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Eritrea Malaria, HIV/AIDS, STD and TB Project
Environmental Analysis

Executive Summary

Introduction

1. This Environmental Analysis (EA) was undertaken to review the components of the Malaria Control Program (MCP) in Eritrea that may have deleterious environmental effects unless properly planned and managed, namely the use of insecticides. The EA does not review or evaluate the national malaria control program *per se*, but rather the vector control operations with environmental implications. It reflects and responds to both the GOE's "National Environmental Assessment Procedures and Guidelines" for project preparation, and the IDA's requirement regarding OP4.09 (Operational Procedures 4.09-Pesticide Management). This EA was carried out over three weeks in April-May, 2000. It included field visits to the three main malarious zones, Anseba, Gash-Barka and Debub. Personal contacts included health and other pertinent staff and people in Asmara and the three Regions.

2. The overall use of insecticides for the health sector is relatively small, and only three compounds are employed, temphos (a larvicide), permethrin (a pyrethroid), and DDT. Each of these compounds is approved by the WHO Pesticide Evaluation Scheme (WHOPES) for use as currently employed. The major concern raised regarding the use of insecticides, is the use of DDT. This EA finds that as currently used, and as proposed in the HAMSET project, the use of DDT in the MCP is consistent with WHO guidelines –which are for specific use: a) when effective, and b) in high risk areas to prevent epidemic conditions.

3. The EA makes recommendations to improve the on-going MCP projects including environmental management for source reduction, larviciding, indoor house-spraying, and impregnated bednets; it also provides additional information for evaluating their individual and combined efficacy. Further recommendations include improving surveillance and monitoring of malaria trends to improve efficiency and use of the vector control methods employed, as much as to improve prevention of epidemics. The EA also recommends developing the entomology laboratory and field station, and allocating funds for training and research to improve the current vector control methodologies. A Pesticide Management Plan (PMP) was prepared following the EA conclusions and recommendations. The PMP will be implemented by the MCP, as part of the HAMSET project, and will be complemented by the project's several components.

4. The conclusions and recommendations of the EA are also included in the HAMSET project to assist in improving vector control in the national MCP. The project will support the Ministry of Health (MOH) to, *inter alia*: a) strengthen efforts to control and reduce the incidence of malaria, and its effects on HIV/AIDS and tuberculosis, and b) phase out the use of DDT by replacing it by a combination of safer insecticide and an integrated malaria control program. The integrated program includes technology, techniques and methods that stress malaria prevention and natural management of the disease vector, and that range from Government implementation to full scale community participation. The project will specifically support environment-based activities that focus on the communities as primary beneficiaries, and that stress post-conflict socio-environmental conditions. Surveillance, improved data collection, measuring efficacy of control methodologies, and testing of alternatives are included in the project to reduce reliance upon, and ensure safe use of insecticides. In addition, following MOH's current preparation of standards for bio-hazardous

waste management for health facilities, the conditions of medical waste (beyond the scope of this EA) particularly as it relates to HIV/AIDS, will be assessed in the first stage of the HAMSET project, and the adequate solutions identified and implemented as appropriate.

Background

5. Eritrea became independent in 1993; it is one of the poorest countries in the world with a GPD/capita of US$ 190. Eritrea's health indicators are among the lowest in the world. Life expectancy is 51 years, infant and child mortality are respectively 72 and 135/1000 (SSA 72 and 93/1000), and maternal mortality is 1000/100,000 (SSA 500/1000). Over 50% of the population are children; about 70% are children and women in child-bearing age. Malaria is one of the primary causes of child morbidity and mortality, and a major cause of complicated pregnancy. During the malaria transmission seasons, malaria accounts for over 30% of the total outpatient morbidity. In 1997-98 an above average rainfall triggered a malaria epidemic that resulted in malaria accounting for 50% and 60-80% of respectively, mortality and morbidity rates across all ages. In addition, malaria has been shown to increase the vulnerability to other diseases, eventually complicating the conditions of tuberculosis and AIDS patients.

6. Malaria occurs in over 75% of the country. The disease is endemic in the lowland areas (<500 m) and in the midlands (500-1500m). Even the highlands, up to 2200m are subject to periodic outbreaks under favorable epidemiological conditions. Eritrea has two malaria seasons following the rainy seasons in the highlands (July-August), and the coastal areas (February-April); the disease is most prevalent in September, October and November. Nine demonstrated or suspected *anopheline* vectors occur, however their distribution, behavior and vector status are poorly known; on-going studies are expected to shed light on their conditions.

7. Around 90% of the malaria cases are reported in Gash-Barka, Anseba and Debub, which hold 60 % of the total population. The number of cases treated by health facilities and by community malaria agents tripled from 1994 to 1998, from respectively 141,213 to 466,016, and decreased to 293,671 in 1999. MOH's statistics for reported cases shows malaria affecting over 67% of Eritrea's population. Two peak years were identified in 1995 and 1998, at respectively 338,552 and 466,016, both resulting in roughly doubling the amount of cases for the previous years.

8. Eritrea's environmental conditions (altitude, rainfall, temperature, etc.) influence the malaria vector populations and have a strong impact on the rate of malaria transmission. These conditions are further complicated by population movements due to trade and, recently, by the displacement of populations due to the military conflict with Ethiopia. The conflict also complicates both estimates of the population affected by malaria, and their treatment. There is a large number of displaced and returnee groups in the malarious areas; they dwell in marginal habitations, often near vector breeding sites and are often not treated, not entering the statistics. Also important, is the social and economic impact that malaria has on the human ecology, and eventually on the environment due to its burdening on poverty. For example, in 1998 over 466 thousand cases of malaria were reported. Assuming, conservatively, that each case debilitates a person for 10 days, the number of lost working days in a year is at 18 thousand person-years. The implications of this loss is the more severe in an agricultural/pastoral society, the results including loss of income, deterioration of health, and loss of school days. The losses are, again, the more severe under post-conflict conditions.

The On-Going Malaria Vector Control Activities

9. The MCP derived from the Ethiopian program, and started after Independence. Malaria figures are available from 1994 to 1999, and show the integrated approach towards vector control adopted by MOH. The approach is consistent with the overall national emphasis on community participation and self-reliance. The total MCP fulltime staff, including the MOH in Asmara, the Zobas and sub-zobas is around 30 people; day laborers are hired and trained annually for house-spraying; community malaria agents (volunteers) assist in all villages. Several agencies, bi- and multilaterals, and PVOs are working with the MCP. Assistance ranges from data collection to training, vector control, and provision of drugs.

10. **Environmental vector control.** Consists of source reduction, i.e., elimination of vector breeding sites. It includes mostly filling and/or draining standing or slowly running water sites that may serve as *anopheline* breeding areas. The work is carried out during the breeding season, and is effective in arid regions. However, seasonal rivers or *wadis* that run only during the rainy seasons are main breeding sites, due to the water puddles left along the drying riverbeds after the rains. In 1999 the MCP filled or drained 31,953 breeding sites, through participation of around 37,000 community members. Very few of the sites had permanent fauna, and no endangered species are known to exist in the areas likely to be drained or filled; source reduction required caution in areas likely to be used for water collection, washing clothes, etc..

11. **Larviciding.** The breeding sites that cannot be eliminated by environmental management are treated with larvicidae. In 1999, 9888 ml. of temphos were applied to 1086 breeding sites, down from 1997, when 50,740 ml were applied to 3200 breeding sites. Temphos, recommended by WHO Pesticide Evaluation Scheme, is safe enough to be added to drinking water, and has little impact on non-target fauna. The GOE prohibited the previous use of motor oil.

