GBS Australia Maud Creek Gold Mine

Biting Insect Assessment Progress Report

Medical Entomology Branch, DHCS
Allan Warchot June 2007

Background

Terra Gold, a subsidiary company of GBS Australia, plans to recommence mining at Maud Creek in December 2007 (Notice of Intent, URS 2006). It is proposed that minimal expansion of the existing open pit will occur, to facilitate development of an underground decline. It was initially planned to crush, mill and float ores at Maud Creek, with concentrates transported to Union Reefs Mine for further treatment. It has now been proposed to transport all ore to Union Reefs Mine for processing.

The Maud Creek mine site is located adjacent to the Gold Creek and Maud Creek ephemeral creeklines and associated low lying drainage areas. Maud Creek and Gold Creek and their associated low lying drainage areas were expected to be sources of pest and disease carrying mosquito species, while mining operations have the potential to create new mosquito breeding sites or exacerbate existing mosquito breeding sites. Due to the absence of mosquito information in the Maud Creek area, it was a requirement of the environmental approval process to consider mosquitoes and their potential health impact to workers, and the potential for the mine site to create new mosquito breeding sites or exacerbate existing mosquito breeding sites.

The Medical Entomology Branch was commissioned by URS Australia Pty Ltd to conduct a baseline biting insect assessment of the proposed Maud Creek mine site, which was to include monthly trapping for 12 months to monitor seasonal trends in mosquito populations, a site visit to locate actual and potential mosquito breeding sites, and an evaluation of development plans and processes to determine the potential of the mine site to create or exacerbate mosquito breeding. Recommendations are to be provided in an assessment report, outlining the potential for mosquito borne disease and pest problems, and measures that can be utilised to reduce the impact of mosquitoes on the workforce and reduce the potential for the mine site to create mosquito breeding. Adult mosquito trapping commenced in April 2007 and will continue until March 2008. Preliminary results of the baseline biting insect assessment are provided below.

Results

Mosquito trapping

The results of two trapping episodes have been collated as Tables 1 & 2. Trap Sites are shown in Figure 1. Trapping on the night of the full moon in April 2007 revealed high numbers (489 females) of the pest and disease vector mosquito *Aedes normanensis* at Trap Site 3, located near the north-east corner of the existing waste rock dump (Table 1). Moderate numbers of *Ae. normanensis* (151 females) were also recorded at Trap Site 2, located near the south side of Gold Creek near the existing access track, while low numbers (93 females) were recorded at Trap Site 1, located adjacent to the antenna installation near the site office demountable.

Anopheles amictus was recorded in moderate numbers (130 females) at Trap Site 3 in April 2007 (Table 1), while other species were recorded in relatively low numbers, including the potential vector mosquitoes *Culex annulirostris* and *Anopheles annulipes s.l.* The salt marsh mosquito was recorded in very low numbers at Maud Creek mine, despite the mine site being located a long distance from any tidal area.

Trapping on the night of the full moon in May 2007 revealed minimal numbers of mosquitoes at all sites. *Anopheles annulipes s.l.* was the most common mosquito collected in May 2007, with 19 adult females collected at Trap Site 3.

Field visit 21 March 2007
Access was restricted during the March 2007 field visit, due to the road washout at the Gold Creek crossing, therefore only a small portion of the mine lease could be surveyed for mosquito breeding.

Gold Creek was flowing in March 2007, and no mosquito breeding was located during sampling in the section of the creek east of the road crossing. The existing pit was steep sided and had minimal margin vegetation growth, and aquatic predators of mosquito larvae were plentiful. No mosquito breeding was located in the existing pit. There were some shallow depressions located on the east side of the waste rock stockpile, and low level mosquito breeding was recorded, with *Culex annulirostris* the mosquito species found breeding.

An examination of aerial photography revealed the major potential mosquito breeding sites to be the large low lying plain north-west of the existing open pit, and seasonally flooded areas associated with Gold Creek and other ephemeral creek lines within and adjacent to the mine lease. Gold Creek, Maud Creek and other ephemeral creek lines within and adjacent to the mine lease are also potential mosquito breeding sites, particularly where margin vegetation is present.

Discussion

Mosquito species present
General information on the breeding sites for the major pest and potential disease vector mosquitoes in the Top End of the NT is provided in Appendix 1. A discussion on select important mosquito species collected during April and May 2007 trapping is provided below.

1. Aedes normanensis
Preliminary trapping revealed that *Aedes normanensis* would be seasonally present in high numbers within the mine lease. This species will be most abundant in the wet season months of December to April, when rainfall floods low lying areas associated with creeklines within and adjacent to the mine lease. The large low lying plain north-west of the existing waste rock dump is potentially the major breeding site for this species affecting Maud Creek mine. *Aedes normanensis* is a potential vector of Ross River virus (RRV), Barmah Forest virus (BFV) and Murray Valley encephalitis virus (MVEV), and is also a severe pest mosquito which bites in shaded areas during the day, and at night.

2. Culex annulirostris
The common banded mosquito *Culex annulirostris* was recorded during trapping at Maud Creek mine. Only low numbers were recorded during the April and May 2007 trapping, although potentially significant habitat exists within the mine lease. Several depressions associated with the existing waste rock dump (east side) were found breeding *Cx. annulirostris* in March 2007, these sites were likely to have been created by the construction of the waste rock dump. The large low lying plain located north-east of the waste rock dump is a potentially significant breeding site, as well as other low lying areas associated with the nearby ephemeral creeklines, especially if these areas are vegetated with grass and semi-aquatic vegetation. These low lying areas are likely to be breeding sites in the wet season and early dry season, however adult mosquito trapping revealed minimal numbers in April and May, indicating low productivity in the late wet season/early dry season. Highest numbers of this species in Katherine occurs from January to March (MEB Annual Report 2005/06), therefore it can be expected that peak abundance of this species will occur from January to March at Maud Creek Mine, with moderate to high numbers likely to be expected.

At present, the existing open pit has minimal potential as a mosquito breeding site, due to the presence of steep sides and hence minimal margin vegetation. As the pit will be dewatered to allow

underground mining, it will not be a potential mosquito breeding site during the life of the mine, but could become a potential mosquito breeding site when mine operations cease and the pit fills with water.

Culex annulirostris is a serious pest species and a potential vector of RRV, BFV, MVEV, Kunjin virus (KUNV) and many others. This species bites at night so will only affect unprotected workers after sundown.

3. Anopheles annulipes s.l.

Anopheles annulipes s.l. is a potential vector of malaria (Russell 1987), and was recorded in low numbers at Maud Creek Mine. Trap Site 3 was the most productive trap site, indicating the presence of nearby flooded vegetated areas, possibly the poorly draining areas associated with the waste rock dump. Other potential breeding sites for this species at Maud Creek Mine would include vegetated cut off pools in the ephemeral creek lines in the mine lease, and seasonally flooded low lying areas. This species is likely to be most abundant at the mine site from January to May.

4. Anopheles amictus

Anopheles amictus is a potential vector of malaria (Russell 1987), and was recorded in relatively high numbers at Trap Site 3 in April 2007. Potential breeding sites would have included those potential breeding sites for *An. annulipes s.l.* mentioned above. *Anopheles amictus* is likely to be most abundant at the mine site from January to May.

5. Aedes vigilax

The salt marsh mosquito *Aedes vigilax* was recorded in very low numbers at Maud Creek Mine, despite the mine site being located a large distance from any tidal area. *Aedes vigilax* can disperse over 60km with favourable wind conditions, and is recorded every year in Katherine, sometimes in pest numbers (MEB Annual Report 20005/06). It is possible that pest numbers of this species could affect the mine site in November to January, when humid conditions enable this species to live longer. *Aedes vigilax* is a potential vector of RRV and BFV, and bites in shaded areas during the daytime as well as at night.

Personal protection

There will be periods of the year when personal protection from mosquitoes will be required. Extensive information can be found in Appendix 2 ‘Personal protection from mosquitoes and biting midges in the NT’. In summary, mosquito abundance at the mine site is likely to be highest from January to May, therefore it is this period of the year when personal protection will be required after sundown, and possibly during the daytime in shaded areas if *Aedes normanensis* is present. Salt marsh mosquitoes may periodically affect the mine site from November to January, and if present in pest numbers personnel will be required to take personal protection measures in shaded areas during the daytime, as well as at night.

Malaria

Malaria is not endemic to Australia, but there is always the risk of re-introduction if a worker sourced or returning from overseas with malaria is bitten by an *Anopheles* species mosquito at Maud Creek Mine. Therefore, any worker sourced or returning from an overseas country where malaria is endemic, who experiences high fever should be kept indoors away from mosquito bites until cleared of malaria or treated for malaria by a health professional.

