



SHIRE of WYNDHAM | EAST KIMBERLEY

MOSQUITO MANAGEMENT PLAN

2016 |

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1 INTRODUCTION

The Shire of Wyndham East Kimberley (the Shire) Mosquito Management Plan (MMP) is an operational program that gives guidance to the Shire on the control and management of seasonal mosquitoes.

The MMP presents an integrated approach, which examines various control measures that can be used to minimise the number of adult mosquitos present in populated areas and to reduce the risk of mosquito-borne disease.

Mosquito management within the Shire is necessary for two reasons:

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

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

1.1 Shire of Wyndham East Kimberley

The Shire covers an area of 121,000 square kilometres and is one of four local governments that make up the Kimberley region. The Shire experiences extremes in weather with distinct dry and wet seasons which greatly influence mosquito breeding patterns.

Kununurra

Kununurra is located in the Ord Valley, situated near to Lily Creek Lagoon. Kununurra was developed in the early 1960s to service the construction of the Ord Irrigation Scheme. The town has seen the transformation of ancient river plains into one of Australia's most diverse and productive agricultural areas. Harnessing the mighty Ord River opened up the area to horticulture, agriculture, aquaculture and eco-tourism.

From its beginnings as a service town for workers, Kununurra has grown to a population of about 7000 people and is home to most of the Shire's residents and town services.

Kununurra experiences temperatures consistently high in the summer months along with a relatively high rainfall, mostly experienced from November to March. The mean annual rainfall for Kununurra is 858mm. It is during these months mosquito populations increase due to the favourable weather conditions and significant amount of pooling water in surrounding bush land.

Wyndham

Wyndham is Western Australia's most northern town and the second largest town in the Shire. It is a small town with a population of just 1000, but Wyndham was once a bustling town, with the arrival of news of gold discoveries at Halls Creek.

Wyndham, like Kununurra, is surrounded by cliff and gorge country and has five rivers flowing into the Cambridge Gulf. The Cambridge Gulf is a massive waterway providing access to recreational mariners and commercial fishing operators with entry points into five rivers, being the Pentecost, Forrest, King, Durack and Ord Rivers as well as numerous creeks.

Wyndham experiences consistently high temperatures in the summer months along with a relatively high rainfall, mostly experienced from November to March. The mean annual rainfall

for Wyndham is 840mm. It is during these months mosquito populations increase due to the favorable weather conditions and significant amount of pooling water in surrounding bush land.

Aedes vigilax mosquitoes breed naturally on the tidal salt marsh surrounding Wyndham. Due to the close proximity of Wyndham to this significant breeding area populations of mosquitoes are common throughout the year and are noticeably problematic after large tides.

Remote Areas

The vast area of the Shire includes many remote communities, resorts, working cattle stations and mining camps. The largest remote community is Kalumburu, the most northern settlement in Western Australia, with a population of approximately 400 people. Many of these remote locations are inaccessible by road during the wet season. Due to resource restraints and the inaccessibility of these remote locations during the peak mosquito season, this mosquito management plan focuses on the main population centres of Kununurra and Wyndham.

1.2 Goal & Objectives

The goal of this Plan is to reduce nuisance and disease risk associated with mosquito populations by committing to environmentally and financially sustainable mosquito management practices.

The objectives of this Plan are to:

1. Identify existing and potential breeding areas;
2. Detail the preferred mosquito management options;
3. Ensure public education and awareness campaigns are ongoing;
4. Inform land owners, residents, Shire staff and the general public of Council's mosquito management actions;
5. Ensure information retention by documenting mosquito management actions;
6. Strategically guide the financial direction of mosquito management.

