Mosquito Management Code of Practice

August 2014

Acknowledgements

This document is a revision of the original Mosquito Management Code of Practice as developed in 2002. There was a substantial review in 2011/2012 by a technical reference group comprised of Queensland Government and local government members. This current version contains minor modifications from this review.

How to use this Code

Under Section 319 of the *Environmental Protection Act 1994*, all persons in Queensland must fulfill their '*general environmental duty*'. This is defined as follows: "A person must not carry out an activity that causes, or is likely to cause, environmental harm unless the person takes all reasonable and practicable measures to prevent or minimise the harm."

To comply with the general environmental duty, a person should undertake those measures in the Code that are most appropriate to the situation. In selecting which measures are appropriate to each situation, consideration must be given to the:

(a) nature of the harm or potential harm; and
(b) sensitivity of the receiving environment; and
(c) current state of technical knowledge for the activity; and
(d) likelihood of successful application of the different measures that might be taken, and
(e) financial implications of the different measures as they would relate to the type of activity.

This Code contains a range of measures that can be applied to various circumstances and at various levels – program, planning and operational. Therefore, the Code should not be used without consideration of the particular circumstances of a situation before any of the measures contained in the Code are implemented.

Authorisation and amendment of the code

Under section 318E(1) of the *Environmental Protection Act 1994*, the Minister may, by gazette notice, make codes of practice stating ways of achieving compliance with the general environmental duty for an activity that causes, or is likely to cause, environmental harm. Once the code has been gazetted, it may also be amended by gazette notice.

This environmental code of practice commenced on 12 December 2014 and has effect for seven years. To continue to have effect the code of practice must be reviewed and approved by the Minister by 11 December 2021.

Foreword

There are significant numbers of Queenslanders that are infected each year with mosquito borne diseases such as Ross River virus and Barmah Forest virus. Queensland has the highest incidence of Ross River virus in Australia. A further complication from a human health perspective is that there is an absence of vaccines to prevent these diseases.

Mosquito management is therefore a major issue for many Queensland local governments. Increasing development particularly in coastal areas is placing ever increasing pressure on local government to develop and put into effect mosquito management programs.

The primary focus for mosquito management in Queensland is related to public health issues and disease control. Provisions of Chapter 2 of the *Public Health Act 2005* provide local government with the statutory support to undertake mosquito control activity and to prevent and control public health risks in relation to mosquitoes.

Mosquito management is not just about application of insecticides. The availability of more environmentally friendly insecticides and improving knowledge about other techniques to manage mosquitoes such as habitat modification and biological control are changing the way local government undertakes mosquito control and this trend is likely to continue.

Mosquitoes are part of our natural environment and it is recognised that various works undertaken to control mosquitoes may have some adverse environmental impacts. The community and State environmental protection legislation both place importance on ensuring that environmental harm is minimised during any mosquito management activity. Adverse environmental impacts can be minimised if best practice is followed and this is where the Mosquito Management Code of Practice will be particularly valuable as it covers a wide range of matters that need to be considered in any mosquito management program.

I encourage local government to become familiar with and adopt the Mosquito Management Code of Practice as it provides a comprehensive guide to minimising adverse environmental impacts that might occur as mosquito management is carried out in Queensland.

Greg Hallam PSM
Chief Executive Officer
Local Government Association of Queensland

Table of Contents

1.0 Nature and Purpose of the Mosquito Management Code of Practice

General environmental duty

A person must not carry out any activity that causes, or is likely to cause, environmental harm unless the person takes all reasonable and practicable measures to minimise the harm.
Section 319, EP Act 1994.

Environmental harm

This is any adverse effect, or potential adverse effect, (whether temporary or permanent and of whatever magnitude, duration or frequency) on an environmental value, and includes environmental nuisance.
Section 14, EP Act 1994

Environmental value

This is a quality or physical characteristic of the environment that is conducive to ecological health, public amenity or safety.
Section 9, EP Act 1994

Under the *Environmental Protection Act 1994* (EP Act), the Minister may approve a code of practice stating ways of achieving compliance with the general environmental duty for any activity that causes, or is likely to cause, environmental harm (Section 548).

The management of mosquitoes for purposes of public health and community wellbeing is carried out in many areas of Queensland. Various activities that contribute to the overall management of mosquitoes have the potential to have an adverse impact on the environment.

The purpose of this Code of Practice is to provide local governments, organisations, commercial enterprises and individuals involved in the control of mosquitoes with a means of demonstrating that reasonable and practicable measures are being taken to minimise environmental harm from selected mosquito control activities. The Code is not intended to deal specifically with vectors of dengue and it is recognised that the *Queensland Dengue Management Plan 2010-2015* is available separately at www.health.qld.gov.au. The aim of that plan is to minimise the number of locally acquired cases of Dengue in Queensland by strengthening and sustaining risk based surveillance, prevention and control measures for both human cases and the mosquitoes that carry the Dengue virus.

Codes of practice approved under the EP Act are not mandatory. However, compliance with a code of practice would provide a defence against a charge of unlawfully causing environmental harm. Should a local government involved in mosquito management choose not to use the Mosquito Management Code of Practice, they would need to rely on other means to indicate that there has been due diligence and compliance with the general environmental duty.

Aerial larviciding of a saltmarsh (photo courtesy of Brisbane City Council).

2.0 Scope

This Code of Practice has been developed so that it can be applied at the program or planning level and at the operational level when specific mosquito control tasks are being executed.

An essential component of a Mosquito Management Program (MMP) is Integrated Mosquito Management (IMM). This is the implementation of a number of mosquito control techniques to collectively contribute to the management of mosquitoes in a way that may reduce reliance on chemicals to reduce mosquito numbers and disease risk, taking into account environmental impact, sustainability and cost effectiveness.

It is emphasised that individual components of the Code should not be considered in isolation as environmental protection measures identified in MMPs can best be achieved through a broad range of techniques and approaches.

It is intended that this Code of Practice for the management of mosquitoes may be used by all local governments (and local government contractors) involved in the implementation of mosquito management programs established to reduce disease incidence or risk in Queensland.

The Code will be reviewed regularly to ensure that the information contained is current and relevant to mosquito management.

3.0 Mosquito Incidence and Control Requirements in Queensland

3.1 Species distribution in Queensland

Exotic mosquitoes

The Department of Agriculture, fisheries and Forestry (DAFF) routinely monitors first port areas to prevent exotic mosquito species such as *Aedes albopictus* from establishing in Queensland. The natural range of this species includes South East Asia, West Papua and Papua New Guinea. In recent years *Ae.albopictus* has become established in much of the USA and parts of Europe and the Torres Strait.

Over 220 species of mosquito have been identified in Queensland. They are found in a wide range of habitats, with some being widespread and common, while others are rare and localised. An overview of the common species and their disease associations is provided in Table 1.

Several exotic mosquito species have the potential to become established in Queensland. The Asian Tiger Mosquito, *Aedes albopictus*, has been detected on several occasions at Queensland ports, where it has been successfully eradicated. It has colonised the majority of Torres Strait island communities since its detection in 2005. This species poses a direct threat to mainland Queensland. It was detected and eradicated on the Queensland mainland (Bamaga) in 2009. It is a vector of Dengue Fever and exotic diseases such as Chikungunya. Incursions of an exotic mosquito species into certain areas of Queensland may lead to intensive efforts by local and state governments to prevent establishment of such species.

Table 1 Some Common Mosquito Species in Queensland

MOSQUITO SPECIES	DISTRIBUTION	PREFERRED BREEDING SITES	CONCERN OR RISK	CONTROL ACTIVITY
Aedes aegypti	North Queensland south to Gympie and east to Roma.	Prefers containers. Associated with human habitation.	Vector of dengue and CHIK.	Localised control performed during dengue outbreaks
Aedes alternans	Widespread.	Saline and fresh wetland.	RR Isolated. Rarely abundant.	
Ae. normanensis	Inland and northern areas.	Temporary ground pools.	BF, MVE, RR isolated.	
Ae. notoscriptus	Widespread, urban and rural.	Domestic and natural containers.	Significant domestic pest. Vector of BF, RR, heart worm in dogs.	Control depends on householders.
Ae. procax	Most of coastline.	Temporary freshwater (sometimes brackish) groundpools.	Occasional pest, vector of RR and BF, potential vector of CHIK.	Some control in southeast.
Ae. vigilax	Most of coastline.	Temporary pools in saltmarshes flooded during higher tides or by rain.	Major pest species. Vector of BF, RR and heart worm in dogs. Potential vector of CHIK.	Widely controlled in southeast.
Ae. vittiger	Coastal and inland riverine areas.	Temporary freshwater pools, predominantly after flooding.	Major pest species.	Some control in southeast.
Anopheles annulipes	Widespread.	Temporary and permanent pools (sometimes brackish), streams and along edges of wetlands. Will also use artificial containers.	May be a pest in the vicinity of extensive wetlands.	
An. bancroftii	Coastal, higher rainfall areas.	Shaded freshwater, often in hyacinth swamps.	Potential early dry season pest.	
An. farauti	Coastal north of Townsville.	Similar to *An. annulipes*. More readily in brackish water.	The most important potential carrier of malaria.	Localised control in areas receptive to malaria.
Coquillettidia linealis	Widespread.	Probably as for *Cq. xanthogaster*	May be a serious pest in the vicinity of freshwater wetlands. BF, RR isolated. Potential vector of CHIK.	
Cq. xanthogaster	Widespread.	Permanent and semi-permanent waterholes with aquatic plants. Larvae attach to plant tissues below the water surface.	Occasional pest.	
Culex annulirostris	Widespread.	Fresh water wetlands, 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 BF, JE, Kunjin, MVE, RR and heart worm of dogs.	Some control in southeast.
Cx. quinquefasciatus	Widespread.	Commonly found in polluted water close to human habitation. Breeding can be prolific in waterways polluted by sewage or organic matter.	Night-biting occasional pest. BF, RR isolated. Vector of heart worm in dogs.	
Cx. sitiens	Coastal saline and brackish.	Commonly found in pools formed when high tides flood the upper limits of marine and estuarine wetlands.	Occasional pest where residential areas are close to breeding sites. RR isolated.	Controlled in some southeast Queensland coastal areas.
Mansonsia uniformis	Widespread, mainly coastal.	As for *Cq. xanthogaster*	May be a serious pest in the vicinity of freshwater wetlands. RR isolated.	
Verrallina funerea	Coastal.	Slightly brackish and fresh water pools in tea tree and other wetlands adjoining tidal areas.	Vector of RR, BF isolated. Can be a significant pest in residential areas adjacent to breeding sites.	Target in hot spots in southeast.

