MOSQUITO MANAGEMENT PLAN

The Rivergums Estate
Lots 8, 801, 803 and 9020 Baldivis Road, Baldivis

Prepared by:

RPS

38 Station Street, SUBIACO WA 6008
PO Box 465, SUBIACO WA 6904
T: 618 9211 1111
F: 618 9211 1122
E: environment@rpsgroup.com.au
W: rpsgroup.com.au

Prepared for:

CEDAR WOODS PTY LTD

PO Box 788
WEST PERTH WA 6872

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SUMMARY

Cedar Woods Properties Limited proposes to develop Lots 8, 801, 803 and 9020 Baldivis Road, Baldivis for residential purposes. The proposed structure plan is bound by Safety Bay Road to the north, the Kwinana Freeway to the east, smaller landholdings to the south and Baldivis Road to the west. It includes residential areas, Public Open Space areas and a man-made open drainage basin.

All residential development requires appropriate management of surface water and groundwater. This can include subsurface drainage, open drainage lines, constructed lakes, and wetlands. All open water areas have the potential to contribute to mosquito breeding habitat, therefore adequate mosquito management measures need to be determined and implemented to ensure that any proposed development does not increase the incidence of mosquitos.

This Mosquito Management Plan provides management recommendations in relation to mosquito habitat and control options. Management measures are summarised in Table 1. The management measures proposed aim to ensure a balance between environmental values and mosquito management. Confirmation of support from the City of Rockingham through endorsement of this plan is required to progress implementation.

Table 1: Mosquito Management Measures

Management Techniques	Description	Responsibility
Lake/Basin Design	Provision of hard wall edging to address wave action and to prevent generation of areas of very shallow standing water.	Proponent in consultation with Local Government
	Minimise fringing vegetation to reduce breeding areas.	Proponent
	Limit vegetation shading water to prevent optimal breeding conditions.	
	Installation of an aeration unit in the centre of the lake/basin.	
Drainage	Piped drainage with limited manholes.	Proponent
	Design of drainage features to reduce holding time of water within surface water bodies.	
Physical Control	Maintenance of gross pollutant traps.	Proponent for first two years (proponent maintenance period) then Local Government
	Thinning of any fringing wetland vegetation to reduce breeding areas.	
	Removal of dead and decaying vegetation from waterways.	
Lighting	Use of yellow incandescent bulb or yellow fluorescent lights surrounding the proposed water body, and elsewhere where appropriate.	Proponent in consultation with Local Government
	Provision of education packages about back yard lighting to residents.	Proponent in consultation with Local Government
Public Education	Provision of public education packages for residents detailing ways to minimise mosquito numbers and bites.	Proponent in consultation with Local Government
Notification on Title	Notifications are to be placed on Certificate of Titles advising landowners of the proximity of their lot to known mosquito breeding areas.	Proponent
Chemical Control	Application of Larvicide to control mosquito larvae in water bodies if and when required.	Local Government (if needed)
	Application of Adulticides to control adult mosquitos. This is applied in the form of a fogging application toxic to mosquitos.	

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1.0 INTRODUCTION

1.1 Background

Cedar Woods Properties Limited (Cedar Woods) proposes to develop Lots 8, 801, 803 and 9020 Baldivis Road, Baldivis (the site) for residential purposes (Figures 1 and 2). The site forms part of The Rivergums Estate. The landholdings extend over an area of approximately 75.47 ha and are situated within the City of Rockingham approximately 8 km from the Rockingham city town centre.

The site is currently zoned "Urban" under the Metropolitan Region Scheme (MRS) and "Development" under the City of Rockingham Town Planning Scheme No. 2 (Department for Planning and Infrastructure, 2009).

To enable the development to proceed, a Mosquito Management Plan (MMP) is required to be prepared for The Rivergums Estate Structure Plan in accordance with the City of Rockingham's Planning Services Committee recommendations (City of Rockingham Planning Services Committee, 2009). These recommendations advise that the proponent must address the following matter to the satisfaction of the City during the Structure Plan advertising period:

> *A Mosquito Management Plan being prepared, which includes mosquito trapping/monitoring and the preparation of management strategies to address the breeding of mosquitos in the Structure Plan area.*

1.2 Proposed Structure Plan

A Structure Plan for the site was prepared by Roberts Day, and adopted by the City of Rockingham in 2008. The Structure Plan encompasses the land bound by Safety Bay Road to the north, the Kwinana Freeway to the east, smaller landholdings to the south and Baldivis Road to the west (Figure 3). Lot 801 is a disjointed parcel of land located to the south of the remainder of the site (Figure 3) but is included in the Structure Plan.

The structure plan incorporates the following elements:

- 487 "R20" single residential lots.
- Forty-seven "R30" single residential lots.
- One "R40" Grouped Housing site (accommodating a maximum of twenty-two dwellings).

- 13.3 ha of public open space (POS) incorporated into four separate sites ranging in area from 0.41–7.40 ha.
- One 14 ha joint primary and high school site.

1.3 Purpose of Mosquito Management Plan

This Mosquito Management Plan provides a framework for the management of on-site mosquitos within The Rivergums Estate. It aims to protect the health and welfare of existing and future residents of The Rivergums Estate. The Mosquito Management Plan details management measures to control both long and short term impacts of mosquitos (Environmental Protection Authority, 2000).

This Mosquito Management Plan provides the following:

- Definition of the existing site environment and locations of potential mosquito breeding areas (water bodies).
- Results of an initial ground survey and summer monitoring (December 2009) results.
- Recommendations of management techniques to minimise mosquito numbers and associated problems.
- Recommendations for mosquito monitoring.
- Outline of responsibilities for short and long-term management.
- Discussion of potential health issues to future human population in the area from mosquito borne disease.

