Mosquito Management Plan

Elgas LPG Storage Facility
130 Cormorant Road Kooragang

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Summary

This Mosquito Management Plan (MMP) has been prepared for a LPG Gas Storage facility on land at 130 Cormorant Road Kooragang.

A variety of mosquito species have been recognised within the Port Stephens Local Government Area that not only cause distress to people, but are vectors for diseases such as Ross River Fever.

Management strategies to reduce the mosquito populations within and surrounding the site, as well as
preventing direct bites from mosquitoes for employees and visitors of the proposed development have been recommended. Management measures include:

- Maintenance of gardens and grounds;
- Maintenance by employees;
- Biological control;
- Chemical control;
- Self-protection from mosquito bites.

These management measures if undertaken successfully will help in the reduction of mosquito abundance across the site and bring awareness to those people working and staying at the resort in personal mosquito protection measures.

It is also noted that the majority of the staff employed on site will be working indoors in an office environment and are at very low risk. The workers that will be usually be working outside need to have Personal Protective clothing at all times due to the nature of the product they will be working resulting in minimal exposure to direct mosquito bites.

1.0 Introduction

This report aims to provide general information regarding mosquitoes, the importance of treatments and the process treatments that should be undertaken to maximise success of reducing the mosquito population and to minimise environmental harm.

It also aims to aid in the identification of potential mosquito breeding grounds within and adjacent to the site.

The MMP identifies specific objectives and goals, which include:

- Increase awareness of employees and occupants of their personal responsibilities of protection from mosquitoes and reducing breeding sites for mosquitoes; and

- Measures to keep mosquito populations to acceptable levels through various forms of treatment and control.

2.0 Mosquito Ecology

Mosquitoes are an important component of wetland ecosystems as they recycle nutrients, provide food for
birds, bats, amphibians, fish and macro invertebrates and pollinate some plants. Kooragang Island is a mix of large expanses of industrial activity and extensive wetlands It is these wetlands which are prime breeding grounds for various mosquito species

The Kooragang Island region contains over 23 species of mosquitoes (**Appendix 1**). These are predominately either Estuarine or Freshwater mosquitoes as identifies in plate 1

Living with Mosquitoes in the Lower Hunter & Mid North coast region of NSW, 2nd Edition December 2009

