The background of the page is a close-up photograph of a green leaf, showing its intricate vein structure. A large, white, semi-transparent geometric shape, resembling a stylized leaf or a large 'L' shape, is overlaid on the top-left portion of the page. The text is positioned within this white area.

Background Reporting

KARNUP DISTRICT STRUCTURE PLAN

Appendices.

Note: The three (3) scenario options referred to in this Report have been removed from this document. The scenarios were prepared to assist consideration and discussions with DPLH/WAPC and Agencies regarding mosquito risk, and were not intended to provide design solutions for the DSP area.

The visioning and design process, informed by stakeholder engagement and technical investigations, is subject to subsequent project phases.

To avoid confusion and misrepresentation of the scenarios in the early stages of this project, the scenario plans have been removed.

Appendix 1

Mosquito Risk Assessment and Management Plan (MRAMP)

KARNUP DISTRICT STRUCTURE PLAN

MOSQUITO RISK ASSESSMENT AND MANAGEMENT PLAN (MRAMP)

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**KARNUP DISTRICT STRUCTURE PLAN
MOSQUITO RISK ASSESSMENT AND MANAGEMENT PLAN (MRAMP)**

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DOCUMENT:

Karnup District Structure Plan
Mosquito Risk Assessment and Management Plan (MRAMP)

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EES-07_02_V5

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EXECUTIVE SUMMARY

The suburb of Karnup, situated within the City of Rockingham (the City), has been identified As a future urban cell within strategic plans.

In advance of rezoning and subdivision of the Karnup 'Urban Expansion Area', the Planning Framework requires the City to prepare a District Structure Plan (DSP) for the approximately 2,000 ha parcel identified in the subject land (**Figure 1**). An input to the DSP includes the development of a Mosquito Risk Assessment and Management Plan (MRAMP) – this report.

Review of Historical and Intensive Monitoring Data

Historical and contemporary monitoring undertaken adjacent to or within the subject land indicates the presence in high numbers of species of mosquitoes known to carry Ross River Virus (RRV) and Barmah Forest Virus (BFV) that breed in fresh and brackish water habitats.

The purpose of this MRAMP is to analyse relevant adult and larval mosquito data and outline recommended design controls for implementation into the DSP area consistent with the Peel Mosquito Management Group's (PMMG) mosquito management program.

The following points are relevant:

- Urban expansion in areas located within reasonable proximity to saltmarsh and wetlands means that residents, visitors and occupants are at risk of being affected by mosquito-borne disease that can cause detriment to health, wellbeing and loss of amenity.
- Six historical data sets (some of over 14 years duration) and 12 months of intensive (seven additional sites) data from within the DSP area were examined.
- A limited review of mosquito larval data was undertaken.
- Based on long period sampling at a series of monitoring sites within and immediately adjacent to the DSP areas, the following points are relevant (refer to **Figure 7**, HT and MOH series):
 - The period of records is between 60 and 178 months;
 - Both the Serpentine wetlands (HT-04) and Anstey Swamp (DOH13) are close to sources of mosquito breeding; and
 - HT-02 also reflects recruitment from Anstey Swamp.
- In relation to intensive adult monitoring:
 - Traps established along Paganoni Road (southern traverse, see **Figure 7**) returned consistently high adult numbers, with breeding sites likely from Paganoni Swamp, Anstey Swamp and the Serpentine system, or any combination of these;
 - Returns from both the western and eastern most sites were influenced by occasional adult emergence events. Average numbers were generally within threshold levels;
 - Adults trapped at the central site (Mallee Drive) were always elevated (14 or the 18 sampling events exceeded the threshold levels;
 - Sites comprising the norther traverse and northern outliers were influenced by occasional adults emergence events. Average number were generally within threshold levels.

While some larval monitoring data is available, sample locations are clustered on the Serpentine wetland chain (RO series in **Figure 7**). The effect of breeding from Paganoni and Anstey Swamps can only be inferred, but as indicated by adult monitoring data, is likely to be significant.

The outcome of the adult data analysis undertaken has identified that mosquito issues are more widespread and potentially more impactful from a public health perspective than previously thought, with significant breeding indicated from both the Serpentine wetland chain to the east of the DSP area, and Paganoni and Anstey Swamps to the south and west.

Mosquito Management

Best practice Integrated Mosquito Management combines various methods to minimise interaction between mosquitoes and the public and to reduce the risk of mosquito-borne disease.

Direct interventions include, but are not limited to:

- Removal of breeding habitat by physical modification.
- Application of larval growth inhibitors/pesticides.

Indirect approaches to reduce human-mosquito conflict, for example:

- Utilising planning mechanisms to create adequate buffers from significant breeding wetlands.
- Adoption of planning practices in terms of:
 - Building design;
 - Water Sensitive Urban Design (WSUD) appropriately re-considered to limit the formation of mosquito breeding habitat;
 - Notifications on Title advising the prospective landowner of the presence of mosquito breeding habitat in the vicinity of the land; and
 - Development and implementation of site-specific Mosquito Management Plans.
- Educating the public to avoid mosquitoes.
- Harvesting of aquatic vegetation.
- The design of roads and prevention of animal and vehicle access.
- Modifications to non-residential land use (e.g., quarrying, market gardening, animal husbandry) are undertaken in such a way as to minimise the potential for mosquito breeding.

Once control strategies have been implemented, it is essential that ongoing monitoring and surveillance is carried out.

Best outcomes in mosquito mitigation require an upfront implementation strategy with a 'one-in-all-in' approach for all landholdings within the DSP area. This is to ensure the orderly planning of the DSP area from a land use spatial planning perspective.

Risk Assessment

Jardine *et al.* (2015) provided empirical data on the prevalence of mosquito-borne virus infections within zones (1 km intervals) radiating from known mosquito breeding habitat within the Peel region concluding that overall, the data show that those living within 2 km of mosquito breeding habitat were at increased risk of contracting RRV.

In applying this knowledge, a risk map (**Figure 8**) has been developed that reflects zones with the DSP area that occur within 1 km and 2 km of known mosquito breeding habitat, and a risk assessment conducted (**Table 16**) that identifies the various strategies that combine to reflect Integrated Mosquito Management.

The risk assessment identified that pre-mitigation risk is generally assessed in the moderate to high range, with a single extreme assessment associated with the construction of residences within close proximity (assessed to be < 1 km) from known mosquito breeding habitat.

It is concluded that the implementation of key mitigation measures identified in **Tables 10 – 14**, have the potential to effectively reduce all identified risk scores to the moderate range. This occurs through the reduction of productive mosquito breeding habitat and providing adequate separation, thereby avoiding the potential for resident interaction with areas of mosquito activity wherever practicable.

Way Forward

Should subdivision and development of the DSP area occur in accordance with the State Planning Framework, mosquito breeding habitat areas will need to be appropriately managed to minimise public health risk. It is acknowledged that the mosquito nuisance and disease risk will not be fully eradication, however, a series of recommendations are made (**Section 7**) to enable effective management of vector and nuisance mosquitoes.

The mosquito management strategy (**Appendix 5**) provides a planning framework to guide land use spatial planning within the DSP area to arrive at a balanced outcome.

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APPENDIX 5	Mosquito Risk Assessment and Management Plan Planning Considerations
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LIST OF ABBREVIATIONS

BFV	Barmah Forest Virus
City	City of Rockingham
CLAG	Contiguous Local Authorities Group
DBCA	Department of Biodiversity, Conservation and Attractions
DoH	Western Australian Department of Health
DPLH	Department of Planning, Lands and Heritage
DSP	District Structure Plan
EHO	Environmental Health Officer
EPA	Environmental Protection Authority
EVS/CO₂	Encephalitis Vector Survey/Carbon Dioxide
LGA	Local Government Authority
MCAC	Mosquito Control Advisory Committee
MRAMP	Mosquito Risk Assessment and Management Plan
MVE	Murray Valley Encephalitis
PMMG	Peel Mosquito Management Group
POS	Public Open Space
RRV	Ross River Virus
SoM	Shire of Murray
WAPC	Western Australian Planning Commission

LIST OF DEFINITIONS

Adulticide	Insecticide used to kill adult mosquitoes.
BFV	Barmah Forest Virus, a virus transmitted to humans through the bite of a vector mosquito.
CLAG	Contiguous Local Authorities Group, comprised of one or more Local Government Authorities that share a common mosquito problem, usually in the form of natural or man-made habitat that breed mosquitoes which subsequently impact on surrounding communities.
EVS/CO₂	A mosquito trap outfitted with a light and dry ice to attract adult mosquitoes.
Larvicide	Biological or chemical agent used to kill mosquitoes in the innocuous larval stage before the adult develop and disperse.
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 using mitigation measures.
Mosquito	A small flying insect of the family Culicidae. The females are characterised by having a long proboscis adapted for piercing the skin of humans and animals to suck their blood.
Nuisance	An act of a mosquito which causes inconvenience or annoyance to humans and/or animals.
RRV	Ross River Virus, a virus transmitted to humans through the bite of an infected mosquito.
Threshold	The level or number of mosquitoes (adult/larval) present before a control strategy is implemented.
Vector	A vector is an insect or animal that transmits a disease to other animals or humans. In essence, a vector is a carrier of a disease.

1. INTRODUCTION

1.1 Background

In 2018, the Western Australian Government released the South Metropolitan Peel Sub-regional Planning Framework (Planning Framework) to provide guidance to Local Government Authorities (LGA) on the preparation of Local Planning Schemes, Local Planning Strategies and Structure Plans (Department of Planning, Lands and Heritage/Western Australian Planning Commission, 2017).

Since the 1980s, the suburb of Karnup situated within the City of Rockingham (City) has been identified as a future urban cell within strategic plans. The Planning Framework confirms the intended footprint for urban expansion designating Karnup as an 'Urban Expansion Area' to serve as a key urban growth corridor for the South Metropolitan Peel sub-region.

In advance of rezoning and subdivision of the Karnup 'Urban Expansion Area', the Planning Framework requires the City prepare a District Structure Plan (DSP) in collaboration with the Department of Planning, Lands and Heritage (DPLH) for the approval of the State Government. Consequently, in 2023 the City appointed a Consultant Team to undertake the necessary technical investigations and to prepare the Karnup DSP, in close liaison with the City (City of Rockingham, 2023). This body of work includes the development of a Mosquito Risk Assessment and Management Plan (MRAMP) – this document.

The Karnup DSP area (DSP area) comprises approximately 2,000 ha and extends from Stakehill Drive in the north to Paganoni Road in the south, from Mandurah Road, Fletcher road and Nairn Drive in the west, and to Kwinana Freeway in the east (**Figure 1**).

The DSP area includes land already zoned 'Urban Deferred' and owned by DevelopmentWA on the southern side of Stakehill Road, along with 130 ha of land reserved 'Parks and Recreation', and the Karnup Station Precinct located in the south-western corner of the DSP area. The DSP area also comprises a large proportion of fragmented landholdings that are predominantly zoned 'Rural' and 'Special Rural' (City of Rockingham, 2023).

The DSP area is located to the west of the Serpentine River where riverine water comes mainly from tidal water movement upstream of the Peel-Harvey Estuary. As mosquitoes require an aquatic environment to breed during their larval stage, large tracts of low-lying saltmarsh surrounding the Serpentine River provide known mosquito breeding habitat. Mosquitoes have the potential to disperse from these perimeter saltmarsh areas through Karnup due to prevailing winds and the ability of some species of mosquito to fly many kilometres from their breeding sites (City of Rockingham, 2023).

Research conducted by the Department of Health Western Australia (DoH) into mosquito disease incidence and identification of mosquito vector species, has identified several species of mosquito known to carry Ross River Virus (RRV) and Barmah Forest Virus (BFV) that breed in fresh and brackish water habitats. Two of these species, *Aedes camptorhynchus* (Southern saltmarsh mosquito) and *Aedes vigilax* (Summer saltmarsh mosquito), commonly breed in coastal wetlands and tidal marshlands, however *Aedes camptorhynchus* may also breed in temporary fresh groundwater sites.

In the South-West region, the area of greatest risk of contracting either virus has historically been on the southern Swan Coastal Plain between Mandurah and Busselton with the high incidence of contracting the disease(s) being recorded during the months September – May.

In particular, people living up to 5 km of saltmarshes or brackish wetlands (i.e., estuaries and tidal rivers such as the Peel Inlet and Serpentine River) and freshwater wetlands as found within and adjacent to the DSP area, are at the greatest risk of contracting RRV and/or BFV diseases (Department of Health, 2010).

Urban expansion in areas located within close proximity to saltmarsh and wetlands means that residents, visitors and occupants are at risk of being affected by mosquito-borne disease that can cause detrimental effects to their health, wellbeing and loss of amenity. To understand the extent of mosquitoes affecting the DSP area and their potential impact, the City has been undertaking a Mosquito Monitoring Program (MMP) and the data collected has been provided to the Consultant Team for use in the preparation of this MRAMP.

1.2 Aim and Objectives

The principal aim of this MRAMP is to understand the potential implications of mosquitoes upon residents and occupants of any future urban development within the DSP area, and to provide recommendations to reduce their exposure to offsite and onsite mosquito breeding habitat to manage potential mosquito-borne disease risk.

In keeping with the requirements of the City, the principal objectives of this MRAMP include:

- (a) Analysing the City's mosquito monitoring data with respect to the potential water holding areas within the DSP area and offsite breeding habitat around the Serpentine River system to address potential mosquito-borne disease risk;
- (b) Outlining recommended design controls for implementation in the DSP area to reduce the exposure of residents, visitors and occupants to onsite and offsite mosquito breeding; and
- (c) Ensuring that the MRAMP is developed in alignment with the Peel Mosquito Management Group's (PMMG) mosquito management program (**Appendix 1**).

This MRAMP has been prepared in consultation with the City, the DoH and the DPLH.

1.3 Guiding Documents

The following documents have been used as guidance in the implementation methodology, data analysis and the preparation of this report:

- Department of Health 2019a, *Mosquito Management Manual*. Prepared by the Environmental Health Directorate, Government of Western Australia Department of Health.
- Department of Health 2020, *A guide to developing a mosquito management plan for Local Government*.
- Department of Planning and Infrastructure 2011, draft *Planning Policy for Mosquitoes and Development*.
- Shire of Murray 2018, *Shire of Murray Local Planning Policy – Mosquitoes*.

2. STATUTORY FRAMEWORK

2.1 *Public Health Act 2016*

Under the *Public Health Act 2016* and Regulations¹, the DoH has a state-wide charter to protect public health.

The Act's relevance to local government is described in Part 2 Division 2, whereby local government is authorised and directed to carry out the provisions of the Act. Part 3 deals with the general public health duty to ensure all persons take reasonable and practical steps to prevent and minimise any harm to public health. Part 4 provides a broad and flexible framework capable of capturing both known and emerging public health risks.

Part 5 of the Act (yet to be enacted) will require each Local Government Authority (LGA) prepare a Local Public Health Plan. Part 9 deals with the monitoring of notifiable infectious diseases and would therefore encompass the threat to public health from mosquito-borne diseases.

The DoH coordinates the surveillance and management of mosquitoes of public health significance across Western Australia and plays a key role in supporting local government programs through the Contiguous Local Authorities Group (CLAG) funding scheme. The scheme is a mechanism for LGAs to access funding for health-driven mosquito management activities (Department of Health, 2019).

Through the Act, and the associated State Public Health Plan for Western Australia 2019, the City is committed to protecting, promoting and enhancing the health and wellbeing of its residents and visitors by actively playing a key role in the management of mosquitoes. As part of this responsibility, the City is a member of the PMMG whose members include the DoH, City of Mandurah and Shires of Murray and Waroona.

2.2 *Planning and Development Act 2005*

The purpose of the *Planning and Development Act 2005* is to provide for an efficient and effective land use planning and system in Western Australia and to promote the sustainable use and development of land.

Through the Structure Plan and Subdivision application processes, the DPLH refers Subdivision applications to a range of State Government agencies seeking their comments and recommendations with respect to the imposition of conditions on the proposed Subdivision.

The Western Australian Planning Commission (WAPC) has the power to impose conditions of approval on any land development proposal considered to be located within a mosquito vector high-risk area. This includes the provision to impose a Notification on a land title that are potentially affected by a relatively permanent hazard, for the purpose of notifying prospective purchasers of the potential hazard.

¹ The former *Health Act 1911*, now known as the *Health (Miscellaneous Provisions) Act 1911* and all regulations made under the former *Health Act 1911*, will continue to be the main enforcement tool, until the provisions of the *Public Health Act 2016* (the Act) are proclaimed over the coming years.

2.3 *Transfer of Lands Act 1893 (as amended)*

Under the Western Australian *Transfer of Lands Act 1893* (as amended) the WAPC is able to impose a Notification (or Memorials) on land titles.

The use of Notifications, in the form of a section 70A Notification, is increasingly being applied by the WAPC to land developments located within 2 km of saltmarsh wetlands (the zone where the majority of RRV cases occur in the South-West of Western Australia).

TO be consistent with best practice and other local governments in the PMMG, Notifications on title pursuant to section 165 of the *Planning and Development Act 2005* may be recommended to the WAPC by the City for residential developments located within 2 km of known mosquito breeding habitat.

Table 1 (over the page) highlights the statutory and policy framework relating to mosquito management in Western Australia and specifically within the City's municipal boundaries.

TABLE 1: Mosquito Management Statutory and Policy Framework

Acts, Statutes and Functions	Legislative mechanisms/activities	Administering agency
<i>Public Health Act 2016</i> and proposed new Subsidiary legislation – <i>Pest and Vector Regulations</i>	<ul style="list-style-type: none"> • General public health duty. • Management of infectious diseases and related conditions capable of responding to both known and emerging risks to public health. • To protect persons from the public health risks from biting insects and pesticides used to control pest numbers. 	DoH City of Rockingham
Department of Health 2019b, <i>State Public Health Plan for Western Australia 2019-2024</i>	<ul style="list-style-type: none"> • Provides high level strategic directions focusing on prevention, health promotion and health protection that aim to prevent disease, illness, injury, disability and premature death in Western Australia. • Reduce exposure to environmental health risks (including mosquito-borne diseases). 	DoH City of Rockingham
<i>Health (Pesticides) Regulations 2011</i>	<ul style="list-style-type: none"> • Control of pest management activities such as the use of chemical larvicides to control mosquito larvae. • Licensing of pest management technicians involved in the use of chemical larvicides. • Possession, use and disposal of pesticides (e.g., mosquito larvicides, adulticides). 	DoH City of Rockingham
Department of Health 2019a, Mosquito Management Manual	<ul style="list-style-type: none"> • Environmental considerations in mosquito management. • Management of mosquito through control mechanisms. • Mosquito surveillance and monitoring techniques. • Planning, funding and legislative requirements of mosquito management and control. 	DoH City of Rockingham
Department of Health 2020, <i>A Guide to Developing a Mosquito Management Plan for Local Government</i>	<ul style="list-style-type: none"> • To identify mosquito breeding areas and potential breeding locations. • To provide an easy access document to convey information to future staff. • To inform, guide and assist developers, consultants, land owners, residents, council staff and the general public of Council’s mosquito management actions and guidelines. • TO work with other local governments in the region to ensure mosquito management is carried out in a cooperative manner and to ensure complimentary mosquito management across LGA borders. • To strategically guide the financial direction of mosquito management. 	DoH City of Rockingham

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Acts, Statutes and Functions	Legislative mechanisms/activities	Administering agency
<i>Planning and Development Act 2005</i>	<ul style="list-style-type: none"> • State planning policies. • Regional and Local Planning Schemes. • Subdivision and development control (e.g., to ensure development does not create additional mosquito breeding habitat via planning controls such as buffer requirements, subdivision design and public open space (POS) design) 	WAPC DPLH City of Rockingham
<i>Planning and Development (Local Planning Schemes) Regulations 2015 Schedule 2 Clause 67 (r)</i> <i>Local Government Act 1995</i>	<ul style="list-style-type: none"> • Specifies the suitability of the land for the development, considering the possible risk to human health and safety, including the potential risk for vector-borne disease(s). • Ensure land (e.g., Council Reserves) remains tidy and free from overgrown vegetation to prevent mosquito breeding habitat and harbourage from forming. • Containment of stormwater and rainwater to prevent mosquito breeding habitat from forming within standing water. 	DPLH City of Rockingham DPLH City of Rockingham
Department of Planning and Infrastructure 2001, draft <i>Planning Policy for Mosquitoes and Development</i>	<ul style="list-style-type: none"> • Referral of Subdivision and Structure Plans to Municipal Environmental Health Officers for assessment of mosquito risk. • Use of risk mapping and when to apply planning controls. • Promote awareness of mosquito issues and guidelines. 	DPLH City of Rockingham
<i>Transfer of Lands Act 1893</i> (as amended)	<ul style="list-style-type: none"> • Section 70A allows Notifications to be placed on a property's Certificate of Title to ensure any current or future owners are aware of matters which may impact the enjoyment of that property when it is located in close proximity to known mosquito breeding areas. 	
Department of Water and Environmental Regulation (DWER) 2023, <i>Better Urban Water Management Guidelines</i>	<ul style="list-style-type: none"> • To ensure that the impact of mosquitoes potentially breeding in stormwater systems constructed as part of a development are to be included in local urban water management plans. • To ensure stormwater drainage systems are designed so that drainage occurs within 96 hours to prevent mosquito breeding habitat formation. 	DWER City of Rockingham
Shire of Murray 2018, <i>Shire of Murray Local Planning Policy - Mosquitoes</i>	<ul style="list-style-type: none"> • The policy applies to rezoning, Structure Plans, Subdivisions and development proposals for: <ul style="list-style-type: none"> - New residential and other development that may be sensitive to the impact of mosquitoes within 5 km of existing mosquito breeding areas adjoining the Peel-Harvey Estuary and nearby lakes/wetlands; and 	Shire of Murray

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Acts, Statutes and Functions	Legislative mechanisms/activities	Administering agency
	<ul style="list-style-type: none">- Proposed residential and other development that may be sensitive to the impact of mosquitoes that may be further than 5 km of existing mosquito breeding areas, where the proposed will potentially increase mosquito breeding, within new stormwater systems, artificial lakes and canals.	

3. EXISTING ENVIRONMENT

3.1 Climate

The DSP area experiences a dry Mediterranean climate of hot, dry summers and cool, wet winters. Long-term climate data at the Bureau of Meteorology's (BoM) Anketell Stations (Station No. 009259), previously the closest BoM station to the DSP area, indicates that it is in an area of moderate rainfall receiving approximately 797 mm on average annually over the period of records (2003-2020). Most of the rainfall is received between May and July (**Chart 1**). The average temperature ranges from 11.5 °C to 24.6 °C (Bureau of Meteorology 2020).

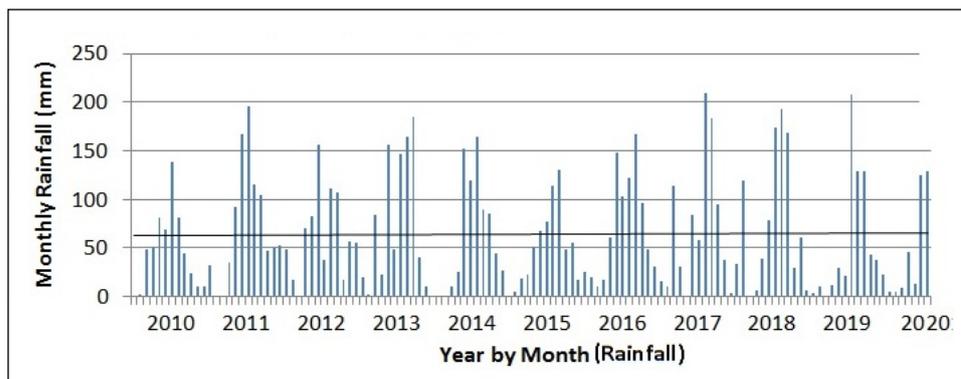


CHART 1: Monthly Rainfall at Anketell Meteorological Station (2010-2020)

3.2 Topography and Soils

The topography of the DSP area varies, with undulating elevations ranging to approximately 35 m Australian height datum (AHD), and low points of 5 m AHD (**Figure 2**).

The DSP area is located within the Spearwood dune formation that formed approximately 40,000 years ago and is made up of yellow brown sands of marine origin of varying thickness overlying Tamala limestone. The Spearwood dune formation still contains iron salts and some calcium carbonate. Deeper in the soil profile, the dissolved calcium carbonate can reform and come out of solution eventually forming solid limestone.²

The environmental geology of the DSP area, mapped by the Geological Survey of Western Australia (Gozzard 1986), identifies the following:

- Sand (S7) (7339): The majority of the site is categorised as a “flat to gently undulating sandplain with pale and yellow sand, medium to coarse-grained, sub-angular to well-rounded quartz”.
- Clayey Sand (Scp) (7397): Located in the south-west area of the site, this unit is described as “black, fine to medium-grained quartz sand with clay matrix, variable organic matter of lacustrine origin”.
- Peaty Clay (Cps) (7437, 7424, 7416, 7422, 7410, 7387, 7394, 7391, 7399, 7393, 7045): Several small pockets of areas are found within the site and are described as “dark, grey and black, soft variable organic content, some quartz sand in places, of lacustrine origin”.

² Dr Gary Middle (accessed online 19 June 2023) <http://www.garrymiddle.net/geomorphology-of-swan-coastal-plan>

- Sand (S8) (7263): Located on the eastern portion of the site, this unit is described as “very light grey at surface, yellow at depth, fine to medium grained, sub-rounded quartz, moderately well sorted, of eolian origin”.

The soil units of the DSP area are shown in **Figure 3**.

3.3 Groundwater

The *Perth Groundwater Atlas* (Department of Water, 2004) identifies that the groundwater flow beneath the DSP area is generally in a west to south-westerly direction. Based on the groundwater mapping, the minimum groundwater levels are approximately 3 m below ground surface (BSG), while the maximum groundwater levels measured in the north of the DSP area indicate a depth to groundwater of 3.3 m BGS.

Groundwater contours are shown in **Figure 5**.

3.4 Surface Hydrology

A series of wetlands³ have been identified with the DSP area including:

- Conservation Wetland (COW; UFI 6413, 6446, 6411, 6624, 6636, 6630.)
- Resource Enhancement Wetland (REW; UFI 6429, 6634, 6548, 6641, 6638, 6626, 6625)
- Multiple Use Wetland (MUW; UFI 6428, 6426, 16051, 15848)

The locations of the wetlands are shown in **Figure 4**.

The surrounding context of the DSP area identifies some significant surface water features that support free standing water, most notably Anstey Swamp located to the west of the DSP area, Paganoni Swamp located to the south and Lake Amarillo located to the east of the Kwinana Freeway. These are characterized by an interconnecting watercourse and major perennial drainage lines.

Emerge Associates conducted an investigation of the Department of Water and Environmental Regulation’s (DWER) regional groundwater monitoring bores within and in the vicinity of the DSP area using the DWER’s Water Information Tool⁴.

Eleven bores were identified for the DSP area which contained groundwater level data ranging from 1975 to 2023. The bores used in this investigation were: MANSWIM01-18 D, T430(I), T430(O), T440, T441, T490, T530(I), T540A, T580A, Anstey Swamp and Paganoni Swamp, with all available groundwater level data required from DWER to allow the assessment of more recent groundwater levels (i.e., the last 10 years of data). These data allowed the development of annual average maximum, minimum and average groundwater contours (AAMax, AAMin, Ave) for the DSP area.

Based on this information, the groundwater contours were interpolated based on the annual average groundwater levels and the locations of the 11 bores in the vicinity of the DSP area.

³ Hill A.L., Semeniuk C.A., Semeniuk V. and Del Marco, A. 1996, *Wetlands of the Swan Coastal Plain Volume 2a: Wetland Mapping, Classification and Evaluation, Wetland Atlas*. Water and Rivers Commission and the Department of Environmental Protection, Perth

⁴ Available from: <https://www.wa.gov.au/service/natural-resources/water-resources/water-information-reporting#water-information-reporting-tool>

Results of this interpolation were compared to the DWER Lower Serpentine Hydrological Studies (2012) as a validation against a known dataset which was found to generally align with the DWER dataset with some inconsistency along the eastern boundary which was likely due to a lack of groundwater information at this location. Groundwater flows from the northeast to the southwest of the DSP area under a low hydraulic gradient with groundwater considered to be occurring close to the surface in low-lying areas of the DSP area. An assessment of the extent of surface inundation was undertaken based on the interpolated annual average groundwater contours and topographic contours of the DSP area to investigate the likely extent of mosquito breeding habitat. Results of this indicate that there is likely no risk of surface inundation within the DSP area but areas of inundation being noted adjacent to the DSP area to the north, west, south and east.

All of these locations are associated with existing wetlands (Stakehill, Anstey and Paganoni Swamps) or hydrological features (i.e., Serpentine River) with the greatest amount of inundation being associated with the AAMax groundwater contours (**Figure 6**).

The AAMax levels have been used to delineate the extent of seasonal inundation for the purposes of identifying potential mosquito breeding habitat. Based on existing information, inundation depths (AAMax) on the western wetland chain are a maximum 1 m. Inundation depths in the adjacent Serpentine riverine system are up to 3 m.

While this mapping is considered appropriate for the purposes of this MRAMP, it should be further refined with additional site-specific hydrological investigations to support the future stages of planning (e.g., (Local) Structure Plans) within the DSP area.

3.5 Vegetation

Over two-thirds of the DSP area is identified as belonging to the Karrakatta Complex-Central and South. This vegetation complex is described as “Predominantly open forest of *Eucalyptus gomphocephala* (Tuart) – *E. marginata* (Jarrah) – *Corymbia calophylla* (Marri) and woodland of *E. marginata* – *Banksia* species (Webb A. *et al.* 2016).

The south-east portion of the DSP area is identified as belonging to the Yoongarillup Complex. This vegetation complex is described as “Woodland to tall woodland of *E. gomphocephala* with *Agonis flexuosa* (Peppermint) in the second storey. Less consistently an open forest of *E. gomphocephala* – *E. marginata* – *C. calophylla* (Webb A. *et al.* 2016).

4. MOSQUITO BIOLOGY AND ECOLOGY

To understand the complexities of the transmission of mosquito-borne disease and nuisance mosquito problems, the life cycle and habitat preferences of the various mosquito species found within the DSP area need to be understood (Russell 2009).

4.1 Mosquito Life Cycle

The mosquito life cycle identified on **Plate 1**, consists of four distinct stages: egg, larva, pupa and adult. The larval and pupal stages of the life cycle are aquatic, feeding on microscopic organisms, decaying vegetation or bottom detritus, however it is only the adult that is regarded as a pest. Adult female mosquitoes require a blood meal in order to obtain the necessary protein required to produce a large number of eggs (usually between 100-500).

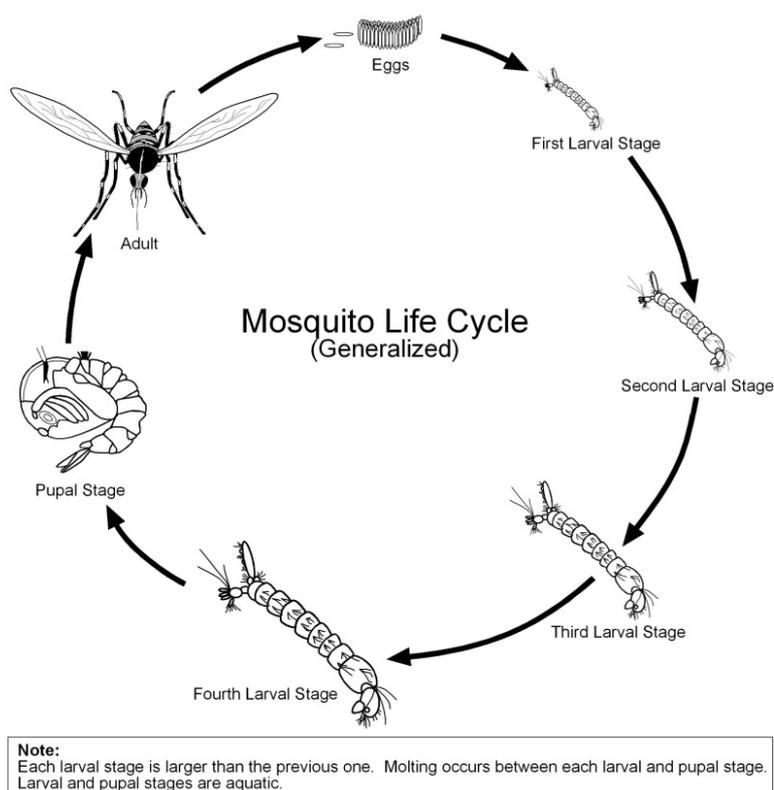


PLATE 1: Mosquito Life Cycle⁵

4.1.1 Egg

Depending upon the species, an adult female mosquito may lay several hundred eggs on or around a water body, and all require water for their complete development. The eggs of the *Anopheles* species are laid singly on the surface of the water and are not resistant to desiccation and therefore will not be viable if the waterbody dries out. *Anopheles* species are therefore generally associated with permanent or semi-permanent waterbodies.

⁵ Source: Purdue University 2016, Mosquito Life Cycle (Generalized), Available from: <https://extension.entm.purdue.edu/publichealth/images/downloads/lifecycle-mosquito.jpg>

The eggs of the *Culex* species are laid in rafts of up to 200 eggs which float the water surface. The eggs are not resistant to desiccation and are also generally associated with permanent or semi-permanent waterbodies. The eggs of the *Aedes* species are laid singly on the damp edges above the receding waterline. Resistant to desiccation, the eggs can remain viable for a considerable amount of time until the area is inundated through rainfall or tidal action. *Aedes* species are able to colonise a wide range of breeding sites from temporary to semi-permanent or permanent sites which have fluctuations in water level. An important feature of the *Aedes* species is that not all of the eggs will hatch at the same time. Some will hatch a few days after the initial hatch and a portion will not hatch until the site is inundated at a later date.

4.1.2 Larva

The egg hatches out into a larva that is entirely aquatic and goes through four developmental stages known as instars, with the average larval development time being between five and seven days. Larva feed on microscopic organisms in the water or on decaying vegetation with some species habitually feeding at the water surface (e.g., *Anopheles* sp.), some in the middle range below the surface (e.g., *Culex* sp.) and others typically feeding on the bottom (e.g., *Aedes* sp.).

The rate of larval growth or development through the larval stages is dependent on a number of environmental factors including temperature, larval density within the breeding site and the availability of food with different species exhibiting varied rates of development depending on ambient conditions. During summer when environmental conditions are most favourable, *Anopheles* and *Culex* species may complete larval development within seven to 10 days, which *Aedes* species may take only four to five days.

4.1.3 Pupa

After the larva has developed to the fourth instar stage and completed its growth within this stage, it moults and develops into a pupa. The pupa is still mobile but has ceased feeding. The pupa will generally complete its development in water; however, it does have the ability to survive in a moist environment if the breeding site dries out before the adult mosquito has emerged. The duration of the pupal stage is dependent on temperature but is generally in the order of two to three days for *Anopheles*, *Aedes* and *Culex* species and six to nine days for *Coquillettidia* species. The adult mosquito develops within the casing of the pupa.

4.1.4 Adult

After emerging from the pupal casing the adult mosquito rests on the water surface to allow its cuticle to harden. Males will generally emerge before the females and will often have a shorter life-span. Upon emergence, the first meal for both sexes are a carbohydrate meal of nectar or plant juices. Mating will then take place usually near the breeding site and often at dusk. Females only mate once with the sperm packet serving to fertilise all batches of eggs that she produces. In order for the development of the eggs to occur, the female requires protein which may be provided either from nutritional reserves from the larval stage or from blood. While males do not bite humans or feed on blood from any source, the females will seek a blood meal before embarking on an ongoing cycle of feeding, resting, egg development and egg laying.

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 generally survive for no more than four weeks. However, with vector species, the older the female becomes the greater the concern with regard to disease transmission because there will be a greater

chance that she will have taken an infected blood meal and be able to pass the infection on to the next host animal.

4.2 Breeding Habitat

Mosquitoes have the ability to breed in a number of habitats depending on the species, including:

- Saltmarsh – coastal, saline or brackish;
- Freshwater – rivers, lakes, inland or coastal;
- Shallow flooded plains and grassland;
- Permanent or temporary lakes, ponds, drains, creeks;
- Low-lying lands with standing water;
- Main and roadside drains;
- Constructed wetlands; and
- Domestic containers around the home including pot plant plates and trays, septic tanks, drains and gutters, water tanks, neglected swimming pools and ponds.

Most mosquito species are active for only part of the year determined by the seasonal availability of breeding sites. Regional and local weather will generally have the greatest influence on the production of mosquitoes for a given area over short periods of time (Whelan, 2019), with most species displaying a pattern of seasonal abundance with fluctuations associated with meteorological conditions (Russell 2009).

Mosquito breeding requires optimal weather conditions with rainfall, temperature and humidity being the major factors in their breeding life cycles, often dictating how long standing water will support breeding, how quickly the breeding cycle will be completed and how active the emergent adults are. Once the adults have emerged, temperature, humidity, and wind speed and direction will all influence how far and wide adult mosquitoes will disperse.

Eight species of mosquito have been consistently represented in the adult monitoring traps conducted during the course of the monitoring programme undertaken by the City during 2022-2023. **Table 2** (over the page) summarises the breeding habitat characteristics and the pest/nuisance and vector status (i.e., whether the species is a known or potential carrier of RRV, BFV, MVE or Kunjin) of each species.

4.3 Temperature

The time taken for development from egg to adult varies greatly with environmental variables, particularly temperature (Whelan 2019) which plays an important role in relation to adult mosquitoes: extremes of temperature are detrimental to adult populations reducing their number to below nuisance levels quickly, while milder temperatures assist their survival and dispersal (Lindsay 2011). Some species may take weeks to develop, or even enter 'larval hibernation' under winter conditions, while the same species may take four to five days to develop during the summer (Lindsay 2011). *Anopheles* and *Culex* species larvae respond to favourable summer conditions and may complete development within seven days while *Aedes* species may take only four days. Water temperatures of between 20-25 °C are favourable to most mosquito species (Russell 2019).

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TABLE 2: Major Breeding Characteristics of Mosquito Species Trapped in the DSP Area

Species	Breeding habitat characteristics	Pest	Vector risk	Dispersal capabilities	Active season
<i>Aedes camptorhynchus</i>	Brackish to fresh ground pools and tidal saltmarsh areas.	✓	RRV, BFV	3-5 km from breeding site	Winter, Spring and early Summer
<i>Aedes hesperonotius</i>	Generally, appears to breed mainly in tea-tree swamps.		RRV	1-3 km	August-October
<i>Aedes notoscriptus</i>	Tree holes, rock pools, artificial containers (domestic water supply, pot plant plates, stormwater drains).	✓	RRV, BFV in humans and heartworm in dogs	0.4 km	Year round
<i>Aedes ratcliffei</i>	Fresh groundwater pools with or without vegetation, often in shaded swamps with high tannin content.	✓	RRV, BFV	1 km	September-November
<i>Aedes vigilax</i>	Temporary pools in coastal saltmarshes that flood during high tides or by rain and brackish swamps.	✓	RRV, BFV in humans and heartworm in dogs	100 km	October-April
<i>Anopheles annulipes</i>	Temporary and permanent pools, streams and along edges of wetlands, generally freshwater but also in polluted and brackish water. Will also use artificial containers.	rare	Potentially RRV but not considered an important vector	Unknown	In the South-West all year round peaking in Summer
<i>Culex annulirostris</i>	Shallow freshwater sites, also brackish and polluted waters, usually with vegetation. Breeding can be prolific in low-lying areas that hold water for a few weeks after heavy rain.	✓	Most important mosquito disease vector in Australia. Vector of RRV, BFV, Kunjin and MVE in humans and heartworms in dogs.	10 km	November-March
<i>Culex globocoxitus</i>	Freshwater swamps and ground pools.		Yielded isolates of RRV and BFV. Does not generally bite humans.	No data	All year, peak season July-November

Sources: Department of Health 2019a; Russell 2009; Webb C. *et al.* 2016

4.4 Rainfall

Mosquitoes are often most prolific in very temporary waterbodies, however, within a particular habitat, other factors such as sunlight or shade, the presence or absence of emergent vegetation and predators, as well as prevailing winds may also be key factors determining breeding habitat formation.

With a breeding cycle of two-four weeks, the length of time that the surface expression of groundwater is found on-site is an important determinant in increasing the duration of breeding habitat availability for some species (Lindsay 2011). For example, *Aedes camptorhynchus* will breed in a wide range of temporary swamps, ground pools and coastal brackish water/tidal saltmarsh areas over the autumn-early summer period, being especially abundant during winter. A rapid rise in the number of *Aedes* species can be expected soon after rainfall or high tides that top up ground pools (Lindsay 2011).

4.5 Wind

Wind is an important determinant in reducing the likelihood of mosquitoes in wetlands with expanses of open water as increased wave action on the water surface will reduce the insect's survival prospect and prevent mosquito breeding by disrupting the larvae and pupae at the water surface (Midge Research Group of Western Australia 2007). Wind action can also prevent the spread and hinder the growth of algae, aquatic floating ferns and duck weed that offer shelter and protection to larvae from both wave action and aquatic predators (Australian Mosquito Control Association 2008).

4.6 Tides

Since the opening of the Dawesville Channel in 1994, the Peel Inlet, Harvey Estuary and the lower reaches of the Murray and Serpentine Rivers have experienced the anticipated impacts of higher and more frequent tides. This has led to changes in the estuarine ecology, particularly the fringing riparian vegetation, and with it an altered regime of tidal and wind driven flooding upstream.

The Serpentine River experiences tidal exchange up to a point that is located approximately 4 km between Lake Road Bridge and Karnup Road Bridge, resulting in tidal exchange to the north of Lake Amarillo (Siemon *et al.* 1993). The tidal exchange results in flooding of the narrow fringing saltmarshes along the extent of the Serpentine River and Goegrup Lake to the southwest of the DSP area during normal winter tides (Water and Rivers Commission 1998).

The major vectors of arboviruses within the southwest of Western Australia are the saltmarsh species *Aedes camptorhynchus* and *A. vigilax*. These species predominantly breed in temporary, brackish saltmarsh areas associated with riparian environments such as those associated with the Serpentine River. These temporary pools are often formed after inundation by very high tides. In addition, local rainfall events, flooding and wind can cause the pools to flood and initiate larval hatching.

A distinct interrelationship has been shown to exist between tidal heights reached within the Peel Harvey estuary system and mosquito breeding sites that determine the scale, degree and regularity of saltmarsh mosquito breeding activity (City of Mandurah 2019). Observations indicate that tide heights in excess of 0.76 m recorded at the Peel Inlet station have the potential to inundate the lower lying fringing samphire areas of the Serpentine

River triggering the hatching of eggs and a new cycle of larva (**Appendix 1**). At levels below 0.80 m, the most northerly extent of any inundation would appear to vary depending on prevailing winds at the time of the peak tide⁶.

4.7 Dispersal

Many mosquito species produce only one generation per year, while others can have two to five or more. Under favourable environmental conditions, and by having a high reproductive potential and short life cycle, the abundance of mosquitoes can increase reaching nuisance levels in a very short space of time.

While many species typically move relatively short distances (50-100 m) from their larval habitats (providing appropriate blood sources are available in the vicinity), some species have a flight range of 1-5 km; this is often wind-dependent. Dispersal is therefore an important factor in mosquito ecology and vector management decision-making process.

Physical buffers protect residents from mosquitoes as many species are not known to travel long distances. By example, representative dispersal distances are indicated in **Chart 2**.

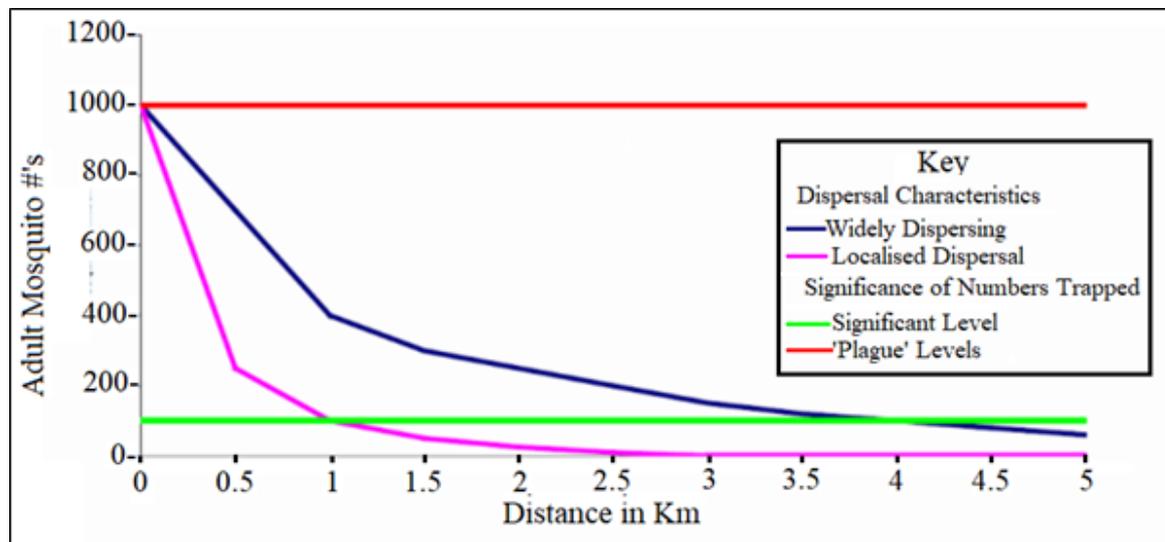


CHART 2: Typical mosquito dispersal distances (modified from Ballina Shire Council 2006)

⁶ Observations of tidal height inundation and mosquito species abundance were as a result of mosquito monitoring conducted by Rankine Mosquito Management during the proposed Keralup Scheme Amendment between 2008 and 2013 (Water and Rivers Commission 1998).

5. EXISTING MOSQUITO ENVIRONMENT

5.1 Ground Survey Assessment

A ground survey assessment and mapping of potential mosquito breeding sites throughout the DSP area and immediate surrounds was identified as a key objective.

Prior to undertaking the ground survey, a desktop survey of detailed aerial imagery (scale 1:100000 and 1:5000) of the DSP area and the Department of Biodiversity, Conservation and Attractions (DBCA) *Geomorphic Wetlands of the Swan Coastal Plains* dataset mapping⁷ was undertaken to identify potential mosquito breeding sites.

During the ground survey assessment undertaken in April 2023, the location of potential mosquito breeding habitat identified for assessment (either during the desktop survey or found to be present during the ground survey) were recorded using a GPS unit for later digital mapping. In some areas, particularly in Anstey Swamp, accessing potential breeding habitat was made difficult by the dense thickets of vegetation bordering the wetland.

Completed ground survey field sheets are provided in **Appendix 2**.

