UNITED STATES GOVERNMENT
MEMORANDUM

AGENCY FOR INTERNATIONAL DEVELOPMENT

Santo Domingo, Dominican Republic

Date: December 14, 1990

From: Robert P. Mathia - PDS

To: The Files

Subject: Project Assistance Completion Report (PACR), Vector Control Project No. 517-0235

The attached report will serve as PACR for the subject project.

Attachment: a/s

Distribution:

LAC/DR
PPC/CDIE
PRG
CON

USAID VECTOR CONTROL PROJECT (517/0235)
F I N A L   R E P O R T

1. Introduction

The University of South Carolina (USC), the Pontificia Universidad Catolica Madre y Maestra (PUCMM) and the Servicio Nacional de Erradicacion de la Malaria (SNEM) signed a cooperative agreement in August, 1986 to establish a Vector Control Project (VCP) in the Dominican Republic (DR). The purpose of the project was to foster an institutional capability in the DR to research and test ecologically and economically sound intervention methods to control vector-borne diseases, specifically malaria and dengue. The goal of the Project was to promote a healthier living environment in the country by improving the nation's ability to reduce the incidence of vector-borne diseases.

The University of South Carolina received funding in the amount of 1.5 million dollars to implement the USAID Vector Control Project (VCP) for a three year period. In addition, host country funding (PL 480 monies) was authorized in the amount of 600,000 pesos. USC was responsible for administering these funds.

This final report will summarize the activities, accomplishments and obstacles experienced throughout the life of the Project.

2. Start-up of the project

Dr. Mac Tidwell, Project Coordinator, arrived in the Dominican Republic in January 1987 after an extensive search for a qualified individual to fill this position. In September 1986, scientific equipment, office supplies and vehicles (in the amount of $163,343.00) were procured by the University of South Carolina for Project use. These goods were delivered in the Dominican Republic in March 1987. Host country funding (PL 480 monies), was not disbursed to the Project until April 1987. Since these monies were needed to pay locally employed personnel and for local purchases, these delays caused a lag in the implementation of the Project.

PUCMM provided temporary facilities for the Project on the campus in Santiago. SNEM also provided laboratory and insectary space for the dengue work in Santo Domingo. A permanent laboratory was constructed at PUCMM and opened in May of 1989. Construction of the lab took much longer than anticipated due to the delay in receiving PL 480 funds and the shortage of locally available building materials.

The Advisory Committee, consisting of members from each of the cooperating institutions along with AID personnel, was established early in the life of the VCP and met periodically throughout the duration of the Project.

3. Technical assistance

USC faculty and outside consultants provided expertise to the VCP in the following areas: in-country training (both formal and on-the-job training), the use and maintenance of spray equipment, safe use of pesticides, field and laboratory techniques of sampling mosquitoes and evaluating control measures, health promotion and community participation in Ae. aegypti source reduction, etc. Special assistance/training was provided during their in-country periods for the VCP's candidates who were working on their master's degree . A total of 675 man-days of consultation work was provided to the Project. An increase in the number of consulting days compared to that shown in the Project Paper was necessary to provide an operational assistant to the project coordinator to meet the daily operational/administrative needs during the increased activity of the extension period. Also, because of the frequent breakdown of some spray equipment and Project vehicles combined with the difficulty of obtaining qualified local mechanics to work on the equipment, it was necessary to obtain the services of qualified mechanics from the U.S.

4. Accomplishments

4.1 Dengue

4.1.1 Selection of Study Sites

Study sites were selected based on available records from SNEM and preliminary surveys conducted by Project staff.

In April 1987, Ensanche Espaillat, a lower middle class barrio encompassing ca. 41 ha (100 acres) in the northeast section of Santo Domingo was selected as the principal study site. This site is representative of many of the older middle class barrios of the city. In addition, initial inspections revealed substantial populations of Ae.aegytpi. The majority of the dwellings are single story, cement block construction. As is typical of many areas of Santo Domingo, water is provided to Ensanche Espaillat several times a week. There may be periods of one to four weeks when piped water is not available and must be obtained from other sources. Such water is stored most commonly in 55 gal drums which provide an ideal habitat for Ae. aegypti breeding. Mejoramiento Social a nearby barrio with similar characteristics, was selected as the second study site to compare Ae. aegypti indices and various control interventions. A third but poorer barrio, Gualey, which is contiguous with E. Espaillat was also selected for comparative studies. Gualey is characterized by small wooden/tin shacks which are densely packed. It is located next to the Rio Ozama. Open sewer ditches cross the area and drain into the river. Additional areas were used in Santiago for community participation evaluation.