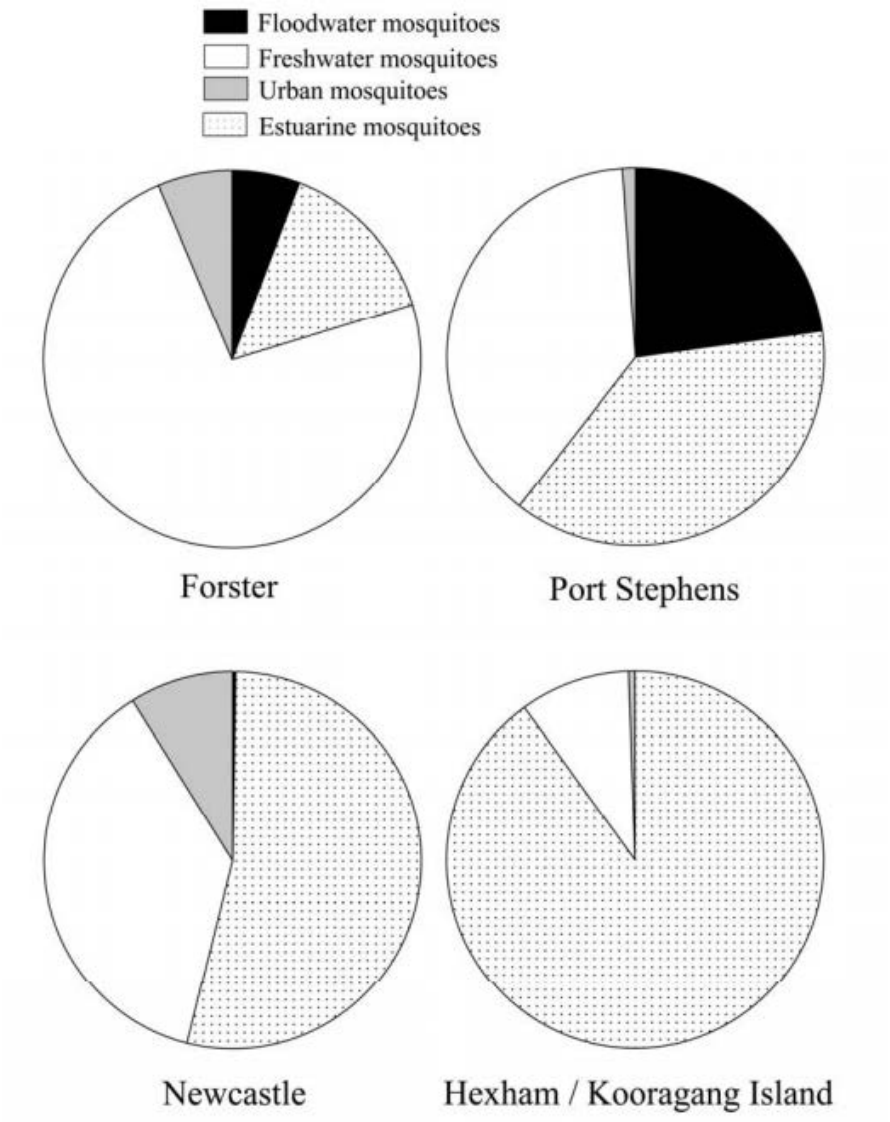

Plate 1: Portion of four mosquito categories at four locations within the Lower Hunter and Mid-North Coast region of NSW (Webb and Russell 2009)

There are five main mosquitoes' species that could be associated with the site at Kooragang Island and are namely,

a) *Estuarine Mosquitoes*
   i. *Aedes vigilax*
   ii. Aedes alternans
   iii. Culex sitiens

b) Freshwater Mosquitoes
   i. Culex annulirostris
   ii. Coquillettidia linealis

Of the relatively short-lived life of a mosquito, the lifecycle consists of four distinct stages: eggs, larvae, pupae and adults (Plate 1).