12. **Insecticide treated bednets.** The use of the impregnated bednets started in 1995 (Gash-Barka) and 1997 (Anseba). Their distribution is via the Zoba Malaria Coordinator to the sub-zoba, and then to the communities. In the high risk zones distribution is through the local authorities and the malaria personnel. The bednets cost 30 Nakfa (approx. US$ 3.0), but are distributed at no cost to families that can not afford paying, and to displaced persons. Re-impregnation is free of cost. The revenues from bednet sale are invested in a rotating fund to support distribution and re-impregnation. Education about the use of bednets is provided by the Zoba, sub-zoba and village malaria agents; these in turn are responsible for re-impregnation. The insecticide used for impregnation is permethrin. Over 91,000 bednets were distributed in 1999, while only 14% were re-impregnated; figures are not available for rates prior to 1999. The problems identified in the Eritrean bednet program are similar to those of other countries, i.e., distribution prior to establishing effective community education, monitoring for appropriate use, and a reimpregnation system, and insufficient collection of malaria epidemiological data. Part of this data is being collected under a USAID funded project.

13. **Biological Control.** The MCP is trying biological control through larvivirous fish, however on a small scale. This control is most successful, as show in other countries, to control mosquitoes in man-made habitats, and can be most useful in arid zones. The MCP experiment is mostly in the Northern and Southern Red Sea Zobas, and includes areas around hospitals and clinics.

14. **Residual house/wall spraying.** MOH's policy regarding insecticide spraying is to conduct residual house/wall-spraying only in areas subject to malaria epidemics and in resettlement zones. Since the start of the MCP, spraying with DDT has been mostly in Gash-Barka, Anseba and Dabub. DDT application has increased from negligible levels in 1996 to larger amounts, in an effort to stem the increasing number of reported malaria cases. House-spraying by MCP is not extensive; the 352 villages sprayed in 1999 represent only 17% of the malarious villages.[1] The MOH' stated policy is to: 1) further reduce house-spraying and increase environmental management and bednet use according to reductions in malaria rates; and 2) test and establish alternatives to replace DDT.

15. **Insecticide resistance.** Resistance testing of the principal malaria vector has been limited. The results indicate no resistance to permethrin or DDT, both leading to 100% mortality of female *An. Gambiae*. Testing with malathion however, showed *An Gambiae* mortality to vary from 83-98% in Gash Barka to 95% in Anseba, and 100% in Debud.[2]

16. **Chemical compounds applied for vector control and possible toxicity.** The Table below presents the three chemicals used by the MCP as it regards their potential toxicity and WHO Classification.

		Temphos	Permethrin	DDT
Mammalian Toxicity (LD50)	Dermal (rat)	>4000 mg/kg	2500 mg/kg	250-500 mg/kg (in oil)
	Oral (rat)	8600 mg/kg	500 mg/kg	113 mg/kg; 3000 mg/kg (powder)
WHO Classification by Hazard		Class IV: "unlikely to present acute hazard in normal use"	Class II: "moderately hazardous" depending on formulation and concentration used	Class II: "moderately hazardous" depending on formulation
Comments			Based on toxicity of the active ingredient, while operationally they are used at much lower concentrations (e.g. 0.20-0.50 g/m2 on nets) than organochlorine or organophosphate compounds	formulation used: 75% Water Dispersable Powder (WPD). In Feb. 2000, WHO noted that POPS[3] granted a general exemption on DDT production and use limited to vector control. WHO fully supports DDT use under certain conditions in African countries where it is still effective. DDT use by Eritrea's MCP is fully justified and in accordance w/ the POPS exemption and WHO guidelines, until better solutions are tested by the MCP

17. **Environmental guidelines of IDA and GOE.** This EA reflects both IDA's and the GOE's environmental policies. The HAMSET project under consideration was registered for screening by the Department of Environment (Ministry of Land, Water and Environment), where it was cleared as Category B: "because of their type, size, location and/or mode of

[1] For example, of the 2,089 malarious villages (out of a total of 2,564 in Eritrea) only 17% underwent DDT house-spraying in 1999. In Gash- Barka, all 784 villages are malarious, while 128 (16%) underwent spraying, and in Dabub, 579 of 884 villages are malarious, but only 38% were sprayed.

[2] Testing was in 5 locations (2 in Gash-Barka/Sept-Oct, 1998; 2 in Debub, Oct-Nov, 1998; 1 in Anseba, Oct., 1999), 100 adult female *An. gambiae* were tested with WHO test kits using 4% DDT impregnated test filter papers: in all trials, mortality was 100% in all replicates. In the same localities, at the same time, female *An. gambiae* were tested with WHO test kits using 5% malathion impregnated test filter papers: observed mortality ranged from 100% in Debub, to 83-98% in Gash-Barka, and 95% in Anseba. A 100% mortality of *An. gambiae* was obtained in bioassay trials with permethrin impregnated bednet material.

[3] International Action on Certain *Persistent Organic Pollutants* (POPS).

operation: could lead to significant negative impacts if not carefully planned". And "the potential environmental impacts associated with the project type are: predictable on the basis of prior experience; capable of avoidance or mitigation through design and management; overall environmental impacts should be relatively small-scale if the project is well designed."

Conclusions and Recommendations

18. **Development of an integrated malaria vector control approach.** The vector control component of the MCP is an integrated effort. It includes environmental management (source reduction), larviciding, use of impregnated bednets, biological control, and residual spraying in houses in high risk areas. The major concern in the MCP includes the need for: more research and training, increased community participation; collection of baseline data (biological, socio-economic); developing methods to measure efficacy of the integrated components, together and individually; understanding the economics of Integrated Vector Management (IPM); and programs for continued adaptation; and testing of alternatives to chemicals in use. The success of the MCP, including environmental control, larviciding, biological control, and the use of bednet depends on strengthening surveillance to identify breeding sites versus distance to human dwellings, as well as monitoring and follow-up, support from local administrations and the communities in affected areas, collaboration with other sectors, and community education and training regarding malaria, health and water use and management

19. **DDT use**. The continued use of DDT for malaria control is supported subject to: annual testing for efficacy (susceptibility of target vectors) and monitoring for potentially negative environmental impacts in the malaria zones; testing of the economic and biological suitability of alternative insecticides to replace DDT. The EE concludes that the Zoba malaria coordinators are very experienced, and the equipment is generally carefully cleaned and stored before the spraying season. In addition, the field personnel have good experience with spraying. Since the EE was carried out prior to the spraying season, handling, storage and transport of insecticides was not seen. Nonetheless, insecticides are reported to be moved (after delivery) quickly from the central stores to the Regions, and then to the sub-regions just before spraying therefore presenting no major problems. The EE nonetheless recommends the testing of alternatives to support replacing of DDT as house spraying within the second year of the proposed HAMSET project.

20. **Possible Alternative Insecticides.** The EA recommends testing several alternatives to the chemicals currently in use, including: a)temphos: *Bacillus thuringensis israelensis (Bti),* a biocontrol agent effective as larvicide against anophelines; b) permethrin: several pyrethroids, including cypermethrin, lambdacyhalothrin, cyfluthrin and deltamethrin; and c) DDT: pyrethroids; their cost is higher (for the active ingredient), however the dilutions are great which reduces the cost, transport costs are reduced due to reduced bulk, and most are packaged in "sachets" or plastic or foil packages for individual pump charges, reducing handling and worker exposure, and related costs. Other alt

21. **Pesticide Management Plan.** The PMP consists of four major activities summarizing the EA's recommendations: a) test efficacy of DDT and alternative insecticide compounds to initiate the phase-out schedule for use of DDT; b) capacity building and strengthening the infrastructure of the national MCP, focusing on entomology and epidemiology training, collection of baseline biological data to support implementation and monitoring of integrated vector control; c) develop IEC strategy for community-based implementation and maintenance of insecticide impregnated bednets that focus on community education and

participation, is based on local knowledge and practices, and is adapted to community organization; and d) improve collection and analysis of data for information on cost-effectiveness for the different (integrated) methods of malaria vector control. The PMP is an integral part of the HAMSET project, and will be complemented by other project components as appropriate.