4.1.2 Baseline Data

The collection of baseline data on the bionomics of Ae. aegypti was essential in order to provide information that could be used as a basis for testing intervention methods. Baseline data were obtained using traditional methods of estimating Ae. aegypti populations as well as actual counts of immatures in water containers and sweep-net captures and biting collections of adults inside houses.

In all three areas, essential water storage containers were the most numerous, and these represented a high percentage of all positive larval habitats for Ae. aegypti. Cement lined 55 gal drums are the most important source of mosquito production in most areas and, while the average number of larvae per drum was more than 800, one drum was recorded with approximately 2,000 immatures of Ae. aegypti. It is estimated that in many barrios, 60 mosquitoes or more may be produced daily from a single premise, more than 80% of these being produced in drums. This level of productivity would provide at least 10 mosquitoes each day for every man, woman and child living in these areas. This high rate of mosquito production (>4,000/ha) has also contributed to the surprisingly high numbers of mosquitoes found in approximately 20% of the houses. In a five minute capture period by two workers more than 200 Ae. aegypti were netted from a single dwelling. The role that these high numbers of mosquitoes may play in dengue transmission is unknown (see Appendix 1).

Researchers in Puerto Rico have found that a density figure of 4 on the international scale of 1-9 by Brown (based on a composite score of larval indices) was associated with increased transmission of dengue. Vector Control Project investigations revealed that the premise, container and Breteau indices in baseline study areas were respectively 80, 50, and 200 or higher which corresponds to the maximum density figure of 9 on the scale by Brown, and as such, emphasizes the high risk for dengue transmission.

There was variation in the larval indices among the barrios; however, in a comparison of house, container, and Breteau indices with the average number of females per house (female density index), only the container indices were similar among the three study areas on three dates. There was no significant relationship between adult densities and any of the three larval indices. This may have been due to the high levels of mosquito populations in the areas masking any differences that may be present at lower population densities. Although some data is now available on larval indices in Santo Domingo (See Table 1 Appendices 1 and 2) little data is available on the associated adult densities from these areas.

Stratification is the characterization of transmission areas using epidemiological aspects as well as associated factors (e.g. the presence of streets to permit access to vehicles with mounted spray equipment) for consideration in control programs. With the lack of apparent correlation of larval indices and adult population counts in high mosquito density areas, the lack of adequate serological data and other factors, meaningful stratification is not yet possible. However, a system for use as a guide to stratification for dengue prevention and control is presented in Appendix 2. In addition a dengue research matrix is discussed and given in Appendix 3.

Susceptibility tests were conducted on larval and adult stages of Ae. aegypti populations from Santo Domingo using standard WHO procedures and kits. Larval tests indicate that the populations had significant levels of resistance to temephos (abate) but not to malathion. The resistance to temephos is alarming because this is a safe insecticide that can be used even in potable water and its continued use could lead rapidly to a higher level of resistance. In adult tests, a high level of resistance was detected to DDT. The populations also had relatively high levels of resistance to propxur, fenitrothion, and permethrin. In acquiring insecticides for routine control or emergency use, findings of the VCP on insecticide resistance of Ae. aegypti should be used as a guide. A detailed presentation of susceptibility test results is given in Appendix 4.

In conclusion, considering the high population densities of Ae. aegypti, the endemicity of all four dengue serotypes, the continuing use of essential water storage containers and the common occurrence of non-essential containers, it is considered likely that Santo Domingo will experience a serious epidemic of dengue with increased incidence of dengue hemorrhagic fever unless appropriate preventive measures are taken. In addition, a careful selection and limited use of insecticides is indicated in order to avoid making the Ae. aegypti populations even more resistant and to ensure that the future control efforts result in some degree of success. Under the economic constraints existing in the DR, it is recommended that insecticide application be reserved only for perifocal treatment of dengue positive houses and adjacent premises or in the case of a dengue epidemic. (See Appendix 5).

4.1.3 Testing and Evaluation of Intervention Methods

Several methods of intervention for the prevention and control of dengue were tested in the study area of Santo Domingo and Santiago.