While there was limited opportunity for mosquito larval dipping to be undertaken (many areas observed were dry or inaccessible due to thick ground storey vegetation), in the several instances where standing water was accessible, qualitative samples were collected and presence of larvae confirmed.

5.2 Larval Monitoring

The City has a network of eight historical larval monitoring sites (RD 01 to RD 08, 2014-2023) located east and generally south of the junction of Paganoni Road (i.e., focussed on recruitment from the Serpentine wetland chain). Data from RD 01 to RD 06 proximal to the DSP area is briefly reviewed. Larval dipping locations are identified in **Figure 7**.

The majority of monitoring sites are dry from late spring until the following sustained seasonal rainfall or long period return events. Additional factors that influence water presence at dipping sites includes tidal pumping, fluctuations of the underlying groundwater table, presence of breeding adults and ambient temperatures leading up to the larval monitoring event.

Larval density (defined as the number of mosquito larvae per m² of water surface) is calculated using the following formula:

$$\begin{aligned} N &= \text{Number of larvae in the sample} \\ S &= \text{Surface area of scoop cm}^2 (\pi \times \text{radius}^2) \\ \text{Number of larvae per m}^2 &= \frac{1000 \times N}{S} \end{aligned}$$

With **Table 3** summarising the results over the six-month period to mid-September 2023. The data is presented in **Chart 3** (over the page).

⁷ Source: *WA Atlas*, Available from: <https://www2.landgate.wa.gov.au/bmvf/app/waatlas/>

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TABLE 3: Larval Monitoring Results (20/02/23 to 12/09/23)

	20/2/23	23/2/23	1/3/23	2/3/23	8/3/23	27/3/23	3/4/23	5/4/23	11/4/23	17/4/23	24/4/23	1/5/23	4/5/23	17/5/23	22/5/23	18/7/23	25/7/23	28/8/23	5/9/23	12/9/23	
	s1	s2	s3	s4	s5	s6	s7	s8	s9	s10	s11	s13	s14	s15	s16	s17	s18	s19	s20	s21	
EES-07-R01	160	1380	900	6400	1420	1420	750	350	230	810	260			420	80				430	70	
EES-07-R02																					
EES-07-R03										580	170										
EES-07-R04										880	150	1080	410	480	160	3300	950				
EES-07-R05																1600	720				
EES-07-R06																3690	1090	780	750	90	
EES-07-R07	130	810	270	1020	510		350	850	30	890	220	700	380	540	140	530	240				
EES-07-R08	390	3020	1570	9950	1410		390	1520	510	810	0	500	220			1080	260		670	120	
criterion	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000

0	sampled but no larvae observed
dry/cns	did not or could not sample (dry or inaccessible due to flooding)
171	larvae collected but below treatment threshold (<1000/m2)
1200	larvae collected and above treatment threshold

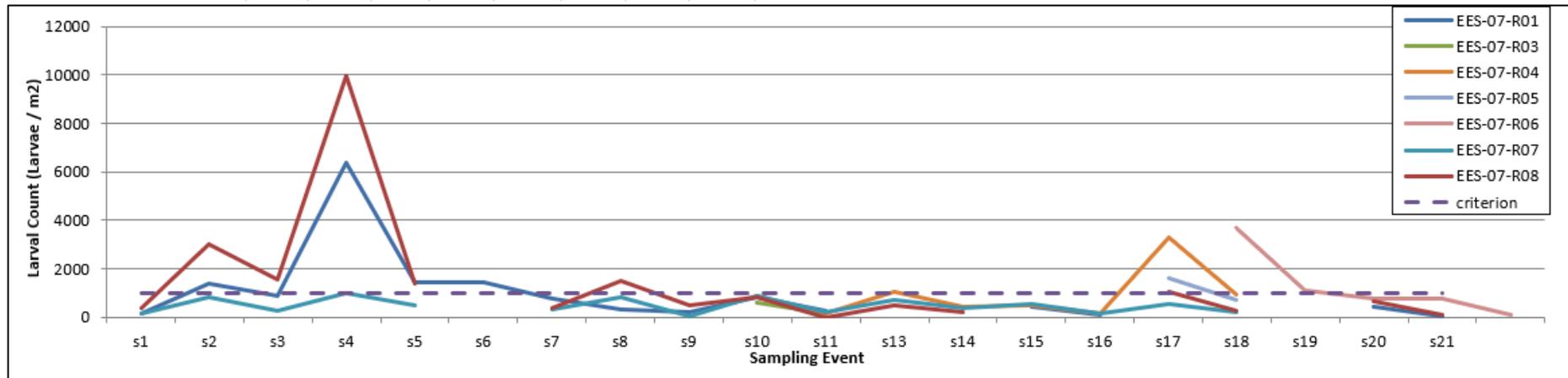


CHART 3: Larval Monitoring Graphed Results

Larvae, principally from *Aedes* species, were caught during each of the 21 monitoring events conducted six months to September 2023 and at sites able to be sampled (i.e., containing water and not flooded). When able to be sampled, larval densities (per m²) ranged from 30-9950/m². The highest estimated larval densities peaked at all sites sampled on the 2nd March 2023.

A management response (e.g., larviciding treatment) is generally triggered when larval numbers are more than the adopted criterion of 1000 larvae/m².

Experience of the PMMG indicates primacy of control of mosquito populations during the early larval stage. Early identification of large developing mosquito populations through the implementation of a rigorous larval monitoring programme can be used to trigger control responses using various chemical agents. Due to short mosquito recruitment time, the detection of large adult populations through trapping, and resulting treatment response is unlikely to inhibit a further emergence.

Long-term larval monitoring currently carried out by the City is coordinated with other PMMG members and focussed on the Serpentine wetlands. These data are combined with tidal records to identify responses, generally aerial treatments, to mitigate mosquito-borne diseases and suppress saltmarsh mosquito populations across the season. The PMMG notes larval monitoring as key in *...program's ability to respond with aerial larvicide treatments without hindrance was critical in achieving the season's outcomes* (PMMG 2023).

Control options for the management of mosquito larvae are discussed in **Section 7.2**. No programmed larval monitoring of Paganoni and Anstey Swamps is currently undertaken.

Summarised results of the City's ongoing larval monitoring programme reviewed here are presented in **Appendix 3**.

5.3 Adult Monitoring

5.3.1 Historical Monitoring Data

Two accessible historical datasets provide background information on mosquito species presence and numbers. These are summarised in **Table 4** (over the page) and complete results presented in **Appendix 4**.

Key parameters, averaged long-term adult trapping data is provided in **Table 5** and trap site locations shown in **Figure 7**.

Based on long-period monitoring at a series of monitoring sites within and immediately adjacent to the DSP area, the following points are relevant:

- The period of record is between 60 and 178 months;
- Both the Serpentine wetlands (HT-04) and Anstey Swamp (DOH13) are sources of mosquito breeding, with Anstey Swamp significantly more so; and
- HT-02 also reflects recruitment from Anstey Swamp.

TABLE 4: Details of Accessible Historical Datasets Accessed

Identifier	Source	Period		Length (months)	Description
		From	To		
HT-02	City of Rockingham	mid 2014 32°24'42.29"S	present 115°47'3.52"E	169	Near continuous extended period record of intensive site T5-central west in the DSP area and adjacent to Fletcher Road.
HT-03	City of Rockingham	mid 2014 32°24'33.40"	present 115°48'42.92"E	169	Near continuous extended period record of intensive site T7-central east in the DSP area.
HT-04	City of Rockingham	mid 2014 32°24'33.40"S	present 115°48'42.92"	169	Near continuous record 2014 to present between fringing Serpentine wetlands and Kwinana Freeway.
HT-08	City of Rockingham	mid 2014 32°24'59.73"S	Aug 2018 115°48'13.34"	68	Extended period record centrally within the DSP area.
MOH 12	Department of Health	Sept 2008 32°26'3.29"S	Jan 2012 115°47'5.59"	60	Extended period record of intensive site T6 - in southwest of the DSP area between Fletcher Road and Anstey Swamp.
MOH 13	Department of Health	Sept 2008 32°25'46.35"S	Jan 2012 115°47'10.62"	60	Extended period record of trapping in the south near central of DSP area adjacent to Paganoni Road.

The location of adult trapping with a brief analysis of the historical monitoring data for the period August 2014 to April 2023 is included in Appendix 4^{8 9}

Based on long-term monitoring at a series of monitoring sites within and immediately adjacent to the DSP area (as shown in Chart 4 over the page), the following points are relevant:

- Principal *Aedes vigilax* recruitment would seem to be from Anstey Swamp and the wetland extension to the south principally Paganoni Swamp (DOH12), particularly during the months December-April;
- In percentage terms, *A. camptorhynchus* is generally more prevalent within the DSP area and approximate the representation of *A. vigilax* at site HT-04 adjacent to the Serpentine wetlands; and

⁸ Limited further relevant trapping data is available from earlier Department of Housing studies undertaken as an input to the (then) Keralup Stage 1 Scheme Amendment. A number are described in the field record sheets presented as **Appendix 2**.

⁹ The historical adult mosquito monitoring program undertaken by the City and consultants acting on behalf of the Department of Health (DoH) involves setting out carbon dioxide (CO₂) baited light traps (EVS⁹ trap) that comprises a small incandescent bulb, a fan, a catching container and a solid insulated container that holds the dry ice (the source of CO₂).

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- Other significant mosquito species also trapped during the long-term monitoring data reviewed (not trapped during the City’s intensive monitoring) indicates:
 - *Aedes alboannulatus* has no known association with any human transmitted viruses; and
 - *Aedes notoscriptus* has been shown to be infected and may have an important role in RRV transmission.

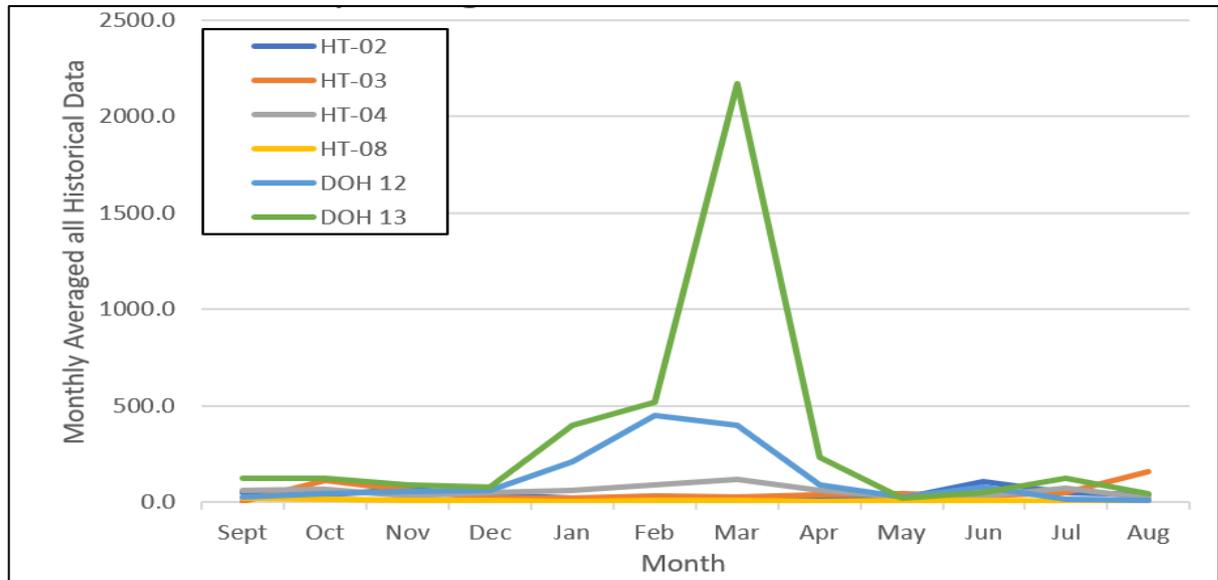


CHART 4: Monthly Averaged Captures, All Sites

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TABLE 5: Key Parameters and Averaged Long-term Adult Trapping Data

Trap Site	N	Total trapped	Speciation		Trap No.		Months #’s >50	Peak	Highest sp.	Abundance		Comments	
			Genera	Spp.	Range	Ave.				%	Next Highest Sp. %		
HT-04	166	10277	4	15	0-656	58.0	7	Oct Mar July	<i>Aedes camptorhynchus</i>	41.2	<i>Aedes vigilax</i>	11.3	Adjacent to Serpentine wetlands
HT-03	136	16302	5	15	0-880	49.9	3	Spring	<i>Aedes camptorhynchus</i>	58.1	<i>Anopheles annulipes</i>	14.1	Northeast, 1 km from Serpentine wetlands
HT-08	65	735	4	12	0-51	17.3	0	Spring	<i>Aedes camptorhynchus</i>	45.8	<i>Aedes vigilax</i>	26.9	Centrally within DSP area
HT-02	163	6672	5	13	0-580	42.0	2	Late Spring Winter/	<i>Aedes camptorhynchus</i>	59.1	<i>Aedes vigilax</i>	11.6	West central. Adjacent to Anstey wetlands
DOH 13	60	23252	4	14	0-12792	610.0	9	Sept-April	<i>Aedes vigilax</i>	81.8	<i>Aedes camptorhynchus</i>	9.9	West-southwest within Anstey wetlands
DOH 12	60	8916	4	13	0-2198	226.1	7	Late Spring/Autumn	<i>Aedes vigilax</i>	73.8	<i>Aedes camptorhynchus</i>	13.4	Southwest corner bordering Paganoni Road and wetlands

5.3.2 Intensive (Adult) Monitoring Data

From October 2022, a further 10 intensive monitoring sites were established by the City within the DSP area (**Appendix 4**), the characteristics and location of each of these sites are provided in **Table 6**.

TABLE 6: Details of Intensive Adult Trapping Sites

Location	Coordinates S	Coordinates E	Description
T1 – Yellow North	32°22'28.73"S	115°49'28.68"E	Parkland cleared woodland area located at the Karnup Road Picnic area (old school). Limited understorey.
T2 – Orange East	32°23'41.19"S	115°49'2.71"E	Grove of trees on elevated land in cleared former pasture. No standing water in vicinity.
T3 – Orange North	32°23'33.22"S	115°49'33.51"E	Grove of trees in cleared former pasture adjacent to small Resource Enhancement (dry) wetland (likely perched water table).
T4 – Red North	32°23'55.81"S	115°49'13.45"E	Grove of trees in cleared former pasture adjacent to small Conservation Category (dry) wetland (likely perched water table).
T5 – Yellow Centre	32°24'42.29"S	115°47'3.52"E	Low Open woodland of landscape planted trees at tourism site fronting Fletcher Road. Limited understorey of ornamentals and pasture grasses. Irrigation and occasional water filled containers.
T6 – Yellow South	32°25'26.97"S	115°47'0.45"E	Open forest of Eucalypts and <i>Banksia</i> with dense understorey within Anstey Swamp and in close proximity to Fletcher Road. Equates to MOH 12 site. Shielded from winds.
T7 – Red Centre	32°24'33.40"S	115°48'42.92"E	Cleared open woodland of <i>Agonis flexuosa</i> with pasture grasses under adjacent to Amarillo Drive. Exposed to prevailing winds.
T8 – Orange Centre	32°24'59.73"S	115°48'13.34"E	Previously cleared <i>Banksia/Casuarina</i> open woodland with minimal adjacent to Mallee Drive. Exposed to prevailing winds.
T9 – Red South	32°26'0.62"S	115°48'5.44"E	Stand of <i>Casuarina</i> on elevated land with minimal understorey. Exposed to prevailing winds.
T10 - Orange South	32°25'59.92"S	115°47'27.34"E	Occasional remnant tree in cleared land fronting Paganoni Road near the junction of Fletcher Road. Occasional pasture grasses on bare soils. Exposed to prevailing winds.

Monitoring site locations are shown in **Figure 7**.

Detailed site trap data is provided in **Appendix 4**, with key points summarised in **Table 7** (over the page).

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TABLE 7: Summary Intensive Adult Trapping Data

Parameter	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	Summary												
# events	18	16	18	15	21	22	21	18	18	18	Total events 185												
Ave #/trap/event	21.8	20.8	37.0	14.1	30.3	107.8	24.2	128.3	68	126	Ave all events 59												
Trigger (>50 count)	2	2	3	0	3	15	2	15	10	11													
Max. # any event	81	85	159	44	118	359	56	365	210	840													
Date of peak count	5 Dec 22	3 May 23	2 Jan 23	4 Apr 23	20 Dec 22	3 Jan 23	21 Feb 23	3 May 23	30 May 23	30 May 23													
Total female trapped	383	375	657	248	656	2379	538	2304	1483	2262	11285												
Dominant Species	Total	%	Total	%	Total	%	Total	%	Total	%	Total	%											
<i>Aedes camptorhynchus</i>	190	48	204	54	252	38	80	32	478	73	6500	55	338	63	1133	49	922	62	1584	70	6500	57.6	
<i>Aedes vigilax</i>	32	8	102	27	238	36	97	39	64	10	3274	28	123	23	892	39	463	31	594	26	3274	29.0	
<i>Aedes notoscriptus</i>	94	24	1		0		1	0	18	3	193	1	26	5	31	1	3	0	2	0	193	1.7	
<i>Culex annulirostris</i>	27	7	6	2	107	16	34	14	5	1	439	6	17	3	57	3	9	1	23	1	439	3.9	
<i>Culex globocoxitus</i>	2	2	39	10	37	6	34	14	14	2	329	2	6	1	38	2	76	5	36	2	329	2.9	
<i>Aedes hesperonotius</i>	34	9	0	0	4	1	0	0	48	7	344	6	5	1	115	5	0	0	3	0	344	3.0	
																						11079	98.2%

Based on short-period (12-month) adult trapping (10 sites) within the DSP area, the following points are relevant:

- A total of 11250 adult female mosquitoes were trapped in 185 trapping events at an average of 59 specimens/trap;
- Adult mosquito numbers were significantly lower in the central eastern and north-eastern portions of the DSP area, adjacent to Kwinana Freeway;
- Ten species from four genera were identified; of these six species (refer to **Table 7**) made up 98.2 % of total numbers trapped; and
- In relation to the species most often trapped:
 - *Aedes camptorhynchus* and *A. vigilax* comprised 57.6 % and 29.0 % of the total respectively
 - Next most common species trapped was *Culex annulirostris*, a distant 3 %

5.3.3 Discussion of Monitoring Data

Long-term adult monitoring data indicates that significant mosquito breeding is occurring both in the Serpentine wetland chain and Anstey Swamp. It could further be inferred that breeding also occurs in Paganoni Swamp south of Paganoni Road, with this having the potential to impact on the southern portion of the DSP area.

These general observations would seem to be supported by the limited adult intensive mosquito monitoring undertaken in the DSP area as follows:

- No data reflecting adult mosquito numbers in the northwest of the DSP area (refer to **note a in Figure 7**) is available from either the historical or intensive datasets. Accordingly, there is no measure of constraints posed by mosquitoes in this area;
- Trapping site T8 (central east) continually returns high adult numbers during trapping. Consistent with other central eastern and northeastern monitoring sites, the proportion of *A. vigilax* is higher relative to southwestern sites, possibly indicating the Serpentine wetland system as the primary recruitment source;
- The source of elevated adult trap numbers in the T8 area (refer to **note b in Figure 7**) should be further investigated to determine contributing breeding areas;
- Trapping site T6 (southwest central) continually returns high adult numbers during monitoring likely due to recruitment from Anstey Swamp and prevailing southwest afternoon winds;
- Trapping sites T10 and T9 (southern central and southeastern) within the DSP area continually return high adult numbers during monitoring events likely due to recruitment from Paganoni Swamp and prevailing southwest afternoon winds; and
- The Karnup Station Precinct located to the southwestern corner of the DSP area (refer to **note c in Figure 7**) occurs within 1 km of both Paganoni Swamp and seasonal waters in Anstey Swamp. To present, no monitoring has been undertaken that reflects this site.

The locations of the intensive and historical monitoring sites are shown in **Figure 7**.

6. NUISANCE AND HEALTH IMPACTS

6.1 Nuisance Complaints

All complaints are taken and recorded by the City's Environmental Health Officers (EHO). **Table 8** (over the page) identifies the number of complaints recorded by the City during the 2011-2023 timeframe. Of the suburbs identified, Karnup has the highest number of complaints recorded (91) followed by Baldivis (68)¹⁰

The following action(s) may be taken by the City depending on the nature of the complaint:

- An assessment of the location of potential mosquito breeding habitat through a site inspection and larval sampling where possible.
- Provision of educational brochures (e.g., *Fight the Bite*¹¹) to private property owners including residences.
- Setting up a mosquito EVS/CO2 trap at the complainant's property to determine whether there is a nuisance or disease risk. Mosquito species are identified and numbers counted to determine whether the nuisance or disease threshold is exceeded.
- Control strategies may be used at the source of breeding if found to exceed the threshold levels.

¹⁰ Source: Peel Mosquito Management Group (CLAG) *Mosquito Management Annual Report (2021-2022)*

¹¹ Western Australian Department of Health Fight the Bite campaign brochure available from: https://www.health.wa.gov.au/~/_media/Files/Corporate/general-documents/Fight-the-bite-campaign/brochure-at-home.pdf

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TABLE 8: City of Rockingham Mosquito Complaint Numbers by Year and Suburb

Suburb	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023*	Total
Baldivis	0	1	8	2	0	4	16	16	5	3	6	7	0	68
Cooloongup	1	2	2	0	0	0	1	2	1	2	4	5	0	20
Golden Bay	0	0	0	0	0	0	2	0	0	6	1	6	1	16
Hillman	0	0	0	0	0	1	1	4	0	0	0	0	0	6
Karnup	1	1	1	0	0	0	2	4	0	26	14	19	23	91
Port Kennedy	0	1	2	0	2	2	6	24	3	1	1	8	3	53
Rockingham	0	0	4	2	0	5	6	5	4	5	10	9	2	52
Safety Bay	0	0	0	0	5	0	4	1	3	2	1	1	2	19
Secret Harbour	0	0	1	0	0	0	3	4	1	0	1	3	1	14
Singleton	0	0	1	1	0	1	2	0	0	13	9	10	4	41
Shoalwater	0	0	4	0	1	0	0	0	3	0	0	2	0	10
Waikiki	0	1	2	2	1	0	0	2	1	1	0	3	1	14
Warnbro	0	0	0	1	0	1	3	3	1	1	1	2	0	13
Total	2	6	25	8	9	14	46	65	22	60	48	75	37	417

Source: PMMG/CLAG (2022)

6.2 Acquired Cases of Mosquito-borne Disease

As previously discussed, the two most common mosquito-borne viruses causing human disease that are of public health concern to the DoH in the South-West of Western Australia are RRV and BFV (Department of Health 2011).

Under the *Public Health Act 2016*, confirmed cases of both RRV and BFV diseases are notifiable meaning that a medical practitioner who diagnoses a patient with either of the viruses is required to inform the DoH of their diagnosis. Once the DoH informs the City of the mosquito-borne disease notification, a City EHO will conduct an interview with the patient in an attempt to identify the most likely place of exposure to the mosquitoes.

The RRV serologically confirmed cases, doctor-notified and laboratory reported data for the City, provided by the DoH identified the following cases of RRV and BFV in the City during the 2021-2023 timeframe (**Table 9**).

TABLE 9: Reported Cases of Mosquito-borne Diseases (2021-2023)

Mosquito-borne Disease	No. Notified Cases		Long-term Average	
	2021-2022	2022-2023	2021-2022	2022-2023
RRV	18	24	35.8	30.6
BFV	0	0	0.6	2.3

Source: Peel Mosquito Management Group 2021-2023

The long-term cases of notified RRV and long-term mean over the 2010-2022 timeframe are shown in **Chart 5** (Peel Mosquito Management Group 2022). Peak notifications are often associated with a strong *La Nina* event due to increased rainfall and higher tides.

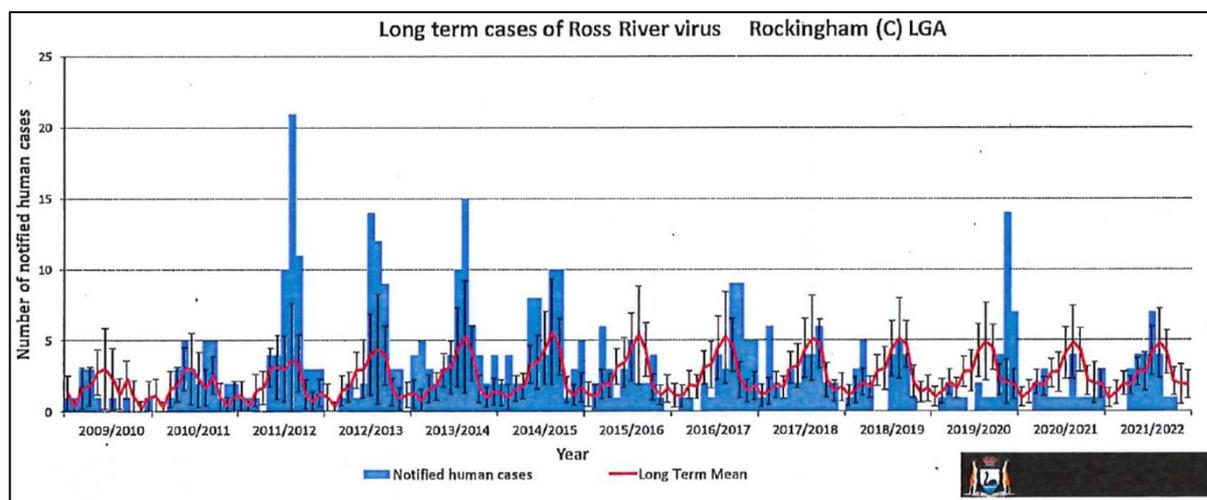


CHART 5: Long-term Cases of Ross River Virus (Rockingham LGA)¹²

¹² Source: Peel Mosquito Management Group (CLAG) *Mosquito Management Annual Report (2021-2022)*

7. RECOMMENDATIONS FOR MOSQUITO MANAGEMENT

For subdivision and development of the DSP area to occur, significant adjacent mosquito habitat areas will also need to be appropriately managed. It is acknowledged that while the mosquito nuisance and disease risk will not be fully eradicated, the following integrated management approach provides a basis upon which chemical and physical controls and education together with land use spatial planning can guide the future development of the DSP area with an acceptable level of risk.

7.1 Monitoring

The principal of the monitoring programme is to enable effective management of vector and nuisance mosquitoes in the DSP area to ensure that the health and amenity of residents and occupants are protected without undue adverse environmental impacts. It is anticipated that intensive mosquito monitoring will be undertaken concurrently with progressing work on the DSP.

7.1.1 Recommendations for Adult Monitoring

To further assess the risk of potential mosquito-borne disease in the DSP area, it is recommended that:

1. Intensive mosquito monitoring (two sites in addition to those making up the City's long-term monitoring programme) be conducted over a minimum of a further 12-months to establish mosquito population and species abundance over time.
 - a) Karnup Station Precinct in the southwest of the DSP area: There is no data at present from this specific area relating to either intensive or historical datasets. With the potential for visitation well into the evening and location within the area of influence (i.e., within 1 km in each case) of both Paganoni and Anstey Swamps significant mosquito breeding habitat, additional trapping in this location is recommended to be conducted by METRONET/DPLH (**Figure 7**).
 - b) Source of sustained high adult mosquito numbers at the Mallee Drive trapping site (adult site T8): This falls beyond the immediate zone of influence (1 km) from each of the Serpentine wetland chain and Anstey and Paganoni Swamps, and proximal to neighbourhood clusters. Further trapping with analysis of species representation would aid in confirming the location of breeding site(s) (**Figure 7**)

The selected sites identified in **Figure 7** should provide an overall representation of the potential breeding areas within the DSP area. The use of additional/reassigned adult monitoring sites will allow a more detailed evaluation of the mosquito breeding areas subject to time and cost of the monitoring.

Monitoring of adult mosquito populations will be carried out on a fortnightly basis between September and April (peak breeding season for most vector species), and once per month for the remainder of the year (May to August) using EVS/CO₂ traps suspended approximately 2 m above the ground in a sheltered position. The traps are to be set out in the afternoon and picked up early the following morning after sunrise.

When the traps are collected, the collection bags are to be removed and placed in cool boxes contained dry ice until they are processed. A record of ambient environmental data and trap information will also be recorded during monitoring.

Following identification of trap catches to species level, information including locality, date, collector's name, monitoring site, collection type, species and sex will be recorded on a speciation datasheet. Records of the trap results for each monitoring session and location will be added to an electronic database.

Data will be review on a monthly basis, although if trap numbers are higher than normal (particularly vector species) and exceed the thresholds during a given monitoring session, chemical control is recommended.

7.1.2 Recommendations for Larval Monitoring

Eight long-term larval monitoring sites have been established to quantify species and larval numbers within the Serpentine wetland chain east and immediately south of the Kwinana Freeway and Paganoni Road respectively (**Figure 7**). Results of a review of the most recent six months of data from site proximal to the DSP area are briefly discussed in **Section 5.2**. Long-term larval monitoring currently carried out by the City is coordinated with the PMMG members and is focused on the Serpentine wetlands chain.

There is no time-series data on larval recruitment in either Anstey or Paganoni Swamps which significantly limits the ability to identify breeding habitat, timing of emergence and contribution to adult mosquito nuisance within the DSP area.

Management of mosquito larvae in coastal wetlands (for example Anstey and Paganoni Swamps as opposed to the extensive estuarine systems in the Peel-Harvey System) present additional levels of complexity in that the DSP area is:

- Influenced by more complex (and less predictable) hydrological regimes;
- Representative of a broader range of vegetation habitats that makes accessibility difficult and canopy thickness would prevent aerial treatments;
- Generally, are in closer proximity to existing urban areas; and
- Managed for a broader range of outcomes by a range of agencies.

To establish a baseline to enable management decisions relating to larval control, it is recommended that:

2. A selection of additional larval monitoring locations (up to four) and otherwise as agreed to reflect productive areas within Anstey Swamp, be identified and regular larval monitoring be initiated for the period of additional adult monitoring followed by review.
3. A selection of intensive larval monitoring locations (additional two) be selected to reflect productive areas within Paganoni Swamp to be monitored for the period of additional adult monitoring followed by review.

Larval monitoring is to be carried out at the same frequency as the adult monitoring programme when surface water must be present.

The standard dipper is used to take 5-10 samples at regular intervals each monitoring point with each sample examined for mosquito larvae. Importantly, if larvae are present, the growth stages are to be recorded with late instar larvae and pupae extracted and reserve. Larvae and pupae collected should be allowed to develop such that species (where practicable) and the genus be recorded.

Other observations made and recorded onto field data sheets may include: depth/extent of standing water, distribution of the larvae, presence of other macro-invertebrates/waterbirds,

water quality or any event that it is thought may be impacting on either the waterbody or the mosquito larvae. Larval density (i.e., the number of mosquito larvae/m² of water surface) is calculated using the formula identified in **Section 5.2**.

The hydrology of Anstey Swamp is not well understood. Preliminary investigations (discussed in **Section 3.4**) were conducted using DWER's Water Monitoring Tool. The groundwater contours were interpolated based on the annual average groundwater levels of 11 bores located within and in the vicinity of the DSP area and indicate that inundation depths (AAMax) on the western wetland chain are a maximum 1 m., while inundation depths in the vicinity of the adjacent Serpentine riverine system is to 3 m.

4. Preliminary 'standing water levels' identified on **Figure 6** have been determined. These levels require further refinement at the LSP stage to inform planners on separation distances between proposed development area and mosquito breeding habitats.

7.1.3 Liaison with Statutory Land Management Agencies

A series of Swan Coastal Plains (SCP) wetlands have been identified within the DSP area (**Section 3.4** and **Figure 4**). The EPA, in drafting its *Position Statement 4* (PS4) (EPA 2002), builds on the *Wetlands Conservation Policy for Western Australia* (Government of Western Australia 1997) in defining clear objectives for the management of wetlands on the SCP. These objectives may conflict with the effective management of mosquitoes (e.g., larviciding, draining).

Clearing and urbanisation disrupt the natural hydrological regime in many wetlands, particularly those on the SCP. Many wetlands now reach a higher water level in winter, inundating more areas of vegetation, retaining water later during the annual cycle and keeping fringing vegetation covered for a longer period, to the detriment of ecological values.

Where effective larval control may require access to or modification to prescribed or other wetlands such as Anstey and Paganoni Swamps, a cogent argument and/or approvals from the land managers (i.e., DBCA) must be sought before change can be affected. It is recommended that:

5. The anthropogenic constraints to free drainage through Anstey Swamp in the form of constructed causeways have disrupted the natural drainage processes resulting in water being retained, increased vegetation growth and increased mosquito breeding habitat formation. These causeways should be assessed and opportunities to maintain free drainage identified with the DBCA as the land manager.
6. Early and ongoing liaison with the DBCA be initiated to develop mechanisms to communicate and undertake studies and works within prescribed wetlands with a view to allowing for the effective management of mosquito populations.

7.2 Control Options

Mosquito mitigation measures are currently in place for the Serpentine wetland system (Lake Amarillo) to the east of the DSP area, however measures have yet to be established for the western wetlands, namely Paganoni Swamp (due south of the DSP area) and Anstey Swamp (due west). Monitoring and management of the latter area has been found to be challenging to date due to the dense vegetation and generally inaccessibility of these sites.

Best practice Integrated Mosquito Management is an ecosystem-based strategy that focuses on the long-term management of mosquito populations to prevent the incidence of mosquito-borne diseases through the implementation of control options (Neville and Walker 2023). This combines various methods to minimise interaction between mosquitoes and the public to reduce the risk of mosquito-borne disease.

It is acknowledged that such a programme must be environmentally and economically sustainable over the long term (refer to **Section 10.2**).

Early identification of large mosquito populations through the implementation of a rigorous monitoring regime (larval and adult) may allow for a combination of the following direct or indirect control options to be implemented.

- Physical control – manipulating the existing environment to reduce mosquito breeding habitat or making conditions unsuitable for adult mosquitoes;
- Chemical control – through the application of chemicals to kill mosquito larvae; and
- Cultural controls – community-based educational programmes to inform residents and occupants how to prevent mosquito bites – cover up, repel, and clean up.

Direct interventions include, but are not limited to:

- Removal of breeding habitat by physical modification; and
- Application of larval growth inhibitors/larvicides.

Indirect approaches reduce human-mosquito conflict, for example:

- Utilising planning mechanisms to create adequate buffers from significant breeding wetlands;
- Adoption of planning practices in terms of:
 - Building design
 - WSUD appropriately considered to limit mosquito breeding habitat from forming
 - Notification on Certificate of Title
 - Development and implementation of site-specific Mosquito Management Plan
- An assessment of the location of potential mosquito breeding habitat through a site inspection and larval sampling where possible;
- Educating the public to avoid peak mosquito activity;
- Planting native sedges and harvesting exotic aquatic vegetation;
- Designing roads, prevention of animal and vehicle access into wetlands; and
- modifications to non-residential land uses (e.g., quarrying, market gardening, animal husbandry) are undertaken in such a way as to minimise the potential for mosquito breeding habitat being formed.

Once control strategies have been implemented, it is essential that ongoing monitoring and surveillance is carried out. This work is critical to the overall programme and will enable:

- Timely decision making regarding when management strategies need to be implemented;
- Effectiveness of management strategies to be assessed;
- Known mosquito breeding sites to be further defined; and
- Identification of potential new mosquito breeding sites.

These management strategies are further discussed in the following sections.

7.2.1 Physical Control

Drainage Systems

Development in the DSP area will incorporate WSUD principles as per the document *Better Urban Water Management*¹³ (Western Australian Planning Commission and Department of Planning and Infrastructure 2008).

When assessing the potential for existing stormwater infrastructure to create mosquito breeding habitat, the management measures identified in **Table 10** should be considered.

TABLE 10: Physical Control Measures to be Considered for Management of Mosquito Populations

Activity	Recommended Measure
Stormwater Mgmt.	<ul style="list-style-type: none"> • Post-development drainage to protected wetlands will not increase as a result of the development. • Ensuring that stormwater runoff throughout the development area is infiltrated in less than 96 hours, • Lots will provide adequate retention/detention to manage the first 15 mm of runoff from roof areas on site. • First 15 mm of runoff (1 year 1 hour ARI event) is infiltrated within 12 hours after cessation of rain • Monitoring for weeds, standing water and potential mosquito breeding in bioretention basin and drainage swales will be conducted quarterly, or in response to complaints or notifications • Maintenance of detention storage basins/drains should be undertaken on an annual basis to remove weeds, dead plants and to thin out vegetation as required in accordance with the various approved water management plans at development sites, or in City controlled basins • Stormwater pits should be designed to ensure that the base is free draining. • Drain design should discourage mosquito breeding by being shaped appropriately; incorporation of U-shaped drains which drain more effectively than L-shaped drains. • Where the base of a pit is located within groundwater average annual maximum groundwater level (AAMGL), the pit base is to be sealed. Outlet points are to be free draining for the system to empty. • Base invert levels of all swales, basins, sumps or other water infiltration feature are to have a minimum clearance of 500mm from the invert to the AAMGL • A gully optimisation program is established to service all pits within road reserves/swales/detention basins and be undertaken twice per year (at the end of autumn and beginning of spring), plus as required to prevent a build-up of organic matter and to ensure that the system remains free-flowing. • Outflow drains/bubble-up pits from swales and basins should be maintained regularly to ensure free flowing drainage is maintained
Nutrient Mgmt.	<ul style="list-style-type: none"> • Nutrient inputs (via fertilisation practices) will be managed as per an Urban Water Management Plan developed for the purpose to ensure that the water quality of the downstream environment does not decline

¹³ https://www.wa.gov.au/system/files/2021-07/GD_Better_Urban_Water_Management_0.pdf

Wetland Vegetation

Mosquitoes use surrounding wetland vegetation as harbourage or a protective corridor through to residents in search of a blood meal. Inappropriate landscaping in existing or proposed POS areas (e.g., thick groundcovers, dense shrubbery and hedging plants) and wetland buffers (e.g., restoration of wetland vegetation) has the potential to make these areas highly attractive to mosquitoes.

Management measures to prevent the formation of mosquito breeding habitat include, but are not limited to, those indicated in **Table 11**.

TABLE 11: Wetland Related Physical Control Measures to be Considered for Physical Control of Mosquito Populations

Activity	Recommended Measure
Mgmt. of Wetland Vegetation	<ul style="list-style-type: none"> • Maintaining the structural diversity of native plant species in rehabilitation and excluding weed/undesirable species Sedge growth within wetlands (in particular <i>Typha</i> sp.) and existing drainage basins should be thinned out annually (or on an 'as-needs' basis) and weed growth monitored and controlled. • A regular maintenance program is essential to ensure that any culverts within wetlands are working efficiently through the removal of organic matter build-up. • Floating debris and emergent vegetation should be removed on a regular basis to prevent dense stands from forming. • Vegetated areas within and/or adjacent to wetlands and drainage basins should be maintained in order to thin out dense stands of vegetation likely to impede water flow.

Landscaping and POS

The presence of bushland in urban areas increases the opportunity for mosquitoes to harbour in bush foliage. This is particularly true when bushland forms a continuous feature through buffer zones and/or urban residential areas.

Ideally, POS with limited vegetation should be located between the mosquito breeding habitat and residential areas to create an area that is refractory to mosquito dispersal, thereby reducing the number of mosquitoes potentially impacting residents and occupants. The peripheries closest to the known mosquito breeding habitat should be retained as either POS, or as low density as possible such as light industry, commercial, retail (A. Jardine, DoH *pers. comm.* 20/09/2023).

The POS within the DSP area should be regularly inspected and maintained to reduce potential mosquito habitat, including but not limited to activities listed in **Table 12**.

TABLE 12: POS Related Control Measures to be Considered for Physical Control of Mosquito Populations

Activity	Recommended Measure
POS Design	<ul style="list-style-type: none"> • To prevent harbourage habitat from forming, it is recommended that where statutes allow, clearing of dense vegetation should be considered if it presents an unreasonable mosquito risk of harbourage. • Open areas should be incorporated into the design to allow prevailing winds to disperse mosquitoes.
POS Mgmt.	<ul style="list-style-type: none"> • Grassed areas should be mowed regularly and clippings removed from site. • Nutrient inputs (via fertilisation practices) should be managed as per an Urban Water Management Plan developed for the purpose to ensure that the water quality of the downstream environment does not decline.

- Monitoring for weeds, standing water and potential mosquito breeding in POS and drainage swales should be conducted quarterly, or in response to complaints or notifications.

7.2.2 Chemical Control

Chemical control of mosquito larvae involves the application of chemical substances to physically damage or hormonally disrupt their development.

The use of chemicals must form part of a larger integrated approach to mosquito management and should be considered a 'stand-alone' control strategy. Every effort should first be made to prevent mosquito breeding through physical control activities, such as habitat source reduction or breeding site maintenance reducing the need for chemical applications. Avoiding over-application of chemicals with the same mode of action will also help to prevent the development of chemical resistance.

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. Pre- and post-treatment larval and adult mosquito monitoring is essential to assess the effectiveness of the application of larvicide.

The larvicides currently recommended by the DoH for mosquito control are S-methoprene, *Bacillus sphaericus* (*Bs*) and *Bacillus thuringiensis israelensis* (*Bti*):

- S-methoprene¹⁴ is a larvicide which is a highly specific insect growth regulator that interferes with the normal development of mosquito larvae, preventing the emergence of breeding, biting adults. This ingredient is exempt from the poisons schedule. The pellets are generally effective for at least 30 days, however environmental conditions can negatively impact the product's effectiveness and the length of time that it will remain active within the environment;
- *Bs* kills mosquito larvae when the larvae ingest the bacterial spores in moist or wet areas such as lakes, coasts, streams, swamps, and drainage ditches. No harmful effects are expected to occur to the public when pesticide products with this active ingredient are applied according to label directions¹⁵; and
- *Bti* is a biological or a naturally occurring bacterium found in soils. It contains spores that produce toxins that specifically target and only affect the larvae of the mosquito and is non-toxin to humans and could be effective in controlling mosquitos carrying Zika, dengue and chikungunya¹⁶.

These larvicides are exempt from poisons scheduling and are target-specific with respect to mosquito larvae and either kill the larvae or prevent the emergence of adult mosquitoes.

Where resources and access permits, larviciding is triggered by the presence of high numbers of mosquito larvae (1000 larvae/m²) are present and when the nuisance/vector species are trapped in significant numbers and where physical management of the site is not appropriate.

¹⁴ Further information online at: <http://www.pacificbiologics.com/index.php/larvicides/prolink>

¹⁵ USEPA https://www3.epa.gov/pesticides/chem_search/reg_actions/registration/fs_PC-119803_06-May-14.pdf

¹⁶ USEPA <https://www.epa.gov/mosquitocontrol/bti-mosquito-control##1>

Larvicides should only be applied in accordance with the manufacturer's instructions regarding recommended application rates using calibrated equipment by operator's who are trained in mosquito management.

As a general guideline for determining when to implement mosquito control measures, mosquitoes are considered a 'nuisance' when the number of adult mosquitoes trapped at a single location in an EVS/CO₂ trap exceeds 50 individuals over the normal sampling period (12-18 hours). In addition to the general threshold level described above, Lindsay (2011) notes that there are some general reference numbers when using CO₂ baited traps that can also be used for four mosquito species:

- *Aedes vigilax* - 20 adults represent a significant mosquito problem;
- *Aedes camptorhynchus* – counts of > 30 adults indicates that there is a mosquito problem;
- *Aedes notoscriptus* - counts of > 30 adults indicates that there is a mosquito problem; and
- *Culex annulirostris* – 100+ adults indicates that there is a mosquito problem.

Exceedances to the thresholds indicated above will confirm whether there is a disease risk requiring ongoing monitoring. It will help to validate residential complaints and may inform advice/requests to owners to implement a range of cultural control strategies (e.g., maintaining pool water quality, removing old vehicle tyres).

Chemical and/or Nutrient Reduction

Dense larval populations usually occur in nutrient-rich habitats that are often associated with fertiliser run-off from residential lawns and gardens, golf courses and agricultural activities. Channels draining urban areas similarly carry large nutrient loads, especially following early or unseasonal rainfall events. Community awareness and education regarding the proper use of fertilisers can avoid excessive run-off into artificial lakes, wetlands and streams thereby helping to reduce potential mosquito population increases.

7.2.3 Cultural Control

The public has a key role and responsibility in any integrated management programme to manage mosquitoes and it is important that the local community is kept informed so that they can be actively involved in ensuring their own well-being. Cultural control strategies include examining best practice as promoted in the DoH *Fight the Bite* campaign aimed at preventing mosquito bites – cover up, repel, clean up (Department of Health 2016).

Copies of the DoH information pamphlet *Fight the Bite* has and will continue to be made readily available to City residents at the Council Offices and on the City's website. The pamphlets provide personal preventative measures to avoid being bitten by mosquitoes. These personal measures are broadened to include construction and a range of residential activities listed in **Table 13** (over the page).

TABLE 13: Cultural Control Support Measures for the Management of Mosquito Populations

Activity	Recommended Measure
Construction	<ul style="list-style-type: none"> • Where possible undertake the early construction works between May to October to avoid peak mosquito activity season. • Undertake temporary drainage measures and remove vessels that may facilitate pooling of water. • Drainage or runnelling of periodic pools of stranding water following long period return rainfall events. • Workers to wear PPE (long clothing), be provided with mosquito repellent, undertake training/awareness raised during start-up meetings. • Minimise hours working at dawn and dusk.
Built Form Design	<ul style="list-style-type: none"> • The built form response should include: <ul style="list-style-type: none"> - fitting all doors and windows with insect screens and screened outdoor enclosures including a fully enclosed alfresco area associated with each dwelling - encouraging the use of yellow globes in exterior lights of houses and locating lights away from doorways - using blackout blinds and curtains - planting shrubs and plants that have open canopies to allow light and wind movement, thereby making them less likely to harbour mosquitoes during the day - avoiding plants that hold water in the core of the plant and can provide ideal breeding conditions for the species <i>Aedes notoscriptus</i>
Habitation	<ul style="list-style-type: none"> • Provision of educational signage within POS areas informing and educating the public about their responsibilities for personal preventative measures. • Notifying the DoH through the City when high numbers of vector species are observed or recorded on the site. • Notifying residents of management measures that can assist in eliminating potential breeding habitat including but not limited to: <ul style="list-style-type: none"> - disposing of all containers of water - emptying pot plant drip trays once a week or fill with sand - emptying and cleaning animal drinking water once a week - managing swimming pools by running the filter on a regular basis - regularly chlorinate your swimming pool and maintain disinfection levels - using a skimmer to remove any surface debris or dead leaves - when not in use (i.e., at night), placing a cover over the swimming pool to prevent chemicals evaporating • Filling in or draining depressions in the ground that hold water. • Avoiding over-watering lawns. • Screening rainwater tanks and/or add paraffin oil to cover the surface. • Ensuring roof guttering does not hold water. • Personal preventative measures that can be used by individuals to avoid being bitten by mosquitoes include: <ul style="list-style-type: none"> - avoiding being outside at dawn and dusk when mosquitoes are most active - ensuring insect screens on houses are installed and intact - installing café blinds or screens in outdoor entertainment areas to prevent mosquitoes entering these areas - wearing long, light-coloured, loose-fitting clothing when outdoors in mosquito-prone areas and at dawn and dusk - applying personal repellents to all areas of exposed skin containing DEET (N, N-diethyl-meta-toluamide) or Picaridin - in outdoor entertainment areas using mosquito repellents to repel mosquitoes - recognising and avoiding areas of mosquito activity - turning off outdoor lights to reduce mosquitoes that are attracted to light.