Eritrea, HIV/AIDS, STD Malaria and TB Control Project

Environmental Analysis

Abstract: This Environmental Analysis (EA) was undertaken to review those components of the malaria control program in Eritrea that might possibly have deleterious environmental side-effects unless properly planned and managed. The major concern is in the continued use of the insecticide DDT for residual house-spraying to control epidemics. This evaluation finds that as proposed, the use of DDT in this program is consistent with WHO guidelines for use: a) when effective, and b) used in high risk areas to prevent epidemic conditions. However, the EA recommends that a plan to phase out DD be developed and alternate, replacement insecticides tested and implemented to replace DDT. The overall use of insecticides is relatively small, and only three compounds are employed (DDT; temphos, a larvicide;permethrin, a pyrethroid), all approved by WHO Pesticide Evaluation Scheme (WHOPES) for use as employed. Further recommendations are made on the need to improve surveillance and monitoring of malaria trends to improve efficiency and more effective use of the vector control methods employed. It is also recommended that an entomology laboratory, and a field station, be developed as part of this program, and that adequate funds be provided for training entomologists and research activities to improve the current vector control methodologies.

A. Background:

1. Eritrea is one of the poorest countries in the world (GPD/capita US$ 190) and it is in the early stages of development, having obtained independence in 1993. Eritrea's health indicators are among the lowest in the world. Life expectancy is 53 years, infant and child mortality are respectively 72 and 135/1000, and maternal mortality is 1000/100,000. Over 50% of the population are children and nearly 70% is composed of children and women in child-bearing age. Malaria is one of the primary causes of child morbidity and mortality, along with diarrhea and respiratory infections.

2. Although this proposed World Bank Project (Annex 1) will assist the Eritrean Ministry of Health (MOH/GOE) strengthen their existing efforts to control and reduce the incidences of malaria, HIV/AIDS, and tuberculosis (Tb), this Environmental Analysis (EA) will deal only with the malaria component. Although all health conditions have some environmental interactions, the need to control malaria transmission by reducing the man-vector contact by environmental management (e.g., draining or filling vector breeding sites) or the use of chemical insecticides requires scrutiny and evaluation of potential deleterious environmental impacts...whether the insecticide application is to breeding sites, by house spraying or impregnating bed-nets or other materials.

3. Conversely, natural environmental conditions (altitude, rainfall, temperature, etc.) influence vector populations and thus may have a very strong impact on the rate of malaria transmission. Man-made environmental parameters such as housing conditions, land and

water use and the agricultural use of the same or similar insecticides in malarious areas often influence the distribution and intensity of malaria transmission.

4. During the transmission season, malaria accounts for over 30% of the total outpatient morbidity. It occurs over about 75% of the country's surface are, and approximately two-thirds of the population live in malaria endemic areas. The predominant forms of malaria in the country are caused by the parasites *Plasmodium falciparum* and *P. vivax*. In the 1970's, falciparum and vivax malarias had a relative frequency of 60 and 40% respectively: however, by 1996, to date, falciparum malaria has increased to over 90% of the malaria cases reported. The primary mosquito vector is *Anopheles gambiae s.l.*, with several secondary vectors in different ecological zones. The number of malaria cases reported treated by health facilities and community malaria agents has increased from 141,213 in 1994, to 466,016 in 1998, and 293,671 in 1999.... despite the control efforts described below. Approximately 90% of the malaria cases are reported from three Regions (Gash-Barka, Anseba and Debub), with 60 % of the national population. Malaria is most prevalent in September, October and November, following the distinct rainy seasons in the highlands (July - August) and the coastal areas (February - April).

5. The data used for reviewing these environmental interactions were provided by various GOE ministries and offices: the quality of the data may not always be equal, and/or uniformly available by regions, sub-regions and the central headquarters. And, as will be noted in the body of the text, other agencies, bilateral and multilateral donors are active in assisting the malaria program, so that various administrative, training, and information management needs mentioned in this report are being planned outside of this project. These are discussed in the appropriate sections of this report and in the recommendations for WB coordination with other malaria-related support activities in the country. However, it should be noted that this Environmental Evaluation report is not meant to be a review or evaluation of the malaria control program, *per se*, as observations have been restricted to the vector control operations with environmental implications and not to areas such as diagnosis and treatment.

B. Description of ongoing malaria vector control activities (1994-1999 data and 2000 plans):

6. The current malaria control program was derived from the Ethiopian program after independence in 1993. It took several years to get started, but figures are available from 1994 - 1999, demonstrating the integrated approach towards vector control that the Ministry of Health has adopted. In part, this is consistent with the overall national emphasis on community participation in health and other endeavors as well as self-reliance.

7. The malaria control staff in the MOH includes: the Program Manager, and three sections (Operations, Entomology, and Epidemiology) with offices in Asmara and a staff of 6-8. In each of the six Regions (Zobas) there is a malaria coordinator with 3-5 inspectors who work in the sub-zobas. In all there are ~ 30 full-time malaria staff. Day laborers are hired and

trained annually for spraying: community malaria agents (volunteers) assist in virtually all villages.

8. This evaluation was conducted over a three week period (April - May, 2000): field visits to the three most malarious zones (Anseba, Gash-Barka and Debub), and contact was made with health and other pertinent personnel both in Asmara and the Regions visited (Annex 2).

9. The statistics provided by the MOH (CDC Division which compiles the Malaria statistics) show that malaria affects over 67% (or 1.8 million) of the estimated 2.7 million population of the country. Malaria cases are reported by both: a) the Hospitals/ Health Facilities, (HHF) and b) the Community Health Agent(CHA).

Table 1.Reported number of treated cases, 1993-99

Source	1993	1994	1995	1996	1997	1998	1999
HHF	**85,743**	**88,280**	**116,671**	**129,908**	**171,245**	**273,319**	**179,501**
CHA	**n/a**	**52,933**	**221,881**	**76,735**	**81,476**	**192,697**	**114,170**
Total	**(85,743)**	**141,213**	**338,552**	**206,643**	**252,721**	**466,016**	**293.671**

10. Transmission occurs in parts of all six Regions (Zobas), and is distributed over about 75% of the surface of the country. The disease is not only endemic in the lowland areas (<500 m) but in the midlands (500m - 1500m): even the highlands up to 2200m are subject to periodic outbreaks under the most favorable epidemiologic conditions. Heavy rains in 1998 probably contributed to increased transmission, enhanced by population movements resulting from military action on the borders (also see Section 6.2). In Eritrea, nine demonstrated or suspect anopheline vectors occur, although their distribution , behavior and vector status are poorly known. Ongoing studies funded by USAID's Environmental Health Project are will clarify some of these issues.

Note: Because of the long, ongoing military conflict on its borders, it is difficult to estimate the national population and, consequently, the numbers of people affected by malaria. There are large returnee populations in the most malarious areas, and these people dwell in marginal habitations, often near vector breeding sites: there are Eritrean returnees from neighboring countries, and others who have been displaced within their Regions, fleeing the border conflict. According to the World Bank office in Asmara, the Bank and other international agencies estimate the population to be ~ 3.5 million, although malaria figures place the population at 2.7 million.

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11. The integrated anti-vector measures carried out by the malaria control program (and in the order listed by the Program) are as follows:

12. Environmental vector control (= source reduction, elimination of vector breeding sites): This consists of filling and/or draining standing or slowly running sites of water that may serve as

anopheline breeding sites. The malaria coordinators in the Regions and the village malaria agents are responsible for identifying and coordinating this work, on a weekly basis during the breeding season. This type of activity is especially effective in arid regions where breeding sites can be identified, especially where water leaks around wells or from irrigation dams. Rivers that run only during the rainy season and course through the many villages, are especially important breeding sites, when water "puddles"along the drying beds.