1.3 Strategic Implications

In accordance with the Shire's Strategic Community Plan 2012-2022, our mission is to enable the East Kimberley to develop in a manner that will achieve social, cultural, economic and environmental benefits for all. The Mosquito Management Plan strives to address the following strategic directions:

Goal 2: Greater returns from regional investment to ensure sustainable provision of appropriate physical and social infrastructure

Objective 2.4: High standard of health and community facilities and services available to all residents

Strategy 2.4.2: Ensure community compliance with Environmental Health regulations

Goal 3: Protection and enhancement of lifestyle values, community facilities and the environment to provide safe and inviting communities

Objective 3.4: Protection and enhancement of community facilities

Strategy 3.4.1: Manage, maintain and upgrade public parks and amenities to ensure they meet community need and are accessible to people of all ages and abilities

1.4 Statutory Requirements

Department of Health

Health Act 1911

Part VII of the Health Act 1911 provides modes of dealing with nuisance and preventing spread of infectious disease, which can be applied to mosquito breeding sites.

Shire of Wyndham East Kimberley

Health Act 1911 – Shire of Wyndham East Kimberley Health Local Laws 2003

Part 6, Division 2 of the Health Local Laws 2003 details measures to be taken to prevent mosquito breeding.

Department of Environment Regulation

Environmental Protection Act 1986The Convention on Wetlands of International Importance (the Ramsar Convention)

The Shire contains two Ramsar listed wetlands: the Lakes Argyle and Kununurra Ramsar site and the Ord River Floodplain Ramsar site.

2 NUISANCE & DISEASE RISK

Mosquito management within the Shire of Wyndham East Kimberley is important to address both mosquito-borne disease risk and nuisance mosquitoes.

2.1 Mosquito-borne Disease Risk

Not every mosquito species is a vector of disease. However, known vectors of mosquito-borne diseases, such as Ross River virus (RRV), Barmah Forest virus (BFV), Murray Valley encephalitis (MVE) and West Nile virus Kunjin strain (WNV_{KUN}), are present within the Shire. These diseases all have a significant impact on the health, social and financial well-being of residents and visitors to the region.

Ross River virus and Barmah Forest virus

Ross River virus (RRV) and Barmah Forest virus (BFV) are the two most common mosquito-borne diseases in Australia. The two viruses have similar life cycles and cause similar symptoms in people. In nature, RRV and BFV pass back and forth between animals and mosquitoes. The only way humans can catch the diseases is through the bite of a virus-carrying mosquito.

The WA Department of Health has developed RRV risk maps based on proximity to known mosquito breeding habitats and historical RRV rates. Kununurra has been categorised as having a frequent high RRV disease risk, indicating that the town experiences problems with nuisance and disease carrying mosquitoes most years. The crude rate of RRV in Kununurra

is 2.5 cases per 1000 residents per year. Wyndham has a lower incidence with a crude rate of 1.5 cases of RRV per 1000 residents per year.

Overall, there have been 177 cases of RRV reported between 2003/04 and 2014/15 in the Shire of Wyndham East Kimberley. This represents an average of 15 cases per year and an annual age standardised rate of 191 cases per 100,000 population over this period which is a statistically significant increase of almost 5 times compared to the rate for the state as a whole. The BFV rate in the Shire is also significantly higher at approximately 4 times the State rate.

Murray Valley encephalitis virus and West Nile virus Kunjin strain

Murray Valley encephalitis virus (MVE) and West Nile virus Kunjin (WNV_{KUN}) strain are endemic in the Kimberley region and can be active during and in the months following heavy wet season rains with February to April being the season of most risk. In nature, MVE and WNV_{KUN} cycle between mosquitoes and water birds, while humans are only incidental hosts. Disease symptoms caused by MVE occur in approximately one in 1000 people bitten by infective mosquitoes. Most do not develop symptoms at all.

No human cases of MVE have been detected in recent years in Wyndham or Kununurra. The last human case of MVE in the Shire was detected in 2011 and historical records indicate that five human cases of MVE have been detected within the Shire since 1989, three in Kununurra, one in Wyndham and one in Oombulgurri. The Shire has had three reported cases of WNV_{KUN}, since 1989 all from Kununurra, with the most recent occurring in 2006.

Exotic and emerging mosquito-borne diseases

Exotic diseases such as Dengue, Zika virus, Chikungunya, Malaria, Yellow fever and Japanese encephalitis are transmitted by mosquito species that are not present in the Kimberley region. Local transmission of these viruses does not occur in Western Australia.