This Mosquito Management Plan has been written in accordance with the EPA's Guidance Statement No. 40: *Guidance Statement for Management of Mosquitoes by Land Developers* (Environmental Protection Authority, 2000), the *Mosquito Management Manual* (Department of Health, 2006) and the recommendations of the City of Rockingham's Planning Service Committee Meeting Minutes (City of Rockingham Planning Services Committee, 2009).

2.0 EXISTING ENVIRONMENT

2.1 Topography

The subject land is undulating with an approximate elevation ranging from nine metres Australian Height Datum (mAHD) in the south-western corner of the site to 4 mAHD along the eastern boundary (Figure 4).

2.2 Soils and Geology

The geology of site has been mapped at a regional scale by Gozzard (1983). The majority of the site is mapped as Clayey Silt (Mc_2) of the Guildford formation, being dark greyish brown, mottled in part with variable clay content. A section of land on the western boundary is mapped as sand (S_8), described as typically grading from light grey at the surface to yellow at depth. These soils are associated with having a "moderate to low" risk of Acid Sulfate Soils (ASS) occurring within three metres of the ground surface (Western Australian Planning Commission, 2009).

A sumpland in the west of the site is mapped as sand (S_7), described as pale yellowish brown, medium to coarse grained of residual original (Tamala Limestone). This sumpland is associated with having a "high to moderate" risk of ASS occurring within three metres of the ground surface (Western Australian Planning Commission, 2009).

2.3 Wetlands

The majority of the site is recognised as a Multiple Use Wetland (MUW) under the Department of Environment and Conservation's (DEC) *Geomorphic Wetlands Dataset* (Figure 5). The wetland is a seasonally waterlogged palusplain that generally corresponds to the flood plain of the Peel Main Drain (Department of Environment and Conservation, 2008).

2.4 Surface and Groundwater Hydrology

Average Annual Maximum Groundwater Level (AAMGL) has been estimated to be 4.5 metres Australian Height Datum (mAHD). On-site bore monitoring over the last six years and anecdotal evidence from previous landowners suggests that the annual fluctuation is around 1 metre (m).

Currently a number of open drains traverse the site providing a link between the sumpland and the Peel Main Drain. These assist in controlling current groundwater and surface water across the site. As part of the construction of the development, these drains will be modified to be closed drains below the ground surface.

The Peel Main Drain is east of the eastern boundary of the site. The drain connects Folly Pool and Maramanup Pool to the north and east of the study area respectively. The flood fringe of the drain enters the eastern portion of the site. The drain is separated from the site by the Kwinana Freeway.

The site is also located within the area subject to the *Environmental Protection (Peel Inlet – Harvey Estuary) Policy 1990*. This policy was prepared to reduce the input of nutrients, particularly phosphorus, into the Peel–Harvey Estuary through a number of measures, which includes appropriate land management by landowners in the policy area.

2.5 Vegetation and Flora

Vegetation Complexes are groups of vegetation types that occur in patterns relating to soil and geomorphology. A large part of the Swan Coastal Plain has been mapped for vegetation complexes by Heddle et al. (1980).

Heddle et al. (1980) has mapped the vegetation within the study area as being Karrakatta Complex – Central and South in the western portion of the site and Serpentine River Complex in the east. Description of each of these vegetation types are given below:

- **Karrakatta Complex – Central and South** predominantly open forest of *Eucalyptus gomphocephala, E. marginata – E. calophylla* and woodland of *E. marginata* – Banksia species.

- **Serpentine River Complex** closed shrubs of Melaleuca spp and fringing woodland of *Eucalyptus rudis – M. rhaphiophylla* along streams.

Very little intact native vegetation remains within the site due to historical pastoral activities. The sumpland area supports areas of reed beds and some native trees along the northern boundary.

The site is not identified within Bush Forever (Government of Western Australia, 2000), however, Maramanup Pool approximately 1 km to the east of the study area is recommended for protection within a Bush Forever Site.

2.6 Surrounding Land Use

Properties in the immediate locality, on the eastern side of Baldivis Road, have been rezoned to "Urban" and are being subdivided for residential development. The Baldivis town centre and associated residential developments are located to the north-west of the site. The Kwinana Freeway borders the site to the east. The Baldivis Tramway Nature Reserve runs parallel to Baldivis Road along the western boundary of the site.

3.0 MOSQUITO BREEDING IN THE EXISTING ENVIRONMENT

An initial ground survey was conducted in May 2009 to determine the pre-development mosquito breeding areas and to assess future mosquito monitoring requirements. The initial ground survey was undertaken by a mosquito specialist, Rankine Mosquito Management. The preparation and survey comprised of the following work:

- A desktop study using aerial photography, DEC's *Geomorphic Wetlands dataset, and Wetlands of the Swan Coastal Plain* (Hill et al. 1996) and development footprint to identify potential mosquito breeding sites prior to the ground survey being conducted.

- A ground survey was conducted on 10 May 2009, to confirm presence/absence of potential breeding sites identified in desktop assessment. Those potential breeding locations were recorded geographically (GPS) for future mapping.

- Survey of proposed site to determine pre development breeding sites and to determine potential post-development breeding sites.

- Determine and recommend a future mosquito management program.

- During the ground survey, potential mosquito breeding sites that contained surface water were sampled using a standard larval dipper. Due to the timing of the ground survey (early May) and the absence of rainfall within the week immediately preceding the survey, there were limited opportunities for larval surveying to be undertaken.

Additional mosquito monitoring was undertaken in December 2009, to ascertain the species of mosquitos present and their numbers at two strategic locations, near a permanent water body and in the proposed POS/living stream area as agreed with the City of Rockingham. The results of this monitoring can be found in Section 4.0 of this report.

The Department of Health provides advice for the management of mosquitos. The Department of Health recommend that the following be undertaken:

- *Initial survey:* The objective of an initial survey is to define the nature and extent of mosquito numbers and species. This survey provides baseline information for comparisons to "during" and "post-" construction monitoring.