8. RISK AVOIDANCE THROUGH LAND USE PLANNING

The outcome of the data analysis undertaken has identified that mosquito issues are more widespread and potentially more impactful from a public health perspective than previously thought. As a result, the 1 km mosquito ‘flight zone’ measure applied under the current policy context significantly impacts the DSP area, and the ability for the land to be developed for primarily urban purposes as envisaged by the Planning Framework unless a more considered and pragmatic approach is adopted.

To inform the potential for residential development and other sensitive land uses in mosquito risk areas identified within the DSP area, a desktop review of relevant case studies has been undertaken by using the following documents for guidance:

- Shire of Murray (2018) Local Planning Policy – Mosquitoes.
- Northern Territory Health (2023) Guidelines for Preventing Biting Insect Problems for Urban Residential Developments at Subdivisions in the Top End of the NT.

8.1 Shire of Murray

The Shire of Murray (SoM) has been identified as having certain areas with frequent ‘high’ and occasionally ‘very high’ mosquito related disease risk according to environmental conditions (Department of Health 2016). Accordingly, the SoM has implemented a Local Planning Policy (LPP) that facilitates a risk management approach to mosquito mitigation at the development planning phase proposing the following buffers for residential related development in mosquito risk areas (**Table 14**).

TABLE 14: Buffers to Residential Related Development in Mosquito Risk Areas

Residential Lot Sizes	Distance to Saltmarsh
Minimum 2 hectares	0 – 300m
Minimum 1 hectare	300 – 500m
Minimum 4,000sqm (R2.5)	500m – 1km
Residential sized lots less than 4,000sqm (with rural-residential or cleared rural land buffer)	1 – 2km
Residential sized lots less than 4,000sqm (with no rural-residential or cleared rural land buffer)	km or greater

The SoM LPP identifies, in addition to residential development, other developments which may be sensitive to mosquito impacts and that is best ‘discouraged’ in buffer zones, including: tourist accommodation, lifestyle villages and night-time recreational developments.

In addition to this LPP, and in planning for the DSP area, more intensive urban development land uses that may potentially be deemed sensitive to mosquito risk may include education establishments (i.e., schools) or other large-scale developments whereby users spend extended periods of time outdoors. This may apply to courtyards, piazzas or the like, to Activity Centres, hospitals and other outdoor communal spaces where exposure to mosquitoes is increased.

8.2 Northern Territory

The Northern Territory health guidelines for biting insects recommends a 1.6 km buffer from large ‘uncontrolled’ areas of mosquito breeding habitat to urban residential unless the breeding sites are targeted for modification (NT Health 2023). Further recommendations, identified in **Table 15**, include rural-residential blocks being established closest to grassy creek lines, swamps and seasonally flooded areas, to reduce the density of people living adjacent to mosquito breeding areas, and to provide a diversion to mosquito dispersal.

TABLE 15: Distance to Mosquito Source

Residential Lot Sizes	Distance to Mosquito Source
2 ha or greater	0 – 300m
1 ha or greater	300 – 500m
0.4ha (4,000sqm) or greater	> 500m

The Northern Territory health guidance also recommends that where practicable, a semi-rural or rural subdivision or industrial buffer should be incorporated into a residential subdivision design to increase the effectiveness of the buffer zone. Incorporating rural-residential and/or an industrial land use as a buffer will generally reduce the separation of the risk down to 1 km.

8.3 Land use Planning Risk Assessment

It is recognised that mosquito mitigation measures are already in place for the Serpentine wetland system (Lake Amarillo) to the east of the DSP area facilitated through the PMMG. However, measures have yet to be established for the wetlands located west and south of the DSP area, being Anstey and Paganoni Swamps, respectively.

Monitoring and management of these wetlands from a mosquito management perspective is challenging due to the dense vegetation, high tree canopy, and general inaccessibility of these sites.

In response to these findings, a development strategy has been prepared by CDP Town Planning and Urban Design to guide recommendations of this response (**Appendix 5**). The development strategy references proven case studies in Western Australia and Northern Territory and provides various urban development scenarios commensurate with the level of mosquito mitigation and management applied. It is acknowledged that the level of intensification of urban areas will be subject to a multitude of land uses, environmental and physical design measures that will collectively be implemented subject to proximity to the mosquito breeding source.

If subdivision and development of the DSP area is to occur in accordance with the Planning Framework, mosquito habitat areas will need to be appropriately managed to minimise public health risk. It is acknowledged that the mosquito nuisance and disease risk will not be fully eradicated, however the development strategy provides a framework on which to guide land use spatial planning in the DSP area to arrive at a balanced outcome.

It is expected that mosquito management will include relevant DoH and Local Authority regulated treatment, including those programmes currently implemented by the PMMG.

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As recommended by the DoH, the use of chemicals to control mosquitoes will form part of a larger integrated approach to mosquito management and should not be considered a stand-alone control strategy. Every effort should first be made to prevent mosquito breeding through physical control activities, such as habitat source reduction and breeding site maintenance.

9. RISK ASSESSMENT OF DSP AREA

9.1 Risk Assessment Methodology

The term “risk” is defined as the probability of loss of suffering harm. The risk presented by increased exposure to significant mosquito breeding areas does not reflect a typical pollutant or health-based profile application, however the methodologies remain relevant in identifying stressors and outcomes. Potential impacts on residents, mosquito control technicians and the broader environment (e.g., habitat alteration, non-target insect mortality, vertebrate mortality) from control measures are all relevant.

A “risk assessment” process is used to estimate risks to the personnel, community members or the environment. Risk assessment and risk management tools are common for all forms of risk assessment. Further details of the Risk Assessment Methodology used is included in **Appendix 6**.

Health and environmental risk assessments are often complex and do not allow for development of a full numerical approach as for engineering risk assessment. Many aspects are not fully quantifiable or have a very large degree of uncertainty¹⁷. In order to overcome these problems, the risk is often assessed using so-call Risk Level Evaluation Matrices or Consequences-Frequency Matrices (CFM) which are diagrams with consequence and frequency classes on the axes.

This technique allows classification risks based on expert knowledge where quantitative data is constrained based on the frequency of occurrence of a particular event and consequence of the outcome. These are provided in various forms to address engineering, human health, or environmental concerns.

Risk assessment is informed by the findings of scientific or medical research. Jardine *et al.* (2015) provided empirical data on the prevalence of mosquito-borne virus infections within zones (1 km intervals) radiating from mosquito breeding habitat within the Peel region as shown in **Chart 6**.

The authors concluded that overall, the data show that those living within 2 km of mosquito breeding habitat were at increased risk of contracting RRV disease.

These data are supported by empirical data resulting from ‘mark and release’ studies such as occurred at Muddy Lake wherein the Shire of Capel determined flight ranges that indicated large numbers reported (66 %¹⁸) were recaptured within 1 km of the release point (Jardine *et al.* 2014), with the learnings being incorporated into guidance documents such as the SoM LPP¹⁹ (Shire of Murray 2018). The implications of the 1 km and 2 km flight ranges when applied to the DSP area are shown in **Figure 8**. However, as the field survey and monitoring data indicate, the impact of flight ranges will be varied based upon the location of known mosquito breeding habitats both on and offsite. To understand the potential risk and implications for future development of the DSP area, a detailed desktop analysis has been undertaken to refine the mosquito breeding habitat delineation based on hydrological data and aerial imagery for Anstey and Paganoni Swamps.

¹⁷ This may be related to the difficulty to define hazard scenarios, map, and characterize the elements-at-risk, or define the vulnerability using a vulnerability curve.

¹⁸ Two-thirds of the mosquitoes were recaptured within 1 km of the release site, a further 20 % within 3 km.

¹⁹ All proposed developments within 5 km of a defined mosquito source (e.g., the Peel-Yalgorup System) are required to undertake a risk assessment to determine the relevant planning and design measures that should be applied to the development.

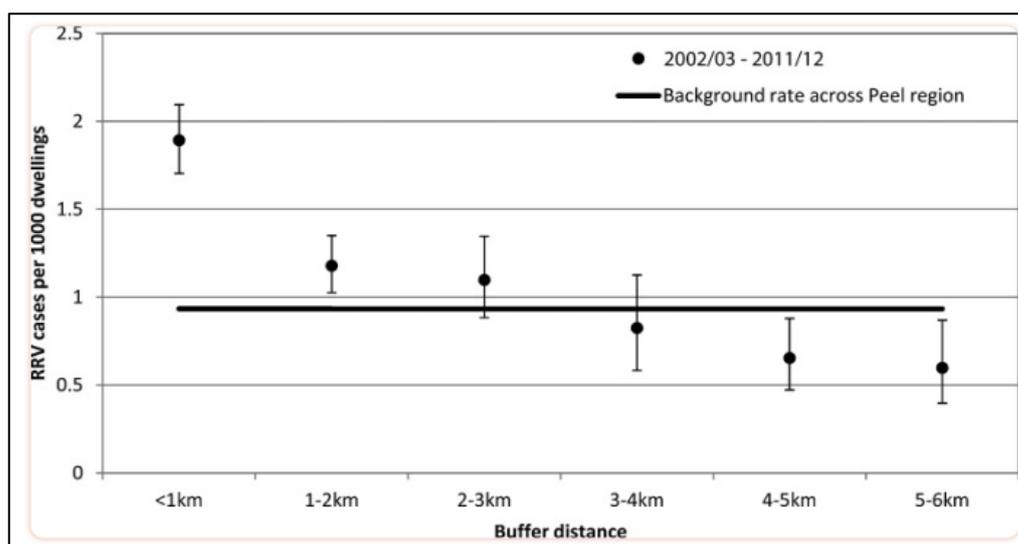


CHART 6: Number of RRV Cases/1000 Dwellings Versus Buffer Distance from a Mosquito Breeding Habitat, Peel Region (July 2002 - June 2012)

9.2 Risk Assessment Results

A risk assessment, consistent with the procedures of the SoM LPP, has been undertaken for the DSP area. The risk assessment identified that the pre-mitigation risk is generally assessed in the moderate to high range, with a single extreme assignment associated with the construction of residences within close proximity (assessed to be < 1 km) from known mosquito breeding habitat.

Table 16 (over the page) presents a risk matrix providing quantitative risk assessment and risk reduction potential for the DSP area during development. For brevity, key mitigation measures are identified and reference drawn to more detailed listings of measures provided in **Tables 10-13** inclusive.

Management measures identified have the potential to effectively reduce all identified risk scores to the moderate range through adequate separation, reducing productive mosquito breeding habitat and avoiding the potential for, and areas of mosquito activity whenever practicable.

It is important to note that in the risk matrix, the risk to construction workers is discounted as workers are:

- Normally fully-covered;
- Wear and are aware of the need to wear personal protective equipment (PPE);
- Generally aware of the hazards posed by mosquitoes and mosquito-borne viruses; and
- Generally absent during critical dawn/dusk periods (non-residential).

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TABLE 16: Risk Matrix Providing Quantitative Risk Assessment and Risk Reduction Potential for Karnup DSP

Activity	Factor	Impact	Inherent Consequence	Inherent Likelihood	Inherent Risk Score	Mitigation Measure	Residual Consequence	Residual Likelihood	Residual Risk Score
Construction Phase (Normally fully covered, wear of PPE, aware of hazards, absent during critical dawn / dusk period)	Local mosquito habitat(s) – pooling onsite (e.g., laydown areas, stockpiles, vehicle tracks, drums, tyres)	Reduced human health from mosquito-borne disease due to the creation of mosquito breeding habitat.	4	3	12	Prominent amongst those measures identified in Table 10 : <ul style="list-style-type: none"> Undertake temporary drainage measures and remove vessels that may facilitate pooling of water. Site Superintendent to be vigilant in monitoring the presence of standing water (monitor weekly). Drainage or runnelling of periodic pools of stranding water following long period return rainfall events. 	3	2	6
		Reduced amenity due to the creation of mosquito breeding habitat.	2	3	6		2	3	6
	Local mosquito habitat(s) – adjacent to wetlands	Human health – mosquito-borne disease	4	2	8	<ul style="list-style-type: none"> Where possible undertake the bulk of construction works between May to November. 	4	1	4
		Nuisance – mosquito presence onsite	2	3	6		2	2	4
	Presence of construction staff on-site	Reduced human health from mosquito-borne disease due to the creation of mosquito breeding habitat.	2	3	6	<ul style="list-style-type: none"> Workers to wear PPE (long clothing), be provided with mosquito repellent, undertake training/awareness raised during start-up meetings. Minimise hours working at dawn and dusk. 	3	2	6
		Reduced amenity due to the creation of mosquito breeding habitat.	3	4	12		<ul style="list-style-type: none"> Workers to wear PPE (long clothing), be provided with mosquito repellent. Minimise hours working at dawn and dusk. 	3	2

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Activity	Factor	Impact	Inherent Consequence	Inherent Likelihood	Inherent Risk Score	Mitigation Measure	Residual Consequence	Residual Likelihood	Residual Risk Score
Residential Occupancy	Drainage infrastructure – increased incidence of standing water prior to infiltration	Reduced human health from mosquito-borne disease due to the creation of mosquito breeding habitat.	4	4	16	Prominent amongst those measures identified in Table 11 : <ul style="list-style-type: none"> All drainage infrastructure is to be designed in accordance with <i>Better Urban Water Management</i> guidelines (Department of Planning, 2008): Retention and detention treatments to be designed such that immobile stormwater is infiltrated within 96 hours, to reduce health risks relating to mosquitoes. 	4	2	8
		Reduced amenity due to the creation of mosquito breeding habitat.	2	5	10		2	3	6
	Recreational use of Wetlands, Parks and POS	Reduced human health from mosquito-borne disease due to the exposure of residents to mosquitos	3	3	9	In addition to those measures identified in Table 12 : <ul style="list-style-type: none"> Nutrient inputs (via fertilisation practices) will be managed as per an Urban Water Management Plan Regular monitoring and management of weeds, standing water and potential mosquito breeding in POS and drainage swales 	3	2	6
		Reduced human health from mosquito-borne disease due to the exposure of residents to mosquitos	2	4	8		2	3	6
	Local mosquito habitat(s) – pooling water localised to individual lots (e.g., pools, ponds, tyres)	Reduced human health from mosquito-borne disease due to the creation of mosquito breeding habitat.	4	3	12	In addition to those measures identified in Table 13 : <ul style="list-style-type: none"> Notify residents on how to avoid potential mosquito vector mosquitoes by providing residents with the educational brochure <i>Fight the Bite</i> (Department of Health 2016). Notify residents on how to avoid potential mosquito nuisance by providing residents with the educational 	4	2	8
		Reduced amenity due to the creation of	2	3	6		2	2	4

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Activity	Factor	Impact	Inherent Consequence	Inherent Likelihood	Inherent Risk Score	Mitigation Measure	Residual Consequence	Residual Likelihood	Residual Risk Score
Local mosquito habitat(s) – adjacent and onsite wetlands and recreational use of parks and reserves		mosquito breeding habitat.				brochure <i>Fight the Bite</i> (Department of Health 2016).			
		Reduced human health from mosquito-borne disease due to the creation of mosquito breeding habitat.	4	3	12	<ul style="list-style-type: none"> Provide signage of educational material contained within the brochure <i>Fight the Bite</i> (Department of Health 2016) to alert users to the risk of mosquito-borne disease and nuisance mosquitoes. 	4	2	8
Location of lots within high-risk (<1 km) of significant mosquito areas		Reduced amenity due to the creation of mosquito breeding habitat.	2	4	8		2	2	4
		Reduced human health from mosquito-borne disease due to proximity to significant mosquito breeding habitat.	4	5	20	<p>In consideration of the separation distances to significant mosquito breeding areas as applied in other jurisdictions and discussion in Section 8.</p> <ul style="list-style-type: none"> Where possible, and through the application of planning land use mechanisms, locate larger lots and lower risk land uses closes to, and smaller lots furthest from breeding areas to create a buffer of ≥ 1km around major mosquito breeding sources. Impose notifications on title for lots in close proximity (< 2 km) to known mosquito breeding areas. <p>Table 13 is also relevant to this factor.</p> <ul style="list-style-type: none"> Dwellings to install mosquito screening on all external doors and windows and outdoor entertaining areas. 	4	3	12
		Reduced amenity due to proximity to significant mosquito breeding habitat.	2	4	8		2	2	4

10. IMPLEMENTATION AND REPORTING

10.1 Stakeholder Engagement

The effective management of mosquitoes is a complex issue and there needs to be a coordinated approach and a ready exchange of information between stakeholders for it to be successful. The City's engagement with key stakeholders for the development of the DSP area has already commenced.

Department of Health

Long-term and intensive monitoring of the DSP area and surrounds conducted by the City and the PMMG indicates that there is the potential for high levels of mosquito activity being observed in some areas. Advice from the DoH has been sought in order to determine the potential mosquito-borne disease risk for development of the DSP area.

Department of Planning, Lands, and Heritage

Consideration should be given to the location of the DSP area with respect to the potential impact upon future residents from mosquito activity. On the basis of the results of recommended further intensive monitoring, Council should continue to liaise with the DPLH to discuss the implications of siting any areas of intensive residential development that are particularly close to known mosquito breeding areas.

Consideration should be given to the following during the DSP planning process:

- Reducing densities where possible in high-risk areas through the implementation of zoning and land use control, lot sizes and buffers;
- Determining what physical controls (e.g., WSUD) are required to reduce the risk of additional mosquito breeding habitat being formed;
- Examining what built-form responses can be mandated in order to avoid ongoing human exposure to mosquitoes; and
- Incorporating cultural controls through public mosquito avoidance education via the City's website, deploying *Fight the Bite* and mosquito risk signage in existing and proposed POS areas.

Environmental Agencies

A major land manager within the DSP area is the DBCA, specifically wetlands and associated reserves identified in **Figure 4**. The area of land within the DSP area identified as *Geomorphic Wetlands of the Swan Coastal Plains* managed by the DBCA comprises approximately 33.2 ha.

Adjoining land that includes mosquito breeding and harbourage habitat includes Anstey Swamp, Paganoni Reserve and the Serpentine River Floodplain.

Due to the presence of EPA protected wetlands, WAPC Bush Forever Sites (Sites 379 and 278) and the DBCA reserves within the DSP area, liaison with the environmental agencies will be required to provide an effective regional approach to mosquito management.

Peel Mosquito Management Group

Regular monitoring incorporating the additional two adult monitoring sites will help in the understanding of the source of mosquito breeding habitat within the DSP area. Over the course of the proposed monitoring timeframe, monitoring data should be shared with the PMMG members to determine where specifically the risk of vector mosquitoes is located.

10.2 Funding of Mosquito Mitigation Measures

Mosquito management for the DSP area will require a collaborative between State and Local Government, including the DPLH, DoH and PMMG. Funding for any additional mosquito mitigation is currently very limited.

To enable treatment of Anstey and Paganoni Swamps, and therefore enable development of within the DSP area consistent with the Planning Framework, additional and ongoing funding from the State Government will be required.

Mosquito mitigation requires an upfront implementation strategy with a 'one-in-all-in' approach for all landholdings across the DSP boundary to ensure the orderly and proper planning of the DSP area from a land use spatial planning perspective.

The *ad hoc* development of individual landholdings without consideration of mosquito risk should be discouraged as, without the rigours of District Planning, the equitable provision and distribution of community and service infrastructure and complementary land uses will not occur.

Without District Planning to identify local needs, the lack of suitable land uses to support residential development will only expose the shortcomings of the local areas which placing unnecessary community and servicing infrastructure pressures on adjoining neighbourhoods/districts.

The 'one-in-all-in' approach to the preparation of a Mosquito Management Strategy and State Government funding to assist with mitigation will assist with the DSP area being developed to its full potential.

Without prejudice to any formal preparation and final funding arrangements, this is subject to Local and Stage Government review, the Development Strategy offers recommendations for the interim and ongoing management of mosquito mitigation.

10.3 Reporting

An annual report will be prepared capturing all management actions outlined in this MRAMP over the previous 12 months. The report should include, but not be limited to, the following:

- Results of the larval and adult monitoring programme;
- RRV/BFV disease notifications and follow-up documentation;
- Control strategies implemented;
- Details of any changes to the programme since the previous annual report was published;
- Details and activities undertaken as part of the educational programme;
- Recommendations for changes to the management actions and planning for the following year; and
- Any significant events, findings and recommendations.

A copy of the annual report will be forwarded to the PMMG and the DoH for their review and comment.

The key management actions relating to programme implementation and reporting are summarised in **Table 17** (over the page).

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TABLE 17: Responsibility and Timeframe for Implementing Key Management Actions

Issue	Management Action	Area	Responsibility	Timeframe
Larval Monitoring	Monitoring Program	Existing DSP area program	City of Rockingham	Ongoing
		All areas off-site	PMMG	Ongoing
Adult monitoring	Monitoring Program	All areas onsite*	City of Rockingham	Ongoing
	PMMG Program	All areas off-site	PMMG University of Western Australia	Ongoing
Infrastructure Management	Bio-pockets and detention basin maintenance	All areas onsite	Developers (establishment period) City of Rockingham (following established maintenance period)	Ongoing
	POS maintenance			
	Implementation of WSUD throughout the DSP area			
Planning Controls	Wetland buffer management	All SCP wetland areas onsite	City of Rockingham WAPC	Ongoing
	Built-form controls	Onsite		
	Notifications on Title	All areas onsite		
Public education	Education and awareness program	All areas onsite	Developers	Ongoing
	Existing program	All areas off-site	PMMG	Ongoing
Reporting	Monitoring results	All areas onsite	City of Rockingham	Annually
	Program activities			Annually with a review every three years.

(Note: * 'all areas onsite' refers to public lands only. Monitoring and treatment of private property is the responsibility of the individual landowner)

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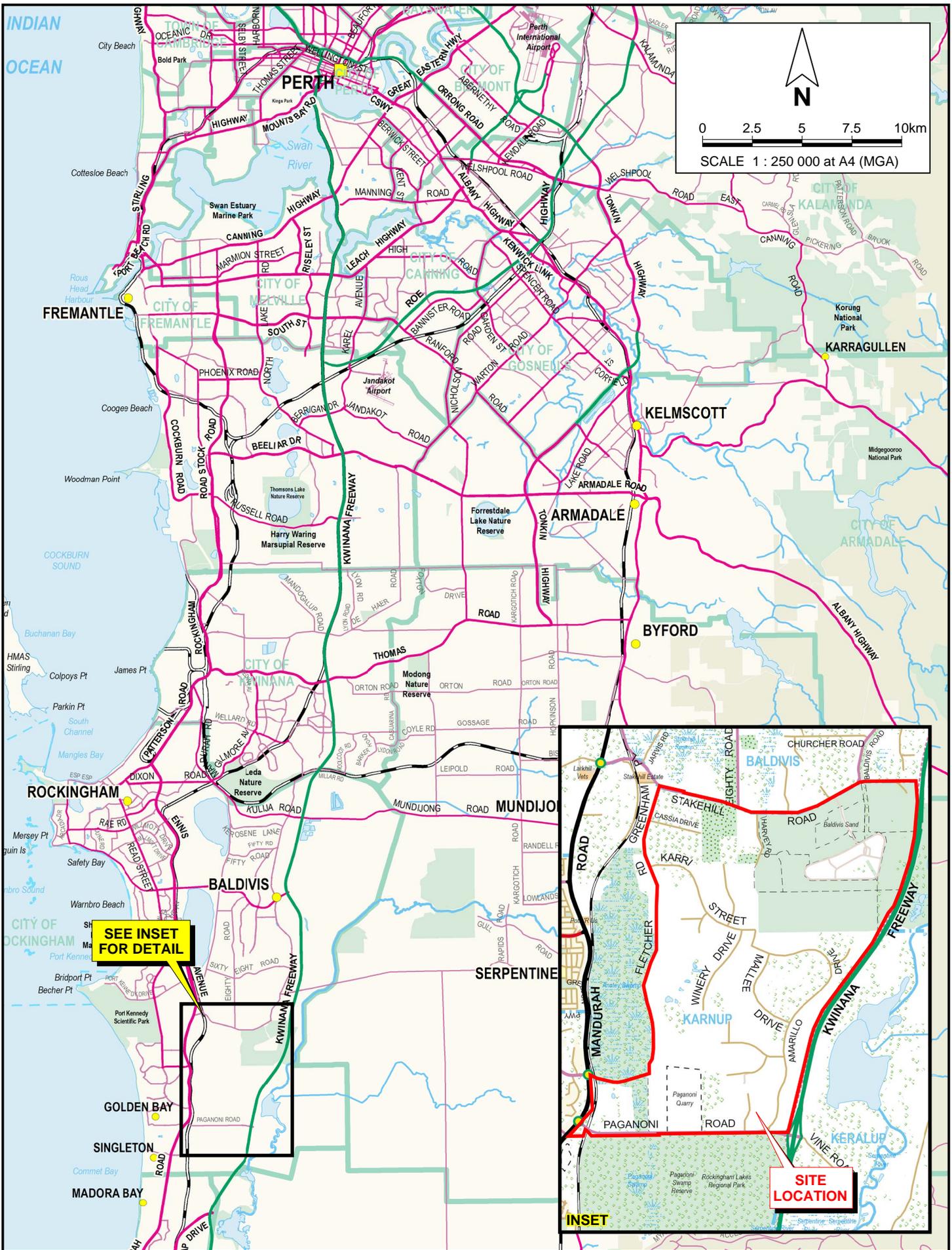
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FIGURES

KARNUP DISTRICT STRUCTURE PLAN

MOSQUITO RISK ASSESSMENT AND MANAGEMENT PLAN (MRAMP)

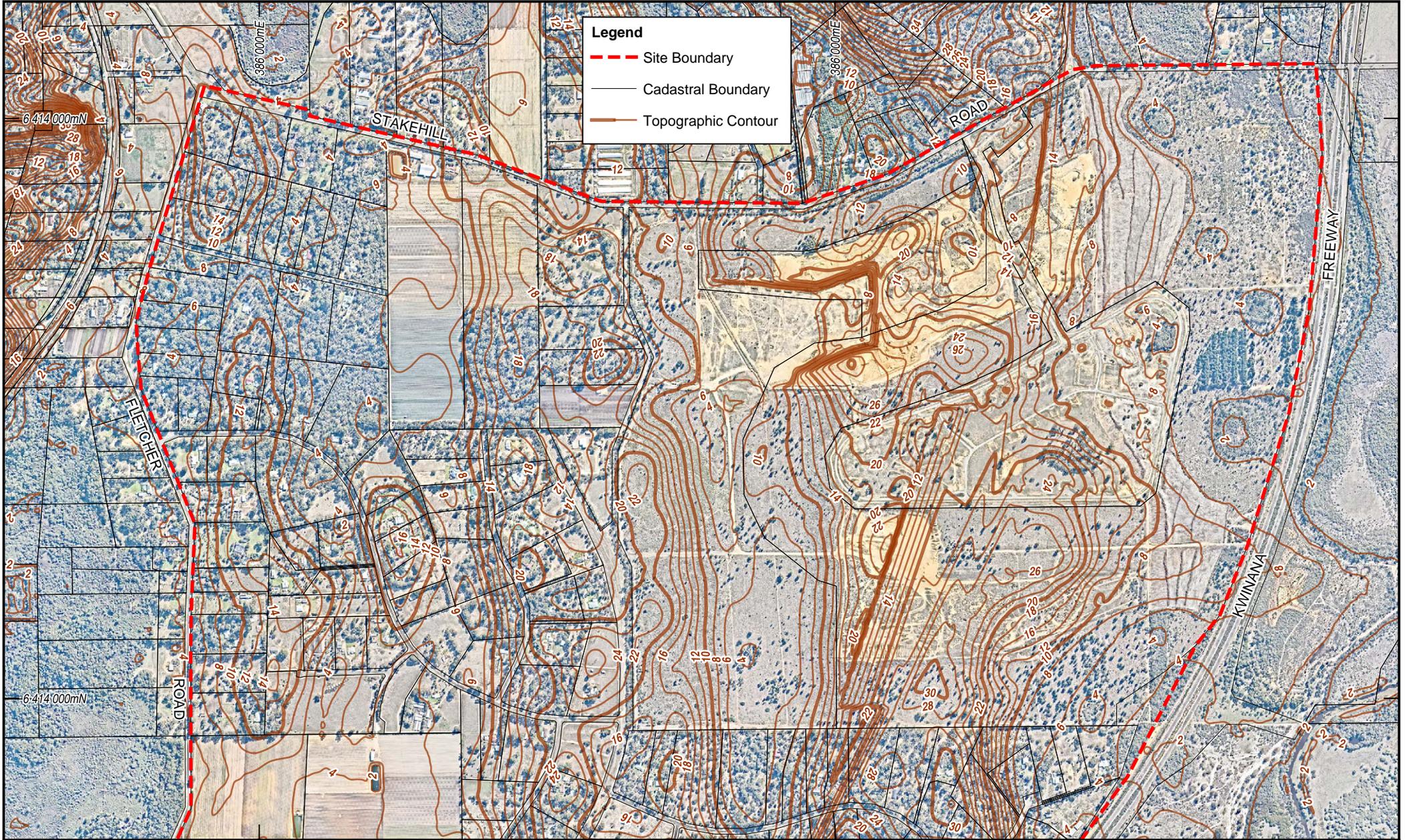


PINPOINT CARTOGRAPHICS (08) 9562 7136 EES-07_02-101.dgn

**Rankine
Mosquito
Management**

Emerge Associates
KARNUP DISTRICT STRUCTURE PLAN
MOSQUITO RISK ASSESSMENT AND MANAGEMENT PLAN
REGIONAL LOCATION

Date: 31 Oct 2023
Drawn: B. Van der Wiele
Figure 1
Report No. EES-07_02



SCALE 1 : 17 500 at A4 (MGA)



**Rankine
Mosquito
Management**

Emerge Associates
KARNUP DISTRICT STRUCTURE PLAN
MOSQUITO RISK ASSESSMENT AND MANAGEMENT PLAN

Date: 11 Nov 2023

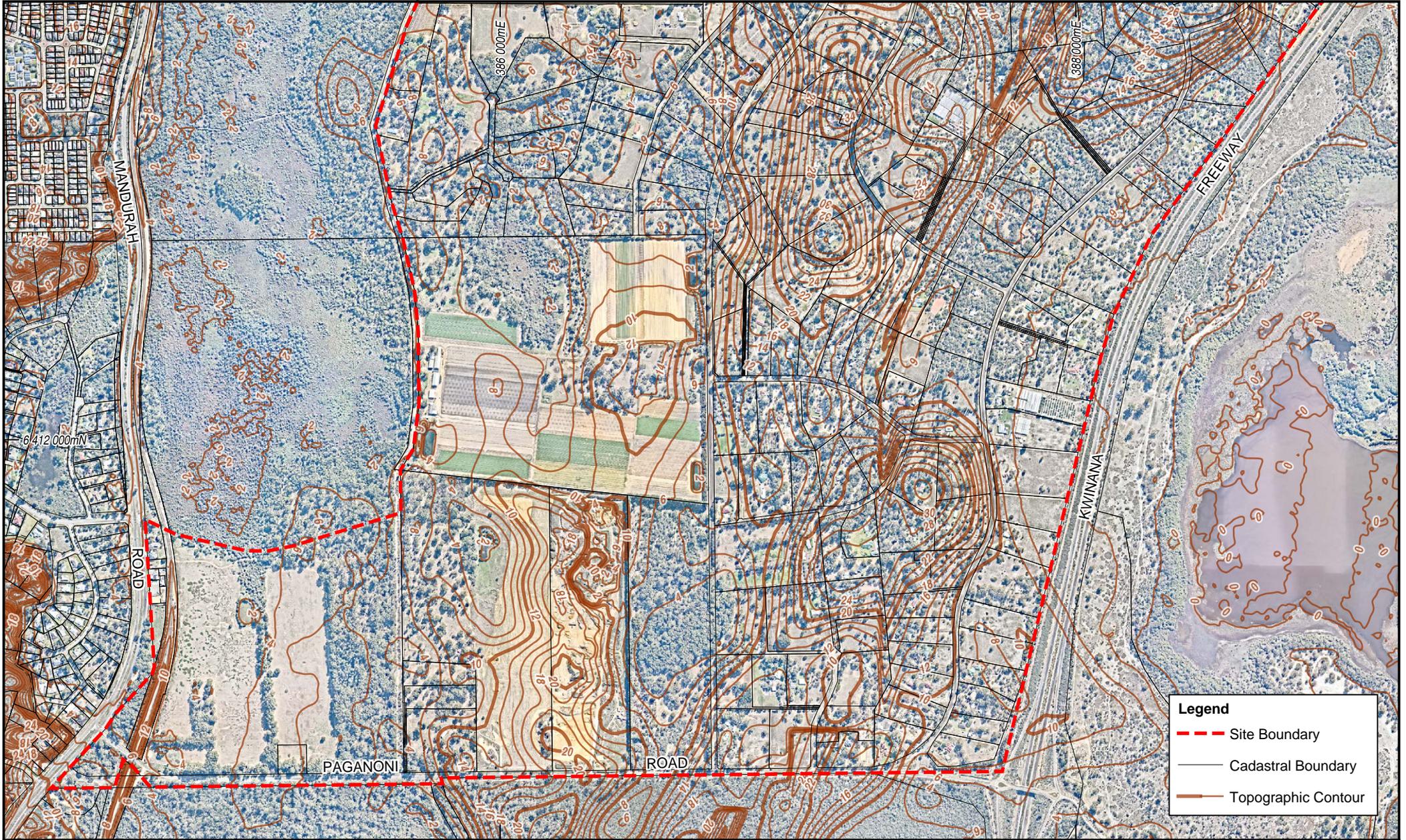
Drawn: B. Van der Wiele

TOPOGRAPHY

Figure 2a

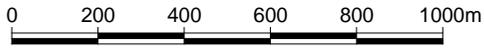
Report No. EES-07_02

CADASTRAL SOURCE: Landgate, May 2023.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown April 2023.
CONTOUR SOURCE: Generated from Geoscience Australia 5m DEM.



Legend

- - - Site Boundary
- Cadastral Boundary
- Topographic Contour



SCALE 1 : 17 500 at A4 (MGA)



**Rankine
Mosquito
Management**

Emerge Associates
KARNUP DISTRICT STRUCTURE PLAN
MOSQUITO RISK ASSESSMENT AND MANAGEMENT PLAN

TOPOGRAPHY

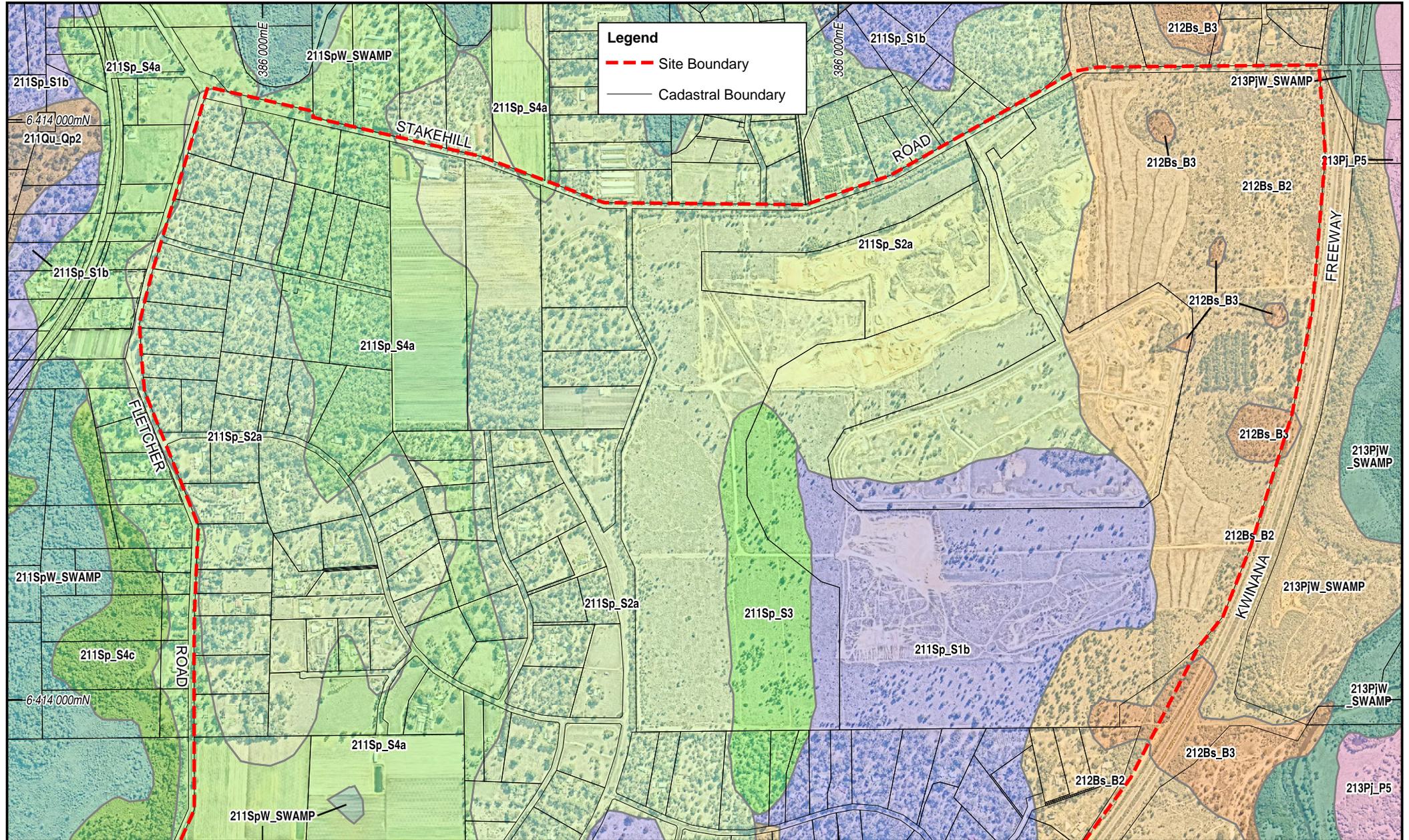
Date: 11 Nov 2023

Drawn: B. Van der Wiele

Figure 2b

Report No. EES-07_02

CADASTRAL SOURCE: Landgate, May 2023.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown April 2023.
CONTOUR SOURCE: Generated from Geoscience Australia 5m DEM.



Legend

- Site Boundary
- Cadastral Boundary



SCALE 1 : 17 500 at A4 (MGA)



**Rankine
Mosquito
Management**

Emerge Associates
KARNUP DISTRICT STRUCTURE PLAN
MOSQUITO RISK ASSESSMENT AND MANAGEMENT PLAN

SOIL UNITS

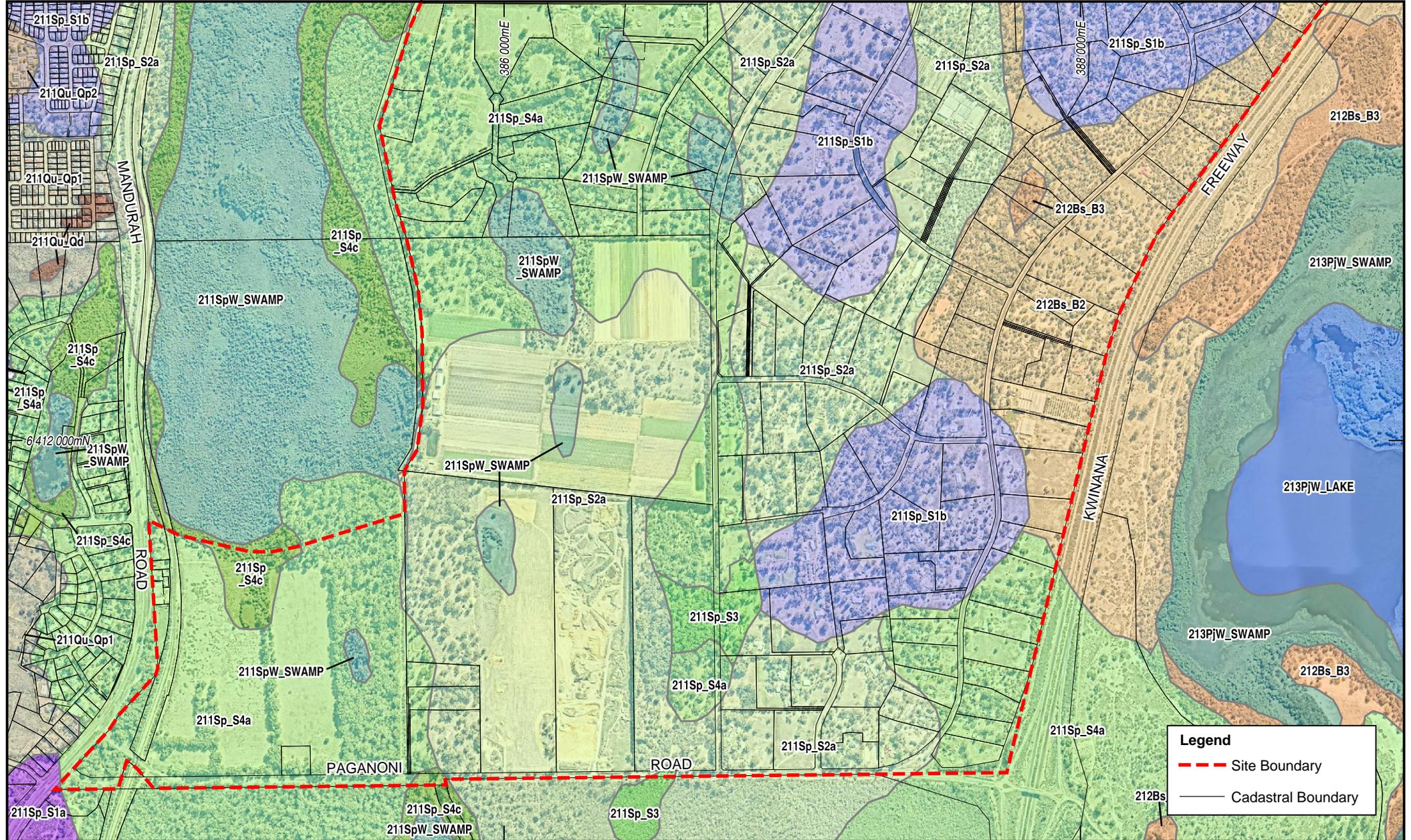
Date: 11 Nov 2023

Drawn: B. Van der Wiele

Figure 3a

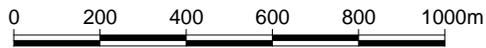
Report No. EES-07_02

SOILS SOURCE: DPIRD, September 2021.
 CADASTRAL SOURCE: Landgate, May 2023.
 AERIAL PHOTOGRAPH SOURCE: NearMap, flown April 2023.



Legend

- - - Site Boundary
- Cadastral Boundary



SCALE 1 : 17 500 at A4 (MGA)



**Rankine
Mosquito
Management**

Emerge Associates
KARNUP DISTRICT STRUCTURE PLAN
MOSQUITO RISK ASSESSMENT AND MANAGEMENT PLAN

SOIL UNITS

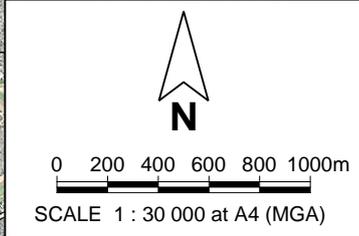
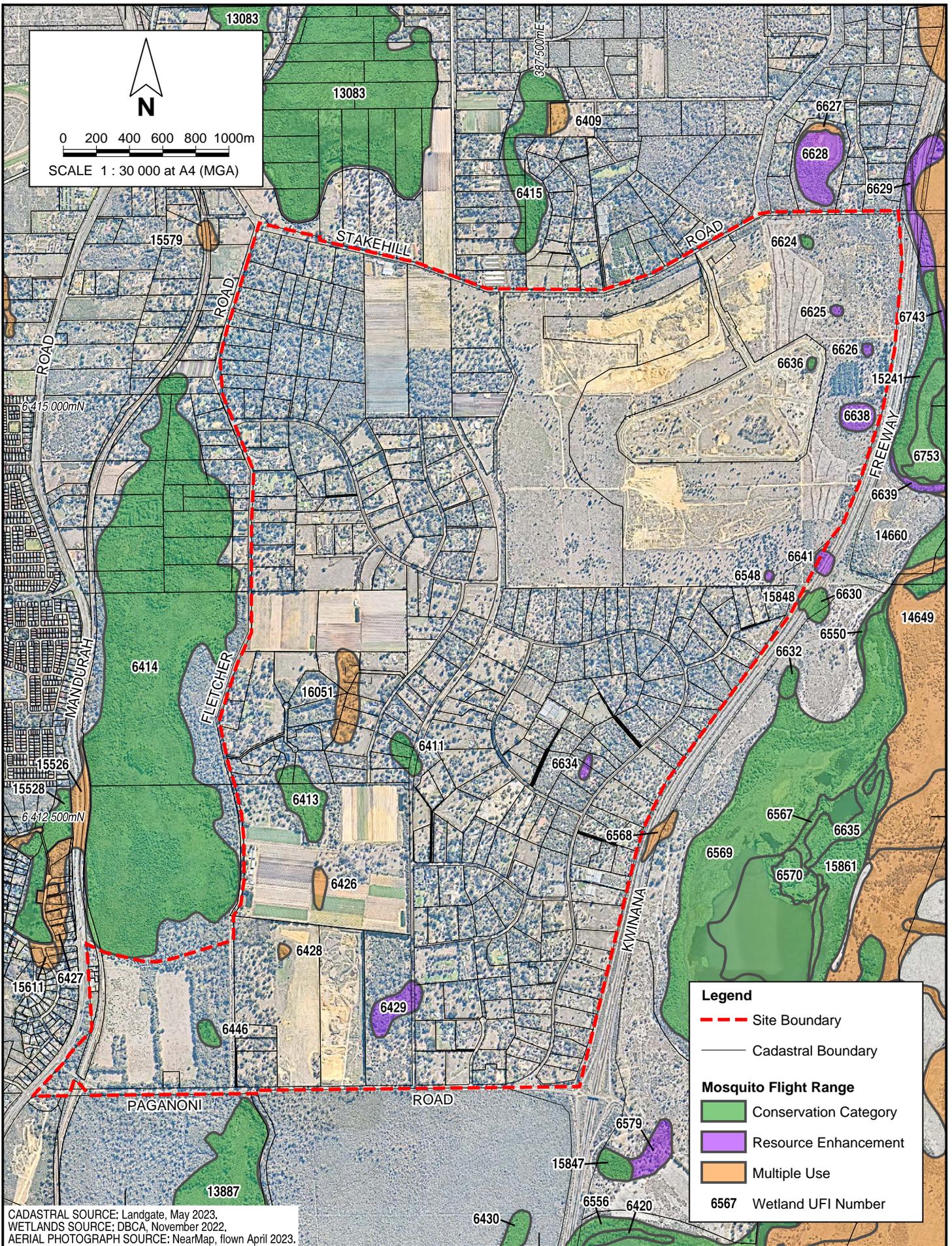
Date: 11 Nov 2023

Drawn: B. Van der Wiele

Figure 3b

Report No. EES-07_02

SOILS SOURCE: DPIRD, September 2021.
CADASTRAL SOURCE: Landgate, May 2023.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown April 2023.