2.2 Nuisance

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

Of particular concern are *Aedes vigilax* mosquitoes, which cause significant nuisance problems for Wyndham. These mosquitoes breed in coastal saltmarshes surrounding Wyndham and are aggressive biters that can travel tens of kilometres from their breeding sites.

3 MOSQUITOES

3.1 Life Cycle

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

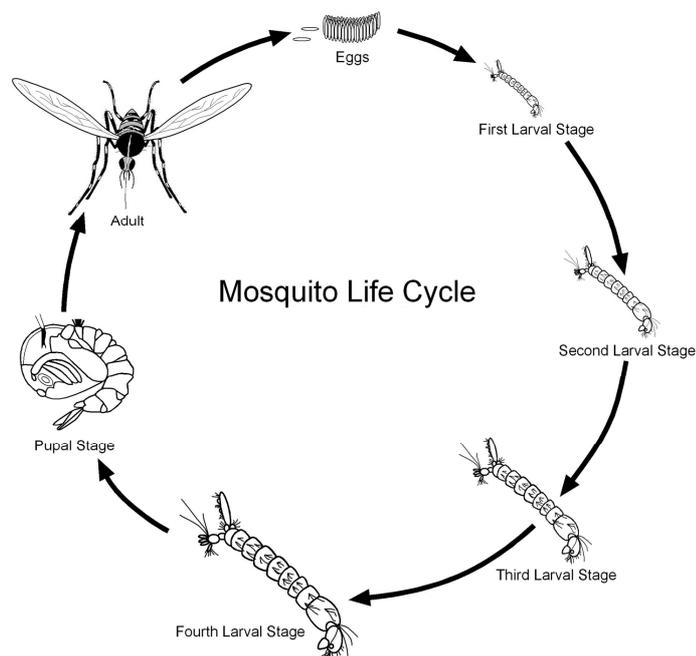
Eggs are laid by the adult mosquito and float on the surface of the water, soil or plants. *Anopheles* species lay their eggs as a single unit on the surface of a water body. *Aedes* deposit their eggs on a moist surface that will eventually be subject to water inundation. The *Aedes* eggs are generally associated with temporary water bodies and are desiccation resistant

meaning they can survive long periods out of the water. *Culex* species deposit their eggs in clusters that float on the surface of a water body.

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

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

The newly emerged adult rests on the surface of the water for a short time to allow itself to dry before flying off to feed. Male mosquitoes do not bite and usually stay close to the breeding site feeding on plant and flower juices. Female mosquitoes travel further afield and firstly seek out a carbohydrate meal of plant juices to increase energy before mating with a male. The females will seek blood after mating and then embark on a cycle of feeding, resting, developing and laying eggs. The average lifespan of an adult female is two-three weeks.



3.2 Species of Interest

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

Different species breed in different habitats and an understanding of the species present can allow for targeted larval investigations and control at the breeding site. Trapping of adult mosquitoes is therefore an important aspect of the management plan allowing for more targeted control actions.

Trapping undertaken by the Department of Health over the last approximately 20 years has identified *Culex annulirostris* as the primary species of concern at the end of the wet season (March/April). *Aedes vigilax* is an abundant species in Wyndham with the highest numbers collected in the middle of the wet season (January/February). *Aedes normanensis* is another

common species of concern in the region and is present all year round but is found in highest numbers in floodplains away from town sites during the wet season. All three of these species have the potential to transmit mosquito-borne diseases.

A summary of these species of interest and others found in the region is provided below.

Culex annulirostris

This species is an important vector of arboviruses; it is the principal vector of MVE and WNV_{KUN} and an important vector of RRV and BFV. *Culex annulirostris* breeds year round in temporary and permanent freshwater, but is most abundant in the mid to late wet season and early dry season.



Breeding Habitat: Permanent/semi-permanent freshwater bodies. Prefers heavily vegetated sites

Active Season: Year round esp. mid wet season to early dry season

Dispersal Capabilities: Up to 10km

Biting Habits: Active dawn, dusk and night

Disease Vector: MVE, WNV_{KUN}, RRV, BFV

Aedes vigilax

Aedes vigilax is a vicious biter, biting throughout the day and night. It can be responsible for nuisance problems in Wyndham, where it breeds in the tidal salt marshes surrounding the town. Eggs of *Ae. vigilax* are desiccation resistant and can survive for months on the dry mud flats. This often leads to a sharp increase in mosquito numbers for Wyndham early in the season when the first high tides or rains inundate the salt marsh allowing the eggs to hatch in large numbers.