- *Operations survey*: Includes monitoring to determine if/when control is required. If control is needed, this survey aims to monitor the effect of the control measures.

- *Evaluation survey*: To assess the effectiveness of the mosquito management plan, monitoring and control measures to determine success.

(Department of Health, 2006)

The Department of Health's recommendations have been fulfilled for an initial survey. The requirements of the operations survey will be met during the proposed monitoring period. An evaluation survey will be undertaken post-completion of the monitoring period and post-development construction.

3.1 Mosquito Breeding Sites

It is widely acknowledged that the critical factor in determining whether mosquitos are likely to be a nuisance or health risk in a residential development is the presence of water, as mosquitos require an aquatic environment to breed during their larval stage (Russell, 1999). Therefore, in order to determine the likely risk of mosquitos breeding within the vicinity of the site, it is necessary to identify potential breeding areas within and near the site and potentially inundated areas.

Although breeding habitat was not present at all identified observation points, (i.e. water, presence of larvae and mosquito activity), several areas have been identified as potential breeding habitat on the basis of landform (i.e. depressions).

3.1.1 Existing Habitats within Proposed Development Site

Construction of Stages 1–7 (located immediately south of the Structure Plan area) has been completed for The Rivergums. A lake was constructed within this development as an interface between Stage 1 and development occurring within Stage 8 (the proposed site) (Figure 6). Between the constructed lake and the new proposed development are a series of small wetlands and depressions (observation points 117–125).

Observation Point No. 119

This seasonal constructed wetland occupies an area of approximately 750 m^2 and is surrounded by fringing vegetation of predominantly *Typha* although there were some areas of native sedges observed (Figure 6). A dense build-up of the weed kikuyu (*Pennisetum clandestinum*) surrounds the outer perimeter of the wetland. The wetland contains the following potential mosquito sources:

- A small depression filled with stagnant water that contained prolific mosquito larvae at various stages of development.
- A dense stand of bulrushes around the wetland creates potential for significant mosquito activity and mosquito larvae habitat due to protection from predators.

This site will be filled post-development and will remove any risk of mosquito breeding habitat.

Observation Points Nos. 120 and 121

Two small depressions are located north of the constructed wetland, encompassing an area of approximately and 40 m^2 and 50 m^2 (Figure 6). Both depressions were dry at the time of the survey and have *Typha* as their dominant fringing vegetation.

Site number 120, will be filled post-development and will remove any risk of mosquito breeding habitat. Site 121 will potentially form part of an extension of the existing constructed lake.

Observation Point No. 122

A concrete drain, which controls the constructed lake levels, connects the smaller wetlands (sites 120 and 121) to the constructed lake to the south (117 and 118). This drain was dry at the time of the survey but has the potential to be inundated and provide potential mosquito breeding habitat.

Observation Point No. 123

An extensive wetland, covering an area of approximately 1500 m^2 is located to the north of a sandy access road, that adjoins the two small depressions (Observation Points No. 120 and 121) via a concrete drain/culvert. This wetland is located adjacent to the Baldivis/Safety Bay Road roundabout (Figure 6). The wetland has high clay/organic content and features an island dominated by Casuarina species. Widely scattered Melaleuca species dominate the upper storey native vegetation around the wetland. Fringing vegetation comprises native sedges and some rushes.

Potential mosquito sources associated with the wetland include stagnant surface water which was observed in a small depression on the eastern side of the island. No mosquito larvae were present at the time of the initial survey, however as it is a degraded area with the probability of residual pools remaining as groundwater levels recede, it is likely to support mosquito activity.

Observation Point No. 124

A spoon drain is located to the east of Observation Point No. 124. This drain is dominated by fringing *Melaleuca* species, and the base of the drain is heavily infested with kikuyu (Figure 6).

Observation Point No. 125

A blue gum (*Eucalyptus globulus*) plantation is located to the north of Observation Point No. 124 (Figure 6). This area may form part of the future residential development. It is unknown at this stage the exact alignment of the Public Open Space area to the west of Observation point 125. If observation Site 125 is not developed, the area could potentially allow mosquitos to migrate further from breeding areas by using these vegetated areas as migration corridors.

Observation Point No. 126

This area is located to the east of Rivergums Boulevard and Crinia Drive, and is dominated by tuart (*Eucalyptus gomphocephalus*) with some blue gum and marri (*Corymbia calophylla*). This area is located near an extensive low-lying area, prone to waterlogging, providing potential mosquito breeding habitat.

This area may form part of the future residential development. It is unknown at this stage the exact alignment of the Public Open Space area immediately west of Observation point 126.

Observation Points Nos. 127 and 128

The south-western boundary of the site is formed by the existing Rivergums development. The southern portion of this vegetation (adjacent to a rampway) comprises a thicket of young tuart trees that potentially provides an ideal harbourage for mosquitos.

A small wetland is located immediately to the south of the tuart thicket (to the east of the Crinia Drive–Corymbia Gardens intersection). This wetland was waterlogged and appears to be fed by groundwater and a spoon drain that runs along the boundary fence line on the wetland's northern boundary. Native rushes fringe the wetland's western boundary, with emergent sedges being scattered throughout the wetland proper. The wetland is likely to provide an ideal mosquito breeding environment due to the dense emergent and fringing vegetation.

3.1.2 Off-site Habitats

Some mosquito species have the capacity to migrate extensive distances from their breeding sites. As such, "off-site" breeding sites have the potential to affect residents within the site. Potential breeding sites were therefore identified within a 5 km radius of the site.