One of the most promising of the interventions tested was the use of vehicle mounted ULV (ultra low volume) and thermal fog space spraying. VCP staff evaluated approximately 30 malathion applications using these methods. Due to low initial mortalities dosage rates were gradually increased from 146 ml/ha (2 oz/acre) to 584 ml/ha (8 oz/acre). Female mosquito population reductions as high as 95% occurred following three sequential applications of 584 ml/ha. In addition, mortalities in thermal fog tests as high as 81 % were recorded in bioassay cages placed in protected areas under beds. Better test results were obtained with thermal fog applications than ULV. The perifocal use of space spraying together with larviciding holds promise for localized dengue control but should be evaluated further under DR conditions. (See Appendix 5).

Another potential intervention that was evaluated by VCP was the use of aerial application for the emergency control of dengue. The DR _Ae. aegypti_ eradication program was discontinued in 1962 due to the development of DDT resistance in this vector, and since that time political decisions have not promoted the development of a continuous _Ae. aegypti_ control program. Therefore, if a dengue epidemic were to occur, reliance must be on emergency control procedures. Santo Domingo has been growing rapidly and since 1986 the estimated number of houses has doubled to more than 408,000 which would imply that with an extensive epidemic the control applications must be capable of covering large areas rapidly. Apart from massive ground based resources, only aerial application could provide this type of rapid coverage.

VCP conducted preliminary aerial spray trials utilizing helicopter and fixed wing aircraft. Evaluation of the aerial spray revealed less than 50 % mortality indicating that the application rates were too low. (See Appendix 6). Utilizing the same rate of insecticidal application, space spraying from vehicles resulted in better penetration and higher mortalities than aerial applications. However, in considering aerial application, the extent of the area to be covered and/or accessibility of the area to vehicles may be a more important than its relative effectiveness. In any event, preliminary evaluations indicate that increased dosage rates will be required.

For political reasons higher application rates could not be tested. However, it is essential that additional tests be conducted to determine effective dosage rates for aerial applications.

During a pilot community participation study in August 1987, a survey revealed confusion regarding the origin of mosquitoes and the transmission of disease. Existing knowledge regarding mosquitoes is apparently a carry over from previous information campaigns against malaria. Most people associated the presence of stagnant water with mosquito production and malaria, but very few associated the mosquito larvae in the relatively clean water in storage containers with dengue fever. Therefore most people believed the foci of mosquito breeding occurred outside the home (in the environment not under their control). There was also some confusion between mosquitoes which occur in polluted water and Aedes aegypti. Following the preliminary survey, a limited neighborhood education program was implemented along with distribution of larvivorous fish and sack drum covers and information on their use. To augment the educational aspect, brochures were developed and distributed at each house to provide information on the life cycle of Ae. aegypti and source reduction approaches. This program was partially successful in increasing awareness of dengue, and many individuals took an active part in decreasing mosquito production on their premises.

The focus of future programs should be on multimedia national campaigns. The VCP collaborated with SNEM and the US Information Service, Santo Domingo to develop a TV public service message regarding the association of dengue with household mosquito production. This message was made available to local TV stations and is being broadcasted to increase public awareness of this problem. Most of the current knowledge about dengue and mosquitoes has been obtained from this type of limited national program. Even with the neighborhood campaigns which the VCP implemented, there was an increase in knowledge about dengue and mosquitoes and a decrease in the mosquito larval populations. PUCMM staff is continuing work on the use of community participation in controlling Aedes aegypti.

Two intervention methods that were combined with the community participation program involved the use of fish and drum covers to control mosquito production in water storage containers.

Mosquitofish, Gambusia and Poecilia were distributed in several barrios in Santo Domingo and Santiago, which had large numbers of water storage drums positive for mosquito larvae. Weekly examinations revealed that wherever fish remained, larvae were controlled. However, even though at least one member of each household was given information on the benefits of having fish in the water storage drums, by eight weeks post-introduction the majority of drums no longer contained fish. There were primarily three reasons for the disappearance of fish: 1) fish were lost when water was removed; 2) fish were lost when the drums were cleaned; 3) individuals who were not aware of the purpose or the importance of the fish removed the fish from the drums.

Subsequent trials involved the use of tilapia in drums. Although either fish was capable of controlling mosquito larvae, future projects should concentrate on the use of tilapia since these fish remained mostly in the bottom of the drum rather than at the water surface like mosquitofish and, therefore were less likely to be removed accidentally.

A vigorous education program should accompany the distribution of fish and voluntary collaborators enlisted to distribute replacement fish and encourage participation. In a preliminary trial of the use of mosquitofish, one such person took an active interest in producing and distributing fish throughout his neighborhood.