Dengue fever

The mosquito that transmits dengue fever, *Aedes aegypti*, has largely been absent from the Northern Territory since the 1960’s, although an incursion into Tennant Creek occurred in 2004, and a two year successful eradication campaign followed to eliminate the mosquito from Tennant Creek. *Aedes aegypti* has recently been found on Groote Eylandt, and an eradication campaign has commenced to eliminate the mosquito from Groote Eylandt and prevent the spread of this species to the NT

mainland. This highlights the risk of the importation of this species from either North Queensland, where it is endemic, or from overseas.

Any used tyres, water drums, rainwater tanks, machinery items that can pond water (ie backhoe buckets, excavator tracks), building material and equipment wrapped in plastic sheeting or with the potential to hold water, and any other item capable of ponding even small amounts of water, which are sourced from North Queensland or Groote Eylandt, has the potential to introduce the dengue mosquito *Aedes aegypti* as drought resistant eggs. Artificial receptacles that have previously held rain water should be treated with a 10% chlorine solution or an appropriate residual insecticide (deltamethrin or lambda-cyhalothrin), to prevent the possibility of the introduction of *Ae. aegypti* into the Maud Creek Mine Site and Katherine.

Mosquito breeding and development aspects

Mine sites have the potential to create or exacerbate mosquito breeding, potentially from the creation of water dams, wetland filters, borrow pits, sediment traps, dry season water discharge, waste water disposal, creek diversions as well as the construction of roads and mine waste dumps. Construction of the mine site should therefore be in accordance to the recommendations provided in Appendix 3 'Guidelines for preventing mosquito breeding sites associated with mine sites'. If mine facilities are constructed in a manner that prevents the creation of mosquito breeding sites, then mosquito control of artificially created areas would not be required. The shallow depressions located on the east side of the existing waste rock stockpile are mosquito breeding sites and should also be rectified as part of this development.

Artificial receptacles such as used tyres, drums, disused machinery and any rubbish items that can collect rain water are potential mosquito breeding sites. Mosquito species that are commonly found breeding in artificial receptacles are *Aedes notoscriptus* and *Culex quinquefasciatus,* with the former a potential vector of RRV. Mosquito species that occasionally breed in artificial receptacles include the potential malaria vector *An. annulipes s.l.* and the major arbovirus vector *Cx. annulirostris.*

Periodic inspections of artificial receptacles should be conducted during the wet season at the mine sites and mine camp, with any receptacle found ponding water either disposed of, stored under cover, have drainage holes drilled or treated with an appropriate insecticide on an appropriate schedule, to prevent potential mosquito breeding and minimise the potential for the re-introduction of *Ae. aegypti* from North Queensland.

It would be costly and time consuming to control mosquito breeding in natural sites surrounding Maud Creek Mine, therefore particular care should be taken to avoid the creation of new mosquito breeding sites. If adult mosquito control is required, the residual insecticides bifenthrin or alpha cypermethrin should be applied to personnel areas to control adult mosquitoes. See Appendix 3 for information on Bifenthrin treatments for adult mosquito control.

Conclusions

- *Aedes normanensis* will be periodically present in high numbers at the Maud Creek Mine Site in the months of January to April, and will pose pest problems and a potential Ross River virus (RRV), Barmah Forest virus (BFV) and Murray Valley encephalitis virus (MVEV) risk.

- *Culex annulirostris* will be present at the Maud Creek Mine Site in the months of January to May, with the months of January to March likely to experience the highest numbers of this species. This species will pose a potential RRV, BFV, MVEV and Kunjin virus risk.

- *Anopheles annulipes s.l.* and *Anopheles amictus* will be most abundant at the mine site in the months of January to May, and will pose a potential malaria transmission risk if a person with malaria is bitten by *Anopheles* mosquitoes at the mine site.

- There is the potential for the re-introduction of the dengue mosquito *Aedes aegypti* to mainland NT from North Queensland or Groote Eylandt. The risk will arise if any used tyres, water drums, rainwater tanks, machinery items that can pond water (ie backhoe buckets, excavator tracks), building material and equipment wrapped in plastic sheeting or with the potential to hold water, and any other item capable of ponding even small amounts of water are sourced from these areas.

- Mine sites have the potential to create or exacerbate mosquito breeding, potentially from the creation of water dams, wetland filters, borrow pits, sediment traps, dry season water discharge, waste water disposal, creek diversions as well as the construction of roads and mine waste dumps. There are mosquito breeding depressions located on the east side of the existing waste rock dump at Maud Creek Mine.

- Further information on mosquito species at Maud Creek Mine will be obtained from the monthly adult mosquito trapping program, which will finish in March 2008. The complete report with recommendations will be provided upon the completion of the adult mosquito trapping program. The conclusions in this interim report were based on the limited mosquito information so far from the Maud Creek Mine and information from various Medical Entomology Branch information sheets and Annual Reports.

Recommendations

- Any used tyres, water drums, rainwater tanks, machinery items that can pond water (ie backhoe buckets, excavator tracks), building material and equipment wrapped in plastic sheeting or with the potential to hold water, and any other item capable of ponding even small amounts of water, which are sourced from North Queensland or Groote Eylandt, should be treated with a chlorine solution (10%) or appropriate residual insecticide (deltamethrin or lambda-cyhalothrin) to prevent to introduction of the dengue mosquito *Aedes aegypti*.

- Any worker sourced or returning from an overseas country where malaria is endemic, who experiences high fever should be kept indoors away from mosquito bites until cleared of malaria or treated for malaria by a health professional.

- The mine site should be constructed in accordance to the recommendations in the MEB guideline ‘Guidelines for preventing mosquito breeding associated with mine sites’.

- All workers should be advised of the potential for mosquito pest problems and mosquito borne disease transmission at the Maud Creek Mine Site, and be advised of appropriate personal protection measures. Refer to the Medical Entomology Branch handout ‘Personal protection from mosquitoes and biting midges in the Northern Territory’.

- Periodic inspections of artificial receptacles should be conducted during the wet season at the mine sites and mine camp, with any receptacle found ponding water either disposed of, stored under cover, have drainage holes drilled or treated with an appropriate insecticide on an appropriate schedule.

- The depressions located on the east side of the existing waste rock dump should be rectified as part of this development.

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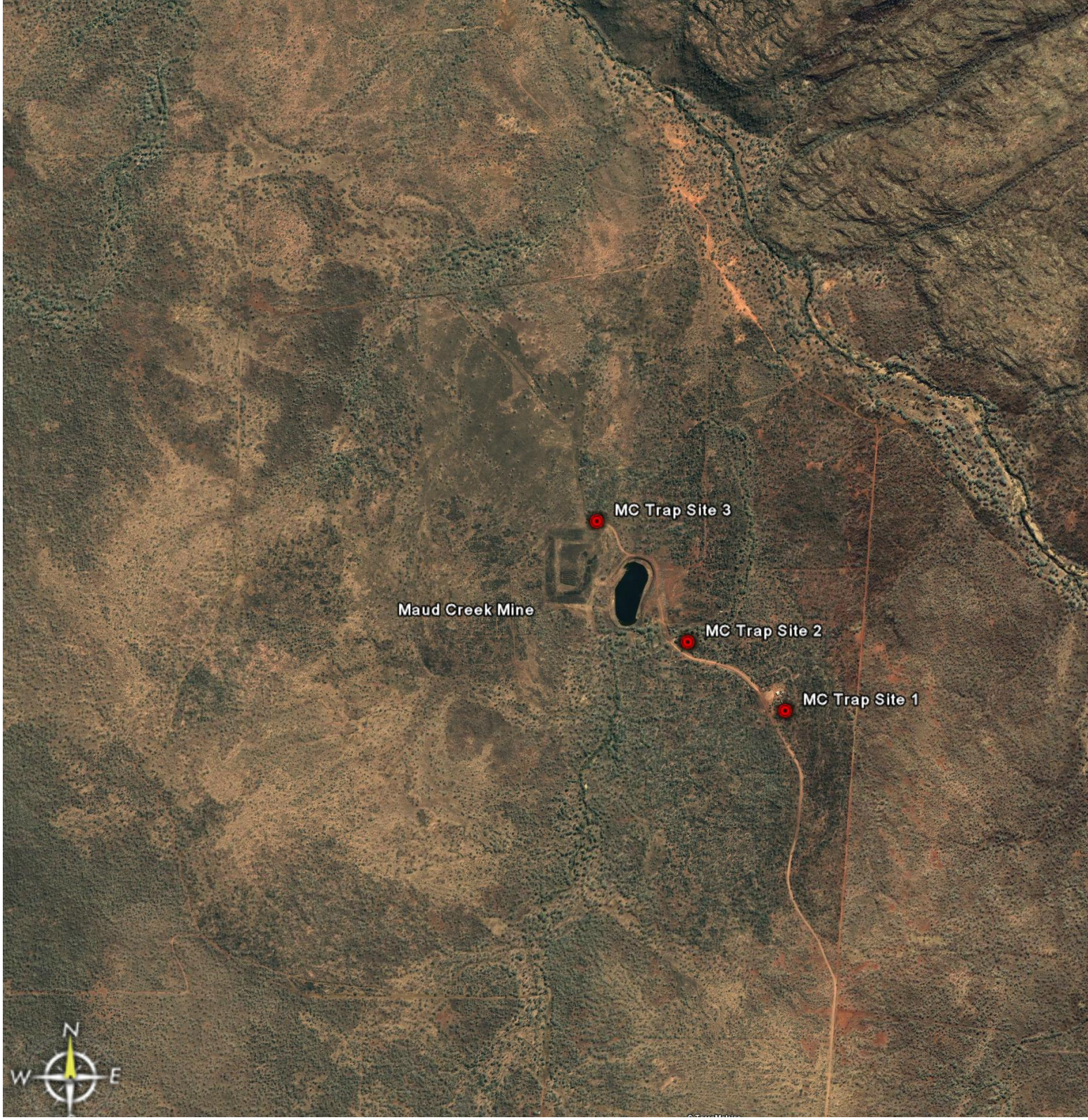
Figures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Maud Creek Mine
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Tables