CADASTRAL SOURCE: Landgate, May 2023.
WETLANDS SOURCE: DBCA, November 2022.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown April 2023.

PINPOINT CARTOGRAPHICS (08) 9562 7136 EES-07_02-104.dgn

Rankine Mosquito Management

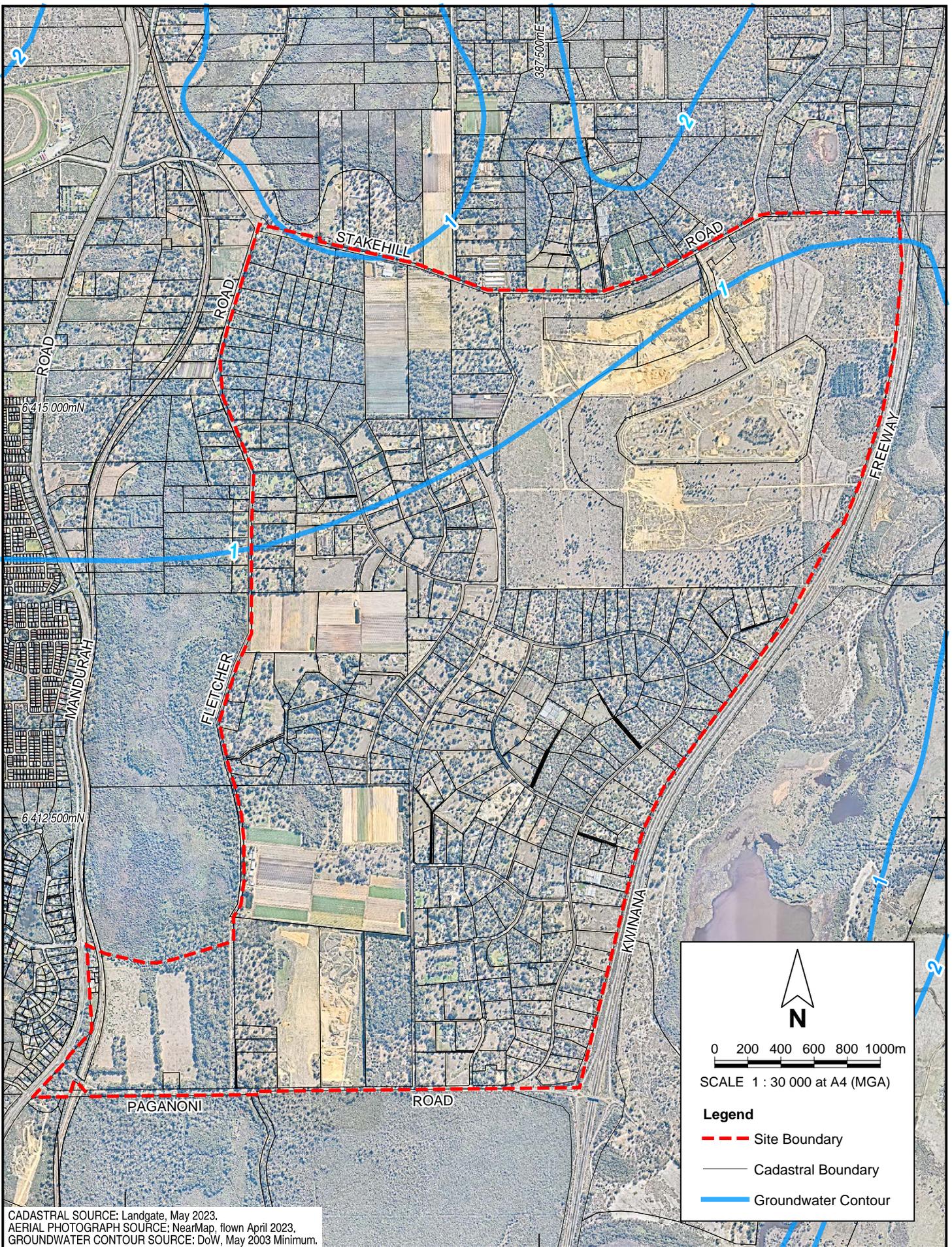
EMERGE ASSOCIATES
KARNUP DISTRICT STRUCTURE PLAN
MOSQUITO RISK ASSESSMENT AND MANAGEMENT PLAN

WETLANDS

Date: 11 Nov 2023
Drawn: B. Van der Wiele

Figure 4

Report No. EES-07_02

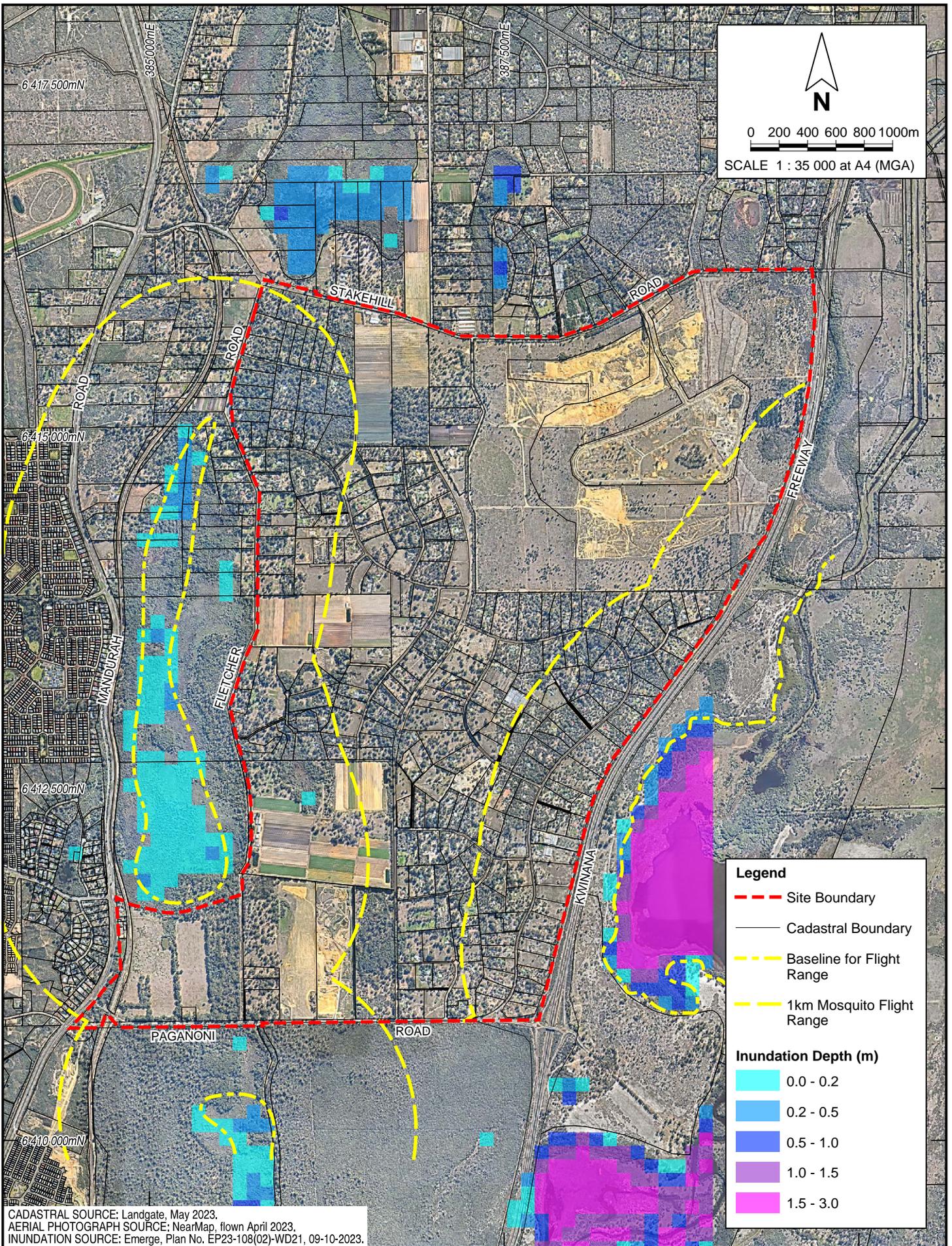


PINPOINT CARTOGRAPHICS (08) 9562 7136 EES-07_02-105.dgn

Rankine Mosquito Management

Emerge Associates
 KARNUP DISTRICT STRUCTURE PLAN
 MOSQUITO RISK ASSESSMENT AND MANAGEMENT PLAN
GROUNDWATER CONTOURS

Date: 11 Nov 2023
 Drawn: B. Van der Wiele
Figure 5
 Report No. EES-07_02



PINPOINT CARTOGRAPHICS (08) 9562 7136 EES-07_02-106.dgn

**Rankine
Mosquito
Management**

Emerge Associates
 KARNUP DISTRICT STRUCTURE PLAN
 MOSQUITO RISK ASSESSMENT AND MANAGEMENT PLAN
WETLAND INUNDATION DEPTHS (AAMGL)

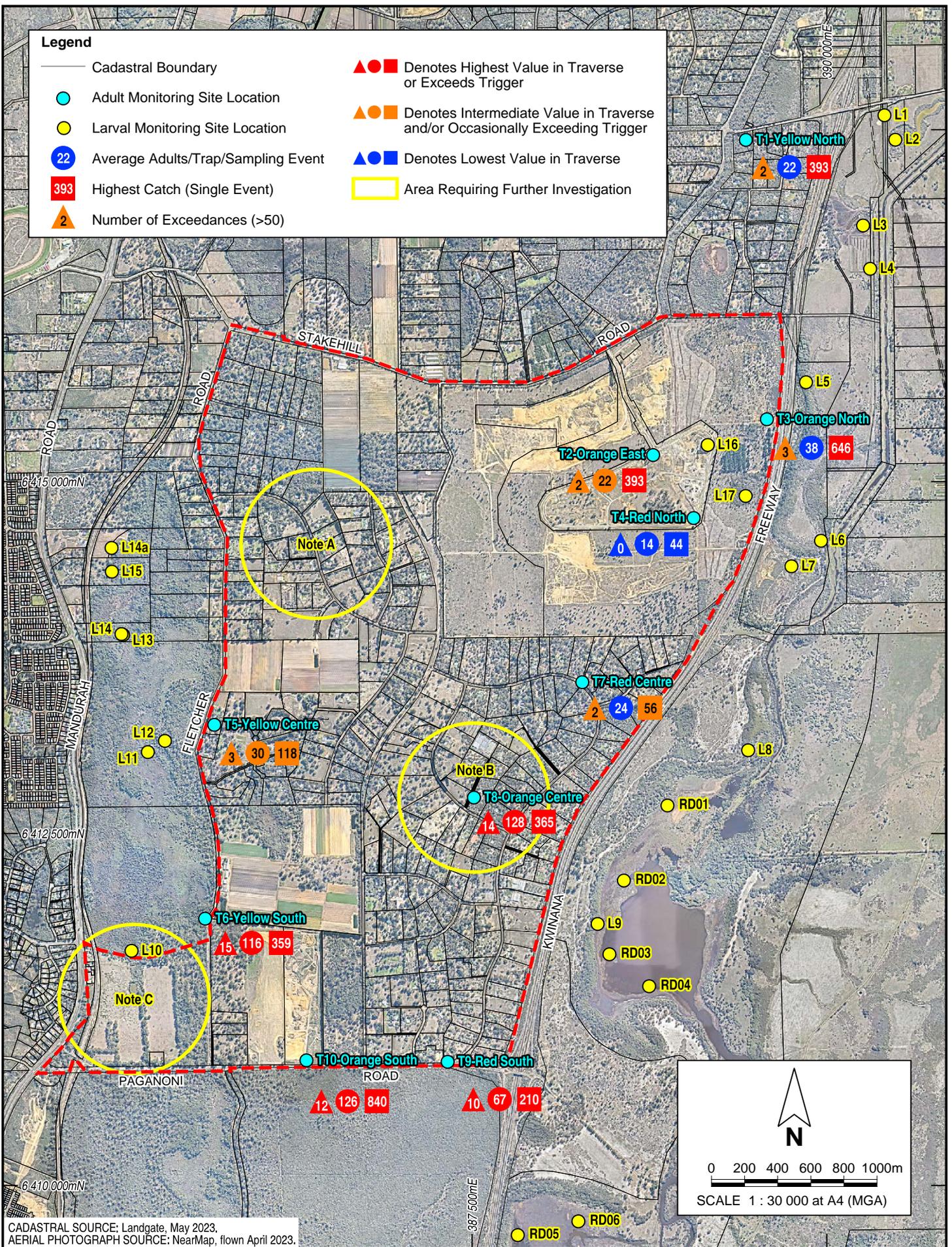
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Figure 6

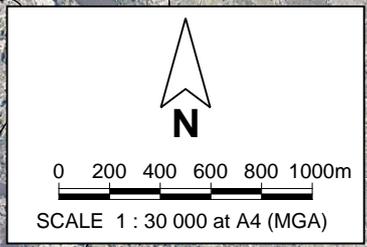
Report No. EES-07_02

Legend

- Cadastral Boundary
- Adult Monitoring Site Location
- Larval Monitoring Site Location
- 22 Average Adults/Trap/Sampling Event
- 393 Highest Catch (Single Event)
- ▲ Number of Exceedances (>50)
- ▲●■ Denotes Highest Value in Traverse or Exceeds Trigger
- ▲●■ Denotes Intermediate Value in Traverse and/or Occasionally Exceeding Trigger
- ▲●■ Denotes Lowest Value in Traverse
- Area Requiring Further Investigation



CADASTRAL SOURCE: Landgate, May 2023.
 AERIAL PHOTOGRAPH SOURCE: NearMap, flown April 2023.



PINPOINT CARTOGRAPHICS (08) 9562 7136 EES-07_02-107.dgn

Rankine Mosquito Management

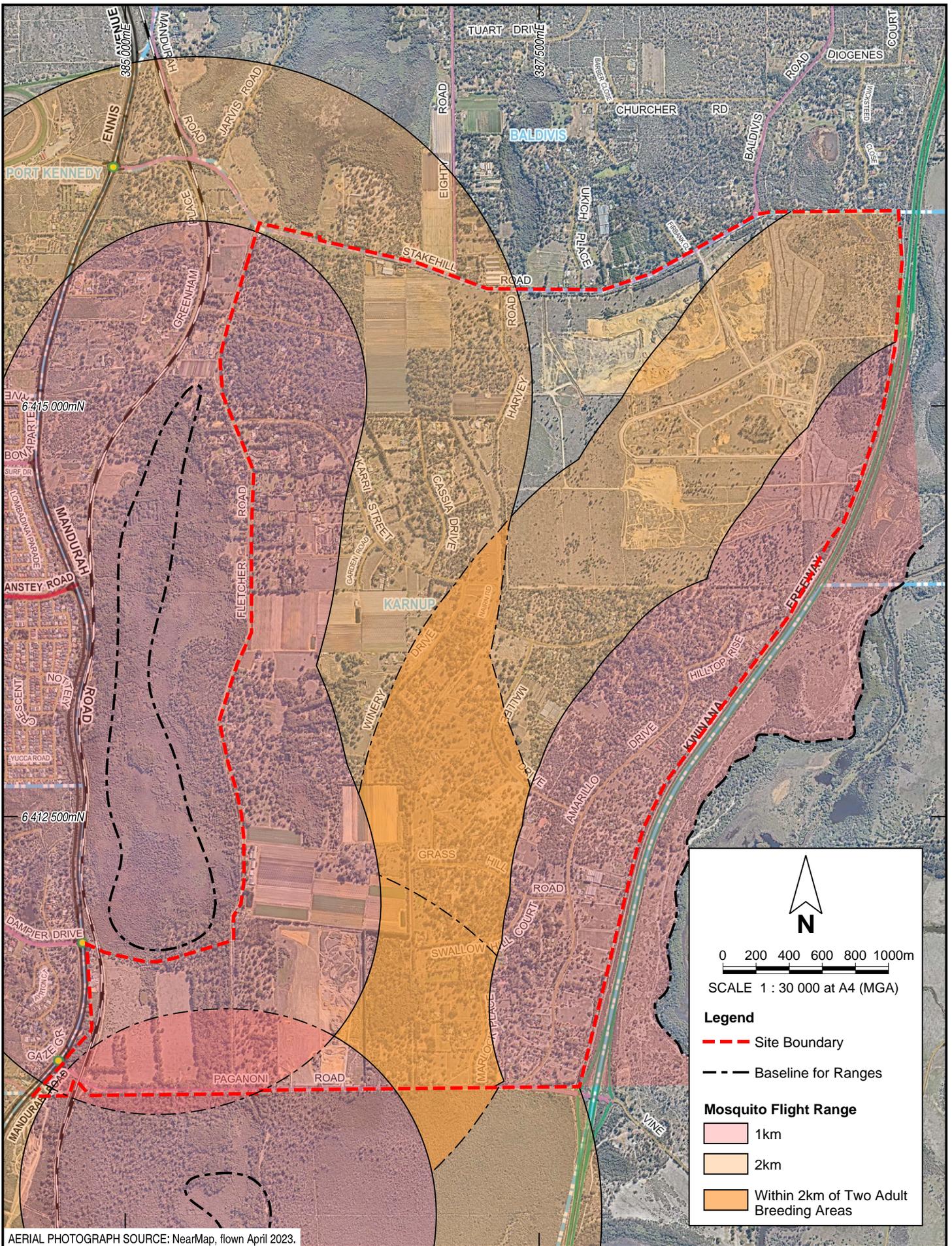
Emerge Associates
 KARNUP DISTRICT STRUCTURE PLAN
 MOSQUITO RISK ASSESSMENT AND MANAGEMENT PLAN

Date: 11 Nov 2023
 Drawn: B. Van der Wiele

MOSQUITO MONITORING SITES

Figure 7

Report No. EES-07_02



AERIAL PHOTOGRAPH SOURCE: NearMap, flown April 2023.

PINPOINT CARTOGRAPHICS (08) 9562 7136 EES-07_02-108.dgn

Rankine Mosquito Management

Emerge Associates
 KARNUP DISTRICT STRUCTURE PLAN
 MOSQUITO RISK ASSESSMENT AND MANAGEMENT PLAN
MOSQUITO RISK ASSESSMENT

Date: 5 Nov 2023
 Drawn: B. Van der Wiele

Figure 8

Report No. EES-07_02

APPENDICES

KARNUP DISTRICT STRUCTURE PLAN

MOSQUITO RISK ASSESSMENT AND MANAGEMENT PLAN (MRAMP)

APPENDIX 1

MOSQUITO MANAGEMENT IN THE PEEL REGION

Source: Peel Mosquito Management Group 2023

Prevention

- ▶ **Avoid** – peak mosquito activity times, one to three hours after dawn and prior to and following dusk.
* Some species of mosquito will bite during daylight hours.
- ▶ **Cover up** – by wearing long loose fitting and preferably light coloured clothing that reduces skin exposure.
- ▶ **Apply** – mosquito repellents when outdoors if mosquitoes are active.
* The most effective repellents are those that contain DEET or Picaridin.
- ▶ **Secure** – doors and windows with insect proof screens to prevent mosquitoes entering housing.
- ▶ **Assess** – your backyard for potential mosquito breeding habitats. Drain water from pot plant bases, screen water tanks, remove containers that could hold water and regularly clean water bowls.



Peel Mosquito Management Group

The Peel Mosquito Management Group is the largest mosquito management partnership of its type in Western Australia. Members include:

- ▶ Department of Health
- ▶ City of Mandurah
- ▶ Shire of Murray
- ▶ City of Rockingham
- ▶ Shire of Waroona
- ▶ And with assistance, The University of Western Australia

Mosquitoes are a part of life in the Peel Region.

Without the programs operation, mosquito borne disease and mosquito populations would be significantly higher in the Peel Region.



Saltmarsh breeding areas, wetlands, drains and other potential breeding sites are monitored and treated regularly for mosquito activity.

For further information on mosquito management efforts undertaken by your council or for information on Ross River or Barmah Forest Virus prevention contact your relevant council.

▶ City of Mandurah

Environmental Health Services
Phone: 9550 3810
Email: health@mandurah.wa.gov.au

▶ Shire of Murray

Environmental Health Officer
Phone: 9531 7777
Email: mailbag@murray.wa.gov.au

▶ City of Rockingham

Health Services
Phone: 9528 0315
Email: council@rockingham.wa.gov.au

▶ Shire of Waroona

Environmental Health Officer
Phone: 9733 7800
Email: warshire@waroona.wa.gov.au



Mosquito Management in the Peel Region



The Peel Harvey Estuary and its associated river systems form a variety of habitats that sustain a diverse range of plant and animal species found within the Peel Region.

Large tracts of saltmarsh are one such habitat which provides ideal conditions for saltmarsh mosquitoes. These saltmarsh mosquitoes are known carriers and can transmit Ross River virus (RRV) and Barmah Forest virus (BFV) and can seriously impact the lifestyle of residents and visitors to the Peel Region when conditions promote their breeding.

Since the early 1990s local governments in the Peel Region in partnership with the Department of Health have successfully implemented a mosquito management program aimed at reducing human cases of mosquito borne disease and minimising the nuisance caused by mosquitoes.

Given that mosquitoes don't recognise local government boundaries it is essential that we work cooperatively to achieve effective and sustainable mosquito management.



People living within up to five kilometres of saltmarsh or brackish wetlands (i.e. estuaries and tidal rivers) as well as freshwater wetlands are at greater risk of contracting Ross River and Barmah Forest Virus diseases and should take particular precaution to avoid mosquito bites. The peak time for the diseases is generally between September and January.

► **Managing Mosquitoes**

Tides that flood saltmarshes lead to mosquito eggs hatching in the Peel Region. Tides in the Peel Harvey Estuary can rise unexpectedly due to low pressure systems, northerly winds and local climatic events. As a guide when tides in the Peel Region reach 0.76m, hatching of mosquito eggs is likely to be initiated on most breeding sites.

Council Mosquito Operations personnel monitor breeding sites to assess the extent and location of mosquito breeding and determine when to conduct treatments.

Larviciding is the main method of mosquito reduction in the Peel Region. This technique targets the mosquito larvae before they emerge as adults and is the most effective control method to reduce adult populations. As large areas (up to 600hectares of saltmarsh) need to be treated the larvicides must be applied by helicopter.

The two main products used are sand based S - methoprene and a liquid product called Bti (*Bacillus thuringiensis israelensis*).

These are the most environmentally appropriate products available and pose very low toxicity to non target organisms and public health.

Many people associate mosquito management with fogging.

In our conditions fogging has proven ineffective and does not specifically target mosquitoes. Targeting mosquitoes while they are in their larval stage is a far more efficient method of managing mosquitoes in our environment.

Whilst the vast majority of the Peel Mosquito Management Group's larvicide treatments are effective in reducing mosquito populations the limitations of the larvicides and environmental conditions do not permit total eradication. This is why even after successful treatments there will always be some residual mosquito activity.

Larviciding treatments are not always effective due to environmental conditions and it is



important that individuals take personal protective measures.

Mosquito-borne diseases in the Peel Region. RRV and BFV are the two most common mosquito borne viruses that cause human disease in Western Australia. In nature RRV and BFV are passed back and forth between animals and mosquitoes. The only way that humans can catch the disease is by being bitten by a mosquito that is carrying the virus.

► **Symptoms**

Symptoms for both viruses are similar and can vary from person to person. Symptoms include painful and or swollen joints, sore muscles aching tendons, skin rashes, fever and tiredness. Other symptoms may also be experienced.

If you feel unwell after being bitten by a mosquito or following contact with mosquitoes arrange to see a Doctor as soon as possible.

Currently there is no vaccine or specific medical treatment for these diseases. For more detailed information on RRV or BFV contact the Department of Health on 9222 4222 or visit www.health.wa.gov.au.



APPENDIX 2

2023 FIELD SURVEY RECORDS

Source: Rankine Mosquito Management 2023

Summary of Observation Point Locations

Larval Sites

Site	Site Coordinates (Lat-Long DMS)	
	Easting	Northing
EES-07_L-01	115° 50' 6.12" E	32° 22' 23.39" S
EES-07_L-02	115° 50' 8.98" E	32° 22' 29.06" S
EES-07_L-03	115° 50' 0.03" E	32° 22' 43.76" S
EES-07_L-04	115° 50' 1.81" E	32° 22' 58.77" S
EES-07_L-05	115° 49' 44.18" E	32° 23' 24.78" S
EES-07_L-06	115° 49' 47.74" E	32° 24' 1.38" S
EES-07_L-07	115° 49' 27.47" E	32°24'33.40"S
EES-07_L-08	115°48'13.34"E	32° 24' 49.52" S
EES-07_L-09	115° 48' 46.33" E	32° 25' 29.21" S
EES-07_L-10	115° 46' 40.49" E	32° 25' 34.21" S
EES-07_L-11	115° 46' 45.51" E	32° 24' 48.4" S
EES-07_L-12	115° 46' 50.14" E	32° 24' 45.87" S
EES-07_L-13	115° 46' 38.76" E	32° 24' 21.11" S
EES-07_L-14	115° 46' 36.35"E	32° 22' 43.76" S
EES-07_L-15	115° 46' 36.36" E	32° 24' 6.69" S

Trap Sites

EES-07_Trap-01	115°49'28.68"E	32°22'28.73"S
EES-07_Trap-02	115°49'2.71"E	32°23'41.19"S
EES-07_Trap-03	115°49'33.51"E	32°23'33.22"S
EES-07_Trap-04	115°49'13.45"E	32°23'55.81"S
EES-07_Trap-05	115°47'3.52"E	32°24'42.29"S
EES-07_Trap-06	115°47'0.45"E	32°25'26.97"S
EES-07_Trap-07	115°48'42.92"E	32°24'33.40"S
EES-07_Trap-08	115°48'13.34"E	32°24'59.73"S
EES-07_Trap-09	115°48'5.44"E	32°26'0.62"S
EES-07_Trap-10	115°47'27.34"E	2°25'59.92"S

City of Rockingham MRAMP

Field Report

Location ID	Well ID: EES-07_Trapp-01 Other ID: 1	
	GPS Coords: E 115°49'28.68"E N 32°22'28.73"S	
Auditor: Hvdw Date: 21/4/23 Time: 8:50		
PHOTOGRAPH ID	Alignment by: <input type="checkbox"/> Orientation along Feature	
	Photo 1 ():	1 (N)
	Photo 2 ():	2 (W)
	Photo 3 ():	3 (S)
	Photo 4 ():	4 (E)
	Photo 5 ():	none
	Photo 6 ():	none
Photo 7 ():	none	
SITE ID	<input type="checkbox"/> Swamp <input type="checkbox"/> Constructed <input type="checkbox"/> Marsh <input type="checkbox"/> Perm. Pond <input type="checkbox"/> Drain <input type="checkbox"/> Temp. Pool / dep	
	Other <u>Trap Site</u>	
COMMENT	UTM Coordinants Zone 40 (WGS84).	

Breeding Site Characteristics

Site Type	Size (m2)	Water	Veg.	Subst.	Shade
Swamp	<5	Fresh	Fringing	Organic	Exposed
Constructed wetland	>5-10	Brackish	Emergent	Mud	½ shade
Marsh	>10-20	Saline	Floating	Sand	Deep
Permanent Pond	>20-50	Running	Algal Mat	Rocky	
Temp. Pool / dep	>50-100	Stagnant	Phytopl.	Concrete	
Natural / semi nat. drain	>100-200	Clear	Samphire	Liner	
Artificial drain	>200-500	Turbid	Rush	Other	
Tyre track	>500-1000	Tannin	Other		
Container	>1000-5000	Foul			
Other (specify)	>0.5 - 1.0 ha	Other			
Trap Site	>1.0 ha				
	Other				

Surrounding Vegetation, within 50m (bold to relevant descriptor)

Projective Foliage Cover of Tallest Stratum (%)					
Tallest Stratum	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)	
Trees >30	Tall closed	Tall open	Tall	Tall open	Woodland
Trees 10-30	Closed	Open	Woodland	Open	
Trees 5-10	Low closed	Low open	Low	Low open	Woodland
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland	
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland	
Herbs/grass (<2m)	Closed herb/grassland	Herb/ grassland	Open Herb/grassland	Ephemeral Herb grassland	

Ground Cover (%)

	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland
Herbs/grass (<2m)	Closed herb/grassland	Herb/ grassland	Open Herb/grassland	Ephemeral Herb grassland

COMMENT

Parkland cleared woodland area located at the Karnup Rd Picnic area (old school). Limited understory.

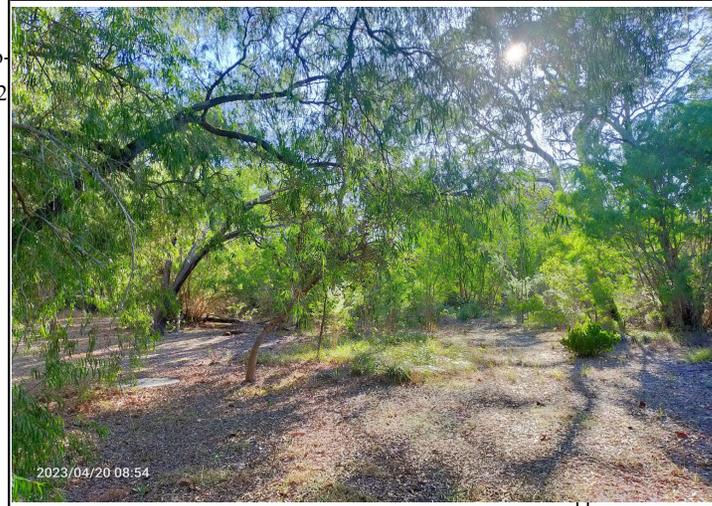
City of Rockingham MRAMP
Field Report

SITE
EES-07_Trap-
Page 2 of 2



(N)

(W)



(S)

(E)



City of Rockingham MRAMP
Field Report

Location ID	Well ID: EES-07_Trap-02 Other ID: 2	
	GPS Coords: E 115°49'2.71"E N 32°23'41.19"S	
	Auditor: Hvdw Date: 21/4/23 Time: 9:20	
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	Photo 2 ():	6 (W)
	Photo 3 ():	7 (S)
	Photo 4 ():	8 (E)
	Photo 5 ():	none
	Photo 6 ():	none
Photo 7 ():	none	
SITE ID	<input type="checkbox"/> Swamp <input type="checkbox"/> Constructed <input type="checkbox"/> Marsh <input type="checkbox"/> Perm. Pond <input type="checkbox"/> Drain <input type="checkbox"/> Temp. Pool / dep	
	Other <u>Trap Site</u>	
COMMENT	UTM Coordinants Zone 40 (WGS84).	

Breeding Site Characteristics

Site Type	Size (m2)	Water	Veg.	Subst.	Shade
Swamp	<5	Fresh	Fringing	Organic	Exposed
Constructed wetland	>5-10	Brackish	Emergent	Mud	½ shade
Marsh	>10-20	Saline	Floating	Sand	Deep
Permanent Pond	>20-50	Running	Algal Mat	Rocky	
Temp. Pool / dep	>50-100	Stagnant	Phytopl.	Concrete	
Natural / semi nat. drain	>100-200	Clear	Samphire	Liner	
Artificial drain	>200-500	Turbid	Rush	Other	
Tyre track	>500-1000	Tannin	Other		
Container	>1000-5000	Foul			
Other (specify)	>0.5 - 1.0 ha	Other			
Trap Site	>1.0 ha				
	Other				

Surrounding Vegetation, within 50m (bold to relevant descriptor)

Projective Foliage Cover of Tallest Stratum (%)				
Tallest Stratum	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)
Trees >30	Tall closed	Tall open	Tall	Tall open
Trees 10-30	Closed	Open	Woodland	Open
Trees 5-10	Low closed	Low open	Low	Low open
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland
Herbs/grass (<2m)	Closed herb/grassland	Herb/ grassland	Open Herb/grassland	Ephemeral Herb grassland

Ground Cover (%)

	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland
Herbs/grass (<2m)	Closed herb/grassland	Herb/ grassland	Open Herb/grassland	Ephemeral Herb grassland

COMMENT

Grove of trees on elevated land in cleared former pasture. No standing water in vicinity

City of Rockingham MRAMP
Field Report

SITE
EES-07_Trap-
Page 2 of 2



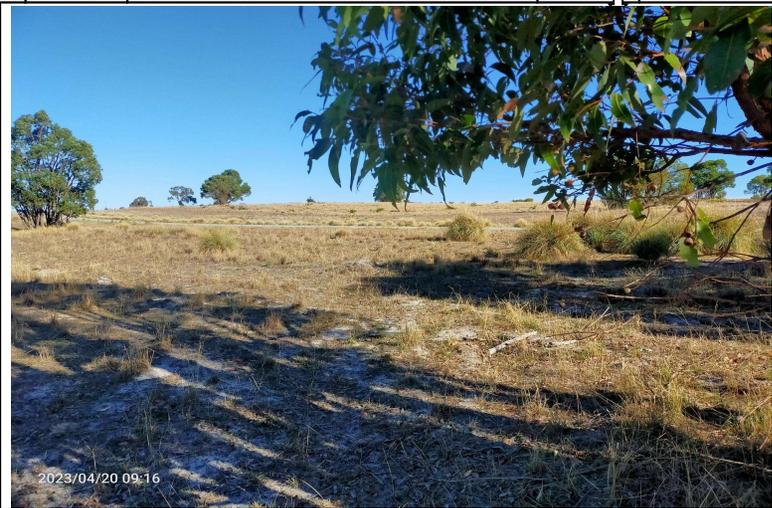
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City of Rockingham MRAMP
Field Report

Location ID	Well ID: EES-07_Trap-03 Other ID: 3	
	GPS Coords: E 115°49'33.51"E N 32°23'33.22"S	
Auditor: Hvdw Date: 21/4/23 Time: 9:33		
PHOTOGRAPH ID	Alignment by: <input type="checkbox"/> Orientation along Feature	
	Photo 1 ():	9 (N)
	Photo 2 ():	10 (W)
	Photo 3 ():	11 (S)
	Photo 4 ():	12 (E)
	Photo 5 ():	none
	Photo 6 ():	none
Photo 7 ():	none	
SITE ID	<input type="checkbox"/> Swamp <input type="checkbox"/> Constructed <input type="checkbox"/> Marsh <input type="checkbox"/> Perm. Pond <input type="checkbox"/> Drain <input type="checkbox"/> Temp. Pool / dep	
	Other <u>Trap Site</u>	
COMMENT	UTM Coordinants Zone 40 (WGS84).	

Breeding Site Characteristics

Site Type	Size (m2)	Water	Veg.	Subst.	Shade
Swamp	<5	Fresh	Fringing	Organic	Exposed
Constructed wetland	>5-10	Brackish	Emergent	Mud	½ shade
Marsh	>10-20	Saline	Floating	Sand	Deep
Permanent Pond	>20-50	Running	Algal Mat	Rocky	
Temp. Pool / dep	>50-100	Stagnant	Phytopl.	Concrete	
Natural / semi nat. drain	>100-200	Clear	Samphire	Liner	
Artificial drain	>200-500	Turbid	Rush	Other	
Tyre track	>500-1000	Tannin	Other		
Container	>1000-500	Foul			
Other (specify)	>0.5 - 1.0 ha	Other			
Trap Site	>1.0 ha				
	Other				

Surrounding Vegetation, within 50m (bold to relevant descriptor)

Projective Foliage Cover of Tallest Stratum (%)				
Tallest Stratum	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)
Trees >30	Tall closed	Tall open	Tall	Tall open
Trees 10-30	Closed	Open	Woodland	Open
Trees 5-10	Low closed	Low open	Low	Low open
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland
Herbs/grass (<2m)	Closed herb/ grassland	Herb/ grassland	Open Herb/ grassland	Ephemeral Herb grassland

Ground Cover (%)

	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland
Herbs/grass (<2m)	Closed herb/ grassland	Herb/ grassland	Open Herb/ grassland	Ephemeral Herb grassland

COMMENT

Grove of trees in cleared former pasture adjacent to small Resource Enhancement (dry) wetland (likely perched water table).

City of Rockingham MRAMP
Field Report

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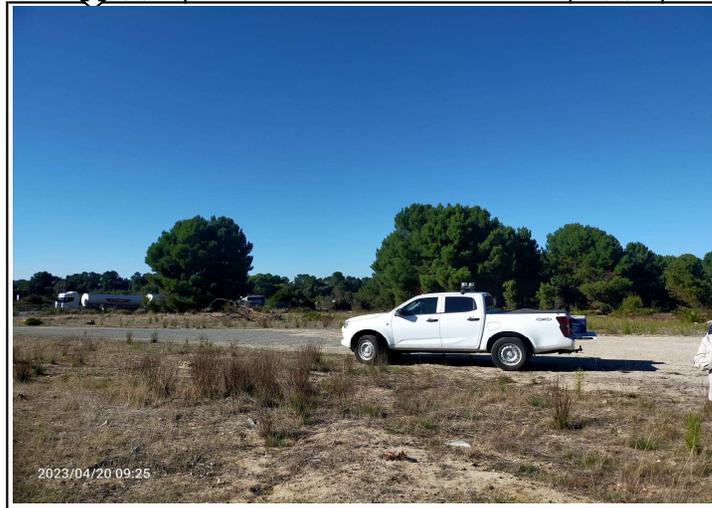
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City of Rockingham MRAMP
Field Report

Location ID	Well ID: EES-07_Traps-04 Other ID: 4 GPS Coords: E 115°49'13.45"E N 32°23'55.81"S Auditor: Hvdw Date: 21/4/23 Time: 9:43
PHOTOGRAPH ID	Alignment by: <input type="checkbox"/> Orientation along Feature <input checked="" type="checkbox"/> Cardinal Angle Photo 1 (): 13 (N) Photo 2 (): 14 (W) Photo 3 (): 15 (S) Photo 4 (): 16 (E) Photo 5 (): none Photo 6 (): none Photo 7 (): none
SITE ID	<input type="checkbox"/> Swamp <input type="checkbox"/> Constructed <input type="checkbox"/> Marsh <input type="checkbox"/> Perm. Pond <input type="checkbox"/> Drain <input type="checkbox"/> Temp. Pool / dep Other <u>Trap Site</u>
COMMENT	UTM Coordinants Zone 40 (WGS84).

Breeding Site Characteristics

Site Type	Size (m2)	Water	Veg.	Subst.	Shade
Swamp	<5	Fresh	Fringing	Organic	Exposed
Constructed wetland	>5-10	Brackish	Emergent	Mud	½ shade
Marsh	>10-20	Saline	Floating	Sand	Deep
Permanent Pond	>20-50	Running	Algal Mat	Rocky	
Temp. Pool / dep	>50-100	Stagnant	Phytopl.	Concrete	
Natural / semi nat. drain	>100-200	Clear	Samphire	Liner	
Artificial drain	>200-500	Turbid	Rush	Other	
Tyre track	>500-1000	Tannin	Other		
Container	>1000-5000	Foul			
Other (specify)	>0.5 - 1.0 ha	Other			
Trap Site	>1.0 ha				
	Other				

Surrounding Vegetation, within 50m (bold to relevant descriptor)

Projective Foliage Cover of Tallest Stratum (%)				
Tallest Stratum	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)
Trees >30	Tall closed	Tall open	Tall	Tall open
Trees 10-30	Closed	Open	Woodland	Open
Trees 5-10	Low closed	Low open	Low	Low open
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland
Herbs/grass (<2m)	Closed herb/grassland	Herb/ grassland	Open Herb/grassland	Ephemeral Herb grassland

Ground Cover (%)

	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland
Herbs/grass (<2m)	Closed herb/grassland	Herb/ grassland	Open Herb/grassland	Ephemeral Herb grassland

COMMENT	Grove of trees in cleared former pasture adjacent to small Conservation Category (dry) wetland (likely perched water table).
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City of Rockingham MRAMP
Field Report

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EES-07_Trap-
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City of Rockingham MRAMP
Field Report

Location ID	Well ID: EES-07_Trap-05 Other ID: 5
	GPS Coords: E 115°47'3.52"E N 32°24'42.29"S
	Auditor: Hvdw θ Date: 21/4/23 Time: 10:35
PHOTOGRAPH ID	<p>Alignment by: <input type="checkbox"/> Orientation along Feature</p> <p style="margin-left: 100px;">↓ <input checked="" type="checkbox"/> Cardinal Angle</p> <p>Photo 1 (): 17 (N)</p> <p>Photo 2 (): 18 (W)</p> <p>Photo 3 (): 19 (S)</p> <p>Photo 4 (): 20 (E)</p> <p>Photo 5 (): none</p> <p>Photo 6 (): none</p> <p>Photo7 (): none</p>
SITE ID	<input type="checkbox"/> Swamp <input type="checkbox"/> Constructed <input type="checkbox"/> Marsh <input type="checkbox"/> Perm. Pond <input type="checkbox"/> Drain <input type="checkbox"/> Temp. Pool / dep Other <u>Trap Site</u>
COMMENT	UTM Coordinants Zone 40 (WGS84).

Breeding Site Characteristics

Site Type	Size (m2)	Water	Veg.	Subst.	Shade
Swamp	<5	Fresh	Fringing	Organic	Exposed
Constructed wetland	>5-10	Brackish	Emergent	Mud	½ shade
Marsh	>10-20	Saline	Floating	Sand	Deep
Permanent Pond	>20-50	Running	Algal Mat	Rocky	
Temp. Pool / dep	>50-100	Stagnant	Phytopl.	Concrete	
Natural / semi nat. drain	>100-200	Clear	Samphire	Liner	
Artificial drain	>200-500	Turbid	Rush	Other	
Tyre track	>500-1000	Tannin	Other		
Container	>1000-5000	Foul			
Other (specify)	>0.5 - 1.0 ha	Other			
Trap Site	>1.0 ha				
	Other				

Surrounding Vegetation, within 50m (bold to relevant descriptor)

Projective Foliage Cover of Tallest Stratum (%)				
Tallest Stratum	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)
Trees >30	Tall closed	Tall open	Tall	Tall open
Trees 10-30	Closed	Open	Woodland	Open
Trees 5-10	Low closed	Low open	Low	Low open
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland
Herbs/grass (<2m)	Closed herb/ grassland	Herb/ grassland	Open Herb/ grassland	Ephemeral Herb grassland

Ground Cover (%)

	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland
Herbs/grass (<2m)	Closed herb/ grassland	Herb/ grassland	Open Herb/ grassland	Ephemeral Herb grassland

COMMENT

Open woodland of landscape planted trees at tourism site fronting Fletcher Rd. Limited understory of ornamentals and pasture grasses. Irrigation and occasional water filled containers.

City of Rockingham MRAMP
Field Report

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EES-07_Trap-
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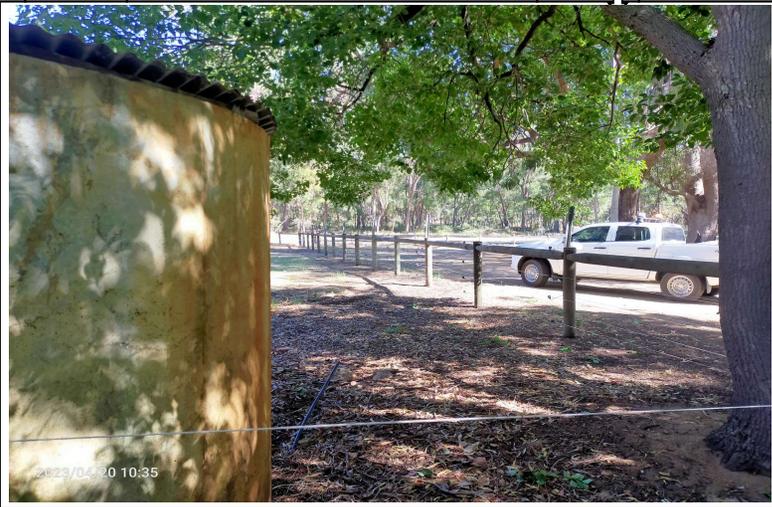
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City of Rockingham MRAMP

Field Report

Location ID	Well ID: EES-07_Traps-06 Other ID: MOH 12 GPS Coords: E 115°47'0.45"E N 32°25'26.97"S Auditor: Hvdw Date: 21/4/23 Time: 10:43
PHOTOGRAPH ID	Alignment by: <input type="checkbox"/> Orientation along Feature <input checked="" type="checkbox"/> Cardinal Angle Photo 1 (): 21 (N) Photo 2 (): 22 (W) Photo 3 (): 23 (S) Photo 4 (): 24 (E) Photo 5 (): none Photo 6 (): none Photo 7 (): none
SITE ID	<input type="checkbox"/> Swamp <input type="checkbox"/> Constructed <input type="checkbox"/> Marsh <input type="checkbox"/> Perm. Pond <input type="checkbox"/> Drain <input type="checkbox"/> Temp. Pool / dep Other <u>Trap Site</u>
COMMENT	UTM Coordinants Zone 40 (WGS84). Adults active

Breeding Site Characteristics

Site Type	Size (m2)	Water	Veg.	Subst.	Shade
Swamp	<5	Fresh	Fringing	Organic	Exposed
Constructed wetland	>5-10	Brackish	Emergent	Mud	½ shade
Marsh	>10-20	Saline	Floating	Sand	Deep
Permanent Pond	>20-50	Running	Algal Mat	Rocky	
Temp. Pool / dep	>50-100	Stagnant	Phytopl.	Concrete	
Natural / semi nat. drain	>100-200	Clear	Samphire	Liner	
Artificial drain	>200-500	Turbid	Rush	Other	
Tyre track	>500-1000	Tannin	Other		
Container	>1000-5000	Foul			
Other (specify)	>0.5 - 1.0 ha	Other			
Trap Site	>1.0 ha				
	Other				

Surrounding Vegetation, within 50m (bold to relevant descriptor)

Projective Foliage Cover of Tallest Stratum (%)					
Tallest Stratum	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)	
Trees >30	Tall closed	Tall open	Tall	Tall open	
Trees 10-30	Closed	Open	Woodland	Open	
Trees 5-10	Low closed	Low open	Low	Low open	
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland	
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland	
Herbs/grass (<2m)	Closed herb/ grassland	Herb/ grassland	Open Herb/ grassland	Ephemeral Herb grassland	

Ground Cover (%)

	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland
Herbs/grass (<2m)	Closed herb/ grassland	Herb/ grassland	Open Herb/ grassland	Ephemeral Herb grassland

COMMENT

Open forest of Eucalypts and Banksia with dense understory within Anstey Swamp and in close proximity to Fletcher Road. Equates to MOH 12 site. Shielded from winds

City of Rockingham MRAMP
Field Report

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EES-07_Trap-
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City of Rockingham MRAMP
Field Report

Location ID	Well ID: EES-07_Trap-07 Other ID: 6 GPS Coords: E 115°47'0.45"E N 32°25'26.97"S Auditor: Hvdw Date: 24/4/23 Time: 10:43
PHOTOGRAPH ID	Alignment by: <input type="checkbox"/> Orientation along Feature # <input checked="" type="checkbox"/> Cardinal Angle Photo 1 (): 25 (N) Photo 2 (): 26 (W) Photo 3 (): 27 (S) Photo 4 (): 28 (E) Photo 5 (): none Photo 6 (): none Photo 7 (): none
SITE ID	<input type="checkbox"/> Swamp <input type="checkbox"/> Constructed <input type="checkbox"/> Marsh <input type="checkbox"/> Perm. Pond <input type="checkbox"/> Drain <input type="checkbox"/> Temp. Pool / dep Other <u>Trap Site</u>
COMMENT	UTM Coordinants Zone 40 (WGS84).