Concurrent with the distribution of fish to households, a study was conducted on the use of nylon sacking material as covers for water storage drums tc limit access to egg-laying mosquitoes. A sufficient number of sacks to cover all water storage drums was provided to a member of each test house and their use explained. Covers were effective in substantially reducing mosquito production in drums when they were conscientiously employed. However, the sack covers were frequently left off especially when the drums were empty or near empty and female mosquitoes continued to lay eggs in the drums. When water was again added to the drum, larvae would develope. Future distribution of covers must involve extensive education and follow up to be successful in long-term reduction of mosquito numbers. Although more substantial lid covers might eliminate mosquito production, the cost of such covers may be prohibitive.

An additional intervention method evaluated included the use of the fungal biological control agent <u>Lagenidium giganteum</u> which was introduced in 55 gal water storage drums in Santo Domingo and Santiago. Results obtained were erratic, infection rates in some drums reached 100% while in others there were no infections. Unfortunately the work using this biological control agent was discontinued per instructions of local health authorities who did not want to introduce new organisms into the habitat. Evaluations of other biological control agents, eg. <u>Toxorhynchites</u>, planaria and copepods were curtailed because of this same unwillingness to allow the use of such agents.

Permethrin was used against <u>Ae</u>. <u>aegypti</u> by application to household curtains. Under the conditions of the test, the mosquito population was not reduced sufficiently.

4.1.4 Contingency plan for emergency management of dengue

A contingency plan for emergency management of dengue in the Dominican Republic was prepared in 1988 by Tonn and Waterman and revised by Tonn 1989. Modification and updating of this document based on operational research findings was done by VCP staff in 1990. (See Appendix 7).

The plan notes that "although emphasis should be placed on continuous prevention rather than emergency measures of Ae. aegypti, history has shown that this is not always practical". However, the inadequacy of piped water and solid waste removal makes routine control expensive and inefficient. While regular control can impede Ae. aegypti populations from increasing to dangerously high levels, the purpose of emergency measures is to reduce rapidly a high population thereby eliminating infected and potentially infective mosquitoes and terminating or curtailing the further spread of the disease.

The aforementioned plan provides a foundation for dealing with a potential outbreak of dengue in the Dominican Republic. The pivotal role of the National Committee for Control of Dengue Epidemics should be emphasized. The membership should be broadly-based, including highly-placed representatives from SESPAS and non-health departments and international agencies so that resources can be pulled from all available sources when the need arises.

The effectiveness of an emergency system depends on the capacity to monitor accurately the change in dengue virus activity or the introduction of a new serotype. In many barrios of Santo Domingo and Santiago, the density of Ae. aegypti is such that a new infection source is all that is needed for an explosive outbreak to occur. The situation is probably also true in other densely-settled population centers. Those involved in the work of the Vector Control Project are aware that the dengue surveillance system is still in the developmental stages. Surveillance data can be used effectively to trigger a crash vector control response only if serum collection is adequate geographically and temporally, and the serology laboratory is well-equipped and well-manned so that they can be relied upon to do a speedy and accurate diagnosis.

In summary the recommendations for dengue control include:

a) Expanding the dengue surveillance system
b) Provide rapid response with localized perifocal treatment of positive case houses and adjacent premises within 100 m. Complete coverage of this area should be made with space spraying, larviciding, and source reduction with emphasis placed on community education and participation.
c) Evaluate increase application rates and new materials for ground as well as aerial space spraying for the emergency control of dengue.
d) Evaluate long term control of Ae. aegypti using biologicals such as Toxorhynchites, copepods, fungi, etc.
e) Place greater emphasis on community education and participation programs for the reduction of Ae. aegypti populations.

Detailed recommendations for the emergency control of dengue are given in Appendix 7.

4.2 Malaria

4.2.1 Selection of study sites

In July 1987, the district of Dajabon was selected as the primary study site for malaria vectors. This district which is in the province by the same name, is located on the northwest frontier with Haiti. The area was selected because of the following reasons: - it was one of the border areas identified by SNEM to be least responsive to malaria control efforts, - it offers a diversity of ecological habitats suitable for the proliferation of anophelines, and - unpublished SNEM records reveal a history of insecticide resistance in *Anopheles* populations of the area. In addition, the area is accessible by road throughout the year, thus enabling year-around field work.

Some work on malaria vectors was later done in Barahona, in the south-western corner of the country, bordering on Haiti, as well as in Elias Piña, Haina and Santiago.