The constructed water body located to the north of Rivergums Boulevard has been engineered to function as a wet detention basin (irrigation basin) for the existing Rivergums Development (Figure 7). The constructed lake comprises predominantly hard vertical edges designed to maximise the effect of wave action to disrupt mosquito survival. On the northern portion of the lake, a narrow beach (approximately 80 m in width) has been formed comprising sandy/organic material. Planted native rushes (*Juncus palidus*) and native shrubs, predominantly *Melaleuca* species, border the water's edge. The introduced bulrush (*Typha orientalis*) is invading this area of water's edge resulting in pockets of stagnating water building up at the most northern end of the vegetation. This area is considered to be conducive to mosquito breeding.

Observations were also made within the tramway reserve in Heritage Park (near Observation Point 129) (Figure 7). The vegetation at this site comprises tuart, jarrah (*Eucalyptus marginata*), *Banksia* species and *Casuarina humilis* with a diverse understorey. This area may potentially act as a harbourage area allowing mosquitos to travel along the vegetated corridor that the Heritage Park comprises.

Maramanup Pool is located approximately 1.5 km south-east of the site (Figure 7). This pool comprises a deep, extensive open water body fringed by a narrow band of *Melaleuca rhaphiophylla* woodland. The pool functions as a major north–south drainage channel, maintaining water throughout the year. Although no evidence of mosquito larvae was observed during the initial ground survey, there is potential breeding habitat within the area.

Outridge Swamp (near observation site 130 and 131) is an extensive conservation management sumpland wetland located to the east of Eighty Road approximately 4 km south-west of the site (Figure 7). The wetland is surrounded by fringing paperbark (*Melaleuca* species) woodland with the majority of the interior of the wetland covered by native rushes and sedges. This vegetation is likely to become seasonally inundated and may provide mosquito breeding habitat as the groundwater table recedes leaving pools of stagnant water.

A small sumpland is located in the middle of the Woodleigh Grove Estate opposite Tincombe Grove approximately 2 km from the site (observation site 132) (Figure 7). The vegetation comprises predominantly tuart woodland and the area may provide for potential mosquito breeding habitat.

Tamworth Hill Swamp (near observation site 133) is an extensive wetland classified as a Conservation Category Wetland (CCW) under DEC's *Geomorphic Wetlands Dataset* (DEC, 2008). The CCW is located to the north of Safety Bay Road and east of Eighty Road approximately 1 km from the site (Figure 7). The vegetation within the CCW comprises fringing paperbark (*Melaleuca* species) woodland with extensive reed beds in the central basin, and as such, has the potential to provide for mosquito breeding habitat.

3.1.3 Potential New On-site Habitats

As construction commences within the proposed development site, it is anticipated that there may be a number of permanent and temporary sites created which will have the potential to support mosquito activity. These include, but are not restricted to:

- Constructed wetlands.
- Compensation basins.
- Multiple use corridors.
- Gross pollutant traps.
- Stormwater gullies.
- Drainage ditches.
- Temporary habitats created by earthworks.

The proposed structure plan includes a constructed lake north of the existing constructed lake as well as three Public Open Space (POS) drainage areas (Figure 8). These sites have the potential to provide mosquito breeding habitat, through still surface water. All constructed wetlands and compensation basins will adhere to the "Chironomid midge and mosquito risk assessment guide for constructed water bodies" developed by the Midge Research Group of Western Australia, 2007.

All created and existing sites will be monitored to determine mosquito numbers and to develop and implement mitigation strategies.

3.2 Mosquito Species

Based on the habitats available five mosquito species have been identified as likely to occur at or in the vicinity of the site (Table 2).

Table 2: Potential Mosquito Species Occurring on Site

Species	Breeding Habitat Description and Distribution	Likelihood of Occurrence on Site
Aedes notoscriptus (Container mosquito)	Clean water situations, especially where the water contains dead leaves. Prevalent in lush, shaded ferneries and other lush cool areas (DoH 2006).	Likely (Rankine Mosquito Management 2009)
Aedes camptorhynchus (Southern saltmarsh mosquito)	Wide variety of temporary and seasonal water bodies following winter/spring rain; brackish wetlands and tidal salt marshes fringing estuaries; dispersal range 3–5 km; most abundant in south-west land division (DoH 2006).	Likely (Rankine Mosquito Management 2009)
Aedes vigilax (Summer saltmarsh mosquito)	Coastal areas when heavy rain or high tides cause temporary pooling of water in salt marsh breeding sites; dispersal range up to 100 km; most abundant in Kimberley region (DoH 2006).	Likely (Rankine Mosquito Management 2009)
Aedes alboannulatus	Rock pools and temporary ground pools, both sunlit and shaded, in fresh water with dead leaves (DoH 2006). Widespread distribution including Perth Metropolitan Area (DoH 2006).	Possible
Aedes clelandi	Variety of temporary fresh water ground pools, including roadside ditches, pools in paddocks and seasonal swamps, especially tea-tree swamps; prefers sunlit and clear water (DoH 2006). Wetter areas of south-west land division west of a line between Albany and Lancelin (DoH 2006).	Unlikely
Aedes hesperonotius	Largely confined to tea-tree swamps; similar habits but less widespread in distribution than *Aedes clelani* (DoH 2006).	Unlikely
Aedes ratcliffei	Paperbark swamps where the water is clear and shaded, but contains a high tannin content (DoH 2006). Wetter areas of south-west land division west of a line from Perth to Albany (DoH 2006).	Unlikely
Aedes sagax	Fresh water temporary ground pools following occasional heavy rain (DoH 2006). Wheatbelt areas of south-west land division (DoH 2006).	Unlikely

Species	Breeding Habitat Description and Distribution	Likelihood of Occurrence on Site
Culex annulirostris (Common banded mosquito)	Heavily vegetated permanent or semi-permanent lakes and swamps; most abundant in Kimberley region (DoH 2006).	Likely (Rankine Mosquito Management 2009)
Coquillettidia sp. *near linealis*	Heavily vegetated swamps and wetlands; dispersal range up to 3 km; most abundant on Swan Coastal Plain (DoH 2006).	Likely (Rankine Mosquito Management 2009)

4.0 PRE-DEVELOPMENT ADULT AND LARVAE MONITORING

Adult and larvae trapping was undertaken in December 2009 as requested by the City of Rockingham to determine the number and species present at The Rivergums. Two sites where chosen due to their proximity to water (Figure 10). Site 1, is located in the north-west corner of the proposed development area in woodland next to the existing natural wetland. Site 2 is located in woodland near the proposed living stream/POS area.

