Department of
Sustainability and
Environment

Framework for Mosquito Management in Victoria

Victoria
The Place To Be

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Framework for Mosquito Management in Victoria

July 2004

Acknowledgments

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Acronymns

AAV	Aboriginal Affairs Victoria
ATV	All terrain vehicle
BFV	Barmah Forest Virus
CAMBA	China-Australia Migratory Birds Agreement
DHS	Department of Human Services
DPI	Department of Primary Industries
DSE	Department of Sustainability and Environment
ECC	former Victorian Environment Conservation Council
EPBC	Environment Protection and Biodiversity Conservation (Act)
FFG	Flora and Fauna Guarantee (Act)
GIS	Geospatial information system
MVE	Murray Valley Encephalitis
IGAE	Intergovernmental Agreement on the Environment
IMM	Integrated mosquito management
IPM	Integrated pest management
JAMBA	Japan-Australia Migratory Birds Agreement
KUN	Kunjin Virus
LCC	former Victorian Land Conservation Council
MRG	Mosquito reference group
PV	Parks Victoria
RRV	Ross River Virus
VIAS	Victorian Institute of Animal Science
VATF	Victorian Arbovirus Task Force
WHO	World Health Organisation

CONTENTS

1. Introduction

1.1 Purpose

Effective mosquito management requires an integrated approach. Such an approach incorporates a statutory framework, policies, guidelines, practices and consultative mechanisms. The approach facilitates best practice, respects and balances competing concerns and interests and is acceptable to key stakeholders.

The four major stakeholders in mosquito management in Victoria are the Department of Human Services (DHS), local government, the Department of Sustainability and Environment (DSE) and Parks Victoria (PV). These stakeholders have different interests and responsibilities. This framework provides strategic and coordinated guidance for the development of future mosquito management programs throughout the State.

Victoria is committed to sustaining and improving community health, protecting the environment for future generations and promoting sustainable development[1]. The purpose of this agreed strategic framework is to assist councils and State government agencies to implement local mosquito management programs in an effective and environmentally appropriate manner, consistent with these commitments. The Framework has been developed following extensive consultation with government agencies, councils and environment and community organisations (Appendices 1 and 2).

1.2 Current situation

More than 275 species of mosquitoes are found in Australia. Fortunately, only a few species bite humans and fewer still are vectors of human diseases. Arboviruses (arthropod borne viruses) are viruses transmitted by mosquitoes. In Victoria they can cause Murray Valley Encephalitis (MVE), Ross River Virus (RRV) and Barmah Forest Virus (BFV) diseases. Other arbovirus diseases reported in Victoria (such as dengue fever) have been acquired interstate or overseas.

Both RRV and BFV diseases are considered endemic throughout Victoria. The number of cases per year varies widely depending on seasonal and other conditions (Table 1). Almost 1300 cases were reported in 1993, but only 55 in 1995. RRV and BFV can be debilitating but not fatal. Major outbreaks of Murray Valley Encephalitis occurred in Victoria 1918, 1951, 1956 with the most recent reported cases in 1974. In that year, 58 cases were recorded, 13 of which were fatal. MVE and Kunjin (KUN) virus, a less virulent virus, are classed as *flaviviruses*. One case of Sindbis was reported in 1999.

Table 1. Arbovirus notifications, Victoria. 1992-2002

Notified diseases	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Ross River Virus	152	1216	62	25	138	1061	113	263	316	357	38
Barmah Forest Virus	21	63	11	7	41	42	17	15	18	19	59
Flavivirus	20	17	10	19	6	6	20	1	13	17	20
Unspecified	0	0	0	4	2	0	24	45	16	5	0
Sindbis virus	0	0	0	0	0	0	0	1	0	0	0
TOTAL	**193**	**1296**	**83**	**55**	**187**	**1109**	**174**	**325**	**363**	**398**	**117**

Kangaroos, wallabies and possums are the most likely natural hosts for RRV but little is known of the hosts of BFV. MVE hosts are humans, other mammals and birds. In Victoria, the localities at most risk of these diseases are rural areas along the Murray Valley, and lower Loddon, Campaspe and Goulburn Valleys in northern Victoria. There is also a significant incidence of RRV and BFV diseases in the coastal areas of Gippsland in southern

Victoria. Disease risk is high where vector mosquito numbers are abundant. Local conditions of irrigation and drainage management, rainfall, tidal fluctuation and temperature are important determinants of mosquito numbers. The impacts of global warming could also see an increase in the number and range of mosquito-borne diseases in the future.

Mosquito species differ in their distribution within Victoria. Appendix 3 sets out the characteristics of the species most frequently trapped in Victoria[2]. It shows that the two most significant vectors for RRV and BFV in Victoria are *Culex annulirostris* (also the chief vector for MVE) in Northern Victoria and *Ochlerotatus camptorhynchus* (Southern Saltmarsh Mosquito) mainly found along the southern coastline.

In addition to being disease vectors, mosquitoes also cause considerable nuisance. Pain and annoyance caused by mosquito bites can have a negative impact on community well being and enjoyment. Personal protection through the use of applied repellents, wearing of appropriate clothing and installation of insect screens offers temporary relief but in some situations the sheer density of mosquitoes and severity of biting constrains outdoor activity.

Mosquitoes are part of the natural environment and an integral part of the food chain for a number of terrestrial, amphibian and aquatic animals. Some mosquito breeding sites are in wetlands of high conservation value including wetlands of national and international significance. Mosquito control is a conservation issue because some physical, chemical and biological practices used to control mosquitoes may have unintended negative effects on the environment.

The main mosquito breeding areas are drains and wetlands. Many of Victoria's significant wetlands are on Crown land managed by public land managers. In Victoria councils carry out virtually all non-domestic mosquito management practice for health and amenity purposes, as part of their responsibilities to residents and visitors. During 2002-03, fifteen city and shire councils implemented mosquito reduction programs ranging in cost from $3,000 to $120,000.

Some mosquito control programs are partially funded by DHS as part of its support for disease prevention. To reduce the risk of disease, the DHS program provides funding for the surveillance and management of vector mosquito breeding sites. It also supports educational activities and materials to inform communities and encourage personal and household mosquito control measures. DHS provides funds for training of mosquito monitors in best practice for monitoring and treatment of sites. The program also includes contracting the Victorian Institute of Animal Science (VIAS) to identify and screen mosquitoes collected from around Victoria for viruses, as well as testing chickens from sentinel flocks and horses for the prevalence of viruses. VIAS reports directly to DHS and councils on testing outcomes.

The primary responsibility of councils is to provide programs and services that respond to the needs and promote the well-being of their ratepayers, including people's wish to avoid being bitten or bothered by mosquitoes. Disease prevention and community well being is the main responsibility of DHS in mosquito control, particularly the prevention of MVE. DSE's responsibility is to protect biodiversity and conservation values and to avoid or minimise environmental risk in the mosquito control process. PV manages parks and reserves to maintain and improve their conservation values for the community and has a responsibility to minimise environmental risk to these values.

2. Legislative framework and agreements

2.1 Community health

Because of the role of mosquitoes as vectors for diseases, health legislation incorporates regulations for the control of mosquito breeding. The Commonwealth reports annually to the World Health Organisation (WHO) on arbovirus programs and furnishes data on the "extent to which its ports and airports are kept free from vectors of epidemiological significance in international traffic"[3]. The Commonwealth also has a formal agreement with Victoria, South Australia and New South Wales to share data on mosquito trapping, virus isolation, seroconversion in sentinel chickens and other appropriate data[4]. Under this Agreement, coordination of information and mechanisms for action in the event of an outbreak of *flavivirus* (KUN and/or MVE) are delineated. Each State is responsible for arbovirus programs within its own boundaries.

DHS has established the Victorian Arbovirus Task Force (VATF) to provide expert advice on mosquito-borne diseases. VATF is made up of experts across various disciplines and specifically is responsible for providing advice:

- on strategies for the control of mosquito-borne diseases and on the implementation of these strategies;
- on on-going surveillance and research programs into arbovirus diseases in Victoria;
- regarding information that should be available to the community on mosquito-borne diseases and prevention methods which can restrict the likelihood and consequences of disease outbreaks; and
- to assist the department in coordinating urgent response in the event of a disease outbreak.

Various States and Territories, as well expert organisations, also participate on the National Arbovirus and Malaria Advisory Committee, an advisory group responsible to the Communicable Diseases Network Australia. The Committee's terms of reference include, but are not limited to, making recommendations on the following.

1. Strategic approaches for arbovirus disease and malaria management and control related to:
    - laboratory support;
    - development of a national arbovirus response plan in association with jurisdictional responsibilities;
    - ongoing research requirements and arbovirus and malaria outbreak investigation; and
    - establishing lines of communications with other interested parties working in the arbovirus and malaria sector.

2. The preparation of a Memorandum of Understanding between the Commonwealth, States and Territories, that details co-operation in relation to arbovirus/malaria and vector surveillance, information dissemination and response plans.

The *Health (Infectious Diseases) Regulations* 2001 empower DHS and councils as their agents to direct owners and occupiers of land to carry out measures to reduce the incidence of mosquito breeding to prevent mosquito-borne diseases. In practice, most mosquito control takes place on public land and councils implement mosquito control activities rather than directing other agencies to do so.

Under Section 29A of the *Victorian Health Act* 1958, "the function of every council under this Act is to seek to prevent diseases, prolong life and promote health through organised programs".

DHS recently released a Municipal Public Health Planning Framework[5] that takes a broad and holistic view of health that goes beyond the treatment or prevention of disease. Municipal public health plans must not only prevent or minimise danger to health, but also enable people living in the municipal district to achieve maximum well being.