Breeding Site Characteristics

Site Type	Size (m2)	Water	Veg.	Subst.	Shade
Swamp	<5	Fresh	Fringing	Organic	Exposed
Constructed wetland	>5-10	Brackish	Emergent	Mud	½ shade
Marsh	>10-20	Saline	Floating	Sand	Deep
Permanent Pond	>20-50	Running	Algal Mat	Rocky	
Temp. Pool / dep	>50-100	Stagnant	Phytopl.	Concrete	
Natural / semi nat. drain	>100-200	Clear	Samphire	Liner	
Artificial drain	>200-500	Turbid	Rush	Other	
Tyre track	>500-1000	Tannin	Other		
Container	>1000-5000	Foul			
Other (specify)	>0.5 - 1.0 ha	Other			
Trap Site	>1.0 ha				
	Other				

Surrounding Vegetation, within 50m (bold to relevant descriptor)

Projective Foliage Cover of Tallest Stratum (%)				
Tallest Stratum	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)
Trees >30	Tall closed	Tall open	Tall	Tall open
Trees 10-30	Closed	Open	Woodland	Open
Trees 5-10	Low closed	Low open	Low	Low open
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland
Herbs/grass (<2m)	Closed herb/ grassland	Herb/ grassland	Open Herb/ grassland	Ephemeral Herb grassland

Ground Cover (%)

	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland
Herbs/grass (<2m)	Closed herb/ grassland	Herb/ grassland	Open Herb/ grassland	Ephemeral Herb grassland

COMMENT	Cleared open woodland of Agonis with pasture grasses under adjacent to Amarillo Drive. Exposed to prevailing winds.
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Field Report

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EES-07_Trap-
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City of Rockingham MRAMP

Field Report

Location ID	Well ID: EES-07_Trap-08 Other ID: 8 GPS Coords: E 115°48'13.34"E N 32°24'59.73"S Auditor: Hvdw Date: 24/4/23 Time: 12:20
PHOTOGRAPH ID	Alignment by: <input type="checkbox"/> Orientation along Feature <input checked="" type="checkbox"/> Cardinal Angle Photo 1 (): 29 (N) Photo 2 (): 30 (W) Photo 3 (): 31 (S) Photo 4 (): 32 (E) Photo 5 (): none Photo 6 (): none Photo 7 (): none
SITE ID	<input type="checkbox"/> Swamp <input type="checkbox"/> Constructed <input type="checkbox"/> Marsh <input type="checkbox"/> Perm. Pond <input type="checkbox"/> Drain <input type="checkbox"/> Temp. Pool / dep Other <u>Trap Site</u>
COMMENT	UTM Coordinants Zone 40 (WGS84).

Breeding Site Characteristics

Site Type	Size (m2)	Water	Veg.	Subst.	Shade
Swamp	<5	Fresh	Fringing	Organic	Exposed
Constructed wetland	>5-10	Brackish	Emergent	Mud	½ shade
Marsh	>10-20	Saline	Floating	Sand	Deep
Permanent Pond	>20-50	Running	Algal Mat	Rocky	
Temp. Pool / dep	>50-100	Stagnant	Phytopl.	Concrete	
Natural / semi nat. drain	>100-200	Clear	Samphire	Liner	
Artificial drain	>200-500	Turbid	Rush	Other	
Tyre track	>500-1000	Tannin	Other		
Container	>1000-500	Foul			
Other (specify)	>0.5 - 1.0 ha	Other			
Trap Site	>1.0 ha				
	Other				

Surrounding Vegetation, within 50m (bold to relevant descriptor)

Projective Foliage Cover of Tallest Stratum (%)				
Tallest Stratum	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)
Trees >30	Tall closed	Tall open	Tall	Tall open
Trees 10-30	Closed	Open	Woodland	Open
Trees 5-10	Low closed	Low open	Low	Low open
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland
Herbs/grass (<2m)	Closed herb/grassland	Herb/ grassland	Open Herb/grassland	Ephemeral Herb grassland

Ground Cover (%)

	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland
Herbs/grass (<2m)	Closed herb/grassland	Herb/ grassland	Open Herb/grassland	Ephemeral Herb grassland

COMMENT

Previously cleared Banksia / Casuarina open woodland with minimal adjacent to Mallee Drive. Exposed to prevailing winds.

City of Rockingham MRAMP
Field Report

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EES-07_Trap-
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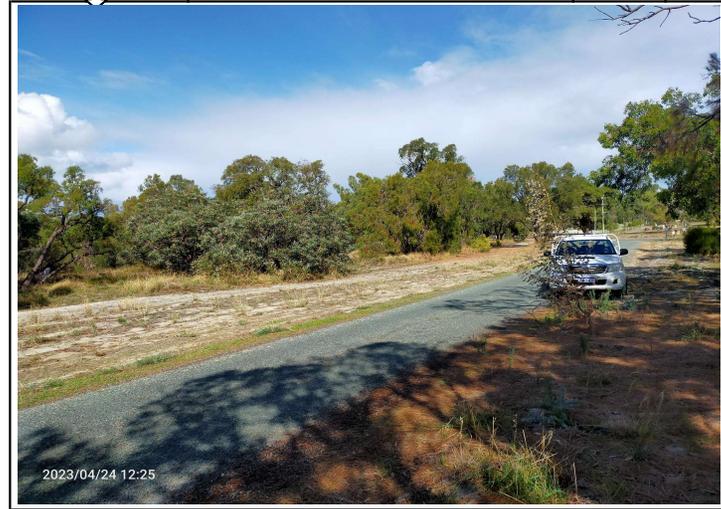
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City of Rockingham MRAMP

Field Report

Location ID	Well ID: EES-07_Traps-09 Other ID: 9 GPS Coords: E 115°48'5.44"E N 32°26'0.62"S Auditor: Hvdw Date: 24/4/23 Time: 11:40
PHOTOGRAPH ID	<p>Alignment by: <input type="checkbox"/> Orientation along Feature <input checked="" type="checkbox"/> Cardinal Angle</p> <p>Photo 1 (): 33 (N) Photo 2 (): 34 (W) Photo 3 (): 35 (S) Photo 4 (): 36 (E) Photo 5 (): none Photo 6 (): none Photo 7 (): none</p>
SITE ID	<input type="checkbox"/> Swamp <input type="checkbox"/> Constructed <input type="checkbox"/> Marsh <input type="checkbox"/> Perm. Pond <input type="checkbox"/> Drain <input type="checkbox"/> Temp. Pool / dep Other <u>Trap Site</u>
COMMENT	UTM Coordinants Zone 40 (WGS84).

Breeding Site Characteristics

Site Type	Size (m2)	Water	Veg.	Subst.	Shade
Swamp	<5	Fresh	Fringing	Organic	Exposed
Constructed wetland	>5-10	Brackish	Emergent	Mud	½ shade
Marsh	>10-20	Saline	Floating	Sand	Deep
Permanent Pond	>20-50	Running	Algal Mat	Rocky	
Temp. Pool / dep	>50-100	Stagnant	Phytopl.	Concrete	
Natural / semi nat. drain	>100-200	Clear	Samphire	Liner	
Artificial drain	>200-500	Turbid	Rush	Other	
Tyre track	>500-1000	Tannin	Other		
Container	>1000-5000	Foul			
Other (specify)	>0.5 - 1.0 ha	Other			
Trap Site	>1.0 ha				
	Other				

Surrounding Vegetation, within 50m (bold to relevant descriptor)

Projective Foliage Cover of Tallest Stratum (%)				
Tallest Stratum	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)
Trees >30	Tall closed	Tall open	Tall	Tall open
Trees 10-30	Closed	Open	Woodland	Open
Trees 5-10	Low closed	Low open	Low	Low open
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland
Herbs/grass (<2m)	Closed herb/ grassland	Herb/ grassland	Open Herb/ grassland	Ephemeral Herb grassland

Ground Cover (%)

	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland
Herbs/grass (<2m)	Closed herb/ grassland	Herb/ grassland	Open Herb/ grassland	Ephemeral Herb grassland

COMMENT

Stand of Casuarina on elevated land with minimal understory. Exposed to prevailing winds.

City of Rockingham MRAMP
Field Report

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EES-07_Trap-
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City of Rockingham MRAMP
Field Report

Location ID	Well ID: EES-07_Trapp-10 Other ID: 10 GPS Coords: E 115°47'27.34"E N 2°25'59.92"S Auditor: Hvdw Date: 24/4/23 Time: 12:03
PHOTOGRAPH ID	Alignment by: <input type="checkbox"/> Orientation along Feature <input checked="" type="checkbox"/> Cardinal Angle Photo 1 (): 37 (N) Photo 2 (): 38 (W) Photo 3 (): 39 (S) Photo 4 (): 40 (E) Photo 5 (): none Photo 6 (): none Photo 7 (): none
SITE ID	<input type="checkbox"/> Swamp <input type="checkbox"/> Constructed <input type="checkbox"/> Marsh <input type="checkbox"/> Perm. Pond <input type="checkbox"/> Drain <input type="checkbox"/> Temp. Pool / dep Other <u>Trap Site</u>
COMMENT	UTM Coordinants Zone 40 (WGS84). Site heavily disturbed (quarrying site)

Breeding Site Characteristics

Site Type	Size (m2)	Water	Veg.	Subst.	Shade
Swamp	<5	Fresh	Fringing	Organic	Exposed
Constructed wetland	>5-10	Brackish	Emergent	Mud	½ shade
Marsh	>10-20	Saline	Floating	Sand	Deep
Permanent Pond	>20-50	Running	Algal Mat	Rocky	
Temp. Pool / dep	>50-100	Stagnant	Phytopl.	Concrete	
Natural / semi nat. drain	>100-200	Clear	Samphire	Liner	
Artificial drain	>200-500	Turbid	Rush	Other	
Tyre track	>500-1000	Tannin	Other		
Container	>1000-500	Foul			
Other (specify)	>0.5 - 1.0 ha	Other			
Trap Site	>1.0 ha				
	Other				

Surrounding Vegetation, within 50m (bold to relevant descriptor)

Projective Foliage Cover of Tallest Stratum (%)					
Tallest Stratum	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)	
Trees >30	Tall closed	Tall open	Tall	Tall open	
Trees 10-30	Closed	Open	Woodland	Open	
Trees 5-10	Low closed	Low open	Low	Low open	
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland	
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland	
Herbs/grass (<2m)	Closed herb/grassland	Herb/ grassland	Open Herb/grassland	Ephemeral Herb grassland	

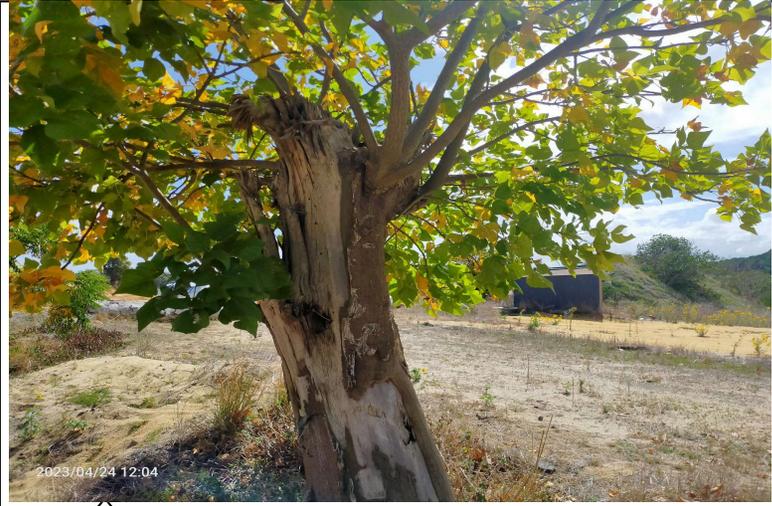
Ground Cover (%)

	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland
Herbs/grass (<2m)	Closed herb/grassland	Herb/ grassland	Open Herb/grassland	Ephemeral Herb grassland

COMMENT	Occasional remnant tree in cleared land fronting Pagenoni Rd near the junction of Fletcher Rd. Occasional pasture grasses on bare soils. Exposed to prevailing winds.
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Field Report

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EES-07_Trap-
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City of Rockingham MRAMP

Field Report

Location ID	Well ID: EES-07_L-01 Other ID: 11	
	GPS Coords: E 115° 50' 6.12" EN 32° 22' 23.39" S	
Auditor: Hvdw \emptyset Date: 21/4/23 Time: 10:41		
PHOTOGRAPH ID	Alignment by: <input type="checkbox"/> Orientation along Feature	
	<input checked="" type="checkbox"/> Cardinal Angle	
	Photo 1 ():	1 (N)
	Photo 2 ():	2 (W)
	Photo 3 ():	3 (S)
	Photo 4 ():	4 (E)
	Photo 5 ():	none
	Photo 6 ():	none
Photo 7 ():	none	
SITE ID	<input type="checkbox"/> Wetland <input type="checkbox"/> Constructed <input type="checkbox"/> Marsh <input type="checkbox"/> Perm. Pond <input checked="" type="checkbox"/> Drain <input type="checkbox"/> Temp. Pool / dep	
	Other <u>Peel Main Drain</u>	
COMMENT	UTM Coordinants Zone 40 (WGS84).	

Breeding Site Characteristics

Site Type	Size (m2)	Water	Veg.	Subst.	Shade
Swamp	<5	Fresh	Fringing	Organic	Exposed
Constructed wetland	>5-10	Brackish	Emergent	Mud	½ shade
Marsh	>10-20	Saline	Floating	Sand	Deep
Permanent Pond	>20-50	Running	Algal Mat	Rocky	
Temp. Pool / dep	>50-100	Stagnant	Phytopl.	Concrete	
Natural / semi nat. drain	>100-200	Clear	Samphire	Liner	
Artificial drain	>200-500	Turbid	Rush	Other	
Tyre track	>500-1000	Tannin	Other		
Container	>1000-5000	Foul			
Other (specify)	>0.5 - 1.0	Other			
Trap Site	>1.0 ha				
	Other				

Surrounding Vegetation, within 50m (bold to relevant descriptor)

Projective Foliage Cover of Tallest Stratum (%)					
Tallest Stratum	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)	
Trees >30	Tall closed	Forest Tall open Open	Forest Tall Woodland	Woodland Open	Woodland Tall open Open
Trees 10-30	Closed				
Trees 5-10	Low closed	Low open	Low	Low open	Low open
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland	
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland	
Herbs/grass (<2m)	Closed herb/grassland	Herb/ grassland	Open Herb/grassland	Ephemeral Herb grassland	

Ground Cover (%)

	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland
Herbs/grass (<2m)	Closed herb/grassland	Herb/ grassland	Open Herb/grassland	Ephemeral Herb grassland

COMMENT	Peel Main Drain. S off Karnup Rd. Slight flows, clear cool fresh. Limited late instar Aedes larvae in fringing emergent grasses
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City of Rockingham MRAMP
Field Report

SITE
EES-07_L-0
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(N)

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City of Rockingham MRAMP

Field Report

Location ID	Well ID: EES-07_L-02 Other ID: 12
	GPS Coords: E 115° 50' 8.98" EN 32° 22' 29.06" S
Auditor: Hvdw θ Date: 21/4/23 Time: 10:58	
PHOTOGRAPH ID	Alignment by:
	Photo 1 (): 5 (N)
	Photo 2 (): 6 (W)
	Photo 3 (): 7 (S)
	Photo 4 (): 8 (E)
	Photo 5 (): none
	Photo 6 (): none
	Photo 7 (): none
SITE ID	<input checked="" type="checkbox"/> Wetland <input type="checkbox"/> Constructed <input type="checkbox"/> Marsh <input type="checkbox"/> Perm. Pond <input type="checkbox"/> Drain <input type="checkbox"/> Temp. Pool / dep Other <u>Trap Site</u>
	COMMENT UTM Coordinants Zone 40 (WGS84).

Breeding Site Characteristics

Site Type	Size (m2)	Water	Veg.	Subst.	Shade
Swamp	<5	Fresh	Fringing	Organic	Exposed
Constructed wetland	>5-10	Brackish	Emergent	Mud	½ shade
Marsh	>10-20	Saline	Floating	Sand	Deep
Permanent Pond	>20-50	Running	Algal Mat	Rocky	
Temp. Pool / dep	>50-100	Stagnant	Phytopl.	Concrete	
Natural / semi nat. drain	>100-200	Clear	Samphire	Liner	
Artificial drain	>200-500	Turbid	Rush	Other	
Tyre track	>500-1000	Tannin	Other		
Contamer	>1000-500	Foul			
Other (specify)	>0.5 - 1.0 ha	Other			
Trap Site	>1.0 ha				
	Other				

Surrounding Vegetation, within 50m (bold to relevant descriptor)

Projective Foliage Cover of Tallest Stratum (%)								
Tallest Stratum	Dense (70-100)		Mid Den (30-70)		Sparse(10-30)		Very Sparse(<10)	
Trees >30	Tall closed	Forest	Tall open	Forest	Tall	Woodland	Woodland	Tall open
Trees 10-30	Closed		Open		Woodland			Open
Trees 5-10	Low closed	Forest	Low open	Forest	Low	Woodland	Woodland	Low open
Shrubs 2-8	Closed Shrub		Open Shrub		Tall shrubland			Tall open shrubland
Shrubs <2	Closed Heath		Open Heath		Low shrubland			Low open shrubland
Herbs/grass (<2m)	Closed herb/ grassland		Herb/ grassland		Open Herb/ grassland			Ephemeral Herb grassland

Ground Cover (%)

	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland
Herbs/grass (<2m)	Closed herb/ grassland	Herb/ grassland	Open Herb/ grassland	Ephemeral Herb grassland

COMMENT

Melaleuca Wetland. occasional pools.

City of Rockingham MRAMP

Field Report

SITE

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City of Rockingham MRAMP
Field Report

Location ID	Well ID: EES-07_L-03 Other ID: 13
	GPS Coords: E 115° 50' 0.03" EN 32° 22' 43.76" S
	Auditor: Hvdw Date: 21/4/23 Time: 11:13
PHOTOGRAPH ID	Alignment by: <input type="checkbox"/> Orientation along Feature <input checked="" type="checkbox"/> Cardinal Angle
	Photo 1 (): 9 (N)
	Photo 2 (): 10 (W)
	Photo 3 (): 11 (S)
	Photo 4 (): 12 (E)
	Photo 5 (): none
	Photo 6 (): none
	Photo 7 (): none
SITE ID	<input checked="" type="checkbox"/> Wetland <input type="checkbox"/> Constructed <input type="checkbox"/> Marsh <input type="checkbox"/> Perm. Pond <input type="checkbox"/> Drain <input type="checkbox"/> Temp. Pool / dep
	Other _____
COMMENT	UTM Coordinants Zone 40 (WGS84).

Breeding Site Characteristics

Site Type	Size (m2)	Water	Veg.	Subst.	Shade
Swamp	<5	Fresh	Fringing	Organic	Exposed
Constructed wetland	>5-10	Brackish	Emergent	Mud	½ shade
Marsh	>10-20	Saline	Floating	Sand	Deep
Permanent Pond	>20-50	Running	Algal Mat	Rocky	
Temp. Pool / dep	>50-100	Stagnant	Phytopl.	Concrete	
Natural / semi nat. drain	>100-200	Clear	Samphire	Liner	
Artificial drain	>200-500	Turbid	Rush	Other	
Tyre track	>500-1000	Tannin	Other		
Container	>1000-5000	Foul			
Other (specify)	>0.5 - 1.0 ha	Other			
Trap Site	>1.0 ha				
	Other				

Surrounding Vegetation, within 50m (bold to relevant descriptor)

Projective Foliage Cover of Tallest Stratum (%)				
Tallest Stratum	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)
Trees >30	Tall closed	Tall open	Tall	Tall open
Trees 10-30	Closed	Open	Woodland	Open
Trees 5-10	Low closed	Low open	Low	Low open
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland
Herbs/grass (<2m)	Closed herb/ grassland	Herb/ grassland	Open Herb/ grassland	Ephemeral Herb grassland

Ground Cover (%)

	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland
Herbs/grass (<2m)	Closed herb/ grassland	Herb/ grassland	Open Herb/ grassland	Ephemeral Herb grassland

COMMENT

Melaleuca wetland reduced to early autumn occasional ponds. Melaleuca overstory with dense native understorey. Water heavily tannin stained, turbid, with no larvae observed.

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Field Report

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EES-07_L-03
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City of Rockingham MRAMP
Field Report

Location ID	Well ID: EES-07_L-04 Other ID: 4
	GPS Coords: E 115° 50' 1.81" EN : 32° 22' 58.77" S
	Auditor: Hvdw θ Date: 21/4/23 Time: 11:26
PHOTOGRAPH ID	<p>Alignment by: <input type="checkbox"/> Orientation along Feature</p> <p style="margin-left: 100px;">↓ <input checked="" type="checkbox"/> Cardinal Angle</p> <p>Photo 1 (): 13 (N)</p> <p>Photo 2 (): 14 (W)</p> <p>Photo 3 (): 15 (S)</p> <p>Photo 4 (): 16 (E)</p> <p>Photo 5 (): none</p> <p>Photo 6 (): none</p> <p>Photo 7 (): none</p>
SITE ID	<input type="checkbox"/> Wetland <input checked="" type="checkbox"/> Constructed <input type="checkbox"/> Marsh <input type="checkbox"/> Perm. Pond <input type="checkbox"/> Drain <input type="checkbox"/> Temp. Pool / dep Other <u>nutrient stripping basin</u>
COMMENT	UTM Coordinants Zone 40 (WGS84).

Breeding Site Characteristics

Site Type	Size (m2)	Water	Veg.	Subst.	Shade
Swamp	<5	Fresh	Fringing	Organic	Exposed
Constructed wetland	>5-10	Brackish	Emergent	Mud	½ shade
Marsh	>10-20	Saline	Floating	Sand	Deep
Permanent Pond	>20-50	Running	Algal Mat	Rocky	
Temp. Pool / dep	>50-100	Stagnant	Phytopl.	Concrete	
Natural / semi nat. drain	>100-200	Clear	Samphire	Liner	
Artificial drain	>200-500	Turbid	Rush	Other	
Tyre track	>500-1000	Tannin	Other		
Container	>1000-500	Foul			
Other (specify)	>0.5 - 1.0 ha	Other			
Trap Site	>1.0 ha				
	Other				

Surrounding Vegetation, within 50m (bold to relevant descriptor)

Projective Foliage Cover of Tallest Stratum (%)					
Tallest Stratum	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)	
Trees >30	Tall closed	Forest	Tall open	Tall	Tall open
Trees 10-30	Closed		Open	Woodland	Open
Trees 5-10	Low closed	Forest	Low open	Low	Low open
Shrubs 2-8	Closed Shrub		Open Shrub	Tall shrubland	Tall open shrubland
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland	
Herbs/grass (<2m)	Closed herb/ grassland	Herb/ grassland	Open Herb/ grassland	Ephemeral Herb grassland	

Ground Cover (%)

	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland
Herbs/grass (<2m)	Closed herb/ grassland	Herb/ grassland	Open Herb/ grassland	Ephemeral Herb grassland

COMMENT	Nutrient stripping trial area. Dry during summer. Potential for larval development when inundated?
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Field Report

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City of Rockingham MRAMP
Field Report

Location ID	Well ID: EES-07_L-05	Other ID: 5
	GPS Coords: E 115° 49' 44.18" N 32° 23' 24.78" S	
Auditor: Hvdw θ Date: 21/4/23 Time: 11:38		
PHOTOGRAPH ID	Alignment by: <input type="checkbox"/> Orientation along Feature	
	Photo 1 ():	17 (N)
	Photo 2 ():	18 (W)
	Photo 3 ():	19 (S)
	Photo 4 ():	20 (E)
	Photo 5 ():	none
	Photo 6 ():	none
Photo 7 ():	none	
SITE ID	<input checked="" type="checkbox"/> Wetland <input type="checkbox"/> Constructed <input type="checkbox"/> Marsh <input type="checkbox"/> Perm. Pond <input type="checkbox"/> Drain <input type="checkbox"/> Temp. Pool / dep	
	Other _____	
COMMENT	UTM Coordinants Zone 40 (WGS84). Seasonal Wetland	

Breeding Site Characteristics

Site Type	Size (m2)	Water	Veg.	Subst.	Shade
Swamp (seasonal)	<5	Fresh	Fringing	Organic	Exposed
Constructed wetland	>5-10	Brackish	Emergent	Mud	½ shade
Marsh	>10-20	Saline	Floating	Sand	Deep
Permanent Pond	>20-50	Running	Algal Mat	Rocky	
Temp. Pool / dep	>50-100	Stagnant	Phytopl.	Concrete	
Natural / semi nat. drain	>100-200	Clear	Samphire	Liner	
Artificial drain	>200-500	Turbid	Rush	Other	
Tyre track	>500-1000	Tannin	Other		
Container	>1000-500	Foul			
Other (specify)	>0.5 - 1.0 ha	Other			
Trap Site	>1.0 ha				
	Other				

Surrounding Vegetation, within 50m (bold to relevant descriptor)

Projective Foliage Cover of Tallest Stratum (%)					
Tallest Stratum	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)	
Trees >30	Tall closed	Tall open	Tall	Tall open	
Trees 10-30	Closed	Open	Woodland	Open	Woodland
Trees 5-10	Low closed	Low open	Low	Low open	Woodland
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland	
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland	
Herbs/grass (<2m)	Closed herb/grassland	Herb/ grassland	Open Herb/grassland	Ephemeral Herb grassland	

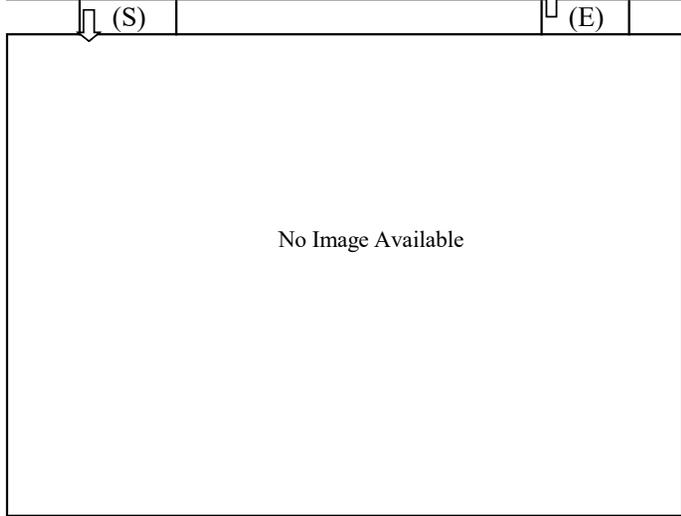
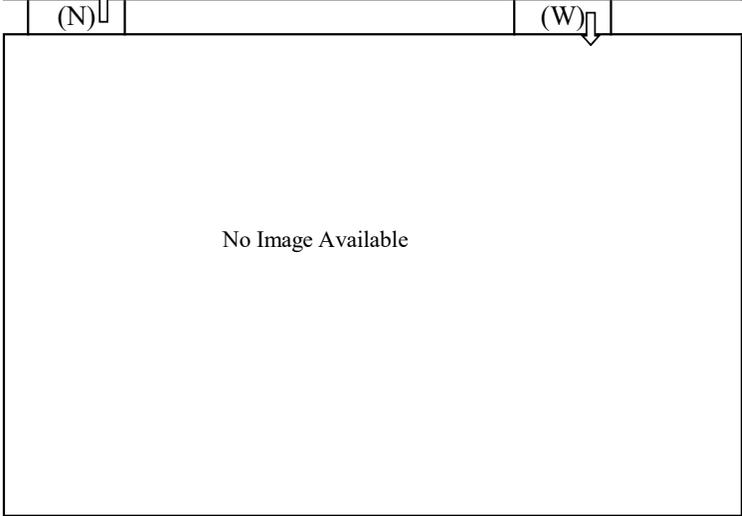
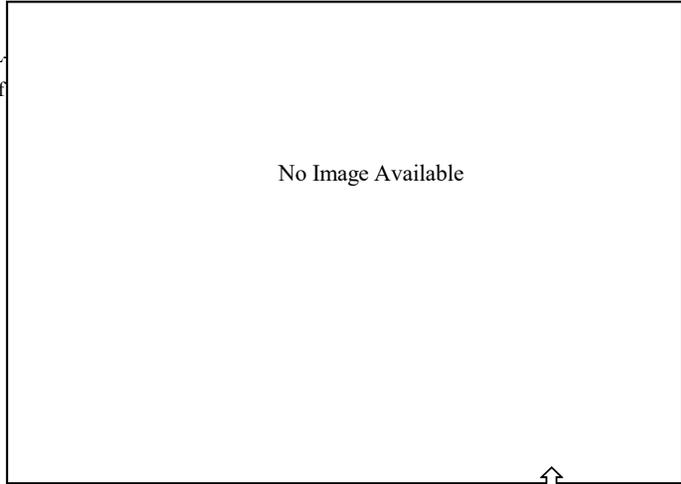
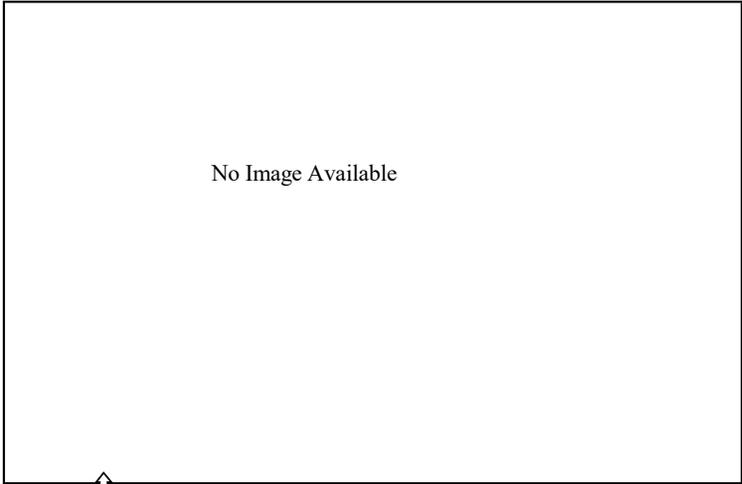
Ground Cover (%)

	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland
Herbs/grass (<2m)	Closed herb/grassland	Herb/ grassland	Open Herb/grassland	Ephemeral Herb grassland

COMMENT	Dense Melaleuca and Casuarina overstory with native rushes below. seasonally inundated? NO PLATES
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Field Report

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EES-07_L
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City of Rockingham MRAMP

Field Report

Location ID	Well ID: EES-07_L-06 Other ID: MOH 12	
	GPS Coords: E 115° 49' 47.74" N 32° 24' 1.38" S	
	Auditor: Hvdw Date: 21/4/23 Time: 12:03	
PHOTOGRAPH ID	Alignment by: <input type="checkbox"/> Orientation along Feature	
	<input checked="" type="checkbox"/> Cardinal Angle	
	Photo 1 ():	21 (N)
	Photo 2 ():	22 (W)
	Photo 3 ():	23 (S)
	Photo 4 ():	24 (E)
	Photo 5 ():	none
	Photo 6 ():	none
Photo 7 ():	none	
SITE ID	<input checked="" type="checkbox"/> Wetland <input type="checkbox"/> Constructed <input type="checkbox"/> Marsh <input type="checkbox"/> Perm. Pond <input type="checkbox"/> Drain <input type="checkbox"/> Temp. Pool / dep Other <u>Seasonal</u>	
	COMMENT UTM Coordinants Zone 40 (WGS84). Adults active	

Breeding Site Characteristics

Site Type	Size (m2)	Water	Veg.	Subst.	Shade
Wetland (seasonal)	<5	Fresh	Fringing	Organic	Exposed
Constructed wetland	>5-10	Brackish	Emergent	Mud	½ shade
Marsh	>10-20	Saline	Floating	Sand	Deep
Permanent Pond	>20-50	Running	Algal Mat	Rocky	
Temp. Pool / dep	>50-100	Stagnant	Phytopl.	Concrete	
Natural / semi nat. drain	>100-200	Clear	Samphire	Liner	
Artificial drain	>200-500	Turbid	Rush	Other	
Tyre track	>500-1000	Tannin	Other		
Container	>1000-5000	Foul			
Other (specify)	>0.5 - 1.0 ha	Other			
Trap Site	>1.0 ha				
	Other				

Surrounding Vegetation, within 50m (bold to relevant descriptor)

Projective Foliage Cover of Tallest Stratum (%)					
Tallest Stratum	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)	
Trees >30	Tall closed	Tall open	Tall	Woodland	Tall open
Trees 10-30	Closed	Open	Forest	Woodland	Open
Trees 5-10	Low closed	Low open	Forest	Low	Low open
Shrubs 2-8	Closed Shrub	Open Shrub		Tall shrubland	Tall open shrubland
Shrubs <2	Closed Heath	Open Heath		Low shrubland	Low open shrubland
Herbs/grass (<2m)	Closed herb/ grassland	Herb/ grassland		Open Herb/ grassland	Ephemeral Herb grassland

Ground Cover (%)

	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland
Herbs/grass (<2m)	Closed herb/ grassland	Herb/ grassland	Open Herb/ grassland	Ephemeral Herb grassland

COMMENT	Extensive seasonal wetland. Melaleuca scrubland with limited understorey
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City of Rockingham MRAMP
Field Report

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EES-07_L
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City of Rockingham MRAMP
Field Report

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(N)

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City of Rockingham MRAMP
Field Report

Location ID	Well ID: EES-07_L-08 Other ID: 8
	GPS Coords: E 115°48'13.34"E N 32° 24' 49.52" S
	Auditor: Hvdw θ Date: 23/4/23 Time: 12:20
PHOTOGRAPH ID	<p>Alignment by: <input type="checkbox"/> Orientation along Feature</p> <p style="margin-left: 100px;">↓ <input checked="" type="checkbox"/> Cardinal Angle</p> <p>Photo 1 (): 29 (N)</p> <p>Photo 2 (): 30 (W)</p> <p>Photo 3 (): 31 (S)</p> <p>Photo 4 (): 32 (E)</p> <p>Photo 5 (): none</p> <p>Photo 6 (): none</p> <p>Photo 7 (): none</p>
SITE ID	<input checked="" type="checkbox"/> Wetland <input type="checkbox"/> Constructed <input type="checkbox"/> Marsh <input type="checkbox"/> Perm. Pond <input type="checkbox"/> Drain <input type="checkbox"/> Temp. Pool / dep Other <u>Seasonal</u>
COMMENT	UTM Coordinants Zone 40 (WGS84).

Breeding Site Characteristics

Site Type	Size (m2)	Water	Veg.	Subst.	Shade
Seasonal wetland	<5	Fresh	Fringing	Organic	Exposed
Constructed wetland	>5-10	Brackish	Emergent	Mud	½ shade
Marsh	>10-20	Saline	Floating	Sand	Deep
Permanent Pond	>20-50	Running	Algal Mat	Rocky	
Temp. Pool / dep	>50-100	Stagnant	Phytopl.	Concrete	
Natural / semi nat. drain	>100-200	Clear	Samphire	Liner	
Artificial drain	>200-500	Turbid	Rush	Other	
Tyre track	>500-1000	Tannin	Other		
Container	>1000-500	Foul			
Other (specify)	>0.5 - 1.0	Other			
Trap Site	>1.0 ha				
	Other				

Surrounding Vegetation, within 50m (bold to relevant descriptor)

Projective Foliage Cover of Tallest Stratum (%)				
Tallest Stratum	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)
Trees >30	Tall closed	Tall open	Tall	Tall open
Trees 10-30	Closed	Open	Woodland	Open
Trees 5-10	Low closed	Low open	Low	Low open
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland
Herbs/grass (<2m)	Closed herb/ grassland	Herb/ grassland	Open Herb/ grassland	Ephemeral Herb grassland

Ground Cover (%)

	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland
Herbs/grass (<2m)	Closed herb/ grassland	Herb/ grassland	Open Herb/ grassland	Ephemeral Herb grassland

COMMENT

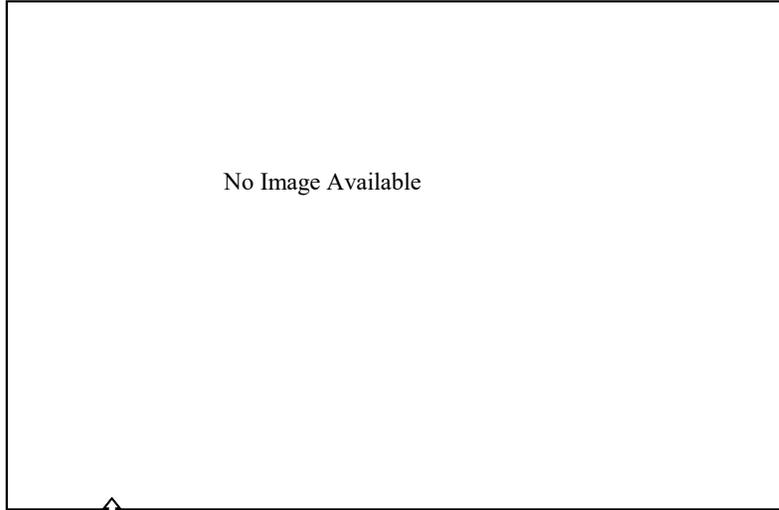
Extensive seasonally inundated melaleuca wetland. NO PLATES

City of Rockingham MRAMP
Field Report

SITE

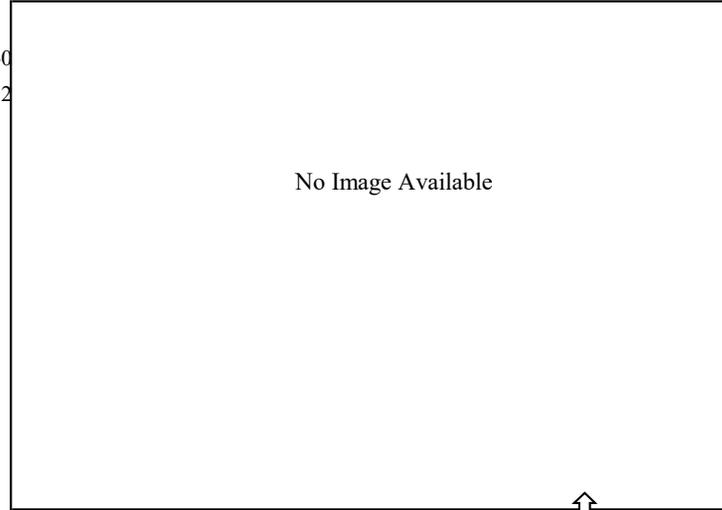
EES-07_L-0

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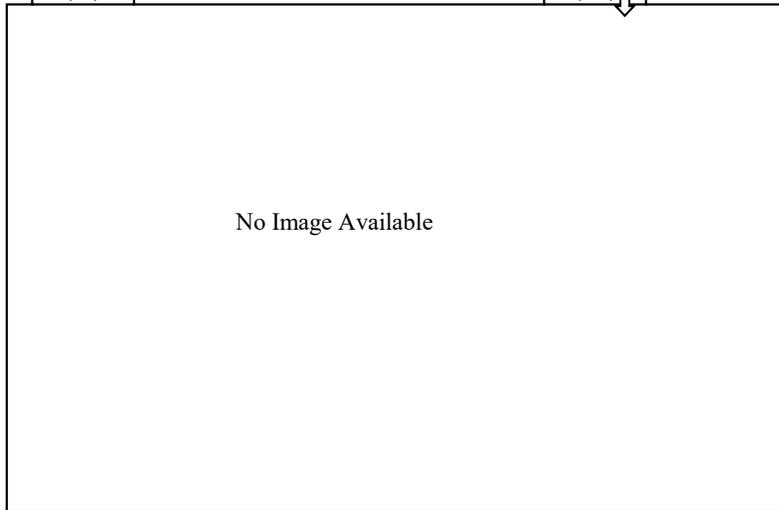
(N) ↑

(W) ↓

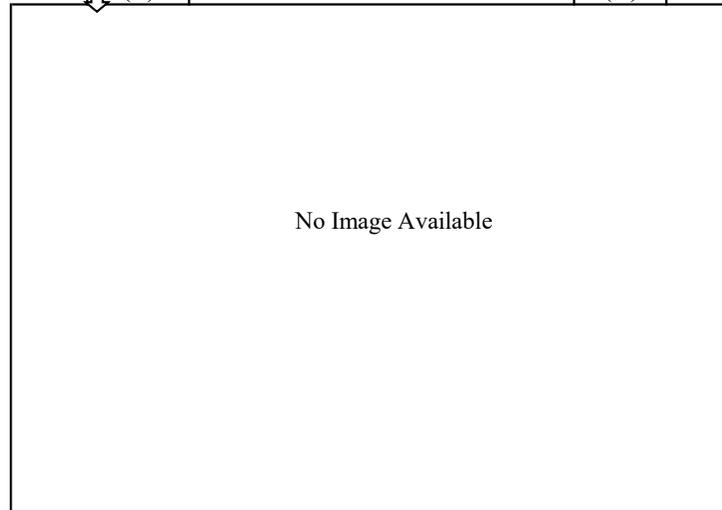


↓ (S)

↑ (E)



No Image Available



No Image Available

City of Rockingham MRAMP
Field Report

Location ID	Well ID: EES-07_L-09 Other ID: 9
	GPS Coords: E 115° 48' 46.33" N 32° 25' 29.21" S
	Auditor: Hvdw θ Date: 23/4/23 Time: 12:48
PHOTOGRAPH ID	<p>Alignment by: <input type="checkbox"/> Orientation along Feature</p> <p style="margin-left: 100px;">↓ <input checked="" type="checkbox"/> Cardinal Angle</p> <p>Photo 1 (): 33 (N)</p> <p>Photo 2 (): 34 (W)</p> <p>Photo 3 (): 35 (S)</p> <p>Photo 4 (): 36 (E)</p> <p>Photo 5 (): none</p> <p>Photo 6 (): none</p> <p>Photo 7 (): none</p>
SITE ID	<input checked="" type="checkbox"/> Wetland <input type="checkbox"/> Constructed <input type="checkbox"/> Marsh <input type="checkbox"/> Perm. Pond <input type="checkbox"/> Drain <input type="checkbox"/> Temp. Pool / dep Other <u>Trap Site</u>
COMMENT	UTM Coordinants Zone 40 (WGS84).

Breeding Site Characteristics

Site Type	Size (m2)	Water	Veg.	Subst.	Shade
Wetland	<5	Fresh	Fringing	Organic	Exposed
Constructed wetland	>5-10	Brackish	Emergent	Mud	½ shade
Marsh	>10-20	Saline	Floating	Sand	Deep
Permanent Pond	>20-50	Running	Algal Mat	Rocky	
Temp. Pool / dep	>50-100	Stagnant	Phytopl.	Concrete	
Natural / semi nat. drain	>100-200	Clear	Samphire	Liner	
Artificial drain	>200-500	Turbid	Rush	Other	
Tyre track	>500-1000	Tannin	Other		
Container	>1000-500	Foul			
Other (specify)	>0.5 - 1.0 ha	Other			
Trap Site	>1.0 ha				
	Other				

Surrounding Vegetation, within 50m (bold to relevant descriptor)

Projective Foliage Cover of Tallest Stratum (%)				
Tallest Stratum	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)
Trees >30	Tall closed	Tall open	Tall	Tall open
Trees 10-30	Closed	Open	Woodland	Open
Trees 5-10	Low closed	Low open	Low	Low open
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland
Herbs/grass (<2m)	Closed herb/ grassland	Herb/ grassland	Open Herb/ grassland	Ephemeral Herb grassland

Ground Cover (%)

	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland
Herbs/grass (<2m)	Closed herb/ grassland	Herb/ grassland	Open Herb/ grassland	Ephemeral Herb grassland

COMMENT

Karnup Wetland. Fringing Samphire, dense Melaleuca surrounding. Adults biting.

