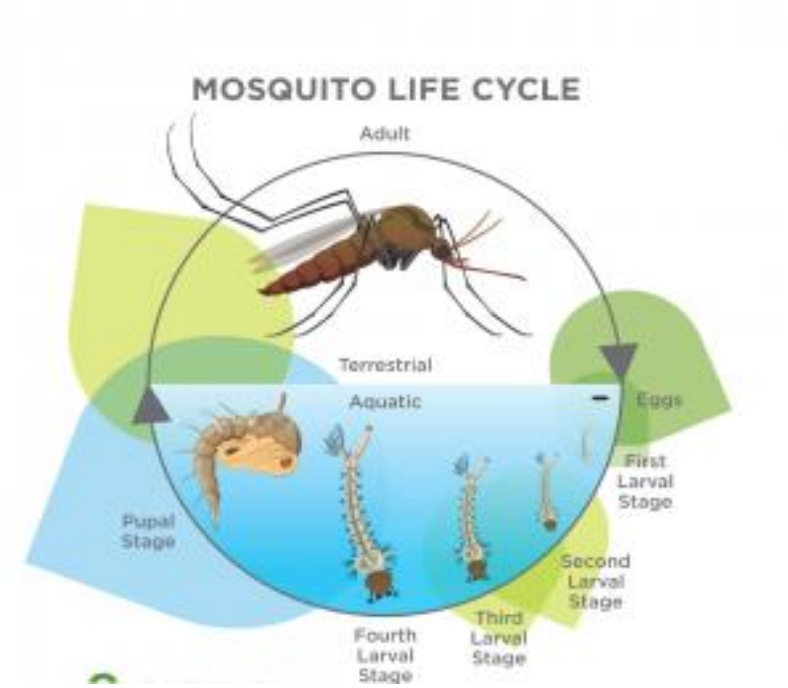

Figure 2: Mosquito life cycle

Larvae are entirely aquatic, feeding on microscopic organisms, decaying vegetation or bottom detritus. Larvae are found just beneath the water surface film because they breathe air using the siphon attached to the tail end of the body that penetrates the water surface. The average larval development time is five to seven days and is dependent on factors such as temperature, food availability, larval crowding, the persistence of water and predation by both fish and macroinvertebrates (DoH 2009).

Pupae are also aquatic but can complete their development on a moist surface if necessary. Pupae remain mobile in the water column but do not feed. On emerging from the pupal case, adults remain on the water surface until they are strong enough to fly (refer to figure 2). Both male and female mosquitoes feed on nectar; however, most females also require a blood meal to produce eggs. Adults reach sexual maturity in one to two days and mostly remain near their emergence site to mate (DoH 2009).

Certain mosquitoes have only one generation per year, but others can have five or more. Under favourable conditions, by having high reproductive potential and a short life cycle, the number of mosquitoes can reach nuisance levels (DoH 2009). The life span of a female mosquito can vary significantly with adults reaching sexual maturity in one or two days. In a natural environment, a female mosquito will survive for no more than 3-4 weeks. However, with vector species, the older the female the greater the concern regarding disease transmission because there will be a greater chance that she will have taken an infected blood meal and be able to pass it on to the next host animal

5.3 Mosquito relationship to disease

Ross River virus (RRV) and Barmah Forest virus (BFV) are the most common mosquito-transmitted viruses causing human disease in Western Australia (WA). The diseases caused by infection with these viruses are known as RRV disease and BFV disease. The two viruses have similar life cycles and cause similar symptoms in people. In nature, RRV and BFV are transmitted back and forth between animals and mosquitoes. The only way humans can catch the disease is by being bitten by a virus-carrying mosquito (DoH 2009).

Murray Valley Encephalitis (MVE) virus and West Nile virus Kunjin Strain (WNV_{KUN}) are two mosquito-borne viruses also found in Western Australia. MVE virus can cause potentially fatal encephalitis (inflammation of the brain) in humans, while WNV_{KUN} is associated with milder febrile illness and only occasionally cause encephalitis (DoH 2009).

5.4 Where do RRV and BFV diseases occur in Western Australia?

RRV and BFV can occur anywhere in WA when conditions are warm enough for the viruses to be active and wet enough for mosquitoes to breed.

In the northern half of WA, it is warm enough at any time of the year, whenever heavy rainfall or unusually high tides occur. The risk of contracting this disease is greater during and just after the wet season.

People living, camping, or recreating near salt marshes, estuaries, tidal rivers and freshwater wetlands are at a greater risk of RRV and BFV infection than people living further away.

5.5 Where do MVE and WNV_{KUN} diseases occur in Western Australia

MVE virus and WNV_{KUN} can be active during and in the months following heavy wet season rains. February to April is the season of most risk, but the risk can commence as early as December and extend to June or July in very wet years. MVE virus and WNV_{KUN} infections are a greater risk near swamps, floodplains, river systems, irrigation areas and major dams. Murray Valley encephalitis and Kunjin diseases are endemic in the northern two-thirds of WA (figure 3).

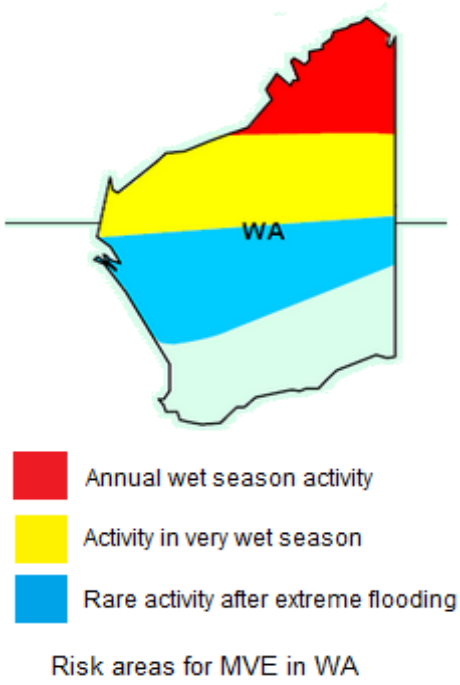

Figure 3: Geographical spread of MVE in Western Australia

Source: DoH 2019

5.6 Nuisance/disease risk

Mosquitoes can transmit three types of pathogens: protozoa (malaria), nematodes (filaria) and viruses (arboviruses). The most important and common type of pathogens transmitted by mosquitoes in Australia is the arboviruses. Ross River (RR) virus disease and Barmah Forest (BF) virus disease are the most common diseases that are transmitted to humans via mosquitoes in Western Australia. Both viruses occur throughout Western Australia when conditions are warm enough for the virus to be active and when it is wet enough for mosquitoes to be active. Although not as common in Western Australia MVE and KUN virus can cause serious health complications. The Western Australian Health Department routinely monitors mosquito populations and flocks of sentinel chicken for the presence of these diseases (DoH 2009).

There are almost one hundred species of mosquitoes in WA and many of them can be serious pests. For people who encounter mosquitos, the bites they inflict can result in itching, swelling and infections at the bite location.

5.7 Historical virus activity in the City of Karratha

For people living or recreating in areas known to be inhabited by mosquitos, there is the risk of contracting one of the diseases listed above. Table 1 is a summary of reported serologically confirmed mosquito-borne disease cases for Karratha since 2011.

There is considerable RRV variation from year to year, as transmission tends to be 'epidemic' in nature. Incidence can be attributed to the amount and pattern of rainfall. Mosquito breeding after high tides may also be responsible for cases in coastal areas (DoH, 2009).

Year	SUBURB / TOWN	RRV	BFV	MVE	KUN	Total
2011	KARRATHA	32	6	0	0	38
2012	KARRATHA	14	2	0	0	16
2013	KARRATHA	14	0	0	0	14
2014	KARRATHA	47	2	0	0	49
2015	KARRATHA	30	3	0	0	33
2016	KARRATHA	7	1	0	0	8
2017	KARRATHA	43	7	0	0	50
2018	KARRATHA	12	2	0	0	14
2019	KARRATHA	11	0	0	0	11
2020	KARRATHA	6	0	0	0	6
2021	KARRATHA	2	0	0	0	2
Total		218	23	0	0	241

Table 1: Serologically confirmed doctor-notified and laboratory reported cases of RR, BF, MVE and KUN virus disease each year at Karratha from January 2011 to July 2021

#Compiled by the Mosquito-Borne Disease Control Branch, WA Department of Health

6 Species of mosquito likely to be present

The most significant species of mosquito found in the northern half of Australia is *Aedes vigilax*. This species has a large dispersal range and can transmit both RRV and BFV. The other mosquito considered significant is *Culex annulirostris*. This is due to its competency in transmitting mosquito-borne diseases found in Western Australia. Table 2 lists the main species of mosquitos likely to be present in the City of Karratha and any relationship to mosquito-borne disease. The key species thought to be primarily responsible for the transmission of mosquito-borne virus in the City of Karratha are listed in table 3.

Species	Breeding Habitat	Pest	Vector
Aedes vigilax	Mangroves and tidal salt marshes	Yes	RR, BFV & JEV
Culex annulirostris	Shallow freshwater sites, also brackish and polluted waters. Breeding can be prolific.	Yes	RR, BF, MVE, WNV_{KUN} & JEV
Aedes notoscriptus	Tree holes, rock pools, artificial containers	Yes	Potential RR, BF and MVE but not considered an important vector
Anopheles annulipes	Ground and rock pools, generally freshwater but also in polluted and brackish water	Rare	Potentially RR but not considered an important vector
Culex sitiens	Brackish waters left by high tides, sometimes freshwater	Yes	JEV
Aedes alternans	Tidal saltmarsh pools	Yes	no
Culex quinquefasciatus	Domestic breeder, both clean and polluted water	Yes	Potential RR, BF and MVE but not considered an important vector. Also JEV

Table 2: main species of mosquito expected to occur in the City of Karratha

Source: Department of Medical Entomology, University of Sydney (2019)

6.1 Aedes vigilax

Characteristic features for a female include a mid-sized mosquito of dark appearance with banded legs; proboscis with pale scaling on the 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 the 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 (refer table 3).

- Breeding Habitat: Mostly coastal and associated with saline habitats including estuaries, mangrove zones and mudflats.
- Active Season: Summer months (although can be active year-round in the north) - Hatching of eggs, dormant in a dry salt marsh, is in response to inundation of mudflats through extremely high tides and/or through rainfall or cyclones.
- Dispersal Capabilities: Up to 100km.
- Vector: Murray Valley encephalitis (MVEV), Ross River Virus (RRV), Barmah Forest Virus (BFV) and Dog Heartworm. Possible for JEV

6.2 Culex annulirostris

Characteristic features for a female include a medium-sized mosquito of brownish to dark appearance with banded legs; proboscis dark scaled with a pale band in the 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 the 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 (table 3).

- Breeding Habitat: Permanent/semipermanent freshwater bodies. Prefers heavily vegetated sites. Culex annulirostris
- 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 and JEV as well as being a vector for myxomatosis and an effective carrier of dog heartworm.

6.3 Aedes notoscriptus:

This species is a major domestic pest species in Australia. Characteristic features for a female include a smallish to mid-sized dark species with conspicuous pale markings and banded legs; proboscis with a 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 the last segment may be all white; abdominal tergites dark with basal patches or constricted bands separated from lateral patches, sternites mostly pale scaled from the base but terminal segments may Aedes notoscriptus be predominantly dark (refer table 3).

- Breeding habitat: clean water within the 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 MvE.