13. There are numerous dams, both from private and public enterprises, in the most heavily malarious areas (Gash-Barka, Dabub and Anseba) that are essential for agriculture, but around which, vector breeding may occur. Generally the water reservoirs are not the major problems (except along the shallow shores during the dry season), but leakage to the rivers and/or irrigation channels frequently produce major vector breeding problems.

14. Through the collaborative efforts mentioned above, during 1999 (January - November) a total of 31,953 mosquito-breeding sites were filled or drained: an estimated 37,000 people participated. This estimate lumps together all breeding sites eliminated, from bucket size through efforts with land-moving equipment, and sites that are weekly disposed of, to those that provide a more permanent solution.

Comments.

15. As successful as environmental control is, it requires good surveillance for identifying breeding sites within mosquito flight range of human dwellings, monitoring and follow-up. It is impossible to implement without the support and understanding of the local administrations and the communities in affected areas. In particular, environmental management calls for collaboration with other sectors, especially agriculture and public works. In addition, the development of programs (IEC) for community education and training, in relation not only to malaria, but to health and water use in general is essential. These are area that will require strengthening to support the integrated vector control measures proposed.

16. Environmental management, as conducted in this program, poses no direct environmental threat, The vast majority of the breeding sites are small water bodies in and about villages, and represent only a fraction of similar sites distant from human habitation. Many of the most important vector breeding sites are man-made (overflow from wells, dams, irrigation canals site, etc.) Very few will have permanent fauna, and no endangered species are known in the areas likely to by drained or filled. Caution should be taken in carrying out source reduction operations so that areas likely to be used by people (collection of water, washing clothes, etc.).

17. Larviciding. Breeding sites that cannot be eliminated by environmental management and are found positive for anopheline larvae are treated with larvicide (Abate is a trade name = temphos, generic) or used motor oil. During the 1999 campaign, 9888 ml. of temphos were applied to 1086 breeding sites: in 1997, some 50,740 ml were applied to over 3200 breeding sites. As indicated below, temphos is recommended by WHO/WHOPES (WHO Pesticide

Evaluation Scheme) for larviciding and can even be placed in drinking water. It has wide global use, not only for malaria, but dengue and blackfly control, and has little impact on non-target fauna.

18. The program employs used motor oil as an inexpensive larvicide in polluted waters or other breeding sites in that are unlikely to be used by man or animals. The use of motor oil should be discouraged as the oil takes a long time to evaporate and contributes to pollution. There are other more volatile oils that can be employed.

Comments:

19. Larviciding, like source reduction mentioned above, requires good surveillance, monitoring and community and multi-sector involvement. As is recommended in the conclusion, larviciding is an areas in which other control agents....such as biological control with *Bacillus thuringensis israelensis (Bti)* or *B. sphaericus (Bs)* could be tested and employed as alternates to temphos. An entomology laboratory with colonies of principal vector species would facilitate the testing of these bio-control agents as alternatives to the currently used chemicals. However, it should be noted that bio-control with bacterial compounds (all of which are larvicides) is currently more expensive than environmentally sound chemicals such as temphos: this includes the cost of the materials and the frequency of application required. Pilot trials with biological control compounds and calculation of the possible cost differential should be carried out under local conditions before deciding to employ them on a broad scale.

20. Insecticide treated bed nets. Use of insecticide impregnated bed nets began in 1995 (Gash-Barka) and 1997 (Anseba). During 1999 a total of 91,772 nets were distributed, bringing the national total to 164,700 family and double-size bed nets sent to the zones for distribution to date. An additional 95,000 are in the warehouse in Asmara, awaiting shipment to the zones in May- June, 2000.

21. The method of distribution is through the Regional (Zoba) Malaria Coordinator, to the sub-zoba, and then in the communities. Distribution is through the local authorities and malaria personnel in zones considered high risk. The price is fixed at 30 Nakfa (approx. US$ 3.0) per net for those who can afford to pay: those who can afford the nets but do not have cash, can purchase them on credit. Those families which are unable to pay will receive nets at no charge. Nets are distributed at no cost to displaced persons. Re-impregnation will be carried out at no cost to the population (although the insecticide used will cost ~US 30 cents per re-impregnation). All funds collected through sale of nets goes into a rotating fund to support the bed net distribution and re-impregnation activities. All nets, regardless of original purchasing agency (e.g., WB, Save the Children, etc.) are distributed through the MOH malaria program as described above.

22. Education on the use of nets is currently provided to the communities by the Zoba, sub-zoba and village malaria workers: these same groups are responsible for re-impregnation. The insecticide employed for impregnation is the pyrethroid permethrin (see next section).

Although over 91 thousand nets were distributed in 1999, only 12,860 (14%) were reported to have been re-impregnated. No figures were available for the re-impregnation rates for nets prior to 1999.

23. The amount of permethrin reported used in 1999 (2832 liters diluted at 1:70) would be sufficient to re-impregnate almost 200,000 nets, more than have been distributed in the country to date.

Comments:

24. The impregnated bed net program has problems similar to that of other countries: i.e., starting broad distribution prior to having systems established for community education, monitoring the appropriate use of the nets, a re-impregnation system, and collection of malaria epidemiological data from communities (or sub- groups) that have or do not have nets. Biological data (now being collected by the USAID/EHP project on vector distribution and behavior (indoor vs. outdoor biting, biting times, etc.) are essential for proper application of all vector control activities......similarly, social data, KAP studies and development of "bottom-up" community based programs are essential as well. If proper information is not collected from the beginning of such programs it will be difficult, if not impossible to determine cost-effectiveness, and the appropriate role of this control method in an integrated program.

25. From the environmental standpoint, non-impregnated bed nets, *per se* ,are neutral: however, with the use of pyrethroids there are some additional considerations. Whereas pyrethroids have very low mammalian and avian toxicity, they are very toxic to aquatic organisms....fish, insects, crustaceans, etc. Therefore, the proper washing and re-impregnation of bed nets, disposal of any waste or washing of containers, gloves, etc., most be a part of the community education component of any bed net program. And, as attitudes and habits concerning the use of bed nets may differ from one community or group to another, it is important to have a social science input into the design and operation of bed net programs to prevent malaria transmission. This is especially important in Eritrea where bed nets, along with environmental management are very important elements of an integrated vector control initiative.

26. Biological Control. Larvivirous fish represent one of the oldest known forms of biological control for mosquitoes. Efforts are being made to evaluate this method of control with *Aphanius dispar*, a top-feeding predator of mosquito larvae and pupae. Trials are underway, both on mass production of *A. dispar* and efficacy in controlling mosquito larvae. The work is being done on a small scale in both the Northern and Southern Red Sea Zobas.

Comments:

27. Use of larvivorous fish, of various species, has been evaluated in many localities around the world over the years. The most successful operations have been to control mosquitoes in man-made habitats such as concrete or stone water tanks, especially in arid zones such as the

Red Sea coast of Eritrea. Studies elsewhere in natural habitats show fish to be less successful in controlling vectors where there are other sources of food and where they may have a negative impact on other aquatic fauna. However, if they can be successfully and economically reared and maintain their populations in man-made habitats in arid areas, they pose no environmental hazard and have a role to play in the most arid zones.

28. Residual house/wall spraying. By MOH policy, this control measure is only conducted in areas subject to malaria epidemics and in resettlement zones. However, it is this method of vector control which is most controversial and a major subject of this evaluation as the insecticide employed is DDT. Details about DDT, WHO's position on its continued use (especially in Africa) are given in Section 3 of this report.

29. Since the establishment of the Eritrean malaria control program, DDT has mainly been used in Gash-Barka, Anseba and Dabub. From a very low level of application in 1996, larger amounts of DDT have been used to in an effort to stem the increasing number of reported malaria cases.