4.2.2 Baseline data

Study of the bionomics of anophelines in Dajabon was accomplished using various sampling methods and devices. Four species of *Anopheles* were encountered. Out of 54,946 anophelines identified, 78.2% were *An. albimanus*, 10.1% were *An. vestitipennis*, 1.5% were *An. crucians*, and 0.1% were *An. grabhamii*. Rice fields, which are extensive in the Dajabon area, and animal watering ponds were the main breeding sites used by the anophelines. The mosquitoes were also found breeding in irrigation and drainage ditches and temporary rain pools.

Studies showed that the anophelines did not rest indoors during the daytime (they were exophilic). Night-time collections from corrals and animal-baited collections showed that all four species of anophelines were attracted to livestock. Observations on human-biting activity revealed that most of the man-mosquito contact took place outdoors in the early evening hours. During this time, nearly all the human population was outside due to the stifling heat inside dwellings. Comparison of indoor and outdoor biting activities showed that 77.3% of the bites by *An. albimanus* were inflicted outdoors. Similarly, 86.8% of the bites by *An. vestitipennis* occurred outdoors. The peak of biting activity by both species was between 9 and 10 p.m. Very little biting occurred indoors after 11 p.m. The proportion of *An. vestitipennis*, the second most abundant species, was higher in man-biting collections and animal-baited net trap captures than in light trap samples.

In order to determine the potential role of the mosquitoes in malaria transmission, their gonotrophic cycle, parity rates, human blood index and infection rate with malaria parasite were assessed. The human blood index, determined by direct ELISA, was 0.08 and

0.12 for An. albimanus and An. vestitipennis, respectively. Double antibody or sandwich ELISA was conducted on 21,952 specimens. As a result of the tests, 2 samples of pooled (ca. 5 specimens/pool) and 11 single specimens of An. albimanus, 1 single specimen of An. vestitipennis, 2 samples of pooled An. crucians and 1 sample of pooled An. grabhamii were found positive for P. falciparum sporozoites in preliminary tests conducted at the ELISA laboratory in Santiago. Eventually only 5 single specimens of An. albimanus were confirmed positive. One reason for the failure to confirm the others may have been antigenic deterioration due to thawing out of frozen specimens while in transit from the Dominican Republic to the United States since dry ice was not available. The vectorial capacity of An. albimanus and An. vestitipennis was determined to be 0.19 and 0.005.

In the Barahona area, An. albimanus was again the most abundant species but unlike in Dajabon, An. crucians was the second most abundant species. The major anopheline breeding sites were found to be the main sugar cane irrigation canals which were choked with vegetation causing the water to move slowly. Proper maintenance of these canals would be an effective source reduction measure. Details of baseline data on anophelines and their analyses are given in Appendix 8.

Susceptibility tests using the World Health Organization (WHO) test kit and procedure were conducted on An. albimanus and An. vestitipennis in Dajabon. The former species showed relatively high levels of resistance to DDT and permethrin. However, it was found to be susceptible to malathion, fenithrothion and propoxur. An. vestitipennis was also significantly resistant to DDT but not to propoxur (see Appendix 9). A high level of resistance to permethrin was also detected in An. albimanus populations in the Barahona area.

In conclusion, based on the findings of the study conducted in Dajabon, where breeding sites are abundant throughout the year, residents spend long evening hours outdoors, vector/man contact occurs mostly at peridomestic sites, the anophelines that enter dwellings do not stay there for long and the two most abundant species are resistant to at least two insecticides, it is highly unlikely that indoor spraying, especially using DDT or pyrethroid insecticides, will provide satisfactory protection against malaria. The situations in Barahona and other studied areas also lead to the same conclusion.

A computer-based data recording and processing system was developed and instituted to replace and improve the manual system that was in use at SNEM. However, following a discussion in which all concerned including an AID representative participated, the computer equipment was placed in the computer services unit of SESPAS. A program for entering and processing SNEM data was developed and discussed with SESPAS computer services personnel so that it could be implemented without difficulty (see Appendix 10).

It was not possible to perform an actual stratification of the DR for malaria control purposes because of the lack of information on all the factors required for such stratification. However a discussion of the concept and a listing of the factors required to do the stratification are presented. Utilizing the recently established computer data recording and processing system and the guidelines for stratification that are provided, SNEM now has the capability to accomplish the task (see Appendix 11).

A malaria matrix to be used as a guide for action in malaria control operations was developed. The matrix serves as a decision-making tool in assessing the nature of malaria transmission and endemicity, as well as vector bionomics, to help select alternative intervention measures. Details of the matrix are given in Appendix 12.