2.2 Environmental protection

Mosquito breeding often takes place in wetlands. Many prime mosquito breeding areas occur in wetlands of international or national significance. Victoria manages wetlands in line with Victoria's Biodiversity Strategy [6] to ensure that the ecological processes and the biodiversity dependent upon terrestrial, freshwater and marine environments are maintained and, where necessary, restored. The strategy outlines outcomes and management responses for wetlands to promote the conservation and wise use of all wetlands. Victoria's approach to the management of wetlands takes into account relevant international and national obligations set out below.

The Ramsar Convention[7] is an inter-governmental treaty which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. Contracting Parties commit themselves to designate wetlands of international importance or Ramsar sites, maintain the ecological character of these sites and promote the wise use of all wetlands within their territory. Australia is a contracting party to the Ramsar Convention. Victoria works with the Commonwealth and other states and territories to implement the Convention. Victoria has 11 Ramsar sites[8], some of which include prime mosquito breeding habitat. Mosquito management is carried out on several of these sites, particularly in southern Victoria. A strategic management plan is in place for each Ramsar site[9].

The Convention on Migratory Species 1983 (Bonn Convention), Japan-Australia Migratory Birds Agreement (JAMBA) and the China-Australia Migratory Birds Agreement (CAMBA) are international agreements for the protection of migratory species and their habitats. Birds listed under these agreements are matters of national environmental significance under the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act).

The EPBC Act addresses matters of national environmental significance including Ramsar sites, listed migratory species and nationally threatened species (some of which depend on wetlands). The Act relates to actions likely to have a significant impact on matters of national environmental significance and ensures these actions are subject to rigorous assessment processes that require approval from the Commonwealth Environment Minister. The Act applies to actions proposed after the Act was proclaimed in July 2000 and does not apply to mosquito control programs that were in place before that date. However, where programs are substantially changed in a way likely to cause significant impact, advice should be sought from the Commonwealth on the need for approval.

For Ramsar sites, an action will require approval if it is likely to have a significant impact on the site's ecological character. An action is likely to have a significant impact if it involves:

- areas of the wetland being destroyed or substantially modified;
- change in the hydrological regime of the wetland;
- the habitat or lifecycle of native species dependant upon the wetland being seriously affected;
- a change in the physico-chemical status of the wetland; or
- the establishment of an invasive species.

For listed migratory species an action is likely to have a significant impact if it:

- substantially modifies important habitat;
- results in the establishment of invasive species harmful to migratory species in areas of important habitat; or
- seriously affects the lifecycle of an ecologically significant proportion of the population of the species. [10]

'A Directory of Important Wetlands in Australia' lists wetlands of national significance[11]. Land managers and planners are encouraged to give these wetlands high priority for conservation. There are 159 wetlands in Victoria listed in the Directory.

The Intergovernmental Agreement on the Environment (IGAE) is an agreement between the Commonwealth, States and Territories to facilitate a cooperative national approach to the environment[12]. The IGAE establishes principles of environmental policy, including what is known as the precautionary principle (see box) which advises caution in situations in which there is lack of full scientific certainty about the environmental consequences of actions.

Precautionary principle

At the United Nations Conference on the Environment and Development, 'The Earth Summit' held at Rio de Janiero in 1992, a series of principles on environment and development were adopted. They included Principle 15, commonly known as the 'precautionary principle':

> *In order to protect the environment, the precautionary approach shall be widely applied by the States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.*

Subsection 3.5.1 of the IGAE, in addition to including the above definition, adds the following as a means of clarifying Australia's application of the precautionary principle:

> *In the application of the precautionary principle, public and private decisions should be guided by :*
> 1. *careful evaluation to avoid, wherever practicable, serious or irreversible damage to the environment; and*
> 2. *an assessment of the risk-weighted consequence of various options.*

The registration and control of pesticides, including those used for mosquito control, is governed by the Commonwealth *Agricultural and Veterinary Chemicals Code Act* 1994.

Many of the mosquitoes breeding areas in Victoria are in wetlands and on public land managed for conservation and other public purposes. National, State and other parks are managed by PV in accordance with the *National Parks Act* 1975. PV also manages conservation reserves. Other Crown land is managed by DSE, usually under delegation to committees of management which are often local Councils. Conservation reserves and other Crown land are managed in accord with the *Crown Land (Reserves) Act* 1978 or the *Land Act* 1958 as well as government-approved recommendations of the former Land Conservation Council and former Environment Conservation Council.

Other State legislation which promotes the conservation and wise use of wetlands and protection of wildlife includes the following:

- The *Catchment and Land Protection Act* 1994 which provides an integrated catchment management framework and facilitates the wise management of land and water resources in a whole of catchment framework.
- The *Coastal Management Act* 1995 under which the Victoria Coastal Strategy has been developed. The strategy implements key provisions of the act relating to the protection of Victoria's coastline.
- The *Environment Protection Act* 1977 which establishes the regulatory framework for protection of environmental assets and provides for the development of State Environment Protection Policies (SEPPs). The SEPP *Waters of Victoria* and its schedules provide a legal framework for government agencies, businesses and the community to protect water quality. Specific schedules have been developed for Western Port, the Gippsland Lakes and Port Phillip Bay.
- The *Flora and Fauna Guarantee Act* 1988 (FFG Act) provides a legislative framework for the conservation of biodiversity in Victoria. It provides for the listing of threatened species and communities and the preparation of action statements for these species and communities. It also allows for the listing of potentially threatening processes.
- The *Wildlife Act* 1975 provides for the protection of wildlife. Wildlife includes indigenous vertebrate fauna, specified introduced vertebrates and invertebrates listed as threatened under the FFG Act. No species of mosquito is listed under this Act. Therefore, mosquitoes are not protected in Victoria.
- The *Planning and Environment Act* 1987 is critical to planning and land use in Victoria. Under the Act, the State Planning Policy Framework includes a biodiversity objective to "*assist the protection and conservation of biodiversity*". Under a separate clause it requests planning and responsible authorities to *"ensure that any changes in land use or development would not adversely affect the habitat values of wetlands"*.

At present there is no formal State policy on the management of mosquitoes in environmentally sensitive sites in Victoria. Council policies and programs for mosquito management focus on protection of residents and visitors from disease and nuisance impacts.

2.3 Cultural protection

The protection of cultural values on land is relevant to both indigenous and post-settlement heritage. The management of mosquitoes may require potentially significant disturbance to cultural heritage sites through land disturbance (for example, construction of drainage channels) and changes to natural water flow.

The Victorian Heritage Register, managed through DSE provides a listing of post-settlement heritage assets to be protected. For protection of indigenous cultural values, both State and Commonwealth legislation may be involved. The State Act (*Archaeological and Aboriginal Relics Preservation Act 1972*) provides legal protection for the physical evidence of the Aboriginal occupation of Victoria. The Commonwealth legislation (*Aboriginal and Torres Strait Islander Heritage Protection Act 1984*) provides legal protection for all Aboriginal cultural property and prohibits anyone from defacing, damaging, interfering with or endangering an Aboriginal place unless prior consent of the local Aboriginal community.

The Commonwealth *Native Title Act 1993* recognises native title rights and sets out the process by which native title is assessed and established. It only relates to public land. Where mosquito control measures are likely to significantly impact on land and on natural water flow, then any native title owners or current claimants must be formally notified. Aboriginal Affairs Victoria (AAV) provides the liaison between the community, agencies and the relevant indigenous communities. Insecticide-spraying programs can be considered a low impact activity under the *Native Title Act* and as such do not require formal consultation before implementation.

3. Responsibilities of State Government, councils and the community

Mosquito management in Victoria is carried out for two reasons: disease control and amenity value. Under the *Health Act*, responsibility for disease control activities rests with the DHS, usually through councils as their agents. A Mosquito Control Program managed by DHS provides 1:1 matching grants to nine councils **(**Appendix 4**)** to carry out mosquito surveillance and management. The Commonwealth Government initiated this program following the 1974 MVE outbreak in northern Victoria. Ten years later, funding responsibility was assumed by the State. Following an outbreak of RRV disease in Gippsland, additional funds were allocated to councils in that region. Under this program, funds are also used for collection and analysis of mosquitoes and blood samples at VIAS at Attwood for disease monitoring and prediction. Some councils outside the DHS program have independently developed and financed programs to address mosquito impacts to residents and visitors to their areas. The largest of these are the Greater Geelong City Council ($120 000 per year) and the Shire of Bass Coast ($30 000 per year).

Local Councils are responsible for mosquito management on council land and can direct private landowners, under the *Health Act* and regulations, to take action to treat mosquito breeding sites. On public land, councils seek to work with State agencies to take appropriate remedial action on land these agencies manage.

Individual citizens are responsible for the maintenance of a healthy environment around their properties for their personal benefit and that of their families. They also have a general communal responsibility to minimise risks to the health and well being of their neighbours. The responsibilities of key stakeholders in mosquito management are outlined in Table 2.