Viruses: BF = Barmah Forest, JE = Japanese Encephalitis, MVE = Murray Valley Encephalitis, RR = Ross River, CHIK = Chikungunya

3.2 Mosquito lifecycle and ecology

Mosquitoes lay eggs on a variety of substrates that are consistent with the requirements of the aquatic stages of specific life histories. Some species lay eggs on the surface of water, others do so on damp ground, or on vegetation at the edge of water holes, or on the damp edges of natural containers such as tree hole cavities or rock pools, and man-made containers such as tyres or rainwater tanks.

Aedes vigilax

Eggs hatch to produce larvae (wrigglers), which grow through four "size" steps (called instars) before becoming pupae (tumblers). The larvae feed on micro-organisms in the water and most species breathe through a tube in the tail which opens to the air as the larvae come to the surface of the water. Pupae do not feed, and breathe through a pair of tubes on the top of the body as they rest at the water surface.

Mosquito larvae in a rapidly drying saltmarsh pool

In warm weather, the larval stage may be as short as four to six days, but in cooler weather this stage will be much longer. The pupal stage is shorter than the larval stage, and may be only two to three days in summer. The adult emerges from the pupal case as it rests at the surface of the water.

Culex annulirostris

Mosquito eggs laid on damp surfaces are usually drought resistant. The eggs remain viable and dormant until the pool, container or cavity is filled by rain water, irrigation or tidal water. This explains why there are outbreaks of mosquitoes within a week or two of rain after a long dry spell. In the case of saltmarsh mosquitoes that hatch with tidal inundation, there are usually cycles of high adult populations that coincide with the tidal pattern from spring to autumn.

Eggs laid on the surface of free water are usually deposited as a raft and hatch within 24 to 48 hours. These mosquito species have no resting stage in the early part of their life cycle. Such species can expand their numbers rapidly after heavy rain by utilising floodwater pools, especially where there are grassy margins.

In a small number of species, larvae and pupae have breathing siphons that are modified to attach to the stems of plants under water. They can obtain oxygen from the plant tissues and through their skin. The larvae are

very difficult to detect using conventional sampling techniques, but the adult mosquitoes of these species can sometimes be significant and abundant pests.

Aedes alternans (scotch grey)

Temporary pools generally provide greater opportunities for mosquito breeding. In permanent water such as dams and creeks, there are often substantial numbers of natural predators of mosquitoes, such as fish and other insects. In these situations, equilibrium has been reached over time. In temporary pools formed after rain or tidal inundation, mosquitoes complete lifecycles before the numbers of predators rise to the level where any significant control occurs.

Only female mosquitoes feed on blood, which is the protein source required to develop eggs. However, both male and female mosquitoes can survive on nectars and other plant secretions. The adult lifespan may be from two to four weeks in summer, but much longer in cooler weather.

Culex quinquefasciatus

Mosquitoes feed on a host for a short period, with usually one to two minutes required to complete engorgement. As the mosquito feeds it injects an anticoagulant 'saliva'. This helps to prevent blood clotting around its mouthparts and may also initially reduce the sensation of being bitten in the host. However, after the mosquito has left there may be a reaction to this foreign substance that causes irritation at the site of the bite.

After feeding on blood the female will rest; preferring a damp, dark sheltered site while the blood is digested and eggs develop. In summer, the eggs can be ready for laying two to three days after a blood meal. After laying eggs, the female will be ready for a further blood meal, with this cycle being repeated up to four to five times.

Aedes notoscriptus

3.3 Importance of mosquito control in Queensland

Mosquitoes are vectors of diseases such as Barmah Forest virus disease, Dengue fever; Japanese encephalitis, Kunjin virus disease, Murray Valley encephalitis and Ross River virus disease in Australia (refer to Table 2 for Queensland data). They can also be a major pest in many areas of the State and are involved in the transmission of dog heartworm.

Table 2 Annual totals of selected notifiable arboviruses reported in Queensland, 2000 - 2013 (Queensland Health)

Mosquito Transmitted Disease	2000	2001	2002	2003	2004	2005	2006	2007
Barmah Forest virus infection	345	601	387	869	583	680	955	826
Chikungunya*	---	---	---	---	---	---	---	---
Dengue	85	42	81	725	275	117	78	120
Japanese encephalitis	0	0	0	1	1	0	0	0
Kunjin virus disease	0	0	0	6	5	1	1	0
Murray Valley encephalitis	0	1	0	0	0	1	0	0
Ross River virus infection	1481	1568	885	2514	2005	1179	2611	2137
Yearly Total	**1911**	**2212**	**1353**	**4115**	**2869**	**2253**	**3645**	**3083**

Mosquito Transmitted	2008	2009	2010	2011	2012	2013
Barmah Forest	1245	797	912	874	981	2224
Chikungunya*	2	4	5	3	0	14
Dengue	233	1033	288	186	243	489
Japanese	0	0	0	0	1	2
Kunjin virus	1	1	1	0	0	3
Murray Valley	0	1	0	0	1	1
Ross River	2846	2149	2395	1219	1951	1787
Yearly Total	**4325**	**3981**	**3601**	**2282**	**3177**	**4520**

Vaccines are not presently available to prevent infection, with the exception of Japanese encephalitis. Therefore, mosquito control assumes major importance in preventing the spread of these diseases.

* Chikungunya became notifiable in Queensland in November 2008

3.4 Responsibility for controlling mosquitoes in Queensland

Queensland Health has overall responsibility under the *Public Health Act 2005* for the control of communicable diseases in Queensland, including mosquito-borne diseases such as Barmah Forest virus infection, Dengue fever, and Ross River virus infection.

Local government has responsibility for the public health risks related to breeding grounds for designated pests and harbourages of designated pests. Mosquitoes are defined as a designated pest.

Translocation

Translocating aquatic organisms has risks for the receiving habitats and endemic organisms. The Commonwealth Publication No 1 (opposite) clarifies translocation issues and sets out agreed national policy principles.

3.5 Major publications applicable to mosquito management in Queensland

1. Commonwealth publication

National Policy for the Translocation of Live Aquatic Organisms – Issues, Principles and Guidelines for Implementation, Ministerial Council on Forestry, Fisheries and Aquaculture 1999
http://data.daff.gov.au/brs/brsShop/data/12105_translocation.pdf

2. Queensland legislation

Public Health Act 2005
https://www.legislation.qld.gov.au/LEGISLTN/CURRENT/P/PubHealA05.pdf

Public Health and Other Legislation Amendment Regulation (No. 1) 2007
www.legislation.qld.gov.au/LEGISLTN/SLS/2007/07SL086.pdf

3. Queensland Health publications

Queensland Dengue Management Plan (DMP) 2010-2015
http://www.health.qld.gov.au/dengue/documents/dengue-mgt-plan.pdf

Guidelines to minimise mosquito and biting midge problems in new development areas, March 2002
http://www.health.qld.gov.au/ph/Documents/cdb/14804.pdf

Chemical or biological controls used in declared Fish Habitat Areas

Chemical or biological controls used in declared Fish Habitat Areas are addressed in Fish Habitat Area Code of Practice 01 (refer 4(a) opposite).

Runnelling

Under the *Fisheries Act 1994*, approval is required to interfere with marine plants and to undertake works in declared Fish Habitat Areas. Runnel construction may trigger development approval (*Sustainable Planning Act 2009*). DAFF recognised local government runnelling programs are implemented in accordance with MP06 (refer 4(b) opposite). Runnel maintenance is to follow self-assessable development code MP02 (refer 4(c) opposite).

Gambusia spp.

Species of this exotic fish are declared noxious in Queensland and must not be released in Queensland waters. Native fish are effective in controlling mosquito larvae and guidance on selection is provided by DAFF (refer 4(d, e and f)

4. Department of Agriculture, Fisheries and Forestry publications

(a) Fish Habitat Area code of practice – *The lawful use of physical, pesticide and biological controls in a declared Fish Habitat Area (FHACoP01), February 2005*
http://www.nprsr.qld.gov.au/managing/pdf/code-of-practice.pdf

(b) *Minor impact works in a declared fish habitat area or involving the removal, destruction or damage of marine plants* – Code for self-assessable development (MP06), January 2013
http://www.daff.qld.gov.au/__data/assets/pdf_file/0010/73927/MP06-minor-new-works-June2012.pdf

(c) *Maintenance works on existing lawful structures (other than powerlines and on-farm drains) in a declared fish habitat area or involving the removal, destruction or damage of marine plants* – Code for self-assessable development – MP02
http://www.daff.qld.gov.au/__data/assets/pdf_file/0015/51603/MP02-Existing-lawful-structures-2011.pdf

(d) *Native fish for mosquito control in South-east Queensland*. A Brochure
http://www.daff.qld.gov.au/fisheries/recreational/freshwater-fish-stocking/native-fish-for-mosquito-control

e) *Stocking native fish for mosquito control in fresh waters, Guidelines for local governments, housing developers, community groups and private landowners*, QI05090 (available from DAFF)

(f) *Field Guide to Common Saltmarsh Plants of Queensland (2010). Louise Johns, DAFF, PR10-4286* and Common Saltmarsh Plants of Queensland poster (available from DAFF).

5. Department of Environment and Heritage Protection Publication:

Strategy for the Conservation and Management of Queensland Wetlands
http://wetlandinfo.ehp.qld.gov.au/resources/static/pdf/resources/reports/wetland-strategy.pdf

6. Mosquito Control Association of Australia Inc. Publication:

Australian Mosquito Control Manual
Details on this publication are available from the online store at:
http://www.mcaa.org.au/

4.0 Environmentally Sustainable Mosquito Management

Artificial wetlands

In the larval stage, mosquitoes live in water habitats, many of which are environmentally significant. Breeding habitats can range from artificial containers and rain filled depressions to saltmarsh swamps and can vary in size from a few square centimetres to hundreds of hectares. Any site that holds water for more than a few days has the potential to breed mosquitoes.

It is neither possible nor environmentally responsible to attempt to remove or control all mosquito breeding sites. The focus should be one of management of mosquito populations to achieve the desired outcomes. When developing a Mosquito Management Program (MMP), a wide approach should be taken in its design and where possible, the program should be linked to a wider environmental management program.

Saltmarsh wetlands

Mosquitoes range across administrative boundaries and can travel many kilometres from their breeding location. The establishment of regional mosquito control committees can prove beneficial in providing a coordinated and integrated approach to the successful management of mosquitoes.