Each site was monitoring weekly for a three week period in December 2009. Carbon dioxide baited/EVA traps (adult mosquito traps) where set in the early afternoon and collected the following morning. In addition, larvae monitoring was undertaken using a standard dipper at set points around the trapping site, with approximately 5–10 samples taken at each location. The results for both adult and larvae monitoring are detailed in Section 4.1 and 4.2.

4.1 Site 1 Mosquito Monitoring

4.1.1 Site 1 Adult Monitoring

Mosquito numbers trapped at this site where consistently high during the monitoring period, which was predicted as the monitoring site is adjacent to a permanent water body. Species type and sex was determined (where possible). The presence of males indicates that the species is localised as males do not travel far from the area they were bred.

Table 3: Site 1 Adult Mosquito Monitoring Results

Species	Date		
	07.12.09	14.12.09	21.12.09
Aedes alboannulatus	1	0	2
Anopheles annulipes	7	24	0
Culex annulirostris	191	130	127
Culex australicus	6	8	3
Culex quinquefasciatus	0	4	0
Coquillettidia species near linealis	0	4	5
TOTAL	**205**	**170**	**137**

4.1.2 Site 1 Larvae Monitoring

Larvae samples where taken at Site 1 to determine which species where breeding on site. The results are detailed below in Table 4.

Table 4: Site 1 Mosquito Larvae Monitoring Results

Species	Date		
	07.12.09	14.12.09	21.12.09
Anopheles annulipes	0	4 (1 male)	0
Culex annulirostris	8 (4 males)	16 (11 males)	0
TOTAL	**8**	**20**	**0**

4.2 Site 2 Adult Mosquito Monitoring

4.2.1 Site 2 Adult Monitoring

Mosquito numbers trapped at Site 2 were consistently lower than those numbers recorded at Site 1. It is believed that this is attributed to site one having overhanging vegetation over the water, increasing the preferred breeding habitat for many species.

Table 5: Site 2 Adult Mosquito Monitoring Results

Species	Date		
	07.12.09	14.12.09	21.12.09
Aedes alboannulatus	2	0	2
Aedes notoscriptus	2	1	3
Anopheles annulipes	4	4	3
Culex annulirostris	5	35	20
Culex australicus	1	1	0
Culex quinquefasciatus	0	7	2
Culiseta atra	1	0	0
Coquillettidia species near linealis	1	13	5
TOTAL	**16**	**61**	**35**

4.2.2 Site 2 Larvae Monitoring

Larvae samples where taken at Site 2 to determine which species where breeding on site. The results are detailed below in Table 5.

Table 6: Site 2 Mosquito Larvae Monitoring Results

Species	Date		
	07.12.09	14.12.09	21.12.09
Species unable to be identified	3	0	0
TOTAL	**3**	**0**	**0**

4.3 Mosquito Species Identified at The Rivergums

Eight species of mosquitos where identified in December 2009, during the trapping program. Below is a description of each of the mosquito species found at The Rivergums.

4.3.1 *Aedes alboannulatus*

This species is common and breeds in a wide variety of freshwater habitats including rock pools, temporary ground pools and containers. It bites during both daytime and night-time and presents a nuisance to humans. Their eggs are resistant to desiccation. It is most commonly found between May and October.

4.3.2 *Aedes notoscriptus*

This species is found in a variety of natural and domestic habitats, including rock holes, small containers and stormwater drains or where water quality is reasonable. It has a limited flight range and bite during the daytime in cool shaded areas.

4.3.3 *Anopheles annulipes*

This species is known to breed in a variety of habitats from permanent to semi permanent pools and containers. It bites during the daytime and night-time, making it a nuisance to humans.

4.3.4 *Culex annulirostris*

This species is a freshwater breeder and is typically only present in later winter to late spring. It is known to breed in a variety of different habitats. It will bite during both daytime and night-time. It has a flight range of up to 3 km.

4.3.5 *Culex australicus*

This species is not known to bite humans. It is found in open freshwater sites that have emergent vegetation. It has been known to breed in moderately brackish and polluted water. It is commonly found in built up areas and road gullies.

4.3.6 *Culex quinquefasciatus*

This species bites in the middle of the night, both indoors and outdoors. They are generally active during the warmer months of the year.

4.3.7 *Culiseta atra*

This species does not bite humans.

4.3.8 *Coquillettidia species near linealis*

This species is known to viciously bite during the night-time. It prefers semi permanent or permanent freshwater habitat, with dense emergent vegetation.

5.0 POTENTIAL IMPACTS

5.1 Human Health

Mosquitos have the potential to cause serious risk to human health. Mosquitos can act as transmitters or "vectors" of a variety of diseases that can impact human health (Environmental Protection Authority, 2000). Mosquitos can transmit disease through one of two methods – either mechanical or biological. Mechanical transmission is when the pathogen has no biological association with the mosquito and is merely carried by the mosquito as a body contaminant depositing it from one source to another. Biological transmission is when the pathogen or parasite lives within the mosquito (host) and is passed on through a bite. Biological transmission is the predominant form of transmission of disease to humans (DoH, 2006). Diseases transferred to humans via mosquitos are called arboviruses.

The two main arboviruses in Australia are Ross River Virus and Barmah Forest Virus. Both cause debilitating chronic diseases in humans, but are not fatal.