Table 2. Current responsibilities undertaken by lead agencies

AGENCY	KEY RESPONSIBILITIES
Department of Human Services	Manage and advise on statewide mosquito surveillance and control programs. Provide strategic direction for the control and prevention of disease; monitoring and prediction of disease prevalence; training of local government and other key agency staff in mosquito management techniques; provision of funding to designated local government mosquito management programs. Manage and fund laboratory support services relating to virology and entomology programs. Co-ordinate emergency response activities in disease outbreak situations.
Department of Sustainability and Environment	Provide strategic direction for park and reserve management, flora and fauna management and implementation of the Ramsar Convention in Victoria. Provide strategic direction for catchment and water management, forest management, coastal and port management; relevant research and monitoring of species and habitat values; leasing, licensing and management of public land. Undertake strategic and statutory land use planning including the administration of the Victorian Planning Provisions.
Department of Primary Industries	Provide strategic direction for fisheries management and research, agricultural services and sustainable development of Victoria's energy and mineral resources. Provide laboratory support services on contract to DHS relating to the virology and entomology of mosquitoes.
Parks Victoria	Manage Victoria's parks, reserves and references areas, including the Murray River Reserve. Support appropriate research activities and promote community education on conservation and the environment. Approve mosquito management programs carried out on PV managed land. Provide access for mosquito management activities and inform park and reserve users of programs.
Councils	Provide local services and support to residents on health and community welfare, tourism, conservation and recreation. Develop strategic and statutory planning provisions, approve and monitor planning developments. Manage Council public land for community benefit, including mosquito management where appropriate. Co-ordinate mosquito management plans with other relevant Council plans such as stormwater management plans.
Community	Provide personal protection against mosquito bites through adequate use of repellents, wearing of appropriate clothing, and fitting of door and window screens on houses. Become well informed on the conditions likely to lead to increased mosquito-related risks to health and well being in the local community. Eliminate or minimise mosquito-breeding sites likely to affect family and neighbours.

4. Risk assessment framework

Mosquito management is carried out to protect community health and well-being by reducing risks of mosquito borne disease and reducing the pain, annoyance and economic loss (to business or property values) caused by mosquito biting. Treatment of mosquito breeding sites may increase risks to the environment, in particular wetland ecosystems.

An assessment of risks to the community and to the environment should be a basic requirement of any mosquito management program. The level of health and community risks involved and the environmental sensitivity of the areas to be treated will determine the actions to be taken and the materials and methods to be used.

The risk associated with an action can be considered as:

the likelihood of an outcome x *the consequences of that outcome.*

Standards Australia has developed a generic framework for the management of risk[13]. This standard has been applied to a number of scenarios including environmental management, feasibility studies and animal health. Where the system being considered is complex (such as health or environment) and/or where specific factual data is limited, the risk assessment process may need to draw on data from similar national and international situations, historical information and expert knowledge.

4.1 Risk to health and well-being.

The assessment should look at the risk of disease and the reduction in community well-being due to nuisance biting. The risk could be defined as:

the likelihood of being bitten by arbovirus-carrying or nuisance mosquitoes

x

the health and social impacts of being bitten by these mosquitoes

The likelihood of being bitten is affected by the number and species of mosquitoes, and the presence and activities of vulnerable humans. The impact of contracting MVE is likely to be greater than that of contracting RRV. The impact of being bitten by a nuisance mosquito is less again. The likelihood of contracting mosquito borne disease is also dependent on the “pool” of vertebrate hosts in a viraemic state and the presence of vector species at any particular time.

In Victoria, risk assessment associated with mosquito management has not been clearly developed. However some elements of risk assessment are reflected in the DHS program which responds to health risks on the basis of past outbreaks of MVE and increased incidence of RRV and BFV diseases. Councils, also carry out programs in response to expressions of community concern. Table 3 provides criteria for determining the level of risk for community health and well-being.

Table 3. Level of risk to community health and well-being

Level of risk to health and well-being	Criteria
Very high	Incidence of MVE. High MVE potential (as determined by DHS)
High	MVE in the past. High incidence of RRV or BFV in last 5 years.
Moderate	Abundance of nuisance mosquitoes. Some RRV or BFV in past.
Low	Usually low density of nuisance mosquitoes.

Currently most of the disease incidence data has been gathered on a council basis and can therefore only be generally applied at a particular mosquito breeding site. It can, however form the basis for initial decision-making at municipal level on the need for council action.

4.2 Community perceptions of risk

Local citizens and community groups have identified abundant mosquitoes as a risk to tourism, land values and local investments, as well as a severe nuisance. Complaints to councils reflect concerns about actual or potential economic impacts and signify a general concern with community well-being and health. Some assessment can be made to determine the level of community concerns about the impacts of mosquitoes.

A simple approach has been developed following discussions with key stakeholders. It is based on the number of requests for action that councils receive in relation to a particular local area. The number of requests adopted as benchmarks will vary from one location to another depending on population and other local variables. Councils should identify specific numbers of requests that equate with the level of concern. An example is given below in Table 4.

Table 4. Example of how a council might rate the level of community concern

Level of concern	Criteria
High	>30 requests/year to council
Moderate	5-30 requests/year to council
Low	<5 requests/year to council

4.3 Risk to environment

Ecosystems are complex and many of the implications of mosquito management intervention have not been comprehensively studied. Therefore the *Precautionary Principle* should be applied when designing mosquito management programs. Treatment practices are mainly associated with wetlands and can have a range of impacts on a particular site dependent on the methods and materials used. The environmental impacts of mosquito management practices are potentially damaging if adequate information is not available and environmental safeguards are not applied. See Appendix 5 for further information on environmental impacts of current practices and materials.

Assessment of environmental risks in relation to mosquito management should initially involve assessing the environmental sensitivity of a site in order to determine the likely impacts of various methods and materials. Environmental sensitivity is often reflected in the recognised significance of the site, eg. National Park, Ramsar site. (Table 5).

Table 5 Environmental sensitivity

Environmental sensitivity	Criteria
Very high	Matter of national significance as defined under EPBC Act (eg Ramsar site, important habitat of nationally threatened species or listed migratory species).
High	National Park, State or Coastal Park, Marine National Park, Marine Sanctuary or other parks or reserves proclaimed under the *National Parks Act* 1975. Wetlands listed in “Directory of Important Wetlands in Australia”. Conservation reserves established under former LCC and ECC processes and protected under the *Crown Land (Reserves) Act* 1978 or the *Land Act* 1958.
Moderate	Important regional wetlands.
Low	Other wetlands of lower conservation value. The built environment. Threatened or migratory fauna species not present.

The following steps to assess environmental risk are based on the Wetland Risk Assessment Process under the Ramsar Convention [14]. The level of detail required for adequate risk assessment will depend on the sensitivity of the area under consideration and the level of data available. Assessing both community health and environmental risks for a particular site will enable sites to be ranked according to both priority and environmental sensitivity. This ranking forms the basis for an annual program of mosquito management.

*Step 1 - Identify the problem***.** The first step is to identify the nature of the problem and identify what is to be protected. It includes identifying the area proposed for treatment and proposed treatment methods and materials.

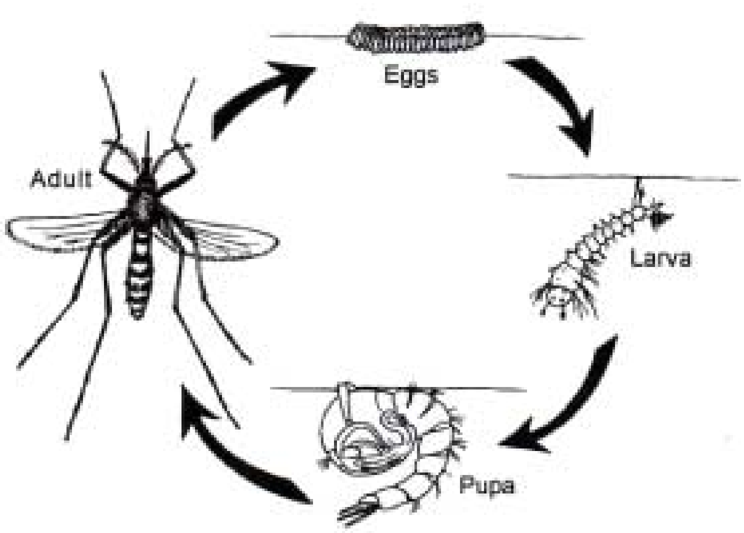
Step 2 - Identify the extent of exposure. This step estimates the likely extent of the area to be treated in comparison to the total area of similar ecosystem within the wetland and the frequency or timing of treatments.

*Step 3 - Identify the adverse effects***.** This step evaluates the likely extent and impact of adverse changes on the wetland. The level of evaluation needs to be related to the environmental sensitivity of the site. Data from field studies should be used where possible. Where such data is unavailable, data from other studies should be reviewed and expert opinion sought. Where field studies are considered necessary, the cost can be substantial and stakeholders should take a cooperative approach to resource such studies.

Step 4 - Identify the risk. Based on the available information, an assessment is made of the likelihood of adverse effects occurring and the consequences of that impact on the environmental values of the site or ecosystem as a whole. This approach involves judgement as to the importance of different elements, depending on the circumstances and sites.

Management of the risk also needs to take into account political, social, economic, and technical factors, and the respective benefits and limitations of each risk-reducing action. It is a multi-disciplinary task requiring communication between site managers and experts in relevant disciplines. Monitoring should be undertaken to verify the effectiveness of the risk management decisions and should function as a reliable early warning system, detecting the failure or poor performance of risk management decisions so that remedial action can be taken to prevent serious environmental harm occurring. An effective program also requires an understanding of the life cycle of the mosquito targeted in the area (Figure 1).

Figure 1. Life cycle of a mosquito



During summer, adult mosquito may develop from eggs within seven days.

Eggs

Most species lay their fertilised eggs on the surface of the water. However, the Southern Saltmarsh Mosquito (*Ochlerotatus camptorhynchus*) lays eggs on moist soil at the base of vegetation in saline areas. These eggs will normally hatch within two days of the next high tide, heavy rain or flood.

Larvae

Larvae ("wrigglers") tend to concentrate in shallow areas where they gain most shelter from larger predators. The larvae pass through four development stages (instars) over as little as five days. Larvae feed up to the mid 4th instar.