Breeding Habitat: Coastal saltmarsh and brackish swamps

Active Season: Oct-Dec; Mar-May

Dispersal Capabilities: Up to 100km

Biting Habits: Vicious; all times

Disease Vector: RRV, BFV

Aedes normanensis

Aedes normanensis breeds in a variety of fresh water breeding sites, ranging from temporary ground pools, to large temporary swamps. Adults bite humans during the day and evening, and will also bite a range of mammals and birds. The species is found throughout the year, depending on local conditions. Eggs of *Ae. normanensis* are also desiccation resistant and significant numbers of adult mosquito can rapidly emerge following wet season rainfall.



Breeding Habitat: Temporary freshwater pools along rivers/creek lines

Active Season: Nov-Jan & Mar-May

Dispersal Capabilities: 2-3km

Biting Habits: Vicious, nocturnal, and dusk and dawn if humid

Disease Vector: RRV, BFV

Culex quinquefasciatus



Breeding Habitat: Clean or polluted water – domestic environment, artificial containers.

Active Season: Year round

Dispersal Capabilities: Limited

Biting Habits: Active in dawn, dusk and night

Disease Vector: Poor disease vector in WA

Aedes notoscriptus



Breeding Habitat: Clean water within the domestic environment; artificial containers

Active Season: Year round / wet months

Dispersal Capabilities: 0.4km

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

Disease Vector: RRV

Mansonia uniformis



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Breeding Habitat: Heavily vegetated freshwater especially with Typha/water lilies

Active Season: Jul-Nov

Dispersal Capabilities: 1-3km

Biting Habits: Vicious, all times in shade

Disease Vector: MVEV, RRV, WNV_{KUN}

Aedes tremulus



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Breeding Habitat: This species breeds in palm tree junctions as well as artificial containers.

Active Season: Mar-Apr

Dispersal Capabilities: 0.2-0.3km

Biting Habits: Vicious, dawn and dusk

Disease Vector: WNV_{KUN}

Anopheles annulipes



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Breeding Habitat: Permanent and semi-permanent freshwater

Active Season: All year, peak in wet season

Dispersal Capabilities: Unknown

Biting Habits: Night time; occasional in day times

Disease Vector: None

4 BREEDING SITES – LAND OWNERSHIP AND RESPONSIBILITY

A number of different breeding sites within the Shire contribute to mosquito populations. Some of these areas are monitored and treated by the Shire; others are the responsibility of external agencies. The Shire is responsible for management of breeding sites on Shire properties. This includes parks and gardens, Shire facilities and Shire roads and drainage systems. Some important existing and potential breeding sites and the responsible agencies are detailed below.

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 Shire conducts education campaigns to encourage residents to clean up and help them identify potential backyard breeding sites. If necessary, the Shire can undertake enforcement action to require residents or owners to remove backyard-breeding sites.

Sewage Ponds

The Kununurra Sewage ponds are well maintained by the Water Corporation and no mosquito larvae have been found here in larval surveys to date. The Shire routinely monitors adult mosquito numbers in the area and will liaise with the Water Corporation if the ponds are found to be breeding mosquitoes.

Wyndham currently has two sets of sewage ponds. The ponds managed by the Water Corporation are well maintained and still in use. The other set of ponds is owned by the Shire and was part of the discontinued wastewater re-use scheme. The disused ponds are usually dry, but fill with water during the wet season. The ponds become a breeding site at this time and require treatment with larvicide when standing water is present.

Ord Irrigation Cooperative

A study on the Ord River irrigation area in 2003 found larger numbers of adult *Culex annulirostris* within the irrigation area compared with the town site during the dry season. The breeding of this mosquito year-round in the irrigation area increases the risk of mosquito-borne disease transmission around Kununurra even during the dry season.