5.1.1 Ross River Virus

Ross River Virus was first described in Western Australia in 1956 in the south-west. It was first isolated from *Culex annulirostris* mosquitos in Derby in 1977. Over 9,700 confirmed cases of Ross River Virus have been reported between 1984 and 2006. It has been estimated that the economic cost of this disease is $1,755 per case, resulting in over seventeen million dollars (Department of Health, 2006).

Ross River Virus has been known to be transmitted by the following species of mosquitos:

- *Culex annulirostris.*
- *Aedes annulirostris.*
- *Aedes vigilax.*
- *Aedes camptorhynchus.*
- *Aedes normanensis.*

5.1.2 Barmah Forest Virus

Barham Forest Virus was first isolated in the south-east Kimberley in 1989. The first recorded outbreak of Barham Forest Virus in the south-west of Western Australia was in 1993. The number of cases has been relatively low compared to Ross River Virus, with the largest outbreak in 2005–2006 with over 170 reported cases (Department of Health, 2006).

Barmah Forest Virus has been known to be transmitted by the following species of mosquitos:

- *Aedes vigilax.*
- *Aedes camptorhynchus.*
- *Culex annulirostris.*
- *Aedes notoscriptus.*
- *Coquillettidia linealis.*

6.0 RISK ASSESSMENT

The Department of Health (DoH) have released in August 2007 guidelines on risk assessment for constructed water bodies to determine the risk of a water body to breed and harbour mosquitos and chironomid midges.

6.1 Risk Assessment Methodology for the Proposed Constructed Water Body

Design elements are scored with a risk rating number. Each element has its own risk rating numbers ranging from one to seven, with one representing low risk. This number is then added up to provide a score to determine the overall risk of the water body to breed and harbour mosquitos. Please refer to Appendix I for the DoH risk assessment matrix and scoring process.

The table below details the scoring of the risk matrix (according to the DoH guidelines) for the proposed constructed wetland within The Rivergums Estate (See Figure 3).

Table 7: Risk Assessment Matrix

Category	Risk Rating Number	Risk category/ description
Hydrology of the Water Body	3	Water body does not dry out and water level fluctuates
Location of the Water Body to Residential Areas	3	Nearest resident is located between 100 m and 200 m from the water's edge.
Form of the Water Body	1	80%–100% of the water bodies edge is hard vertical edge thereby maximising the effect of wave action.
Shape of the Water Body	1	Shape of the water body is simple in order to facilitate good water circulation.
Wind related parameters – long axis	1	The long axis of the water body is in line with known prevailing wind directions or is of a circular nature.
Wind related parameters – land level	2	Constructed wetland located in a depression so that surrounding land slopes down to the waters edge.
Depth of the Water Body	2	Between 60 cm and 2 m.
Mechanical circulation	2	Volume of water body circulated every 24 hrs or longer
Aquatic vegetation	2	Emergent vegetation in small stands parallel to predominant wind direction.
Terrestrial vegetation	1	Buffer vegetation mainly planted down wind of the water body or surrounding entire water body and with clear open space provide between buffer vegetation and nearest residence.

Category	Risk Rating Number	Risk category/ description
In flow water quality	3	In flow water has low levels of nutrients
Engineering considerations	1	Inbuilt ability to "draw down" or lower the water level mechanically.
Engineering considerations – access	1	Sufficient access for personnel and machinery to undertake routine maintenance or implement control measures.
TOTAL	23	

The Department of Health's risk assessment score ranges are detailed below:

A score of 13–24: Low risk water body which is unlikely to produce midge or mosquitos in sufficient numbers so as to create a nuisance or pose a health risk. It is likely that minimal monitoring and maintenance would be required. It is recommended that all future constructed water bodies fall within this category.

A score of 25–36: Medium risk. Increased probability of midge or mosquito breeding so as to create a problem. Requires improved monitoring and ongoing maintenance in order to prevent problems occurring. Not recommended for future constructed water bodies.

A score of 37–47: High risk. Strong probability of water body experiencing problems with nuisance midge/mosquitos or both. Would require extensive monitoring and maintenance programs. It is recommended that these types of constructed water bodies should not be approved or built in the future.

A score 23 results indicated that the constructed water body at The Rivergums is low risk and is unlikely to pose an increased risk of nuisance mosquitos to the local and surrounding residents (Department of Health, 2007).

7.0 REGULATORY REQUIREMENTS

7.1 Development Proponent

The Environmental Protection Authority's (EPA) Guidance Statement Number 40 – Management of Mosquitoes by Land Developers states that project proponents must demonstrate to the EPA that mosquito management is incorporated into proposed developments and mitigation measures will be implemented when and where appropriate (Environmental Protection Authority, 2000).

7.2 Department of Health (WA)

The Department of Health is responsible for the protection of public health in Western Australia, which includes the threat from mosquito borne disease. The Health Department is involved in Mosquito Management in the following ways:

- Partial funding of mosquito control programs for local governments.
- Provision of advice, expertise, training and warnings on mosquito borne disease and control to local governments, state government and the private sector.
- Provision of assistance to local governments during severe outbreaks of mosquito borne disease.

7.3 Local Government

Under the *Health Act 1911* mosquito control is the responsibility of local government. This includes the control of nuisance and potential disease carrying mosquitos and the protection of residents from exposure to mosquito borne disease (Environmental Protection Authority, 2000).

8.0 MANAGEMENT TECHNIQUES TO MINIMISE IMPACT OF MOSQUITOS

The following section details management techniques to help minimise and manage the risks associated with mosquitos breeding within the site and the surrounding area.

8.1 Constructed Lake Design

Incorporating mosquito management design features into constructed lake design should also consider environmental outcomes to ensure that a balance is achieved within the development. There are a variety of management measures that can be incorporated into the design of the drainage area as well as long and short term management to ensure the area does not contribute to mosquito breeding whilst maintaining environmental values.