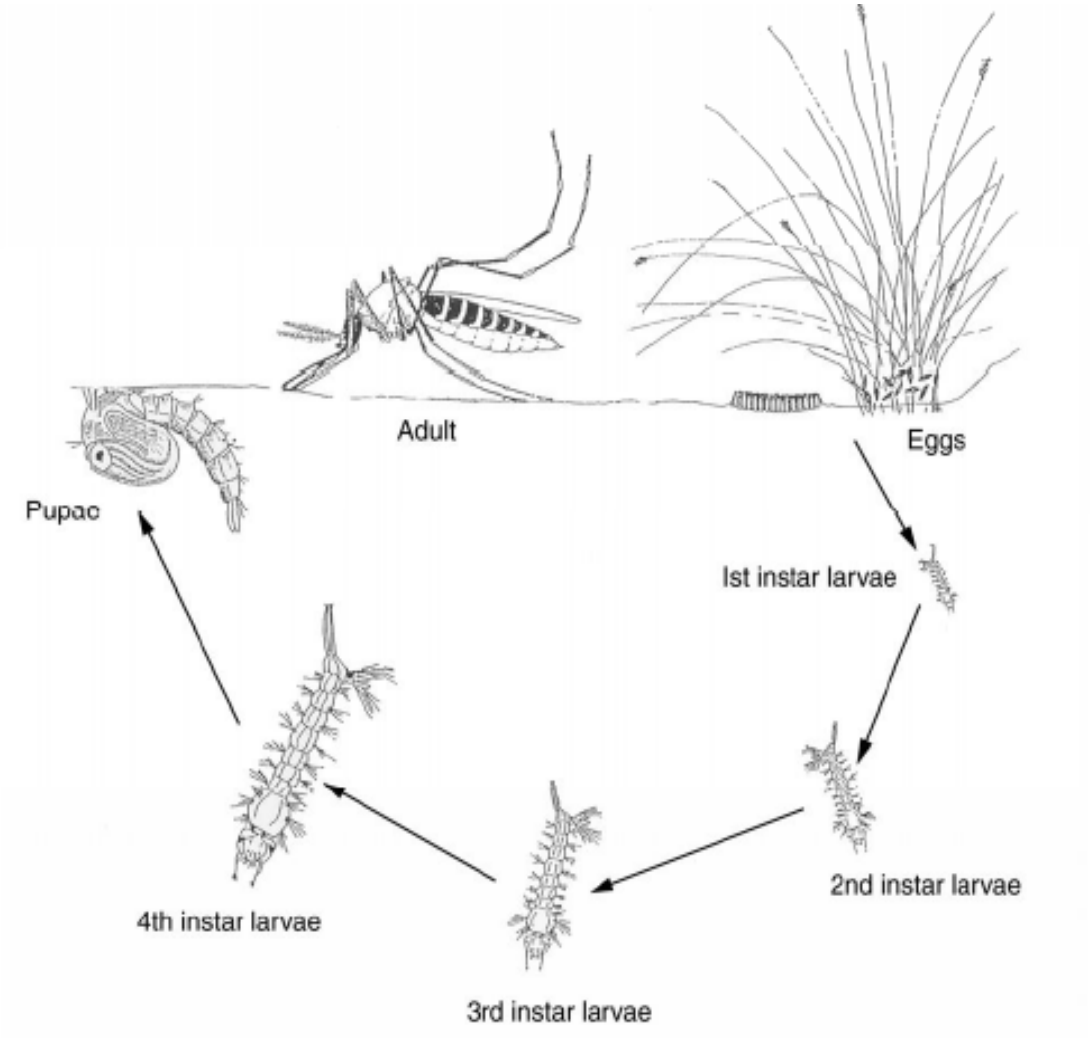

Plate 2: The lifecycle of the Mosquito including eggs, four larval stages, pupae and adult (Webb and Russell 2009)

Adults lay fifty to several hundred eggs on or around water bodies, depending on the species, and all require water for their complete development (Webb and Russell 2009). Water bodies can include natural and manmade varieties such as wetlands, temporary pools after rainfall or water holding containers (tins, plastic tubs, tyres etc).

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

Pupae remain mobile in the water column but do not feed. Inside the body casing of a pupa, larval tissues break down, developing into the adult. On emerging from the pupal case, adults remain on the water surface until they are strong enough to fly. Both male and female mosquitoes feed on nectar. However, most females also require a blood meal to produce eggs (Webb and Russell 2009). Adults reach sexual maturity in one to two days. Temperature, fluctuating climate, tidal flow and irrigation practices are also influential for mosquito breeding. Breeding is more abundant in warmer seasons and numbers peak in mid-spring through to autumn.

Of the notable species of concern to the site, **Table 1** outlines various factors relating to the habit for each Species

Table 1 Habit factors of notable mosquito species

Mosquito Species	Larval Habitat	Pest status	Activity
Ae. Vigilax	Temporary estuarine	Major biting pest and vector	Nov – Apr
Ae. Alternans	Temporary estuarine & brackish	Biting pest close to breeding habitat	Nov – Apr
Cx. Sitiens	Semi-perm. estuarine	Biting pest close to breeding habitat	Feb – Apr
Cq. Linealis	Permanent freshwater	Biting pest close to breeding habitat	Nov – Mar
Cx. annulirostris	Permanent & temporary freshwater	Major biting pest and vector	Jan – Mar

2.1 *Aedes vigilax*

This species is a dark, medium sized mosquito with pale bands on the legs. The larvae of this species are usually associated with tidally influenced saltmarsh and mangrove habitats, but can also utilise other saline and brackish water habitats such as flooded sedge lands and forests (eg. Casuarina spp. and Melaleuca spp.). Eggs are laid at the base of vegetation and/or on damp soil and can tolerate desiccation for many months.