6.4 Culex quinquefasciatus

Culex quinquefasciatus breeds predominantly in domestic environments, commonly associated with man-made structures. It is a major domestic pest. Medium-sized mosquito of brownish appearance; proboscis dark but often with some pale scaling midway on the underside; scutum with golden and bronzy narrow scales; wings all dark scaled; hind legs with femur pale almost to the tip except for dark scales along length dorsally, remainder of legs all dark scaled except for pale patch at tibial-tarsal joint; abdominal tergites dark scaled with pale basal bands constricted laterally and not merging with lateral patches except perhaps on terminal segments, sternites generally pale scaled but with a few to more dark scales scattered medially

- Breeding habitat: Many types of artificial environments near human habitation, containers, and ground pools. Often associated with heavily polluted water
- Active season: Year-round
- Dispersal Capabilities: Minimal
- Biting Habits: Generally, at night, but seems to prefer birds
- Disease vector: low for RRV and MvE. Possible for JEV

Mosquito	Distribution	Dispersal capability from the breeding site	Biting habit; biting period	Active season	Human Disease carrier in WA
 *Aedes vigilax*	Northern and western parts of WA	Up to 100 km	Vicious; all times	Warmer months	RRV and BFV
 *Aedes notoscriptus*	All of WA	About 0.4 km Prefer to stay around houses	Vicious; active dawn and dusk; occasionally at night and daytime; prefers shade	Year around North of WA more in the wet session	RRV
 *Culex annulirostris*	All WA except extreme southwest of WA	Up to 10 km	Active in dawn, dusk and night	Year-round	MVE, $WNV_{KUN,}$ RRV, BFV and JEV

Table 3: Key species considered likely to transmit mosquito acquired disease

Source: DoH, 2019

7 Sentinel chicken surveillance

MVEV and WNV_{KUN} viruses are maintained in a bird - mosquito - bird cycle throughout the north of WA. The Department of Health manages a sentinel chicken program, which provides an early warning for MVEV and WNV_{KUN} activity within the State. Currently, 23 sentinel chicken flocks are spread across major towns and communities in the Kimberley, Pilbara, Gascoyne, Midwest and Wheatbelt regions of WA.

When an infected mosquito bites a chicken, it develops antibodies to the virus but does not become sick. It makes an excellent sentinel species as it does not develop elevated levels of the virus and therefore cannot transmit the virus back to mosquitoes or people.

Blood is collected by trained environmental health officers, vets or volunteers, with the blood samples being couriered to Path West to be analysed. When antibodies to MVEV and WNV_{KUN} are isolated from a chicken flock, the DoH in conjunction with local government will issue a timely media statement, advising residents and travellers to affected regions of the

increased risk of severe mosquito-borne diseases and the need to take personal protection measures to prevent being bitten by mosquitoes (DoH website).

8 Exotic Mosquito Monitoring

Mosquito monitoring at the Port of Dampier is the responsibility of the Department of Agriculture, Water, and the Environment's Biosecurity division. The program is conducted in consultation with medical entomology and other organisations. They intensively monitor for and treat any incursions of foreign mosquito species through the seaports.

The Department provides quarantine inspection services for the arrival of international passengers, cargo, mail, animals and plants or their products into Australia. The Department is responsible for preventing the introduction of exotic mosquitoes. This responsibility extends to all potential pathways of pest entry into Australia.

In accordance with the International Health Regulations, the Department conducts monitoring and surveillance for specified disease vectors within 'the quarantine zone' at all first ports within Australia. Monitoring and surveillance activities are undertaken at a level appropriate for the risk category defined for each port.

The Northern Australia Quarantine Strategy (NAQS) consists of three sub-programs funded and managed by the Department. NAQS is responsible for identifying and evaluating risks and providing early warning of quarantine pests through a program of monitoring, surveillance, and public awareness across northern Australia and in neighbouring Indonesia, Timor-Leste and Papua New Guinea.

The two species most significant due to their proximity to Western Australia and their ability to spread disease are:

- The *Aedes aegypti* mosquito is the main type of mosquito that transmits dengue fever. It is present in many tropical countries around the world including north and central Queensland and parts of southern Queensland.
- *Aedes albopictus:* common name, 'Asian tiger mosquito,' has invaded areas of the Pacific, the Americas, Africa, and Europe (figure 5). This mosquito has been intercepted in various Australian seaports in recent years and has now become established on several Torres Strait islands in northern Queensland and threatens to invade mainland Australia.

Figure 4: Aedes aegypti

Figure 5: Aedes albopictus

9 Japanese Encephalitis Virus (JEV)

Japanese Encephalitis Virus was first observed in Australia in 1996, with several cases of encephalitis detected in people living on Badu Island in the Torres Strait. Three cases of JEV occurred on the island during 1995, two of which were fatal. Surveys conducted on the island identified isolates of JEV from people and *Culex annulirostris* mosquitoes during the outbreak (DOH 2009).

Until recently JEV was isolated to the very tip of the Cape York peninsular and was not considered a virus endemic to mainland Australia. This all changed in February 2022 when Japanese encephalitis was detected and confirmed in piggeries in Victoria, Queensland and New South Wales. On 4 March, cases were also detected in South Australia. JEV has been declared a Communicable Disease Incident of National Significance and considerable federal government support has been provided to assist the states. Further investigation will determine the extent of the virus in Australia (DOH 2022).

Most Japanese encephalitis virus infections in people are asymptomatic, however, those with severe infection (which occurs in less than one per cent of cases) may experience neck stiffness, coma, and more rarely, permanent neurological complications or death. Encephalitis is the most serious clinical consequence of infection. The illness usually begins with symptoms such as the sudden onset of fever, headache and vomiting (DOH 2022).

JEV isolates have been removed from over 35 species of mosquito in Australia. Under laboratory conditions, several species of mosquito are competent at transmitting JEV. Two domestic species of mosquito have been assessed as significant vectors of JEV in Australia, Cx. annulirostris and Cx. sitiens. Both of these mosquitos are known to occur in the Pilbara region(DOH,2009).

JEV infections have been identified in domesticated and wild animal species. Known host animals include:

- Pigs (feral and domestic) develop high levels of viraemia and are also major amplifiers of the virus (Animal Health Australia, 2022).
- Waterbirds, particularly birds of the family Ardeidae (wading birds), such as herons and egrets, are the main natural reservoirs of JEV and are important amplifying hosts (Animal Health Australia, 2022).

- Horses are considered dead-end hosts that do not develop viraemia of sufficient levels to infect mosquitoes (Animal Health Australia, 2022).
- Cattle, sheep, goats, dogs, sparrows, pigeons, chickens and ducks over 6 weeks of age, water buffalo, rodents, reptiles, amphibians and macropods are considered susceptible to infection but are also believed to be dead-end hosts that do not contribute to disease transmission (Animal Health Australia, 2022).
- Humans are not considered to be significant in the epidemiology of the disease. Humans are considered dead-end hosts that do not contribute to disease transmission (Animal Health Australia, 2022).

As a response to the 2022 JEV outbreaks, a national working group of communicable disease, vaccine and arbovirus experts has been established.

The working group will support Australia's response to the JEV situation. This will include:

- mosquito surveillance and control measures
- identification of those at direct risk, and for the rollout of vaccines.

Public health communications regarding mosquito protection will target affected communities.

The Australian Government's health and agriculture departments are working very closely with their state government counterparts to ensure a swift and coordinated response (DOH 2022).

10 Climate

Below is a summary of the weather typically experienced in Karratha. Karratha has a hot climate. Temperatures are warm to hot all year round, with low rainfall, most of which falls in late summer due to the influence of tropical cyclones and the monsoon, although there is a second rainfall peak in early winter as the northern edges of cold fronts occasionally cause rain in the region. It is rare for any rain to fall in the period from August to December. Winter minimum temperatures rarely drop below 10 °C, while maximums stay in the mid to high 20 °C and days are sunny with low humidity. Summers are hot and usually dry although the erratic influence of the monsoon can cause periods of high humidity and thunderstorms (source: Wikipedia, 2021)

Climate data for Karratha													
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Record high °C	48.2	47.7	45.8	41.3	37.6	32.8	34.0	35.4	40.7	44.7	44.8	46.9	48.2
Average high °C	35.9	35.8	36.1	34.3	30.0	26.5	26.3	28.3	30.8	34.1	35.1	35.8	32.4
Average low °C	26.7	26.7	25.9	22.7	18.3	15.1	13.8	14.3	16.9	20.8	23.1	25.6	20.8
Record low °C	20.5	19.4	17.0	14.7	10.8	7.1	6.9	8.0	10.0	11.1	16.0	18.7	6.9
Average rainfall mm	49.1	78.0	47.8	17.6	28.3	35.3	14.3	4.3	1.3	0.4	1.4	14.0	291.8
Source: Bureau of Meteorology[5]													

Table 4: Climate summary for the CofK

11 Tides and cyclones

Tidal storm surges and flooding associated with heavy rains, which often accompany cyclones, can produce extensive breeding habitats for mosquitoes. Residents of affected areas may be particularly vulnerable to mosquito exposure if their housing and insect screens are damaged by a cyclone. (DOH, 2009)

The mosquito breeding habitat created by cyclones can include vast areas of:

- temporary ground pools
- pools along receding river floodplains
- tidal saltmarshes in low lying coastal areas
- natural or man-made containers
- overflow and pooling of storm and wastewater management infrastructure (such as sewage lagoons).

As well as being a nuisance, mosquitoes that breed in post-cyclonic conditions can also be vectors of disease and the number of mosquitos that impact communities can be significant. In part, this is due to the inundation of fresh and saline water as well as the warmer temperatures that shorten the time taken for mosquitoes to emerge as adults.

The north of Australia is also subject to regular tidal events. Tidal information is especially relevant in predicting the activity of the northern salt marsh mosquito, *Aedes vigilax*. Typically, higher tides can induce the hatching of Aedes vigilax larvae. Predicted tide heights can provide an indication of when this is likely to occur. Tidal data collected by the Department of Transport can be useful to determine when tidal trigger points occur. Figure 6 (below) is an example of tidal data logging, showing high and low tides as well as residual measurements. These residual measurements are especially useful when tides exceed the expected forecast height. Gathering a combination of field observations and matching them with tidal data may be useful in setting trigger points that can help pinpoint the timing of saltmarsh monitoring.

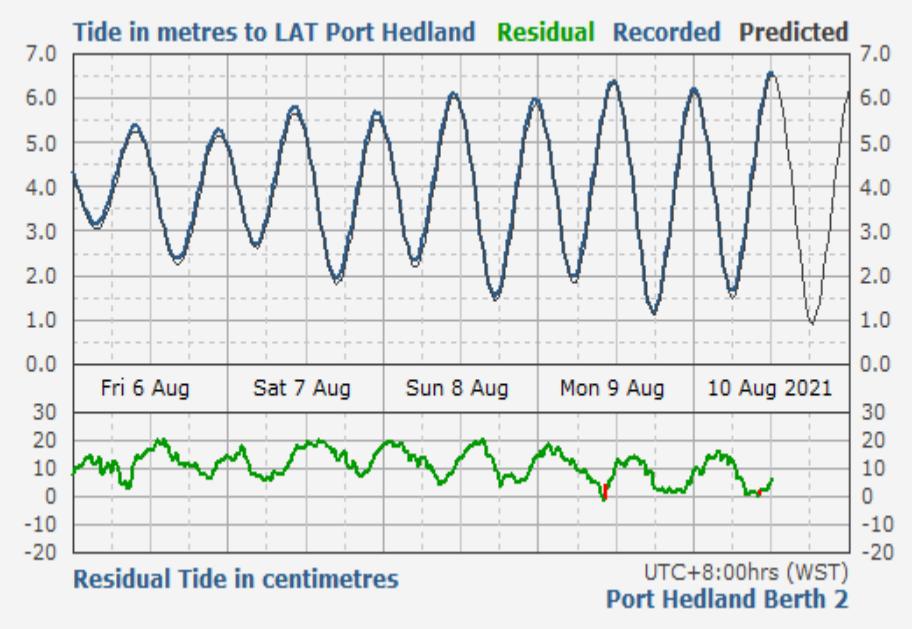

Figure 6: Department of Transport real-time tide data for Port Hedland

12 Adult Monitoring

Monitoring of adult mosquito populations is proposed to be conducted on a fortnightly basis between December and April, and once per month for the remainder of the year (May to November). Additional trapping will be necessary if seasonal conditions or significant weather events occur. Traps are deployed in the early afternoon and picked up the following morning. The trapped mosquitoes are then counted and identified to species level, with results recorded into the appropriate datasheet. There will be a total of seventeen adults trapping sessions per year. Results uploaded to the WA Health mosquito atlas at the completion of routine trapping. Adult trapping Standard Operating Procedure (SOP) can be found at the end of this document.