Adjacent to the proposed site is a constructed lake, which covers just over 2 ha, which was constructed as part of the previous Rivergums stage. The lake is hydraulically connected to an area to the north, which currently acts as a spill over basin, in large rainfall events. This drainage area lies within the proposed development. This drainage area has the potential to contribute to mosquito breeding if appropriate management measures are not implemented.

The construction of the drainage basin, to assist with surface water drainage, ground water recharge and overflow from the adjacent constructed lake, can be designed using either hard or soft edging. Soft edging is comprised of native rushes and sedges which provide environmental value by contributing to nutrient reduction, prevent erosion and provide habitat for native fauna but can also contribute to mosquito breeding by providing ideal habitat. Hard edging can contribute to wave action by refraction and reduce the chance of standing water, yet the environmental benefits are minimal (as no native vegetation is used).

The City of Rockingham has advised that the following management techniques be applied to the design and construction of the permanent water body. The detailed design of the water-body and the POS area will be provided in the landscape design plan, which will require approval from the City of Rockingham prior to implementation:

- Hard wall edge treatment to minimise the area of shallow depth zones which can create standing pools of water at the edge which are more favourable as breeding areas.

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- Hard wall edge treatment to minimise the area of shallow depth zones which can create standing pools of water at the edge which are more favourable as breeding areas.

- All vegetation is to be planted on an elevated embankment to ensure that it is not submerged at any time. This removes potential mosquito breeding habitat. Further details of this will be provided in the landscape design plan. The vegetation type and location will also be detailed further in the landscape design plan.

- Installation of an aeration unit in the centre of the permanent water body to prevent standing pools of water.

Below are further design recommendations based on the primary aim of mosquito reduction:

- Limit of vegetation shading water to reduce potential breeding habitat.

- Incorporation of design elements to minimise the chance of algal growth which is used as a food source for mosquitos.

8.2 Drainage

Drainage within the proposed development will be designed to minimise the length of time in which drainage run-off is stored in the drainage system, in order to reduce the chance of mosquitos breeding in retained stormwater. Engineering advice, based on modelling indicates that water in drainage swales, from most rainfall events, is expected to dissipate within a few hours. Storm events such as 1 in 100 year event, water is expected to remain in the swales for up to seventy-two hours. This is not expected to be in the sufficient time for mosquito breeding to occur.

Piped drainage throughout the proposed development will have limited manholes. This reduces any standing water exposure to mosquitos, thus eliminating a potential breeding site.

8.3 Physical Control

Potential breeding locations within the water bodies and the site drainage system can have the potential to generate nuisance populations of mosquitos if not properly maintained. Such areas may include:

- Inadequately maintained gross pollutant traps or stormwater outlets adjacent to the lake that may have small areas of stagnant water trapped by accumulated litter and debris.

- Shallow margins along the edge of the lake.

- Dense stands of reeds and rushes where water circulation and movement of larval predators is inhibited.

- Marginal and floating vegetation, and associated debris, which may harbour breeding mosquitos.

In order to avoid generation of these potential breeding areas maintenance procedures including cleaning of gross pollutant traps and stormwater outlets, thinning of reeds and rushes and removal of dead and decaying vegetation will be undertaken as required. All of these actions improve water circulation and enable better access of natural predators to breeding areas, which will limit further nuisance populations of mosquitos.

8.4 Street Lighting

Some types of lighting can act as a mosquito attractant. Outdoor and street lighting can contribute to luring mosquitos into unwanted areas. Yellow incandescent bulbs or yellow fluorescent tubes rather than white light can reduce the attractiveness to mosquitos.

The following measures are recommended to reduce the incidence of mosquitos in the residential areas of the development:

- Where appropriate the installation of yellow incandescent bulbs or yellow fluorescent tubes to replace conventional white lighting. This should be implemented in Public Open Space and/or near public facilities such as barbeques, boardwalks, and foreshore paths, as well as for any street lighting surrounding the proposed water body.

- Education aimed at residents informing them of lighting options for backyards.

8.5 Public Education

Public education regarding the issues relating to mosquitos in the area will be provided to all residents within The Rivergums development. This educational material will explain the reasons why mosquitos breed in the area, why they can be a nuisance and potential health risks associated with the mosquitos, methods for reducing potential breeding habitat and minimising the risk of mosquito attacks.

The methods for reducing the risks will include being aware of the seasonality and conditions which are likely to cause elevated risk levels and the need to avoid outdoor activities at certain times of the day during spring and summer unless adequately protected, appropriate protection (e.g. clothing, insect repellent), and adequate garden and outdoor area maintenance (plant pots and other garden items can create artificial water bodies for mosquitos to breed).

8.6 Notification on Title

All land purchasers within The Rivergums Estate development will be alerted to the risks of mosquito-borne disease associated with living in the region by a notification on the title of all individual lots sold. Notifications are to be placed on Certificate of Titles advising landowners of the proximity of their lot to known mosquito breeding areas.

8.7 Chemical Control

The Department of Health recommends an integrated approach to managing mosquitos due to their persistent nature. Chemical control measures may be required where larval and adult monitoring indicate the potential for high uncontrolled breeding resulting in nuisance populations of mosquitos. Chemical controls should be viewed as a last resort in mosquito management, and only applied when mosquito numbers present a nuisance and threaten the health of residents. There are two commonly used chemical control methods, ones that kill larvae – larvicides and ones that kill adult mosquitos – adulticides. It is recommended that both forms of chemical control are used, where and when appropriate (Department of Health, 2006).

Chemical control should only be used when monitoring data shows population of larvae and/or mosquitos are present at trigger levels.

8.7.1 Trigger Levels

The Department of Health, through the development of the Mosquito Management Manual recommends trigger levels to instigate management control of mosquito numbers. The recommended trigger level for adult flying mosquitos is greater than fifty individuals. This trigger value was exceeded four out of six monitoring events (see Table 3 and Table 5 for results).