Larvae are tolerant of a wide range of salinities and have been collected from highly saline (>40ppk) saltmarsh pools to freshwater flooded grasslands. Population increases of this species are closely linked to the inundation of habitats by the highest tides of each month, and/or major rainfall events, and the adults can disperse great distances (> 10 km) from breeding habitats. The species is a severe nuisance biting pest.

2.2 Aedes alternans

This species is a very large, sandy coloured mosquito commonly known as The Hexham Grey or Scotch Grey. The larvae of this mosquito are predatory on other mosquito larvae and aquatic invertebrates. Although this species causes significant nuisance biting close to breeding habitats, it is not considered an important arbovirus vector. Population increases of this species are linked to the same tidal and rainfall inundations that trigger increases in Ae. vigilax populations, consequently, the abundance of Ae. alternans is usually overshadowed by Ae. vigilax beyond some particular localities. This species is categorised as a Floodwater Mosquito as the larvae are associated with ephemeral ground

2.3 *Culex. Sitiens*

Culex sitiens is a dark, medium sized mosquito, usually abundant during the late summer and early autumn. The larvae of this species are commonly found, often in large numbers, in permanently inundated saline to brackish habitats, including saltmarsh and mangrove habitats. This species does not disperse far from breeding habitats and is not considered a significant pest or vector, primarily as it is a bird-feeding mosquito. On occasion, exceptionally large populations of immature mosquitoes may be detected in estuarine wetlands during late Summer and early Autumn.

2.4 *Coquillettidia linealis*

Coquillettidia linealis is a medium sized, dark mosquito with golden scales on the thorax. This species is common along the NSW coast and, while it is generally not a serious pest, there is the potential for this species to be an occasionally significant nuisance biter although little is known of its role in arbovirus transmission. The larval biology of this species differs markedly from most other mosquitoes in the region. The Page 13 Living with Mosquitoes in the Lower Hunter & Mid North coast region of NSW, 2nd Edition December 2009 larvae have a modified siphon that, instead of connecting to the water/air interface to breathe, attaches to the roots and/or stems of aquatic vegetation to obtain air. The larval developmental period is temperature dependent and may be as long as many months. In the Hunter region of NSW, it is thought that the species has two major peaks of abundance, one in early spring and another in mid-Summer.

2.5 *Culex annulirostris*

Culex annulirostris is a medium sized, light to dark coloured mosquito with a banded proboscis. This species is the major nuisance biting and vector species throughout inland areas of NSW, particularly in the major river basins and irrigation areas.

Larvae are commonly collected from a range of freshwater habitats from flooded grasslands to permanent, well-vegetated wetlands. While the importance of this species is generally overshadowed by estuarine mosquitoes in coastal areas, this mosquito is becoming of greater concern as constructed freshwater wetlands are increasingly incorporated into urban developments along the NSW coast.

3.0 Site Assessment

The site has been assessed for the potential for mosquitoes to occur. As previously discussed, the abovementioned species can be grouped into one of two habitats: Estuarine and Freshwater Mosquitoes.

The site currently has no surface water or areas where water will pond. The site is generally cleared, with minimal areas to breed the subject lot would be considered a low risk.

This assessment found that although the site would be low risk it may be affected by:

Estuarine Mosquitoes

The most common mosquito associated with this environment is *Aedes vigilax.* This species is one of the most common in the Hunter and Mid North Coast region. Large populations of this species occur during the summer months and can travel many kilometres from estuarine environments. The mosquito is known to be a major biting pest. This type of mosquito is likely to be the most common on site as a result of the Hunter Wetlands National Park to the north and east of the site.