30. Table 2. Reported spray coverage (by villages, houses and population benefited), quantities of DDT used, and total (CHA +HHF) reported number of cases of malaria. The 352 villages reported sprayed in 1999 represent only 17% of the villages termed "malarious".

Table 2. Spray coverage

Description	**1994**	**1995**	**1996**	**1997**	**198**	**1999**
Villages sprayed	19	13	2	18	148	352
Houses sprayed	9,272	13,742	600	12,385	49,482	113,789
People benefited	41,403	3,868	2,400	30,035	166,244	225,857
Total malaria reported	141,213	338,552	306,643	252,721	466,016	293,671
Kgs. DDT 75%WDP	**1981**	**2748**	**120**	**3272**	**14112**	**21886**

31. Some of these figures are not consistent: for example the number of people shown to have benefited in 1995 is much lower than in 1994, even though many more houses were sprayed in 1995.

Comments:

32. The house spray component of the Eritrean malaria control program is not extensive. For example, of the 2,089 malarious villages (out of a total of 2,564) only 352 (17%) were sprayed with DDT in 1999. In Gash- Barka, all 784 villages are considered malarious, but only 128 (16%) were sprayed; in Dabub, 579 of 884 villages are considered to be malarious, yet only 38% were sprayed with DDT. It is also the stated policy of the MOH to: 1) reduce household spraying further and rely more of environmental management and impregnated bed nets when malaria rates are reduced and; 2) initiate search for alternate compound(s) to

replace DDT if house spraying is needed when economic and epidemiologic data indicate that this is feasible.

33. As in the use of bed nets, it is difficult to evaluate the effectiveness of residual spraying. One possibility is to compare the number of new cases of malaria (and mosquito densities, biting rates or inoculation rates) between villages that have or have not been sprayed. At least three successive years are required to determine if a correlation exists.

34. If some level of residual house spraying is to be retained in the Eritrean malaria control, steps should be taken to select an alternate insecticide to replace DDT. Most likely this would be a pyrethroid....lambdacyhalothrin, deltamethrin or cypermethrin. A laboratory should be made available to test resistance/susceptibility status of these compounds to *An. gambiae* and other vector species, followed by pilot trials to test efficacy under field conditions.

35. Using the guidelines and recommendations of WHO regarding the use of DDT in Africa for malaria control (Annex 3), and as stated by the Minister of Health (Annex 4), there can be no objection to the manner and quantity used in the current Eritrean program:

- the GOE regulates the use of DDT only for malaria control,
- there is no recorded vector resistance to DDT in Eritrea (although systematic testing is needed),
- application is based on epidemiological evidence in malarious, high-risk areas,
- applicators (spray-men) are either MOH employees or local hires trained by MOH,
- steps will be taken under this project to test alternate compounds to replace DDT when epidemiologically and economically feasible

C. Chemical compounds applied for vector control and possible alternatives (see WHO Data Sheets (Annex 5).

36. <u>Temphos</u> (= Abate). This organochlorine insecticide has been widely used globally as a mosquito and blackfly larvicide for over 25 years, because of its efficacy and low mammalian and avian toxicity. Various formulations are available (liquid, granular for slow release, etc.) and are recommended by WHO/WHOPES. In this program fewer than 10 liters (active ingredient) are used in most years: the maximum was ~51 liters (a.i.) in 1998.

37. Mammalian Toxicity (LD50) is: Dermal (rat) >4000 mg/kg Oral (rat) 8600 mg/kg WHO Classification by Hazard: Class IV "unlikely to present acute hazard in normal use".

38. <u>Permethrin.</u> This pyrethroid insecticide is one of the earliest, having been used for approximately 30 years as a residual spray, a repellent, and more recently in Eritrea and elsewhere for impregnation of bed nets. It is used by a number of military groups for impregnation of clothes as a repellent and durability even after repeated washings. It is produced in numerous formulations, and approved by WHO/WHOPES. In this program 2832 liters of permethrin were used in 1999 to impregnate bed nets.

39. Mammalian Toxicity (LD50) is: Dermal (rat) 2500 mg/kg Oral (rat) 500 mg/kg

40. WHO Classification by Hazard is: Class II "moderately hazardous".....depending on formulation and concentration used. This is the same Classification as for other pyrethroid insecticides: this based on the toxicity of the active ingredient, although operationally they are used at much lower concentrations (e.g. 0.20 - 0.50 g/m2 on nets) than organochlorine or organophosphate compounds.

41. DDT. At the recent (February 2000) WHO conference on DDT held in Harare, Zimbabwe, WHO noted that the Intl. Action on Certain *Persistent Organic Pollutants* (POPS) granted a general exemption *on DDT* production and use limited to vector control (the full Delegates' Report is attached as Annex). WHO fully supports the use of DDT, under certain conditions of use, especially in African countries where it is still effective . The conditions of use in this project are presented in Section 2 (above), justifying its continued use in the Eritrean malaria control campaign.

42. Mammalian Toxicity (LD50) is:
Dermal (rat) 250-500 mg/kg (in oil) Oral (rat) 113 mg/kg 3000 mg/kg (powder)

43. WHO Classification by Hazard is: Class II "moderately hazardous"....depending on formulation. In this program the formulation used is 75% Water Dispersible Powder (WPD).

44. Possible Alternative Insecticides: At present the malaria control program uses only the three insecticides described above: (temphos for larviciding; DDT for house/ wall spraying; and permethrin for impregnating bed nets). All are performing well at present, but possible alternates should be tested in the event resistance is developed by the malaria vectors to either of the compounds currently in use. Example of possible alternatives are:

- Temphos may be replaced by, or alternated with, *Bacillus thuringensis israelensis (Bti)*
- a bio-control agent effective as a larvicide against anopheles. The active ingredient is an endotoxin produced by this spore-forming bacterium: the toxin: when ingested in the gut of the mosquito larvae the toxin destroys the endothelium, killing the larvae. The toxin of *Bti* is effective only against dipteran insects (flies, gnats, mosquitoes, etc.). The commercial products (e.g., Vectobac) are available as powders, granules and "blocks" for slow release. The potential drawbacks are the shorter period of effectiveness (`30-40 days depending on water temperature, acidity, etc........whereas temphos may last up to 90+ days, and the cost (both of the material and the increased application required.

- Permethrin may be replaced by a number of other pyrethroids, including cypermethrin, lambdacyhalothrin, cyfluthrin and deltamethrin. All are approved by WHO for impregnating bed nets, all are risk classified as Class II as "moderately hazardous"...depending on formulation and concentration used (the same as permethrin). Only the pyrethroids have the necessary physical characteristics (high vapor pressure) and low toxicity (at the concentrations used) suitable for bed net impregnation.

- DDT, over the years in many countries, has been replaced by organophosphate compounds often of greater acute toxicity, requiring more extensive worker safety training and monitoring (for cholinesterase depression). With the advent of the pyrethroids mentioned above, these compounds have become the most common replacements for DDT. They are more expensive (for the active ingredient), but the dilutions are great, reducing the cost. In addition, transport costs are reduced because of reduction of bulk and most are packaged in "sachets" or plastic or foil packages for individual pump charges reducing handling and worker exposure to the insecticide. Because insecticide prices vary considerably depending on quantity purchased, shipping requirements, etc., it is important that a detailed local costing be made, along with trials for efficacy, in comparing the alternative materials to be used as DDT is phased out.

Note that one should not use the same pyrethroid insecticide for both indoor spraying and impregnation nets as this may enhance the development of resistance.