Ord Irrigation Co-operative (OIC) undertake maintenance of irrigation channels to prevent them from becoming mosquito breeding habitats.

Lily Creek Lagoon

Lily Creek Lagoon is a potential breeding site in close proximity to the main residential areas of Kununurra. Mosquitoes can breed around the edges of the lagoon and in association with vegetation, particularly cumbungi. Management of cumbungi is discussed in the Lake Kununurra and Lily Creek Lagoon Vegetation Management Plan 2008 (under review) and requires input from a number of agencies. The lagoon is part of the Ramsar listed wetland Lakes Argyle and Kununurra. The Lakes are managed by the Water Corporation and the Department of Water. The Department of Environment and Conservation is responsible for management of Ramsar values. Any proposed mosquito management activities within Lily Creek Lagoon or any part of the Ramsar site will require liaison with these agencies.

The Wyndham Port is an important potential route for the introduction of exotic mosquito species. The responsibility of the port lies with Cambridge Gulf Limited (CGL). The Department of Agriculture undertake routine surveillance at the Port for exotic mosquito species and issue bi-annual vector monitoring reports.

5 ENVIRONMENTAL CONSIDERATIONS

As the most northern region of Western Australia, the Kimberley often has unpredictable weather patterns. The spectacular and varied natural environment in the Kimberley provides for a wide range of temporary, seasonal and permanent mosquito breeding sites. Some environmental variances that can greatly influence mosquito populations are:

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

All of these weather factors play an important role in mosquito management and need to be considered during the implementation of the program.

Weather variables are recorded when undertaking monitoring and surveillance. They must also be taken into account before doing any chemical treatments.

6 MONITORING & SURVEILLANCE

Monitoring and surveillance is a vital part of this Plan and is used to determine required control actions. A review of the Shire's mosquito control was conducted by a consultant medical entomologist in September 2015. This review identified a number of breeding sites that require ongoing monitoring and surveillance. The recommendations in this report have been incorporated into routine monitoring and surveillance actions. A summary of all recommendations of the review is provided in Appendix One.

6.1 Larval Survey

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

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

The findings of these surveys will determine if there is a need for the application of larvicide to prevent the emergence of adult mosquitoes. The threshold for larvicide treatment in freshwater sites is an average of two third or fourth instar larvae per dip. Mosquito larvicides are not effective at the late fourth or pupal stage, therefore it is critical that if a mix of 3rd and 4th instars are observed that the larvicide is applied immediately. If 4th instars and pupae are observed it

is too late to apply larvicide and the only chemical control option is to wait for the adults to emerge and conduct adult fogging. In tidal sites with thick vegetation, the presence of an average of two 3rd/4th instar larvae per dip will trigger treatment. In sites where natural predators of larvae are evident dips resulting in early instars, but very few or no third and fourth instars, may indicate that biological control is sufficient. If practical, the site should be reinspected 1 or 2 days later to determine if the biological control is effective or if the cohort has progressed through to 3rd/4th instar and requires larvicide to be applied.

6.2 Adult Trapping

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

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

Trap collections of more than 100 *Aedes vigilax* or 200 *Culex annulirostris* within 500m of residential areas indicates a pest problem and potential disease risk and will trigger increased public awareness activities. Trap collections of over 500 *Culex annulirostris* within 500m of residential areas would be regarded as a severe pest problem and potentially significant disease risk. This will trigger discussions with the Department of Health regarding the appropriate control response.

6.3 Sentinel Chicken Program

The Shire participates in the sentinel chicken surveillance program coordinated by the Department of Health. The program provides an early warning of an increased level of mosquito-borne virus activity.

When a chicken is bitten by an infected mosquito, it develops antibodies to the virus but does not become sick. Furthermore, they do not develop high levels of the virus in their blood (thus, they cannot pass the virus back to mosquitoes and on to humans). Therefore, the disease cannot be spread from sentinel chickens to human populations.

There is currently one flock of chickens in Kununurra and one flock in Wyndham. Blood samples are taken from the chickens fortnightly in the wet season and monthly in the dry season. Samples are sent to the PathWest laboratory in Perth for analysis. Detection of virus in the chickens will trigger increased public awareness activities and liaison with the Department of Health regarding appropriate control actions.