Table 1

BASELINE MOSQUITO MONITORING RESULTS MAUD CREEK MINE

Date collected	4/4/2007																											
	Ae. (?) species 1&0		*Ae. (Fin) notoscriptus*		*Ae. (Mac) tremulus*		*Ae. (Muc) alternans*		*Ae. (Neo) lineatopennis*		*Ae. (Och) normanensis*		*Ae. (Och) vigilax*		*An. (Cel) amictus*		*An. (Cel) annulipes s.l.*		*Cx. (Cul) pullus*		*Cx. (Cux) annulirostris*		*Cx. (Cux) bitaeniorhynchus*		*Cx. (Cux) palpalis*		**TOTALS**	
Trap location	No. of females	No. of males	No. of females	No. of males	No. of females	No. of males	No. of females	No. of males	No. of females	No. of males	No. of females	No. of males	No. of females	No. of males	No. of females	No. of males	No. of females	No. of males	No. of females	No. of males	No. of females	No. of males	No. of females	No. of males	No. of females	No. of males	**Total No. of females**	**Total No. of males**
Maud Creek Mine Site 1 - Adjacent to aerial near mine camp	0	0	1	0	6	1	0	0	0	0	93	0	1	0	7	0	0	0	1	0	5	0	0	0	0	0	**114**	**1**
Maud Creek Mine Site 2 - Gold creek, approx 40m east of access road, south side of creek	0	0	1	0	1	0	0	0	26	0	151	0	1	0	9	0	2	0	1	0	5	0	1	0	0	0	**198**	**0**
Maud Creek Mine Site 3 - Ajdacent to NE corner of waste rock stockpile	2	0	0	0	5	0	5	0	14	0	489	0	2	0	130	0	17	0	17	0	12	0	0	0	2	0	**695**	**0**
TOTALS	**2**	**0**	**2**	**0**	**12**	**1**	**5**	**0**	**40**	**0**	**733**	**0**	**4**	**0**	**146**	**0**	**19**	**0**	**19**	**0**	**22**	**0**	**1**	**0**	**2**	**0**	**1007**	**1**

Please note: When "Trap failure mosquitoes" and "Not collected" = "1" in the insect species columns, this means that the corresponding trap site was a trap failure or the trap was not set/collected.

Table 2

BASELINE MOSQUITO MONITORING RESULTS MAUD CREEK MINE

Date collected	03/05/2007																			
	Ae. (Cha) elchoensis		*Ae. (Fin) kochi*		*Ae. (Fin) notoscriptus*		*Ae. (Mol) pecuniosus*		*Ae. (Och) vigilax*		*An. (Cel) amictus*		*An. (Cel) annulipes s.l.*		*Cx. (Cux) annulirostris*		*Cx. (Cux) palpalis*		**TOTALS**	
Trap location	No. of females	No. of males	No. of females	No. of males	No. of females	No. of males	No. of females	No. of males	No. of females	No. of males	No. of females	No. of males	No. of females	No. of males	No. of females	No. of males	No. of females	No. of males	**Total No. of females**	**Total No. of males**
Maud Creek Mine Site 1 - Adjacent to aerial near mine camp	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	**3**	**0**
Maud Creek Mine Site 2 - Gold creek, approx 40m east of access road, south side of creek	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	**2**	**0**
Maud Creek Mine Site 3 - Ajdacent to NE corner of waste rock stockpile	3	0	0	0	1	0	2	0	0	0	9	0	19	0	1	0	1	0	**36**	**0**
TOTALS	**3**	**0**	**1**	**0**	**1**	**0**	**2**	**0**	**1**	**0**	**9**	**0**	**20**	**0**	**3**	**0**	**1**	**0**	**41**	**0**

Please note: When "Trap failure mosquitoes" and "Not collected" = "1" in the insect species columns, this means that the corresponding trap site was a trap failure or the trap was not set/collected.

Appendix 1

Northern Territory Government

Department of Health and Community Services

PROBLEM MOSQUITO SPECIES IN THE TOP END OF THE NT PEST AND VECTOR STATUS HABITATS AND BREEDING SITES

P.I. Whelan
Medical Entomology Branch
Department of Health and Community Services
1997

Minor update April 2007

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PROBLEM MOSQUITO SPECIES IN THE TOP END OF THE NT
PEST AND VECTOR STATUS HABITATS
AND BREEDING SITES

Peter Whelan
Senior Medical Entomologist
NT Department of Health and Community Services
1997
Minor update January 2004

These summary tables are intended as a guide and for assistance to environmental health officers and other public health officers involved in mosquito awareness, surveillance and control programs. They are of a general nature only. They are based on selected literature and my 25 years of field experience as an entomologist in the NT.

Flight range
Adult mosquitoes generally disperse in reasonable numbers, at least 1.6 km from their breeding site. However, some fly much longer distances in search of blood meals (eg. *Ae. vigilax, Ae. normanensis* and *Cq. xanthogaster*) and some generally do not fly far at all (eg. *Ve. funerea, Ae. kochi, Ae. tremulus, Cx. quinquefasciatus* and *Ma. uniformis)*

Species identities
Where there are species complexes which are difficult or impossible to separate morphologically, there is no data regarding the vector capacity of the individual members of the complex. For example, *An. farauti s.s.* (formerly *An. farauti* No. 1) is a probable vector of malaria in New Guinea and was probably responsible for the Cairns epidemic in 1942. However, there is no indication of the vector performance of *An. hinesorum* (formerly *An. farauti* No. 2) or *An. torresiensis* (formerly *An. farauti* No. 3) in Australia.

Pest levels
Pest level is very subjective and depends on the population of people subjected to attack and their habits/clothing/location at sunset in an overall setting of size and productivity of nearest breeding sites. CO2 trap levels below the threshold may still be a localised nuisance but are not regarded as at a significant pest level. CO2 trap thresholds generally hold for the Top End of the NT but may vary under different local conditions such as, proximity to breeding site and productivity of breeding site, the topography and vegetation between breeding sites and residential areas, and location and exact position of mosquito traps.

Total of all species present at a given location gives an indication of the total pest level. For protected people, (people inside screened houses at night after sundown) there is no real pest problem even at very high levels. Before sundown the pests in residential areas are primarily *Aedes vigilax* and *Aedes notoscriptus* within flight range of breeding sites and on a seasonal basis. Other species can be pests in shaded/heavily vegetated areas at times during the day but generally have peak biting levels in the first two hours after sundown.