Freshwater Mosquitoes

Areas of Freshwater associated with the Wetlands National Park and any areas of pooled rain or domestic water offer habitat for this mosquito type. Whilst many of the freshwater mosquitoes pose no threat to the community, there are some species that can become a nuisance such as *Coquillettidia linealis.*

Table 2 assesses the risk for potential breeding grounds for mosquitoes.

Table 2 Risk Assessment for Potential Mosquito Breeding Sites

Type of Risk	Risk Level	Comments
Hunter Wetlands	HIGH	These are stagnant water bodies and are favoured by mosquitoes as breeding grounds. They are therefore regarded as a high-risk area.
Stormwater Drains	MODERATE	The charged stormwater pits have the potential to be a moderate risk for mosquito breeding.
Open Space	LOW TO MODERATE	Any items that can contain water after rainfall

4.0 Recommendations - Post Development

There are a number of methods in reducing mosquito numbers around the proposed facility and minimising the effect they will have on future employees and resort occupants. Physical and biological controls options have been discussed below. Mosquitoes will be active during the summer months, and are greatest in numbers during the two to three-week period following high tides and/or major rainfall events.

4.1 Maintenance of the gardens and grounds

Maintenance of the grounds and gardens help to reduce the breeding grounds for mosquitoes. Removing an available breeding site is more effective than killing mosquitoes because it breaks the breeding cycle.

Mosquitoes need as little as three tablespoons of water to lay eggs, and mosquito eggs can hatch in as little as three days. It is strongly advised that standing water within the site is removed. Employees are encouraged to identify trouble spots (Mosquito Breeding Sites) – anywhere there is water that stands for more than three days.

4.2 Maintenance by Employees

Future employees should be made aware of potential breeding sites (i.e. they breed in still fresh or salty water) for mosquitoes. Sources of breeding sites for mosquitoes could be:

- Clogged gutters
- Open drains
- Open water containers
- Landscape areas
- Trays under pot plants
- Areas where water ponds
- Hardstand areas

Employees can reduce breeding sites around the workplace by following some of the following steps:

- Removing all opportunities for water to collect (e.g. tins, jars, ash trays and other rubbish items and all depressions in the ground that may hold water);
- During the peak breeding season of November to April regularly flush through the water in the charged stormwater pits;
- Screen all openings to tanks or other large containers with wire gauze no coarser than 1mm mesh;
- Install a spring-loaded door closer so that all doors close quickly;
- Do not leave doors and windows open without screens in place;
- Keep roof gutters in good repair and regularly remove leaves and debris so that pools do not form and trim trees to prevent leaves and debris from blocking roof gutters;
- Avoid growing plants in the landscaped gardens with leaves that can trap water eg. Bromeliads.

4.3 Biological Control

Biological control of mosquito populations is generally achieved to some degree through predation by other organisms. Natural predators of mosquitoes include fish, predacious mosquito larvae, other insects, crustaceans, spiders, fungal diseases, nematodes, protozoans, aquatic birds, amphibians, microbats and some reptiles.

Macroinvertebrates, such as waterbugs (*Hemiptera*), dytiscidae beetle larvae (*Coleoptera*), dragonflies (*Anisoptera*) and damselflies (*Zygoptera*) are generally more successful predators of mosquito larvae than fish in heavily vegetated areas (Chester 1990). When a system is not heavily vegetated, fish and some larvicides derived from bacteria are generally the most effective means of controlling mosquito numbers.

A more recent popular proposal for biological control of adult mosquitoes is encouraging the presence of microbats through the implementation of bat houses or planting trees that will provide habitat for local microbat species.

More than ten microbat species in the Hunter region exhibit feeding behaviours over saltmarsh habitats such as those surrounding the site. Whilst the presence of microbats may contribute to a reduction of mosquito presence, it cannot be considered an exclusive or conclusive mosquito biological control.

4.4 Chemical Control

Chemical control can be an effective method in reducing mosquito numbers, however chemicals can also have detrimental effects on environmental and human health. It is most commonly used when mosquito numbers are quite large and disease is a risk to society.