4.2.3 Testing and evaluation of intervention methods

The application of Bti granules to ditches with Anopheles larvae was found to reduce larval populations. However, within 48 h of treatment neonate larvae were collected from treated sites. These trials indicated that Anopheles are susceptible to Bti at recommended rates but its short residual action would make it necessary to apply this larvicide every 7-14 days.

Results of thermal fogging trials in Barahona using malathion have shown that there is an immediate impact on the population of anophelines. In cases of impending or actual outbreaks of malaria, therefore, malathion or carbamate insecticides can be used as space sprays (thermal fog) in the external environment since no resistance was detected to these insecticides. The application should be made in the evening when the mosquitoes are foraging, and can be repeated every 3 days for as long as necessary to interrupt malaria transmission.

Accordingly, the recommendations to be made with respect to malaria control include:

(a) Termination of indoor spraying
(b) Emphasizing case detection and timely treatment
(c) Source reduction where feasible (as in Barahona)
(d) Thermal fogging in case of an outbreak using organophosphorus or carbamate insecticides
(e) Conducting further operational studies to improve application techniques, to evaluate alternative measures, and provide cost estimates for the selected method(s).

Detailed recommendations for malaria control in the DR are given in Appendix 13.

5. Institutional strengthening

The institutional strengthening of PUCMM and SNEM was accomplished in the following ways:

- establishment and equipping of laboratories that can be used for the study of arthropod vectors of diseases and their control;
- development of a cadre of workers with field and laboratory research skills within both SNEM and PUCMM, with hands-on experience in surveillance, laboratory and field implementation of control and evaluation measures as well as long and short-term training;
- the creation and fostering of inter-institutional collaboration between PUCMM and SNEM. Such collaboration was weak at the beginning, but has improved substantially since early 1989 when a new director of SNEM was named.

5.1 PUCMM

The PUCMM has given good support to the Vector Control Project and has made all efforts to benefit from it. The medical entomology laboratory and insectary at PUCMM have already achieved a highly functional state. The laboratory is equipped with facilities to perform various entomological studies including the detection of sporozoite antigens in mosquitoes using the double antibody sandwich ELISA as well as mosquito blood-meal host determination by the direct ELISA. The laboratory is equipped with a computer that can be used to record, process and analyze data obtained from field and laboratory research. For accomplishment in manpower development see under "TRAINING".

5.2 SNEM

Early in the life of the Project SNEM's role in Project activities was weakened by the lack of stability due to the frequent change of Directors and other senior personnel as well as the failure to identify one person to work with the Project Coordinator. The capability of SNEM has been upgraded through the participation of many of their technical personnel both in the malaria and dengue surveillance and control activities of the Project. As a result, SNEM now has the ability to carry out such operations on its own or in collaboration with PUCMM. For example, 6 SNEM personnel were involved in the collection of Ae. aegypti baseline data as well as the application of control measures. They were also responsible for evaluating the changes in the pre-and post-application population levels of Ae. aegypti, as well as the effect of insecticide applications on caged mosquitoes. Under the leadership of the new director, major progress has been made by SNEM in improving communication and developing close collaboration with PUCMM and USC.

6. Constraints and delays

The Project Paper included some unrealistic concepts and a number of unattainable targets to be achieved in the life of the project. For example, as pointed out by both the mid-term and subsequent evaluation teams, the breaking up of the three-year term of the Project into four phases and compartmentalizing operations by such phases was not strictly feasible because biological phenomena follow seasonal cycles and cannot be limited by man-made timetables. Another example is the stipulation that the Project was to test 6 methods of vector control. Again both evaluation teams have pointed out the futility of such pre-determination of the number of methods to be tested. In another instance, it was stated that a "measurable reduction in incidence of malaria and dengue fever" would follow the implementation of the Project. Although the long-term impact of the Project may produce such a reduction, this was not a specific objective as the actual control of malaria and dengue is the responsibility of the National Directorate of Health and SNEM. Another discrepancy was the requirement that work on Ae. aegypti and Anopheles mosquitoes be conducted in the same areas. This was not a feasible proposition considering that malaria is primarily a rural disease while dengue mainly occurs in urban areas.