MAJOR PEST AND VECTOR MOSQUITO SPECIES

IN THE TOP END OF THE NT*

Peter Whelan, Medical Entomology Branch, Department of Health and Community Services 1997

SPECIES	PEST STATUS [1]	VECTOR STATUS
An. annulipes s.l. [2]	Widespread pest, bites at night and will enter houses.	Potential malaria vector.
An. bancroftii	Major pest, widespread, bites anytime near breeding site, nightly or shaded areas elsewhere.	Potential malaria vector.
An. farauti s.l. [2]	Local pest, bites at night. Uncommon, except near mostly sub-coastal and extensive freshwater or brackish swamps.	Major potential vector of malaria.
An. hilli	Coastal pest, bites at night, enters houses. Common near brackish water swamps.	Potential malaria vector.
An. meraukensis	Local pest, bites after dark. Very common near extensive freshwater swamp.	Not potential malaria vector.
Ae. normanensis	Major pest, bites in evening and night within 3 km of breeding sites. Plagues in inland areas a week after widespread flooding rains in wet season.	Major vector of Ross River and Barmah Forest viruses. Potential vector of MVEV. Potential vector of many other arboviruses.
Ae. notoscriptus	Local urban pest, receptacle or tree hole breeder, bites persistently, anytime in cool shade. Found naturally in forest areas.	Potential Ross River virus vector. Major vector of heartworm of dogs.
Ae. tremulus	Local urban pest, receptacle or tree hole breeder, bites at sundown and dawn. Often caught in forest areas.	No diseases.
Ae. vigilax	Major pest, bites day or night within 5 km of breeding sites. Plagues associated with high tides in late dry season, early wet season. Fly up to 60 km in pest numbers.	Major vector of Ross River and Barmah Forest virus diseases and dog heartworm. Potential vector of many other arboviruses.
Cx. annulirostris	Major pest, very common and widespread in both urban an rural areas. Bites mainly in evening and at night.	Major arbovirus vector of Murray Valley encephalitis virus (MVEV), Kunjin virus, Ross River virus (RRV) and Barmah Forest virus (BFV) and dog heart worm. Vector of numerous other arboviruses.
Cx. quinquefasciatus	Major urban pest, bites at night, indoors, rests indoors, populations common with polluted water in dry season.	Potential arbovirus vector (MVEV). Vector of heartworm of dogs.
Cx. sitiens	Localized coastal pest, breeds in brackish or tidal waters, disperses widely, bites at night.	Probably no diseases. Possible RRV disease.
Cq. xanthogaster	Major localized pest near extensive reed swamps, disperses widely, bites at night, or in dense shade in day, attracted to lights.	No diseases. Filariasis in frill neck lizard
Ma. uniformis	Localized pest, bites at night near the breeding site, attracted to lights, does not disperse far from breeding sites.	No diseases.
Fl. kochi	Local pest at breeding site, does not disperse. Restricted to *Pandanus* thickets.	No diseases.
Ve. funerea	Local pest near breeding grounds, does not disperse. Common by day only locally inclosed forest near tidal brackish swamps & Creeks.	Potential RRV and BFV arbovirus vector.

*** Adapted and revised from P. Liehne et al. "Mosquitoes and biting midge investigation, Palmerston 1982 -85".**

BIOLOGICAL ATTRIBUTES OF THE MAJOR PEST AND VECTOR MOSQUITO SPECIES IN THE TOP END^ OF THE NT*

Peter Whelan, Medical Entomology Branch, Department of Health and Community Services 1997

SPECIES	IMMATURE STAGES	ADULT STAGES
An. annulipes s.l.	Eggs laid singly on water surface; any freshwater body but numerous near *Eleocharis* reed swamps; temporary or permanent; some receptacles; larvae float on water surface and feed on particles on top of water.	Feeds on a variety of mammals include cattle and humans. Bites at night, especially dawn and dusk. Flies up to 2 km from breeding site; rests in cool shady locations such as stream margins, drains etc.
An. bancroftii	Eggs laid singly. Dark larvae, feeds at water surface; found in heavily shaded fresh to slightly brackish ground pools or swamps, especially in paperbark or *Eleocharis* reed swamps.	Feeds on all mammals readily; will fly up to 4 km from breeding site; bites any time near breeding site, nightly or in shade elsewhere.
***An. farauti s.l.* (Includes *An. farauti, An. hinesorum* and *An. torresiensis*)**	Eggs laid singly on surface; larvae feed on water surface. *An. farauti* breeds in brackish water; *An. hinesorum* and *An. torresiensis* breed in freshwater swamps and pools. Larval habitat often sunlit.	Bites readily at night; feeds on humans, other mammals and birds. Will fly approximately 2 km from the breeding site.
An. hilli	Eggs laid singly on surface; larvae feed at surface; sunlit or shaded brackish to saline ground pools or swamps. Numerous in *Schoenoplectus* reed swamps near coast.	Bites humans, cattle and horses; mainly after sunset. Disperses up to 4 km from breeding site.
An. meraukensis	Eggs laid singly on surface of water; larvae feed at the surface; usually in freshwater *Eleocharis* reed swamps, sunlit or shaded.	Bites readily at dusk, feeds on humans and other mammals.
Ae. vigilax	Eggs deposited singly in the mud or near plant stems in suitable habitats; breeds in tidal pools and marshes, usually those filled by tides in upper tidal zone associated with *Schoenoplectus littoralis* or landward ill draining mangrove areas; larvae browse on substrate.	Major and severe pest species; adults feed very readily on humans, other mammals and birds, day or night; will fly up to 60 km, highest numbers within 5km of breeding sites; shelter in thick vegetation.
Ae. kochi	Eggs laid singly on the axils of *Pandanus* leaves. Larvae feed on detritus and debris in the water collected in the axil space.	Severe pests near the breeding sites. Do not disperse far from the breeding habitat.
Ae. normanensis	Eggs deposited singly in drying mud substrate in poorly draining floodways. Pale larvae can be inconspicuous in colloidal clay suspension water. Tend to dive to bottom when disturbed. Feed by browsing on substrate. Mainly inland rural habitats.	Major pest species. Extreme numbers after flooding rains for 1- 2 weeks. Feeds readily on humans and other mammals, mainly in evening and night. Will fly 3 - 5 km in pest numbers.
Ae. notoscriptus	Eggs laid singly on the sides of tree holes. Dark larvae hang from the surface by siphon and feed by browsing on the substrate. Common in domestic receptacle habitats.	Feeds on humans and all mammals; bites day or evening in the cool shade. Does not disperse widely.
Cx. annulirostris	Eggs deposited as rafts of up to 200 on the water surface; larvae hang from surface and feed on suspended particles; breed in freshwater pools and swamps with emergent vegetation temporary or permanent; will colonize domestic receptacles and breed readily in semi polluted water in storm drains or sewage effluent with vegetation.	Adults are the most common species encountered in the NT and are present throughout the year; feed at night and will bite humans, other mammals and birds; will fly distances of up to 10 km from the breeding site, although common up to 4 km from breeding site.
Cx. quinquefasciatus	Eggs laid as rafts on the surface; breeding grounds are polluted to fresh domestic waters; major sources are septic tanks, leach drains, primary sewage ponds and other polluted ground waters.	Severe domestic pest of humans but will feed on poultry and dogs as well; will feed and rest indoors; bites at night; flies up to 1 km from breeding site.

SPECIES	IMMATURE STAGES	ADULT STAGES
Cx. sitiens	Eggs laid as rafts on surface; brackish coastal ground pools under tidal influence with or without vegetation; larvae hang from the surface and rest on bottom. Feed on suspended matter or on substrate.	Bites mammals and birds at night; pest near coast, will fly up to 5 km but common within 2 km of breeding site.
Cq. xanthogaster	Eggs laid as small raft on the surface; larvae attach themselves to the stems of aquatic plants by a modified siphon and obtain oxygen from the plants; breed in semi-permanent to permanent swamps with emergent vegetation; associated with *Eleocharis* and *Typha* reeds, water lilies and paperbark; larvae feed on suspended material in the water.	Adults are strong fliers and will disperse widely up to 3 - 5 km. Readily feed on birds and mammals including humans; rest in cool vegetation and bite mainly at dusk, also shade during day. Strongly attracted to light and easily disturbed.
Ma. uniformis	Eggs laid as small cluster attached to the under surface of floating leaves water lilies and plant stems; larval habitats and breeding area similar to *Cq. xanthogaster*.	Adults bite humans, other mammals and birds readily at night. Severe pest in cool shade near breeding site during the day and evening; generally does not fly more than 1 - 2 km from breeding sites; strongly attracted to light; adults rest in dense vegetation; pest in the wet season near breeding areas only.
Ve. funerea	Eggs laid singly on moist substrate at edge of breeding area, usually shaded with some salt influence. Dark larvae hang from water surface, generally feeding by browsing on the bottom of the water body.	Vicious biter in cool shaded vegetation near breeding site in day and in evening. Does not continue biting in sun. Do not disperse far from the breeding habitat.

*** Adapted, revised and expanded from P. Liehne et al. "Mosquitoes and biting midge investigation, Palmerston 1982-85".**

^ Applicable for general area of Top End north of and including Mataranka, Larrimah, from Victoria River to Roper River mouths.