City of Rockingham MRAMP
Field Report

SITE

EES-07_L-09

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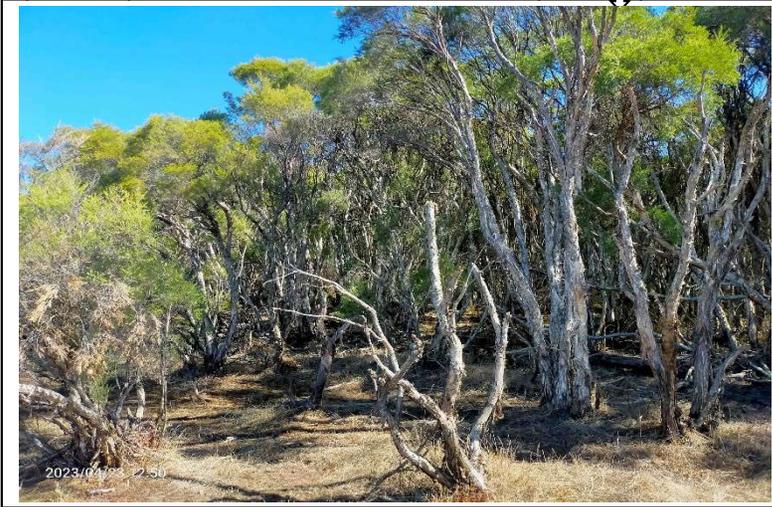
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(E)



City of Rockingham MRAMP
Field Report

Location ID	Well ID: EES-07_L-10 Other ID: 10
	GPS Coords: E 115° 46' 40.49" N 32° 25' 34.21" S
	Auditor: Hvdw θ Date: 23/4/23 Time: 13:53
PHOTOGRAPH ID	<p>Alignment by: <input type="checkbox"/> Orientation along Feature</p> <p style="margin-left: 100px;">↓ <input checked="" type="checkbox"/> Cardinal Angle</p> <p>Photo 1 (): 37 (N)</p> <p>Photo 2 (): 38 (W)</p> <p>Photo 3 (): 39 (S)</p> <p>Photo 4 (): 40 (E)</p> <p>Photo 5 (): none</p> <p>Photo 6 (): none</p> <p>Photo 7 (): none</p>
SITE ID	<input checked="" type="checkbox"/> Wetland <input type="checkbox"/> Constructed <input type="checkbox"/> Marsh <input type="checkbox"/> Perm. Pond <input type="checkbox"/> Drain <input type="checkbox"/> Temp. Pool / dep Other <u>Seasonal</u>
COMMENT	UTM Coordinants Zone 40 (WGS84). Site heavily disturbed (quarrying site)

Breeding Site Characteristics

Site Type	Size (m2)	Water	Veg.	Subst.	Shade
Seasonal wetland	<5	Fresh	Fringing	Organic	Exposed
Constructed wetland	>5-10	Brackish	Emergent	Mud	½ shade
Marsh	>10-20	Saline	Floating	Sand	Deep
Permanent Pond	>20-50	Running	Algal Mat	Rocky	
Temp. Pool / dep	>50-100	Stagnant	Phytopl.	Concrete	
Natural / semi nat. drain	>100-200	Clear	Samphire	Liner	
Artificial drain	>200-500	Turbid	Rush	Other	
Tyre track	>500-1000	Tannin	Other		
Container	>1000-500	Foul			
Other (specify)	>0.5 - 1.0 ha	DRY			
	>1.0 ha				
	Other				

Surrounding Vegetation, within 50m (bold to relevant descriptor)

Projective Foliage Cover of Tallest Stratum (%)				
Tallest Stratum	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)
Trees >30	Tall closed	Tall open	Tall	Tall open
Trees 10-30	Closed	Open	Woodland	Open
Trees 5-10	Low closed	Low open	Low	Low open
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland
Herbs/grass (<2m)	Closed herb/ grassland	Herb/ grassland	Open Herb/ grassland	Ephemeral Herb grassland

Ground Cover (%)

	Dense (70-100)	Mid Den (30-70)	Sparse(10-30)	Very Sparse(<10)
Shrubs 2-8	Closed Shrub	Open Shrub	Tall shrubland	Tall open shrubland
Shrubs <2	Closed Heath	Open Heath	Low shrubland	Low open shrubland
Herbs/grass (<2m)	Closed herb/ grassland	Herb/ grassland	Open Herb/ grassland	Ephemeral Herb grassland

COMMENT

S. end of Anstey Swamp. Dense Melaleuca and Casuarina. Seasonal, no water at present. Adults biting.

City of Rockingham MRAMP
Field Report

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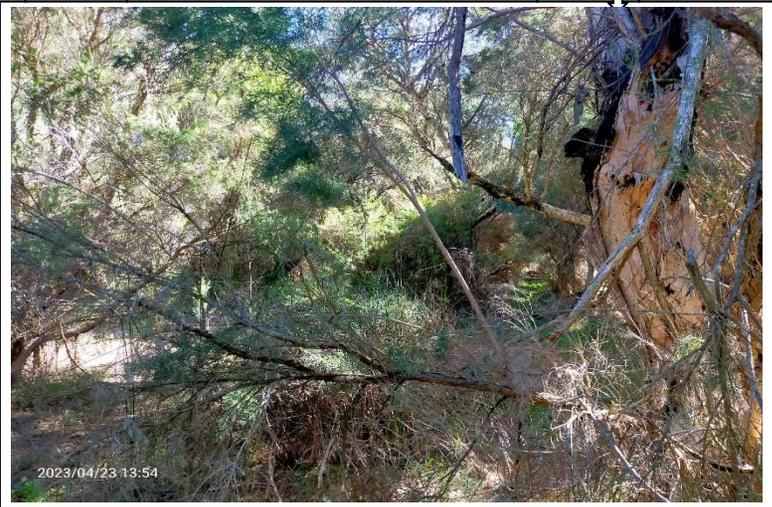
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Field Report

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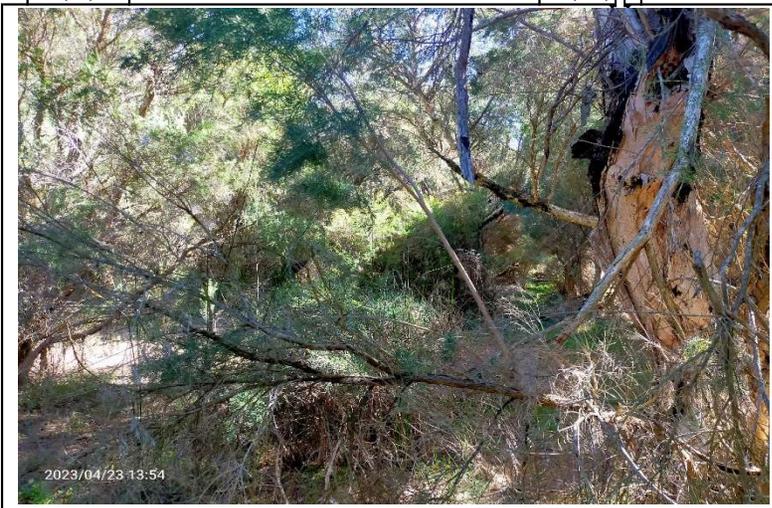
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Field Report

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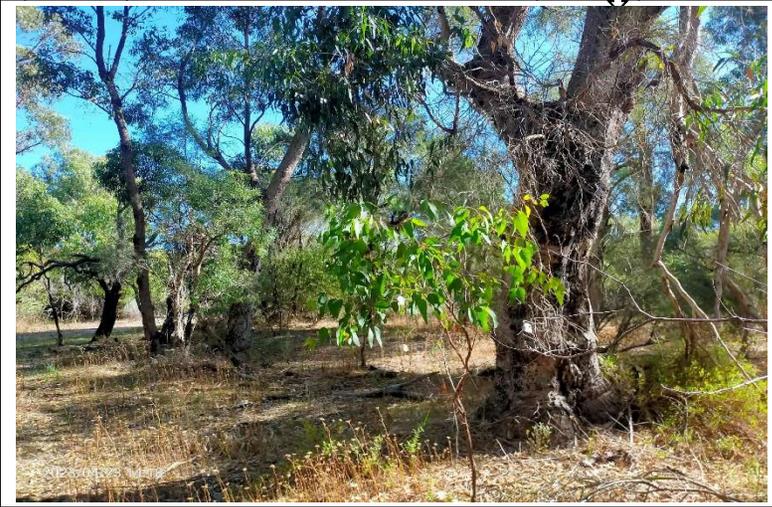
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Field Report

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Field Report

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Page 2 of 2



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City of Rockingham MRAMP
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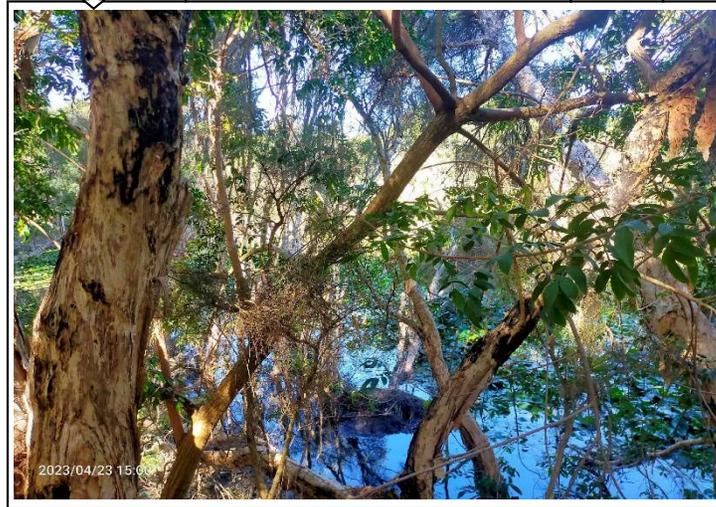
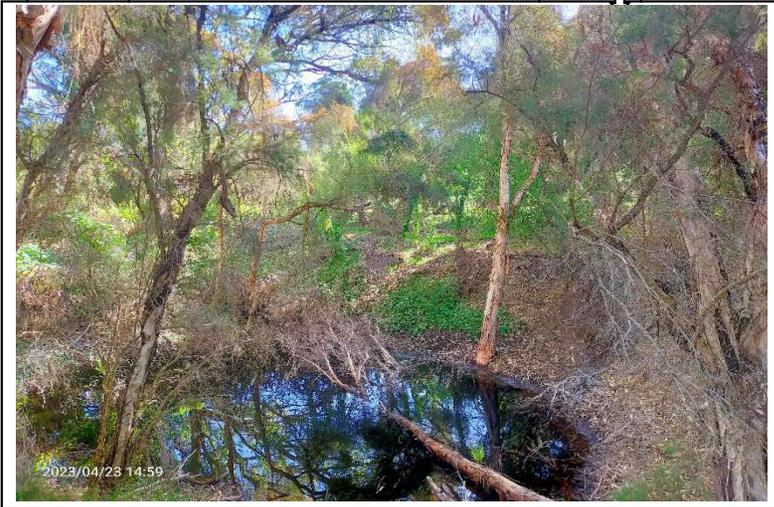
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APPENDIX 3

LARVAL MONITORING DATA (2022 – 2023)
(Source: City of Rockingham 2023)

	RO6	dry / cns						
	RO7		√	85 larvae caught	1st instar	10	10	850
	RO8		√	152 larvae caught	2nd instar	10	10	1520
11/4/23	RO1		√	23 larvae caught	4th instar	10	10	230
	RO2	dry / cns						
	RO3	dry / cns						
	RO4	dry / cns						
	RO5	dry / cns						
	RO6	dry / cns						
	RO7		√	3 larvae caught	4th instar	10	10	30
	RO8		√	51 larvae caught	4th instar	10	10	510
17/4/23	RO1		√	81 larvae caught	1st instar	10	10	810
	RO2	dry / cns						
	RO3		√	58 larvae caught	1st instar	10	10	580
	RO4		√	88 larvae caught	2nd instar	10	10	880
	RO5	dry / cns						
	RO6	dry / cns						
	RO7		√	89 larvae caught	2nd instar	10	10	890
	RO8		√	81 larvae caught	2nd instar	10	10	810
24/4/23	RO1		√	26 larvae caught	4th instar	10	10	260
	RO2	dry / cns						
	RO3		√	17 larvae caught	4th instar	10	10	170
	RO4		√	15 larvae caught	4th instar	10	9	150
	RO5	dry / cns						
	RO6	dry / cns						
	RO7		√	22 larvae caught	4th instar	10	9	220
	RO8		√	0 no larvae caught		10	0	0
1/5/23	RO1	dry / cns						
	RO2	dry / cns						
	RO3	dry / cns						
	RO4		√	108 larvae caught	2nd instar	10	10	1080
	RO5	dry / cns						
	RO6	dry / cns						
	RO7		√	70 larvae caught	1st instar	10	10	700
	RO8		√	50 larvae caught	1st instar	10	10	500
4/5/23	RO1	dry / cns						
	RO2	dry / cns						
	RO3	dry / cns						
	RO4		√	41 larvae caught	3rd instar	10	10	410
	RO5	dry / cns						
	RO6	dry / cns						
	RO7		√	38 larvae caught	3rd instar	10	10	380
	RO8		√	22 larvae caught	2nd instar	10	8	220
17/5/23	RO1		√	42 larvae caught	3rd instar	10	7	420
	RO2	dry / cns						
	RO3	dry / cns						
	RO4		√	48 larvae caught	3rd instar	10	9	480
	RO5	dry / cns						
	RO6	dry / cns						
	RO7		√	54 larvae caught	4th instar	10	6	540
	RO8	dry / cns						
22/5/23	RO1		√	8 larvae caught	3rd instar	10	5	80
	RO2	dry / cns						
	RO3	dry / cns						
	RO4		√	16 larvae caught	3rd instar	10	9	160
	RO5	dry / cns						
	RO6	dry / cns						
	RO7		√	14 larvae caught	4th instar	10	6	140
	RO8	dry / cns						
18/7/23	RO1	dry / cns						
	RO2	dry / cns						
	RO3	dry / cns						
	RO4		√	330 larvae caught	3rd instar	10	10	3300
	RO5		√	160 larvae caught	3rd instar	10	10	1600
	RO6		√	369 larvae caught	3rd instar	10	10	3690
	RO7		√	53 larvae caught	3rd instar	10	10	530

	RO8	dry / cns	√	108 larvae caught	3rd instar	10	10	1080
25/7/23	RO1	dry / cns						
	RO2	dry / cns						
	RO3	dry / cns						
	RO4		√	95 larvae caught	3rd instar	10	10	950
	RO5		√	72 larvae caught	3rd instar	10	10	720
	RO6		√	109 larvae caught	4th instar	10	10	1090
	RO7		√	24 larvae caught	4th instar	10	9	240
	RO8	dry / cns	√	26 larvae caught	3rd instar	10	9	260
28/8/23	RO1	dry / cns						
	RO2	dry / cns						
	RO3	dry / cns						
	RO4	dry / cns						
	RO5	dry / cns						
	RO6		√	78 larvae caught	1st instar	10	10	780
	RO7	dry / cns						
	RO8	dry / cns						
5/9/23	RO1		√	43 larvae caught	1st instar	10	10	430
	RO2	dry / cns						
	RO3	dry / cns						
	RO4	dry / cns						
	RO5	dry / cns						
	RO6		√	75 larvae caught	1st instar	10	10	750
	RO7	dry / cns						
	RO8		√	67 larvae caught	1st instar	10	10	670
12/9/23	RO1		√	7 larvae caught	2nd instar	10	6	70
	RO2	dry / cns						
	RO3	dry / cns						
	RO4	dry / cns						
	RO5	dry / cns						
	RO6		√	9 larvae caught	2nd instar	10	7	90
	RO7	dry / cns						
	RO8		√	12 larvae caught	2nd instar	10	6	120

APPENDIX 4

SELECT HISTORICAL ADULT AND INTENSIVE TRAPPING DATA (2008 – 2023)

**Source: Rankine Mosquito Management and City of
Rockingham 2023**

APPENDIX 4
SELECT HISTORICAL ADULT AND INTENSIVE MOSQUITO MONITORING CONDUCTED IN OR
ADJACENT TO THE SUBJECT LAND

A4.1 Adult Trapping Methods

The historical adult mosquito monitoring program undertaken by the City and consultants acting on behalf of the Department of Health (DOH) involves setting out carbon dioxide (CO₂) baited light traps (EVS¹ trap) that comprises a small incandescent bulb, a fan, a catching container and a solid insulated container that holds the dry ice (the source of CO₂). As there is a variation in species that are collected using light as an attractant alone, using light plus CO₂ provides a combination of attractants enabling the collection of a more diverse and representative range of species that may be on-site (Whelan, 2019).

The EVS traps are suspended up to 2 m above the ground in a sheltered position, with traps being set out in early to late afternoon and collected the following morning after sunrise. When the traps are collected, the collection bags are removed and placed in a cooler containing dry ice (to preserve the specimens) until they are returned for processing.

At the office, the mosquito samples are decanted into a sterilised container and if there are excessive numbers of individuals, the container is weighed to obtain a rough count. If the samples are not identified immediately, the sample container is placed in the freezer until such time as identification to species level can be undertaken.

Trap results are recorded on a standardised form that includes information such as locality, date collector's name, monitoring site, collection type, genus, species and sex, and meteorological data. Records are kept of the trap results of each monitoring session and added to the electronic baseline monitoring program database.

A4.2 Results of Historical Adult Monitoring

Two accessible historical data sets provide background on mosquito species presence and numbers. These are summarised in **Table A 4-1**

¹ EVS refers to Encephalitis Virus Surveillance.

TABLE A4-1: Details of Accessible Historical Data Sets Accessed

Identifier	Source	Period			Description
		From	To	Length (months)	
HT-02	City of Rockingham	mid 2014	present	169	Near continuous extended period record of intensive site T5 - central west in the DSP area and adjacent to Fletcher Rd.
		32°24'42.29"S	115°47'3.52"E		
HT-03	City of Rockingham	mid 2014	present	169	Near continuous extended period record of intensive site T7 - central east in the DSP area.
		32°24'33.40"	115°48'42.92"E		
HT-04	City of Rockingham	mid 2014	present	169	Near continuous record 2014 to present between fringing Serpentine wetlands and Kwinana Freeway.
		32°24'33.40"S	115°48'42.92"		
HT-08	City of Rockingham	mid 2014	Aug 2018	68	Extended period record centrally within the DSP area.
		32°24'59.73"S	115°48'13.34"		
MOH 12	Department of Health	Sept 2008	Jan 2012	60	Extended period record of intensive site T6 - in SW of DSP area between Fletcher Rd and Anstey Swamp.
		32°26'3.29"S	115°47'5.59"		
MOH 13	Department of Health	Sept 2008	Jan 2012	60	Extended period record of trapping in S near central of DSP area adjacent to Paganoni Rd.
		32°25'46.35"S	115°47'10.62"		

Ten adult monitoring sites were established by the City, with records available over the period August 2014-15 and principally to present (mid-April 2023). Four sites (referred to in this review as HT-02, HT-08, HT-03 being W to E centrally across the site and HT-04 E of the Mitchell Freeway opposite the subject land), and are reported here. Excepting the historical data reviewed, trap sites are principally established south of Paganoni Rd. and east of the Kwinana Freeway, within and adjacent to drainage features of Serpentine River.

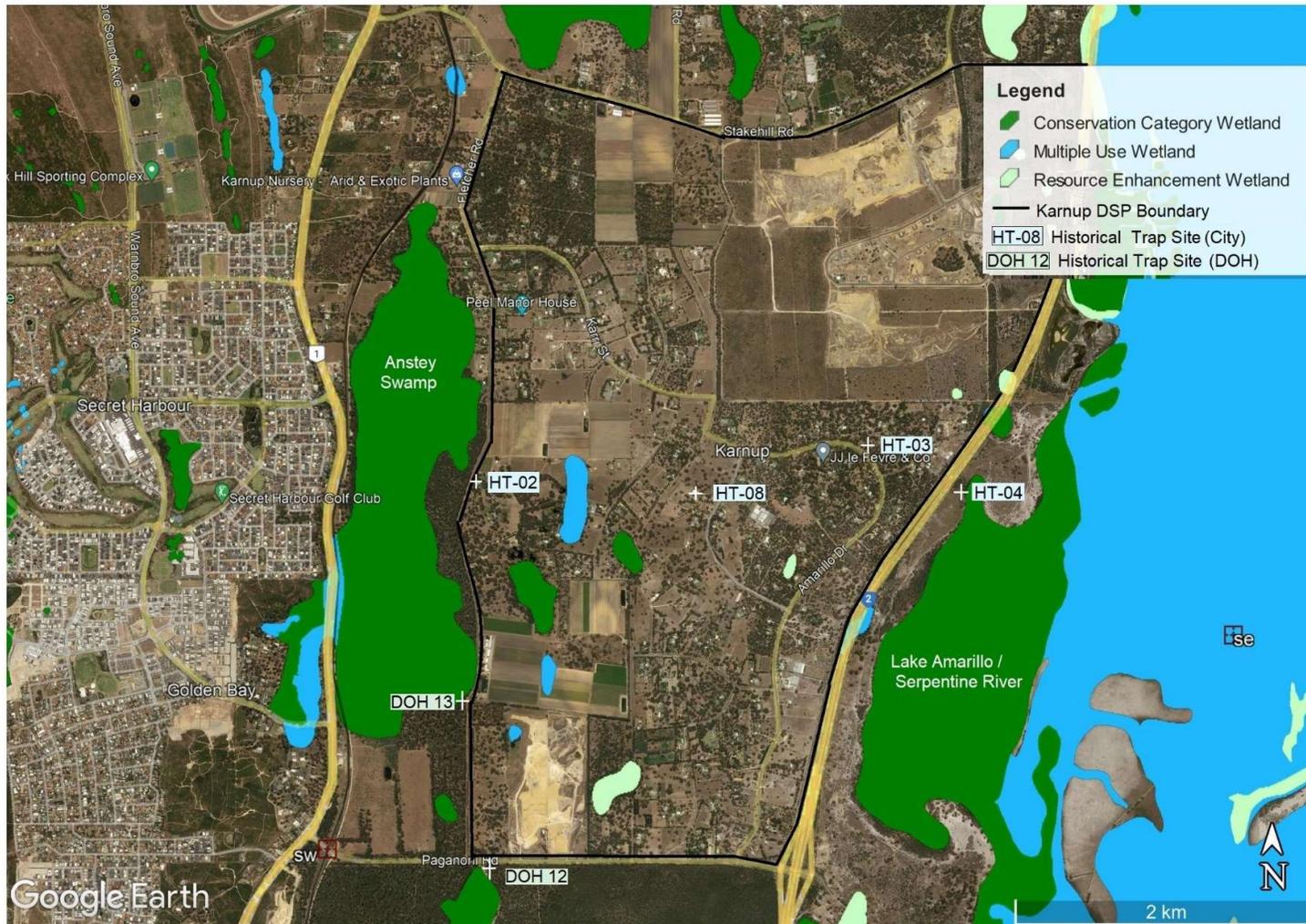
Department of Health intensive monitoring was undertaken initially at 10 (and expanded to 14) sites to assess impacts on future development sites fringing the Serpentine River. As for the City's sites, these sites were principally concentrated south of the subject land, and E of the Kwinana Freeway, except for sites DOH 12 and DOH 12.

Adult trapping sites HT-04 and DOH 12 occur on the fringe of the respective wetland chains that box the DSP site to the E and W respectively.

Monitoring site locations are identified in **Figure A4.1** and are determined not only by their proximity to potential breeding/harbourage areas but also for the need that they be accessible throughout the year to enable continuity of data gathering.

Site HT-04 [32°24'33.40"S / 115°48'42.92"]: Site is located on the western fringe of the W winter standing water level of the Serpentine drainage line associated wetlands approximately 500 m E of the Kwinana Freeway. Set within a Melaleuca Open woodland, the site is heavily shaded with protection from prevailing winds.

Figure A4-1: Location of the Historical Trap Sites



Brief descriptions of the historical sites are as follows:

Site HT-03 [32°24'33.40"S / 115°48'42.92"E], Amarillo Drive: This site is located in woodland cleared perimeter overstory trees surrounded by pastures. Located E centrally within the subject land (**Plate A4.2**, the site is partially shaded and subject to winds.



PLATE A4.2: Historical Adult monitoring site HT-03

Historical adult monitoring site locations are shown in **Figure A4.1**.

Site HT-08 [32°24'59.73"S / 115°48'13.34"E], Mallee Drive: This site is located in woodland cleared *Banksia* / *Casuarina* road verge in an urban residential / acreage area with minimal understory. Located centrally within the subject land (**Plate A3.3**, the site is partially shaded and subject to winds.

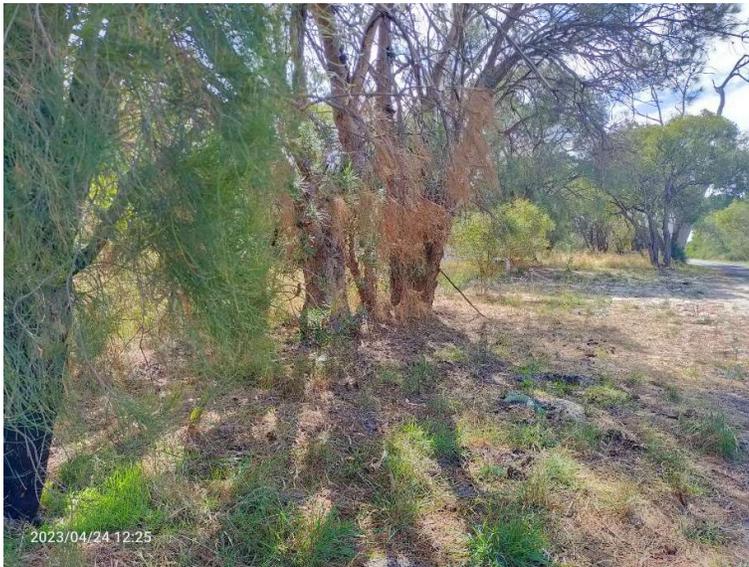


PLATE A4.3: Historical Adult monitoring site HT-08

Site HT-02 [32°24'42.29"S / 115°47'3.52"E], Peel Winery Estate: This site is located in woodland cleared *Eucalypts* bordering pastures and a tourism attraction in an urban residential / acreage area

with minimal understory. Located centrally within the subject land and E of the Conservation Category Anstey Swamp (**Plate A4.4**), the site is partially shaded and subject to winds.



PLATE A4.4: Historical Adult monitoring site HT-02

A3.2.1 Site HT-04

Over the period mid-2014 to present 166 successful monitoring events were conducted. Adult mosquito speciation and population data for Site HT-04 is presented in **Table A4-2** (over the page). The trap site is adjacent to seasonal wetlands of the Serpentine group of wetlands, and in close proximity to permanent water.

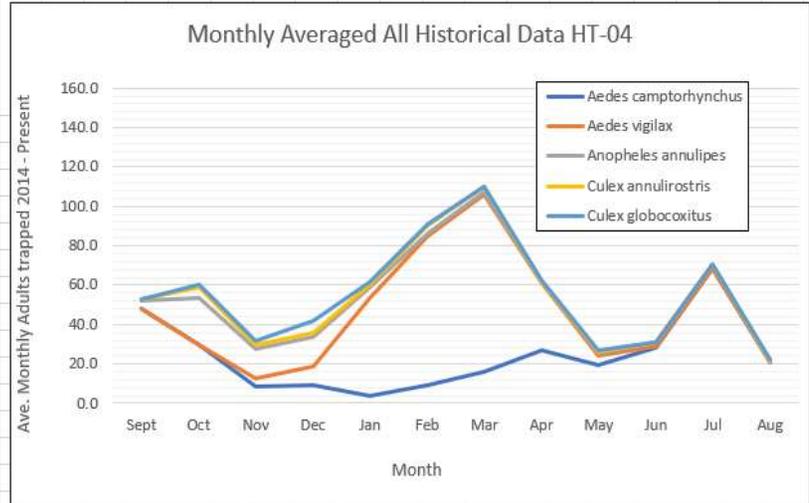
A total of 10,277 adult mosquitoes belonging to four genera and 15 species were trapped during the reporting timeframe. Trap numbers ranged from 0 – 656 specimens with the highest trap number recorded on the 21 Jan. 2021 (*Aedes vigilax*). The average number of adults trapped per monitoring session was approximately 58.0 specimens, with seven months exceeding an average of 50 adults trapped.

Averaged monthly data indicates elevated values peaking in the range 60 to 100 adults per trap in October, March and July.

The most abundant species, constituting 41.2 % of the total adults trapped (4112 specimens), was *Aedes camptorhynchus* (Southern Saltmarsh Mosquito). Breeding in a wide variety of temporary swamps, ground pools and coastal brackish water and tidal saltmarsh areas over the late spring-early summer period (Whelan, 2019), *Aedes camptorhynchus* is a vicious biter which will attack humans throughout the day in shaded locations and is more prevalent in the mornings, at dusk and after sunset (Russell, 1996). *Aedes camptorhynchus* is one of the major vectors of Ross River virus and is an effective experimental vector of Barmah Forest virus in the south-west of Western Australia (Webb *et al.*, 2016).

TABLE A4-2: Site HA-04 Averaged Adult Monitoring Data (September 2014 – April 2023)

HT_04 Monthly Averaged All Historical Data															
	n=														
	13	18	19	11	17	13	17	14	10	9	11	14			
	Average catch per Trapping Event - Mid 2014 to Present														
Species	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Annual total	% Total	Max Count
Aedes alboannulatus	0.0	0.1	0.6	3.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	0.7	36.0
Aedes camptorhynchus	47.8	29.4	8.3	9.0	3.5	9.0	15.8	27.2	19.7	28.0	68.3	20.9	286.8	41.2	310.0
Aedes clelandi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.3	0.0	3.0
Aedes hesperonotus	4.2	1.3	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	5.6	0.8	54.0
Aedes notoscriptus	0.0	1.3	0.2	1.4	1.3	0.4	0.2	0.1	0.0	0.0	0.0	0.2	5.2	0.7	24.0
Aedes ratcliffei	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.7	0.1	3.0
Aedes sagax	0.0	0.0	0.0	0.0	0.0	0.0	8.2	0.0	0.0	0.0	0.0	0.0	8.2	1.2	140.0
Aedes vigilax	0.0	0.1	4.1	10.0	50.3	76.2	90.1	33.6	4.4	0.9	0.2	0.0	269.8	38.8	656.0
Anopheles annulipes	4.4	23.9	15.4	14.9	5.1	1.2	1.1	0.9	1.7	2.1	1.7	0.9	73.3	10.5	67.0
Anopheles atratipes	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	1.0
Coquillettia sp. nr linealis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Culex annulirostris	0.3	5.6	1.8	1.8	1.2	4.3	2.8	0.0	0.4	0.0	0.1	0.0	18.3	2.6	68.0
Culex australicus	1.2	1.2	0.3	0.2	0.1	0.0	1.1	0.0	0.0	0.0	0.1	0.0	4.1	0.6	19.0
Culex globocoxitus	0.4	1.6	1.9	6.3	1.5	0.1	0.1	0.3	0.6	0.0	0.2	0.1	12.9	1.9	43.0
Culex quinquefasciatus	1.2	1.2	0.5	0.3	0.1	0.0	1.4	0.1	0.0	0.2	0.4	0.1	5.4	0.8	19.0
Culex atra	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tripteroides atripes	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.3	0.0	0.2	0.7	0.1	3.0
Total	59.5	65.8	33.3	47.1	63.8	91.2	120.8	62.4	27.1	31.6	71.3	22.4	696.0	100.0	



The next dominant species was the Saltmarsh species *Aedes vigilax* (Saltmarsh Mosquito) accounted for 38.8 % of all adult mosquitoes trapped during the reporting timeframe (3,933 specimens). *Aedes vigilax* is a vicious biter biting readily during the day with peak activity around dusk and is a vector of both RRV and BFV (Whelan, 2019) and is also known to carry dog heartworm (Webb *et al.*, 2016).

Anopheles annulipes returned 11.3 % of the total adults trapped (1181specimens). Principally known to breed in temporary and permanent pools, streams and along edges of wetlands, the species is generally present in freshwaters but also known from polluted and brackish waters. The species is potentially a RRV vector but not considered important.

Recording of male specimens would not seem to be complete. Based on limited data, males would seem to make up about accounted for 2.8 % of the total adults trapped (single years data (36 specimens). Regardless of their species, male mosquitoes do not usually move far from their breeding habitat. The number of males trapped at Site HT-04 indicates that the monitoring site's location is in reasonable proximity to mosquito breeding habitat.

A4.2.2 Site HT-03

Over the period mid-2014 to present 136 successful monitoring events were undertaken. Averaged monthly adult mosquito speciation and population data for Site HT-03 is presented in **Table A4-3** (over the page). The trap site is approximately 1.0 km to seasonal wetlands of the Serpentine group of wetlands, and to the WNW (not in line with prevailing winds).

A total of 16,302 adult mosquitoes belonging to five genera and 15 species were trapped during the reporting timeframe. Trap numbers ranged from 0 – 880 specimens with the highest trap number recorded on the 14 Aug. 2018 (predominantly *Ae. camptorhynchus*). The average number of adults trapped per monitoring session was 49.9 specimens, with 3 months exceeding an average of 50.

Averaged monthly data indicates elevated values peaking in the range 110 to 160 adults per trap during spring.

The most abundant species, constituting 58.1 % of the total adults trapped (4112 specimens), was *Ae. camptorhynchus* (Southern Saltmarsh Mosquito). Breeding in a wide variety of temporary swamps, ground pools and coastal brackish water and tidal saltmarsh areas over the late spring-early summer period (Whelan, 2019), *Ae. camptorhynchus* is a vicious biter which will attack humans throughout the day in shaded locations and is more prevalent in the mornings, at dusk and after sunset (Russell, 1996). *Ae. camptorhynchus* is one of the major vectors of Ross River virus and is an effective experimental vector of Barmah Forest virus in the south-west of Western Australia (Webb *et al.*, 2016).

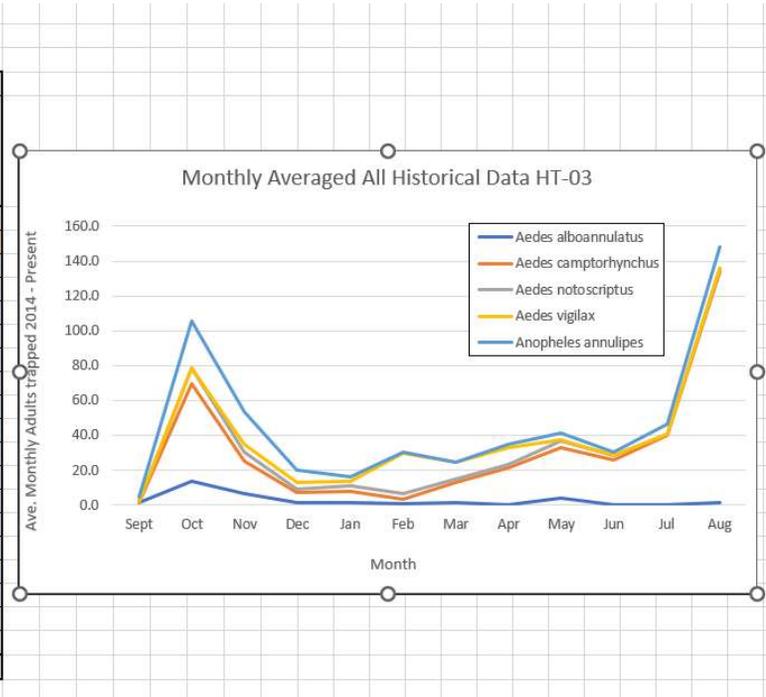
The next dominant species was *An. annulipes* that returned 14.1 % of the total adults trapped (1173specimens). Principally known to breed in temporary and permanent pools, streams and along edges of wetlands, the species is generally present in freshwaters but also known from polluted and brackish waters. The species is potentially a RRV vector but not considered important.

Aedes vigilax (Saltmarsh Mosquito) accounted for 9.0 % of all adult mosquitoes trapped during the reporting timeframe (854 specimens). *Aedes vigilax* is a vicious biter biting readily during the day with peak activity around dusk and is a vector of both RRV and BFV (Whelan, 2019) and is also known to carry dog heartworm (Webb *et al.*, 2016).

TABLE A4-3: Site HA-03 Averaged Adult Monitoring Data (September 2014 – April 2023)

HT_03 Monthly Averaged All Historical Data

Species	Average catch per Trapping Event - Mid 2014 to Present												Annual total	% Total	Max Count
	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug			
<i>Aedes alboannulatus</i>	1.1	13.7	6.7	1.4	1.4	0.8	1.5	0.0	4.0	0.0	0.0	1.1	31.8	5.3	116.0
<i>Aedes camptorhynchus</i>	0.0	55.7	18.5	5.4	6.5	2.4	11.4	21.4	28.7	25.7	40.0	132.5	348.3	58.1	880.0
<i>Aedes clelandi</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Aedes hesperonotus</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.6	0.1	6.0
<i>Aedes notoscriptus</i>	0.7	8.9	5.3	2.0	2.8	3.5	1.7	2.0	4.1	2.4	0.8	2.4	36.7	6.1	54.0
<i>Aedes ratcliffi</i>	0.0	0.3	0.0	0.0	0.0	0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.7	0.1	3.0
<i>Aedes sagax</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Aedes vigilax</i>	0.0	0.0	4.5	3.8	3.0	22.7	9.7	9.3	0.3	0.4	0.0	0.0	53.7	9.0	123.0
<i>Anopheles annulipes</i>	2.9	27.1	18.7	7.2	2.3	0.7	0.5	2.0	3.9	1.6	5.3	12.1	84.4	14.1	96.0
<i>Anopheles atratipes</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.0
<i>Coquillettidia sp. nr linealis</i>	0.0	0.8	0.3	0.1	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	0.3	6.0
<i>Culex annulirostris</i>	0.0	2.0	3.1	0.8	1.3	2.6	0.3	1.4	0.0	0.0	0.0	0.0	11.5	1.9	40.0
<i>Culex australicus</i>	0.0	0.4	0.2	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.9	0.2	5.0
<i>Culex globocoxitus</i>	0.0	0.3	1.2	0.9	2.7	0.0	0.6	0.5	1.5	0.0	1.0	1.4	10.0	1.7	30.0
<i>Culex quinquefasciatus</i>	0.0	2.1	1.5	1.1	2.1	1.3	0.1	0.0	0.0	0.0	2.3	8.0	18.6	3.1	88.0
<i>Culex atra</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Tripteroides atripes</i>	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3	0.1	3.0
Unidentified Aedes	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	1.0
Criterion	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0			
Total	4.7	111.4	60.2	22.8	22.5	34.3	26.3	36.5	43.1	30.1	49.5	157.7	599.3	100	



Recording of male specimens would not seem to be complete. The low number of males trapped at Site HT-03 would indicate that the monitoring site's location is distant to mosquito breeding habitat.

A4.2.3 Site HT-08

Over the period mid-2014 to August 2018, 65 successful monitoring events were undertaken. Averaged monthly adult mosquito speciation and population data for Site HT-08 is presented in **Table A4-4** (over the page).

A total of 735 adult mosquitoes belonging to four genera and 12 species were trapped during the reporting timeframe. Trap numbers ranged from 0 – 51 specimens with the highest trap number recorded on the 14 Oct. 2014 (predominantly *Ae. camptorhynchus*). The average number of adults trapped per monitoring session was 17.3 specimens, with no months exceeding an average of 50.

Averaged monthly data indicates elevated values peaking in the range 12 to 19 adults per trap during spring.

The most abundant species, constituting 45.8 % of the total adults trapped (362 specimens), was *Ae. camptorhynchus*. Breeding in a wide variety of temporary swamps, ground pools and coastal brackish water and tidal saltmarsh areas over the late spring-early summer period (Whelan, 2019), *Ae. camptorhynchus* is a vicious biter which will attack humans throughout the day in shaded locations and is more prevalent in the mornings, at dusk and after sunset (Russell, 1996). *Ae. camptorhynchus* is one of the major vectors of Ross River virus and is an effective experimental vector of Barmah Forest virus in the south-west of Western Australia (Webb *et al.*, 2016).

The next dominant species was *Aedes vigilax* accounted for 26.9 % of all adult mosquitoes trapped during the reporting timeframe (173 specimens). *Aedes vigilax* is a vicious biter biting readily during the day with peak activity around dusk and is a vector of both RRV and BFV (Whelan, 2019) and is also known to carry dog heartworm (Webb *et al.*, 2016).

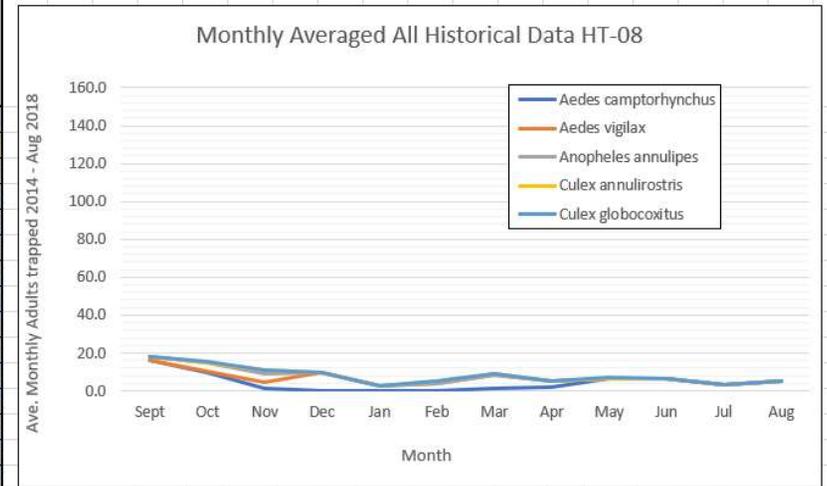
Anopheles annulipes returned 9.7 % of the total adults trapped (84 specimens). Principally known to breed in temporary and permanent pools, streams and along edges of wetlands, the species is generally present in freshwaters but also known from polluted and brackish waters. The species is potentially a RRV vector but not considered important.

Recording of male specimens would not seem to be complete. The low number of males trapped at Site HT-08 would indicate that the monitoring site's location is distant to mosquito breeding habitat.

TABLE A4-4: Site HA-08 Averaged Adult Monitoring Data (September 2014 – August 2018)

HT_08 Monthly Averaged All Historical Data

Species	Average catch per Trapping Event - Mid 2014 to Aug 2018 (incomplete)												Annual total	% Total	Max Count
	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug			
Aedes alboannulatus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.7	0.6	2.0
Aedes camptorhynchus	16.1	9.6	1.6	0.0	0.0	0.0	1.0	2.1	6.8	6.3	3.0	5.0	51.5	45.8	51.0
Aedes clelandi	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aedes hesperonotus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Aedes notoscriptus	0.4	0.3	0.7	0.8	0.8	2.8	0.3	0.4	0.5	1.7	0.0	0.0	8.6	7.7	9.0
Aedes ratcliffei	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.6	5.0
Aedes sagax	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.5	3.0
Aedes vigilax	0.0	1.0	2.7	9.8	2.3	4.0	7.3	3.1	0.0	0.0	0.0	0.0	30.2	26.9	36.0
Anopheles annulipes	1.6	4.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	10.9	9.7	17.0
Anopheles atratipes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coquillettia sp. nr linealis	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.3	0.3	2.0
Culex annulirostris	0.3	0.4	2.0	0.0	0.2	1.0	0.9	0.0	0.0	0.0	0.0	0.0	4.6	4.1	14.0
Culex australicus	0.1	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.3	1.0
Culex globocoxitus	0.3	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	1.4	1.2	5.0
Culex quinquefasciatus	0.0	0.0	0.0	0.0	0.0	2.2	0.4	0.0	0.0	0.0	0.0	0.0	2.6	2.3	10.0
Culex atra	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	18.8	16.5	12.0	10.8	3.3	10.6	10.1	5.7	7.8	8.7	3.0	5.3	112.5	100.0	



A4.2.4 Site HT-02

Over the period mid-2014 to April 2023, 163 successful monitoring events were undertaken. Averaged monthly adult mosquito speciation and population data for Site HT-02 is presented in **Table A4-5** (over the page).

A total of 6672 adult mosquitoes belonging to five genera and 13 species were trapped during the reporting timeframe. Trap numbers ranged from 0 – 580 specimens with the highest trap number recorded on the 8 June, 2022 (predominantly *Ae. camptorhynchus*). The average number of adults trapped per monitoring session was 42.0 specimens, with two months exceeding a daily average of 50.

Averaged monthly data indicates elevated values peaking in the range 67 to 110 adults per trap during late winter / spring.

The most abundant species, constituting 59.1 % of the total adults trapped (4002 specimens), was *Ae. camptorhynchus*. Breeding in a wide variety of temporary swamps, ground pools and coastal brackish water and tidal saltmarsh areas over the late spring-early summer period (Whelan, 2019), *Ae. camptorhynchus* is a vicious biter which will attack humans throughout the day in shaded locations and is more prevalent in the mornings, at dusk and after sunset (Russell, 1996). *Ae. camptorhynchus* is one of the major vectors of Ross River virus and is an effective experimental vector of Barmah Forest virus in the south-west of Western Australia (Webb *et al.*, 2016).

The next dominant species was *Aedes vigilax* accounted for 11.6 % of all adult mosquitoes trapped during the reporting timeframe (806 specimens). *Aedes vigilax* is a vicious biter biting readily during the day with peak activity around dusk and is a vector of both RRV and BFV (Whelan, 2019) and is also known to carry dog heartworm (Webb *et al.*, 2016).

Aedes notoscriptus (container mosquito) returned 7.3 % of the total adults trapped (521 specimens). are found in a variety of natural and peri-domestic habitats including tree and rock holes, small containers and stormwater drains; especially early in the season where the water quality is reasonable and the drains contain leaf litter, tyres, gutter, bird baths etc. *Aedes notoscriptus* has a limited flight range and will bite during the day in cool well shaded areas.

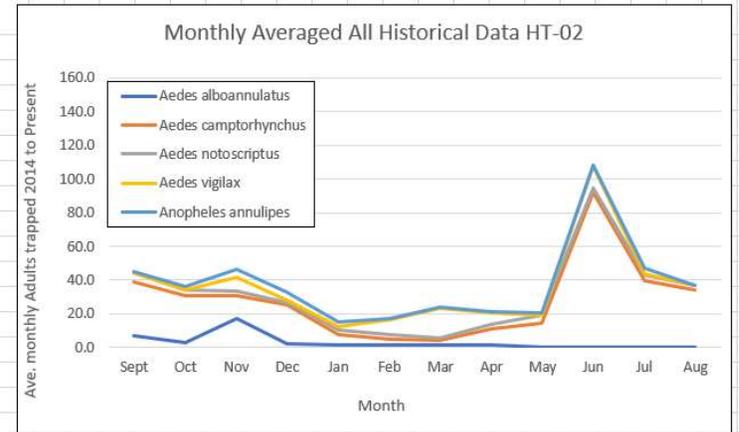
During RRV outbreaks, *A. notoscriptus* has been shown to be infected and may have an important role in RRV transmission (Whelan, 2019); the species has also been incriminated as an important vector of dog heartworm (Russell, 1996).

Recording of male specimens would not seem to be complete. Based on limited data, males would seem to make up about accounted for 0.6 % of the total adults trapped (single years data - 6 males collected). Regardless of their species, male mosquitoes do not usually move far from their breeding habitat. The number of males trapped at Site HT-02 would imply that the monitoring site's location is not proximal to mosquito breeding habitat.