45. Insecticides used for crop protection: In a country where agricultural insecticides are used in both the public and private sector, it is difficult to estimate the total quantities. This is especially true in countries that are subject to desert locust outbreaks, during which intensive application of insecticides is required. The Ministry of Agriculture (MOA/GOE)' has provided a list of insecticides used by the Plant Protection Service during 1998 (Annex 6). This list includes a large number of both organochlorine and organophosphate compounds, six and nine, respectively. These accounted for over 41 tones in 1998. Cypermethrin is the only pyrethroid recorded on the MOA list, with 278 liters used in Dabub in 1997 and 1998. However, we have no national statistics on the private sector usage of insecticides in commercial agriculture. An example was obtained during a visit to a large (4000 ha.) cotton plantation near Tessene (Gash-Barka). Aerial spraying is conducted five times per season with 3500 liters of several insecticides including organophosphates and the OC Ensosulfan. It is safe to say that the agricultural use of insecticides, both in quantity and diversity of types is far greater than the limited use of three compounds in public health....but we do not know how much greater.

46. It should be noted that the MOA has an active program of Integrated Pest Management (IPM) in its crop protection section. The entomological expertise developed in agriculture will have a healthy influence on the public health sector in developing similar programs.

47. Insecticide resistance: A properly functioning vector control program that utilizes insecticides must have the capability to test the efficacy of the insecticides employed. Insecticide resistance should be checked regularly in all important vector species in areas of insecticide application for vector control and in areas where insecticides are used for crop protection. To date, resistance testing of the principal malaria vector, *Anopheles gambiae*, has been very limited: the secondary anopheline vectors have not been studied to date. One cycle of testing DDT and malathion (by conventional WHO resistance/susceptibility test kits,

using insecticide impregnated filter papers) was conducted during 1998 and 1999 in three Regions (Zobas). In addition, the pyrethroid permethrin has been tested once by bioassay for efficacy against *An. gambiae* exposing the vectors (under a plastic cone) to swaths of bed-netting material impregnated with this insecticide. The results were as follows:

- in five locations (two in Gash -Barka, Sept.- Oct., 1998; two in Debub, Oct.- Nov., 1998; one in Anseba, Oct. 1999), 100 adult female *An. gambiae* were tested with WHO test kits using 4% DDT impregnated test filter papers: in all trials, observed mortality was 100% in all replicates.

- in the same localities, at the same time, female An. gambiae were tested with WHO test kits using 5% malathion impregnated test filter papers: observed mortality ranged from 100% in Debub, to 83-98% in Gash Bark, and 95% in Anseba.

- 100% mortality of *An. gambiae* was obtained in bioassay trials with permethrin-impregnated bednet material.

48. Observations: Testing for insecticide resistance is important, not only to determine the efficacy of the compounds in use, but also in the selection of alternative compounds should there be a need to replace the currently used compound(s). And, because insecticides are expensive, it is essential to select those that may be effective over a long period of time. Furthermore, economic studies have shown that malaria control programs which rely largely on insecticide application, may use as much as 75% of their budget on the purchase of insecticides, equipment for application, salaries for applicators, etc. The Eritrean malaria control program, as described above, is developing an integrated vector control (=management) approach, not solely dependent on insecticides, but chemical control will be a part of this integrated control effort for the foreseeable future. Therefore for economic and operational reasons it is important that the resistance patterns of all important vectors be known from the different ecological zones in the country. The Geographic Information System (GIS) techniques that the USAID/Environmental Health Project is introducing into Eritrea for mapping vector distribution and behavior can be used equally to plot geographic areas of pesticide usage and sites of testing for insecticide resistance.

49. Although vector resistance can be determined in the field, it is easier and more efficient to have a laboratory devoted to this activity, especially for screening new insecticides. At present there are no colonies of insecticide susceptible vector species that are needed for baseline studies. In addition there are no laboratories for insecticide residue analysis (which could be shared with the agricultural authorities). Such a lab is needed to analyze, after spraying, the precise amount of insecticide "active ingredient" (a.i.) that is on the wall, or bednet after treatment.

50. Overall, the development of a capability for testing insecticide resistance is essential for evaluating ongoing control programs, selection of alternative compounds when needed, and operational quality control of ongoing insecticide application activities.

D. Other Environmental and Safety Issues

51. Safe use procedures: As this evaluation took place before the spraying season,, it was not possible to review the training of day-laborers who are hired annually to do house spraying. However, the Zoba malaria coordinators are very experienced men. Regardless, it would be good to have an annual review of training procedures prior to the start of spraying, and to assure that protective clothing, boots, gloves and dust masks are available for all workers in each zone. The temperatures are hot, but not oppressive, especially in the areas above 1000 m, and protective clothing should be worn when spraying DDT.

52. It was noted that equipment such as spray tanks were carefully cleaned and stored before the spraying season: equal attention should be paid to cleaning equipment in the field, and disposing of excess insecticide so as not to contaminate animal and/or human water sources. The malaria field personnel have had years of experience with spraying: on the other hand impregnation of bed nets is a relatively new procedure, and various approaches (impregnation by MOH, NGOs, community action, individual, etc.) are being used in different countries. In order to effectively and safely apply the insecticide being used, the procedure for 1) educating the community about malaria and mosquitoes; 2) distributing the nets and their effective use, and: 3) re-impregnation and care of the nets, should all form one " packet" and the IEC and malaria staff need to develop this in the local context. This will require the addition of social scientists to the "malaria team" to conduct KAP or related studies and baseline data in all areas (entomological, epidemiological and socio-economic). The very low re-impregnation noted in this campaign is an indication that this has not been done and the people have not understood, or accepted, the concept of impregnated nets. As the use of impregnated nets is one of the major components of the integrated control concept, this could present a real problem. No large numbers of nets should be distributed a better system is in place.

53. What has been said above is general for the education needed by the general population... especially when developing and integrated program with large emphasis on methods such as bed nets and environmental management (source reduction). The malaria staff is too small, and otherwise occupied, to do this along with its other duties.

54. Because this review was made before the spraying season, the whole process of handling, storage and transport of insecticides was not seen. Although the three insecticides being used in this program do not present major risks, standard warehousing and handling procedures should be followed. Insecticides are reported to be moved (after delivery) quickly from the central stores to the Regions, and then to the su-regions before spraying.

55. The central warehouse in Asmara is adequate for short time storage (1-2 months for powdered insecticide formulations) but not for long periods. Transport to the Regional stores is by commercially rented (not central government) vehicles. It is not known whether

the commercially hired truckers and laborers were familiar with, or trained in handling insecticides, or used any protective clothing. The only Regional (Dabub) warehouse visited was suitable only for short-term (1-2 months) storage.

F. Other Environmental Considerations

- There is no question that broad climatic changes that produce high , or even excessive, rainfall or drought will have local effects on malaria transmission. The same can be said of large population movements caused, as in Eritrea, by persons displaced by military conflicts. However, to understand these patterns and changes, baseline and systematic data over a period of time are necessary: some of these data are just being collected in Eritrea. Some of the data collected by the Zones (e.g. Anseba) indicates that although there was an big increase in malaria (epidemic) in 1998, the increase occurred in almost all of the known malarious areas in the zone (albeit not at the same rate), but it did not indicate that it was localized or caused by mass movements of people (Annex 7).

- Although we have a tendency in an EE such as this to review the potential deleterious impacts that malaria control programs , especially by the use of insecticides, may have on components of the natural environment, we seldom consider the impact, both social and economic, that malaria itself has on the human ecology. For example, in 1998, there were over 466 thousand cases of malaria reported in Eritrea: assuming that each case debilitates a person for 10 days (a conservative estimate), we can calculate a loss of almost 13 thousand person-years: if we calculate the lost number of working days in a year, the loss is 18 thousand person-years. This is a serious loss in an agricultural/pastoral society (and to children at school).