The following sites are the adult trapping locations. Several of these sites are also used by DoH staff when they do their northern trapping run.

12.1 Trap 1- Pegs Creek

Trap 1 is located in the bush adjacent to Pegs Creek

Figure 7: Location of adult trap 1

12.2 Trap 2- Karratha Country Club

Trap 2 is located in the northeast corner of the Country Club

Figure 8: Location of adult trap 2

12.3 Trap 3- Hillview Rd, Karratha

Trap 3 is located in vegetation

Figure 9: Location of adult trap 3

12.4 Trap 4- Jennifer Creek

Trap 4 is located in vegetation close to the Jennifer Creek bridge

Figure 10: Location of adult trap 4

12.5 Trap 5- Dampier

Trap 5 is located in the bush east of Hampton Oval

Figure 11: Location of adult trap 5

12.6 Trap 6- Wickham

Trap 6 is located in vegetation next to the Point Samson-Roebourne Rd.

Figure 12: Location of adult trap 6

12.7 Trap 7- Roebourne

Trap 7 is located in vegetation next to the Harding River area.

Figure 13: Location of adult trap 7

12.8 Trap 8- Point Samson

Trap 8 is located at the Northern end of Bill Miller Dr. in bushland.

Figure 14: Location of adult trap 8

12.9 Trap 9- Nickol Flats

Trap 9 is located in vegetation adjacent to Nickol Flats, near Millars Road

Figure 15: Location of adult trap 9

13 Larval Monitoring

The city has a dedicated Pest Control Officer who surveys and treats mosquito breeding areas regularly. The city has a proactive mosquito control program that involves pre-treating areas which may become inundated during rainfall events. Different breeding sites within the region contribute to mosquito populations when conditions allow. These areas are monitored and treated by the city as needed. The city is responsible for the management of potential breeding sites, including parks, gardens, Council facilities, roads and drainage systems and some coastal wetlands. 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.

The breeding locations identified in this plan have been provided by City staff. This local knowledge is often crucial when planning mosquito management activities. The MMP also aims to document this information for future City staff. The breeding sites have been broken down into their regional locations and proximity to the major population centres.

Larval Monitoring is proposed to be carried out at the same frequency as the adult monitoring programme when surface water is present. Additional dipping may be required if seasonal conditions or significant weather events occur. Each sample is examined for the presence of mosquito larvae, recording the number and their growth stages. Additional observations including water quality or any event that is thought to be impacting either the wetland or the mosquito larvae will be made and recorded. Several dips are usually undertaken at the same site and the number of mosquito larvae within each dip is estimated. An average will be calculated, based on the number of dips taken and then converted to obtain an overall estimate of the number of mosquito larvae at each site (larvae per m2). Results are recorded in the appropriate datasheet. Larvae may be identified under a microscope or reared in emergence cages and identified as adults. The procedures will be subjected to ongoing review to ensure that they remain relevant as the program develops. There will be a total of 17 larval dipping sessions per year. Results are to be uploaded to the excel datasheet and the WA Health mosquito atlas at the completion of each routine trapping

Monitoring is vital to ensure the correct timing of control options and to assess the effectiveness of the control program. The most environmentally sound and effective time to control mosquitos is during the larval stage while the insects are in a localised area and before adults emerge and disperse on the wing. The monitoring sites detailed below are proposed as baseline monitoring sites, other sites may be identified or created in the future. These sites should be assessed and considered as routine monitoring sites as part of the annual review of the MMP.

13.1 Karratha breeding sites

Various roadside drains and natural water bodies throughout Karratha and the Karratha Industrial Estate can become inundated quickly and, depending on the amount of water produced, may not drain completely. The areas listed below are high priority target locations for mosquito monitoring and mosquito management in the City of Karratha.

13.1.1 Gwen Creek.

Gwen Creek is a tributary of the Murchison River (figure 16). This breeding site is located southeast of Karratha in the Karratha Industrial Area. The creek can be inundated by tides or rainfall. This site has been given the code COKL1.

Figure 16: Image showing the location of Gwen Creek larval monitoring site.

13.1.2 Nickol Tidal Flats

Nickol tidal flats are located to the north of Karratha (figure 17). It is as named, a tidal flat that is inundated after tides, storm surges or heavy rain. This is a large area with a perimeter of nearly 16km. This site has been given the code COKL6.

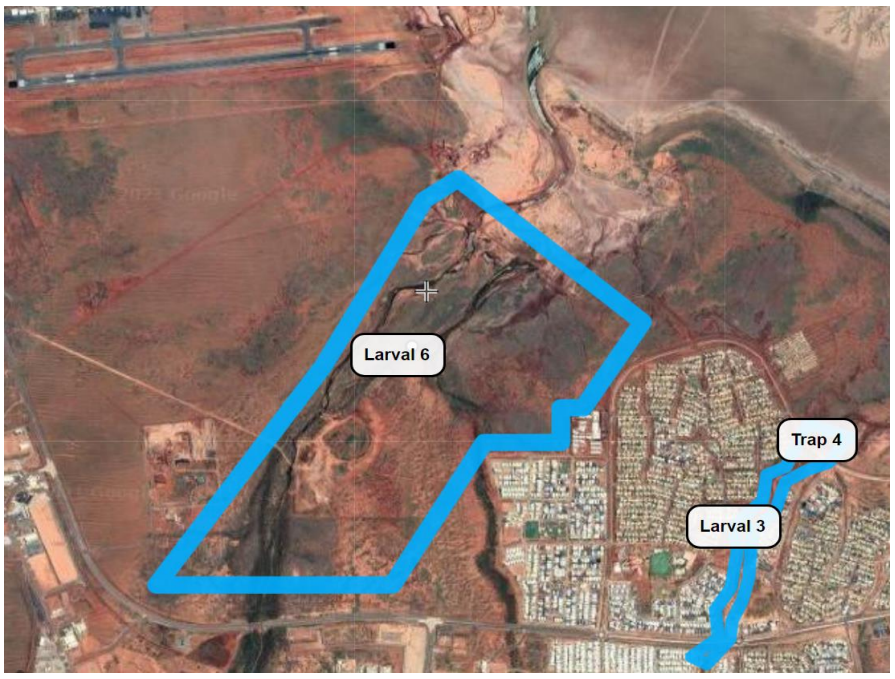

Figure 17: Image showing the location of the Nickol Tidal Flats larval monitoring sites

13.1.3 Jennifer Creek

Jennifer Creek runs north to south through Karratha (figure 18). The site can be inundated by either tide, storm surge or rainfall. This site has been given the code COKL3.

Figure 18: Image showing the location of the Jennifer Creek larval monitoring site.

13.1.4 Karratha Country Club

The area to the north of the Karratha Country Club has been identified as a site that should be included as a baseline larval monitoring site (figure 19). The site is likely to be inundated after tidal and storm surge events. The site has been given the code COKL4

Figure 19: Image showing the location of the Karratha Country Club monitoring site

13.1.5 KIE Effluent Ponds

The Water Corporation has ponds within the Karratha wastewater treatment plant. The plant is located to the northwest of the KIE and is used to treat wastewater from the KIE (figure 20). The site is used to hold secondary treated wastewater and will generally always contain water. The site has been given the code COKL5.

Figure 20: Image showing the location of the LIA effluent pond monitoring site

13.1.6 Pegs Creek Tidal Flats

Pegs Creek tidal flats are located to the North of Karratha (figure 21). The site is as named, a tidal flat that is inundated after tides or storm surges or heavy rain. The site has been given the code COKL7.

Figure 21: Image showing the location of the Pegs Creek tidal flat monitoring site

13.1.7 K1 Effluent Ponds

The K1 effluent ponds are used infrequently by the Water Corporation to hold treated wastewater (figure 22). The site also has the potential to be inundated following heavy rain. The site has been given the code COKL8.

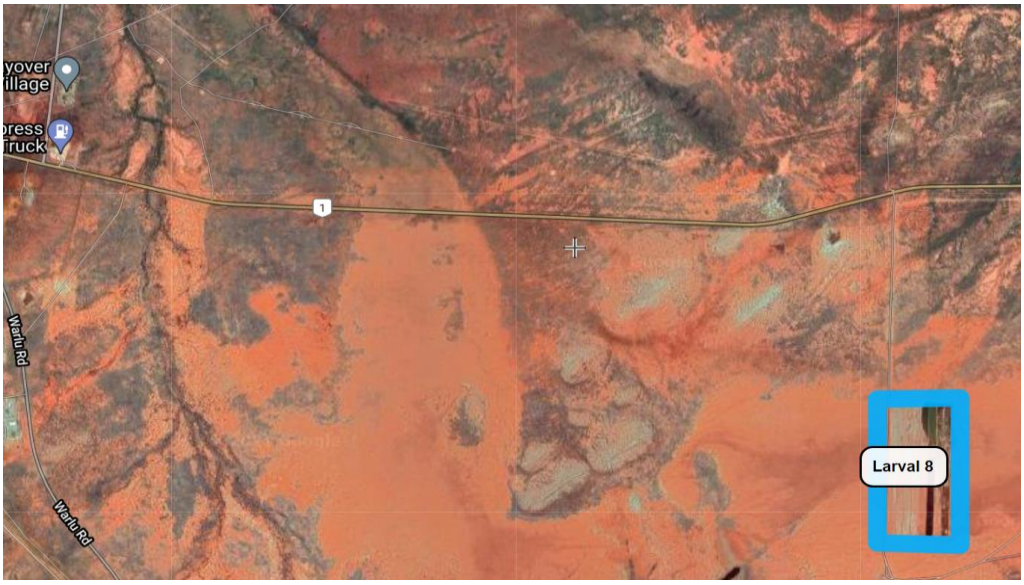

Figure 22: Image showing the location of the K1 effluent ponds

13.1.8 Old Gap Ridge WWTP ponds

The Old Gap Ridge wastewater treatment plant was decommissioned several years ago, but the ponds are currently used as storage for overflow treated wastewater (figure 23). The site has the potential to produce large numbers of mosquitos under the right conditions. The site is currently managed by the Water Corporation.

Figure 23: Image showing the location of the Old Gap Ridge wastewater treatment plant

13.2 Roebourne Breeding Sites

13.2.1 Harding River.

This site can support mosquito breeding following rainfall or water discharge from the Harding Dam. As the water recedes from such events mosquito larvae can breed in the isolated pools that remain. Figure 24 shows the area that will form part of the baseline monitoring program. The site is referred to as COKL2.