Pupae

Mosquito pupae are referred to as "tumblers" because of their shape and the way they swim with a tumbling action. The pupae do not feed and the adult emerges after as little as two days in summer.

Adult

Temperature, wind, humidity and light determine the activity of adult mosquitoes. Some species are active during the day (diurnal), others at night (nocturnal) while others have their peak activity at dawn and dusk (crepuscular).

Female mosquitoes require a blood meal from vertebrate hosts to provide the protein needed to mature their eggs. Eggs develop within the female within 48-96 hours depending upon temperature; they are then deposited in a suitable site starting the life cycle again. The female then seeks another blood meal to mature the next batch of eggs. Some species are known to disperse up to 12 kilometres from their breeding sites but it is believed that most move within a 1-2 kilometre range.

Derived from Standfast, H. A. Mosquito Biology: http://www.mcaa.org.au/page6.html

5. Framework for mosquito management

5.1 Principles of mosquito management

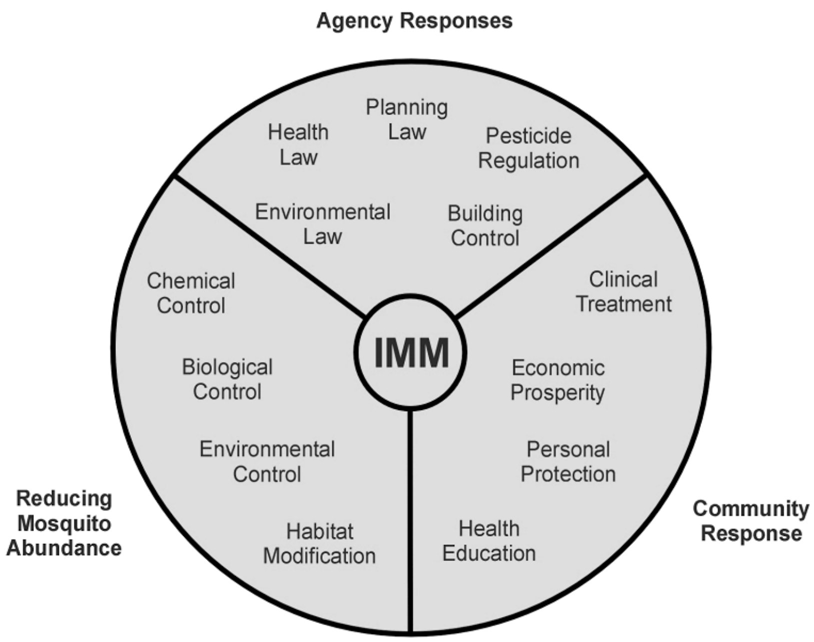
The following list identifies some emerging principles of Integrated Mosquito Management (IMM). Mosquito management attempts to solve existing problems and to prevent or mitigate future problems. IMM includes community involvement and recognises the importance of stakeholder coordination. It locates the use of physical, chemical and biological methods within a broader context of educational and planning strategies.

- Mosquito management involves health, environmental and socio-economic values.
- While disease control is the primary focus, reduction in nuisance value of mosquitoes is a legitimate aspect of improved community well being.
- Mosquitoes are an integral part of the ecosystem and their treatment may have positive and negative environmental impacts.
- Effective mosquito management requires a holistic approach and the cooperation and coordination of all stakeholders.
- Integrated mosquito management includes mosquito reduction, personal protection, community education and land use planning.
- Coordinated programs and on-going monitoring are necessary for effective mosquito management in the long term.
- Treatment of mosquito larvae or adults is an on-going activity.
- Treating larvae is generally more effective and targeted than treating adult mosquitoes.

5.2 Promoting integrated mosquito management

Some of the roles, powers and actions of agencies and the community in the IMM process are portrayed in Figure 2.

Figure 2 Integrated mosquito management [1]



1 Derived from McGinn, D. and Muller, M (1997) Saltmarsh Mosquito control – towards best practice. *Arbovirus Research in Australia.* 7:194-197.

The development of an IMM program in Victoria will require inputs from key agency and community stakeholders to work in a cooperative and coordinated way to achieve effective outcomes. Elements of the program will include:

- provision of the legal, financial and administrative infrastructure;
- interventions to reduce mosquito numbers at critical times of the year;
- personal and community action to minimise mosquito biting; and
- research and monitoring to provide a sound basis and timing for future action.

Mosquitoes do not respect municipal boundaries. It may be appropriate in some regions of the State for neighbouring councils to set up a mosquito reference group (MRG) which could assist with the coordination of actions across municipal boundaries. Such a group could also provide a forum to share information (and maybe resources) between councils and promote partnerships for research on subjects of relevance across a region. The group should comprise key technical, social and community stakeholders from the region.

5.3 Decision making process

The decision making model (Figure 3) outlines a process to allow the various elements of a complex situation to be systematically considered in an appropriate order and priority. It can be used to assist decision making at two levels as follows.

1. The municipal level where the decision is whether to implement a mosquito management program and identify the elements of that program. This decision is based primarily on *disease control* and *the level of community concern*.
2. The site level where the specific characteristics of the local ecosystems including environmental sensitivity affect the decision making process, along with social and management factors.

5.4 Decisions at municipal level

Community health risk and *community concern* are the two elements that will determine if any action should be taken within the municipal area and the nature of that action. In the context of IMM, Councils may respond to health risks and community concern in several ways.

- Treat mosquitoes on a site by site basis.
- Educate and inform local communities on mosquito life cycles and impacts, health risks and elements of a council's program.
- Provide financial or technical support for personal and community risk reduction measures such as the use of repellents or window screens, better building design and incentives for appropriate action on private land.
- Implement planning strategies to minimise mosquito risk, for example through use of buffer zones, location of housing and residential developments, and design and maintenance of roadside drainage systems and constructed wetlands.

Based on the levels of health risk and community concern identified in Tables 3 and 4, a *set of decisions* (see Table 6) can be developed. Each Council will have to make the judgement whether to implement a mosquito management program and the elements of that program in the light of its own circumstances. All options should be considered before coming to a decision. Where risk levels are high or very high, councils may consult with DHS to decide on action to be taken.

Table 6 Possible actions for levels of risk

Health and Well Being risk	Community concern	Possible action taken			
		Treatment of mosquitoes	**Community education**	**Support community action**	**Planning strategies**
Very High	Any level	Yes	Yes	Yes	Yes
High	Any level	Yes	Yes	Maybe	Yes
Moderate	High	Yes	Yes	Maybe	Yes
	Moderate	Maybe	Yes	No	Yes
	Low	No	Yes	No	Maybe
Low	High	Maybe	Yes	No	Maybe
	Moderate	No	Yes	No	Maybe
	Low	No	Maybe	No	No

5.5 Decisions at site level

Once the decision is made to manage mosquito impacts in a local government area, potential treatment sites need to be individually assessed. Site assessment takes into account legal status, physical characteristics and the risk of environmental and social impacts from treatment. It also needs to consider the actual size and shape of the site and its area in relation to the total area of similar environmental sensitivity.

Location of site

Most mosquitoes usually only move within a few kilometres of their breeding site although they can be blown by wind 12 kilometres or more. The location of the site in relation to the prevailing winds and the proposed beneficiaries need to be considered. Some communities could be affected by mosquitoes from a number of nearby sites and the treatment of one site alone may be of little use. The number of beneficiaries likely to be affected by a particular mosquito breeding site should also be considered in prioritising sites.