Marshlands capable of allowing prolific mosquito breeding are often part of sensitive sites such as declared Fish Habitat Areas and Marine Parks

4.1 Mosquito Management Programs (MMPs)

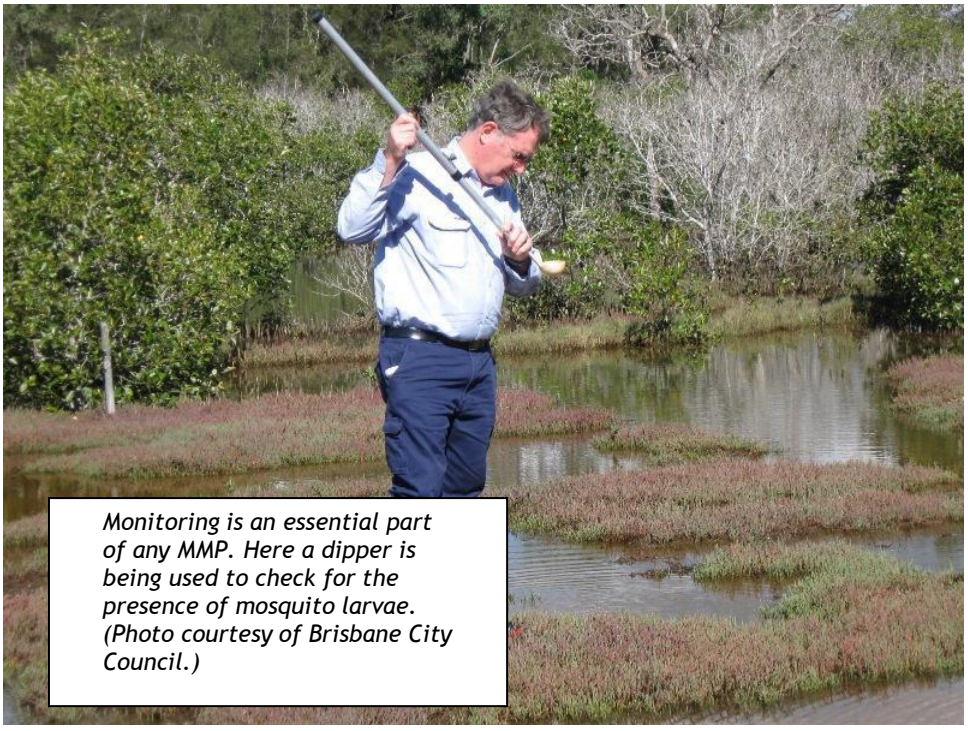
Developing a MMP is necessary when management of mosquito populations is required. In the development of the program, the desired outcomes and levels of control must be clearly established and identified. The MMP contains a range of activities that together produce the desired results.

Integrated Mosquito Management (IMM) is an integral component. Figure 1 indicates the overall process in the development of a MMP and the various control options that need to be considered when developing the program.

A MMP contains a balance of direct and indirect control methodologies that are environmentally compatible and economically feasible and are aimed at reducing mosquito populations to desired levels. The direct (reactive) control methodologies include chemical control, biological control, habitat modification and source reduction, while the indirect (proactive) methodologies include public education and awareness and developmental planning. The basic scope of a MMP is included in Table 3.

Non-target effects - Mosquito management activities can have detrimental effects on species that use the same habitats as mosquitoes. This may be caused by sensitivity to chemicals and habitat change.

The adoption of an overall approach to mosquito control as per Figure 1 is necessary to ensure that each site is evaluated on its merits and all possible control options considered. Population dynamics and treatment thresholds need to be addressed and will form part of the overall risk assessment that will dictate how a site is managed.



Monitoring is an essential part of any MMP. Here a dipper is being used to check for the presence of mosquito larvae. (Photo courtesy of Brisbane City Council.)

Following development of the MMP, monitoring of the various components is necessary to ensure that the program is operating effectively and that outcomes meet the desired levels. The monitoring should include a variety of activities such as database maintenance, larval and adult mosquito surveillance, general observations and control assessment.

The information obtained from the monitoring will provide data to assist with the overall assessment and determination of the program's success.

4.2 Guidance for developing an environmentally sound MMP

Mosquito Management Programs, while covering issues from general administration to public education, also determine the impact that mosquito management activities will have on the environment. There are many variables that will influence how MMPs are developed but there are also a number of generic points that should be taken into account by those bodies developing such a program.

These are as follows:

- Its sophistication will depend on the scale, local characteristics, and environmental sensitivity of the area where the management activity is to be targeted.
- It should be implemented or supervised by suitably trained staff.
- It should provide a commitment to continual improvement to prevent environmental harm through the integrated application of mosquito management measures.
- It should provide the framework for setting specific objectives and targets to minimise environmental harm.
- It should facilitate documentation of those activities undertaken to implement the program.
- It should allow for the monitoring and evaluation of the program and maintain or develop linkages with wide environmental management programs.

Further guidance on development of a MMP is included in Appendix A.

Figure 1 – Mosquito Management in Queensland

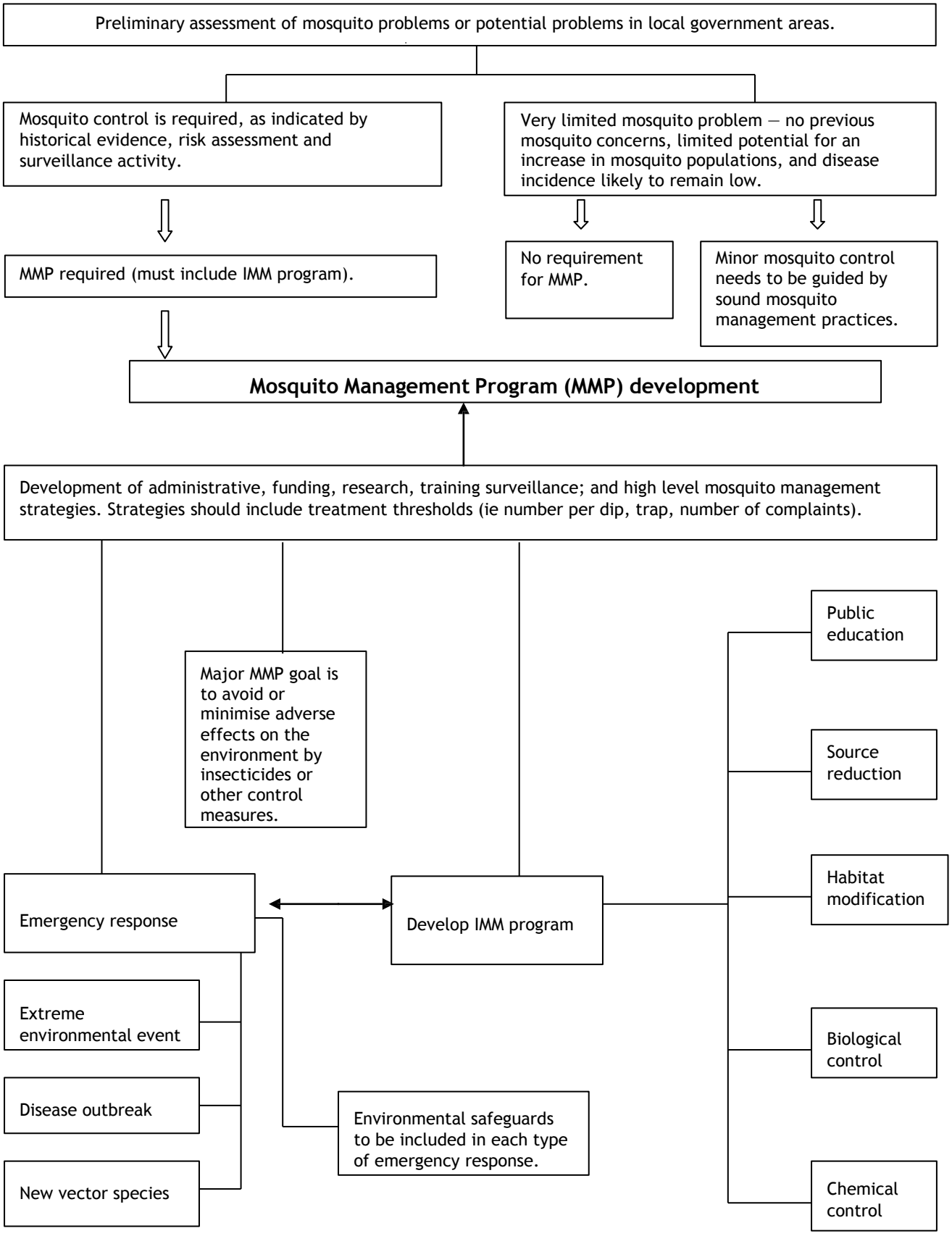


Table 3 Basic Scope of an MMP that would meet the requirements of the Mosquito Management Code of Practice

Selected components of a mosquito management program	Requirements for compliance with the Mosquito Code of Practice
Development of a strategy for management of mosquitoes including treatment thresholds.	Each problem breeding area is considered when developing the overall mosquito management strategy. Broad thresholds of mosquito numbers for each species common to an area are established for various surveillance methods to provide guidance on when control activity should commence.
Develop a mosquito surveillance program to support management strategies.	A mosquito surveillance program is established for mosquito species for which control activity is warranted. Surveillance methods are available for all mosquito life stages (egg to adult) depending on species.
Develop strategies to minimise risk of environmental harm.	Areas likely to need emergency mosquito control measures that have particularly sensitive environmental values such as presence of rare and endangered species and distinctive breeding patterns of native wildlife, are identified. Control practices, e.g. chemical application equipment, selection of insecticides and application techniques, that would cause the least actual or potential harm to the environment are formulated and documented.
Develop as part of the MMP an integrated mosquito management program (IMM) to suit the area where mosquito control is required.	The IMM program includes as many components as feasible that will, in combination, lead to minimal environmental harm during mosquito population management, taking into account practicability and cost effectiveness. Pursue alternatives to the use of insecticides in the management of mosquitoes when appropriate.
Review and evaluate the MMP.	Review the MMP every three years to ensure the program's continuous improvement in regard to the environmental effect of the program.

5.0 Mosquito Control

Improperly stored tyres provide another breeding site

5.1 Source reduction

For the purpose of this Code, source reduction refers to the removal/eradication of container breeding sites generally associated with human habitation. The preference of some mosquitoes (e.g. *Ae aegypti, Ae albopictus and Ae notoscriptus)* for containers and the disease risks associated with these species results in high demand for sustained control activity and increasing insecticide use during disease outbreaks.

5.2 Habitat modification

Habitat modification refers to the limited manipulation of wetlands in particular circumstances to reduce their capacity for mosquito breeding. Emphasis is placed on enhancing natural ecological processes and predator populations that can maintain mosquito numbers within acceptable limits.