Figure 24: Image showing the location of the Harding River larval monitoring site.

13.3 Point Samson Breeding Sites

- The tidal flats on the southern side of the Point Samson Roebourne Road will flood periodically during heavy rainfall, but also during king tides. This area is a priority for pre-cyclone larviciding.

13.4 Wickham Breeding Sites

- The Wickham town central drainage reserve will flood during heavy rainfall or cyclonic events and the water may remain and stagnate for up to a few months. Especially where the drain passes under Point Samson-Roebourne Rd.
- The watercourse continues to the eastern side of Point Samson Roebourne Rd in the salt flats extending back towards the Water Corporation effluent ponds and northeast along the waterway towards Point Samson (figure 25). This area is swampy and difficult to access but is a high priority for pre-cyclone larviciding.

Figure 25: Image showing the location of the Wickham drain breeding sites

13.5 Dampier Breeding Sites

Various roadside drains and natural water bodies throughout Dampier can become inundated after heavy rain. Rapid breeding of mosquitoes may occur depending on the amount of water and its ability to drain away.

14 Mosquito management strategies

The tools used to achieve the management objectives for the CofK MMP 2021 are:

- Physical – Ensure the built form prevents breeding and protects residents.
- Chemical – Use of larvicides and adulticides.
- Biological – Promote backyard habitats for mosquito predators.
- Cultural – Education for residents to encourage the implementation of personal preventative measures to protect against mosquito exposure.

The following mosquito management measures are set out in order of effectiveness at reducing risk. This follows the hierarchy of control (figure 26):

- Physical controls, such as habitat modification, filling practices, drainage, and urban design strategies.
- Chemical controls, such as bio-chemical treatment of breeding grounds and adult mosquitoes to minimize larval development and dissemination of adult mosquitoes, respectively.
- Administrative controls, such as training and procedures to increase community awareness of mosquito risks, complaints register and monitoring program to track the effectiveness of higher-order controls, etc.
- Personal protective equipment, such as personal repellents and protective clothing reduces a person's likelihood of being bitten.
- Medical diagnosis and treatment, to mitigate the severity of ill-health effects that may arise from a person being infected by the disease.

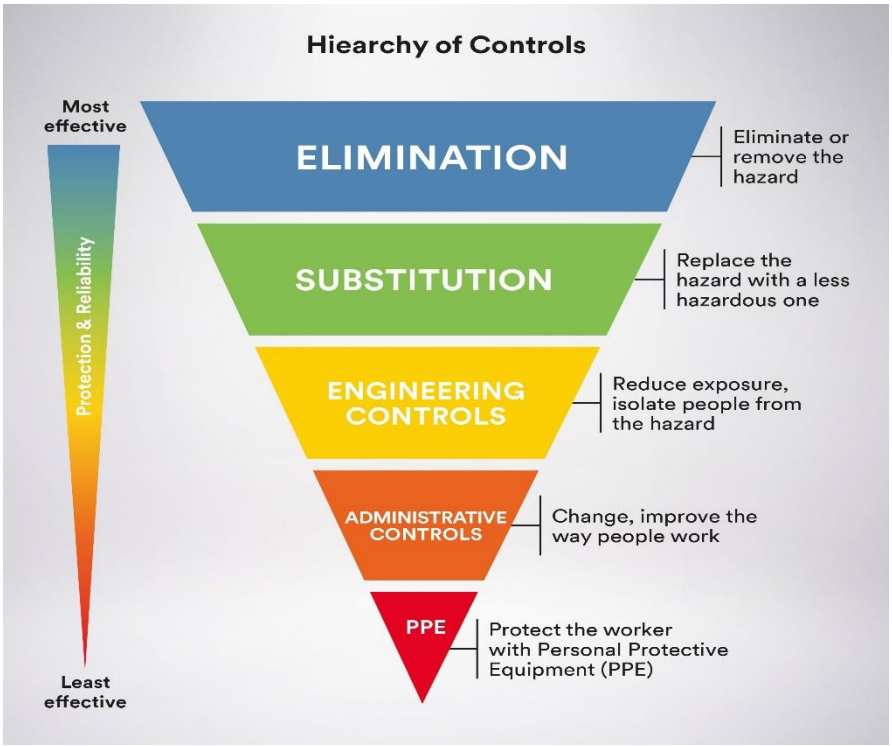

Figure 26: The Hierarchy of Control

14.1 Physical control measures

Physical control methods measures 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 is 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 that provides harbourage for adult mosquitoes.
- Cleaning up yards to remove containers that will collect water.
- 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. The importance of maintaining clean and deep margins is paramount, with the following methods being useful in reducing mosquito populations:

- Removal of marginal and floating vegetation and debris.
- Maintenance of the integrity and slope of margins.
- Maintenance of depth and flow, by modifying trench design as required.

NOTE – Water drains in Karratha were cleared of vegetation several years ago. A few inches of soil were removed from the bottom of Jennifer Creek during this process, exposing groundwater, which is only just below the surface. Since then, these drains have been monitored as potential mosquito breeding sites. The water depth in this drain is insufficient to use briquettes. Hand-dosed Biopren sand is used instead.

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

- Inspect house and yard and remove any accumulations of water.
- Empty pot plant bases weekly or fill the base with sand to absorb water.
- Ensure rainwater tanks are screened.
- Keep swimming pools maintained. Birdbaths, fishponds, and ornamental pools should be washed out weekly and where possible stocked with suitable native fish.
- Yard clean-ups and sealing of septic tanks.

14.1.1 Management Strategy

M1- Maintain the structural integrity of drains, ensuring depth and flow are maintained.

M2- Monitor water levels in drains and low-lying areas to ensure water conditions do not change.

M3- Where possible, drain or infill drains and low-lying areas to remove potential breeding sites.

M4- Ensure residential areas are well maintained.

14.2 Chemical control measures

There are two forms of chemical control for mosquitoes; larvicides that are used to kill larvae; and adulticides that are used to kill adults.

14.2.1 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 spread disease.

Larvicides are the most environmentally sound and effective way to control mosquitoes in the larval stage before they become biting adults. The WA Department of Health suggests that larviciding, where possible, should be used in preference to adulticiding. When mosquito larval activity is confined to a single breeding site the area that requires treatment is clearly defined and is generally much smaller than the area that would need treatment once they become adults. Larvicides specifically target mosquitoes, thus their impact on other insects can be minimised through appropriate use (DoH, 2009).

Initiating a larvicide program requires identifying breeding sites and monitoring the number of mosquito larvae present to determine if, and when, mosquito control is required. This will be done as part of the monitoring program. Dipping for larvae will be conducted wherever water is present. If the average number of dips produces larval captures greater than the determined threshold, chemical treatment will be applied.

Larvicides are available in granular, pellet and briquettes forms and can last up to 3 months, meaning they can be used for areas in which water is held for longer periods. Larvicides are extremely useful when known breeding sites are close to residential areas. Advantages of larvicide treatment include:

- 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; and
- Reducing populations at the larval stage limits ongoing breeding, making ongoing control easier

Disadvantages:

- The ability to treat an area with larvicide 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. The city has backpack sprayers that can be used to apply pellets to larger breeding sites.

Larvicides approved for use in Australia are listed below:

- Bti larvicide:

The bacterium Bacillus thuringiensis israelensis (Bti) produces a protein crystal that contains several microscopic pro-toxins that when ingested can destroy the gut wall, killing mosquito larvae within 12 hours. Commercial formulations of the bacterial culture product are available, with liquid Bti formulations most often used. The greatest benefit of Bti is that it is highly specific to mosquito larvae and very few non-target effects have been recorded when the product is applied at recommended rates. Unlike chemical insecticides (e.g. household fly spray) that kill insects on contact, this larvicide must be ingested by the mosquito larvae. It is only under the specific conditions within the gut of the mosquito larvae that the toxins are released and break the lining of the gut.

- S-methoprene larvicide

The insect growth regulator, s-methoprene is a synthetic mimic of the juvenile hormone produced by insect endocrine systems and is an effective control agent of pest mosquitoes without adversely affecting non-target organisms. When absorbed by the larvae, development is interrupted and larvae fail to successfully develop into adults, usually dying in the pupal stage. A side benefit of s-methoprene is that it retains mosquito larvae and pupae in the aquatic ecosystem long enough to provide food for predators. This product is available in several different formulations, including the slow-release briquettes, which ensure the ongoing release of the larvicide providing ongoing control for up to 150 days. Pellets are used for smaller water-holding containers such as tanks and drains and are effective for 30 days.

- Bs larvicide

Bacillus sphaericus (Bs) Strain 2362 is a naturally occurring, spore-forming bacterium found throughout the world in soil and aquatic environments. At the time of sporulation, *Bs* produces a delta-endotoxin, which is toxic to many species of mosquito larvae when ingested.

Below is a summary of approved larvicides, their mode of action and control period.

Larvicide group	Active constituent	Control period	Mode of action	Application timing
Bacterial toxin	*Bacillus thuringiensis* subsp. *Israelensis (Bti)*	One larval generation	Damages gut lining and prevents nutrient absorption, after ingestion. Death occurs within 24 hours.	Apply during feeding stages. Late 1st to early 4th instar
	Bacillus sphaericus (Bs)	Up to 3 weeks	As above. Replicates in water, producing spores that kill mosquito larvae, after ingestion. Product of choice for polluted environments eg. sewage lagoons.	Late 1st to early 4th instar (residual effect provides coverage for 3 weeks)
Insect growth regulator (IGR)	(S) - methoprene	Liquid: one generation Granule: one generation Pellets: 30 days Briquets: < 150 days	Absorbed through outer cuticle, disrupts larval development. Death is more protracted. Mosquitoes fail to emerge as adults and usually die at pupal stage.	Timing is important. Apply 2nd to early 4th instar.

Table 5: Summary of approved larvicides (Chemical control of mosquitos, DoH)

For mosquito larvae, the threshold for treatment is broken into two basic approaches. Firstly, for smaller areas that are expected to hold water for longer than 5 days a trigger threshold of more than 10 larvae per dip shall initiate a larviciding program based on their developmental stage, water quality and the species present. Smaller areas will typically include stormwater retention basins and roadside gullies. For larger areas, a lower threshold value has been applied to reflect the potential for larger overall numbers of adult mosquitos to emerge from these environments. For waterbodies such as tidal creeks, wetlands, saltmarshes, and wastewater ponds a threshold of average dips is set at 5, or 500 larvae per square metre. Chemical treatments will be applied when mosquito larval sampling demonstrates exceedances of the thresholds. Table 6 below summarises these values for easy reference.

Breeding Environment	Larvicide Threshold
Smaller areas- roadside gullies & basins	Average of 10/dip (1000/m2)
Larger areas- tidal creeks, salt marshes, and WW ponds	Average of 5/dip (500/m2)

Table 6: Larviciding threshold values for different water bodies

14.2.2 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.

When planning adult mosquito control measures, it is important to understand when adult mosquitoes constitute a nuisance and if their presence will impact public health. In general, a 'nuisance' is when the number of adult mosquitoes caught at a single location in an EVS/CO2 trap exceeds 50 individuals in one night. In addition to the general threshold level described above, Lindsay (2011) notes that there are some general reference numbers when using CO2 baited light traps that can also be used:

- More than 20 adult Aedes vigilax per trap/night
- More than 30 Aedes notoscriptus per trap/night
- 100+ Culex annulirostris per trap/night.