6.4 Mosquito-borne Disease Notifications

Mosquito borne diseases (RRV, BFV, MVE and WNV_{KUN}) are notifiable diseases in Western Australia and are required to be reported to the Department of Health. The Kimberley Population Health Unit then notify the Shire of cases reported within its jurisdiction. Where possible, SWEK's Environmental Health Officers contact these cases to determine the

location and timing of exposure as accurately as possible. The information remains completely confidential and is used solely to inform mosquito management activities and guide the Department of Health and the Shire of Wyndham East Kimberley to prevent the spread of mosquito borne disease.

6.5 Complaints

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

Where possible all complaints should be made on the Mosquito Nuisance Complaint form, which includes important information to allow officers to follow-up. All complaints received must be forwarded to an Environmental Health Officer for investigation. Where possible an adult trap will be set near to the complaint address to identify the causative species.

6.6 Exotic Species Surveillance

There is potential for introduction of exotic species to the Shire via either the Wyndham Port or travellers coming from Queensland. Species such as *Aedes aegypti* or *Aedes albopictus* are a particular threat as these species are vectors of exotic mosquito borne diseases such as dengue, yellow fever and Zika virus, and are prevalent in Indonesia and many other parts of south-east Asia.

In Wyndham, larval monitoring for exotic species is conducted at the Port by the Department of Agriculture, with reports provided to the Department of Health. In Kununurra there is currently no exotic species surveillance program, however one will be established before the 2016/17 wet season.

Any specimens that are suspected of being exotic species must be immediately referred to the WA Department of Health Medical Entomologist for confirmation and advice.

7 MOSQUITO CONTROL METHODS

In order to be effective, this Mosquito Management Plan uses an integrated approach incorporating four control methods: cultural control, physical control, biological control and chemical control.

7.1 Cultural Control

One of the most important aspects of this mosquito management plan is public education.

It is not possible, nor desirable to completely eradicate mosquitoes from the environment. Despite the control actions detailed in this Plan there will always be some mosquitoes present and risk of mosquito-borne disease within the Shire. In addition, mosquito control activities are most active around the major town sites of Wyndham and Kununurra, however many residents and tourists will be exposed to mosquito bites in more remote locations where mosquito control is not undertaken. This includes residents living in rural areas, as well as people taking part in

recreational activities such as fishing and camping. For these groups the only way to reduce the risk of disease is to prevent mosquito bites by using personal protection measures.

Due to the highly transient residential population in the region, it is important that educational programs are ongoing to ensure all residents receive information. It is also essential to communicate this message to the large number of tourists that visit the region in the dry season months, particularly during the early dry season.

Public education will begin towards the end of the dry season and will be active throughout the wet season. Activities will be intensified when surveillance indicates that disease risk is high, either due to high mosquito numbers detected in adult traps, or when sentinel chicken seroconversions occur.

Education materials will be based around the Department of Health's "Fight the Bite" campaign and communication 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 is likely;
- Public notices of planned chemical and physical mosquito control activities; and
- Displaying appropriate signage while in the field conducting monitoring or treatment.

7.2 Physical Control

Physical control methods are measures taken to reduce the potential for mosquito breeding and harbourage by modifying the natural or built environment.

Examples of physical control actions include:

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

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

7.3 Biological Control

Biological control refers to the natural predation of mosquito larvae, for example by fish. Biological control occurs naturally in many water bodies and when present will reduce the

need for other control methods. The introduction of fish can also be an effective, long-term control for mosquito breeding in man-made situations such as backyard ponds.

Introduction of fish to natural environments will not form part of this Plan due to the large size and ephemeral nature of many breeding sites, as well as the potential environmental impact.

7.4 Chemical Control

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

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

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

7.4.1 Larvicides

Larvicides kill mosquito larvae and/or prevent the emergence of adult mosquitoes. Larvicides are used to treat known breeding sites in close proximity to residential areas.