Wetlands Definitions, Policies and Legislation

The *Strategy for the conservation and management of Queensland's wetlands* released in 1999 sets out the Queensland Government's objectives for wetlands and details initiatives to encourage and assist sustainable management of wetlands. The Strategy can be downloaded at http://wetlandinfo.ehp.qld.gov.au/resources/static/pdf/resources/reports/wetland-strategy.pdf.

One of the Strategy's objectives is to avoid further loss or degradation of natural wetlands. Associated with this is the requirement to minimise adverse ecological impacts in any strategy for limiting the spread of disease, including vector control.

The Strategy also focuses on specific initiatives that need to be utilised to avoid further loss or degradation of wetlands. A number of these initiatives have relevance for mosquito management activity and involve:

- The restoration and rehabilitation of degraded natural wetlands; and
- Development of guidelines and methods for ecologically safe control of vectors with an aquatic stage in their life cycle.

The *Strategy for the conservation and management of Queensland's wetlands* defines wetlands as "*areas of permanent or periodic/intermittent inundation, whether natural or artificial, with water that is static or flowing fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed 6m*".

This definition is further specified in the Queensland Wetland Program definition and the Queensland Wetland Program Definition Guideline (http://wetlandinfo.ehp.qld.gov.au/wetlands/what-are-wetlands/definitions-classification/wetland-definition.html).

Wetlands are found throughout Queensland and come in a wide variety of forms, including:

- Rivers and creeks
- Lakes, lagoons and billabongs
- Swamps, marshes and bogs
- Saltmarsh and mangrove communities
- Fens, peatlands and springs
- Inshore reefs and coastal waters
- Artificial dams and drains.

Queensland has the most diverse array of wetlands in Australia and they are broadly classified into estuarine, marine, lacustrine (lakes), palustrine (bogs and swamps), riverine and subterranean systems.

A number of additional legislative controls have been implemented for the further protection and sustainable management of Queensland wetlands. For further information, see the Department's website (https://www.ehp.qld.gov.au/ecosystems/wetlands/wetlands.html) and the Wetland*Info* website (http://wetlandinfo.ehp.qld.gov.au/wetlands/index.html).

6.0 Environmental Management

As of 1 July 2013, the State Assessment and Referral Agency (SARA) within the Department of State Development, Infrastructure and Planning is the single lodgement and assessment point for all development applications where the state has a jurisdiction under the *Sustainable Planning Act 2009* (SPA). All approvals under SPA previously managed by the Department of Environment and Heritage Protection and the Department of Agriculture, Fisheries and Forestry are now handled by SARA. The State Development Assessment Provisions (SDAP) provides all the assessment criteria and can be found at:
http://www.dsdip.qld.gov.au/development-applications/sdap.html.

Aquaculture and disturbance to fish habitats are considered fisheries development, and therefore may require a development approval issued under SPA and the Integrated Development Assessment System (IDAS). Potentially, an environmental authority, or a resource allocation authority (a form of resource entitlement) may also be required under the *Fisheries Act 1994*. This is a complex area, and discussion with the regional State Government fisheries office is advised.

Some of the works outlined in the mosquito control code may trigger assessment under the *Sustainable Planning Act 2009* or referenced in the Coastal Management Plan, which provides non-regulatory policy guidance to coastal land managers and commenced on 18 March 2014: http://www.ehp.qld.gov.au/coastalplan/. The works that are likely to trigger this legislation are the habitat modification works and runnelling, and issues to be considered would be:

- Destruction of areas mapped as Matters of State Environmental Significance (MSES) or Matters of National Environmental Significance (MNES).
- Increased erosion potential associated with works.
- Impact to sediment transport process and other coastal processes.
- Changes to tidal inundation and storm tide inundation offsite.

Overall, the impacts are likely to be small, but consideration needs to be given to works that may trigger assessment under the legislation. More information on approvals administered by the Department of Environment and Heritage Protection can be found at:
http://www.ehp.qld.gov.au/coastal/development/index.html.

The Department of National Parks, Recreation, Sport and Racing also administers legislation including the *Nature Conservation Act 1992*, the *Nature Conservation Regulation 1994*, the *Marine Parks Act 2004* and the *Marine Parks Regulation 2006*.

A Marine Park Permit is usually required prior to the use of a Marine Park for purposes of mosquito control activity. Use of the Marine Park could include the application of insecticides targeting mosquito larvae or adults and the carrying out of works to influence water flow over open marshlands, such as through installations of 'runnels', to modify mosquito breeding habitat.

The *Nature Conservation Act 1992* and the *Nature Conservation Regulation 1994* both place emphasis on the management of protected areas. The control of mosquitoes in those areas to which the above legislation applies, through such measures as the application of insecticides and carrying out of habitat modification works also requires approval or permit.

6.1 Freshwater wetlands (natural and modified) and artificial wetlands

Objective: To reduce mosquito breeding in natural and modified freshwater and artificial wetlands by utilising natural predators of mosquito larvae and pupae and managing vegetation to prevent improved conditions for mosquito breeding and development of new mosquito habitats.

One characteristic is the ephemeral nature of many of the freshwater wetlands. This reflects the State's great climatic variation and seasonal variability. This has particular implications for mosquito management where human health issues are of concern. There are many different types of freshwater wetlands and it is important to consider potential implications for the wetlands in any mosquito control activities.

Consideration could be given to design solutions that reduce mosquito breeding with minor changes to the wetlands, which would reduce the need to treat it for mosquitoes. The protection, rehabilitation and effective management of freshwater wetlands and appropriate design of artificial wetlands such as through attention to edge slopes, and shape and orientation of ponds, can reduce the incidence of mosquito species capable of transmitting disease. When freshwater wetlands are managed to prevent mosquito breeding, there is less reliance on insecticides to suppress mosquito numbers to the required levels.

An increasing problem is the establishment of exotic weed species (http://wetlandinfo.ehp.qld.gov.au/wetlands/ecology/) in Queensland freshwater wetlands. The establishment of some weed species will improve the breeding habitat for mosquitoes by increasing sites available for egg deposition (e.g. olive hymenachne (*Hymenachne amplexicaulis*)) and by providing greater protection against predators (e.g. floating aquatic weeds such as salvinia (*Salvinia molesta*), water hyacinth (*Eichhornia crassipes*) and water lettuce (*Pistia stratiotes*)).

Weed invasion of wetland areas can increase the potential for mosquito breeding and the demand for control activity

There is a legal responsibility to manage the impacts of weeds declared under the current *Land Protection (Pest and Stock Route Management) Act 2002* and the new *Biosecurity Act 2014* and local government local laws.

Acceptable practice for the limited modification of freshwater wetlands for mosquito control is detailed in Table 4.

Managing weed invasions and the productivity and form of new plant associations can have a substantial impact on MMPs.

For more information on wetland weeds and pests, and on wetland monitoring, see the Wetland*Info* website.

Table 4 Limited Modification of Freshwater Wetlands

Specific habitat modification issues	Accepted practice for carrying out limited wetland	Requirements for compliance with the mosquito code of practice
Development of aquatic refuges in ephemeral wetlands.	The presence of suitable native aquatic animal species, specific to the area, to rapidly recolonise ephemeral wetlands as the wetland refills can be effective in controlling mosquitoes. As a consequence, insecticide usage may be reduced.	Ephemeral wetland sites selected for the development of aquatic refuges do not contain rare or threatened wildlife and do not change the ephemeral nature or type of the wetland. The aquatic refuge does not alter the overall character (wetland type) and functioning of the wetland. Consideration has been given to the relative size of the refuge to the original wetland and the location of the refuge and how it connects to the wetland.
Reduction of certain exotic vegetation from natural and artificial wetlands, including drainage lines.	The invasion of natural wetlands by certain exotic species can result in improved and new habitats for mosquitoes. The management and eradication of exotic weeds in wetlands needs to be considered as part of any IMM to reduce mosquito breeding habitat in existing wetlands and to prevent expansion of breeding sites.	Consideration has been given to removal/eradication of exotic weed species from natural wetlands where practicable, in accordance with a weed control program and should preferably be done in accordance with a rehabilitation plan. Monitoring of weed infestations that are likely to increase mosquito habitat is undertaken where practicable so that early eradication/control actions are instigated to avoid development of mosquito breeding. Selection of plant species for use in artificial wetlands takes into account the potential for the selected species to contribute to mosquito breeding potential of the wetland. Any minor manipulation of natural wetlands to maintain mosquito numbers below the threshold value as determined by the MMP do not result in a change in the natural functioning or integrity (wetland type) of the wetland.

6.2 Saltmarsh modification

K3 runnelling machine used by Redland City Council

Objective: To reduce mosquito breeding in selected areas of saltmarsh through runnelling and to facilitate improving access to treated sites by natural predators of mosquito larvae and pupae.

Runnelling is the main form of modification applied to some suitable saltmarsh wetlands for mosquito control. Runnelling reduces the potential of saltmarsh wetlands to support mosquito larvae by increasing tidal flushing and improving access of predators to marshland. It may also lead to reduced egg laying by adult mosquitoes.

Where appropriate, this form of habitat modification can be an effective component of an integrated mosquito management program. However, there are environmental consequences that may occur when runnelling programs are implemented, such as the necessary disturbance to marine plants and resultant increased wetness of saltmarsh substrates. Implementation of runnelling must minimise the risk of any long term effects on saltmarsh communities (refer Table 5).

Runnel construction

Any proposal for runnelling as an option for minimising mosquito breeding in intertidal salt marshes must be accompanied by a thorough evaluation of the site to determine the potential of the site for habitat modification, expected environmental impacts of such action and extent of anticipated mosquito control.

Before modifying any intertidal wetlands, approvals may be required from Fisheries Queensland (a division of DAFF) under the *Fisheries Regulation 2008* and self-assessable development codes may be required under the *Sustainable Planning Regulation 2009*. Department of Environment and Heritage Protection approvals may also be required. These agencies have full details of requirements that must be met and likely conditions that would be imposed. A list of contacts and information sources is provided in this Code of Practice (refer to Section 9).

For more information, contact Fisheries Queensland regarding:

- Removal or damage of tidal fish habitats (e.g. mangroves and saltmarsh vegetation) (protected under *Fisheries Act 1994, s123*);
- Where works are proposed within a declared Fish Habitat Area (fisheries resources are protected in declared Fish Habitat Area under *Fisheries Act 1994, s122*); and
- Self-assessable development codes.