Exceedances to the thresholds indicated above will confirm whether there is a nuisance and/or disease risk requiring ongoing monitoring. Monitoring adult mosquito numbers helps to validate residential complaints. If thresholds are exceeded, then owners can be requested to implement control strategies e.g., maintaining pools and removing old tyres. Chemical treatment of adult mosquitoes will not be undertaken on City public open spaces and reserves unless there is a public health risk.

Advantages of undertaking adulticide treatment include:

- Fast knockdown of biting adults in times of high public health risk; and
- Residual surface sprays can be used as barrier sprays with longer-lasting effects.

Disadvantages of adulticide treatment:

- Fogging is only a temporary control - mosquitoes are likely to re-enter treated areas from adjacent untreated areas, meaning treatments must be repeated regularly;
- Target-specific formulations are not 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;
- Adulticides are highly toxic to fish and other aquatic organisms and cannot be used near wetlands; and
- Labour and chemical costs associated with ongoing fogging treatments can be very high.

Adulticides can be applied as a residual barrier spray or as fogging using handheld or vehicle-mounted equipment. Residual barrier treatments involve the application of a synthetic pyrethroid to any surface where adult mosquitoes may land. This may include internal/external building walls, eaves, fences, vegetation, or foliage. If applied appropriately, the product binds well to surfaces and can provide control for 6-8 weeks. Residents can have these applications applied by a licenced pest technician. It is important to note that these products are not target-specific and will knock down all other insects that come into contact with the product. They are also toxic to fish and other aquatic fauna so should not be applied near waterways (DoH,2009).

Fogging involves the application of an adulticide, generally a synthetic pyrethroid, via thermal or ultra-low volume (ULV) space spraying equipment. The mode of action of synthetic pyrethroids involves disruption of the nervous system, resulting in paralysis and eventual death of the adult mosquito. As adulticides are not target-specific, fogging is only recommended when there is a severe nuisance problem or an imminent public health risk. There is no residual effect from these products. Fogging activities should be planned appropriately to ensure wind conditions are optimal, there is no rain, and the product will not drift over wetlands or water bodies where fish may be present (DoH,2009).

A common misconception is that fogging does not require any monitoring of the target population, or at the very least, only requires monitoring of adult numbers to evaluate treatment efficacy. It is important to note that larval monitoring helps to anticipate the timing of adult emergence and therefore, the likely timeframe in which fogging will need to take place (DoH, 2009).

Thermal fogging requires the adulticide to be first diluted in a carrier liquid (often oil-based). The fogging equipment uses hot gas to heat and vaporise the liquid. On application, the vapour hits cold air and condenses to form a visible white fog (as seen below). Ultra-low volume (ULV) or cold fogging equipment uses large volumes of air at low pressure to break up the liquid into droplets. The spray droplets are generated without the need for heat. Water-based diluents can be used, which are more environmentally favourable. The white fog associated with the thermal application is not observed with ULV application (DoH, 2009).

Application of adulticides will only occur when the disease risk to public health outweighs the risk to the environment. A standard operating procedure sheet for fogging has been included in the SOP section at the end of this document. Before any adulticiding is conducted the City will advertise its intent to carry out mosquito control activities. This will include information outlining the following

1. Timing of the application. An approximate window for application is ok as conditions may change from night to night. Should the weather not be favourable in the prescribed window, then another weather window will be advertised and the current one is withdrawn.
2. The location where the adulticiding will be conducted.
3. Notify bee owners listed on the City's register.
4. Advertise the intent to adulticide through social media, emails and the City web page.
5. Notify emergency services to avoid any false reports of fire or spills.

At the commencement of adulticiding activities a notice should be issued advising the completion of the mosquito control measure using the same media as above.

14.2.3 Management Strategy

M5- If mosquito numbers exceed threshold numbers, chemical treatments will be conducted until physical control is re-established

M6- Larviciding and adulticiding to be carried out through ground-based application using chemicals and techniques approved by the DoH.

M7- Before any adulticiding is conducted the City will advertise its intent to carry out mosquito control activities

14.3 Biological control measures

Biological control involves the introduction or promotion of naturally occurring species that are harmful to the species and harmless to non-target species as reasonably and economically achievable. The major biological control agents are fish, aquatic beetles, and aquatic bugs. Aquatic beetle larvae and aquatic bugs can be very efficient mosquito larvae predators. Aquatic bugs can live in water containing higher organic matter levels. Biological controls can become ineffective when vegetation is dense within the wetland and therefore marginal vegetation should be eliminated or kept to a minimum (DoH, 2009). 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. The 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.

14.3.1 Management Strategy

M8- Maintain the abundance and diversity of predator species within the natural wetlands through the promotion of a healthy ecosystem.

14.4 Cultural control measures

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 therefore a risk of mosquito-borne disease within the region. One of the most important aspects of this plan is public education. Due to the infrequency of rainfall events in the region, and the ongoing mosquito monitoring and management regimes employed by the City, the periods when mosquitoes cause a nuisance are limited. Ongoing educational programs will ensure all residents and visitors to the region regularly receive information. While mosquito control activities are in place around townsites, many residents and tourists will be exposed to mosquito bites in remote locations where mosquito control is not undertaken. This includes 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 should commence towards the end of the dry season and continue throughout the wet season. Public education should be intensified when surveillance indicates that disease risk is high, due to high mosquito numbers detected in adult traps or public complaints in particular areas. The DoH has an excellent resource called fight the bite, which provides a variety of materials. Education strategies may include the following:

- Information displays at local events, particularly outdoor events.
- Letter PO 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.
- Signage at known mosquito hot spots warning people of the risk presented from exposure and potential virus infections.
- Public notification of planned chemical and physical mosquito control activities.
- Displaying appropriate signage while in the field conducting monitoring or treatment.

The education program will also provide information on personal protection measures. The Western Australian Department of Health recommends the following precautions be taken for people living in, or close to, known mosquito breeding habitats:

- Avoid outdoor exposure particularly around dawn and dusk when mosquitoes are most active.
- Wear protective (long, loose-fitting, light-coloured) clothing when outdoors.
- Apply a repellent containing diethyltoluamide (DEET) or picaridin evenly to all areas of exposed skin.
- Ensure insect screens are installed and remain in good condition.
- Use mosquito nets or mosquito-proof tents when camping or sleeping outdoors.

14.4.1 Management Strategy

M9- Implement a ‘fight the bite’ campaign to educate and inform the residents of the City of Karratha about personal preventative mosquito measures.

15 Mosquito management response associated with cyclones

When local communities are impacted by tropical cyclones, the City's environmental health team will move quickly to identify mosquito breeding sites and gather accurate surveillance data. Staff will also ensure there is a suitable supply of appropriate chemicals and insecticide application equipment.

Larval mosquito control is the most effective option in minimising public health risk, as it reduces the emergence of potential adult mosquitoes before they have the chance to spread disease. Larvicide application will only be effective if it is applied at an appropriate time in larval development, primarily in the second and third instar stage. It is therefore critical that a larval dipping survey be undertaken before deciding on when to apply the treatment.

Mosquito larvae develop more rapidly as the water temperature increases. Therefore, the timing of the larvicide application after the flooding or tidal inundation will vary. Ongoing larval surveillance is required to determine the optimum treatment timing. After mosquito larvae have developed to the late fourth instar or pupal stage, larvicide products are no longer effective and the only option is to wait for the adults to emerge and treat using an adulticide. Barrier spray adulticides kill adult mosquitoes landing on the treated surface. Adulticide fogging targets adult mosquitoes and should not be carried out in residential areas unless there is a severe nuisance problem or demonstrated high public health risk. Regular fogging will likely be required for several days or even weeks after the breeding event as the adulticide will only kill adult mosquitoes flying in the immediate vicinity.

Given the rapid response that may be required in the pre and post period of a cyclone crossing, the City may need to allocate additional resources to assist them in effectively controlling larval and adult mosquitos if the situation requires. This will include having additional trained staff available to help conduct monitoring and treatment.

In the advent of a large outbreak of mosquitoes, a public awareness campaign should be conducted to inform the public of the nature of the situation and any associated public health risks. Information should also be included on any control measures being undertaken and recommendations on simple things that individuals can do to avoid being bitten. Information may be disseminated to the public through appropriate health promotion avenues, including brochures, posters, print media, television, radio, websites, and social media, as well as liaising with relevant community groups. (Disaster and Emergency Management for Environmental Health Practitioners, health.gov.au)

15.1.1 Management Strategy

M10- Provision for additional staff and resources for mosquito management following a cyclone, where required.

M11- Provision for additional chemicals to support mosquito control operations, where required.

M12- Initiate a public information program.

M13- Communicate the situation with WA Health and Incident Controler (if applicable)

16 Stakeholders

If an MMP is to be an effective tool for mosquito management in the City of Karratha, many parties need to be involved. These can range from large companies, government departments, state authorities, local community groups, planning departments and local indigenous groups to name a few. Land ownership and responsibility are important considerations, however, many of the mosquito management decisions defer to local government. Increased commitments to mosquito management from all stakeholders will help reduce the financial burden placed on the City.

16.1 Internal Stakeholders

In most cases, the role of mosquito management is delegated to the environmental health team. But, given the complex nature of mosquito management, there needs to be an understanding across other departments of how to plan for and manage infrastructure and minimise the risk of mosquito outbreaks.

16.1.1 City of Karratha Staff

All City staff should be informed of the need to protect themselves from mosquito bites using PPE and repellents. Where practical outdoor staff should be informed at times when increased mosquito activity is occurring so work practices can be altered to suit the conditions.

16.1.2 Environmental Health Staff

The implementation and ongoing management of this plan and the commitments made through the MoU will be primarily administered through the City's Environmental Health team.

16.1.3 Planning and Technical Services

Mosquito management requires an integrated approach between Planning, Technical Services and Environmental Health. This is particularly important where urban design, construction and/or drainage can create a potential for mosquito breeding.

16.1.4 Parks and Gardens and Operations

The maintenance of City assets can help reduce the potential for mosquito breeding. Typical measures that can help reduce mosquito breeding include, maintaining clean and open drainage structures and ensuring nutrient runoff is kept to a minimum.

16.1.5 Marketing & Communications

The City's Marketing & Communications team will assist in disseminating information about mosquito warnings, public health advice, planned mosquito management activities and general 'fight the bite' campaign media.

16.1.6 Management Strategy

M14- Ensure City officers are aware of the risk mosquitoes represent and that they are adequately protected.

M15- Ensure Planning and Technical Services officers are made aware of any mosquito management related issues.

M16- Ensure Parks and Gardens and Operations staff minimise the potential for mosquito breeding by maintaining drainage structures and minimising fertilizer runoff.

M17- Engage the Marketing & Communications team regularly to promote City mosquito management activities and 'Fight the Bite' material.

16.2 External Stakeholders

External stakeholders will play an important role in ensuring this MMP is effective in managing mosquito numbers.

16.2.1 Water Corporation

The Water Corporation is responsible for treating wastewater, and supplies treated wastewater used to reticulate the City's parks and gardens. There is potential for mosquitoes to breed in treatment plant ponds and reuse tanks, especially where physical and chemical control measures fail. (e.g. unplanned effluent discharge or damage to exclusion barriers on reuse tanks). Maintaining constructive dialogue with the Water Corporation will help ensure the effectiveness of the mosquito control program.