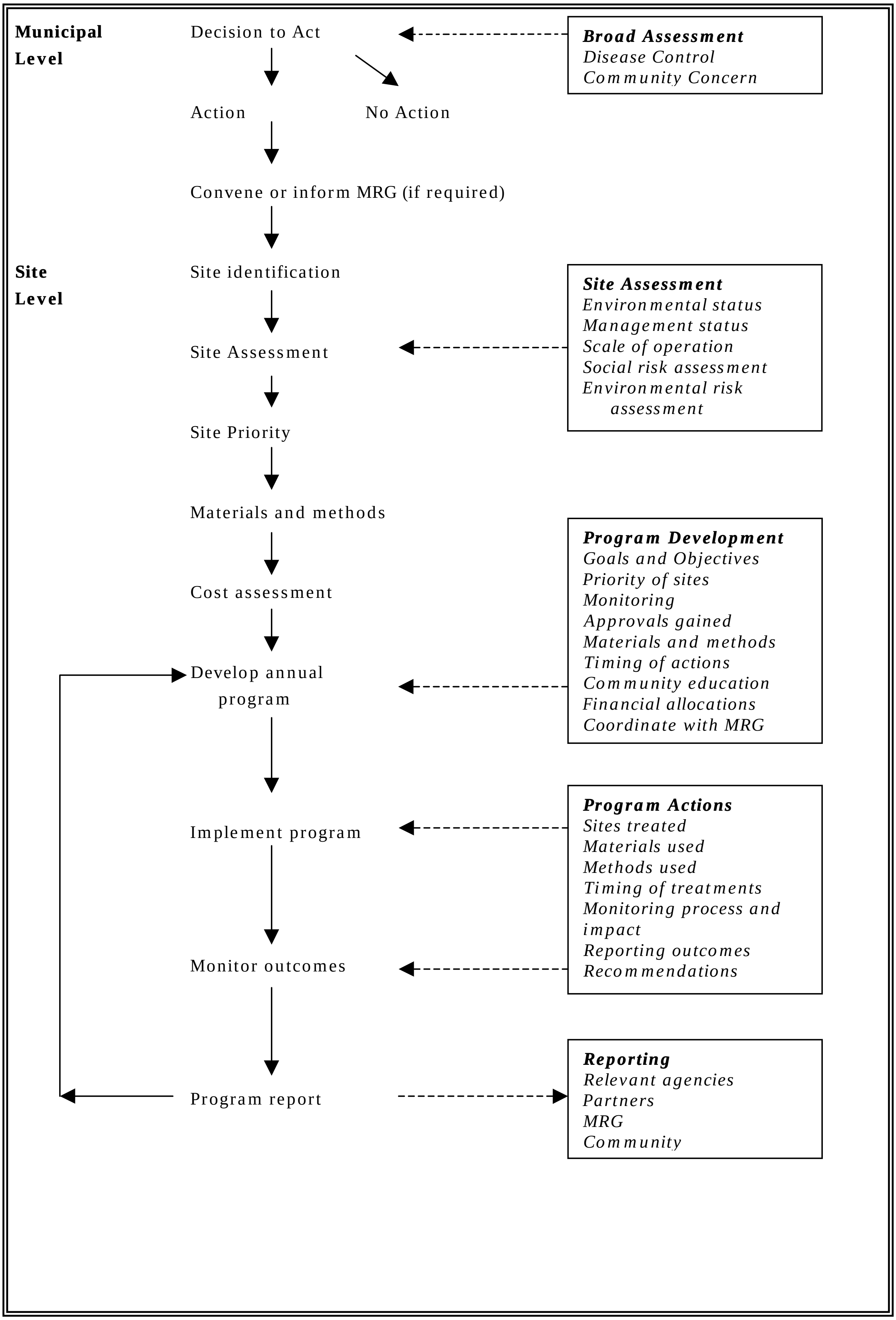
Environmental status

The *environmental sensitivity of a site* (as classified in Table 5) will determine acceptable materials and methods to be used. In highly sensitive sites, targeted larvicides and environmentally friendly spreading methods are the only treatments likely to be approved by site managers.

Cultural status

All land has some level of cultural status involving indigenous, post-settlement or landscape values. Most mosquito management practices involve low impact physical actions on the land, such as spraying larvicide, which are unlikely to endanger these values or invoke procedural rights under the *Native Title Act*. However there are some practices (such as draining low-lying areas) which can impact on land and the natural movement of water. If undertaken on Crown land they are valid acts under the *Native Title Act* and it is necessary to afford any native title holders or claimants formal notice of the intention to undertake such acts and allow a period for comment.

Figure 3 Decision making model



Materials and Methods

Materials and methods used in Victoria and other States for mosquito management reflect assessment of site sensitivity, degree of disease risk and availability of treatment options. The materials and methods available can be expected to change and improve over time so it is important to make decisions based on current skills, knowledge and best practice. A more detailed assessment of the interactions between materials, methods and ecosystems is given in Appendix 5

Habitat modification is used as a long-term management strategy overseas and in some parts of Australia. It includes construction of drains and runnels[1] to flush out larvae from isolated pools, and the slashing of fringing vegetation to expose breeding sites to wind and predators. Habitat modification is unlikely to be approved for environmentally significant wetlands in Victoria, as it is inconsistent with conservation goals in Victoria's Biodiversity Strategy. Slashing or removal of native vegetation is inconsistent with Victoria's Native Vegetation Management Framework [15]. However habitat modification may be a cost-effective long-term strategy for built and highly modified environments.

All the pesticides currently registered for mosquito control have been extensively researched in Australia and overseas for their impacts on various ecosystems (mainly wetland ecosystems). They have been used for more than 20 years in Victoria on sites of varying environmental sensitivity with no obvious detrimental impact. However little research has been done to date under Victorian conditions.

Most mosquito management programs focus on treating mosquito larvae, although for emergency situations a quick knockdown of adult mosquitoes may be needed to restrict the spread of disease.

The main pesticides used are:

- adulticides (*malathion* and various *pyrethroids*); and
- larvicides:
  - chemical - an organo-phosphate *temphos (Abate);*
  - biological - a naturally occurring organism *Bacillus thuringiensis israeliensis* (*Bti);*
  - growth inhibitor - *s-methoprene.*

Bti and *s-methoprene* are the most targeted materials for larval reduction with studies demonstrating minimal impact on a range of non-target species overseas and elsewhere in Australia. Larvae ingest these materials over the short time (maybe five days) that they are actively eating. *Methoprene* is used where sites are difficult to monitor and manage and where a longer-term slow release treatment (over a month) would be more effective. Various formulations as granules, liquids, briquettes or sand mix are used where appropriate for specific situations. Appendix 5 outlines further information on these pesticides based on research and long term use.

The four main application methods used in Australia are:

- aerial spraying via helicopter or fixed wing aircraft;
- vehicles spraying, fogging or spreading directly from formed tracks;
- vehicles on other tracks or across dry ground often using all terrain vehicles (ATVs) which are multi- wheeled or tracked vehicles with low ground impact; and
- foot based dispersal using backpack spreaders or sprayers or hoses from a stationary vessel.

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[1] Small shallow spoon drains to link isolated pools within wetlands to main drains, or tidal influence in saltmarshes.

Boats and hovercraft can also be used for water based access and transport of materials.

Choosing the most appropriate pesticide materials and delivery methods for IMM will depend on the environmental sensitivity of a site and the area to be treated. Table 7 suggests a basis for selection of materials and methods appropriate to areas of differing environmental sensitivities.

Table 7 Selection of Materials and Methods

Environmental sensitivity	Suitable materials	Suitable delivery methods
Very high	*Bti or methoprene*	Aerial (helicopter*), vehicles on formed roads, ATVs on dry formed tracks, approved access methods and routes. Foot-based backpacks or hoses.
High	*Bti or methoprene*	Aerial (helicopter), ATVs on formed roads, dry tracks, approved access routes. Foot-based backpacks or hoses.
Moderate	*Bti, methoprene or temphos*	Aerial (helicopter,), Vehicles on dry land and tracks. Foot based backpacks and hoses.
Low	*Temphos, Malathion, Bti, methoprene*	All

*Suitable where accurate GIS based fly runs, records of flight paths and field monitoring of material dispersal are available. Consideration on effects on wildlife is important, for example timing treatment in relation to bird feeding, roosting or breeding patterns.

Cost assessment

The cost of treating a site will vary depending on the area, materials, methods and timing. A measure of cost per head of the affected number of people should be taken into account in prioritising sites for future treatment. Because of the short "window of opportunity" for larval treatment, the ability to regularly monitor larval development and treat a site quickly is paramount for cost effective action.

5.6 Monitoring and prediction

Monitoring is a key requirement at site, municipality and State level for program management, further development, reporting and future prediction.

At site level, records and annual reports are needed on:

- adult and larval monitoring;
- activities carried out and timing;
- materials and methods used;
- area treated;
- costs involved; and
- impacts of the treatment.

These records are important not only for program assessment over time but also for the information of land managers responsible for the environmental health of the area. Physical and technical information should be supplemented by qualitative assessment of the impact of the program on local communities.

At municipal level, accumulated records of site information should be made available to the land managers as a basis for working with councils as they develop mosquito management programs across the municipality. This data can also be used in discussions on changes to site priorities, policy funding and other program elements. Some municipalities also have responsibilities for monitoring and sampling as part of the DHS arbovirus program.

At State level, information available to DSE, PV and DHS is part of the input of local practitioners into policy, research and program development. Effective reporting enables DSE, PV and DHS to maintain an ongoing record of mosquito management activities to inform future planning and management decisions.

DHS maintains a record of disease incidence that should be available each year to all councils and agencies with significant mosquito management programs. DHS also has reporting responsibilities on arbovirus programs at national and international level.

Assessment of climatic data and disease surveillance, through virology assessments at VIAS Attwood, provide councils with further information for planning and implementing management programs.

5.7 Emergency action

DHS (in conjunction with the Victorian Arbovirus Task Force) is responsible for initiating an emergency control program to minimise the incidence and spread of arboviruses. The control program will be carried out if DHS considers that there is an actual or potential outbreak of MVE and/or a very high incidence of RRV or BFV in a particular area or region.

Agreed land and water management policies need to be in place prior to emergency action to ensure minimum environmental impacts. During an emergency, materials and methods not ordinarily used should be closely monitored.

Closing areas of public land to human access is another possible emergency action where there is a high risk of mosquito borne diseases affecting visitors to such areas. Closures can be authorised by the relevant authorities under the *National Parks Act* and the *Health Act*.

Clarification from the Commonwealth needs to be sought on the implications of emergency action on matters of national environmental significance where the EPBC Act would normally require prior approval for changes to normal programs.

5.8 Coordination across boundaries

The basic unit for disease recording and program management is the council. However breeding sites, mosquito impacts and land status cross these boundaries and mechanisms may be needed to take account of this. Neighbouring councils could convene a regional mosquito reference group where coordinated action is warranted. Such a group would provide a forum for regional program coordination, information exchange, consistency in program development and works approvals. Mosquito reference groups could identify future research needs for their regions and provide support and guidance for councils initiating IMM programs. Such groups should have representation of key stakeholders from councils, DHS, PV, DSE, relevant private land managers and the community. Similar organisations have been set up in Queensland and overseas.[1]

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[1] For example the North East Moreton Mosquito Operation in Queensland and Mosquito Control Districts in a number of States in the USA.

5.9 Resolving conflict and building cooperation

The key organisations implementing mosquito management are DHS, councils and PV and DSE. Cooperation, commitment and a professional approach to mosquito management are required to resolve issues and implement a successful mosquito management program that takes into account the different responsibilities of each of the stakeholders. This framework sets out a systematic process for developing a local mosquito management program based on risk management. Appropriate resources should be made available to resolve issues and support the development of coordinated programs based on the best available data and the process outlined in this framework. Technical, social, political and resourcing matters affecting mosquito management arise at regional and State level. It may be useful to convene regional and state forums to promote cooperation and coordination, as required.