The Department of Health recommend that if two consecutive monitoring sites present more than fifty larvae present, larviciding should be undertaken. If numbers are consistently significantly higher than fifty, then adulticiding would be considered. This would be undertaken in conjunction with the City of Rockingham.

8.7.2 Larvicide

Larvicides target and kill mosquito larvae. They eliminate the potential of nuisance and disease carrying mosquitos reaching adulthood. The areas targeted by larviciding are much smaller than adulticiding, and therefore presents a much easier way to manage mosquito populations. By targeting larvae, you eliminate the opportunity for adult mosquitos to spread and breed.

Some disadvantages include, the cost and time of mapping and sourcing the breeding sites to larvicide. This is inherently difficult as breeding sites can be hard to define due to infrequency and are season dependant, being mainly summer and spring months. In addition to this, larvicide is only effective to larvae for a small window of opportunity and this can present logistical difficulties.

Bacillus thuringiensis var. *israelensis* (Bti) and *Bacillus sphaericus* are the two most environmentally friendly larvicides available in Western Australia and most commonly used (Department of Health, 2006).

Larvicide application will be undertaken for inundated areas within the proposed development site when appropriate. It is recommended that larviciding be undertaken after significant rainfall at sites that show signs of mosquito larvae developing. The Department of Health recommend that if two consecutive monitoring sites present more than fifty larvae present, larviciding should be undertaken.

8.7.3 Adulticide

Once mosquitos have emerged as adults, the only effective form of control is adulticiding. It is a cheaper alternative that larviciding, especially in large areas. However it is weather dependant as it is applied in a fogging application and therefore requires no wind. Adulticiding can be problematic if applied around waterways as the active ingredient is lethal to fish.

Adulticiding (fogging) uses chemicals which biodegrade rapidly in sunlight. Should fogging be required strict controls will be used to ensure timing and frequency is in line with risk principles to balance the environmental outcomes and the protection of the community from serious illness.

Bifenthrin (Reslin) and cypermethrin (Dipthor ULV or Cynoff ULV) are the most commonly used adulticides used for fogging in Western Australia (Department of Health, 2006).

The City of Rockingham uses adulticiding as a last resort for the management of mosquitos. Application can be costly and is highly wind dependant. Barrier fogging is applied to areas where mosquitos are emerging as adults with the aim of killing them before they move into residential/build-up areas. If any monitoring sites show emerging adults in high number adulticiding can be used.

9.0 MOSQUITO MONITORING REQUIREMENTS

9.1 Monitoring Requirements

Areas within and around the site were found to have a number of potential permanent, seasonal and temporary breeding sites. The proposed drainage areas located north of the constructed lake, could potentially contribute to mosquito nuisance and health risk to the new residents of The Rivergums. Other smaller areas, such as the three POS/drainage areas also have the potential to contribute to mosquito populations. These areas will be monitored pre-development to determine baseline mosquito population and species information to aid in future management of the site.

The frequency and length of the pre-, during and post-construction monitoring program will be determined in consultation with the City of Rockingham and the Department of Health to ensure that an appropriate monitoring program is implemented.

Similarly, appropriate management actions such as frequency of the use of larvacides and adulticides will be determined in consultation with the City of Rockingham.

9.2 Adult Mosquito Monitoring Program

An initial ground survey undertaken at the site by mosquito management specialists, Rankine Mosquito Management, indicates that for pre-construction monitoring, three sampling sites will be sufficient to provide baseline information. These sites are shown on Figure 9 (sampling sites M1, M2 and M3).

Sampling will be undertaken using EVS/CO_2 monitoring traps. Traps will be set in the mid afternoon and will be collected in the early morning.

The adult mosquito monitoring is subject to change dependant on Structure Plan design changes and negotiation with the City of Rockingham. An annual report will be submitted to the City of Rockingham detailing the monitoring results for both mosquito adults and larvae, for the duration of the monitoring period. The length of the monitoring period will be determined in conjunction with the City of Rockingham.

9.3 Larvae Monitoring Program

Larvae monitoring is dependent on surface water presence and therefore each sampling set may vary. Ideally sampling should occur within a week of significant rainfall and coincide with adult mosquito monitoring. The frequency of larvae monitoring for pre-, and post-construction will be determined in consultation with the City of Rockingham and the Department of Health.

Larvae monitoring will involve 5–10 samples using a standard dipper at set points around each breeding site. Pupae and fourth instar larvae will be collected for rearing and identification.

The larvae monitoring is subject to change dependant on Structure Plan design changes and negotiation with the City of Rockingham. An annual report will be submitted to the City of Rockingham detailing the monitoring results for both mosquito adults and larvae, for the duration of the monitoring period.

10.0 CONCLUSION

Development of Stages 8–12 is proposed at The Rivergums, Baldivis. This proposed development will increase the residential population of Baldivis and potential health risks associated with mosquitos may increase without management.

This Mosquito Management Plan identifies the potential as well as existing (pre-development) mosquito breeding sites, numbers and species. It also describes design and management measures to be undertaken to limit the risk of nuisance mosquitos as well as potential health risks. The proposed measures include:

- Maintenance of pollutant traps and stormwater outlets to prevent water pooling.
- Provision of adequate habitat for naturally known predators such as dragonflies and beetle larvae.
- Reduced street lighting in residential areas to prevent the incidence of mosquitos being attracted to residential areas.
- Hard edge lake construction can contribute to wave action through refraction to prevent pooling and stagnant water.
- Drainage design to minimise the length of time water is standing/pooling.
- Public education of new residents to the health risks associated with mosquitos and measures they can use to reduce the risks.

Potential additional measures which can be implemented if needed include:

- Larviciding.
- Adulticiding.

Implementation of this management plan will ensure that mosquitos do not become a health or nuisance issue for local residents of The Rivergums and the surrounding area.

Additionally, implementation of this plan will ensure that the existing mosquito breeding sites within the project area will be appropriately managed.

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