16.2.2 Contiguous Local Authority Group

The DoH provides funding for mosquito control activities through the Mosquito Control Advisory Committee (MCAC). This is available to local governments where there is an actual or potential risk to public health. (Department of Health, 2009). The MCAC encourages the formation of Contiguous Local Authority Groups (CLAG) to maintain effective, integrated control programs. The City signed an MoU with the DoH in 2020 which formalised the CLAG group. This allows the City to access the support and funding through the scheme. Some of the supports offered include:

- mosquito larvicides
- adulticides (in northern WA only). When larviciding of large water bodies, during and after the wet season is unrealistic
- public education efforts, including Fight the Bite campaign
- mosquito management related equipment
- minor earthworks to eliminate mosquito breeding sites; and
- mosquito management related training and development

17 Budgeting and Staffing

The implementation and operation of a successful MMP require an adequate number of staff hours to get the work done and adequate supplies of mosquito control materials and equipment. The amount of work required depends on the degree to which mosquito management measures are required. The City will monitor the mosquito management work required and allocate additional budget and staff resources to mosquito management when and where required to address high levels of nuisance and/or public health risk. The City will ensure it has a sufficient number of officers trained to assist with mosquito management if additional staff are ever required.

The City can also access additional funds through the CLAG funding opportunities supported by the DoH. This is done by making funding applications to the MCAC. Funding applications are made to the MCAC to support:

- Chemical control strategies
- Physical control strategies
- Cultural control strategies (e.g. Fight the Bite)
- Mosquito management equipment; and
- Training and development

The level of mosquito activity is dependent upon several environmental factors and there can be significant variations in mosquito activity seasonally and annually. Consequently, the amount of monitoring and management measures implemented may vary. The CLAG is required to contribute to the trust fund and ensure that additional funds are available when mosquito activity is greater than normal.

17.1.1 Management Strategy

M18- Monitor mosquito management work required and allocate additional budget and staff resources to mosquito management when and where required to address high levels of nuisance and/or public health risk.

M19 – Ensure there is an adequate number of officers trained to assist with mosquito management if additional staff are required.

M20- Utilize CLAG funding to assist with mosquito management.

18 Mosquito management – monitoring and surveillance

18.1 Baseline Monitoring

A good understanding of local conditions is important when planning a mosquito control program. For this reason, a 12-month baseline monitoring program will be undertaken. The baseline monitoring program will provide valuable information in assessing the level of mosquito activity and the risk to the community of mosquito-borne disease. Both larval and adult mosquito monitoring will be undertaken. The programme will be initiated immediately following the approval of this plan.

Whenever a larvicide treatment programme is in place, larval monitoring should be undertaken on a weekly basis. This is particularly necessary if a species has a development cycle of 7 – 10 days from 1st instar to adult emergence. This will be especially relevant during hotter months, particularly after cyclones or heavy thunderstorms. Monitoring should also be carried out to confirm the effectiveness of a larvicide treatment.

18.1.1 Management Strategy

M21- Initiate baseline mosquito survey

M22- After completion of the baseline survey, review data and procedures before implementing the ongoing monitoring program.

18.2 On-going Monitoring Program

The On-going Monitoring Program (OMP) will be established in accordance with the guidelines established by the DoH. The OMP will be established to assess the success of control techniques that have been implemented and guide future implementation of control measures. The OMP will also help to evaluate whether the implementation of the mosquito control techniques has impacted the environment in any way.

Monitoring throughout the programme will incorporate the following considerations:

- Determining which species of mosquito larvae are present at monitoring sites.
- Determining which adult mosquito species are present within the vicinity of monitoring sites.
- Monitoring fluctuations in the number of target mosquitoes. This will include an estimate of the adult population size based on trapping results using a single CO_2 baited insect trap, an estimate of larval abundance within the water bodies and an indication of whether mosquito breeding is carried out in the same locations throughout the entire year, which is important for effective larvicide treatments.
- Any environmental impacts associated with the implementation of any mosquito control techniques.
- Water quality monitoring to guide the type of chemical agents used.
- Investigating potential new or unknown breeding sites.

As part of the OMP, ongoing larval and adult monitoring should be carried out on a fortnightly basis between November and April and monthly during the remainder of the year utilising the same monitoring sites used for the baseline monitoring survey. The frequency of monitoring may need to increase, particularly in summer when reproduction rates are far shorter or when assessing the effectiveness of larval treatments. Larvae will be collected at each site using a standard larval dipper, with 10 dips. The monitoring of adult mosquitoes will be done using a single CO_2 baited insect trap. Mosquitoes are considered a "nuisance" if the number caught in the trap at a single location over a normal sampling period (12-18 hours) exceeds 50 individuals (EPA, 2000). For mosquitoes that are known or suspected carriers of disease, appropriate control techniques must be implemented should larvae individuals be caught in "nuisance" numbers. Nuisance numbers generally refer to adult mosquitoes. Where the breeding site for larvae of vector species is unlikely to dry out before they complete their cycle of development, the breeding site will be treated. Weekly larval monitoring will be undertaken at breeding sites after cyclones or heavy thunderstorms to confirm the effectiveness of a larvicide treatment.

18.2.1 Management Strategy

M23- The ongoing monitoring program will be initiated at the completion of the monitoring program.

M24- Monitoring will be undertaken to ensure that additional mosquito breeding is not occurring at sites not included in routine larval monitoring.

18.3 Sentinel Chicken Surveillance

The DoH manages a sentinel chicken program, which provides an early warning for MVEV and WNV_{KUN} activity within the State. MVEV and WNV_{KUN} viruses are maintained in a bird - mosquito - bird cycle throughout the north of WA. The City of Karratha participates in the Sentinel Chicken Bleeding program. The sentinel flock is located at the City's Operations Centre in the Karratha Industrial Estate. There are also 2 flocks located at Harding Dam which are managed by the Water Corporation.

Blood samples are obtained from the City's flock of 12 chickens on a fortnightly basis and analysed for the presence of Murray Valley Encephalitis and Kunjin Virus. Should any positive results occur, the DoH issues media releases warning both residents and visitors to the region of the presence of the disease, to reduce exposure.

18.3.1 Management Strategy

M25- Continue to participate in the DoH sentinel chicken program as a means of detecting the presence of mosquito-borne diseases.

M26- Ensure staff are fully trained in the collection of samples from the sentinel chicken flock

19 Training and Staff Development

The success of any mosquito management plan relies on relevant staff having a good understanding of the plan and how it applies to them. Environmental Health staff should be trained in mosquito management and be familiar with the procedures, safety and correct use of the equipment and chemicals. The DoH can assist with the provision of training to improve the capacity of staff to undertake mosquito management activities.

19.1.1 Management Strategy

M27- Environmental Health Officers and other relevant staff should attend the DoH mosquito management course, which covers all the necessary skills and competencies required for mosquito management.

M28- All City staff involved in the management of mosquitoes should be briefed on the objectives and implementation of the MMP.

20 Recordkeeping/ Reporting

The City is committed to mosquito control and the public health of residents and visitors in the region. As part of this commitment, the City will implement the MMP and the MoU with the Western Australian Department of Health (appendix 5). The MoU requires the City to continue to undertake health-driven mosquito management within the LGA. The MoU details the specific reporting and record-keeping required by the DoH.

The following is a list of mosquito management activities that will be included in annual reporting.

20.1 CofK reporting

- Results of all adult and larval monitoring
- Details on the adult and larval treatment programs.
- Disease notifications, including follow-up interviews.
- Summary of any significant event that increases mosquito management resourcing and cost.
- Education program details.
- Financial reporting.
- Staff training.
- Any technical or operational changes are required for future mosquito management.
- Recommendations for changes to management actions and planning for the coming year.
- Any improvements that can be made to the program.

20.2 CLAG reporting

The following is a list of commitments detailed in the MoU that the City will contribute under the CLAG agreement.

- A formal MMP.
- A CLAG funding submission and a cover letter by a specified date requesting annual funds from the DoH.
- A CLAG annual report to the DoH includes financial statements, invoices for CLAG purchases, adult and larval mosquito survey data and details of all chemical treatments (including dates, products used and size of treatment).

20.2.1 Management strategy

M29- Prepare an annual report that satisfies the conditions outlined in the MoU and submit the report to the DoH.

21 Review

There will be an ongoing need to review and refine the program. A monitoring and reporting program will be prepared in consultation with the DoH. The monitoring and reporting program will track the performance of management strategies. The aim will be to review the MMP:

- Every 5 years or as a result of significant change in mosquito activity.

The signed CLAG MoU recommends that the MoU be reviewed every 5 years. This presents an opportunity to review both the MoU and the MMP at the same time.

21.1 Management strategies

M30- Document all activities

M31- Investigate and review the effectiveness of the mosquito control program.

M32- Review MMP every 5 years

M33- Review MoU every 5 years

22 Management strategy timing and responsibility

All management strategies have been listed below in the table, with timing and responsibility noted.

Measure	Management Strategy	Timing	Responsibility
Physical control measure	M1- - Maintain the structural integrity of drains. Ensure depth and flow are maintained. Care to be taken to not remove excess soil at the base of roadside drains	ongoing, quarterly inspections	City
	M2- Monitor water levels in the drains and low-lying areas to ensure water conditions do not change.	ongoing	City
	M3- Where possible drain or fill to remove potential breeding sites	as required	City
	M4- Ensure residential areas are well maintained.	ongoing	City/Residents
Chemical control measure	M5- If mosquito numbers exceed threshold numbers, chemical treatments will be conducted until a physical control is established	As required	City
	M6- Larviciding and adulticiding to be carried out through ground-based application using chemicals and techniques approved by the DoH	as required	City
	M7- Before any adulticiding is conducted the CofK will advertise its intent to carry out mosquito control activities	Before adulticide application	City
Biological control measures	M8- Maintain the abundance and diversity of predator species within the natural wetlands through the promotion of a healthy ecosystem	ongoing	City/DBCA
Cultural control measures	M9- Implement a 'fight the bite' campaign to educate and inform the residents of the City of Karratha about personal preventative mosquito measures.	Once MMP is endorsed	City/DoH
Mosquito management response due to cyclone	M10- Provision for additional staff and resources following a cyclone	As required	City
	M11- Provision for additional chemicals to support mosquito control operations	As required	City
	M12- Initiate a public information program.	As required	City
	M13- Ongoing communication with DoH	Ongoing	City//DoH
Internal stakeholder engagement	M14- Ensure City staff are aware of the risk mosquitoes represent and that they are adequately protected	Ongoing	City
	M15- Ensure Planning and Technical Services officers are aware of the role they play in mosquito management	Ongoing	City
	M16- Ensure that Parks and Gardens and Operations staff minimise the potential for mosquito breeding by maintaining drainage structures and minimising fertilizer runoff	Ongoing	City
	M17- Engage the Marketing and Communications team regularly to promote City mosquito management activities and promote 'fight the bite' material	As required	City/Media
Budget and staff	M18- Monitor mosquito management work required and allocate additional budget and staff resources to mosquito management when and where required to address high levels of nuisance and/or public health risk.	As required	City/DOH
	M19- Ensure there is an adequate number of officers trained to assist with mosquito management.	During the baseline period	City

	M20- Utilize CLAG funding to assist with mosquito management.	Ongoing	City
Base-line monitoring	M21- Initiate base-line mosquito survey	12 months from the endorsement of MMP	City
	M22- After completion of the baseline survey, review data and procedures before implementing the ongoing monitoring program.	After baseline monitoring	City
On-going monitoring program	M23- The ongoing monitoring program will be initiated at the completion of the baseline survey.	After baseline monitoring	City
	M24- Monitoring will be undertaken to ensure that additional mosquito breeding is not occurring at sites not included in routine larval monitoring.	Ongoing	City
Sentinel chicken program	M25- Continue to participate in the DoH sentinel chicken program as a means of detecting the presence of mosquito-borne diseases.	Ongoing	City/DOH
	M26- Ensure staff are fully trained in the collection of samples from the sentinel chicken flock	Annual refresher or as required	City/DoH
Staff training and development	M27- Environmental Health Officers and other relevant staff participating in mosquito management should attend the DoH mosquito management course, which covers all the necessary skills and competencies required for mosquito management	DoH conducts training every 2 years	City/DoH
	M28- All City staff involved in the management of mosquitoes should be briefed on the objectives and implementation strategy for the MMP.	As required	City
Recordkeeping/ Reporting	M29- Prepare an annual report that satisfies the conditions outlined in the MoU and submit the annual report to the DoH.	Annually in August	City
Review	M30- Document all activities	Ongoing	City
	M31- Investigate and review the effectiveness of the mosquito control program.	Annually	City
	M32- Review MMP every 5 years once ongoing monitoring has commenced.	Every 5 years	City
	M33- Review MoU every 5 years.	Every 5 years, unless changes to MoU are required	City/DoH

Table 7: Responsibility table for CofK MMP

23 References

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Appendix 1

Standard operating procedures (SOP) for mosquito monitoring and treatment procedures

SOP 1

Adult Mosquito Trapping

Objective: To determine the abundance and species composition of mosquitoes using an EVS/CO2 (Encephalitis Virus Surveillance/carbon dioxide) trap.