SEASONAL PREVALENCE OF THE MAJOR PEST AND VECTOR MOSQUITO SPECIES IN THE TOP END OF THE NT* Peter Whelan Medical Entomology Branch, Department of Health and Community Services 1997	
SPECIES	**SUMMARY OF BIOLOGY & SEASONAL PREVALENCE**
An. annulipes s.l.	Freshwater streams and vegetated swamps. Low to moderate numbers in the wet season, the persistence of populations after the wet season dependent on surface water.
An. bancroftii	Freshwater, paperbark and *Eleocharis* reed swamps and creeks. High to very high numbers at post wet and early dry season, when emergent vegetation at peak and standing water starting to recede.
An. farauti s.l.	Brackish and freshwater species, in vegetated swamps or creeks. Low to moderate numbers in late wet and early post wet season.
An. hilli	Brackish/saltwater breeder, often associated with *Schoenoplectus* reed swamps or creeks or remnant pools in landward mangroves. Low numbers except near extensive brackish water swamps in late wet and early dry season.
An. meraukensis	Open shallow freshwater *Eleocharis* reed swamps and creeks. Moderate to high numbers in the late and immediate post wet season,
Ae. kochi	Breeds in *Pandanus* axils. Moderate numbers in wet season in *Pandanus* thickets.
Ae. normanensis	Floodwater, ground pool breeder in poorly draining floodways associated with creeks and rivers. Very high numbers during wet season, absent at other times.
Ae. notoscriptus	Tree hole or artificial receptacle breeder. Low numbers in wet season but persists in dry season with artificial breeding sites.
Ae. tremulus	Tree hole or receptacle breeder. Low numbers in wet season and early dry season.
Ae. vigilax	Breeds in tidal to brackish swamp or tidal pools in creeks. Extreme numbers in the very late dry and early wet season.
Cx. annulirostris	Breeds in the vegetated margins and pools in permanent and semi-permanent swamps, creeks and floodways Exploits temporary vegetated ground pools in wet season. High numbers in polluted or wastewater with vegetation in dry season. High to very high numbers in the early to mid dry season.
Cx. quinquefasciatus	Domestic water sites, often with organic pollution. Moderate numbers in mid to late dry season, but can be present all year.
Cx. sitiens	Breeds in salt to brackish coastal pools or swamps. Low numbers except locally in tidal pools in upper tide zone in late dry, early wet season, and late wet season.
Cq. xanthogaster	Breeds in freshwater *Eleocharis* reed swamps and creeks. Very high numbers in mid to late dry season when maximum plant growth present in permanent and semi permanent swamps and creeks.
Ma. uniformis	Same as *Cq. xanthogaster* but more associated with floating vegetation, (water lilies). Moderate to very high numbers near habitats in late wet, early dry season.
Ve. funerea	Brackish to tidal ground pools in tidal creeks and swamps, often in shade. Localised pest numbers in the pre wet and wet.
*** Adapted, revised and expanded from P. Liehne et al. "Mosquitoes and biting midge investigation, Palmerston 1982-85".**	

PROBLEM MOSQUITO SPECIES IN THE TOP END OF THE NT
PEST AND DISEASE VECTOR STATUS
Peter Whelan 1997
Medical Entomology Branch, Department of Health and Community Services

Species/	Nuisance status	Disease Vector Status		Potential vectors in the NT	Peak Abundance
(Common Name)		**Current**	**Potential**		
Aedes vigilax (Salt marsh mosquito)	+++++	+++	++++	RRV BFV	September - January
Aedes normanensis (Floodwater mosquito)	+++++	+++	++++	RRV BFV	January - April
Culex annulirostris (Common banded mosquito)	+++++	+++++	+++++	MVEV, KUN RRV, BFV, JEV, others	January - August
Culex gelidus (The frosty mosquito)	+	+	+++	MVEV, KUNV, RRV BFV, JEV, others	January-April
Culex palpalis (Freshwater banded mosquito)	+++	++	+++	MVEV, KUNV RRV, BFV, JEV, others	January-August
Anopheles bancroftii (Black malaria mosquito)	+++	Nil	+	Malaria (possible)	February - July
Coquillettidia xanthogaster (The golden mosquito)	+++	Nil	Nil	None known	March - August
Mansonia uniformis (Waterlily mosquito)	+++	Nil	Nil	None known	March - June
Anopheles farauti s.l. (Australian malaria mosquito)	+	Nil	+++++	Malaria (probable)	March - June
Culex quinquefasciatus (Brown house mosquito)	+++	+	+	MVEV (possible)	January - Jun
Aedes notoscriptus (Receptacle mosquito)	+	+	++	RRV (probable)	Jan - June
Verrallina funerea (Brackish water mosquito)	+++	+	++	RRV, BFV (probable)	Oct - Jan

LEGEND

RRV - Ross River virus BFV - Barmah Forest virus	MVEV - Murray Valley encephalitis virus JEV - Japanese encephalitis virus KUNV - Kunjin virus	+ Minor pest on Disease Potential	+++++ Major pest on Disease Potential

PROBLEM MOSQUITO SPECIES IN THE TOP END OF THE NT
INDICATIVE PEST LEVELS
Peter Whelan 2002
Medical Entomology Branch, Department of Health and Community Services

Species	Main distribution	Peak Period	CO_2 Trap at Residence *	CO_2 Trap at Monitoring Site #
Aedes vigilax	Top End, north of Wave Hill, Larrimah and Borroloola	September - January	20	50
Aedes normanensis	Subcoastal Top End south to Ti Tree	January - April	30	50
Culex annulirostris	NT wide	January to August	50	600
Anopheles bancroftii	Top End north of Victoria and Roper River, south to Larrimah	February - July	30	300
Coquillettidia xanthogaster	Top End north of Victoria and Roper River, south to Larrimah	March - August	30	300
Mansonia uniformis	Top End south to Larrimah	March - June	30	200
Anopheles farauti s.l.	Top End north of Port Keats inclusive, Pine Creek, and Numbulwar	March - June	30	50
Culex quinquefasciatus	NT wide, primarily near residential areas	January - June	20	30
Ochlerotatus notoscriptus	NT wide, generally near residential areas	January - June	30	30
Verrallina funerea	Top End primarily coastal and sub-coastal but occasionally south to Larrimah	Nov - March	20	200

Pest Levels

* Indicative significant pest threshold levels (mosquitoes per CO_2 trap per night) at residence for relatively unprotected people at peak biting times.

Indicative significant pest threshold levels (mosquitoes per CO2 trap per night) in residential areas from monitoring sites close to but outside of residential areas, and for monitoring sites between the residential areas and major mosquito breeding areas that are within 2km of residential areas.

Problem Mosquito Species In The Top End Of The NT Habitat and Flight Range Peter Whelan 1997 Medical Entomology Branch, Department of Health and Community Services			
Species/Common name	**Habitat Description**	**Habitat Indicators**	**Flight Range & Pest Solutions**
Aedes vigilax (Salt marsh mosquito)	Brackish reed swamps Upper mangrove margin and tidal creek extremities	Extensive mangrove areas with freshwater creek entry. Tidally or sea spray affected rock pools, depressions in coastal sand dunes and vegetated areas above tidal limit. Disturbed upper tidal areas. Tidal brackish swamps with *Schoenoplectus* reeds.	0 - 5 km major pest 5 - 50 km pest numbers 50 - over 200 km dispersal
Aedess normanensis (Floodwater mosquito)	Flooded freshwater sub-coastal or inland floodways and creeks	Broad, flat sub-coastal and inland drainage floors of minor and major creeks.	0 - 2 km major pest 2 - 5 km pest numbers
Culex annulirostris (Common banded mosquito)	Freshwater and coastal reed swamps. Streams, storm drains, and sewage effluents	Extensive reed swamps with *Eleocharis* or *Typha* reeds. Temporary flooded grasslands in sub-coastal and inland areas with organic matter. Sewage effluent and organic waste water with grass, *Lemna* (Duckweed), *Azolla* (water fern).	0 - 3 km major pest 2 - 10 km pest numbers 10 - 15 km dispersal
Verrallina funerea *(brackish mosquito)*	Upper reaches of mangroves with fresh water inflow. Rain filled coastal swamps	Brackish mangroves & mangrove fern. Schoenoplectus reed swamps. Shaded rainfilled coastal depressions & creeklines. Under beach hibiscus & Casuarina trees	0-500m minor pest Day pest in closed forest near breeding sites.
Anopheles bancroftii (Black malaria mosquito)	Freshwater and coastal reed swamps. Shaded streams and swamps	Extensive seasonally inundated *Melaleuca* paperbark swamps. *Eleocharis* and *Typha* reed swamps.	0 - 3 km major pest 3 - 5 km pest numbers
Coquillettidia xanthogaster (The golden mosquito)	Freshwater swamps with reeds Vegetated streams	Extensive *Eleocharis* and *Typha* reed swamps. Paperbark creek lines.	0 - 3 km major pest 3 - 5 km pest numbers
Mansonia uniformis (Waterlily mosquito)	Extensive freshwater reed swamp	Extensive *Eleocharis* and *Typha* reed swamps with water lilies.	0 - 2 km major pest 2 - 3 km dispersal
Anopheles farauti s.l. (Australian malaria mosquito)	Coastal and brackish reed swamps Freshwater swamps and vegetated streams	Brackish *Schoenoplectus* and *Eleocharis* reed swamps. Upper reaches of mangrove creeks with freshwater influence.	0 - 1.5 km minor pest 1.5 - 3 km dispersal
Culex quinquefasciatus (Brown house mosquito)	Storm drains, artificial receptacles Septic tanks Waste water ponds	Polluted ground or artificial receptacles. Filamentous green algae, *Lemna* (Duckweed), Azolla (water fern), or high organic water. Tyres, drums and other receptacles	0 - 500 m major pest 500 m - 1 km pest numbers
Aedes notoscriptus (Receptacle mosquito)	Tree holes or artificial receptacles	Trees with natural collections of water including *Eucalyptus, Ficus, Poinciana* and *Adansonia*. Tyres, drums, pot plant drip trays, roof gutters, rainwater tanks.	0 - 500 m minor pest 500 m - 1 km dispersal