Advantages:

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

Disadvantages:

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

In small breeding sites, larvicides can be applied by hand without any specialist equipment. The Shire has two Maruyama backpack sprayers that can be used to apply pellets to larger breeding sites. The following larvicides are currently used as part of the Shire's mosquito management program:

(S)-methoprene

(S)-methoprene is an insect growth regulator that is absorbed by larvae and prevents them from developing into normal pupae. This product is available in several different formulations,

including the slow-release briquettes, which ensure 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.

Bti (*Bacillus thuringiensis var. israelensis*)

This product is a bio-larvicide which is ingested by larvae and destroys the gut lining. Bti will kill larvae within 24 hours, but does not have any residual effect.

Both larvicides are target specific for mosquitoes and do not impact on non-target species when applied at label rates. Therefore, calibration of application equipment is important to ensure product is being applied as close as possible to target rates. Regular calibration and maintenance of application equipment will be undertaken in accordance with manufactures instructions and chemical labels and materials safety data sheets (MSDS).

7.4.2 Adulticides

Adulticides are those chemicals that kill mosquitoes at the adult stage. They are the only chemical control option once flying adults have emerged.

Advantages:

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

Disadvantages

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

Application of adulticides will only occur during times of high disease risk when the risk to public health outweighs the risk to the environment. The decision to use adulticides is made in consultation with the WA Department of Health Medical Entomologist.

The following adulticides are currently used as part of the Shire's mosquito management program:

Twilight ULV Mosquito Adulticide Concentrate

This chemical is used in the Cougar ULV sprayer and is a phenothrin and piperonyl butoxide based insecticide concentrate that must be diluted in carrier oil for application. Application of this chemical must be carefully timed to occur when mosquitoes are most active. Application will also depend on weather conditions.

Biflex AquaMax Insecticide

This chemical is a bifenthrin insecticide that is used as a barrier treatment. It is diluted in water and sprayed on surfaces such as dense vegetation and fences to kill mosquitoes that land on the surface. Application is by a knapsack sprayer.

8 STAKEHOLDERS

8.1 Internal Stakeholders

Ideally, residential developments should be located well away from extensive mosquito breeding sites to minimise mosquito management requirements. However, this is often not achievable in the East Kimberley region due to the magnitude of the natural environment and potential breeding areas in comparison to the size of town sites. Nevertheless, the Shire's planning department routinely refer development applications for environmental health assessment, at which time the appropriateness of proposed land use can be considered.

The Shire's Infrastructure department have responsibility for a number of areas that affect mosquito management including stormwater drains and vegetation management. Effective delivery of this plan, particularly physical control methods, will require close liaison with Infrastructure.

8.2 External Stakeholders

The Shire of Wyndham East Kimberley is a Contiguous Local Authority Group (CLAG). This means the Shire works in cooperation with the Department of Health with regard to mosquito management. As a CLAG, the Shire is eligible for a contribution from the state government of up to 50% for mosquito control chemicals. Decisions regarding appropriate application of these chemicals are therefore made in consultation with the Department of Health.

Other external stakeholders include Department of Environment and Conservation, Department of Water, the Water Corporation and Ord Irrigation Co-operative.

9 TRAINING

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

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

- Calibration techniques
- Information technologies/geographical information systems
- Budget management

The Department of Health offer an in depth mosquito management course in Mandurah approximately every two years which teaches most skills and competencies required.

10 RESOURCE REQUIREMENTS

Operating and implementing an effective mosquito management program is dependent on ongoing human and operational resources. Resource requirements will fluctuate significantly depending on the severity of the mosquito-breeding season, which is largely dependent on environmental variables.

Environmental Health Officers are primarily responsible for implementing this Plan. However, mosquito management is only a small part of the Shire's environmental health responsibilities and assistance is required from other staff. This can include assistance with monitoring activities, physical control activities or application of chemicals. A 4WD vehicle is also required for mosquito management work.

Through CLAG funding the Department of Health provides a 50% contribution towards chemicals; however, this amount is dependent upon the Shire's own budget allocation. It is a requirement of CLAG funding that some money is put in a mosquito management reserve fund each year. This money can be utilised in years when mosquito-borne disease risk/nuisance is greater than normal, following a request to the Department of Health.