Runnelling is a self-assessable development under Code MP06

Queensland runnelling programs involving marine plant disturbance and/or performed in a declared Fish Habitat Area (FHA) are covered under self-assessable development code *Minor impact works in a declared fish habitat area or involving the removal, destruction or damage of marine plants* (MP06). Code MP06 covers the development of runnelling programs and management issues such as harm to marine plants, erosion, spoil disposal, and the disturbance of acid sulphate soils. Prescribed requirements include:

- Preparation of a MMCOP Mosquito Management Program (endorsed by Fisheries Queensland)
- Methods and designs for runnelling
- Notification and on-site signage
- A resource allocation authority in a declared FHA (*Fisheries Act 1994)*.

Runnel maintenance is a self-assessable development under Code MP02

Maintenance of runnels is covered under self-assessable development code *Maintenance works on existing lawful structures (other than powerlines and on-farm drains) in a declared fish habitat area or involving the removal, destruction or damage of marine plants* (MP02*)*.

Activities outside Code MP02 and MP06 require a fisheries development approval (*Fisheries Act 1994* and *Sustainable Planning Act 2009)*. See the following website for current information on DEHP approvals:
http://www.qld.gov.au/environment

The issues that DEHP would assess under the coastal plan would be:

- Destruction of areas of high ecological significance or marine ecological significance mapped under the Coastal Plan.

- Erosion issues associated with works (the CMD encompasses the erosion prone zone).
- Sediment transport process and other coastal processes (under the SPP works in the CMD are required to prevent impacts on these).
- Any changes to storm tide inundation offsite.

Overall the impacts are likely to be small, but the works will trigger assessment by DEHP under the legislation.

Table 5. Accepted design and construction practices for runnelling in marine wetlands

Specific runnelling issues	Accepted practices for runnelling in marine wetlands	Requirements for compliance with the Mosquito Management Code of Practice
Erosion control	There is potential for marine wetlands to become eroded during both the construction and operational phases of runnelling programs. Erosion control measures are generally covered in any approvals or permits required for runnelling works.	Erosion resulting from the installation or operation of a runnelling system occurs to an extent that exceeds limits imposed by the applicable self-assessable development codes, permits or approvals, is reported to the agency/agencies responsible for the initial approval or permit.
Acid sulphate soils	Marine wetlands are highly likely to contain potential acid sulphate soils that will vary in depth below the soil surface. The issue of acid sulphate soils (ASS) or potential acid sulphate soils (PASS) is generally covered in any approvals or permits required for the runnelling works.	ASS disturbed during installation of a runnelling system, or during its operation, to an extent that exceeds limits imposed by the applicable self-assessable development codes, permits or approvals, then the situation must be reported to the attention of the agency/agencies responsible for the initial approval or permit.
Noise management	Some runnel construction machinery has the potential to produce noise emissions that are particularly noticeable because of the openness of the areas being treated. These noise emissions may disturb local residents and certain fauna, particularly wading/migratory bird species. The planning of runnelling activity therefore needs to take into account timing of operations and any likely adverse environmental impact.	Regular maintenance is to be carried out according to the recommendations of the manufacturer of the runnelling machinery to ensure that noise levels are kept within the design specifications of this equipment. Construction work occurs only during normal working hours (7 am to 6 pm). Where it may be imperative that works occur outside of normal working hours to take advantage of low tidal ranges and dry conditions. If this occurs, the surrounding community is to be advised as soon as feasible of the proposed operations. Construction work is not scheduled to coincide with feeding or roosting activity of wading/migratory bird species.
Spill management	Refer to the section on staff training and operational procedures Table 11.	

6.3 Biological control

Objective: The objective of the biological control component of the integrated mosquito management program is to keep mosquito populations within acceptable limits as determined in MMPs through the use of biological agents. At the same time, aquatic ecosystems must be protected from adverse influences of the biological agents.

For details on acceptable practices for the biological control of mosquitoes refer to Table 6.

Department of Agriculture, Fisheries and Forestry Approvals

Fisheries Queensland (DAFF) administers fish stocking restriction in Queensland waters under the *Fisheries Act 1994* and *Fisheries Regulation 2008*. Stocked fish species must be native to drainage basin locations. Possessing or releasing non indigenous fish is an offence, (Section 90 of the *Fisheries Act 1994*).

Stocking public waters (dams, streams and other waterways) with fish to increase predation of mosquito larvae requires a General Fisheries Permit (stocking crown waters) from Fisheries Queensland (DAFF), in accordance with the *Fisheries Act 1994* and *Fisheries Regulation 2008*. Native fish suitable for use in mosquito control within drainage basins are included in Appendix B. Permits issued for stocking in declared Fish Habitat Areas (*Fisheries Act 1994*) are recognised under Fish Habitat Area Code of Practice 01 (FHACoP 01).

Stocking of private waters, such as farm dams, with fish does not require a Fisheries Queensland (DAFF) permit provided the fish are native to the area.

Table 6. Accepted practices and code compliance for introduction and use of biological agents

Biological control agent	Accepted practices for selection and introduction of biological control agents	Requirements for compliance with the Mosquito Management Code of Practice
Fish	Only native Australian fish species are to be used in any biological control programs (refer *Stocking native fish for mosquito control in fresh waters, Guidelines for local governments, housing developers, community groups and private landowners* (DAFF Guidelines) and to Native Fish for mosquito control (http://www.daff.qld.gov.au). These documents should be used as general advice. Enquiries to determine permit requirements and whether new information is available should be directed to DAFF. Options for the source of fish for stocking, includes the purchase of fish from licensed aquaculturists. The relocation of fish within a river system through collection from the wild is only permitted if using approved recreational apparatus and in accordance with fisheries regulations Adequate documentation is required to gauge the effectiveness, distribution, and impact of fish as a biological control agent. The release of fish needs to be executed in a way that does not facilitate the movement of other introduced species, such as exotic freshwater snails and plant species throughout the drainage basin.	Only fish approved by DAFF may be used in any biological control program. Stocking is undertaken in accordance with *Stocking native fish for mosquito control in fresh waters, Guidelines for local governments, housing developers, community groups and private landowners* (DAFF guidelines). Detailed records of any introductions are kept and maintained. Fish are collected from areas known to be free of exotic plant and aquatic fauna. Water used to transport fish is derived from a source free of exotic plants and fauna.
Other aquatic predators	Invertebrates such as dragon fly nymphs, copepods, water beetles (adults and larvae), and water bugs, that have the ability to act as biocontrol agents should be considered for use in MMPs. These biocontrol agents have potential for increased use, either in areas/situations where useful species are not present, or in areas where they have not reached their maximum effect.	Only native aquatic invertebrates should be used in any biological control or enhancement program. Aquatic invertebrates collected from areas considered to be free of exotic plant and aquatic fauna. Water used to transport aquatic invertebrates is derived from a source considered to be free of aquatic exotic plants and fauna.
Mosquito parasites and pathogens	Development work is being undertaken nationally and internationally on the potential to control mosquitoes by using pathogens and parasites. This work offers potential and may assume greater importance in future biocontrol efforts.	Use of mosquito parasites and pathogens is prohibited unless approved by the Department of Agriculture, Fisheries and Forestry and the Australian Department of Environment and Heritage.
Genetic manipulation	Transfer of genetic material into mosquito species could have major implications for future mosquito control activity.	Use of genetically modified mosquitoes is prohibited unless approved by the Gene Technology Regulator located within the Australian Department of Health and Ageing. The Queensland link to this regulator is through the Biotechnology Regulation Unit located in the Office of the Information Commissioner, Department of Innovation and Information Economy.

More information can be found at http://wetlandinfo.ehp.qld.gov.au/wetlands/ecology/

6.4 Chemical control

Objective: The objective of the chemical control component of IMM is to complement and assist natural and other mosquito control mechanisms in maintaining mosquito populations within acceptable limits determined in MMPs for reasons of public health and community wellbeing, while minimising adverse environmental effects of insecticide use.

DAFF approvals

Biosecurity Queensland (DAFF) administers legislation on application and use of chemicals for mosquito control under the *Agricultural Chemicals Distributions Control Act 1966 (and Regulation 1998)* and the Queensland *Chemical Usage (Agricultural and Veterinary) Control Act 1988* (and *Regulation 1999*).

Use of a pesticide in a declared Fish Habitat Area is permitted under a code of practice (Section 621 *Fisheries Regulation 2008*). Fisheries Queensland (DAFF) administers Fish Habitat Area Code of Practice (FHACoP01) (*Fisheries Act 1994*) for this purpose.

For details on acceptable practices for the use of chemicals in the control of mosquitoes refer to Tables 7 to 10.

General requirements for all chemical control activities

Chemicals used in the control of mosquitoes are applied using ground and aerial application techniques. General guidance on the application of chemicals both from the air and from the ground is as follows:

- Chemicals used must be registered or permitted products for mosquito control.
- Products selected must be used in accordance with manufacturer's specifications (i.e. as per label).
- Treatments must be required/justified taking into consideration the location of any environmentally sensitive areas. Sensitive areas include declared Fish Habitat Areas (*Fisheries Act 1994*) which are covered under FHCoP 001 to ensure activities comply with the MMP.
- Treatments must not be applied prior to a mosquito breeding event unless the product is designed for that purpose.
- All equipment used in chemical control must be calibrated prior to use and maintained so that application rates are consistent with performance specifications of the equipment.
- Chemicals are to be stored in a manner that complies with AS 2507 — 1998 *The Storage and Handling of Agricultural and Veterinary Chemicals*.
- Operators should hold an appropriate licence for the application of mosquito control products as required by relevant State legislation. Where a licence is not required then appropriate training and instruction should be a pre-requisite to the application of chemicals.
- A database should be established to record all monitoring and treatment data.

Aerial Application and Flying Fox Roosts

There are four species of protected flying foxes in Queensland. The Grey-headed and Spectacle Flying Foxes are protected under the federal EPBC Act. The Little Red and Black Flying Foxes are protected under the Queensland Nature Conservation Act. Before undertaking aerial application in an area that contains a flying fox roost, local government should contact

their regional Senior Wildlife Ranger to seek advice and assess whether a Damage Mitigation Permit will be required.