Appendix 2

Northern Territory Government
Department of Health and Community Services

PERSONAL PROTECTION FROM MOSQUITOES & BITING MIDGES IN THE NT

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April 2004*

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* Minor revisions 2004

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PERSONAL PROTECTION
FROM MOSQUITOES & BITING MIDGES

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Department of Health and Community Services
April 2004

Adapted from paper by P. Whelan in "Australian Mosquito Control Manual" by a panel of authors, Editors C. Morris and P. Dale. Australian Mosquito Control Association, 1998, ISBN 0-646-35310-1.

1.0 MOSQUITO & BITING MIDGE BITES

Mosquitoes and biting midges (genus Culicoides and sometimes erroneously called sand flies) can reach sufficient numbers in various localities to be considered serious pests. The bites themselves can be painful and extremely annoying, and people suffer varying degrees of reaction to bites (Lee 1975). However the possibility of the spread of various diseases by their blood sucking habits to either humans or animals is a more serious outcome. Mosquitoes can carry viruses such as Murray Valley encephalitis, Kunjin, Ross River, and Barmah Forest virus, which cause human disease (Russell 1995). Biting midges do not carry any pathogens in Australia that cause human disease.

Female mosquitoes or biting midges bite to take blood from their hosts, which is necessary for the development of eggs.

Mosquitoes and biting midges show considerable variation in their preference for hosts. Some species feed selectively on cattle, horses, marsupials, amphibians, birds or humans, while other species are relatively indiscriminate feeders.

The time of feeding varies for different species. Many mosquitoes feed just after sunset while others are more active at other times including late in the night, in the late afternoon, or in the early morning. Biting midges are most active in the evening and early morning.

The place of feeding by mosquitoes or biting midges is varied. Some species, such as the brown house mosquito, readily entering houses to feed on people, while others will only bite people outdoors.

When a mosquito or biting midge bites, fine stylets sheathed in the proboscis are inserted into the skin. Blood is sucked up through one of the channels in the stylets, while saliva is injected down an adjacent channel. This saliva contains substances that the human body recognises as foreign and often stimulates a bite reaction. Sometimes the saliva can contain viruses or other pathogens that can cause disease.

Some people can become very sensitive after being bitten and suffer a general reaction from further bites. The bites may itch for days, producing restlessness, loss of sleep and nervous irritation. Scratched bites can lead to secondary infections and result in ugly scars. On the other hand, some people become tolerant to particular species and suffer little after-effects from repeated bites.

Biting insects create problems in the enjoyment of outdoor activities, causing a reluctance to enter certain areas after sundown or forcing people to be confined to insect-proof areas at certain times of the year. Personal protection and avoidance measures can offer considerable protection from bites, as well as offering protection against mosquito-borne disease.

2.0 MOSQUITO & BITING MIDGE AVOIDANCE

A sensible precaution to prevent biting insect attack is to avoid areas that are known to have high biting insect activity.

The upper high tide areas near creeks or low-lying areas, particularly near salt marsh habitats, can be significant sources of salt marsh mosquitoes (particularly *Ochlerotatus vigilax* and various other pest mosquitoes (Russell 1995). The period of high salt marsh mosquito activity is usually during the late dry season and early wet season in tropical latitudes. Generally they are prevalent for one to two weeks after the highest tides of the month or significant rain. Dense vegetation near the breeding sites should be avoided during the day over this period. Pest problems during the evening and night can occur within 3 km of productive breeding sites (Whelan, Merianos et al., 1997).

Other areas of high mosquito activity are the large seasonally flooded areas associated with rivers or drainage lines, flooded coastal swamps, extensive reed swamps and lagoons, ill defined or poorly draining creeks, extensive irrigation areas, and wastewater disposal facilities. Densely shaded areas near these habitats should be avoided during the day, and accommodation areas should be at least 3 km from extensive areas of these habitats.

Extensive areas of mangroves or estuarine areas with sandy beaches are potential sources of biting midges. These midges have seasonal and monthly population peaks with the monthly peaks usually associated with the tidal regime. When camping or choosing a permanent living site, a separation distance of at least 2 km from these areas is recommended unless specific biting insect investigations indicate there are no seasonal pest problems (Whelan 1990, Whelan, Hayes et al., 1997).

If camping or selecting house sites near creeks, rivers or lagoons, choose localities of the water body which have steep margins or little marginal emergent vegetation, have swiftly running water with little marginal pooling or vegetation, or do not arise from or empty into a nearby swamp area. Exposed beaches or cliffs away from mangrove or estuary areas are preferred sites to avoid both mosquitoes and biting midges. In more inland areas, locations on hills or rises at least 3 km from ill defined drainage lines, poorly flowing creeks and seasonally flooded areas should avoid the worst mosquito problems.

In residential areas, a local source of mosquitoes may be the cause of the problem. Check nearby potential artificial sources of mosquitoes such as disused swimming pools, receptacles such as tyres and drums, blocked roof gutters, old fishponds, or localised ponding of drains. Sites with mosquitoes breeding can be rectified by physically removing the source or through the use of insecticides.

3.0 SCREENING

The best method of avoiding attack at night is to stay inside insect-screened houses. Screens can be made of galvanised iron, copper, bronze, aluminium or plastic. Near the coast, iron or copper screens are not recommended because of the corrosive action of salt sprays. Homes near biting midge breeding sites require either fine mesh screens or lightproof curtains.

Screens should be of the correct mesh, fit tightly and be in good repair. Biting insects frequently follow people into buildings and for this reason, screen doors should open outward and have automatic closing devices. Insecticides such as permethrin or deltamethrin sprayed on or around screens may give added protection against mosquitoes or biting midges, but care is needed as some insecticides affect screens.

It is advisable to use an insect proof tent when camping near potential biting insect areas. Coastal areas subject to attack by biting midges require tents to be fitted with a finer mesh screening.

4.0 MOSQUITO NETS

Mosquito nets are useful in temporary camps or in unscreened houses near biting insect breeding areas. Generally standard mosquito nets are not sufficient to prevent biting midge attack. White netting is best as mosquitoes accidentally admitted into the net are easily seen and killed. The net is suspended over the bed and tucked under the mattress. An aerosol pyrethrin spray can be used to kill mosquitoes that enter the net. Care is needed not to leave exposed parts of the body in contact with the net, as mosquitoes will bite through the net. Nets can be made more effective by impregnation with permethrin (Lines et al. 1985).

5.0 INSECT PROOF CLOTHING

Head nets, gloves and boots can protect parts of the body, which are not covered by other clothing. Head nets with 1-1.5 meshes to the centimetre are recommended for good visibility and comfort, and additional treatment of the net with a repellent will discourage insect attack. Thick clothing or tightly woven material offers protection against bites. Light coloured, long sleeved shirts and full-length trousers are recommended. For particular risk areas or occupations, protective clothing can be impregnated with permethrin or other synthetic pyrethroid insecticides such as bifenthrin to give added protection (Burgess et al. 1988). Sleeves and collars should be kept buttoned and trousers tucked in socks during biting insect risk periods. Protection is very necessary near areas of salt marsh, mangroves, or large fresh water swamps where the various species of mosquitoes may be very abundant during the day in shaded situations, as well as at night.