An important point that was not anticipated was the lag time between the stateside purchasing of equipment, supplies and vehicle parts and the delivery in the Dominican Republic; delivery took as long as four months. In addition, air shipments of replacement parts were stolen when they arrived in Santo Domingo which resulted in extended delay of project activities. Another problem encountered was the shortage of qualified mechanics to work on the spray equipment and vehicles and as a result, some spray units as well as project vehicles that were crucial to field operations were inoperable for extended periods of time thus curtailing field activities. The evaluation of focal fogging for malaria reduction and the selection of optimal insecticide application rates for dengue control could not be completed for this reason.

6.1 Host country funding (PL 480)

The delay in the disbursement of PL 480 monies hampered the operation of the Project on many occasions. As mentioned, the first allotment of PL 480 funds was not received until April, 1987. As a result, field travel by Project and SNEM employees for work on malaria and dengue could not be undertaken as scheduled. The Project Coordinator had to find money from other sources in order to fund scheduled field activities. Since PL 480 funds were unavailable to the Project on a timely basis, completion of the Project laboratory took much longer than originally anticipated.

6.2 PUCMM

The Project did not encounter major problems in its relations with PUCMM. However, a more cohesive interaction between PUCMM and SNEM in the Project's infancy would have been beneficial to all parties.

6.3 SNEM

During the life of the Project, SNEM had five different directors and 7 different senior officers. This lack of stability was a hindrance to collaboration with that institution. Toward the end of the Project, a new director for SNEM was appointed and a close collaborative relationship was established. However, in spite of the SNEM Director's enthusiastic support and participation, the unexpected departure of two key SNEM technical officers during the extension period resulted in a shortage of personnel and as such, had a limiting effect on the testing and evaluation of abate, the development of a continuing SNEM dengue control program, the demonstration of small scale source reduction, and SNEM involvement in community education and participation programs.

7. Training

To develop the capability of the scientific and technical manpower of PUCMM and SNEM, a variety of instructional approaches were used. The main training methods included on-the-job training not only for SNEM field workers and technical staff but also for the three masters candidates as well. In addition, in-country short courses and out-of-country courses in the United States were also provided. As was pointed out in the contingency plan for emergency management of dengue (which would apply to malaria as well), no plan of action can be developed without continuous training and research to ensure proper selection and implementation of actions.

7.1 On-the-job training

At least 6 malaria technicians from SNEM were involved in the malaria field and laboratory work. This has enabled them to learn field sampling techniques using various devices and methods. In addition, the technicians had the opportunity to learn identification procedures for Anopheles mosquitoes and to recognize their breeding habitats. In the field laboratory at Dajabon, staff have participated in dissections for parity determination as well as conducting susceptibility tests to determine the level of resistance in Anopheles mosquitoes. In the main laboratory at Santiago, PUCMM faculty and technicians have been given specialized training in the use of indirect ELISA to detect sporozoites in mosquitoes and in the use of direct ELISA to determine the blood-meal source of engorged mosquitoes.

Although the numbers varied from time-to-time, approximately 6 SNEM technicians were directly involved in the work on Ae. aegypti carried out by the Project in Santo Domingo. These technicians have mastered methods of sampling Ae. aegypti eggs using ovitraps as well as sampling larvae from intra- and peridomiciliary water containers. Regarding adult sampling, the technicians have used aspirators and aerial nets. The latter procedure was developed during the course of the Project. The participation in the application and evaluation of Ae. aegypti control measures has provided another learning opportunity for the technicians. They have developed the capability to carry out fogging and ULV applications and to monitor the effectiveness of such measures by exposing mosquitoes in bioassay cages and by conducting pre- and post-application net and biting collections and egg surveys. Microscopes were located in the lab space provided at SNEM and the technicians were given training in the identification and dissection for parity rates in Ae. aegypti. They also took part in the establishment and maintenance of an Ae. aegypti colony.

7.2 In-country short courses

In-country courses included a diversity of subjects ranging from basic applied operations and safe handling of pesticides to mosquito taxonomy, epidemiology and control of epidemic dengue and health education and community participation. Courses were offered to SNEM field workers, students, and military, medical and other health professionals. Fourteen in-country courses were provided for more than 345 participants. A listing of all courses given or sponsored by the project is provided in Appendix 14.