TABLE A4-5: Site HA-02 Averaged Adult Monitoring Data (September 2014 – April 2023)

HT_02 Monthly Averaged All Historical Data

Species	Average catch per Trapping Event - Mid 2014 to Present												Annual total	% Total	Max Count
	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug			
<i>Aedes alboannulatus</i>	6.7	2.6	17.0	2.2	1.8	1.5	1.6	1.2	0.0	0.4	0.3	0.0	35.4	7.0	96.0
<i>Aedes camptorhynchus</i>	32.0	28.2	13.6	23.0	5.6	3.2	2.8	9.8	14.2	91.6	39.6	34.2	297.8	59.1	493.0
<i>Aedes clelandi</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Aedes hesperonotus</i>	0.0	0.2	0.2	0.3	0.9	1.1	0.6	0.0	0.0	0.0	0.0	0.0	3.3	0.6	14.0
<i>Aedes notoscriptus</i>	6.0	3.2	2.6	1.7	2.7	3.2	1.4	2.6	5.0	3.0	2.9	2.5	36.8	7.3	30.0
<i>Aedes ratcliffei</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.0	1.0
<i>Aedes sagax</i>	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.1	0.0
<i>Aedes vigilax</i>	0.0	0.0	8.4	1.4	2.2	8.4	17.6	7.2	0.2	12.6	0.6	0.0	58.3	11.6	150.0
<i>Anopheles annulipes</i>	0.7	2.2	4.6	4.8	2.5	0.9	0.3	0.4	1.3	1.0	3.9	0.0	22.6	4.5	55.0
<i>Anopheles atratipes</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Coquillettidia sp. nr linealis</i>	0.0	0.0	0.3	0.3	1.5	0.0	0.1	0.0	0.0	0.0	0.0	0.0	2.2	0.4	16.0
<i>Culex annulirostris</i>	0.0	0.5	0.6	0.3	0.8	0.3	0.2	0.1	0.0	0.0	0.1	0.0	3.0	0.6	9.0
<i>Culex australicus</i>	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1	0.0
<i>Culex globocoxitus</i>	3.0	2.1	2.4	5.8	1.4	1.2	1.8	0.5	0.7	0.4	1.1	0.4	20.8	4.1	49.0
<i>Culex quinquefasciatus</i>	0.5	0.1	0.8	0.2	0.3	1.2	1.3	0.1	0.5	0.1	0.2	2.2	7.5	1.5	32.0
<i>Culex atra</i>	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
<i>Tripteroides atripes</i>	0.0	0.0	15.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.4	3.1	1.0
Total	48.9	39.1	66.9	40.0	19.6	20.9	27.7	21.9	21.8	109.1	48.7	39.3	504.0	100.0	



A4.2.5 Site DOH 12

Over the period Sept 2008 to Jan 2012 incl, 60 successful trapping events were undertaken at site DOH 12. Averaged monthly adult mosquito speciation and population data for Site DOH 12 is presented in **Table A4-6** (over the page). Note the changed vertical scale from the City records presented in sections A3.2.1 - A3.2.4 inclusive.

A total of 8916 adult mosquitoes belonging to four genera and 13 species were trapped during the reporting timeframe. Trap numbers ranged from 0 – 2198 specimens with the highest trap number recorded on the 4 March, 2011 (almost entirely *Ae. vigilax*). The average number of adults trapped per monitoring session was 226.1 specimens, with seven months exceeding a daily average of 50.

Averaged monthly data indicates elevated values peaking in the range 57 to 451 adults per trap during the Late spring Autumn period

The most abundant species, constituting 73.8 % of the total adults trapped (5764 specimens), was *Ae. vigilax*. *Aedes vigilax* is a vicious biter biting readily during the day with peak activity around dusk and is a vector of both RRV and BFV (Whelan, 2019) and is also known to carry dog heartworm (Webb *et al.*, 2016).

The next dominant species was *Ae. camptorhynchus* which accounted for 13.4 % of all adult mosquitoes trapped during the reporting timeframe (946 specimens). Breeding in a wide variety of temporary swamps, ground pools and coastal brackish water and tidal saltmarsh areas over the late spring-early summer period (Whelan, 2019), *Ae. camptorhynchus* is a vicious biter which will attack humans throughout the day in shaded locations and is more prevalent in the mornings, at dusk and after sunset (Russell, 1996). *Ae. camptorhynchus* is one of the major vectors of Ross River virus and is an effective experimental vector of Barmah Forest virus in the south-west of Western Australia (Webb *et al.*, 2016).

Aedes notoscriptus (container mosquito) returned 4.7 % of the total adults trapped (418 specimens) and are found in a variety of natural and peri-domestic habitats including tree and rock holes, small containers and stormwater drains; especially early in the season where the water quality is reasonable and the drains contain leaf litter, tyres, gutter, bird baths etc. *Aedes notoscriptus* has a limited flight range and will bite during the day in cool well shaded areas.

During RRV outbreaks, *A. notoscriptus* has been shown to be infected and may have an important role in RRV transmission (Whelan, 2019); the species has also been incriminated as an important vector of dog heartworm (Russell, 1996).

Recording of male specimens would not seem to be complete. Based on limited data, males would seem to make up about accounted for 0.15% of the total adults trapped (12 males collected). Regardless of their species, male mosquitoes do not usually move far from their breeding habitat. The number of males trapped at Site DOH 12 would imply that the monitoring site's location is not proximal to significant mosquito breeding habitat.

A4.2.6 Site DOH 13

Over the period Sept 2008 to Jan 2012 incl, 60 successful trapping events were undertaken at site DOH 13. Averaged monthly adult mosquito speciation and population data for Site DOH 13 is presented in **Table A4-7** (over the page). Note the changed vertical scale from the City's records presented in sections A3.2.1 - A3.2.4 inclusive.

A total of 23252 adult mosquitoes belonging to four genera and 14 species were trapped during the reporting timeframe. Trap numbers ranged from 0 – 12791 specimens with the highest trap number recorded on the 4 March, 2011 (almost entirely *Ae. vigilax*). The average number of adults trapped per monitoring session was 610 specimens, with nine months exceeding a daily average of 50.

Averaged monthly data indicates elevated values peaking in the range 80 to 2170 adults per trap during the September to April period driven by high *Ae. vigilax* numbers. A secondary peak occurs during the winter months following conditions more amenable for *Ae. camptorhynchus* development (42 to 121 adults per trap).

The most abundant species, constituting 81.8 % of the total adults trapped (19458 specimens), was *Ae. vigilax*. *Aedes vigilax* is a vicious biter biting readily during the day with peak activity around dusk and is a vector of both RRV and BFV (Whelan, 2019) and is also known to carry dog heartworm (Webb *et al.*, 2016).

The next dominant species was *Ae. camptorhynchus* which accounted for 9.9 % of all adult mosquitoes trapped during the reporting timeframe (1783 specimens). Breeding in a wide variety of temporary swamps, ground pools and coastal brackish water and tidal saltmarsh areas over the late spring-early summer period (Whelan, 2019), *Ae. camptorhynchus* is a vicious biter which will attack humans throughout the day in shaded locations and is more prevalent in the mornings, at dusk and after sunset (Russell, 1996). *Ae. camptorhynchus* is one of the major vectors of Ross River virus and is an effective experimental vector of Barmah Forest virus in the south-west of Western Australia (Webb *et al.*, 2016).

Aedes alboannulatus returned 4.6 % of the total adults trapped (1093 specimens) and is a common species which breeds in a wide variety of freshwater habitats including rockpools, temporary ground pools and containers and can be a minor pest in/near bushland area (Russell, 1996). Most were trapped during the winter months.

As with most *Aedes* species, *A. alboannulatus* eggs are resistant to desiccation. It is a significant nuisance species as it bites humans during the day and at night and is more commonly found between May and October. *Aedes alboannulatus* has no known association with any human transmitted viruses (Whelan, 2019).

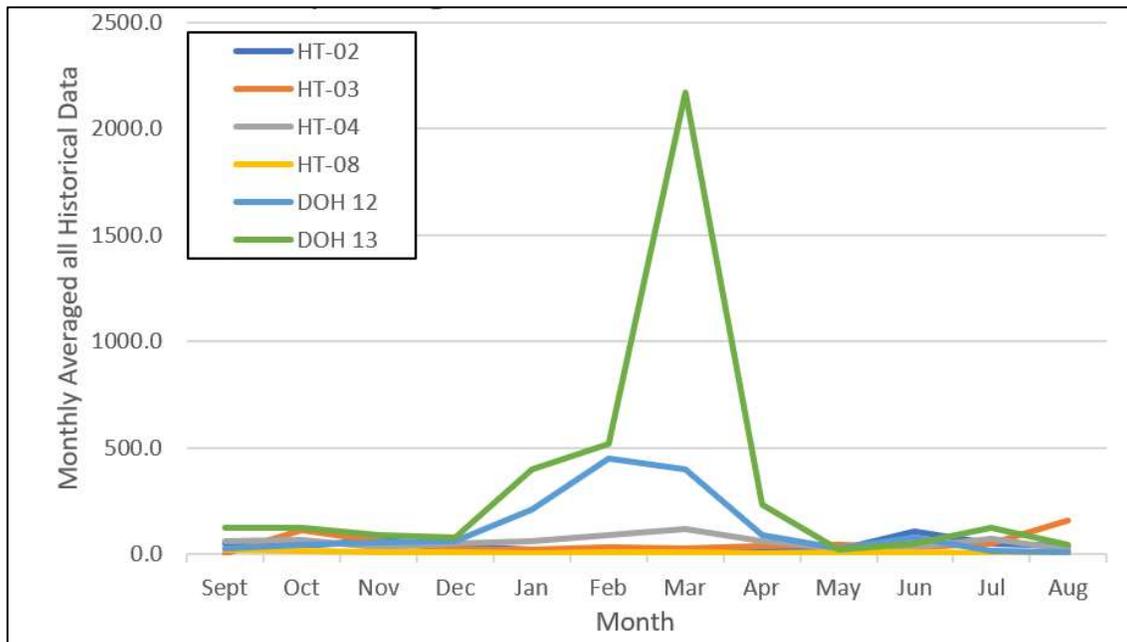
No male examples of the species were trapped. Regardless of their species, male mosquitoes do not usually move far from their breeding habitat. The number of males trapped at Site DOH 13 would imply that the monitoring site's location is not close to significant mosquito breeding habitat.

A4.2.7 Synthesis

Based on long period sampling at a series of sampling sites within and immediately adjacent to the DSP area, the following points can be made:

1. Both the Serpentine wetlands and Anstey Swamp are sources of mosquito breeding, with Anstey Swamp significantly more so (**Chart A4-1**).

CHART A4-1 Monthly Averaged Captures, All Sites



2. Principal *Ae. vigilax* recruitment would seem to be from Anstey Swamp and the wetland extension to the S, particularly during the warmer months.
3. *Aedes. camptorhynchus* is generally more prevalent in percentage terms within the DSP area, and approximate the representation of *Ae. vigilax* at site HA-04 adjacent to the Serpentine wetlands.
4. Of significant mosquito species also collected during the long-term monitoring reviewed:
 - *Aedes alboannulatus* has no known association with any human transmitted viruses,
 - *Aedes. notoscriptus* has been shown to be infected and may have an important role in RRV transmission

A4.3 Results of Intensive Adult Monitoring

Adult monitoring methods described in section A4.1 are relevant to this section.

From October 2022 a further 10 intensive sites have been established within the DSP area, the characteristics and location of each of these sites being provided in **Table A4-8**.

TABLE A4-8: Details of Intensive Adult Trapping Sites

Location	Coordinates S	Coordinates E	Description
T1 – Yellow North	32°22'28.73"S	115°49'28.68"E	Parkland cleared woodland area located at the Karnup Rd Picnic area (old school). Limited understory.
T2 – Orange East	32°23'41.19"S	115°49'2.71"E	Grove of trees on elevated land in cleared former pasture. No standing water in vicinity
T3 – Orange North	32°23'33.22"S	115°49'33.51"E	Grove of trees in cleared former pasture adjacent to small Resource Enhancement (dry) wetland (likely perched water table).
T4 – Red North	32°23'55.81"S	115°49'13.45"E	Grove of trees in cleared former pasture adjacent to small Conservation Category (dry) wetland (likely perched water table).
T5 – Yellow Centre	32°24'42.29"S	115°47'3.52"E	Open woodland of landscape planted trees at tourism site fronting Fletcher Rd. Limited understory of ornamentals and pasture grasses. Irrigation and occasional water filled containers.
T6 – Yellow South	32°25'26.97"S	115°47'0.45"E	Open forest of Eucalypts and Banksia with dense understory within Anstey Swamp and in close proximity to Fletcher Road. Equates to MOH 12 site. Shielded from winds
T7 – Red Centre	32°24'33.40"S	115°48'42.92"E	Cleared open woodland of Agonis with pasture grasses under adjacent to Amarillo Drive. Exposed to prevailing winds.
T8 – Orange Centre	32°24'59.73"S	115°48'13.34"E	Previously cleared Banksia / Casuarina open woodland with minimal adjacent to Mallee Drive. Exposed to prevailing winds.
T9 – Red South	32°26'0.62"S	115°48'5.44"E	Stand of Casuarina on elevated land with minimal understory. Exposed to prevailing winds.
T10 - Orange South	32°25'59.92"S	115°47'27.34"E	Occasional remnant tree in cleared land fronting Pagenoni Rd near the junction of Fletcher Rd. Occasional pasture grasses on bare soils. Exposed to prevailing winds.

T1 – Yellow North [32°22'28.73"S / 115°49'28.68"E], Karnup Road: This site is in parkland cleared woodland area located at the Karnup Rd Picnic area. The site is representative of the NE portion of the subject land (**Plate A3.5**), and distant from immediate water sources. The site is partially shaded and subject to limited wind effects.

Intensive adult monitoring site locations are shown in **Figure A4.2**.



Figure A4-2: Location of the Intensive Trap Sites



PLATE A4.5: Intensive Adult monitoring site T1

T2 – Orange East [32°23'41.19"S / 115°49'2.71"E], The site is in a grove of remnant trees that comprise a low open woodland on elevated land in cleared former pasture (**Plate A4.6**), and distant from immediate water sources. The site is partially shaded and subject to wind effects. The site is representative of unimproved land in the NE portion of the subject land.



PLATE A4.6: Intensive Adult monitoring site T2

T3 – Orange North [32°23'33.22"S / 115°49'33.51"E], The site is in a grove of remnant trees that forms a low open woodland on elevated land in cleared former pasture (**Plate A4.7**), and is adjacent to a small seasonally dry conservation category wetland (FID 5631) likely established on a perched water table. The site is partially shaded with limited wind effects.



PLATE A4.7: Intensive Adult monitoring site T3

T4 – Red North [$32^{\circ}23'55.81''S$ / $115^{\circ}49'13.45''E$], The site is in a grove of remnant trees that forms a low open woodland on elevated land in cleared former pasture (**Plate A4.8**), and is adjacent to a linear dry depression that would appear to seasonally hold water and is likely established on a perched water table. The site is partially shaded with limited wind effects.



PLATE A4.8: Intensive Adult monitoring site T4

T5 – Yellow Centre [$32^{\circ}24'42.29''S$ / $115^{\circ}47'3.52''E$], The site is located adjacent to a tourism venue and comprises a grove of parkland cleared mature trees that form an open woodland gradually rising land (**Plate A4.9**), The site is approximately 100m top the tree line surrounding Anstey Swamp. The site is partially but susceptible to wind effects. A number of water filled containers are evident.



PLATE A4.9: Intensive Adult monitoring site T5

T6 – Yellow South [$32^{\circ}25'26.97''S$ / $115^{\circ}47'0.45''E$], The site is located within the boundary of the Anstey Swamp Reserve (FID 1443), a substantial Conservation Category wetland with permanent water. Overstory consists of open forest intact protected both from direct sun and wind effects (**Plate A4.10**).



PLATE A4.10: Intensive Adult monitoring site T6

T7 – Red Centre [$32^{\circ}24'33.40''S$ / $115^{\circ}48'42.92''E$], The site comprises remnant open woodland over pasture located within a semi-rural development area. Under dappled shade, the area is subject to wind effects wind effects (**Plate A4.11**).



PLATE A4.11: Intensive Adult monitoring site T7

T8 – – Orange Centre [$32^{\circ}24'59.73''\text{S}$ / $115^{\circ}48'13.34''\text{E}$], The site comprises remnant Banksia / Casuarina open woodland with minimal understory located within a semi-rural development area. Under dappled shade, the area is subject to wind effects wind effects (**Plate A4.12**).



PLATE A4.12: Intensive Adult monitoring site T8

T9 – – Red South [$32^{\circ}26'0.62''\text{S}$ / $115^{\circ}48'5.44''\text{E}$], the site comprises a stand of remnant Casuarina on elevated land with minimal understory (**Plate A4.13**). Opposite Paganoni Rd., the site is exposed to prevailing winds



PLATE A4.13: Intensive Adult monitoring site T9

T10 – Orange South [$32^{\circ}25'59.92''S$ / $115^{\circ}47'27.34''E$], the site comprises Occasional remnant tree in cleared land fronting Pagenoni Rd near the junction of Fletcher Rd (**Plate A4.14**). Fronting Paganoni Rd., the site is near the junction of Fletcher R. With occasional pasture grasses on bare soils, the site is exposed to prevailing winds.



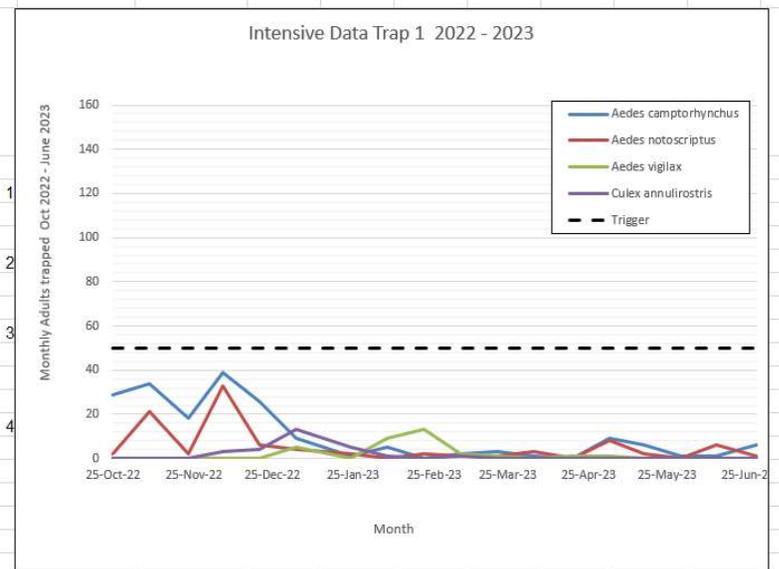
PLATE A4.14: Intensive Adult monitoring site T10

A4.3.1 Site T01, Karnup Road Picnic Site

Over the period Oct 2022 to end June 2023, 18 successful monitoring events were undertaken. Averaged monthly adult mosquito speciation and population data for Site Trap 01 is presented in **Table A4-9** (over the page).

Table A4-9. TRAP 1 - Karnup Road Picnic

Species	25-Oct-22	8-Nov-22	23-Nov-22	6-Dec-22	20-Dec-22	3-Jan-23	24-Jan-23	7-Feb-23	21-Feb-23	7-Mar-23	21-Mar-23	4-Apr-23	19-Apr-23	3-May-23	16-May-23	30-May-23	13-Jun-23	28-Jun-23	TOTAL	TOTAL %
<i>Aedes alboannulatus</i>																			0	0
<i>Aedes camptorhynchus</i>	29	34	18	39	26	9	1	5		2	3	1		9	6	1	1	6	190	48
<i>Aedes clelandi</i>																			0	0
<i>Aedes hesperonotius</i>	1	3	3				5	4	3	7	5		3						34	9
<i>Aedes notoscriptus</i>	2	21	2	33	6	4	2		2	1	1	3		8	2		6	1	94	24
<i>Aedes ratcliffei</i>	2	1	2	2															7	2
<i>Aedes sagax</i>																			0	0
<i>Aedes vigilax</i>						5		9	13	2	1		1	1					32	8
<i>Anopheles annulipes</i>	1			1															2	1
<i>Anopheles atratipes</i>																			0	0
<i>Coquillettidia sp. nr linealis</i>																			0	0
<i>Culex annulirostris</i>				3	4	13	5	1		1									27	7
<i>Culex australicus</i>																			0	0
<i>Culex globocoxitus</i>				3	2	2													7	2
<i>Culex quinquefasciatus</i>																			0	0
<i>Culiseta atra</i>																			0	0
<i>Tripteroides atripes</i>																			0	0
Total	35	59	25	81	38	38	12	18	22	11	5	7	1	18	8	1	7	7	393	100
Ave / trap / event	21.8																			
Exceedences of 50	2																			
Highest single event	81																			
	6-Dec-22																			



A total of 393 adult mosquitoes belonging to three genera and 8 species were trapped during the reporting timeframe. Trap numbers ranged from 1 – 81 specimens with the highest trap number recorded on the 6th Dec. 2022 (predominantly *Ae. camptorhynchus*). The average number of adults trapped per monitoring session was 21.8 specimens, with two months exceeding an average of 50.

The most abundant species, constituting 48 % of the total adults trapped (190 specimens), was *Ae. camptorhynchus*. Breeding in a wide variety of temporary swamps, ground pools and coastal brackish water and tidal saltmarsh areas over the late spring-early summer period (Whelan, 2019), *Ae. camptorhynchus* is a vicious biter which will attack humans throughout the day in shaded locations and is more prevalent in the mornings, at dusk and after sunset (Russell, 1996). *Ae. camptorhynchus* is one of the major vectors of Ross River virus and is an effective experimental vector of Barmah Forest virus in the south-west of Western Australia (Webb *et al.*, 2016).

The next dominant species was *Aedes notoscriptus*, accounting for 24 % of all adult mosquitoes trapped during the reporting timeframe (94 specimens). *Aedes notoscriptus* are found in a variety of natural and peri-domestic habitats including tree and rock holes, small containers and stormwater drains; especially early in the season where the water quality is reasonable and the drains contain leaf litter, tyres, gutter, bird baths etc (Webb *et al.*, 2016).

Anopheles annulipes returned 9.7 % of the total adults trapped (84 specimens). Principally known to breed in temporary and permanent pools, streams and along edges of wetlands, the species is generally present in freshwaters but also known from polluted and brackish waters. The species is potentially a RRV vector but not considered important.

No male presence would indicate that the monitoring site's location is distant to mosquito breeding habitat.

A4.3.2 Site T02, Sand Quarry OE

Over the period Oct 2022 to end June 2023, 18 successful monitoring events were undertaken. Monthly adult mosquito speciation and population data for Site Trap 02 is presented in **Table A4-4** (over the page).

A total of 375 adult mosquitoes belonging to four genera and seven species were trapped during the reporting timeframe. Trap numbers ranged from 0 – 85 specimens with the lowest catches recorded during the summer months and the largest catch recorded on the 3rd May 2023. The average number of adults trapped per monitoring session was approximately 21 specimens.

The most abundant species, constituting 54 % of the total adults trapped, was *Ae. camptorhynchus* (204 specimens). *Aedes camptorhynchus* (Southern saltmarsh mosquito) breeds in a wide variety of temporary swamps, ground pools and coastal brackish water/tidal saltmarsh areas over the autumn-early summer period being especially abundant during June to August (Whelan, 2019). *Aedes camptorhynchus* is a vicious biter which will attack humans throughout the day but more so at dusk and after sunset and is one of the main vectors of both Ross River Virus and Barmah Forest Virus in the south-west of Western Australia (Webb *et al.*, 2016).

The next dominant species was *Ae. vigilax* (Saltmarsh Mosquito) with 27 % of the total adults trapped (102 specimens). *Aedes vigilax* is found in coastal saltmarsh areas and brackish swamps such as flooded sedgeland. A vicious biter biting readily during the day with peak activity around dusk and is generally present during the hotter summer months, *Ae. vigilax* is therefore present over the peak period for RRV infection. *Aedes vigilax* is a vector of both Ross River Virus and Barmah Forest Virus (Whelan, 2019) and is also known to carry dog heartworm (Webb *et al.*, 2016).

A4.3.3 Site T03, San Quarry ON

Eighteen monitoring events were conducted during the reporting timeframe (October 2022 – end June 2023). Adult mosquito speciation and population data for Site T03 is presented in **Table A4-11** (over the page).

A total of 657 adult mosquitoes belonging to three genera and seven species were trapped at Site T03 during the reporting timeframe. Trap numbers ranged from 1 – 159 specimens with the lowest catch recorded on 21 March 2022 and the largest catch recorded on 3rd January 2023. The average number of adult mosquitoes trapped per monitoring session was approximately 37 specimens.

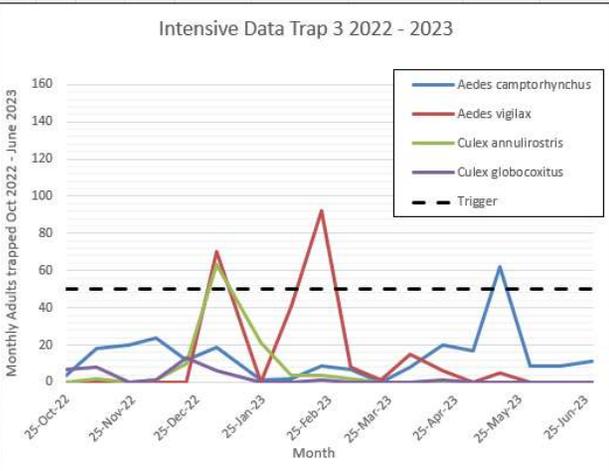
The most abundant species, constituting 38% of the total adults trapped at Site T03, was the Southern saltmarsh species *Ae. camptorhynchus* (252 specimens).

Near co-dominant was *Ae. vigilax* (Saltmarsh Mosquito) with 36 % of the total adults trapped (238 specimens).

Also present in significant numbers was *Cu. annulirostris* comprising 16 % of total catch numbers (107 specimens). *Culex annulirostris* is a freshwater species that is generally only present from late spring through to autumn breeding in a variety of freshwater habitats. An important nuisance-biting pest, this species bites viciously both at dawn, dusk and the early hours of the night.

Table A4-11. TRAP 3 - Sand Quarry ON

Species	25-Oct-22	8-Nov-22	23-Nov-22	6-Dec-22	20-Dec-22	3-Jan-23	24-Jan-23	7-Feb-23	21-Feb-23	7-Mar-23	21-Mar-23	4-Apr-23	19-Apr-23	3-May-23	16-May-23	30-May-23	13-Jun-23	28-Jun-23	TOTAL	TOTAL %
<i>Aedes alboannulatus</i>																			0	0
<i>Aedes camptorhynchus</i>	4	18	20	24	12	19	1	2	9	7		8	20	17	62	9	9	11	252	38
<i>Aedes clelandi</i>																			0	0
<i>Aedes hesperonotus</i>							1	1		2									4	1
<i>Aedes notoscriptus</i>																			0	0
<i>Aedes ratcliffei</i>		6	1		1														8	1
<i>Aedes sagax</i>																			0	0
<i>Aedes vigilax</i>						70		41	92	8	1	15	6		5				238	36
<i>Anopheles annulipes</i>	2	4	1		1	1	2												11	2
<i>Anopheles atratipes</i>																			0	0
<i>Coquillettidia sp. nr linealis</i>																			0	0
<i>Culex annulirostris</i>		2		1	10	63	21	4	4	2									107	16
<i>Culex australicus</i>																			0	0
<i>Culex globocoxitus</i>	7	8		1	13	6			1				1						37	6
<i>Culex quinquefasciatus</i>																			0	0
<i>Culiseta atra</i>																			0	0
Total	13	38	22	26	37	159	25	48	106	19	1	23	27	17	67	9	9	11	657	100
Ave / trap / event	37																			
Exceedences of 50	3																			
Highest single event	159					3-Jan-23														



A4.3.4 Site T04, Sand Quarry RN

Eighteen monitoring sessions were conducted at Site T04 during the reporting timeframe (October 2022 – end June 2023) with no trap failures occurring. Adult mosquito speciation and population data for Site T04 is presented in Table A4-12 (over the page), including a graph of the dominant species trapped.

A total of 248 adult mosquitoes belonging to three genera and six species were trapped at Site T04 during the reporting timeframe, the lowest of any of the trapping sites. Trap numbers ranged from 0 – 44 specimens. Adults were absent from trap on four occasions, variously throughout the year. The largest catch was recorded in traps deployed on the 4rd April 2023 (44 specimens). The average count of adult mosquitoes trapped per monitoring session was approximately 14.

The most abundant species, constituting 39% of the total adults trapped at Site T03, was *Ae. vigilax* (Saltmarsh Mosquito) with 97 specimens.

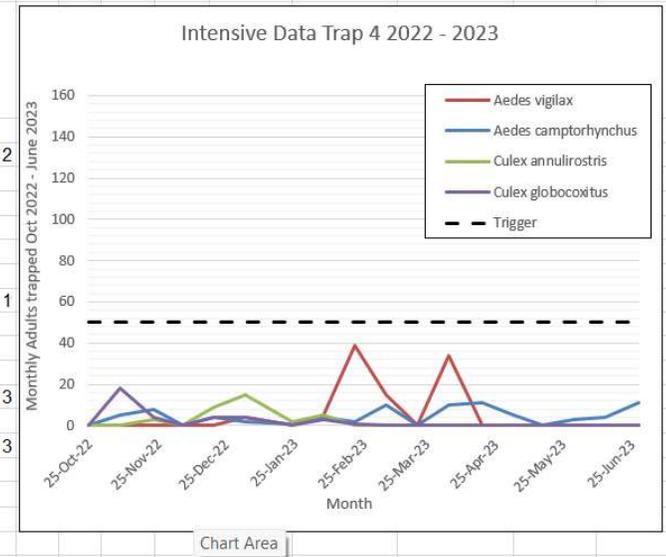
Near co-dominant, with 32 % of the total adults trapped (80 specimens), was the Southern saltmarsh mosquito *Ae. camptorhynchus*.

Also present in significant numbers was *Cu. annulirostis* and *Cu. globocoxitis* each with about 14% of the total catch (34 specimens). *Culex globocoxitis* generally does not bite humans and is most active from July to November. *Culex globocoxitus* is commonly found in coastal areas in the south-west of Western Australia breeding in open swamps and in slightly brackish water.

While there is currently no known link to RRV or BFV (Whelan, 2019) *Cu. globocoxitus* has been shown to be capable of carrying MVE virus in laboratory studies and may be involved in transmission between animals (Russell, 1996).

Table A4-12. TRAP 4 - Sand Quarry RN

Species	25-Oct-22	8-Nov-22	23-Nov-22	6-Dec-22	20-Dec-22	3-Jan-23	24-Jan-23	7-Feb-23	21-Feb-23	7-Mar-23	21-Mar-23	4-Apr-23	19-Apr-23	3-May-23	16-May-23	30-May-23	13-Jun-23	28-Jun-23	TOTAL	TOTAL %
<i>Aedes alboannulatus</i>																			0	0
<i>Aedes camptorhynchus</i>		5	8		4	2	1	4	2	10		10	11	5		3	4	11	80	32
<i>Aedes clelandi</i>																			0	0
<i>Aedes hesperonotius</i>																			0	0
<i>Aedes notoscriptus</i>					1														1	0
<i>Aedes ratcliffei</i>		1	1																2	1
<i>Aedes sagax</i>																			0	0
<i>Aedes vigilax</i>						4		5	39	15		34							97	39
<i>Anopheles annulipes</i>																			0	0
<i>Anopheles atratipes</i>																			0	0
<i>Coquillettidia sp. nr linealis</i>																			0	0
<i>Culex annulirostris</i>			3		9	15	2	5											34	14
<i>Culex australicus</i>																			0	0
<i>Culex globocoxitus</i>		18	4		4	4		3	1										34	14
<i>Culex quinquefasciatus</i>																			0	0
<i>Culiseta atra</i>																			0	0
Total	0	24	16	0	18	25	3	17	42	25	0	44	11	5	0	3	4	11	248	100
Ave / trap / event	14																			
Exceedences of 50	0																			
Highest single event	44																			4-Apr-23



A4.3.5 Site T05, Peel Winery

Twenty-two monitoring sessions were conducted at Site T05 during the reporting timeframe (October 2022 – end August 2023) with a single trap failure occurring on 3 January 2023. Adult mosquito speciation and population data for Site T05 is presented in **Table A4-13** (over the page), including a graph of the dominant species trapped.

A total of 656 adult mosquitoes belonging to three genera and seven species were trapped at Site T05 during the reporting timeframe. Trap numbers ranged from 4 – 118 specimens with the lowest catch recorded on 28 June 2023 and the largest catch recorded on 22nd December 2022. The average number of adult mosquitoes trapped per monitoring session was approximately 30 specimens

The most abundant species and significantly so was *Ae. camptorhynchus* (478 specimens), constituting 73 % of the total adults trapped. Numbers peaked over the summer period, resulting in three exceedances of the trigger level (50 specimens).

The next dominant species was *Ae. vigilax* with 10 % of the total adults trapped (29 specimens).

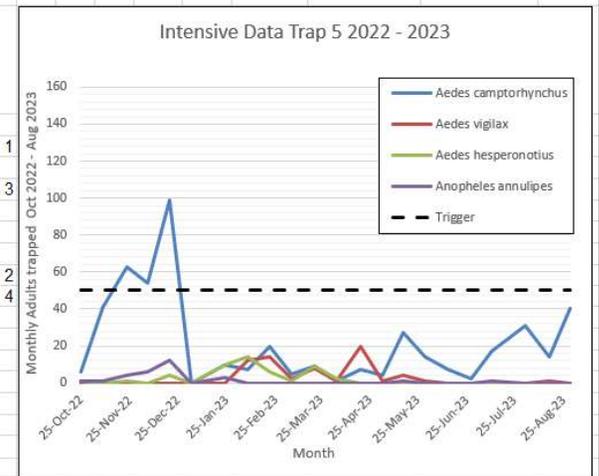
Also present (making up the top 4) were *Ae. hesperonotius* and *An. annulipes* that comprised 7 and 3 % of the total catch respectively.

Anopheles annulipes (Common Australian Anopheles) is an opportunistic species that will breed in a wide variety of habitats, from permanent, semi-permanent or temporary pools and containers. Found throughout the year, with its peak breeding time in summer, *Anopheles annulipes* will readily bite humans during the day with peak biting time being after sunset.

The disease relationship for *A. annulipes* remains uncertain although it is known to be a laboratory vector of malaria and has yielded isolates of RRV from the Murray Valley (Russell, 1996). A number of water containers (drinking troughs were observed adjacent to the sample site.

Table A4-13. TRAP 5 - Peel Winery

Species	25-Oct-22	8-Nov-22	23-Nov-22	6-Dec-22	20-Dec-22	3-Jan-23	24-Jan-23	7-Feb-23	21-Feb-23	7-Mar-23	21-Mar-23	4-Apr-23	19-Apr-23	3-May-23	16-May-23	30-May-23	13-Jun-23	28-Jun-23	11-Jul-23	1-Aug-23	16-Aug-23	29-Aug-23	TOTAL	TOTAL %	
<i>Aedes alboannulatus</i>																							0	0	
<i>Aedes camptorhynchus</i>	6	41	63	54	99		10	7	20	5	9	1	7	4	27	14	7	2	17	31	14	40	478	73	
<i>Aedes clelandi</i>																							0	0	
<i>Aedes hesperonotus</i>	1		1		4		10	14	6	1	9	2											48	7	
<i>Aedes notoscriptus</i>	1	2	2	2												2	3	2	1				3	18	3
<i>Aedes ratcliffei</i>																							0	0	
<i>Aedes sagax</i>																							0	0	
<i>Aedes vigilax</i>								12	14	2	8	1	20	1	4	1					1		64	10	
<i>Anopheles annulipes</i>	1	1	4	6	12		3														1		29	4	
<i>Anopheles atratipes</i>																							0	0	
<i>Coquillettia sp. nr linealis</i>																							0	0	
<i>Culex annulirostris</i>			1				1	2	1														5	1	
<i>Culex australicus</i>																							0	0	
<i>Culex globocoxitus</i>		1		1	3		4	2		3													14	2	
<i>Culex quinquefasciatus</i>																							0	0	
<i>Culiseta atra</i>																							0	0	
Total	9	45	71	63	118	0	28	37	41	11	26	4	27	5	32	17	10	4	19	31	15	43	656	100	
Ave / trap / event	30																								
Exceedences of 50	3																								
Highest single event	118				20-Dec-22																				



A4.3.6 Site T06, Fletcher Road

Twenty-two monitoring sessions were conducted at Site T06 during the reporting timeframe (October 2022 – end August 2023) with no trap failures. Adult mosquito speciation and population data for Site T06 is presented in **Table A4-14** (over the page), including a graph of the dominant species trapped.

A total of 2379 adult mosquitoes belonging to three genera and seven species were trapped at Site T06 during the reporting timeframe, the highest of any trap site. Trap numbers ranged from 5 – 359 specimens with the lowest catch recorded on 25 Oct 2022 and the largest catch recorded on 3rd January 2023. The average number of adult mosquitoes trapped per monitoring session was approximately 108 specimens, with the trigger level being exceeded on 15 occasions, principally over the summer and autumn period.

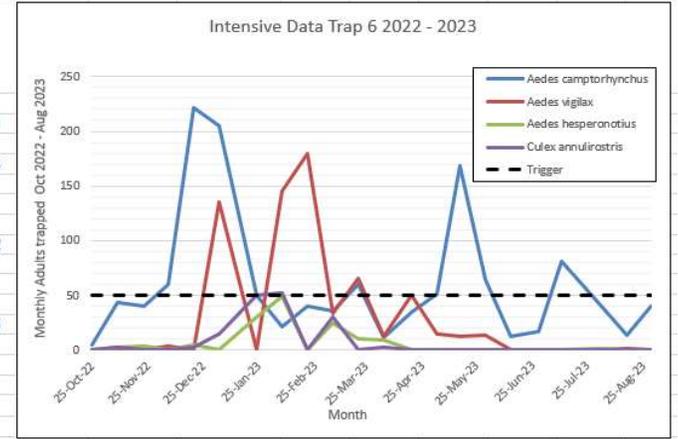
The most abundant species was *Ae. camptorhynchus* (1319 specimens), constituting 55 % of the total adults trapped.

The next dominant species was *Ae. vigilax* with 28 % of the total adults trapped (669 specimens).

Also present (near equally represented and making up the top 4) were *Cx annulirostris* and *Ae. hesperonotius* that each comprised about 7% of the total catch.

Table A4-14. TRAP 6 - Fletcher Road

Species	25-Oct-22	8-Nov-22	23-Nov-22	6-Dec-22	20-Dec-22	3-Jan-23	24-Jan-23	7-Feb-23	21-Feb-23	7-Mar-23	21-Mar-23	4-Apr-23	19-Apr-23	3-May-23	16-May-23	30-May-23	13-Jun-23	28-Jun-23	11-Jul-23	1-Aug-23	16-Aug-23	29-Aug-23	TOTAL	TOTAL %	
<i>Aedes alboannulatus</i>																							0	0	
<i>Aedes camptorhynchus</i>	5	44	40	60	222	205	50	21	40	36	60	11	35	51	168	65	13	17	81	41	14	40	1319	55	1
<i>Aedes clelandi</i>																							0	0	
<i>Aedes hesperonotius</i>		2	4		5		30	49		25	10	9									1		135	6	3
<i>Aedes notoscriptus</i>		5			2		1	1		1				3								1	3	17	1
<i>Aedes ratcliffei</i>																							0	0	
<i>Aedes sagax</i>																							0	0	
<i>Aedes vigilax</i>				4		135		145	180	34	66	13	50	15	12	14						1	669	28	2
<i>Anopheles annulipes</i>		7	5	3	16	2	5																38	2	
<i>Anopheles atratipes</i>																							0	0	
<i>Coquillettidia sp. nr linealis</i>																							0	0	
<i>Culex annulirostris</i>		2			2	15	50	52		30		3											154	6	3
<i>Culex australicus</i>																							0	0	
<i>Culex globocoxitus</i>		4	1	6	6	2	22	2													4		47	2	
<i>Culex quinquefasciatus</i>																							0	0	
<i>Culiseta atra</i>																							0	0	
Total	5	64	50	73	253	359	158	270	220	126	136	36	85	69	180	79	13	17	85	43	15	43	2379	100	
Ave / trap / event	108																								
Exceedences of 50	15																								
Highest single event	359																								
	3-Jan-23																								



Note changed vertical scale

A4.3.7 Site T07, Amarillo Rd

Twenty-two monitoring sessions were conducted at Site T08 during the reporting timeframe (October 2022 – end August 2023) with a single trap failure on 7 Feb 2023. Adult mosquito speciation and population data for Site T07 is presented in **Table A4-15** (over the page), including a graph of the dominant species trapped.

A total of 538 adult mosquitoes belonging to three genera and seven species were trapped at Site T07 during the reporting timeframe. Trap numbers ranged from 3 – 56 specimens with the lowest catch recorded on 24 Jan 2023 and the largest catch recorded on 21st February 2023. The average number of adult mosquitoes trapped per monitoring session was approximately 24 specimens, with the trigger level being exceeded on 2 occasions, principally over the late summer and autumn period.

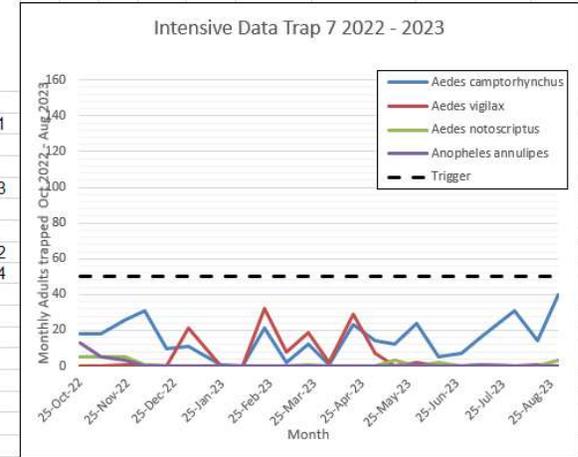
The most abundant species was *Ae. camptorhynchus* (338 specimens), constituting a dominant 63 % of the total adults trapped.

The next dominant species was *Ae. vigilax* with 23 % of the total adults trapped (123 specimens).

Also present (near equally represented and making up the top 4) were *Ae. notoscriptus* and *An. annulipes* that each comprised about 4% of the total catch.

Table A4-15. TRAP 7 - Amarillo Road

Species	25-Oct-22	8-Nov-22	23-Nov-22	6-Dec-22	20-Dec-22	3-Jan-23	24-Jan-23	7-Feb-23	21-Feb-23	7-Mar-23	21-Mar-23	4-Apr-23	19-Apr-23	3-May-23	16-May-23	30-May-23	13-Jun-23	28-Jun-23	11-Jul-23	1-Aug-23	16-Aug-23	29-Aug-23	TOTAL	TOTAL %	
<i>Aedes alboannulatus</i>																							0	0	
<i>Aedes camptorhynchus</i>	18	18	26	31	10	11	1		21	2	12	1	23	14	12	24	5	7	17	31	14	40	338	63	1
<i>Aedes clelandi</i>																							0	0	
<i>Aedes hesperonotus</i>							1		1		1	2											5	1	
<i>Aedes notoscriptus</i>	5	5	5	1							1				3		2		1			3	26	5	3
<i>Aedes ratcliffei</i>																							0	0	
<i>Aedes sagax</i>																							0	0	
<i>Aedes vigilax</i>			1	1		21			32	8	19	2	29	7		2					1		123	23	2
<i>Anopheles annulipes</i>	13	5	3																				23	4	4
<i>Anopheles atratipes</i>																							0	0	
<i>Coquillettidia sp. nr linealis</i>																							0	0	
<i>Culex annulirostris</i>		4	2	1		7	1		2														17	3	
<i>Culex australicus</i>																							0	0	
<i>Culex globocoxitus</i>	1	3		1	1																		6	1	
<i>Culex quinquefasciatus</i>																							0	0	
<i>Culiseta atra</i>																							0	0	
Total	37	35	37	35	11	39	3	0	56	10	33	5	52	21	15	27	7	7	19	31	15	43	538	100	
Ave / trap / event	24																								
Exceedences of 50	2																								
Highest single event	56						21-Feb-23																		



A4.3.8 Site T08, Malee Drive

Eighteen monitoring sessions were conducted at Site T08 during the reporting timeframe (October 2022 – end June 2023) with no trap failures. Adult mosquito speciation and population data for Site T08 is presented in **Table A4-16** (over the page), including a graph of the dominant species trapped.

A total of 2304 adult mosquitoes belonging to three genera and seven species were trapped at Site T08 during the reporting timeframe. Trap numbers ranged from 12 – 365 specimens with the lowest catch recorded on 24 Jan 2023 and the largest catch recorded on 3rd May 2023. The average number of adult mosquitoes trapped per monitoring session was approximately 128 specimens, the highest rate of any of the trap sites. The trigger level was exceeded on 14 occasions, principally over the late summer and autumn period.

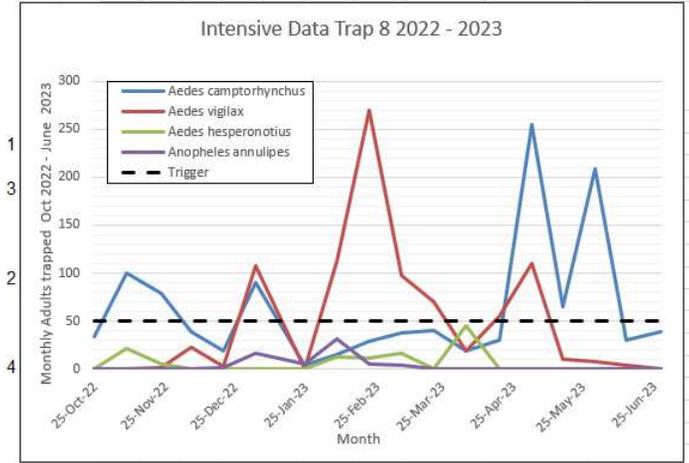
The most abundant species was *Ae. camptorhynchus* (1133 specimens), constituting 49 % of the total adults trapped.

The next dominant species was *Ae. vigilax* with 39 % of the total adults trapped (892 specimens).

Also present (making up the top 4) were *Ae. hesperonotius* and *Cx. annulirostris* with 5 and 3% of the total catch respectively.