There are various commercial chemical controls that are appropriate for different habitats. These chemical controls work on an adult and larvae. Choosing appropriate chemicals for various habitats is important as to minimise the effect upon the environment. For example, slow release formation chemicals have less impact upon the environment, as they require less application.

The effect on non-target species must also be considered before using any chemical on mosquito populations so as not to place other native flora and fauna at risk.

Bacillus thuringiensis israelensis

If mosquitoes reach nuisance levels, an environmentally friendly mosquito control product containing the bacterium *Bacillus thuringiensis israelensis* (BTI) could be considered. BTI produces a protein crystal which contains a number of microscopic pro-toxins that when ingested are capable of destroying the gut wall and killing mosquito larvae. BTI is highly specific to mosquito larvae and very few non-target effects have been recorded. Some disadvantages include its efficacy is reduced in habitats with high organic content and when larval populations are young or near pupation (1st and 4th instar respectively) (Webb and Russell 2009).

Methoprene (or ALTOSID) is a synthetic mimic of juvenile hormone produced in insect endocrine systems and has been shown to be effective in Australian urban environments without adversely affecting non-target organisms (Webb and Russell 2009). This product interrupts the developmental stages of mosquito larvae preventing them from becoming adults.

Temephos (or ABATE) **should be avoided** as it has known adverse effects on non-target species including birds, fish and some invertebrates particularly in estuarine environments.

4.5 Development Planning

Planning for future development should include the following to aid in the reduction of mosquito breeding
sites.

- Stormwater retention and/or drains should be designed to be self-draining and have the siltation depth shallow enough to encourage evaporative drying.
- Rainwater tanks entry points should be sealed or screened to prevent mosquito breeding.

4.6 Self Protection from Mosquito Bites

To prevent not only a mosquito bite that irritates the skin, self-protection measures can be an effective
measure to prevent the spread of disease. Employees of the facility can protect themselves from mosquito bites by:

- Avoiding outdoor activity during the time of day mosquitoes are most active - one hour before and one hour after sunset.
- Using mosquito repellents with at least 20% DEET (about 10% DEET for children age 2-12). Care should be taken to read and adhere to directions for use associated with each product.
- Lighting citronella candles or burn citronella oil.
- Electric Insect Repellers (the type that release insect repellent) are useful. Electronic bug zappers are not effective for mosquito control and they often kill more useful insects.
- Checking doors and windows to ensure they close properly and make sure screens are in good repair.
- Wearing long, loose fitting, light coloured clothing.

Employees can take responsibility for personal protection by reducing contact with mosquitoes. This will be optimised if the employees are educated on mosquito behaviour, such as peak seasons and times of activity, and the disease transmission cycle. This can be done through a pamphlet distributed to employees

5.0 Conclusion

The purpose of this report is to identify key breeding habitat areas and minimise the effects that these insects may have on employees and visitors to the proposed development.

An assessment of the subject site found there where to be no known areas that would be suitable for mosquito breeding pre-construction and post development the majority on the site with be covered with concrete pavement.

The following strategies are aimed at reducing mosquito populations and the effect that populations can potentially have on people.

Recommended Management options as detailed in Item 4 that have been assessed include:

- Maintenance of gardens and grounds;
- Maintenance by employees;
- Biological control;
- Chemical control;
- Self-protection from mosquito bites.

It is also noted that the majority of the staff employed on site will be working indoors in an office environment and are at very low risk.

The workers that will be usually working outside need to have Personal Protective Equipment and clothing on at all times due to the nature of the product they will be working with, therefore greatly reducing the likelihood of bites etc.

Regardless of the control strategies implemented, mosquitoes will always be locally active during warmer months of the year, but we would access this site as a low risk.