Equipment: EVS/CO2 trap. This is the most commonly used mosquito trap in Western Australia. The trap uses dry ice and an LED light as a lure. In the absence of dry ice, co2 cylinders may be used.

Preparation: Before you conduct field-based activities check the items listed below.

- Order dry ice or check that co2 cylinders are adequately filled. 1.5kg of dry ice is required per trap
- Purchase batteries
- Check trap motors, lights and fans are operational

- Check the holes are not blocked at the base of the dry ice tin
- Check catch bags and lids are intact

Considerations when setting the trap:

- set amongst trees/foliage where mosquitoes harbour
- protected from rainfall, high winds and direct sunlight, usually by setting the trap on the western side of a hanging point, as this helps prevent mosquito death and desiccation
- sheltered from sprinklers that may cause water damage to mosquitoes
- free of large numbers of ants or other insects that may access the catch bag and eat the mosquitoes
- accessible by foot, but not in plain view of the public who may tamper with the trap
- set below head height (if not, it can be difficult to remove the trap and may also influence the collection of mosquito species)

Occupational Health and Safety:

- When setting and collecting traps check for the presence of snakes

- Wear appropriate PPE when handling dry ice. Direct contact with dry ice can cause serious burns

Batteries:

- The traps use D-size batteries
- The batteries can be used twice. After the first night use a permanent marker to draw a single line across the base of the battery, after a second night draw a second line to make a cross. After the second night, the battery should be sent for recycling
- A motor should have at least one new battery and one 'once used' battery to ensure it will operate for a full night of trapping

Setting the trap:

- Remove the motor from inside the dry ice tin
- Check the motor for damage
- Put the batteries in the motor
- Fill the tin with dry ice (unless using cylinders)
- Attach the catch bag to the motor
- Check for holes and that the lids are closed properly
- Attach the veranda to the tin

- Attach the tin to the motor
- Turn on. Checking the fan and light are working
- Hang in a suitable spot

Collecting the trap:

- Check the motor and light are still working
- Tap the side of the catch bag until all mosquitoes are in the catch bag.
- Turn motor off
- Detach motor from the catch bag
- Empty remaining dry ice into the esky
- Place catch bag in the esky to kill the mosquitoes.
- Mark the batteries
- Put the motor in the tin for storage

The DoH website has an SOP for trapping if further clarification is required. (DoH Multi-page Template (health.wa.gov.au)

SOP 2

Larval Dipping

Objective: To determine the number and species of mosquito larvae present

Equipment: Items needed include, a larval dipper, vials, pipette, data recording sheets, map of sites, Ph and temperature metre, phone and PPE.

Preparation: check you have all the equipment needed. Ensure you have enough time to cover all sites.

Considerations when larval dipping:

- You tend to cover considerable distances when larval dipping. It is a good idea to have a bag to carry everything.

Occupational Health and Safety:

- There is a risk of snakebite. To minimise the risk work in pairs (if possible), carry a snake bite kit, have a phone with the Saint John Emergency App and tell people where you are going.

- Wear appropriate PPE, including a broad rim hat, insect repellent, gumboots or waders and sunscreen.

Dipping procedure:

- Determine the location of the monitoring site
- Record environmental conditions on the larval monitoring spreadsheet.
- Sample water with the dipper. Noting the number of larvae and growth stage on the larval monitoring spreadsheet.
- Report findings
- Determine if treatment is required. As part of post-treatment monitoring compare dipping numbers to initial numbers and assess treatment effectiveness.
- Enter results on the mosquito atlas.

For further information on larval dipping refer to the DoH website or the Mosquito Management Manual (DoH).

SOP 3

Larviciding (ground-based)

Objective: To apply larvicide to reduce mosquito larval populations

Equipment:

- Chemicals
- tarpaulin
- scales
- calculator
- treatment maps
- tape measure
- funnels and catch containers
- PPE
- Field treatment data record sheets
- larval dippers
- water

Preparation:

- check you have all the equipment needed.
- Ensure you have enough time to cover all sites promptly.

Considerations when larviciding:

- The equipment required will depend on the size, accessibility and number of sites to be treated

Occupational Health and Safety:

- PPE - hat, overalls, visor or eye protection, respirator, or dust mask (read label instruction on larvicide container to determine what is required), gloves, PVC boots
- Larvicide to be used should be stored in a lockable storage box on the vehicle. All larvicides should be accompanied by an appropriate MSDS.

Hand larviciding procedure:

- Check on the vector control map the location of the area to be treated.
- Check that all equipment to be used is in good working order.
- Calibrate the equipment per the manufacturer's instructions to the output rate required.

- Read and be conversant with the rate of application, any restrictions noted on the label.
- Check the chemical can be applied in the current weather conditions.
- Undertake larval check with a dipper to confirm larvae are still present.
- Measure treatment area.
- Calculate the amount of larvicide required.
- Record the above information on the larval treatment datasheet.
- Record date, time and weather conditions on the larval datasheet.
- Mix required larvicide
- Apply larvicide at recommended rates.
- Carry out continual checks on flow/application rates especially at each fill-up to ensure that the correct rate is being applied.
- Record the amount of larvicide used on the datasheet.
- Collect and store all equipment in the vehicle.
- Undertake a final check of the site to ensure that nothing has been left behind.
- Return any unused chemical to a secure storeroom.

- Record data on the CofK chemical spreadsheet

For further information refer to the DoH website or contact the chemical supplier.

SOP 4

Adulticiding (fogging)

Objective:

To minimise the risk of mosquito-transmitted disease during periods of high activity through the use of adulticides (fogging)

Equipment:

- Fogging Unit
- Chemical and water
- Fuel
- Map of sites to be visited
- Datasheets, permanent marker, pen
- Software to record fogging track
- Mobile phone and radio where appropriate
- PPE including gloves, boots, overalls, respirator, face shield and water for washdown.

Preparation:

- Communicate any proposed adulticiding with the DoH before proceeding

- Communicate proposed adulticiding with residents, Businesses, DPIRD and Tourism operators.
- An advanced warning should also be given to beekeepers. A contact list of beekeepers is held by the CofK.
- Ensure all equipment is serviced and in good working order.
- Calibrate fogger to suit chemical and situation (refer to DoH website for detailed calibration procedure)
- Make final checks on weather conditions and application safety

Occupational Health and Safety:

- PPE - hat, overalls, visor or eye protection, respirator, or dust mask (read label instruction on adulticide container to determine what is required), gloves, PVC boots
- Adulticide should be stored in a lockable storage box in the vehicle. All adulticides should be accompanied by an appropriate MSDS.

Procedure:

- Using the manufacturer's instructions start motor
- Fill the chemical tank with adulticide chemical and water/dilutant to the correct concentration as specified by the manufacturer
- Proceed to the predetermined start location
- Engage chemical flow
- Work through predetermined fogging route till complete
- Flush with clean water at the completion
- Record any problems encountered with machinery or application (tag if necessary)
- Record chemical usage, weather information and areas covered
- Enter details onto the datasheet for inclusion in annual reporting
- Advise the DoH on completion of adulticiding

Follow-up adult trapping will help assess the effectiveness of the treatment and guide future management decisions.

Appendix 2

2020-2021 adult trapping data

DATE	LOCATION	NUMBER OF TRAPS	NUMBER OF NIGHTS	NUMBER OF MOSQUITOES	SPECIES	Associated with a Complaint
6/07/2020	Karratha Depo	1	1	400		no
7/07/2020	KIE WWTP	1	1	14		no
8/07/2020	Shallow Well Creek	1	1	120		no
13/07/2020	Shallow Well Creek NE	1	1	45		no
17/08/2020	Shallow Well Creek	1	1	106		no
18/08/2020	Karratha Depo	1	1	75		no
2/08/2020	Country Club	1	1	45		yes
10/11/2020	Harding River	1	1	4	All Male	Yes
30/11/2020	Sholl street (North)	1	1	1	Aedes vigilax	no
1/12/2020	Karratha Depo	1	1	18 (5 Male/13 Female)		no
26/02/2021	Emma St Bulgara	1	1	nil		yes
16/03/2021	Augustas Dr KIE	1	1	23		yes
17/03/2021	Yaandina aged care	1	1	61		yes
17/03/2021	18 Sholl st Roebourne	1	1	9		no
18/03/2021	DSM Lambert road KIE	1	1	84		yes
18/03/2021	City Depot KIE	1	1	102		no
19/03/2021	18 Lewington way Bulgara	1	1	16		yes
14/04/2021	Viveash Way Bulgara	1	1	55 (2 Male/53 Female)	42 Vigilax/11 Annul	yes
19/04/2021	GPO Roebourne	1	1	30 (15 Male/15 Female)	22 Vigilax/8 Sitiens	Yes
20/04/2021	GPO Roebourne	1	1	153 (116 Male/37 Female)	23 Vigilax/14 Sitiens	yes
20/04/2021	18 Sholl St Roebourne	1	1	18 (2 Male/16 Female)	8 Vigilax/8 Sitiens	yes
21/04/2021	GPO Roebourne	1	1	103 (70 Male/33 Female)	26 Vigilax/7 Sitiens	yes
21/04/2021	Roe Airport	1	1	12 Female	12 Aedes Vigilax	yes
22/04/2021	Government Pool Roe	1	1	56 (4 Male/52 Female)	38 Vigilax/14 Annul	yes
22/04/2021	Wombat cres South Roe	1	1	80 (2 Male/78 Female)	19 Sitiens/59 Vigilax	yes
23/04/2021	Karratha golf club tank	1	1	267 Female	70 Annul/197Vigilax	yes
27/04/2021	Karratha golf club tank	1	1	41 Female	9 Annul/32 Vigilax	Yes
12/05/2021	Karratha golf club tank	1	1	378 Female	90 Annul/288 Vigilax	yes
18/05/2021	1 Boyd Court Nickol	1	1	71 Female	28 Annul/43 Vigilax	yes
18/05/2021	Nickol Tidal Flats	1	1	181 (1 Male/180 Female)	22 Annul/158 Vigilax	yes
19/05/2021	22 Shadwick dr M/W	1	1	28 (1 Male/27 Female)	9 Ann/8 Vig/10 Quin	Yes
19/05/2021	Pegs Creek Tank	1	1	24 Female	7 Ann/14 Vig/3 Quin	yes
20/05/2021	7 Petersen crt Pegs	1	1	19 Female	4 Ann/13 Vig/2 Quin	yes
23/05/2021	Nickol Tidal Flats	1	1	836 Female	58/Ann/778 Vig	Yes
27/05/2021	Nickol Tidal Flats	1	1	24 Female	2 Ano/2Ann/15Vig	yes
31/05/2021	Wickham Info Bay	1	1	30 (8 Male/22 Female)	1 Ano/1 Quin/ 19 Vig	yes
13/06/2021	K1 WWTP	1	1	349 Female	28Nor/278Ann/43Quin	no
13/06/2021	Nickol Tidal Flats	1	1	110 Female	40Ano/20Ann/50Vig	no
17/06/2021	K1 WWTP	1	1	929 (70 Male/859 Female)	7Anoph/852Annul	no
22/06/2021	K1 WWTP	1	1	170 (2 Male/168 Female)	7Ano/140Ann/21Quin	no
23/06/2021	K1 WWTP	1	1	122 Female	13Ano/105Ann/4Quin	no
19/07/2021	K1 WWTP	1	1	848 Female	820 Annul/28 Anoph	no
19/07/2021	Nickol Tidal Flats	1	1	109 Female	33Ano/37Ann/39Sitie	no
20/07/2021	Harding River Bore	1	1	31 Female	4 Anoph/27 Annul	no
21/07/2021	K2 WWTP	1	1	202 Female	6 Anoph/196Annul	no