Table 7. Accepted practice and code compliance for the use of chemical agents in aerial larviciding

Specific components of aerial larviciding		Acceptable practice for selection and application of chemicals for aerial larviciding	Requirements for compliance with the Mosquito Management Code of Practice
	Chemical application	Any decision to use aerial larviciding should be made in accordance with the overall MMP, including surveillance activity.	Surveillance activity is carried out on a continuing basis. Level of surveillance to match the sophistication and needs of the MMP.
		Control measures should be effective, well planned and confined to mosquito breeding sites as determined through surveillance activity.	Map mosquito breeding areas and adjacent areas to scale. This will allow for the identification of environmentally sensitive areas and provide the basis for accurate chemical application. Identify appropriate buffers between environmentally sensitive areas and areas to be treated in consultation with the administering authority of such sensitive areas where appropriate. Appropriate wetlands buffer guidelines consulted. Global Positioning Systems (GPS) are used, if available, when mapping mosquito breeding sites and during application of chemicals. Data captured down loaded onto a GIS. Supply pilot with maps clearly indicating • the areas to be treated and • environmentally sensitive areas or activities. (e.g. wetlands, bird roosting or fish spawning) prior to commencing the aerial application of chemicals. Ensure there is adequate signage of possible aerial treatments where these occur around sites such as bikeways and pedestrian tracks. Applicator and treating organisation ensures that formulations are prepared and applied in such a way so as to achieve optimum delivery e.g. even distribution pattern and minimal drift, of the product. This will include an assessment of climatic and flying conditions at the time of application. Controlling authorities should keep a register of persons wishing to be notified of an impending larviciding program. Notification is to be given prior to the treatment.
		Chemicals used in aerial larviciding should be of low toxicity to non-target species and have minimal adverse effects on the environment, to the best of the treatment organisation's knowledge. The selection of chemicals should take into account advances in availability of registered or permitted products.	Chemicals for mosquito control selected on the basis that they are selective against target species and have minimal adverse environmental effects. The chemicals used are specified within the MMP. Post treatment efficacy audits are carried out to document and record effectiveness of treatment and actual application rates.

	Spill management	The risk of spills with aerial application of chemicals occurs principally during reloading, or in the most difficult situation when the aircraft is airborne. The response to these two widely varying situations needs to involve timely action, containment, neutralisation of chemical and notification of relevant agencies.	
		Aircraft reloading	A spill management kit or appropriate clean-up material is carried in every mosquito control vehicle being used to support the aerial operation. Aircraft support crew undergo training in the use of spill management kits prior to commencement of aerial operations.
		Accidental release over targeted or non-targeted area	Where any accidental release of chemical over targeted or non-targeted areas occurs contain the release and remove where feasible, and notify State Emergency Services (if assistance required) and DEHP. Transporting equipment and materials across fragile marshland to be carried out in a way that will minimise impact on the wetland. Light-weight all-terrain work platforms to be used wherever practicable.
	Noise management	Aerial chemical application operations should be carried out in such a way, and using equipment, to minimise noise emissions.	The treating organisation should obtain assurance from the pilot that application equipment is able to operate within design limits. Flight paths over the target area should be planned to minimise noise emission to adjacent residential areas, or undesirable disturbance to wildlife. A register of all complaints should be kept by the treating organisation and be available for review upon request.
	Waste management	Aerial larviciding operations generate waste products that need to be disposed of in an environmentally responsible manner.	For details on code compliance, refer to waste management in Table 11.

Reloading and refuelling as part of an aerial larviciding operation

Table 8. Accepted practice and code compliance for the use of chemical agents in aerial adulticiding

Specific components of aerial adulticiding		Accepted practice for selection and application of chemicals for aerial adulticiding	Requirements for compliance with the Mosquito Management Code of Practice
	Chemical application	Aerial adulticiding should only be considered when there is a public health risk or an emergency situation. Control measures should be confined to mosquito harbourage sites as determined through surveillance activity.	Controlling authorities are to keep a register of persons wishing to be notified of an impending adulticiding program. Notification is to be given, prior to the treatment. Map mosquito breeding areas and adjacent areas to scale. This will allow for the identification of environmentally sensitive areas and provide the basis for accurate chemical application. Determine buffer zones for harbourage areas adjacent to environmentally sensitive areas in consultation with the administering authority for the areas. Appropriate wetlands buffer guidelines should be consulted. Global Positioning Systems (GPS) are to be used, if available, when mapping harbourage sites and during application of chemicals. Supply pilot with maps clearly indicating • the areas to be treated and • environmentally sensitive areas or activities. (e.g. bird roosting or fish spawning) prior to commencing the aerial application of chemicals. Ensure there is adequate signage of possible aerial treatments where these occur around sites such as bikeways and pedestrian tracks. The pilot shall make an assessment of the flying and climatic conditions prior to commencing the chemical application. The pilot and treating organisation to ensure that droplet size of liquid formulations is such that active ingredient reaches only the targeted area.
		Chemicals used in aerial adulticiding are in general more toxic and less selective than chemicals available for larviciding. This should be considered during planning of aerial operations. The selection of chemicals should also take into account technical advances in registered products.	Emphasis should be given to the selection of chemicals that are selective against the target species and have minimal adverse environmental effects. Post treatment efficacy audits are carried out on a routine basis to document and record effectiveness of treatment and actual application rates.
	Spill management	The likelihood of spills occurring is comparable with aerial larviciding.	For details on code compliance, refer to spill management in Table 7.
	Noise management	Operational aspects are similar to aerial larviciding.	For details on code compliance, refer to noise management in Table 7.
	Waste management	Aerial adulticiding operations generate waste products, usually more toxic than aerial larviciding waste products, that need to be disposed of in an environmentally responsible manner.	For details on code compliance, refer to waste management in Table 11.

Table 9. Accepted practice and code compliance for the use of chemical agents in landbased larviciding

Specific components of landbased larviciding		Accepted practice for selection and application of chemicals for landbased larviciding	Requirements for compliance with the Mosquito Management Code of Practice
	Chemical application	Any decision to use landbased larviciding should be made in accordance with the overall MMP, including surveillance activity. Control measures should be confined to mosquito breeding sites as determined through surveillance activity.	Surveillance activity to be carried out in accordance with the level of surveillance required to match the sophistication and needs of the MMP. Identify and map mosquito breeding areas and adjacent areas to scale. This allows for the identification of environmentally sensitive areas and provides the basis for accurate chemical application. For more information see http://wetlandinfo.ehp.qld.gov.au/wetlands/MappingFandD/WetlandMapsAndData.html Determine buffer zones for harbourage areas adjacent to environmentally sensitive areas in consultation with the administering authority for such sensitive areas. Global Positioning Systems (GPS) are to be used if available when mapping mosquito breeding sites and during application of chemicals. Persons applying larvacides to be supplied with maps clearly indicating the areas to be treated and any environmentally sensitive areas. Application techniques must be able to deliver accurate and uniform distribution of the insecticides to provide the basis for effective control. Equipment for the application of chemicals is used in accordance within the manufacturer's instructions and the equipment's capabilities to reduce the potential for any environmental impact (eg, tracks, wheel ruts, and vegetation damage).
		Chemicals used in land based larviciding should be of low toxicity to non-target species and have minimal adverse effects on the environment, to the best of the treatment organisation's knowledge. The selection of chemicals should take into account advances in availability of registered or permitted products.	Chemicals for mosquito control should be selected on the basis that they are effective against target species and have minimal effects on non-target species and minimal adverse environmental effects. Products must be applied at label rates recommended for land based application. Post treatment efficacy audits are carried out on a routine basis to document and record effectiveness of treatment and actual application rates.

	Spill management	Areas selected for treatment for mosquitoes are often vulnerable to chemical spills. Precautions such as offsite refilling and minimisation of quantities of chemical taken on-site need to be adopted on all such areas to minimise risks.	For details on code compliance, refer to spill management in Table 11.
	Noise management	Land based chemical application operations should be carried out in a way that will minimise noise emissions.	For details on code compliance, refer to Table 11 (noise management for ground based larviciding and adulticiding operations).
	Waste management	The use of chemicals for mosquito control generates waste products that need to be disposed of in an environmentally responsible manner.	For details on code compliance, refer to Table 11 (waste management).

Landbased larviciding operation in saltmarsh

Table 10 Accepted practice and code compliance for the use of chemical agents in landbased adulticiding

Specific components of landbased adulticiding		Accepted practice for selection and application of chemicals for landbased adulticiding	Requirements for compliance with the Mosquito Management Code of Practice
	Chemical application	Any decision to use landbased adulticiding to control adult mosquitoes should be made in accordance with the overall MMP, including surveillance activity. Landbased adulticiding operations should not be regarded as an alternative to biological control, habitat modification or larviciding operations. Control measures should be confined to areas where mosquito populations have exceeded or are about to exceed threshold limits as determined in the MMP.	Surveillance activity to be carried out in accordance with the level of surveillance required to match the sophistication and needs of the MMP. Identify and map proposed treatment sites to scale. This allows for the identification of environmentally sensitive areas and provides the basis for accurate chemical application. Identify appropriate buffers between environmentally sensitive areas and areas to be treated, in consultation with the administering authority of such sensitive areas where appropriate. Global Positioning Systems (GPS) are to be used, if available, when mapping breeding sites and during application of chemicals. Maintain a register of persons wishing to be notified of an impending adulticiding program. Notification is to be given prior to the treatment. Persons applying adulticides are to be supplied with maps/information that clearly indicates the areas to be treated and any environmentally sensitive areas which are not to be impacted. Application techniques must be able to deliver accurate and uniform distribution of the insecticides to provide the basis for effective control. Applicators are to ensure that equipment for the application of chemicals is used, within the capabilities of such equipment to be operated in sensitive areas, without causing environmental impact (eg, tracks, wheel ruts, and vegetation damage).
		Chemicals used in land based adulticiding should be of low toxicity to non-target species and have minimal adverse effects on the environment. The selection of chemicals should take into account technical advances in availability of registered or permitted products.	Chemicals for mosquito control should be selected on the basis that they are effective against target species and have minimal effects on non-target species and minimal adverse environmental effects. Post treatment efficacy audits need to be carried out on a regular basis to document and record effectiveness of treatment and actual application rates.

	Spill management	Areas selected for treatment for mosquitoes are often vulnerable to chemical spills. Adequate precautions need to be adopted on all such areas to minimise risks. This includes transporting chemicals to the treatment site.	For details on code compliance refer to spill management for landbased larviciding and adulticiding in Table 11.
	Noise management	Land based chemical application operations should be carried out in a way that will minimise noise emissions.	For details on code compliance, refer to Table 11 (noise management for ground based larviciding and adulticiding operations).
	Waste management	The use of chemicals for mosquito control generates waste products that need to be disposed of in an environmentally responsible manner.	For details on code compliance, refer to Table 11 (waste management).

7.0 Training and awareness

The application of insecticides and the carrying out of other mosquito management operations must be achieved in a way that has regard to the environment. The effectiveness and quality of work undertaken will depend on the level of skill and competence of staff involved. As such, considerable emphasis needs to be placed on the qualifications, supervision and training of staff involved in mosquito management operations (refer Table 11).

Objective:
To minimise environmental impacts through the training and awareness of personnel involved in mosquito management.