6. Developing a local management program

Councils have developed local management programs for mosquito management in various ways for many years, often in conjunction with PV and DSE. These programs need to be developed with common guidelines based on acceptable criteria for materials and methods appropriate to site conditions. The Decision-Making Model (Figure 3) outlines a process to facilitate the development of annual programs based on an assessment of sites, appropriate materials and methods, funds available and likely outcomes.

6.1 Tools for councils

The template shown in Appendix 6 can assist decision-making by councils that are reviewing existing programs, or initiating new programs. The template suggests criteria to be used and will encourage a consistent approach to decision making throughout Victoria. It will also provide a consistent basis for development of programs and facilitate agreement with State agencies and public land managers. Councils are encouraged to use the well-developed process and training materials developed by DHS for monitoring and reporting mosquito information on site.

The timing and extent of treatment can vary greatly with climatic conditions but is usually completed over a six-month treatment period each year. A mosquito management program should provide an agreed basis with the land manager for:

- the identification of sites for treatment;
- the use of specific materials and methods for each site;
- the priority of sites likely to be treated;
- the likely timing of treatments over a season;
- method and format for recording of the number, type and location of treatments;
- method for larval monitoring and recording at sites;
- method for recording and monitoring of adult mosquitoes; and
- method and content of reports to key stakeholders on program inputs and outputs and on the technical and social impacts of the program.

Processes for recording social benefits and for reporting inputs and outcomes on a regular (usually annual) basis should be built into the program.

With an agreed program of action developed by the council and public land managers, long term agreements could be drawn up to remain in place until annual reports, monitoring or other issues bring to light the opportunity or need for change.

6.2 Training for best practice in IMM programs

The training program for mosquito monitors instigated by DHS over the years provides best practice management guidelines for monitoring of mosquitoes, collection of blood samples for analysis and treatment of breeding sites with a range of materials and methods. Some environmental impacts are considered in practice selection. Standard procedures and requirements for chemical handling and machinery use are also identified. The training program provides a background to the key arbovirus diseases in Victoria and the history and current basis for the DHS program. This training program continues to provide useful skills and knowledge for the implementation of IMM.

Staff from councils and other land managers involved in IMM would benefit from additional training in the development of an IMM program, including risk assessment, site analysis and priority setting. Provision of such training could be coordinated at State level with the content and delivery provided by key stakeholders.

7. Actions to strengthen mosquito management

7.1 Policy development

Further policy development is needed by public land managers to enable effective mosquito management programs to be carried out without jeopardising environmental values. Land managers should review existing internal policy and procedures and provide direction on supporting a cooperative approach. DSE should inform and advise committees of management involved in IMM.

As councils are the lead implementation agencies for IMM, it is crucial that they have a clear process to follow, particularly on State managed public land. In policy development, input should be sought from key stakeholders, including the community. Policy development is also needed to accommodate emergency control programs designated by DHS, and to acknowledge, clarify and encourage community involvement and the role of land use planning by all levels of government in mosquito management.

Partnerships between State and local government should be reviewed and strengthened. These partnerships currently include training, information sharing, co-funding and program planning. A collaborative approach should be taken by land managers and councils for further research to underpin mosquito management activities and programs.

7.2 Research needs

Mosquito management has come a long way in terms of materials and methods used, and the monitoring and assessment of sites. But there has been little research on the environmental impact of materials and methods under Victorian conditions. Of prime concern is the lack of information on the environmental impacts of treatments on coastal saltmarshes in Victoria, many of which are designated as areas of national and international significance. Data are available from northern States and overseas, but there are no local studies on key indicator organisms and ecosystems subjected to physical, chemical and biological intervention for mosquito management. Research on the impacts of control materials on fish species for both fresh water and marine environments is also lacking.

Future research should focus on key or “indicator species” likely to be affected by either treatment methods or treatment materials. While priority would be given to select species in sites of high or very high environmental significance, consideration of social and economic issues (eg. the prawn fishery in the Gippsland Lakes) could also occur.

Habitat modification should be investigated as an appropriate long-term mosquito management strategy, particularly in artificial and constructed wetlands when these are not of high conservation significance. Typical examples are wetlands in residential and tourist development sites, farm dams, drains and channels, salt exploitation sites, aquaculture ponds, some water storages and waste water treatment areas.

Council mosquito monitors have local knowledge of the likely triggers for mosquito development in particular sites or municipalities. This knowledge needs to be recorded and made more widely available to others involved in mosquito management such as the land managers and future program managers.

Helicopters have not been used to date to spread larvicides in Victoria. Helicopter spreading should be considered. Helicopters are widely used in Queensland, Western Australia, the Northern Territory and overseas to cover large areas close to residential development in the short times often available during the larval development stage. They leave no physical impact on the ground, but require accurate monitoring of flight paths and knowledge of the climatic conditions under which even distribution of materials can occur. Their use does not appear to disrupt long term feeding patterns of wading birds if precautions are taking to avoid frequent disturbance to feeding or roosting birds.

7.3 Planning provisions and guidance

There are continuing and expanding pressures on coastal and inland water-fringing land for residential and tourist development. Victoria has no formal or focused approach to minimising the potential impacts of mosquitoes through strategic and statutory planning mechanisms. Mosquito exposure risk overlays for municipalities have been developed in other States (WA, NT) for use in the planing process. They have led to the use of buffer strips and permit conditions specifically aimed at reducing mosquito impacts on local residents in new developments.

Of greatest concern is future residential development close to existing mosquito breeding sites in natural and man-made wetlands, both inland and along the coast. Allowing such developments without mechanisms to acquaint prospective buyers of the likely mosquito impacts on their health and well-being will lead to increasing pressures and costs on councils to minimise the impacts through management programs.

Councils in Victoria use a combination of land use zones and overlays to guide, govern and direct future use and development of land in line with the objectives of their Municipal Strategic Statement. Where planning permits are required for a particular land use or development, conditions can be imposed to minimise impacts on environmental, social, landscape and other values. Where the risk to health and amenity from mosquitoes is high, councils should utilise existing planning mechanisms under Victorian planning law to minimise such risk.

In areas of high mosquito incidence, information should be readily available to architects, developers, planners and landowners on ways to minimise mosquito impacts through appropriate design factors, in a similar way to that currently available to counteract aircraft noise in new developments close to airports. The issue of building permits in these situations could include the requirements for effective mosquito protection.

7.4 Refocus existing DHS program

The DHS program has been carried out for about 20 years. Over that time there have been changes in the focus of the program in line with changes in the presence and spread of the key arboviruses of MVE, BFV and RRV diseases. While there have been no cases in Victoria of MVE over that time, BFV and RRV have now become endemic in the community. More information is needed on arboviruses in Victoria, particularly in relation to the possible future impacts of West Nile encephalitis disease. West Nile Virus is spreading rapidly throughout North America but has yet to reach Australia. It can be fatal to humans, other mammals and birds and is related to the milder Kunjin Virus in Australia.

Increasingly, the DHS program is focusing on surveillance mechanisms to provide early warning on possible MVE incidence and on severe localised outbreaks of RRV or BFV. Predictive indicators for MVE occurrence in Victoria are currently imprecise. Recent work by Whelan et al (2003)[16] could provide a basis for examining MVE prediction criteria for Victoria. Such research would link with the current DHS monitoring and surveillance program.

The DHS program includes training of monitors and community education. This framework suggests opportunities for DHS to strengthen the role of community partners in surveillance and health promotion related to mosquito control. Training programs could also be strengthened by including new elements such as risk assessment and program development.

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End notes and references

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[6] Department of Natural Resources and Environment (1997). Victoria's Biodiversity Strategy. Department of Natural Resources and Environment. Victoria.

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[8] Department of Natural Resources and Environment (2002). Management of Victoria's Ramsar Wetlands: Strategic Directions Statement. . Department of Natural Resources and Environment. Victoria.

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[13] Standards Australia (1999) Joint Standards Australia/Standards of New Zealand Committee on Risk Management. Standard AS/NZ 4360:1999.

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[15] Department of Natural Resources and Environment.(2002). Victoria's Native Vegetation Management. A Framework for Action. Department of Natural Resources and Environment. Victoria.

[16] Peter I.Whelan, Susan P. Jacups, Lorna Melville, Annette Broom, Bart J Currie, Vicki L. Kruse, Brett Brogan, Fiona Smith and Phillippe Porigneaux. (2003) Rainfall and vector mosquito numbers as risk indicators for mosquito borne diseases in Central Australia. CDI. 27:1. P110-116.

Appendix 1 Postal survey of local government

An email questionnaire was sent to the Environment Officers of all the 78 City and Shire Councils in Victoria. Thirty six replies (46%) were received including replies from the nine councils participating in the DHS program. Many municipalities reported no mosquito problems.