7.3 Out-of-country short courses

In 1987, 4 members of SNEM who participated in the work of the Vector Control Project attended a 10-day course in Spanish entitled "Bionomia e Indentificacion de Mosquitos de Importancia en Salud Publica" at the USC International Center for Public Health Research in McClellanville, SC. In 1988, a six-week course "Epidemiologia y Control de Malaria y Otras Enfermedades Transmitidas por Vectores" was attended by 4 individuals, 3 of whom were SNEM members who participated in the work of the Project. In the same year the course was given in English and was attended by a member of SESPAS who later became SNEM head of operations. The course in Spanish was attended in 1989 by the new Director of SNEM and 3 members of PUCMM. In the same year, a three-week course on the use of computers for vector control research and program management was attended by the head of SNEM operations and a member of the PUCMM. These courses were also given at the USC Center in McClellanville. In all, 10 SNEM and 5 PUCMM personnel attended 5 out-of-country short courses.

7.4 Long-term participant training

Of the 3 trainees considered for long-term training at the master's degree level, only one had completed the training by the end of the project. Another had still not fulfilled all the requirements. The third candidate left SNEM before starting the training.

8. Extension of the Project

According to the cooperative agreement, the Project was scheduled to terminate on September 30, 1989. However, due to the various obstacles and delays cited above, many objectives remained unfulfilled by EOP. Accordingly, the Project Coordinator submitted a request to AID for a one year, no cost extension. The extension was granted for nine months at the suggestion of an independent review team. The new ending date of May 31, 1990 gave the Project time to work on ongoing and pending activities as well as to address revised objectives as outlined in the independent review document.

9. End of Project status

The PUCMM medical entomology laboratory established by the Project is suitable for conducting investigations on vector control for the prevention/control of malaria and dengue. Three PUCMM faculty members received training and can participate in the design, implementation and evaluation of vector control interventions and perform operational research on such interventions. PUCMM is capable of providing training on vector control including, the safe handling and application of pesticides. Special emphasis was also placed on community education and participation. A professor in health education and promotion at PUCMM was given training in vector-borne diseases and their control at the USC so that she can better coordinate efforts to raise community awareness of the association of Ae. aegypti and dengue and DHF.

SNEM staff have received both formal and on-the-job training and have participated in Ae. aegypti and malaria control investigations. Three senior SNEM staff were trained in the design, management, data collection and evaluation of field trials on vector control measures and are capable of training field staff. Thus, SNEM is in a position to implement and evaluate operational research outcomes in their vector control efforts.

In addition to a new cooperative agreement, a cordial link has been established between PUCMM and SNEM that will enable them to collaborate in vector control operational research.

Based on findings by the Project, criteria were developed for stratification, and control recommendations were made for use in combatting dengue and malaria. A microcomputer system has been established to be used for public health data management.

11. Cost analysis

Budget

The following is a financial summary of expenditures for the Vector Control Project through 27 June 1990. Final financial report is pending.

<u>University of South Carolina - Dollar Budget</u>

As of June 27, 1990	
Direct Cost	1,058,537.91
Indirect Cost	314,917.44
TOTAL EXPENDED	$1,373,455.35

In-Kind Contributions, October 1, 1989 to May 31, 1990

<u>The University of South Carolina (USC)</u>

The University of South Carolina provided the Project with the services of:

5% of Co-Principal Investigator's salary
1 Campus Coordinator's salary
1 half-time secretary's salary
TOTAL $19,618.54

Total In-Kind Contributions by the University of South Carolina from September 11, 1986 to May 31, 1990
TOTAL $150,551.54

<u>Pontificia Universidad Catolica Madre y Maestra (PUCMM)</u>

PUCMM provided -	
Researchers	69,000
Administrative Support (Bookeepers, etc.)	32,400
Salaries funded by PUCMM	101,400 (pesos)
Laboratories: Santiago	45,000 (*)
Total In-Kind Contributions by PUCMM	146,400 (pesos)

*Includes cleaning staff, general services (electricity, etc.)

Servicio Nacional Erradicacion de la Malaria (SNEM)

SNEM Provided-	
Salaries (6 individuals)	38,133
Space	10,560
Equipment (Maintenance)	1,000
Total In-Kind Contributions by SNEM	49,693

PL 480 Funding (Pesos) September 11,1986 through May 31, 1990

RD $600,000.00	Budgeted	Expenditures	Balance
(3 Years)	600,000.00		43,485.35
Salaries			
Medical Entomologists (2)		108,848.66	
Bilingual Secretary		35,877.00	
Driver		25,081.67	
Peace Corps		0.00	
Field Assistant		17,269.92	
Technical Labortory		0.00	
Allowances		34,169.80	
Transportation		36,610.57	
Construction		209,399.82	
Furniture		3,945.05	
Expenses/Operations		79,849.66	
Equipment		5,462.50	
Total	600,000.00	530,814.65	43,485.35