Operator care is required in sensitive habitats.

Table 11 Accepted practices and code compliance for personnel actively involved in mosquito management

Specific interest areas	Accepted practices for personnel involvement in mosquito control operations	Requirements for compliance with the Mosquito Management Code of Practice
Qualifications and training of personnel involved in applying chemicals for mosquito control	Personnel involved in controlling mosquitoes through the application of chemicals should be trained and where required under the *Pest Management Act 2001* and the *Pest Management Regulation 2003* hold relevant qualifications.	Develop standard operating procedures to ensure only appropriately trained and licensed personnel undertake chemical application activities.
Standard operating instructions for equipment	Personnel required to operate mosquito control equipment must be competent to use such equipment and need to receive training in its use.	Mosquito control workers to be appropriately trained in the correct use of any equipment being used for mosquito control purposes, e.g. all-terrain vehicles, adulticiding equipment, and larviciding equipment.
Special skills and competences	An increase in the efficiency of mosquito control activities, and the selection and awareness of different approaches to mosquito control should be promoted through development of knowledge and skill base of staff involved in mosquito management	Mosquito control workers must complete an appropriate course in mosquito control which may address but is not limited to the following: - Basic mosquito biology; - Calibration of equipment; - Safe practice in pesticide handling/application; - Mosquito surveillance; - Collecting and recording of mosquito samples; - IMM; - Chemical control; - Waste handling and spill management; - Biological control; and - Habitat modification. Ongoing training and skill development is required to maintain qualifications and the skills of personnel involved in mosquito management.
Spill management during runnelling works	Operating runnelling machinery within sensitive marine marshlands is feasible but due to the sensitivity of these environments, special precautions need to be taken to ensure that routine equipment maintenance operations are given additional attention. Potential contaminants should be as benign as technically possible.	Where practical, any fluids which can be replaced with vegetable oils are so replaced (e.g. lubricants for hydraulic parts). Refuelling of the machine is carried out off the marsh (similarly for replacement of any liquids, except water). Regular maintenance of equipment is undertaken to reduce potential impacts on the sensitive marine marshlands. Spill management kits or appropriate clean-up materials to be on-site during every runnelling operation. Operators must be trained in how to use the spill management kits and must use such kits when appropriate and as soon as practicable after a spill has occurred.

Spill management for landbased larviciding and adulticiding	The transport and application of chemicals over sensitive and difficult terrain needs to be accomplished in a way that will minimise the risk of occurrence of a spill.	A spill management kit or appropriate clean-up material must be carried in every mosquito control vehicle. Operators must be trained in use of spill management kits and must use such kits when appropriate and as soon as practicable after a spill has occurred. Chemical containers must be securely attached to work platforms and be of a construction that will prevent spillage should the container be tilted or overturned.
Waste management	Waste products generated during the use of chemicals for mosquito control need to be disposed of in an environmentally responsible manner. The nature of the areas where controls are often carried out is conducive to misplacement and loss of containers. Most mosquito breeding areas are environmentally sensitive and procedures need to be in place to ensure that all waste products are removed from the treatment site.	Treating organisation has a container audit system in place to ensure containers are accounted for each day during the application of chemicals and on completion of works. Containers where possible to be recycled. Where this is not possible containers are to be triple rinsed, punctured and disposed of at an approved site. Return expired chemicals to the manufacturer if possible, or dispose of at an approved place.
Noise management	Land based chemical application operations should be carried out in a way that will minimise noise emissions.	Insecticide application equipment is used within the manufacturer's specifications to limit noise emission. Regular maintenance must be carried out on ground application equipment in accordance with the manufacturer's recommendations. Limit the duration of noise emissions from chemical application operations in areas adjacent to residential areas or where wildlife disturbance may occur. A register of all complaints should be kept by the treating organisation.

8.0 Emergency response

Mosquitoes can be a major problem during or following a major event such as flooding caused by rainfall, major runoff or storm surge. Should a State of Disaster be declared for such an event under the *Disaster Management Act 2003* (DMA 2003), then the matters being addressed by the State of Disaster may no longer be subject to the provisions of the EP Act.

However, the *Disaster Management Act 2003* prevails when there is an inconsistency with the provisions of any other Act. Environmental protection will therefore only be compromised when there is inconsistency between the provisions of these two Acts.

There is a trend for disaster situations to be handled at the local level without the need for declaring a State of Disaster. This will place increasing importance on planning procedures to mitigate against the effects of particular events and to allow effective remedial and recovery responses.

There is also potential for an emergency situation to arise if there is a major accidental or natural introduction of exotic mosquitoes or there is an outbreak of mosquito borne disease in Queensland.

For acceptable practices for mosquito control during emergency situations refer to Table 12.

The *Public Health Act 2005* makes provision to address public health emergencies (chapter 8) and when a public health emergency is declared under the *Public Health Act 2005* allows for the exercise of considerable powers to meet the emergency, the provisions of the EP Act still apply. This would also be the case with the *Exotic Diseases in Animals Act 1981* that could require the control of mosquitoes as part of a program to control exotic disease in animals.

Objective: To minimise the environmental impact of mosquito control during emergency situations while still meeting the objectives and aims of programs and activities instigated when an emergency arises.

Table 12. Accepted practices and code compliance for mosquito management activity performed during emergency situations.

Specific interest areas	Accepted practice for mosquito control operations in emergency situations	Requirements for compliance with the Mosquito Management Code of Practice
Mosquito control during a disaster situation	Mosquitoes should only be controlled during a disaster situation in a way that minimises or prevents environmental harm, taking into account priorities, resources and the range of issues that need to be dealt with in the area of the disaster situation.	A section on mosquito management and control is considered for inclusion in each local counter disaster plan prepared by local government, if the issue of mosquito control is probable under any of the disaster scenarios addressed by the counter disaster plan. The Mosquito Management Code of Practice is considered and used in the development of the section on mosquito management in local counter disaster plans. The component of counter disaster plans that deals with mosquito control is reviewed every twelve months for purposes of including up-to-date control techniques (particularly chemicals), having the least detrimental impact on the environment. Mosquito control operations undertaken during a State of Disaster are in accordance with the Mosquito Management Code of Practice where no inconsistency between the EP Act and the Disaster Management Act 2003 (DMA 2003) exists.
Mosquito control following a disaster situation, and when an emergency situation has been established in accordance with legislation other than the DMA 2003	Mosquito control should only be carried out in a way that minimises or prevents environmental harm, while taking into account the reason for which the emergency has been established and any mosquito management or control work done during the disaster situation.	Mosquito control programs need to take into account previous activity undertaken during a disaster situation and the content of relevant sections of counter disaster plans and integrated MMPs. Mosquito management and control activities undertaken during an emergency situation should be guided by the government agency responsible for administering the legislation under which the emergency has been established. Mosquito control operations undertaken during an emergency situation should be in accordance with the Mosquito Management Code of Practice unless the code contains provisions that would prevent effective abatement of the emergency situation. Any diversion from the code should be done in consultation with the DEHP.
Establishment of an emergency situation, other than by the DMA 2003, requiring mosquito control	The response to disease outbreaks, and the introduction and establishment of exotic mosquitoes with the potential to expand the vector base for existing or exotic diseases should be developed taking guidance from the Mosquito Management Code of Practice.	The Mosquito Management Code of Practice should be considered when mosquito control is being planned and implemented under an emergency situation. Mosquito control activities to be guided by the government agency responsible for administering the legislation allowing the emergency to be established. Diversion from the code for purposes of enabling an emergency situation to be brought to a satisfactory solution should be done in consultation with the DEHP.

9.0 General information and contact sources

Contacts:

Mosquito Control Association of Australia Inc.
Secretary MCAA
Queensland Health
Bryden St
WINDSOR QLD 4030
Email: mcaa@winshop.com.au

Mosquito and Arbovirus Research Committee Inc.
Mosquito Management Group
Brisbane City Council
GPO Box 1434 QLD 4001
Phone: 07 3403 0848

Local Government Association of Queensland
PO Box 2230
Fortitude Valley BC QLD 4006
Phone: 1300 542 700

Queensland Health
Communicable Diseases Branch
Queensland Health
PO Box 2368
Fortitude Valley BC QLD 4006
Ph: 07 3328 9724

Department of Agriculture, Fisheries and Forestry
DAFF Business Information Centre 13 25 23

Department of Environment and Heritage Protection
Permit and Licence Management
GPO Box 2454
Brisbane QLD 4001
Phone: 13 QGOV (13 74 68)
Fax: (07) 3330 5875
Email: palm@ehp.qld.gov.au

Fisheries Queensland
Phone: 13 25 23

Reference sources

Australian Mosquito Control Manual. Revised 3rd edition 2008. Published by Mosquito Control Association of Australia. (See website below to order).

Russell, R C. 1993. *Mosquitoes and mosquito-borne disease in Southeastern Australia*. University of Sydney, Department of Medical Entomology, Westmead Hospital, Westmead, NSW. (Currently out of print).

Websites:

American Mosquito Control Association.

Comprehensive resource with many links around the world.

http://www.mosquito.org/

Mosquito Control Association of Australia Inc.

http://www.mcaa.org.au/

University of Sydney – Medical Entomology.

Excellent site with good Australian information and good links.

http://medent.usyd.edu.au/

Dengue website – Queensland Health

http://www.health.qld.gov.au/dengue/

DEHP websites

Wetland Info - http://wetlandinfo.ehp.qld.gov.au/wetlands/index.html

10.0 Glossary

Adulticiding	Application of chemicals to control adult mosquitoes
APVMA	Australian Pesticides and Veterinary Medicines Authority
BF	Barmah Forest virus
CHIK	Chikungunya
DAFF	Department of Agriculture, Fisheries and Forestry
DEHP	Department of Environment and Heritage Protection
EPA	Environmental Protection Agency
MMP	Mosquito Management Program
IMM	Integrated Mosquito Management
JE	Japanese encephalitis
KUN	Kunjin virus
Larviciding	Application of chemicals to mosquito breeding sites to control larvae
MARC	Mosquito and Arbovirus Research Committee Inc.
MCAA	Mosquito Control Association of Australia Inc.
MVE	Murray Valley encephalitis
NRA	National Registration Authority
QFS	Queensland Fisheries Service
QPWS	Queensland Parks and Wildlife Service
RR	Ross River virus
Runnelling	Refers to the construction of shallow spoon shaped channels in intertidal wetlands to enhance natural movement of water on and off the intertidal area, by connecting pools to the tidal source

Appendices

Appendix A

Example framework for use in the development of a Mosquito Management Program

(The wide variation in areas and localities that require some form of mosquito control will influence the final form of a Mosquito Management Program (MMP). Its complexity will depend on such things as the scale, local characteristics and environmental sensitivity of the area involved).