Name	**DHS grant**	**Program * 2002-3 ($,000)**	**Comments**
Campaspe	yes	16.0	CE**brochures and monitoring
East Gippsland	yes	106.0	*Bti, methoprene*. Monitoring. CE-brochures. Conflict between residents, council and PV/DPI. Nuisance value major issue
Gannawarra	yes	3.5	Use *Temphos (Abate)*treatment
Mildura	yes	34.0	*Abate*, weedicide. IPM approach, CE- media, brochures, schools, talks.
Moira	yes	25.0	*Abate*. Mainly drain spraying. Residents want more locations sprayed. CE – brochures, schools, media.
Shepparton	yes	30.0	*Abate* on drains mainly. Some concerns on environmental impacts, spray more locations. Outcomes adequate
Swan Hill	yes	30.0	*Abate*. Mainly private and council land breeding areas. CE
Wellington	yes	38.0	*Bti*, monitor. Control season should start earlier. CE-meetings, brochures.
Wodonga	yes	10.0	Spray *Abate*. CE. Monitoring
Bass Coast	no	10.0	*Bti* hand spread. Monitoring, CE-brochures, media
Ballarat	no	0.0	No significant mosquito management issues.
Banyule	no	0.0	none
Bendigo	no	0.0	CE provided (DHS brochures)
Cardinia	no	0.0	none
Central Goldfields	no	0.0	CE provided (DHS brochures)
Colac	no	0.0	CE– domestic breeding sources
Frankston	no	0.0	Minor *Bti* on council land, Seaford wetlands (Melbourne Water). CE
Geelong	no	120.0	*Bti, s-methoprene*, CE, need a holistic approach, 400 hectares of breeding area close to residential development.
Glen Eira	no	0.0	none
Hobsons Bay	no	0.0	No formal management plan. Inadequate control.
Latrobe	no	0.0	CE (DHS brochure)
Mansfield	no	0.0	none
Maroondah	no	0.0	none
Melbourne	no	0.0	Has prosecuted under Health Act .
Melton	no	0.0	CE-(DHS brochures)
Mornington	no	0.0	none
Moorabool	no	0.0	none
Moyne	no	3.0	*Abate, Baytex (adults)*. Minor ground spraying. CE-Council newsletter
Queenscliffe	no	3.0	*Bti* . CE-media. Breeding sites on DSE wetlands
Stonnington	no	0.0	none
South Gippsland	no	0.0	none
Wangaratta	no	0.5	*Abate*. CE.
Whittlesea	no	0.0	Use the Nuisance Provisions of *Health Act*.
Wyndham	no	0.0	Need recommended guides for owners
Yarra	no	0.0	none
Yarriambiack	no	0.0	none

*2002-03 budget allocation. **CE = Community Education

Appendix 2 People and organisations consulted

Consultations were carried out with local Councils, Parks Victoria and DSE officers, specialist bird watching groups, community groups and research students involved in mosquito management issues.

Organisation	Personnel
Department of Sustainability and Environment	Janet Holmes Richard Loyn Lindy Lumsden Tarmo Raadik Jack Krone Gary Barnes
Department of Human Services	Rodney Moran
Parks Victoria	Wayne Hill Peter Kemp Peter Kambouris Bruce Wehner Scott Coutts Mick Douglas
Department of Primary Industries	John Cooke Anthony Costigan Richard Boekel
Victorian Institute of Animal Science (VIAS)	Elwyn Wishart
Department of Planning and Infrastructure (WA)	Sean Collingwood
Bird Observers Club of Australia	Don Saunders
Municipal Association of Victoria	Conservation Officer
Phillip Island Nature Park	Ashley Reed Scott Campbell
Birds Australia	Dorris Graham Roz Jessop Michael Weston John Peter
Goulburn-Murray Water	Pat Feehan
Bass Shire	Doug Cooney Hilton Chadwick
East Gippsland Shire	Kate Nelson Ian Bate John Roche
Geelong City	Steve Sodomaco Lyndon Ray
Mildura City	Malcolm Hare
Moira Shire	Max Minard Ian Morley

Appendix 2 continued

Organisation	Personnel
Shepparton City	Greg McKenzie Phil Crowe Doug Cousins
Swan Hill Shire	Terry Devereux
Wellington Shire.	Phillip Medhurst Michael Holland
Bairnsdale Business and Tourism	Tom Courtney
French Island Community Association.	Rob Cheetham
St Leonards and Ocean Grove Progress Associations.	Ms B Halpin
St Leonards Caravan Park	Z & R Jankowski
Barwon Heads Progress Association	Dr Robert Gibson
Research Students	Phillip Barton, Deakin University Sharon Haseldi, University of WA.

Appendix 3 Characteristics of mosquitoes in Victoria[1, 2, 3]

Species	Distribution	Preferred breeding sites	Period of activity	Vertebrate hosts	Disease risk
Anopheles annulipes	Throughout State	Ground and rock pools, irrigated pastures. Generally in fresh water; may also be found in polluted or brackish water	Bite predominantly at night	Prefers to feed on mammals, usually cattle, but does bite humans.	Not thought to be an important vector of human disease has yielded isolates of RRV. Inefficient vector of dog heartworm
Coquillettidia linealis	Mainly northern and western regions	Swamps, lagoons and transient grassy pools	Late spring, through summer. Bite during the day, evening and at night	Humans and other mammals	RRV and BFV have been isolated from the species in NSW. Should be considered a vector of concern A significant nuisance..
Culex annulirostris	Widespread in State but mainly in northern Victoria	Ground pools with emergent vegetation including rice fields, flooded pastures and road drains.	Mid spring to late autumn. Most active during two hours at sunset, to a lesser extent at dawn	Humans, other mammals and birds	Important vector of arboviruses including MVE, KUN, BFV and RRV. Also a vector of dog heartworm and probably of myxomatosis in rabbits
Culex australicus	Widespread across the State	Wetlands with thick vegetation and shallow banks, irrigated pastures, occasionally in brackish and polluted water	Spring to autumn	Animals but not humans	May initiate MVE amongst vertebrates early in the season Maybe also an important vector of myxomatosis.
Culex globocoxitus	Common in coastal and inland areas	Swamps and ground pools	Spring to autumn	Rarely bites humans	Not likely to be an important vector of human disease
Culex molestus	Throughout the state	Sewerage ponds, septic tanks, polluted ground water, containers, drainage pits.	Year round, bites at night	Humans and birds	May carry MVE but the importance, as vector of this disease is not known. Major domestic pest in some areas.
Culex quinquefasciatus	Mainly in northern Victoria	Many types of water containers near human habitation, and ground pools.	Warmer months. Bites in middle of night both indoors and outdoors	Prefers birds to biting humans	Is considered a poor or unlikely vector of MVE, KUN, RRV and other arboviruses. Major domestic pest in many areas. Important vector of fowl pox.
Ochlerotatus alternans	Throughout the State in coastal and inland environments	Saline wetlands. Eggs are laid in mud at base of plants and hatch when inundated by heavy rain, high tides or wind. .	Bites by day and night	Humans and other mammals	RRV has been isolated from it in NSW but its importance as a disease vector is not known. Very large mosquito.

[1] NSW Health, The New South Wales Arbovirus Surveillance and Mosquito Monitoring Program, http://www.arbovirus.health.nsw.gov.au/
[2] Sarneckis, Katherine (2002), *Mosquitoes in Constructed Wetlands*. Report to the Environment Protection Authority, Adelaide
[3] Wishart, Elwyn. (2003) VIAS. Personal communication.

Appendix 3 continued

Species	Distribution	Preferred breeding sites	Period of activity	Vertebrate hosts	Disease risk
Ochlerotatus camptorhynchus	Typically a coastal species but may occur inland in brackish riverine areas	Saline wetlands. Eggs are laid in mud at base of plants and hatch when inundated by heavy rain or high tides.	Throughout the year. Vicious biter day and night.	Humans, other mammals and birds	Important known vector of RRV and BFV virus in southern Victoria. Laboratory trials have shown it to carry MVE
Ochlerotatus notoscriptus	Throughout State	Domestic containers and forested areas with tree holes and / or rock pools.	Readily bites humans during the day in shaded areas, but also feeds in evening, at night and in the early morning	Humans and other mammals	Has been shown to carry MVE and to transmit RRV and BFV in laboratory studies. Field role as a vector of arboviruses is not known. Major domestic pest species.
Ochlerotatus sagax	Northern and north western regions	Temporary ground pools with marginal and emergent vegetation. Areas of flood and furrow irrigation. Eggs may persist in soil between irrigations and even between seasons.	Mainly spring species but can be active after summer and autumn flooding	Humans and other mammals	Disease vector status is unknown. RRV has been isolated from mosquitoes in the field and the species has been shown to be capable of carrying MVE in the laboratory.
Ochlerotatus theobaldi	Northern and western regions	As for *Ochlerotatus sagax*	Active in spring and after natural flooding promotes hatching of eggs. Bites mainly during the day but will also bite at night	Humans and other mammals	May carry MVE and RRV but there is no information on the field transmission of these viruses Major pest following extensive rain or flooding.
Ochlerotatus vittiger	Northern and north western regions	As for *Ochlerotatus sagax*	Active from spring, most abundant early to mid summer and after autumn floods. Large mosquito that readily bite humans day and night.	Humans and other mammals	Has been shown to carry MVE in laboratory studies but no evidence for field transmission of human disease. Significant pest in irrigation areas and after floods in riverine areas.

It should be noted that following a reclassification of mosquitoes in 2000, many species formerly within the genus *Aedes* are now placed in the genus *Ochlerotatus*. This classification is used throughout this report.

Appendix 4. DHS mosquito control program

DHS provides approximately $125 000 per year to assist nine designated Councils to carry out IMM. Seven of these Councils are located in the Murray Valley in Northern Victoria. They were the initial recipients of funding from the Commonwealth Government, after the 1974 MVE outbreak, to carry out mosquito control works, community education, mosquito monitoring and blood sampling. East Gippsland and Wellington Shire Councils were subsequently added to the group following significant outbreaks of RRV disease in Gippsland in the early to mid 1980's.