Appendix 3

2020-2021 Dipping and larvicide treatment record

DATE	LOCATION	AVERAGE NUMBER LARVAE PER DIP	NUMBER OF DIPS	IF TREATED PRODUCT USED	TREATMENT AREA	PRODUCT QUANTITY USED	
EXAMPLE	Jennifer Creek	100	5	PROSAND	7HA	2KG	NEW TUB OPENED
11/08/2020	Millars Well Drain	10	6	Prosand		2KG	Half Tub
11/08/2020	Kallama Drain	5	2	Prosand		200g	
11/08/2020	Peterson Drain	10	4	Prosand		200g	
14/08/2020	East West Creek	5	8	Prosand		10KG	
5/11/2020	Harding River	2	6	Prosand		15KG	New Tub Opend
5/11/2020	Harding River	2	6	ProLink Briquets		40	New Tub Opend
10/11/2020	Jennifer Creek South	5	6	Prosand		15KG	New Tub Opern
23/11/2020	Harding River	Dry Baiting	Dry Baiting	Prosand		20kg	New Tub Opend
24/11/2020	Harding River	Dry Baiting	Dry Baiting	ProLink Briquets		50	
15/12/2020	Dampier Drains			ProLink Briquets		40	
15/12/2020	Dampier Drains			Prosand		10kg	
16/12/2020	Harding River			ProLink Briquets		50	
16/12/2020	Harding River			Prosand		10kg	
17/12/2020	Karratha Drains			Prosand		15kg	
14/01/2021	Wickham Tidal Flats	3	10	Prosand		10kg	
9/02/2021	KIE roadside drains			Prosand		10kg	
23/02/2021	Harding River	3	12	Prosand		10kg	
4/03/2021	Millars Well Drains	1	10	Prosand		5kg	
4/03/2021	Dampier Drains			Prosand		5kg	
12/04/2021	Wickham Tidal Flats	5	6	Prosand		10kg	New Tub Opend
12/04/2021	Harding River	6	1	Prosand		5kg	
12/04/2021	Millars Well Drains	5	6	Prosand		10kg	
13/04/2021	Harding River	3	10	ProLink Briquets		80	
21/04/2021	Pegs Creek Tidal Flats edge	3	6	ProLink Briquets		20	
22/04/2021	Harding River South			ProLink Briquets		30	
6/05/2021	East West Creek			ProLink Briquets		50	
6/05/2021	PT Samon Road			ProLink Briquets		50	
12/05/2021	Pegs Creek Tidal Flats	2	30	Prosand		20kg	
18/05/2021	Nickol Tidal Flats	4	50	Prosand		10kkg	
27/05/2021	Pegs Creek Tidal Flats	2	20	VectoBac Granuals		10kg	
28/05/2021	Nickol Tidal Flats	4	30	VectoBac Granuals		10kg	
1/05/2021	Wickham Tidal Flats	4	20	VectoBac Granuals		16kg	
15/06/2021	Millars Well Drains	1	20	VectoBac Granuals		15kg	
15/06/2021	Jenifer Creek	1	10	VectoBac Granuals		10kg	

Appendix 4

Signed CLAG Memorandum of Understanding

Government of Western Australia
Department of Health

Memorandum of Understanding

Karratha Contiguous Local Authorities Group (CLAG)

health.wa.gov.au

Objective:

This Memorandurn of Understanding (MOU) recognises the continuation of the Karratha Contiguous Local Authorities Group (CLAG) to undertake health-driven mosquito management within the City of Karratha.

The Mou outlines the requirements for the continuation of the CLAG, the Principal Stakeholders involved and the responsibilities of each Stakeholder. By signing the MOU, all parties agree to the continuation of the CLAG and the designated responsibilities of each member within the group.

The parties acknowledge that the provisions of this document are not intended to create binding legal obligations between them.

The parties acknowledge that:

a) nothing in this document authorises a party to incur costs or expenses on behalf of the other party; and
b) a party has no authority to act for, create or assume any responsibility, obligation or liability on behalf of, the other party.

Commencement of this MoU:

This MOU shall come into effect from the date that it is signed by all Principal Stakeholders.

Review and amendment of this MoU:

It is recommended that the MOU be regularly reviewed to improve its operation and resolve any issues that may arise. At a minimum, the Principal Stakeholders will review the document every five (5) years.

Earlier review will need to be undertaken if any party wishes to withdraw from or revise the CLAG arrangements. All parties will be required to resign the MOU once any amendments have been finalised.

If the review process indicates that no amendments are required, the existing MOU may remain in place and will not need resigning.

The Karratha Region

The City of Karratha is located in the Pilbara region of Western Australia. The current population sits at approximately 22,000 people. The prevailing climate is dry tropical and semi-arid with less than 290 mm of rainfall per annum. Rainfall generally comes during the summer cyclone season where at times very heavy inundations occur over a relatively short period of time.

Mosquitoes in the Pilbara generally have a reduced access to water for breeding opportunities, compared to other regions in the State. However, they are opportunistic breeders and will reach very high numbers when the conditions are ideal, causing a significant nuisance and potential health risk to the community.

Within the City of Karratha, extensive mosquito breeding is most often associated with above average rainfall or flooding, following a cyclone, as mosquitoes lay their eggs in vast expanses of stagnant water that can remain. Sewage lagoons can also be a source of large numbers of Culex annulirostris, a known mosquito-borne disease vector, if not well maintained.

The City of Karratha's mosquito program aims to minimise the incidence of disease transmitting and nuisance mosquitoes through proactive, integrated mosquito management strategies.

Principal Stakeholders:

This MOU covers the following Principal Stakeholders:

- Department of Health, Western Australia (the Department)
- City of Karratha.

Responsibilities of the Principal Stakeholders:

Department of Health, Western Australia

1. Funding

The Department will provide funding to the CLAG, in accordance with the CLAG Funding Guidelines and following assessment of the CLAG's annual application by the Mosquito Control Advisory Committee (MCAC), to support the following:

- chemical control strategies
- physical control strategies
- cultural control strategies (including Fight the Bite resources)
- mosquito management equipment
- training and development
- other requests (upon consultation with the MCAC).

2. Technical expertise

The Department may also assist the CLAG through the provision of:

- training to improve the capacity of CLAG members to undertake mosquito management activities
- staff to assist in ground surveillance to identify mosquito breeding sites (both natural and man-made)
- assistance with further development and revision of the City of Karratha's mosquito management plan (MMP)
- advice on local issues and possible resolution options
- notified case data related to mosquito-borne disease within the City of Karratha
- mosquito management options (including adulticides/larvicides)
- assistance with the identification of difficult adult and larval mosquitoes from surveillance activities (with advice from relevant specialists as required)
- staff attendance and advice at CLAG meetings
- assistance in developing a

Terms of Reference (TOR) to guide the CLAG's activities (note, the TOR is optional) other advice as required.

City of Karratha

The City of Karratha will contribute to the CLAG by committing to the following:

- nominate a CLAG Chairperson to:
- coordinate CLAG meetings with the Department; o submit annual funding applications and reports to the Department; and o document CLAG related incoming and outgoing communications.
- receive funding from the Department, and where appropriate, establish a: o CLAG operational account (to receive funding from Department) o CL.AG trust account (with the ability to roll funding over between years)
- ensure a formal MMP has been produced, documenting the management program's objectives, nuisance and disease risks, mosquito breeding sites, management strategies, land owners, necessary permits/approvals, budget and resource requirements etc.
- regularly revise the City of Karratha's MMP to ensure management activities are appropriate and reflect current mosquito issues
- submit a CLAG funding submission and cover letter requesting annual funds from the
  Department by the specified date. This request will be assessed by the MCAC
- submit a CLAG annual report to the Department, including financial statements and invoices related to Department CLAG funded purchases, by the specified date. This information is required to ensure the CLAG is eligible to apply for Departmental funding
- contribute 50% of the cost of MCAC approved budget items, unless otherwise specified. The required CLAG contribution will be outlined in the Department's annual funding outcome letter
- contribute to a trust fund, ensuring the CLAG has access to additional funding to manage mosquitoes when the nuisance factor or mosquito-borne disease risk is greater than normal. In regards to the trust fund, the City of Karratha will be required to:
- annually contribute an additional 10% of the CLAG's own contribution to mosquito management (as specified in the CLAG funding submission) to the trust account. Note, this amount is calculated by the Department before any financial carryover is deducted; OR negotiate an alternative trust fund arrangement with the Department that adequately ensures the City of Karratha has the capacity to manage mosquitoes in an abnormally busy mosquito season o seek approval from the MCAC, by way of a written request, to access trust funds o seek approval from the MCAC, by way of a written request, to 'cap' the trust fund .The 'capped' sum represents an amount that the CLAG deems to be sufficient to cover an abnormally busy mosquito season. Once this amount is reached, no further trust fund contributions are required. If the trust

fund falls below the 'capped' amount, CLAG contributions must begin again following the next budget submission

- discuss the CLAG's mosquito management activities with the Department a minimum of three (3) times throughout the season, by way of telephone meetings:
- conduct adult and larval mosquito surveys in alignment with the City of Karratha's MMP and include results in the CLAG's annual report
- maintain accurate records of all chemical treatments (date, product used and size of treatment) and include in the CLAG's annual report
- develop a Terms of Reference (TOR), detailing the function of the CLAG (note, the TOR is optional).

This Memorandum of Understanding is supported by:

The City of Karratha

Ryan Hall
Director DevelopmentServices

Signed: 

Date 2M 1/2.02-0

The Department of Health, Western Australia

Dr Michael Lindsay
A/Executive Director
Environmental Health Directorate
Public and Aboriginal Health Division

Signed: 

Date: e: 29/5/20 (dd/mm/yyyy)