6.0 REPELLENTS

Relief from biting insect attack may be obtained by applying repellents to the skin and clothing (Schreck et al. 1984). Many repellents affect plastics and care is needed when applying them near mucous membranes such as the eyes and lips.

Repellents with the chemical diethyl toluamide (DEET) or picaridin give the best protection. Some specific repellent products, such as Aerogard, which are formulated to repel flies, are generally not efficient against mosquitoes or biting midges. Brands such as Rid, Tropical Strength Aerogard, Bushman's, Muskol, or Repel include specific products that are effective. Those products with higher amounts of DEET or picaridin are usually the most efficient.

Application of repellents over large areas of the body or on extensive areas of children is not recommended particularly those repellents with high concentrations of DEET. Protection from mosquito penetration through open weave clothes can be obtained by applying a light application of aerosol repellent to the exterior of clothing. Repellents should be supplementary to protective clothing and should not be regarded as substitutes.

Personal repellents are available as sprays, creams or gels. The creams or gels usually last longer than the aerosol formulations. Repellents can prevent bites from 2 to 4 hours, depending on the repellents, the species of biting insect, or the physical activity of the wearer.

Electronic insect repellers that emit ultrasonic or audible sounds do not offer any protection against mosquitoes or biting midges. They are based on a false premise and have been found to have no repellent effect under scientific testing (Curtis 1986). Electronic ultrasonic repellers do not repel mosquitoes or biting midges and should not be relied upon for personal protection (Mitchell 1992).

Plants with reported insecticidal properties such as neem trees and the citrosa plant have not been shown to act as mosquito repellents just by growing in the vicinity of people (Mitchell 1992, Matsuda et al. 1996). Growing or positioning these plants near evening activity areas will not prevent mosquito attack. However some plants have some repellency effects as smoke or liniments (see section 12, emergency biting insect protection)

7.0 ANIMAL DIVERSION

Camping upwind near congregations of stock or domestic animals will serve to divert mosquitoes or biting midges to alternative hosts. Similar considerations can be made when planning residential sites and animal holding areas in a rural situation. Dogs of darker colour tend to attract some species of mosquitoes more than lighter colours and can divert some pest problems from people in close vicinity in outdoor situations in the evening.

8.0 LIGHTING DIVERSION

Many mosquito and biting midge species are attracted to light. This can cause pest problems in unscreened houses or when camping. The use of yellow or red incandescent bulbs or fluorescent tubes rather than white light will reduce the attractiveness of lights to insects. An incandescent or ultra violet light placed at a distance from a house or camp can serve to attract insects to an alternative area. This is more effective if the light is close to the breeding site, or between the breeding site and the accommodation area. The attractive lights should not be close to accommodation or directly down wind of accommodation areas. Light proof

curtains or similar screening can be very effective in reducing the attraction of biting insects to areas that are illuminated at night.

9.0 ADULT INSECT CONTROL

If mosquitoes or biting midges have entered a screened area they can be knocked down with pyrethrin aerosols. Care should be taken by reading the label to ensure only knockdown aerosols suitable for spraying in the air are used in proximity to people or food.

Other devices that can be effective at killing and/or repelling biting insects include mosquito coils (Charlwood & Jolley 1984) and electric insecticide pads. These devices are only effective in relatively closed areas such as inside buildings or where there are only slight breezes. They should be backed up with other measures such as suitable protective clothing or repellents

Large scale adult biting insect control can be achieved for short terms (hours) by using portable or industrial fog generators, backpack misters, or heavy duty ultra-low-volume aerosol generators to knock down active adult insects. The insecticides of choice in these machines are Maldison or Bioresmethrin. Control relies on good access, open vegetation, and light breezes in the direction of the breeding or harbouring sites. Application should only be during the peak biting insect activity period of those insects actually causing the problem, which is usually the late evening and early night.

There are some synthetic pyrethroid aerosol products available as outdoor yard or patio repellents. Control will only be temporary (hours) and re-invasion will usually occur within hours or from one to a few days, depending on the species, nearby vegetation, proximity to breeding sites, environmental conditions and times of activity of the pest species.

Application of residual insecticides such as maldison, permethrin or other synthetic pyrethroids sprayed as a mist spray to point of run off on building surfaces or nearby vegetation can sometimes give short term (a few days) relief. This method is useful as a barrier protection when large numbers of mosquitoes or biting midges are present near accommodation or outdoor use areas (Helson & Surgeoner 1985). There are some longer term residual synthetic pyrethroids such as bifenthrin that can be used as barrier sprays and provide a number of weeks protection (Standfast et al 2003). These residual insecticides can be applied according to label recommendations with the aid of a garden sprayer. Care must be taken with all synthetic pyrethroids around fishponds, fish tanks and other nearby fish habitats to avoid spray drift or run off, as these insecticides are efficient fish poisons.

10.0 INSECTOCUTORS AND INSECT TRAPS

Electric insect insectocutors and other trap or killing devices utilising an attracting light or carbon dioxide have been claimed to clear areas of biting insects and thus protect people. These claims have not been substantiated in outdoor situations with people nearby. While trap devices can attract biting insects, as well as a range of other insects, these devices can not be relied on for protection from biting insect attack (Mitchell 1992). When used in outdoor situations it is possible that they can increase local problems by attracting insects to

the vicinity of people. Attractive odours and carbon dioxide emitted by humans then divert the insects from the trap device to the people.

11.0 TREATMENT OF BITES

Relief from bites and prevention of secondary infection can be obtained by the application of various products, either to the skin or internally. The effectiveness of various products is variable, depending on individual reaction. Skin application products include proprietary products such as Eurax, Stingose, Medicreme, Katers lotion, Dermocaine and Paraderm creme, and non-proprietary products such as tea tree oil, eucalyptus oil, aloe vera gel, ice, or methylated spirits.

Ice packs to the general bite site will give usually give immediate relief for painful and itchy bites and swelling or blisters from of mosquitoes and biting midges in particular. The sooner the ice pack is applied after bites or reactions, the better the relief, and can often avoid more intense reactions.

Other products for internal application for more general symptoms include antihistamine products such as Phenergan, Telfast and Vallergan. Check with your doctor or pharmacist for any products for the latest product and safety information.

12.0 EMERGENCY BITING INSECT PROTECTION

There are a number of emergency measures that can be taken when exposed to biting insects with no protection. Sheltering downwind next to smoky fires can offer considerable protection. Burning dung or aromatic and oil producing foliage from plants such as Hyptis (horehound), Vitex (black plum), Calytrix (Turkey bush), Melaleuca species (Paper bark) and Eucalyptus species (gum trees) can make the smoke more effective. A small native plant Pterocaulon serrulatum (warnulpu) has sticky strongly aromatic leaves, and branches are burnt or the moist leaves are rubbed on the skin by Aborigines in the Katherine district to repel mosquitoes (Aborigines of the NT 1988). Climbing relatively high trees or choosing locations exposed to the wind can also offer protection from some species.

Some protection can be obtained by rubbing exposed skin areas with the leaves of certain plants such as eucalypts, turkey bush, warnulpa, paperbarks or tea-trees that contain volatile oils. However these are not as efficient as proprietary repellents containing deet or picaridin. Other emergency protection measures include coating the skin with mud, or burying yourself in shallow sand with some form of head protection. If all else fails, keep running. The best form of protection, and the most comfortable, require an awareness of the potential problems and adequate preparation.

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Appendix 3

Northern Territory Government

Department of Health and Community Services

GUIDELINES FOR PREVENTING MOSQUITO BREEDING SITES ASSOCIATED WITH MINING SITES

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November 2005

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GUIDELINES FOR PREVENTING MOSQUITO BREEDING SITES ASSOCIATED WITH MINING SITES

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November 2005

General Comments

All mining operations need to include a section in an Environmental Management Plan for the monitoring and control of mosquitoes. This is necessary because of the potential of mine sites to provide extensive breeding sites for mosquitoes of pest and disease significance. Mine sites also provide the potential for the introduction of mosquito species and mosquito borne diseases into the NT that are either exotic to the NT or have previously been eliminated.

The monitoring of adult mosquitoes in any new mine should include trapping of adult mosquitoes once a month at a number of sites for the initial 12 months baseline mosquito monitoring program. The baseline mosquito monitoring program provides an indication of the seasonal distribution of the mosquito species present and the relative potential impact of mosquito borne disease to mine personnel.

The monitoring and control of mosquito larvae should be an ongoing operation for the life of the mine. Mosquito larvae must be controlled with an approved mosquito larvicide (*Bacillus thuringiensis* var. *israelensis* or methoprene) as part of an organised monitoring and control program. Any mosquito control program should be discussed with the Medical Entomology Branch of the Department of Health and Community Services with regard to methods and insecticides.