The DHS program also funds:

- the VIAS at Attwood to carry out analyses of mosquito and blood samples, and
- a regular training program for mosquito monitors on taking samples and on treatment of mosquitoes using different materials and methods.

Councils under the DHS program

Mildura Rural City Council
Swan Hill Rural City Council
Gannawarra Shire Council
Campaspe Shire Council
Moira Shire Council
Greater Shepparton City Council
Wodonga Rural City Council
East Gippsland Shire council
Wellington Shire Council

The criteria for funding through this program are based on:

- documented evidence of significant arbovirus disease within the municipality (based on incidence of cases by place of disease acquisition and not by place of residence);
- past history of MVE cases acquired within the municipality.

The Victorian Arbovirus Task Force would then determine the need for a program.

Appendix 5. Environmental implications of treatments

At a generic level, freshwater and saltmarsh ecosystems are well understood and comprise aquatic flora and fauna (including fish and macro-invertebrates, terrestrial and aquatic birds). However, in Victoria, no research has been done on the sensitivity of various key aquatic species to larvicides, the role of mosquitoes in the food chain or the impacts of various forms of habitat modification on saltmarsh characteristics.

Mosquitoes in the food chain

Mosquitoes are an important part of natural ecosystems. The aquatic larvae and pupae can provide a significant food resource in wetlands and other aquatic environments. Adult mosquitoes are also a food source for certain birds and bats. The diet of the Little Forest Bat contains up to 20% of Diptera *spp*. over its summer feeding season, some at least of which would be adult mosquitoes [1]. However, because of the very low biomass of one mosquito, the energy expended for something of such low calorific value makes it a limited food source. Mosquitoes are probably too small to constitute much of the diet for other larger bats and birds. The populations of mosquitoes fluctuate markedly between and within seasons due to the ephemeral nature of the habitat. As such they considered an opportunistic food source rather than a basic requirement for predators. Mosquito larvae are not a significant food source for migratory wading birds which are "mud feeders" and rely more on crustaceans and worms. They could however be an important element of diet for "filter feeders" like spoonbills[2] and ducks[3].

Mosquito larvae are eaten by a number of predator fish where they have access to them. However fish are opportunistic feeders and the larvae would constitute only a proportion of their diet when available[4]. In many areas, especially saltmarshes, mosquito breeding sites are not readily accessible to these predators unless mechanical works are carried out to link isolated pools to larger water bodies via a series of shallow drains (runnels). These predators are, in turn, part of the food chain for waterbirds and other fish.

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 making use of natural ecological processes and predator populations that can maintain mosquito numbers within acceptable limits. The Victorian Biodiversity Strategy outlines its "goals for biodiversity management" which include the need to ensure that: "t*he ecological processes and the biodiversity dependent upon terrestrial, freshwater and marine environments are maintained and, where necessary, restored"*.[5]

Where habitat modification is proposed, it is important to ensure that there will be a minimal impact on natural wetland values. It is often difficult to ascertain what is the total impact of any habitat modification. Several studies have been carried out in Australia and overseas on modification of saltmarshes through various forms. Runnelling has the potential to modify salt marsh hydrology, the chemical characteristics of marsh soil, and marsh topography. Of particular concern is the issue of acid sulphate soils that are found in some estuary sites. Exposure of these soils to air produces sulphuric acid that can generate very acid surface water and have a significant impact on aquatic ecosystems. However trials in south west Western Australia showed little impact on these characteristics when using shallow spoon drains of 6-20 m long, 5-25cm depth and 30-40 cm width on [6]. Other studies indicate that the larger (width and depth) the drains, the greater the likely impact on soil and water characteristics[7].

Modification of saltmarshes to reduce mosquito breeding has proven effective in America and eastern Australia. Mosquito larvae decreased significantly in studies in Queensland [8] and New South Wales[9]. Draining and runnelling also significantly reduced the abundance of larval mosquitoes in south west Western Australian studies. As the main effect on larval numbers seems to be the improved flushing of perched saltmarsh pools to more open waters (and predators), areas with little tidal influence on water levels, such as the Gippsland Lakes, are less likely to benefit from runnelling.

Appendix 5 continued

Wetland modifications likely to significantly impact on matters of national environmental significance, especially though extensive drainage, would come under the EPBC Act. It would then require significant resources, perhaps involving research, to prepare a proposal to the stage where it can be considered for approval. This may be beyond the resources of an individual local Council.

Slashing fringing vegetation (harbours for mature mosquitoes) around wetlands of low conservation value can reduced mosquito harbour. In Victoria, controls to protect native vegetation are relevant to the use of this strategy. With ephemeral freshwater wetlands, the development of aquatic refuges for native predator species allows rapid recolonisation as the wetland refills. Both these practices have the potential to impact on environmental values and should not be carried out without adequate assessment of native species in the area.

Effects of pesticides on non-target species

Much work has been done in other parts of Australia and overseas on the impacts of control agents like Bti and s-methoprene on non-target species. Overwhelmingly these agents have been shown to be highly specific to mosquito larvae and few other macro-invertebrates. They are quickly broken down under UV light and do not remain in soil or aquatic ecosystems. Their margins of safety are a hundredfold to a thousandfold better than that of the safest chemical treatments. Data from studies elsewhere can be used to predict potential impacts (if any) on Victorian wetland species. This may allow research targets to be prioritised in the Victorian context. The objectives of any pesticide component of mosquito management is to complement and assist natural and other management mechanisms while minimising adverse environmental impacts on non-target species. The development of highly specific pesticides for mosquitoes has allowed their effective control in many environmental sensitive areas. Pesticides registered in Victoria as larvicides for mosquito management include temphos , Bacillus thuringiensis israelensis (Bti), and s-methoprene.

Temphos (Abate) is an organophosphate insecticide that has been used extensively in Australia and overseas. Bti is a microbial toxin that acts by destroying the lining of the larval gut following ingestion whereas s-methoprene is a growth inhibitor for larvae. They all break down after about 24 hours, inactivated by UV light. Temphos is increasingly being replaced by Bti and s-methoprene which have been shown to be more targeted to mosquito larvae with little impact on some indicator species of crustaceans[10], birds[11] or frogs [12]. While some studies have shown reductions in some species of macroinvertebrates (particularly Chironomidae- non-biting midges) in the first 2 years after treatment with Bti[13], these populations have subsequently returned to normal after 6 years [14]. In a study of 25 wetlands in Minnesota (USA) on the use of Bti and s-methoprene, no effect was found on the bird community as a whole or on 19 individual bird species three years after treatment [15].

While studies have been done in the USA and Queensland, no sensitivity studies have been done in southern Australia (freshwater and saltwater sites) on appropriate or key species. On the other hand, there has been no obvious change in macro-invertebrates or vertebrate species in saltmarsh areas, beyond usual seasonal changes, where Bti has been used for the last 20 years. Thus, it is reasonable to be confident in using Bti and s-methoprene in environmentally sensitive areas, especially if the sites treated are a small (<20%) part of the total habitat type.

The use of adulticides to treat mosquitoes is not common, except in some cases where significant disease outbreaks require rapid reductions in mosquito numbers. The insecticides registered for use in Victoria are mainly malathion and pyrethroids. These chemicals have a more broadscale impact on non-target species and may have a much smaller impact on overall mosquito numbers than larviciding[16].

Appendix 5 continued

Effects of larvicides on wetland processes

A recent study in freshwater ponds indicates that the rapid build-up of larvae during summer can have a significant repressive effect on slower growing tadpoles, particularly early in the season when tadpoles are small.[17] The use of targeted larvicides could enhance survival and growth of some aquatic biota although more research is needed into the effects of larvicides on natural balances in wetlands.

Scale of any management activity

The scale any treatment of mosquito habitat needs to be taken into account in the assessment of environmental impact. For example, the Gippsland Lakes Ramsar site is 60 000 hectares. Of that there may be a potential for 6 000 hectares of mosquito breeding sites to be treated. About 600 hectares have been identified by local government for treatment making up 10% of the saltmarsh and 1% of the Ramsar site. In this context, provided that there are no threats of "serious or irreversible environmental damage" the scale of the treatment program should be a significant element in the decision-making process.

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Appendix 6. Template for decision-making

1. At Municipal level

Level of Health and Well-being Risk (Table 4)
+
Level of Community Concern (Table 5)

↓

Actions to take (Table 6) → Treat mosquitoes
Community Education
Support Protection
Planning
No Action

2. At Site Level

Assessment Criteria	**Site 1**	**Site 2**	**Site 3**
Environmental sensitivity (see Table 5)			
Matter of National Environmental Significance			
National Parks Act park, nationally important wetland, conservation reserve			
Regionally important wetland			
Degraded/built environment, no threatened species			
Proportion of ecosystem treated in region			
> 40% of same regional ecosystem			
10-40 % of same regional ecosystem			
< 10% of same regional ecosystem			
Area to be treated			
75% of local mosquito breeding sites			
25-75% of local breeding sites			
< 25% of local breeding sites			
Usual water level / tidal influence			
Significantly increases mosquito impacts			
Moderate or irregular effect			
Little or nil impact			
Human population to protect (down wind)			
> 2000 within 2 km of site			
2000-500 within 2 km of site			
< 500 within 2 km of site			
Local community concern (see Table 4)			
> 10 local requests /yr from local area			
3-10 local requests / yr from local area			
<3 local requests /yr from local area			
Main mosquito species present			
MVE, RRV and/or BFV disease vector			
Non- disease biter			
Domestic breeder			
Insect Monitoring in place			
Regularly monitor adult mosquitoes within 2 km			
Regularly monitor larvae on site			
Irregular or nil monitoring.			
Site priority			
Materials			
Methods			

Environmental and site factors

Community

Monitoring