6.0 References

Department of Primary Industries (2013) *Requirements of Releasing Fish into NSW waterways*. NSW Government. Accessed online from: http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0009/459009/English-Requirements-for-releasing-fishinto-NSW-waterways.pdf

Webb, C. E. and Russell, R. C. (2009) *Living with mosquitoes in the Lower Hunter and Mid North Coast Region of NSW*, 2nd Ed. Department of Medical Entomology, Westmead. Accessed online from: http://www.hnehealth.nsw.gov.au/hneph/mosquitoes/Documents/living-with-mosquitoes-dec09.pdf

Appendix 1

Mosquito List for Kooragang Island

(Extract from Webb and Russell 2009)

Living with Mosquitoes in the Lower Hunter & Mid North coast region of NSW, 2nd Edition December 2009

Table 1. The mosquito species recorded from the Lower Hunter and Mid North Coast as part of the NSW Arbovirus Surveillance and Mosquito Monitoring Program 1989-2009.

Species	Forster	Port Stephens	Lake Macquarie	Maitland	Newcastle
Aedeomyia venustipes (Skuse)		+			
Aedes alternans (Westwood)	+	+	+	+	+
Aedes aculeatus (Theobald)	+	+			
Aedes alboannulatus (Macquart)	+	+			+
Aedes australis (Erichson)	+	+			
Aedes bancroftianus Edwards		+			
Aedes burpengaryensis (Theobald)	+	+			
Aedes camptorhynchus (Thomson)	+	+			+
Aedes flavifrons (Skuse)	+	+	+	+	+
Aedes gahnicola Marks	+				
Aedes imperfectus Dobrotworsky	+	+			
Aedes kochi (Donitz)	+				
Aedes mallochi Taylor	+	+			
Aedes multiplex (Theobald)	+	+	+		+
Aedes notoscriptus (Skuse)	+	+	+	+	+
Aedes palmarum Edwards					
Aedes perkinsi Marks		+			
Aedes procax (Skuse)	+	+	+	+	+
Aedes quasirubrithorax (Theobaldi)		+			
Aedes rubrithorax Belkin	+	+			
Aedes theobaldi (Taylor)		+			
Aedes vigilax (Skuse)	+	+	+	+	+
Aedes vittiger (Skuse)	+	+			+
Aedes wasselli Marks		+			
Aedes sp. Marks No. 51			+		+
Anopheles annulipes Walker	+	+	+	+	+
Anopheles atratipes Skuse	+	+	+		
Anopheles stigmaticus Skuse	+	+			
Anopheles amictus Edwards		+			
Coquillettidia linealis (Skuse)	+	+	+	+	+
Coquillettidia variegata (Dobrotworsky)	+	+			
Coquillettidia xanthogaster (Edwards)	+	+	+	+	+
Culex annulirostris Skuse	+	+	+	+	+
Culex australicus Dobrotworsky & Drummond	+	+	+	+	+
Culex bitaeniorhychus Giles	+	+	+	+	+
Culex cylindricus Theobald		+			
Culex edwardsi Barraud	+				
Culex halifaxii Theobald		+			+
Culex molestus Forskal	+	+	+	+	+
Culex orbostiensis Dobrotworsky	+	+	+	+	+
Culex postspiraculosus Lee	+	+			
Culex pseudomelanoconia Theobald		+			
Culex quinquefasciatus Say	+	+	+	+	+
Culex sitiens Weidemann	+	+	+		+
Culex squamosus (Taylor)		+			
Culex sp. No.32 of Marks		+	+		+
Culiseta antipodea (Dobrotworsky)		+	+		
Culiseta inconspicua (Lee)	+	+			
Mansonia uniformis (Theobald)	+	+	+	+	+
Mimomyia elegans (Taylor)	+	+			+
Toxorhynchites speciosus (Skuse)	+	+	+	+	+
Tripteroides atripes (Skuse)	+	+			
Uranotaenia pygmaea Theobald	+	+			
Uranotaenia nivipes (Theobald)					
Verrallina funerea (Theobald)	+	+			
Verrallina sp. Marks No. 52'	+	+	+		+
Total number species	**40**	**47**	**22**	**16**	**23**

Extract from: (Webb & Russell 2009)