G. Donors/Collaborators

56. A number of agencies, international and bilateral, as well as PVOs are working with the malaria control program in Eritrea. Assistance may range from training, to vector control, or provision of drugs. In August 1999 the MOH produced a Plan of Action in the context of Roll Back Malaria (RBM). From that document and others the following list of donors/collaborators is taken: WORLD BANK, UNDP, USAID, WHO/PHARPE, SAVE THE CHILDREN, WHO, UNICEF, ITALIAN COOPERATION, and other partners

H. Development of an integrated malaria vector control approach:

57. The vector control component of malaria control program in the Eritrean MOH is an integrated effort. As mentioned in this document, there are elements of environmental management (=source reduction), larviciding, use of impregnated bed nets, biological control and residual spraying in houses in high risk areas. What must be addressed is:

- need for more research and training, more community participation;
- need for collection of baseline data (biological, socio-economic);
- development of methods to measure efficacy of the integrated components,together and

individually;

- understanding the economics of Integrated Vector Management (IPM); programs for continual adaptation and improvement.

I. Environmental guidelines of WB and GOE:

58. According to the terms of reference of this EE it is to reflect both IDA's and the GOE's environmental policies with priority given to the national. According to the draft (unofficial) National (GOE) Environmental Assessment Procedures and Guidelines, page 12, the project under consideration was registered for screening (Annex 8) would best be categorized as Category B, i.e. "because of their type, size, location and/or mode of operation: could lead to significant negative impacts if not carefully planned". And (Chapter 4, page 14, same document) "the potential environmental impacts associated with the project type are:

- predictable on the basis of prior experience;
- capable of avoidance or mitigation through design and management;
- overall environmental impacts should be relatively small-scale if the project is well designed.

59. Public Health projects are not listed among the Proposed Environmentally Sensitive Areas in the above mentioned document, and the available MLWE questionnaires (mostly dealing with agricultural use of insecticides) were not applicable to this project. Therefore, in the absence of a formal MLWE questionnaire pertaining to the scope of this project, a draft questionnaire (applicable to this project and other insect-borne disease control activities) was drafted and completed in cooperation with the Department of the Environment of the MLWE (Annex 9).

60. This EE has attempted to answer the relevant issues regarding pesticide usage, including that of DDT (the major environmental issue associated with this project) , and development of proper information gathering, analysis and training to reduce insecticide usage to a minimum as part of an integrated vector control program. Regarding insecticide usage this EE draws upon the published approvals of WHO for public health (specifically malaria) use. At the initiation, and later at the conclusion of this work the author discussed the above points and the findings of this environmental evaluation with representatives of both the MOH and the Ministry of Land, Water and Environment (MLWE),

J. Conclusions and Recommendations

61. In drafting these recommendations, the author recognizes that the project being evaluated is much larger than those components (insecticide usage) which are the primary focus of the EE. Also, the parts of what normally would be a management or mitigation plan, are necessarily parts of a much larger national malaria control effort. Therefore, these conclusions and recommendations are offered, to be included into the broader project and to assist in the improvement of the vector control elements of the ongoing national malaria control program. Such issues as surveillance, improved data collection and measuring efficacy of control methodologies are not "stand alone" issues, but are to be included in the project both to

reduce reliance upon and safe use of insecticides as major components of other the total project.

a) The continued use of DDT for malaria control is supported, subject to annual testing for efficacy (susceptibility of target vectors) and monitoring for potentially negative environmental impacts in the ecologically diverse malaria transmission zones of the country Studies are to be initiated to test the suitability of alternate insecticides (pyrethroids) to replace DDT when economically and biologically feasible. All DDT, and other insecticides purchased must meet WHO specifications.

b) Funds should be reserved for establishment of an entomology laboratory to monitor insecticide resistance in malaria vectors, testing alternate compounds (including biological control) and carry out insecticide residue studies (possibly share the latter with Min. of Agriculture as there is no such lab in the country).

c) Reorganize the distribution of insecticide impregnated bed nets so that there is a system by which communities are instructed in malaria-mosquito relations, re-impregnation of nets, proper use and care of nets, and a monitoring system for efficacy is in place. This will involve the social sciences in gathering KAP like studies and other appropriate baseline data..

d) The procedures for selection of houses for spraying with DDT (or its replacement compound) should be standardized and quantified if possible.

e) The strong efforts being made in environmental management (= source reduction) could be strengthened by better collaboration with agriculture, public works and other sectors, by increasing surveillance, monitoring and elimination of breeding sites in and around communities.

f) Continue the studies initiated by USAID/EHP on vector distribution and behavior, expand the technology to other areas (surveillance, plotting use of spraying, source reduction, bed nets, etc. The work should be incorporated into the structure of the Division of Malaria Control and will serve as a base for in-country training of entomologists.

g) Initiate studies to determine the efficacy of spraying, bed nets and environmental management as described in text: these should include analysis of malaria incidence in sprayed vs. non-sprayed communities(or parts thereof, or communities with and without nets.

h) Use of used motor oil is to be discouraged, after introduction and trials with more biodegradable "mosquito " oils and monomolecular layer oils.

i) As the use and re-impregnation of bed nets increases, greater efforts will have to be made to assure that net washing and disposal of re-impregnation waste insecticide does not come in contact with natural aquatic habitats because of the toxicity of pyrethroids to aquatic organisms.

j) The Integrated Vector Control (ICV) program being developed for malaria control requires more personnel and expertise than a program based only on spraying (for example. Therefore, increased staff, at the central level, and at least one field research station are required to carry out the R&D needed by such a program. Funds should be set aside for increased transport and field work as these ICV components are measured in the field for efficacy.

k) A task force (malaria staff, epidemiologists and statisticians) should be assembled to review the current malaria information system, Zoba by Zoba, and the indicators that are being used, or need to be developed, to determine the efficacy and cost effectiveness of the various components of the IVC program.

K. Management Plan:

62. The above recommendations made during this environmental evaluation are broad, as would be expected, considering that insecticides are used as larvicides, household spraying (with DDT), and for impregnating bed nets. As with any integrated program there will be overlap in activities required to assure the efficacy, safety and economy of vector control operations. Accordingly, the management plan recommended below consists of four (4) major activities, each containing elements of more than one of the above recommendations.

63. Activity A - Testing efficacy of DDT and alternative insecticide compounds and initiation of a phase-out schedule for use of DDT (Recommendations 1 and 2). Annual testing (during years 1-5) of susceptibility of vectors in the field to DDT should be conducted using the WHO test kit methodology described in Section 5 of this report. In addition, testing of pyrethroids (cyfluthrin, alpha-cypermethrin, deltamethrin, lambda-cyhalothrin, and others as available, in different formulations should be carried out in years 2 - 3. Those selected as most suitable (based on efficacy, safety and economy) should be pilot- tested against DDT in years 3-5, to begin phasing-out DDT by the fifth year. Establishment of an entomology laboratory, preferably in one of zone offices (Anseba or Bebub, and training (see next Activity) should be planned during year 1 and initiated during year 2, to be operational during years 3-5.

64. Activity B. - Capacity building and strengthening the infrastructure of the National Malaria Control Program (Recommendations 2, 6 and 10). This activity should focus on entomology training and collection of baseline biological data to support the implementation and monitoring all of the integrated vector control components of the national malaria program. It should extend and build upon the USAID/Environmental Health Project's activities including contacts with the International Center for Insect Physiology and Ecology (ICIPE) in Nairobi for training entomology professionals and technicians. The activities should make use of the entomology laboratory (Activity A, above) to be established: a detailed plan should be developed in year 1 for the full 5 year period of the project, identifying nationals to be trained, either at ICIPE, elsewhere, or in-country with consultants, in vector taxonomy, ecology/behavior, mapping and monitoring of vector control activities.