11 ANNUAL REVIEW & REPORT

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

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

This plan will be reviewed annually by 30 June each year with information included in the Shire's annual report. It is important to assess effectiveness of the surveillance program and the overall control program to allow for continuous improvement. An ongoing surveillance program will assess whether the mosquito populations are being reduced and if the control program is achieving reductions in pest problems or mosquito borne disease.

12 REFERENCES

Brockway C and Neville P, *Mosquito investigation within the Shire of Wyndham/East Kimberley – May 2015*, report, Government of Western Australia Department of Health, Perth, 2015.

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North Shire Mosquito Abatement District, *Mosquito Biology*, viewed 3 May 2016, <<http://www.nsmad.com/about-mosquitoes/mosquito-biology/>>

Whelan P, *Review of mosquito control program Wyndham East Kimberley Shire*, Biting Insect Technical and Extension Services, 2016.

13 APPENDIX ONE – CONSULTANT’S RECOMMENDATIONS

In September 2015 a consultant medical entomologist from the Northern Territory was engaged to conduct a review of mosquito management within the Shire of Wyndham East Kimberley. The report generated from this review contained a number of recommendations. These recommendations and any progress made toward them are summarised below.

Section	Recommendation	Comment	Directorate	Progress
4.1	Locate all breeding sites on vector control maps	Working with Infrastructure and IT to create using existing software	Community Development	In progress – to be completed prior to 2016 wet season
4.1.1	Investigate patterns of over-watering	Investigation required	Infrastructure	Not started
	Removal of silt and vegetation from stormwater drains	Routine drain maintenance pre-wet season	Infrastructure	Ongoing
4.1.2	Larvicide treatment of temporary freshwater pools	Temporary solution	Community Development	Ongoing
	Investigate options for permanent source reduction.	Investigation required. Potential for CLAG funding for source reduction projects	Infrastructure	Not started
4.1.3	Reduction of emergent vegetation in Lake Kununurra and Lily Creek Lagoon	This action requires liaison with several external agencies – meeting to be arranged	Community Development	Not started
4.1.4	Install silt traps to Lily Creek lagoon tributaries	Investigation required. Potential for CLAG funding contribution	Community Development & Infrastructure	Not started
4.1.5	Inspect Cattle yard waste water ponds	Investigation required	Community Development	Not started
	Rectify Wyndham effluent disposal pipe	Liaison with Water Corp. required	Community Development	Not started
	Disused wastewater re-use scheme ponds (Wyndham)	Investigate options for rectification	Infrastructure	Not started
4.1.6	Monitoring irrigation channels	Land owners are responsible for maintaining irrigation channels.	Community Development	Ongoing

		Any issues identified will be brought to their attention.		
4.1.7	Monitoring waste water disposal from irrigation channels	Land owners are responsible for maintaining waste water channels. Any issues identified will be brought to their attention.	Community Development	Ongoing
4.1.8	Maintenance and rectification of roadside culverts	Review of all culverts within Wyndham and Kununurra required. Liaison with Main Roads Department required.	Community Development & Infrastructure	Not started
4.1.9	Enhancement of tidal barrier weirs and installation of gabions in Wyndham	Investigation required. Potential to apply for CLAG funding for these projects	Community Development & Infrastructure	Not started
4.1.10	Educating property owners on the importance of managing and maintaining the septic systems	Included in MMP – section 7.1	Community Development	Ongoing
4.2	Exotic vector surveillance – Kununurra town	Included in MMP – section 6.6	Community Development	Not started
4.3	Adult vector monitoring	4 traps set in Wyndham and Kununurra each month	Community Development	Ongoing
	Review trap locations	To be changed after the completion of trapping project in June 2016	Community Development	Not started
4.4	Investigate relocation of the Sentinel Chicken Site - Kununurra	Investigation required to identify alternative sites	Community Development	Not started
	Sentinel Chicken Bleeding	Included in MMP – section 6.3	Community Development	Ongoing
4.5	Adult Monitoring Control - Fogging	Included in MMP – section 7.4	Community Development & Infrastructure	Ongoing
4.6	Public awareness and communications program	Included in MMP – section 7.1	Community Development	Ongoing