	MMP required as determined by: historical evidence, health risk assessment, and surveillance information.	
Mosquito Management Program Framework		
	Features	**Matters for consideration**
1	Mapping and identification of mosquito breeding sites and adjacent inhabited areas.	Mapping should include sensitive sites such as: ➢ National Parks ➢ World Heritage areas ➢ International agreement areas ➢ Conservation parks ➢ Designated Landscape Areas - Cultural heritage ➢ Areas supporting endangered fauna ➢ Wetlands including artificial wetlands (nationally significant wetlands should be given particular attention) For data on the above sensitive areas, contact DEHP. ➢ Fish Habitat Areas For location and information on Fish Habitat Areas, contact DAFF Mapping could also include zones indicating levels of disease incidence, incidence of mosquito species, and mosquito habitat variability (for example areas where weed invasion is occurring or where weed control programs are being instigated). Queensland Wetland Mapping is a good mapping base – see http://wetlandinfo.ehp.qld.gov.au/wetlands/facts-maps/
2	Mosquito management strategies	Mosquito Management Program strategies could cover: ➢ An overall approach to environmentally sound, effective and cost efficient mosquito management in the area involved including specific goals and outcomes. ➢ Cooperative and partnership arrangements to manage mosquitoes in a regional context. ➢ Arrangements to cater for mosquito control in extraordinary situations such as during emergencies.
3	Administrative support for MMP	Funding ➢ The funding allocation for the MMP should preferably identify funding for the various components of the MMP. Staff ➢ The MMP should specify the requirement for staff that are qualified and appropriately trained to undertake the program. Equipment ➢ Specialised equipment is generally required to enable various components of a MMP to be undertaken in an effective and efficient manner. Equipment required for surveillance, habitat modification or application of chemicals should be identified within the MMP and provision made for maintenance, calibration (where necessary), and updating. Standard operating procedures (SOPs) ➢ Consistency and reliability in mosquito management operations can be enhanced through the provision of standard operating procedures to assist staff when using equipment and applying chemicals. The MMP should promote the development and use of such SOPs.

4	Treatable thresholds	For overall mosquito populations (that are implicated in disease transmission) ➢ For basic MMPs differentiation between mosquito species causing concern will be minimal. To account for this and to minimise the potential to impact on mosquito species that are not implicated in human health greater emphasis should be given to other indicators such as habitat type and historical information. For individual species ➢ The more sophisticated MMPs may achieve thresholds for particular species. The advantages of this are that the most effective, and the most environmentally sound treatment can be selected to fit specific situations.
5	Surveillance	Disease incidence ➢ The reason for undertaking mosquito management activity is related to human health. Queensland Health should be used as a major source for data and advice on disease incidence. Mosquito populations (eggs, larvae and adults) ➢ Most MMPs can be expected to pay particular attention to surveillance of mosquito populations as it is through this mechanism that thresholds can be determined.
6	Training	Staff ➢ Trained and proficient staff are essential to the success of every MMP. MMPs should address training needs to ensure that the outcomes and goals of the MMP are met and that the risk of causing environmental harm is minimised.
7	Emergency response	Emergency situations ➢ There are a number of situations that will have a major impact on how MMPs are executed. The main situations identified are: ♦ Extreme environmental events; ♦ Disease outbreaks; and ♦ New vectors. The MMP should therefore link to local counter disaster plans.
8	Local Government Environmental Programs	Environmental programs ➢ Broad environmental programs that are being developed and implemented by some local governments have considerable relevance to mosquito management. As such MMPs should take into account wider environmental programs to ensure that synergies are developed particularly in areas such as wetland protection and management, weed control and rehabilitation and restoration of degraded sites.
9	Research	Those MMPs that place emphasis on habitat modification and chemical usage could be expected to promote opportunities to determine ways by which mosquito management activities can be undertaken so that environmental harm is minimised.
10	Review and evaluation	Time period for review ➢ MMPs should be reviewed at least every three years to determine how the program can be refined and improved. Matters that should receive specific attention in the review include effectiveness of environmental protection measures included in the program, evaluation of chemicals used in the program and likely replacement products, effectiveness of surveillance and whether the goals and outcomes are being met. ➢ Through review and evaluation best practice is maintained ensuring that there is continuous improvement in how mosquitoes are managed with emphasis placed on reducing environmental impacts as opportunities arise (such as through use of new products and adoption of improved mosquito management techniques).

The following sections have particular relevance to development of an Integrated Mosquito Management Program within the MMP

	Features	Matters for consideration
1	Public education	Community tolerance and avoidance of pest mosquitoes ➢ Encourage greater understanding of the mosquito species that are of concern, how they can be avoided and the place of mosquitoes in natural ecosystems. ♦ The advantages of such an activity are less insecticide usage and less demand for habitat modification. Personal protection ➢ Encouragement of individuals within the community to take greater responsibility for their own protection against mosquitoes is an important component of IMM. ♦ This has the potential to lead to lower disease incidence and less demand for use of insecticides. Environmental protection ➢ Some of the habitats preferred by mosquitoes are also sensitive environments and have particular environmental values. This is not readily understood by the general community and attention needs to be given to this aspect in IMM. ♦ Improved understanding about sensitive environments by the community will enhance support for MMPs that utilise a wide range of mosquito management measures. Community engagement ➢ Involvement and assistance of the community, and participative and cooperative approaches. ♦ The community can have considerable resources to assist in identification and monitoring of mosquito breeding habitat. Integrated Mosquito Management should incorporate procedures to tap into the resources of the community to enhance the overall MMP where possible.
2	Source reduction	Domestic ➢ Reduction of breeding sites associated with human habitation and activity. Industrial ➢ Reduction of breeding sites associated with industrial activity. Public lands ➢ Reduction of breeding sites associated with parks and certain public places.
3	Habitat modification	Marine wetlands Freshwater wetlands Artificial wetlands Drainage systems (built forms) ➢ In the above situations habitat modification can be an important mechanism to reduce mosquito breeding, where feasible and desirable. ♦ This can result in reduction in insecticide use but it also has the potential to adversely impact on various non-target species.

4	Biological control	Fish and other aquatic organisms ➢ Reduction in productive capacity of mosquito breeding sites ♦ Results in sustainable lowering of mosquito numbers and avoids environmental contamination by insecticides. The disadvantage is that a stocked population will impact on naturally occurring populations and ecosystems.
5	Use of insecticides	Aerial larviciding and land based larviciding ➢ Any aerial and landbased larviciding selected for use should have low toxicity to non-target species in the aquatic environment. ♦ Larvicides have the potential to prevent mosquitoes completing their life cycle to the adult stage and then dispersing to populated areas. Aerial adulticiding and landbased adulticiding ➢ For both aerial and landbased adulticiding, insecticides selected for use should have the lowest capacity to cause environmental degradation. ♦ Adulticiding should only be incorporated in IMM as a means to achieve control of mosquitoes that have been missed by other control measures. The disadvantage of using adulticiding insecticides is that they may impact on non-target species.

Appendix B

Drainage basins of Queensland and native fish suitable for mosquito control in these drainage basins

East Coast Drainage Division:					
No.	**Name**	**No.**	**Name**	**No.**	**Name**
101	Jacky Jacky Creek	117	Black River	133	Boyne River
102	Olive–Pascoe River	118	Ross River	134	Baffle Creek
103	Lockhart River	119	Haughton River	135	Kolan River
104	Stewart River	120	Burdekin River	136	Burnett River
105	Normanby River	121	Don River	137	Burrum River
106	Jeannie River	122	Proserpine River	138	Mary River
107	Endeavour River	123	Whitsunday Island	139	Fraser Island
108	Daintree River	124	O'Connell River	140	Noosa River
109	Mossman River	125	Pioneer River	141	Maroochy River
110	Barron River	126	Plane Creek	142	Pine Rivers
111	Mulgrave – Russell Rivers	127	Styx River	143	Brisbane River
112	Johnstone River	128	Shoalwater Creek	144	Stradbroke Islands
113	Tully River Murray	129	Water Park Creek	145	Logan – Albert River
114	River Hinchinbrook	130	Fitzroy River	146	South Coast Rivers
115	Island Herbert River	131	Curtis Island		
116		132	Calliope River		
Murray Darling Drainage Division:					
No.	**Name**	**No.**	**Name**	**No.**	**Name**
416	Border Rivers	422	Condamine River	424	Paroo River
417	Moonie River	423	Warrego River		

Gulf of Carpentaria Drainage Division:					
No.	**Name**	**No.**	**Name**	**No.**	**Name**
910	Settlement Creek	917	Gilbert River	924	Embley River
911	Mornington Island	918	Staaten River	925	Wenlock River
912	Nicholson River	919	Mitchell River	926	Dulhunty River
913	Leichhardt River	920	Coleman River	927	Jardine River
914	Morning Inlet	921	Holroyd River	928	Torres Strait Islands
915	Flinders River	922	Archer River		
916	Norman River	923	Watson River		
Lake Eyre Drainage Division:					
No.	**Name**	**No.**	**Name**	**No.**	**Name**
001	Georgina River	003	Cooper Creek	007	Hay River
002	Diamantina River	004	Lake Frome		
Bulloo – Bancannia Drainage Division:					
No.	**Name**				
011	Bulloo River				

Native fish suitable for mosquito control in Queensland drainage divisions

Common name	Scientific Name	Basins
Agassiz's perchlet (olive perchlet)	*Ambassis agassizii*	134-146; 416-424
Crimson-spotted rainbowfish	*Melanotaenia fluviatilis*	416-424
Chequered rainbowfish	*Melanotaenia splendida inornata*	910-928
Desert rainbowfish	*Melanotaenia splendida tatei*	001-007: 011
Duboulay's rainbowfish	*Melanotaenia duboulayi*	134-146
Eastern rainbowfish	*Melanotaenia splendida splendida*	101-133
Empire gudgeon	*Hypseleotris compressa*	101-146; 910-928
Firetail gudgeon	*Hypseleotris galii*	134-146
Fly-specked hardyhead	*Craterocephalus stercusmuscarum fulvus*	101-146
Mueller's perchlet	*Ambassis muelleri*	001-007
Northern purple-spotted gudgeon	*Mogurnda mogurnda*	910-928
Pacific blue-eye	*Pseudomugil signifer*	110-146
Southern purple-spotted gudgeon	*Mogurnda adspersa*	110-146

Source: QDPI (1999) — *Native fish as alternatives to the exotic fish, Gambusia for mosquito control*, DPI Note, Queensland Department of Primary Industries, f99001.