65. Activity C. - Develop IEC strategy for community-based implementation and maintenance of insecticide impregnated bed nets (Recommendations 3 and 9). The low percentage of bed nets reported re-impregnated is an indication of a lack of understanding by the general population on the advantages of an insecticide impregnated bed net as opposed to a plain, un-impregnated bed net. MOH's IEC group should work with the NMCP to develop a local system for distribution and community participation in understanding the mosquito-malaria relationship, proper use and care of the nets and re-impregnation (Recommendation 3). The system should be based on understanding of local knowledge and practices (KAP studies) and adapted to community organization and experiences with other joint community activities. The system should be developed in year 1, field tested in years 2 and 3, and fully operational by the end of the project in all regions. The MOH/IEC section should work jointly with NMCP (Central, regional and sub-regional) and external consultants. As a guide, there is a large WHO and Roll Back Malaria (RBM) literature on such distribution and re-impregnation systems tested in other African countries, and also are available from USAID/EHP and the UK Malaria Consortium (London School of Hygiene and Tropical Medicine).

66. As the use of impregnated bed nets is planned as one of the major vector control activities to reduce the transmission of malaria (and the use of DDT in spraying houses) and is one of the most costly components of the program, it is essential that the IEC-NMCP initiative to develop a national system be initiated as soon as possible in year 1 before further large numbers of bed nets are distributed.

67. As noted in Recommendation 9, the pyrethroid insecticides used for impregnating bed nets are toxic to most aquatic animals (insects, fish, crustacea, etc.) and it is imperative that users understand this and do not dispose of insecticides or wash impregnated (= treated) nets in natural aquatic habitats with such a fauna. The user communities, if properly instructed, will serve as both the best prevention and best monitoring systems, by seeing that insecticides are not used in/by natural habitats or, if so, whether unusual numbers of dead animals occur in such localities near the villages. These concepts should be incorporated in the national system developed to instruct the local communities in the proper use and care of treated bed nets. Coordination of the MOH's IEC group, the NMCP and the Department of the Environment (Ministry of Land, Water and Environment) is essential.

68. Activity D: Improved collection and analysis of data leading to cost-effectiveness information on different (integrated) methods of malaria vector control. A national malaria task force (Recommendation 11) should be established. Its task will be to review the currently employed criteria to determine which of the integrated malaria vector control methods (spraying, bed nets, larviciding, environmental management, etc.) will be used, and where, determine their cost and effectiveness, modify their application if warranted, and monitor the results (Recommendations 4, 5, 6 and 7). This must be done seasonally over the 5 year life of the project. MOH epidemiologists, statisticians and NMCP staff including regional malaria coordinators (with data at regional, sub-regional and village levels) should participate. Cooperation of other ministries (e.g. Agriculture and Environment) should be sought. An

economist from the government or the university should be included. The task force should assist the NMCP in making annual plans and reviewing the progress in testing alternative insecticides to eventually replace DDT, and see that safe practices are continually employed where and when insecticides are employed.

Note

69. The costs for the PMP are included in the project costs. Specific activities are detailed and scheduled in the annexed Pesticide Management Plan Table.

Eritrea HIV/AIDS, STD, Malaria, TB Control Project

Pesticide Management Plan

Activity	Major Steps	Year					Responsibility
		1	2	3	4	5	
A: **Test cost-effectiveness & efficiency of DDT & alternates**	• Identify alternative insecticides and systems to be tested	X					TA/NMCP
	• Order samples & WHO kits	X					NMCP
	• Establish research & monitoring program for test	X	X				NMCP/TA
	• Test DDT and alternatives in all zobas	X	X				Zobas
	• Select specific sites for testing DDT and its alternatives	X	X				Zobas/NMCP
	• Establish agreement w/ agriculture labs or Establish/equip entomology lab and field station	X					MOH
	• Commence lab testing at different concentrations	X					NMCP/Zobas
	• Field test acute & residual	X	X	X			NMCP/Zobas
	• Analysis of tests results		X	X			NMCP
	• Monitor and report testing	X	X	X	X	X	NMCP/TA
	• Perform annual analysis of results	X					NMCP/TA
	• Select alternative insecticides to be employed in program	X					NMCP
	• Pilot trials in villages			X	X		Zobas
	• Develop operational plan to phase out DDT & replace w/ selected compound(s)		X	X			NMCP/TA
	• Implement operational plan to phase out & replace DDT			X	X	X	NMCP/TA
	• Establish research and monitoring			X	X	X	NMCP

Eritrea HIV/AIDS, STD, Malaria, TB Control Project

Pesticide Management Plan

Activity	Major Steps						
B: Capacity building (training) & base line data	• Define adequate research and training	X					TA
	• Identify technical areas for training (e.g., vector ecology behavior, control, insecticide resistance, etc.) in ICIPE	X					NMCP/TA
	• Select individuals for training	X					NMCP/TA
	• Send first group (1 professional & 4 technicians) to ICIPE		X				NMCP
	• Send second group (idem) to ICIPE			X			NMCP
	• Develop curriculum		X				NMCP/ICIPE & USAID/EHP
	• On return: trainees develop research & data collection programs to support vector control in Zobas with highly endemic malaria and epidemic periods				X	X	NMCP/Zobas
	• Train village volunteers, health staff, and commercially hired truckers on chemicals handling as needed, according to chemicals/other systems selected	X	X	X	X	X	NMCP/Zobas
C: IEC Strategy for bednet implementation	• Review available impregnation alternatives and select best(s) one(s) according to socio-cultural and environmental conditions	X					
	• Review WHO/RBM literature on impregnated bednet use	X					IEC/NMCP
	• Establish MOH working group	X					IEC/NMCP
	• Collect base line socio-economic data to develop strategy		X	X			NMCP/Zobas
	• Collect base line vector ecology & behavior data to develop strategy		X	X			NMCP/Zobas
	• Prepare strategy with zobas and sub-zobas						
	• Implement strategy		X	X			NMCP/Zobas
	• Examine malaria transmission w/ and without use of bednets in sentinel sites			X	X	X	NMCP/Zobas
	• Correct strategy according to results in sentinel sites						
	• Prepare and introduce plan for community participation, proper use and re-impregnation of bednets (including monitoring of environmental impacts)			X	X		NMCP/Zobas
	• Establish commune monitoring of malaria transmission and environmental problems due to insecticides employed				X	X	NMCP/Zobas

Eritrea HIV/AIDS, STD, Malaria, TB Control Project

Pesticide Management Plan

Activity	Major Steps						
D: Improve collection & analysis & use of Malaria data	• Select national malaria task force	X					NMCP/TA
	• Define task force role & objectives	X					NMCP/TA
	• Coordinate malaria cpi & environmental issues (social & biological)		X	X	X	X	NMCP/EHU/ DOE
	• Measure efficiency of vector control efforts (house-spraying, bednets, source reduction, fish, etc.)		X	X	X	X	Zobas
	• Monitor efficiency of vector control efforts (house-spraying, bednets, source reduction, fish, etc.)	X	X	X	X	X	NMCP/Zobas
	• Improve and expand vector control efforts (housespraying, bednets, source reduction, fish, etc.)						
	• Establish agreement w/relevant sectors (agriculture, public works, etc.)	X					MOH
	• Coordinate environmental issues w/ Division of Environment-DOE/MLWE		X	X	X	X	NMCP/DOE
	• Initiate and evaluate studies to determine cost effectiveness of the different vector control measures employed			X	X	X	NMCP/TA
	• Strengthen IEC to support integrated vector control	X	X				NMCP/TA
E: Safe use of insecticides for Malaria Control	• Strengthen annual review of training prior to house-spraying	X					NMCP
	• Strengthen system to clean equipment in the field, and as needed establish system to dispose of leftovers/containers	X					NMCP
	• Establish standard procedures for storage,handling, cleaning and disposal	X					NMCP/Zobas
	• Develop for each components adequate: training, transport and storage, disposal, and monitoring	X					NMCP
	• Implement procedures at Central, Zoba & Sub-Zoba levels		X	X	X	X	NMCP
	• Report annually to Malaria Task Force	X	X	X	X	X	NMCP
	• Correct deficiencies as appropriate		X	X	X	X	NMCP/TA