Accommodation for personnel should be sited as far as possible from the most important biting insect breeding sites and be adequately insect screened or otherwise protected to reduce the impact of mosquitoes.

The potential for artificially created mosquito breeding sites can be minimised with the appropriate design of water holding facilities and water management procedures.

1. WATER DAMS

- All water storage dams should be constructed with relatively steep sides (45° slope minimum) to discourage the establishment of semi-aquatic vegetation (eg. *Typha* and *Eleocharis* reeds) that will provide suitable habitats for mosquito breeding.

- Dam margins should be as straight as possible to minimise the linear area available for the establishment of semi-aquatic vegetation.

- Where possible, any closely grouped dams should be joined together to minimise the linear margin of vegetation.

- The bottom of any dam should be graded as level as possible, with a slight slope to one end to form a deeper section for periods of low water. This will remove the potential for the formation of isolated pools as the water level recedes in the dry season.

- Areas surrounding any dam that will be flooded during the wet season should be graded to enable water to drain freely into the dam as the water level recedes, without the formation of isolated pools that are capable of retaining water for a period greater than 5 days.

- There must be no islands formed within any dam. All areas of impounded water should have a relatively deep (2 m) wet season stabilised water level to prevent the emergence of semi-aquatic vegetation.

- Any drainage line directed into a dam must be fitted with a sediment trap or erosion prevention structures just upstream from the dam. This is necessary to prevent the formation of "alluvial fans" that will promote the establishment of semi-aquatic vegetation in the area of the fan where silt will be progressively deposited.

- Any overflow areas from dams should have erosion protection measures to prevent the creation of plunge pools.

- Local native fish should be introduced or have access into any dams where the water quality is suitable for their survival, to provide natural predators for the control of mosquito larvae.

- The margins of any water dam should be inspected annually for vegetation growth such as semi-aquatic vegetation and grass. Any dense marginal vegetation should be herbicided or physically removed, to prevent the vegetation from creation suitable mosquito breeding sites.

2. WET LAND FILTERS

- Wetland filters have the potential to provide prolific breeding sites for mosquito species of pest and disease significance. If no other alternative is available for the treatment and disposal of waste water, a wetland filter should incorporate the ability to annually reduce the build up of any dead vegetation. Plans for wetland filter design and siting should be forwarded to the Department of Health and Community Services (Medical Entomology Branch) at the planning stage to ensure that their potential impact on the health of mine site personnel is minimised.

- Annual maintenance could be achieved by dividing a wetland filter into separate sections. A dual system will enable water to be directed into one section of the filter while vegetation is burnt or otherwise reduced in the other section. An ability to manipulate the water level in the filter to strand or drown vegetation would be beneficial for the management of vegetation and mosquito numbers.

- Stocking the wetland filter with local native fish will provide a significant measure for controlling mosquito larvae. The provision of fish however will not remove the need for annual maintenance of the wetland filter.

- Where appropriate, consideration should be given to the provision of a fish ladder on any overflow facility to enable the dispersal of fish into and upstream of the filter.

- Wetland filters may need to be removed after mining operations are completed to enable the future development of adjacent land.

3. WEIRS

- Any spillways must be fitted with erosion prevention structures to prevent scouring and siltation of creek lines during periods of overflow.

- Fish ladders should be constructed where appropriate to enable the upstream dispersal of fish following periods of dam overflow.

4. MINE WASTE DUMPS

- The final surface of mine waste dumps should be contoured so that the surface area is free draining and has no surface depressions.

- Any runoff from a waste dump should be directed to a silt trap to prevent any siltation of natural creek lines. Siltation in creek lines can promote the formation of isolated pools or disrupt fish ecology and may lead to the subsequent establishment of mosquito breeding sites.

- Mine waste dumps should be located away from natural drainage lines, to prevent the upstream impoundment of natural surface water flows. If impractical to locate mine waste dumps away from natural drainage lines, diversion drains will be required to direct surface water flows around the waste dump.

5. SEDIMENT TRAPS

- Sediment traps need to be designed where possible to be free draining within a period of 5 days after flooding.

- Sediment traps that can not be free draining within 5 days must be steep sided and have a sloping bottom base to one end, with erosion protection (e.g. reno mattress) at the inflow and overflow facility.

- Sediment traps should be maintained by silt and vegetation removal on an annual basis. There should be a designated and designed access path for silt removal.

- Sediment traps with dry season low flows should be sampled for mosquito larvae monthly in the dry season and appropriate mosquito control programs arranged with the appropriate authority.

6. BORROW PITS

- Borrow pits, costeans or scrapes must be rehabilitated, where possible, such that they do not hold water for a period greater than 5 days. These sites within 5km of urban residential areas must be rehabilitated either by filling or rendering them to be free draining.

- Borrow pits that cannot be rehabilitated must be steep sided, have a sloping floor to one end and have surrounding stormwater catchments directed to the upper end, so that they will fill with silt over time.

- There should be no dry season low flows from storm water drainage directed into borrow pits.

7. DRAINAGE PATHS

- Natural drainage patterns should be maintained where possible. Access roads across drainage lines may need to be fitted with culverts of sufficient size to prevent upstream flooding for periods that will enable mosquito breeding. Culverts should be installed flush with the upstream surface level. Erosion prevention structures will need to be constructed on the downstream side of any culvert, and erosion prevention structures may also be required at the headwalls of any culvert.

- Any disruption to surface drainage should be removed at the end of the mining operations.

8. PIT DEWATERING

- Pit water discharge should be free of silt. Dry season pit water discharge should be directed into a water dam, and not into natural drainage lines or creeklines unless there is provision to prevent the growth of semi-aquatic reeds in the discharge area.

9. WASTE WATER DISPOSAL

- Septic tanks must be installed to DHCS guidelines and should be inspected on an annual basis by the Environmental Officer to ensure that tanks and their effluents do not breed mosquitoes.

- Discharge, overflow or excess effluent from sewage treatment systems must be disposed of in a manner approved by DHCS. A sprinkler disposal system is suitable under most situations. Infiltration systems are acceptable if soil conditions are favourable. The discharge of excess effluent into ephemeral creek lines is not acceptable.

- Sewage ponds should be constructed with steep sides with an impervious lining and be regularly maintained to prevent vegetative growth at the margins (see *"The prevention of mosquito breeding in sewage treatment facilities"*, available from the Medical Entomology Branch). Surface debris and algal scum should be removed on a regular basis. Monitoring of mosquito larvae should be conducted in sewage ponds on a regular basis and control treatments conducted when necessary.

- Disposal of water into “Application areas” must ensure that water does not pool for a period greater than 5 days.

10. ARTIFICIAL CONTAINERS

- Rainwater tanks must be adequately screened to prevent the entry of mosquitoes.

- Any container capable of holding water, eg. machinery tyres, drums, disused tyres, tanks, pots, etc. should be stored under cover, be provided with drainage holes, emptied on a weekly basis, treated with an appropriate insecticide on an appropriate schedule, or disposed of in an appropriate dump site to prevent the formation of mosquito breeding sites.

- No used tyres, machinery or other containers that have previously held rain water should be brought to the NT from Queensland unless the containers or machinery has been thoroughly treated with chlorine or an appropriate insecticide to remove the possibility of the introduction of drought resistant eggs of exotic *Aedes* mosquito species.

11. RUBBISH AND GARBAGE DUMPS

- Rubbish and garbage dumps must be operated in such a matter that there is no ground surface or water filled receptale pooling of water for a period greater than 5 days, to prevent the formation of mosquito breeding sites.

- Rubbish and garbage dumps must be rehabilitated by filling and surface contouring to ensure they are free draining and have no surface depressions.

12. DECOMMISSIONING AND REHABILITATION

- A decommissioning and rehabilitation plan should be in place for all mining operations to ensure no actual or potential mosquito breeding sites remain after cessation of mining operations. All disturbed areas should be rehabilitated to be free draining where practical. The proponent should consult the Medical Entomology Branch for input when preparing this document.

- Aspects to consider when decommissioning and rehabilitating a mine site include removing and appropriately grading all sediment ponds, removing all bund walls created for the development, removing infrastructure and artificial receptacles that could pond water, removing water dams and reinstating existing flowpaths where practical, rehabilitating borrow pits, removing wetland filters, sediment traps, and other facilities that could pond water and breed mosquitoes.

- Facilities such as open pit voids and water dams can be left as water holding pits if they are constructed with steep sides (at least 1:2 slope), and stocked with fish during the rehabilitation process.

13. NOTES

- These guidelines replace former guidelines ‘Guidelines for preventing mosquito breeding sites associated with mining sites’, by Brian Montgomery and Peter Whelan May 1997.