Table A4-16. TRAP 8 - Mallee Drive

Species	25-Oct-22	8-Nov-22	23-Nov-22	6-Dec-22	20-Dec-22	3-Jan-23	24-Jan-23	7-Feb-23	21-Feb-23	7-Mar-23	21-Mar-23	4-Apr-23	19-Apr-23	3-May-23	16-May-23	30-May-23	13-Jun-23	28-Jun-23	TOTAL	TOTAL %
<i>Aedes alboannulatus</i>																			0	0
<i>Aedes camptorhynchus</i>	34	100	79	39	19	90	4	15	29	38	40	19	30	255	65	208	30	39	1133	49
<i>Aedes clelandi</i>																			0	0
<i>Aedes hesperonotius</i>		22	5				1	13	12	17		45							115	5
<i>Aedes notoscriptus</i>		4	8	6	5	2		1				1			2		2		31	1
<i>Aedes ratcliffei</i>																			0	0
<i>Aedes sagax</i>																			0	0
<i>Aedes vigilax</i>			2	23	3	107		113	270	98	70	19	55	110	10	8	4		892	39
<i>Anopheles annulipes</i>	4	6	10	1		5			1								1		28	1
<i>Anopheles atratipes</i>																			0	0
<i>Coquillettidia sp. nr linealis</i>																			0	0
<i>Culex annulirostris</i>				1	2	17	5	32	5	4		1							67	3
<i>Culex australicus</i>																			0	0
<i>Culex globocoxitus</i>	12		4	10	5	2	2	1							1		1		38	2
<i>Culex quinquefasciatus</i>																			0	0
<i>Culiseta atra</i>																			0	0
Total	50	132	108	80	34	223	12	175	317	157	110	85	85	365	78	216	38	39	2304	100
Ave / trap / event	128																			
Exceedences of 50	14																			
Highest single event	365		3-May-23																	



Note changed vertical scale

A4.3.9 Site T09, Glow Pavers

Twenty-two monitoring sessions were conducted at Site T09 during the reporting timeframe (October 2022 – end Late August 2023) with no trap failures. Adult mosquito speciation and population data for Site T09 is presented in **Table A4-17** (over the page), including a graph of the dominant species trapped.

A total of 1483 adult mosquitoes belonging to three genera and six species were trapped at Site T09 during the reporting timeframe. Trap numbers ranged from 9 – 210 specimens with the lowest catch recorded on 3rd Jan 2023 and the largest catch recorded on 30th May 2023. The average number of adult mosquitoes trapped per monitoring session was approximately 67 specimens. The trigger level was exceeded on 10 occasions, principally over late summer through winter period.

The most abundant species was *Ae. camptorhynchus* (922 specimens), constituting a dominant 62 % of the total adults trapped.

The next dominant species was *Ae. vigilax* with 31 % of the total adults trapped (463 specimens).

Also present was *Cx. globocoxitus* with 5% of the total catch (76 specimens).

A4.3.10 Site T10, Paganoni Pavers

Eighteen monitoring sessions were conducted at Site T10 during the reporting timeframe (October 2022 – late June 2023) with no trap failures. Adult mosquito speciation and population data for Site T10 is presented in **Table A4-18** (over the page), including a graph of the dominant species trapped.

A total of 2262 adult mosquitoes belonging to three genera and eight species were trapped at Site T10 during the reporting timeframe. Trap numbers ranged from 16 – 840 specimens with the lowest catch recorded on 24th Jan 2023 and the largest catch recorded on 30th May 2023. The average number of adult mosquitoes trapped per monitoring session was approximately 126 specimens, largely driven by a large emergence reporting to the sampling of 30 May 2023 (840 individuals trapped) The trigger level was exceeded on 11 occasions, principally over late autumn through winter period.

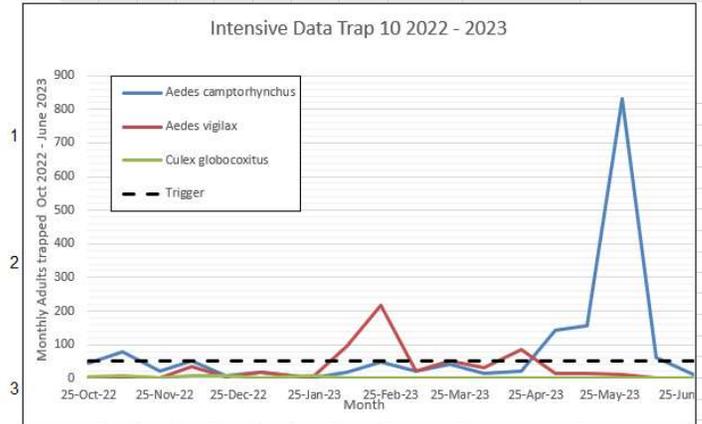
The most abundant species was *Ae. camptorhynchus* (1584 specimens), constituting a dominant 70 % of the total adults trapped.

The next dominant species was *Ae. vigilax* with 26 % of the total adults trapped (594 specimens).

Also present was *Cx. globocoxitus* with 2% of the total catch (36 specimens).

Table A4-18. TRAP 10 - Paganoni Pavers

Species	25-Oct-22	8-Nov-22	23-Nov-22	6-Dec-22	20-Dec-22	3-Jan-23	24-Jan-23	7-Feb-23	21-Feb-23	7-Mar-23	21-Mar-23	4-Apr-23	19-Apr-23	3-May-23	16-May-23	30-May-23	13-Jun-23	28-Jun-23	TOTAL	TOTAL %
<i>Aedes alboannulatus</i>																			0	0
<i>Aedes camptorhynchus</i>	45	80	21	52	8	17		19	47	22	40	15	21	142	155	830	60	10	1584	70
<i>Aedes clelandi</i>																			0	0
<i>Aedes hesperonotus</i>							1			2									3	0
<i>Aedes notoscriptus</i>		1	1																2	0
<i>Aedes ratcliffei</i>		1																	1	0
<i>Aedes sagax</i>																			0	0
<i>Aedes vigilax</i>		3		35	3	16		94	216	22	50	30	85	14	15	10	1		594	26
<i>Anopheles annulipes</i>	4	6			2		2	2	1			2							19	1
<i>Anopheles atratipes</i>																			0	0
<i>Coquillettidia sp. nr linealis</i>																			0	0
<i>Culex annulirostris</i>				1	1	2	7	6	6										23	1
<i>Culex australicus</i>																			0	0
<i>Culex globocoxitus</i>	4	6	2	6	8	1	6	1						2					36	2
<i>Culex quinquefasciatus</i>																			0	0
<i>Culiseta atra</i>																			0	0
Total	53	97	24	94	22	36	16	122	270	46	90	47	106	158	170	840	61	10	2262	100
Ave / trap / event	126																			
Exceedences of 50	11																			
Highest single event	840																			30-May-23



Note changed vertical scale

APPENDIX 5

MOSQUITO RISK ASSESSMENT AND MANAGEMENT PLAN - PLANNING CONSIDERATIONS

Source: CDP Town Planning & Urban Design 2023

MRAMP Addendum

MOSQUITO RISK ASSESSMENT AND MANAGEMENT PLAN PLANNING CONSIDERATIONS

From. CDP Town Planning & Urban Design
Date. 17 November 2023 (Revised)
Job Code. ROCKADSP

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Overview

This memorandum has been prepared to assist Rankin/Emerge in the preparation of a development strategy to complete the Mosquito Management Plan (MRAMP) for the Karnup District Structure Plan (DSP) area.

For context, the outcome of the data analysis undertaken by Rankin has identified that mosquito issues are more widespread and potentially more impactful from a public health perspective than previously thought. As a result, the 1km mosquito 'flight zone' measure applied under the current policy context significantly impacts the DSP area, and the ability for the land to be developed for primarily Urban purposes as envisaged by the South Metropolitan Peel Sub-Regional Planning Framework ('the Planning Framework') unless a more considered and pragmatic approach is adopted.

It is recognised that mosquito mitigation measures are already in place for the Serpentine wetland system ('Lake Amarillo') to the east of the DSP area, however measures have yet to be established for the wetlands located west and south of the DSP area, being Anstey Swamp and Paganoni Swamp, respectively. Monitoring and management of these wetlands from a mosquito management perspective is challenging due to the dense vegetation, high tree canopy, and general accessibility of these sites.

If subdivision and development of the Karnup DSP area is to occur in accordance with the Planning Framework, mosquito habitat areas will need to be appropriately managed to minimise public health risk. It is acknowledged that the mosquito nuisance and disease risk will not be fully eradicated, however the following approach provides a framework on which to guide land use spatial planning in the DSP area to arrive at a balanced outcome.

It is expected that mosquito management will include relevant Department of Health (DoH) and Local Authority regulated treatment, including those programmes currently implemented by the Peel Mosquito Management Group (PMMG).

As recommended by DoH, the use of chemicals to control mosquitoes will form part of a larger integrated approach to mosquito management and should not be considered a stand-alone control strategy. Every effort should first be made to prevent mosquito breeding through physical control activities, such as habitat source reduction and breeding site maintenance.

Recent consultation with DoH officers (September 2023) highlighted that:

- Approval of a Structure plan and subsequent development will increase the risk of mosquito-borne disease being acquired in the area, and there is no mitigation 'silver bullet'. The DoH will continue working with the City to mitigate the risk, but recognising that it will not be properly alleviated. In this case emphasis is on the City to alert future residents of the risks, along with increased mosquito management activities in the area including potentially more frequent aerial larviciding.



- The Karnup DSP area is a high-risk location and putting a large population there isn't ideal, but the DoH is realistic about developments occurring and this site is comparative to other developments in other high-risk areas around Mandurah and elsewhere in the southwest.

Notwithstanding the above, the following design considerations should be thoroughly investigated when preparing the Structure Plan:

- The City should use built form design measures in the construction of accommodation and recreational areas to protect future residents from mosquitoes.
- Public open space with limited vegetation should be located between the mosquito breeding sites and residential areas to create an area that is refractory to mosquito dispersal, thereby reducing the number of mosquitoes impacting residents.
- Preference for periphery areas, closest to the known breeding sites, to be kept as either public open space, or as low density as possible (industry, retail etc).
- Development of more intensive residential development (i.e. dwelling units) can cause problems of mosquito harbourage. Said land uses can be accommodated however would be recommended to include residual sprays on the external walls to mitigate mosquito harbourage.
- Built form design measures (i.e. insect screening on doors and windows and screened outdoor enclosures), public education packages and public signage are encouraged to be included as part of the State and local government conditions of approval consistent with current practices.
- Development of school sites is amenable, but the risk of *Ae. vigilax* during summer periods may cause nuisance when the staff/students are outside.
- Public education of residents and workers is the onus of the City and/or developers, whereby the education programs to raise awareness of mosquito-borne diseases among onsite residents and workers employed for future projects should entail:
 - Avoidance of biting mosquitoes
 - Use of appropriate clothing (supply long-sleeved, light, loose fitting clothing)
 - Use of personal insect repellents (supply workers with repellents containing DEET, picaridin or OLE).

Current Policy Context

Government Policy guiding development in the context of mosquito breeding areas and mitigation of exposure risk is currently limited.

A desktop review of the current Policy context has been undertaken by CDP as follows:

- Shire of Murray *Local Planning Policy - Mosquitoes (2018)*
- Northern Territory Government *Guidelines for Preventing Biting Insect Problems for Urban Residential Developments and Subdivisions in the Top End of the NT (2023)*
- City of Mandurah *Local Development Plan(s) for Frasers Landing (2021 et al)*

Shire of Murray LPP - Mosquitos

The LPP proposes the following buffers for residential related development in mosquito risk areas:

Residential Lot Sizes	Distance to Saltmarshes
Minimum 2 hectares	0 - 300m
Minimum 1 hectare	300 - 500m
Minimum 4,000sqm (R2.5)	500m - 1km
Residential sized lots less than 4,000sqm (with rural-residential or cleared rural land buffer)	1 - 2km
Residential sized lots less than 4,000sqm (with no rural-residential or cleared rural land buffer)	2km or greater



Guidelines for Preventing Biting Insect Problems for Urban Residential Developments and Subdivisions in the Top End of the NT.

These guidelines prescribe an urban residential development buffer of 1.6km for large uncontrolled areas of mosquito breeding sites, unless otherwise offering larger product including:

Residential Lot Sizes	Distance to mosquito source
2ha or greater	0 - 300m
1ha or greater	300 - 500m
0.4ha (4,000sqm) or greater	500m<

Where practical, a semi-rural or rural subdivision or industrial buffer should be incorporated into a residential subdivision design, with the intention of increasing the effectiveness of the buffer zone. Incorporating rural residential and/or an industrial land use as a buffer will generally reduce the separation of the threat down to 1km.

Note: the City of Rockingham has taken the view that the application of lot size criteria (only) is too prescriptive and limited to manage mosquito issues within the City. In this regard, larger lot sizes do not address factors including need and demand for housing in Metropolitan Perth in appropriately located areas, the planning framework, or the likelihood of larger lots containing vegetation that harbours/breeds mosquitoes, and therefore continues to be a source of mosquito risk. The City considers lot size criteria should be only one of a suite of considerations applied to address mosquito risk.

City of Mandurah Frasers Landing Local Development Plan(s) Local Development Plans for Frasers Landing (adopted in 2021 and in other years), contain a provision requiring:

'XX. A Provision of at least one outdoor living area (e.g., patio, deck, balcony), that is fully screened' (in order to address mosquito and midge nuisance and disease risk.'

Sensitive Uses

There is limited guidance in current Policy on the establishment of 'sensitive uses' in proximity to mosquito breeding areas. The Shire of Murray LPP notes that in addition to residential development, other development which may be sensitive to mosquito impacts that is best 'discouraged' in buffer zones includes tourist accommodation, lifestyle villages and night-time recreational developments.

In addition to the LPP, and in planning for the Karnup DSP area, more intensive Urban land uses that may potentially be deemed sensitive to mosquito risk may include education establishments (e.g., schools), community infrastructure (recreation facilities) or other larger scale developments whereby users spend extended periods outdoors. This may apply to courtyards, piazzas or the like within Activity Centres, Hospitals and other outdoor communal spaces where exposure to mosquitoes is increased (noting that the species of disease carrying mosquitoes identified in the area may also be active during the daytime).

Location and design of these uses within the Karnup DSP will need to give careful consideration to minimising mosquito risk.



Potential Development Scenarios

Preliminary discussions with DPLH proposed that a number of development scenarios be explored to enable the potential impact of the MRAMP findings on the development of the DSP area to be understood. The outcomes of these scenarios will assist WAPC in resolving an approach to the DSP area, in consultation with DoH and the City of Rockingham.

The three (3) scenarios are as follows:

- A. **restricted land uses** in identified mosquito risk areas;
- B. **uncontrolled land uses** in identified mosquito risk areas;
- C. a **balanced land use** approach between the two scenarios above.

The following section provides the context for the preparation of the development scenarios, providing guidance and assumptions on land use and development, on which to base each scenario and understand impact.

A. Mitigation with 'Restricted Land Uses' Scenario

Strategy

In the event 'Restricted Land Uses' (and non-sensitive land uses) only are to apply in the 1km 'flight zone' of the Karnup DSP area, the following uses, under definitions listed in the City of Rockingham Town Planning Scheme No.2 (TPS2) may be considered:

Land Use/Zone	Commentary
Special Rural	<ul style="list-style-type: none"> ▪ The Special Rural Zone currently applies to most of the DSP area, excluding the WAPC owned land pertaining to the Karnup Transit Precinct ('Rural'), and Development WA and private land ownership in the north of the DSP area adjacent to Stakehill Road ('Development' zone). ▪ The local government will generally not recommend approval to lot sizes less than two (2) hectares within the Special Rural zone; ▪ Residential - 'Single House' is a permitted use with a maximum of one (1) per lot only. ▪ Portions of the Karnup DSP area are planned for 'Rural Residential' purposes given their environmental qualities, namely the north-west and central-eastern areas. This land generally includes existing landholdings compliant with the minimum lot sizes for mosquito risk areas (0m - 1km of mosquito fly zone), which will partially address the current land use-mosquito buffer considerations. ▪ The retention of this zoning within a 0 - 300m buffer of the mosquito risk assessment area would be consistent with the Policy context for residential development in the vicinity of the mosquito breeding risk area. ▪ Residential development could then gradually increase in density (reduce in lot size) at a rate similar to that defined in the Policy context above.
Service Commercial	<ul style="list-style-type: none"> ▪ 'Non-sensitive' land uses under this definition would be generally accepted in mosquito risk areas; namely Bulky Good Showrooms, Art Gallery, Health Studios, Veterinary Clinic and Commercial Vehicle Parking. ▪ Uses that may be considered 'sensitive' under this zone in relation to mosquito risk include Health Studios, Garden Centre, Childcare premise and Place of Worship, particularly if incorporating outdoor areas. <p>These uses may be restricted from development in the Karnup DSP area via a scheme amendment and/or Structure Plan provisions unless specific mosquito mitigation measures are addressed under a Development Application - this may include (inter alia) restriction of operating hours for outdoor areas.</p>



Light Industry	<ul style="list-style-type: none">▪ 'Non-sensitive' land uses under this definition would be generally accepted in mosquito risk areas; namely Bulky Good Showrooms, Light and Service Industry, Health Studios, Motor Vehicle Wash, Veterinary clinics, Warehouse/Storage etc.▪ Uses that may be considered 'sensitive' under this zone in relation to mosquito risk include Health Studios, Garden Centres, Place of Worship and Recreation - Private, particularly if incorporating outdoor areas. These uses may be restricted from development in the Karnup DSP area via a scheme amendment and/or Structure Plan provisions unless specific mosquito mitigation measures are addressed under a Development Application - this may include (inter alia) restriction of operating hours for outdoor areas.▪ Land uses such as residential, nursing homes, childcare and tourist uses are 'X' uses under this zone, avoiding potential sensitive uses encroaching into the zone.
General Industry	<ul style="list-style-type: none">▪ Similar opportunities to Light Industry but considered a lesser risk by virtue of a less intensive employment population (i.e., more large-scale yard operations).▪ Similar land uses to Light Industry but including Industry-General/ (Licensed), and excluding uses such as Veterinary Clinics, Health Studios, and dry-cleaning premises.▪ Development of this nature will be subject to the environmental conditions of the land, namely potential impact on environmentally sensitive sites adjacent (ground and surface water, light, noise, gaseous emissions etc).▪ A high-level review of the use permissibility for the Light Industry and General Industry zones against the EPA's <i>Guidance for the assessment of Environmental Factors</i> has identified that separation distances to sensitive land uses will apply to specific land uses within these zones (i.e., 24hr service stations generally require a 200m buffer to sensitive land uses).

Whilst the above land uses may be suitable as means to develop land within 1km of mosquito risk areas, these uses may not be necessarily suitable in addressing other 'planning' factors, including:

- General Industrial uses may offer a physical buffer between mosquito risk areas and sensitive land uses, however the applied industrial (noxious related) buffers to both environmentally sensitive areas (wetlands) and sensitive land uses (i.e., residential development) may in fact pose a greater buffer burden overall than any applied mosquito risk buffer.
- Extensive 'linear' configurations of Service Commercial and Industrial areas, say 300m - 1km+ wide may not be commercially viable, and be positioned in less desirable locations in terms of:
 - Access to primary transport networks;
 - Commercial exposure;
 - Customer accessibility and satisfaction of use.
- Rural Residential and Special Rural lots may correlate to:
 - Underutilisation of already identified Urban/Residential lands under the Planning Frameworks;
 - More unmanaged, well vegetated land equating to greater mosquito risk internal to the DSP boundary.

B. Mitigation with 'Uncontrolled Land Uses' Scenario

This scenario assumes that, notwithstanding the mosquito risk, future sensitive land uses may be within the 0 - 1km flight zone of an identified mosquito risk area.

Notwithstanding the risk of mosquito nuisance, disease and illness, this approach may see intensive residential or other sensitive land uses directly interfacing saltmarsh wetlands either external or internal to the DSP boundary. This scenario may follow the same approach as existing, traditional greenfield and brownfield sites directly interfacing freshwater wetlands throughout the Perth Metropolitan Area.



Strategy

This approach will:

- Promote the most (spatially) efficient District Structure Plan design outside of any mosquito risk parameters, and consistent with the Planning Framework; but
- Will still ensure orderly and proper planning is considered for all other environmental, economic and social sustainable factors as guided by State and Local strategic and statutory policy frameworks.

Notwithstanding the uncontrolled land use spatial planning outcomes, it would be expected that extensive mosquito mitigation management programmes be implemented in risk affected areas.

C. Mitigation with ‘Balanced Land Use’ Approach

This approach is proposed to deliver a balanced scenario using outcomes of both the ‘restricted/non-sensitive’ land use and ‘uncontrolled/sensitive’ land use scenarios above.

This scenario is preferred in that it offers a practical balance between:

- the ‘full residential’ development build-out expectations of landowners/developers, and consistent with the Planning Framework; and
- the more cautious approach taken by DoH and Local Government in ensuring the long-term public health and safety and comfort of its future Karnup residents in minimising mosquito borne diseases and illness and general nuisance.

This scenario will also:

- require restriction of certain landholdings from developing sensitive land uses unless specific mosquito mitigation measures are adhered to, both during subdivision and development and long term.
- enable interim non-sensitive land uses to be considered and later replaced by sensitive land uses on the basis mosquito mitigation is better managed over time as the DSP area is gradually built out.

There are no currently identified policy measures that specifically address if 0 – 1km flights zones may be reduced through the offering of environmental or physical barriers within this flight zone area. However, there may be several individual or combined practical design measures implemented at the time of Local Structure Planning, and subsequent subdivision and development, to mitigate mosquito habitat and obstruct the flight zone so sensitive land uses may occupy land closer to the risk source.

These design measures may include (inter alia):

Factor	Strategy
Environment	
Localised wind factors	<ul style="list-style-type: none"> ▪ Consider whether mosquito flight zones can be reduced due to prevailing wind patterns, like that often imposed for noxious industry and agricultural noise and odour buffers. This may be considered at the LSP stage.
Vegetation Management (Wetlands)	<ul style="list-style-type: none"> ▪ Consider how revegetation of wetland areas, particularly the fringe of the wetlands and nearer to urban development, can assist in reducing mosquito habitat.
Vegetation Management (Subdivision/Development)	<ul style="list-style-type: none"> ▪ Consider specific mosquito deterrent plant and tree species for use within future areas of public open space and verge street tree/plantings, particularly on the urban fringe interfacing risk areas.
Waterbody management	<ul style="list-style-type: none"> ▪ Consider whether waterbody management practices generally used for artificial lakes may be implemented for natural systems.



Urban Stormwater Management	<ul style="list-style-type: none"> Ensuring best practice drainage/stormwater management is implemented for all new urban development to minimise breeding environments internal to the DSP area.
Physical Barriers – Land Uses and Urban Design	
Major Road Reserves and other open areas	<ul style="list-style-type: none"> Consider whether major road reserves (i.e., Kwinana Freeway) and other large open land barriers assist to obstruct mosquito flight zones.
Designing out ‘Hot-Spots’ with non-sensitive land uses	<ul style="list-style-type: none"> Designing out identified areas with high concentration of mosquito populations (‘hot-spots’) with non-sensitive land uses. Consider whether concentration of large buildings (i.e., Service Commercial and Industry land uses) adjacent to mosquito ‘hot-spots’ offer a genuine physical barrier to sensitive land use areas.
Designing out ‘Hot-Spots’ with sensitive land uses	<ul style="list-style-type: none"> Designing out urban areas so the ‘less-sensitive’ land uses are closer to the mosquito source, to then transition to more sensitive uses. i.e., Activity Centre and school buildings may be closer to the source (near or partly within the fly zone) however the designated outdoor areas of these uses are designed further away from the source.
Spatial Planning/Urban Grid	<ul style="list-style-type: none"> Designing areas where residents visit for short-term periods (‘non-permanent’), such as public open space, public amenities and other daytime activity nodes, closer to the source so to offer ‘permanent’ areas (residential homes) greater separation to mosquito sources. Depending on where the mosquito source originates, designing the local residential cells in a manner that creates the greatest physical barrier to the source. i.e., building roads and cells on a north-south axis so dwellings may offer a physical barrier to the prevailing winds and mosquito source travelling east-west.
Built-Form Design Measures	<ul style="list-style-type: none"> Consider built-form design options to minimise the mosquito nuisance factor for established residential areas. i.e., this may include mandating designated enclosed (screened) outdoor living spaces for residential areas closer to the mosquito source, with Frasers Landing in the City of Mandurah being one case study.
Stormwater Management	<ul style="list-style-type: none"> Design of stormwater management for subdivisions and on individual sites to limit storage of water and minimise mosquito breeding.
Notifications on Title	<ul style="list-style-type: none"> At the subdivision stage, imposing a notification on title advising prospective purchasers of mosquito risk, consistent with current practise.
Education	<ul style="list-style-type: none"> Adapting the City of Rockingham’s current brochure ‘Mosquito Control in Karnup’ to refer to Urban residential and business land uses, to assist future residents and occupants in minimising mosquito breeding on their properties; and incorporate this information into the City’s education programmes.

Further discussions between the City of Rockingham, DPLH and DoH will be required to determine a suitable approach to progress the DSP having regard to the various considerations addressed above.



Advocacy and Funding of Mosquito Mitigation Measures

Mosquito mitigation requires an upfront implementation strategy with a 'one-in-all-in' approach for all landholdings within the DSP boundary; this to ensure the orderly and proper planning of the area from a land use spatial planning perspective.

The *ad hoc* development of individual landholdings without consideration of mosquito risk should be discouraged as, without the rigours of District Planning, the equitable provision and distribution of community and service infrastructure and complementary land uses will not occur.

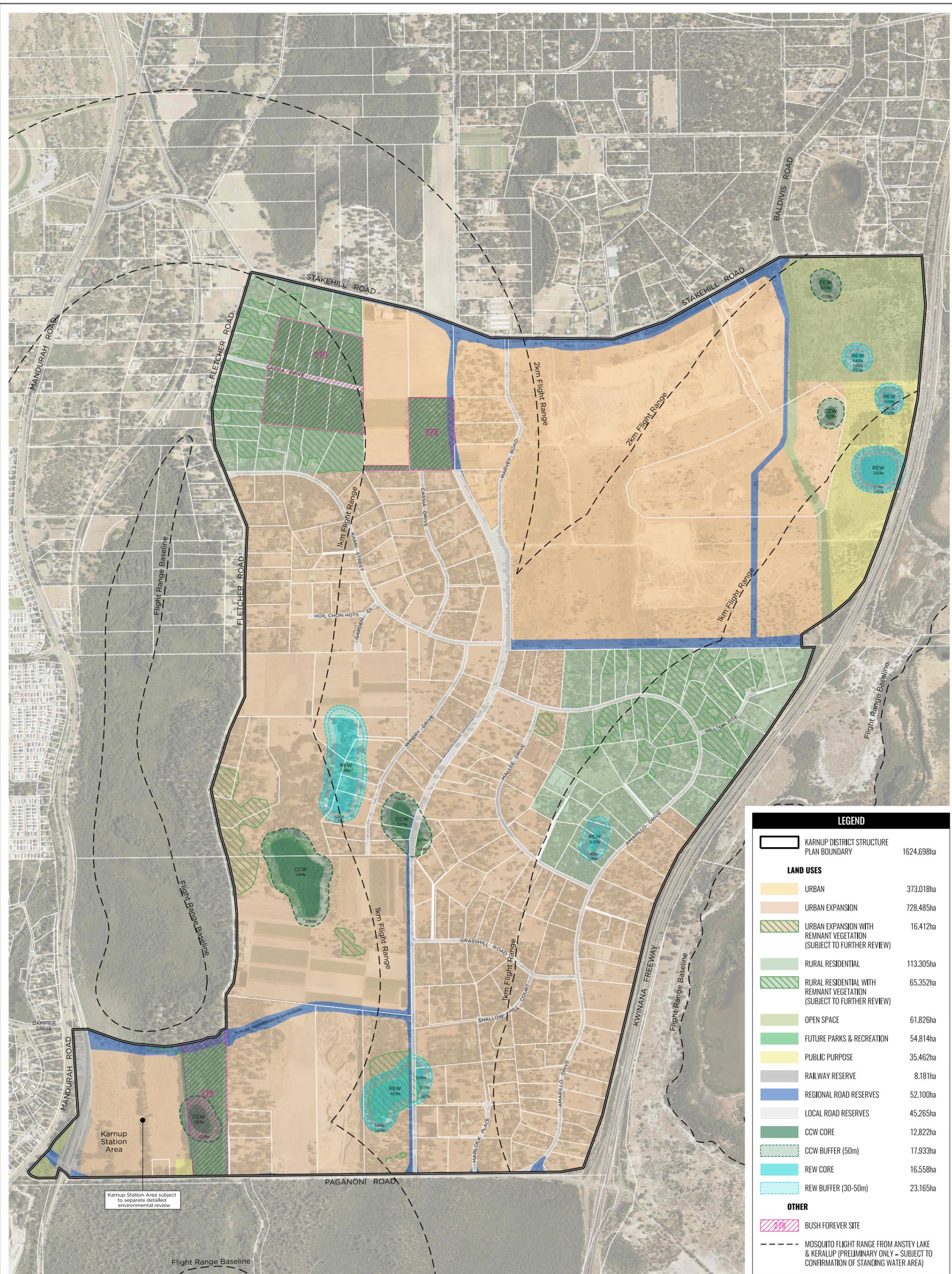
Without District Planning to identify local needs, the lack of suitable land uses to support residential development will only expose the shortcomings of the local area, while also placing unnecessary community and servicing infrastructure pressures on adjoining neighbourhoods/districts.

Mosquito management for the DSP area will also require a collaborative approach between State and local government, including the DPLH, DoH and PMMG. Funding for any additional mosquito mitigation is currently very limited.

To enable treatment of Anstey and Paganoni Lakes, and enable development within the DSP area consistent with the Planning Framework, additional and ongoing funding from the State Government will be required.

Independent of State funding, a mosquito mitigation programme may also be considered through a Development Contribution Plan (DCP); this potentially an additional line-item to standard service and community infrastructure cost items. The DCP option may be considered where:

- At the time of subdivision and development, landowners pay a per hectare/per lot contribution towards the initial mosquito mitigation measures - including:
 - early revegetation and landscaping of identified wetlands, and;
 - open space distribution and landscaping considerations where influenced by mosquito management best practice;
- Funding is also allocated (held) for long-term mosquito management to be undertaken by the City of Rockingham.
- Funding for detailed pre-development works undertaken by the City of Rockingham, DoH or other agreed parties related to mosquito mitigation - including:
 - studies towards potential introduced fauna species to assist with biological control of mosquitoes;
 - vegetation management; and/or
 - other agreed mitigation measures that have clearly demonstrated they assisted the expedited urbanisation of the Karnup DSP area.



LEGEND	
	KARNUP DISTRICT STRUCTURE PLAN BOUNDARY 1624.698ha
LAND USES	
	URBAN 373.018ha
	URBAN EXPANSION 728.485ha
	URBAN EXPANSION WITH REMNANT VEGETATION (SUBJECT TO FURTHER REVIEW) 16.412ha
	RURAL RESIDENTIAL 113.305ha
	RURAL RESIDENTIAL WITH REMNANT VEGETATION (SUBJECT TO FURTHER REVIEW) 65.352ha
	OPEN SPACE 61.826ha
	FUTURE PARKS & RECREATION 54.814ha
	PUBLIC PURPOSE 35.462ha
	RAILWAY RESERVE 8.181ha
	REGIONAL ROAD RESERVES 52.100ha
	LOCAL ROAD RESERVES 45.265ha
	CCW CORE 12.822ha
	CCW BUFFER (50m) 17.933ha
	REW CORE 16.558ha
	REW BUFFER (30-50m) 23.165ha
OTHER	
	BUSH FOREVER SITE
	MOSQUITO FLIGHT RANGE FROM ANSTNEY LAKE & KERALUP (PRELIMINARY ONLY - SUBJECT TO CONFIRMATION OF STANDING WATER AREA)

BASE PLAN

KARNUP

A City of Rockingham Project

DRAFT

NORTH

Scale: 1:20 000 @ A3

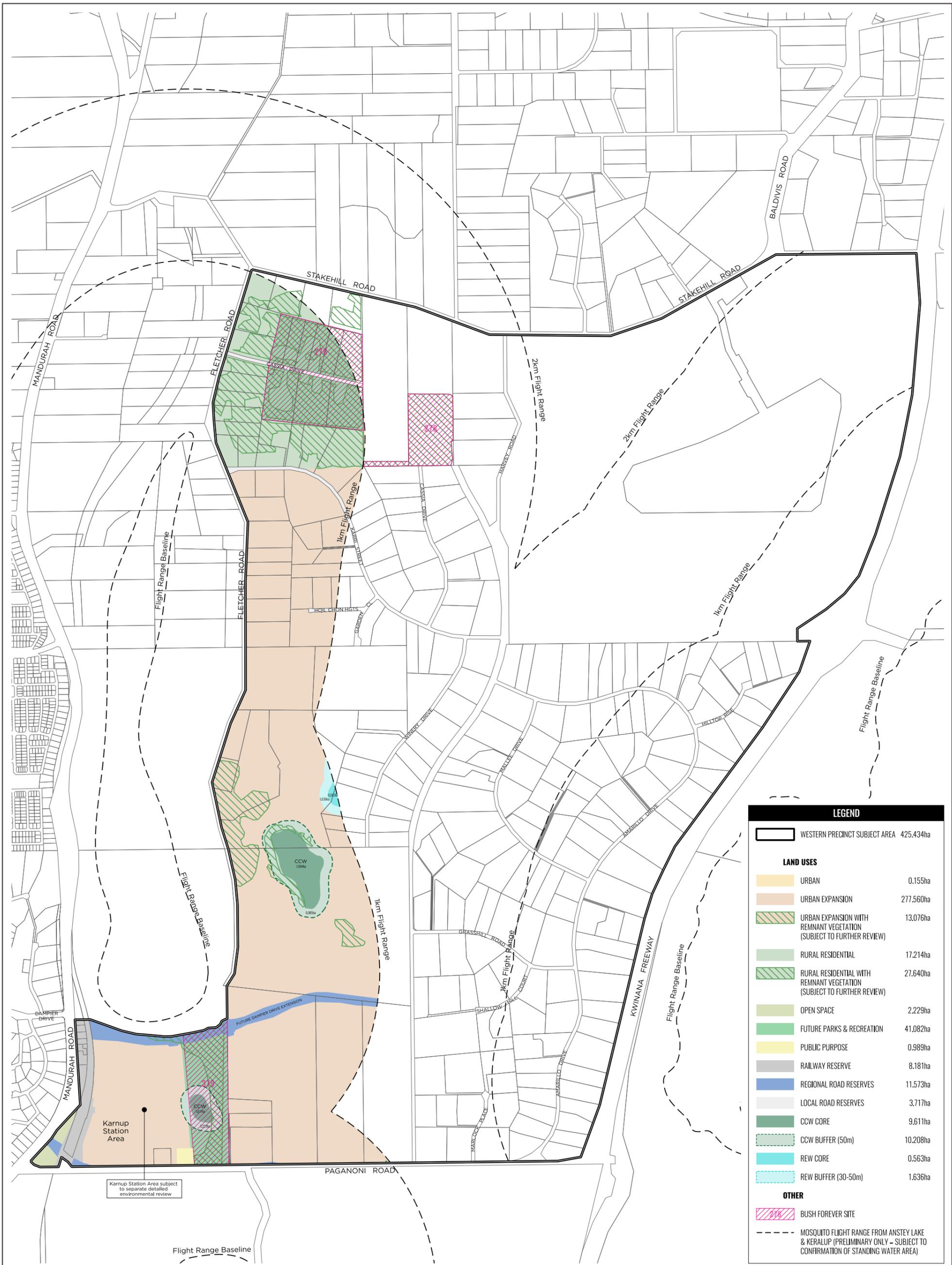
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PLAN: ROCKA-1-001 REVISION: E
 DATE: 06/11/2023 DRAWN: JP
 PROJECTION: MGA 50 PLANNER: CM
 DATUM: AHD CHECK: JH

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LEGEND	
	WESTERN PRECINCT SUBJECT AREA 425.434ha
LAND USES	
	URBAN 0.155ha
	URBAN EXPANSION 277.560ha
	URBAN EXPANSION WITH REMNANT VEGETATION (SUBJECT TO FURTHER REVIEW) 13.076ha
	RURAL RESIDENTIAL 17.214ha
	RURAL RESIDENTIAL WITH REMNANT VEGETATION (SUBJECT TO FURTHER REVIEW) 27.640ha
	OPEN SPACE 2.229ha
	FUTURE PARKS & RECREATION 41.082ha
	PUBLIC PURPOSE 0.989ha
	RAILWAY RESERVE 8.181ha
	REGIONAL ROAD RESERVES 11.573ha
	LOCAL ROAD RESERVES 3.717ha
	CCW CORE 9.611ha
	CCW BUFFER (50m) 10.208ha
	REW CORE 0.563ha
	REW BUFFER (30-50m) 1.636ha
OTHER	
	BUSH FOREVER SITE
	MOSQUITO FLIGHT RANGE FROM ANSTEY LAKE & KERALUP (PRELIMINARY ONLY - SUBJECT TO CONFIRMATION OF STANDING WATER AREA)

LANDUSE SUMMARY - WESTERN MOSQUITO RISK AREA

KARNUP

A City of Rockingham Project

DRAFT

NORTH

Scale: 1:20 000 @ A3

0 200 400 600m

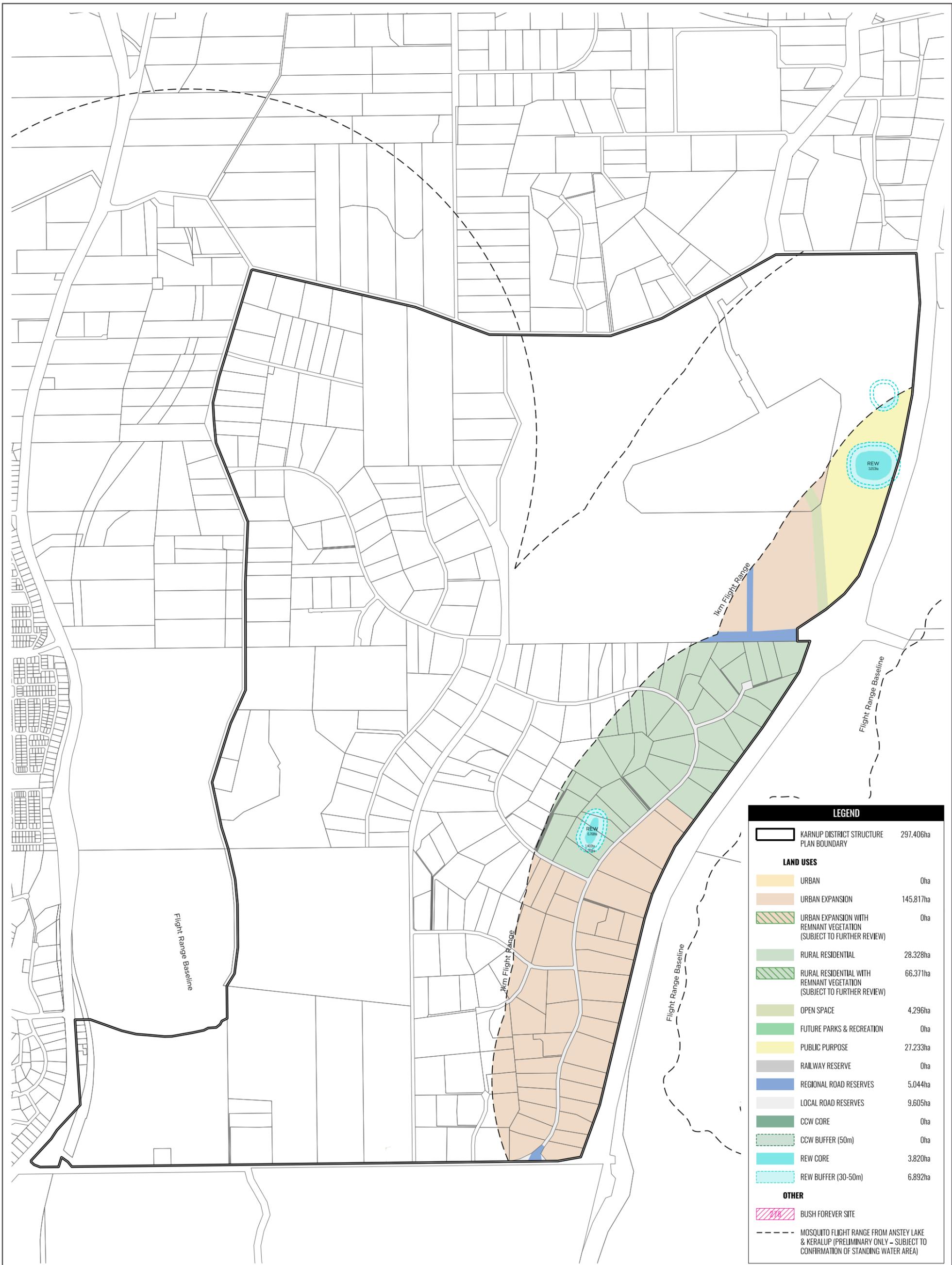
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LEGEND	
	KARNUP DISTRICT STRUCTURE PLAN BOUNDARY 297.406ha
LAND USES	
	URBAN 0ha
	URBAN EXPANSION 145.817ha
	URBAN EXPANSION WITH REMNANT VEGETATION (SUBJECT TO FURTHER REVIEW) 0ha
	RURAL RESIDENTIAL 28.328ha
	RURAL RESIDENTIAL WITH REMNANT VEGETATION (SUBJECT TO FURTHER REVIEW) 66.371ha
	OPEN SPACE 4.296ha
	FUTURE PARKS & RECREATION 0ha
	PUBLIC PURPOSE 27.233ha
	RAILWAY RESERVE 0ha
	REGIONAL ROAD RESERVES 5.044ha
	LOCAL ROAD RESERVES 9.605ha
	CCW CORE 0ha
	CCW BUFFER (50m) 0ha
	REW CORE 3.820ha
	REW BUFFER (30-50m) 6.892ha
OTHER	
	BUSH FOREVER SITE
	MOSQUITO FLIGHT RANGE FROM ANSTEY LAKE & KERALUP (PRELIMINARY ONLY - SUBJECT TO CONFIRMATION OF STANDING WATER AREA)

LANDUSE SUMMARY - EASTERN MOSQUITO RISK AREA

KARNUP

A City of Rockingham Project

DRAFT

NORTH

 Scale: 1:20 000 @ A3

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APPENDIX 6

RISK ASSESSMENT METHODOLOGY

Source: Shire of Murray 2018

RISK ASSESSMENT METHODOLOGY

The term “risk” is defined as the probability of loss of suffering harm. The risk presented by increased exposure to significant mosquito breeding areas does not reflect a typical pollutant or health-based profile application, however the methodologies remain relevant in identifying stressors and outcomes. Potential impacts on residents, mosquito control technicians and the broader environment (e.g., habitat alteration, non-target insect mortality, vertebrate mortality) from control measures are all relevant.

A “risk assessment” process is used to estimate risks to the personnel, community members or the environment. Risk assessment and risk management tools are common for all forms of risk assessment.

Health and environmental risk assessments are often complex and do not allow for development of a full numerical approach as for engineering risk assessment. Many aspects are not fully quantifiable or have a very large degree of uncertainty²⁰. In order to overcome these problems, the risk is often assessed using so-call Risk Level Evaluation Matrices or Consequences-Frequency Matrices (CFM) which are diagrams with consequence and frequency classes on the axes.

This technique allows classification risks based on expert knowledge where quantitative data is constrained based on the frequency of occurrence of a particular event (**Table A**) and consequence of the outcome (**Table B** over the page). These are provided in various forms to address engineering, human health, or environmental concerns, amongst others.

TABLE A: Likelihood of a Hazard Occurring

Level	Description	Probability
5	Almost certain	Expected to occur in most circumstances (more than once per year or greater than 90 % chance)
4	Likely	Will probably occur in most circumstances (at least once per year or between 60 % and 90 % chance)
3	Possible	Should occur at some time (at least once in three years or between 30 % and 60 % chance)
2	Unlikely	Could occur at some time (at least once in 10 years or between 5 % and 30 % chance)
1	Rare	May occur, only in exceptional circumstance (less than once in 15 years or less than 5 % chance)

It should be noted that the term ‘life-cycle’ relates to an individual item or system (for example construction of a housing subdivision) and is not a reference to a mosquito life-cycle.

²⁰ This may be related to the difficulty to define hazard scenarios, map, and characterize the elements-at-risk, or define the vulnerability using a vulnerability curve.

TABLE B: Guidance for Determining Level of Consequence

Impact Rating	Severity
Serious Effect	Large scale detrimental effect that is likely to cause a highly significant effect on: Health: Acute or chronic effects on significant human populations potentially cause loss of life and manifesting as high presentations to medical facilities. Environmental: Local ecosystem factors such as water quality, nutrient flow, community structure and food webs, biodiversity, habitat availability and population structure (e.g., abundance, fecundity, age structure). Long-term recovery period measured in decades.
Significant Effect	Health: Chronic effects on the local communities causing loss of productivity and quality of life and manifesting as increased presentations to medical facilities. Environmental: Detrimental effects that will cause a significant effect on ecosystem factors. Recovery period measured in years or decades.
Moderate Effect	Health: Occasional chronic effects within local communities potentially causing loss of productivity and quality of life and manifesting as increased presentations to medical facilities. Environmental: Impact that will cause a detectable effect in local ecosystem factors. Recover period measured in months to years.
Minor Effect	Health: Short-term amenity loss to areally distributed groups within community, low level of presentations to medical facilities. Environmental: Incidental changes to abundance/biomass of biota in affected area, insignificant changes to overall ecological function. Recover measured in months.
Negligible Effect	Health: Short-term amenity loss to individuals or clusters within the community. Environmental: Short-term, localised and insignificant impacts to habitat populations. Rapid recovery measured in days or months.

The resulting matrix (**Table C**) sums the frequency and severity data into a comparative risk matrix that can be related to the need to act (**Table D** over the page).

TABLE C: Risk Level Evaluation Matrix

Likelihood	Consequence				
	Insignificant (1)	Minor (2)	Moderate (3)	Significant (1)	Serious (5)
Almost Certain (5)	5	10	15	20	25
Likely (4)	4	8	12	16	20
Possible (3)	3	6	9	12	15
Unlikely (2)	2	4	6	8	10
Rare (1)	1	2	3	4	5

The matrix is based upon five classifications of severity and five for likelihood of a hazard. Through the ranking procedure, consideration was given to the magnitude of the consequences and likelihood of a hazard occurring.

TABLE D: Definitions of Risk Category and Management Response

Risk Rating	Description	Action Required
Low 1-3	Acceptable	Accept the risk
Mod 4-9	Monitor	Monitor the risk, consider risk treatments
High 10-16	Treat	Treat the risk; reduce likelihood, consequence or both
Extreme 17-25	Treat	Treat the risk; reduce likelihood, consequence or both

STATEMENT OF LIMITATIONS:

This report has been prepared in accordance with the scope of work set out in the contract, or as otherwise agreed, between the Client and *Rankine Mosquito Management* (RMM).

In preparing the report, RMM has relied upon data, surveys, analyses, designs, plans and other information provided by the Client and other individuals and organisations, most of which are referred to in the report ("the data"). To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report ("conclusions") are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. RMM will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, mis-represented or otherwise not fully disclosed to RMM.

The report has been prepared for the benefit of the Client and no other party. RMM assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report (including without limitation matters arising from any negligent act or omission of RMM or for any loss or damage suffered by any other party relying upon the matters dealt with or conclusions expressed in the report). Other parties should not rely upon the report or the accuracy or completeness of any conclusions and should make their own enquiries and obtain independent advice in relation to such matters.

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