A COOPERATIVE MOSQUITO CONTROL PLAN FOR CAPE CANAVERAL [1] AND THE NASA MERRITT ISLAND LAUNCH AREA INVOLVING FEDERAL, STATE, AND LOCAL AGENCIES [2]

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In order to meet the requirements of the accelerated space program designed, among other things, to land a man on the moon, it has been necessary to greatly expand the missile launch area at Cape Canaveral, Florida. The National Aeronautics and Space Administration (NASA) is presently buying 72,644 acres of land in North Brevard County, and has announced plans to acquire an additional 15,000 acres which will extend northward into Volusia County. The land being acquired is known as the NASA Merritt Island Launch Area (NMILA), and includes all the remaining large, salt-marsh mosquito-breeding areas in Brevard County plus thousands of acres of salt-marsh breeding areas that have been brought under control by the Brevard Mosquito Control District. It is easy to see that the magnitude of the space program would create a considerable impact throughout the area, and that numerous problems would arise because of the impact. Fortunately, certain people were able to foresee some of the many problems, and steps were taken to provide solutions.

In the fall of 1961, The Honorable Farris Bryant, Governor of Florida, General Leighton I. Davis, Commander of the Air Force Missile Test Center, and Dr. Kurt Debus, Head of the NASA Launch Operations Center, met to discuss the Space and Manned Lunar Landing Program planned for Cape Canaveral, and the effect the program would have on the State of Florida. One of the results of the conference was the activation of the Joint Community Impact Coordination Committee.

The Committee was established for the purpose of identifying, discussing, coordinating, and recommending solutions, or a course of action, in connection with problems that will have an impact on Florida communities surrounding the Atlantic Missile Range. The Impact Committee has the twofold function of informing and coordinating. To avoid duplication and to speed completion of effort, the Committee keeps abreast of individual agency plans, and through coordination can arrange the combining of resources of several agencies striving toward a common goal. The Joint Community Impact Coordination Committee is composed of: A. Max Brewer, representing the Governor's Office; Lt. Colonel Clifton A. McClelland, representing the Air Force; and Paul O. Siebeneichen, representing NASA.

Under the Impact Committee are the several subcommittees dealing with such problems as roads, schools, housing, higher education, and of course, mosquito control. The members of the Mosquito Control Committee are: Colonel Clarence Bidgood, Chairman, NASA; Harvey J. Crawford, Air Force Missile Test Center; E. A. Philen, Florida State Board of Health; and Jack Salmela, Brevard Mosquito Control District.

In the course of the meetings that were held by the Mosquito Control Committee, it became apparent that the best and most economical plan for mosquito control on the NASA Merritt Island Launch Area would be a cooperative plan, whereby all concerned would work to-

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[1] Now *Cape Kennedy*.

[2] Presented at the annual meeting of the Florida Anti-Mosquito Association, May 5–8, 1963 in Jacksonville, Florida.

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gether. The Brevard Mosquito Control District was asked to prepare such a proposal. With the omission of tables, several photographs, and a map of the area, and minor changes and corrections, the following was presented to NASA.

GENERAL DESCRIPTION OF AREA. The thousands of acres being acquired by the National Aeronautics and Space Administration in north Brevard and south Volusia Counties for the NASA Merritt Island Launch Area (NMILA) make up a sparsely populated area, which includes a very high percentage of salt-marsh land along the eastern shore of the Indian River, the northern part of the Banana River, and the southern portion of Mosquito Lagoon. The area has not developed as rapidly as other sections of Brevard County due, to a large degree, to the presence of salt-marsh mosquitoes throughout most of the year. Approximately 14,262 acres of salt-marsh mosquito breeding area remain uncontrolled at this time in the NMILA in Brevard County and 1,060 acres in southern Volusia County. In addition to the salt-marsh mosquito breeding areas, there are hundreds of acres which are capable of producing fresh-water species of mosquitoes.

SEVERITY OF THE PROBLEM. It is a common practice for citrus grove workers in this area to wear heavy clothing in the summer months to protect them from mosquitoes while they work. It has been reported that there have been times when the mosquitoes were so numerous they would extinguish the kerosene lanterns used by commercial fishermen working in the area after dark. Since a light does attract salt-marsh mosquitoes, this story is more plausible than it may seem. Mosquito control inspectors have reported on numerous occasions, after a heavy emergence of mosquitoes, that the landing rate count was in excess of 500 mosquitoes landing on the person in a one-minute time interval. During the summer of 1962, the Entomological Research Center, located at Vero Beach, needed a large number of live mosquitoes. Dr. Provost dispatched two of his entomologists to this area after a heavy emergence to sweep adults out of the grass with nets. In one hour they crowded into cages live mosquitoes which, on later killing in Vero Beach, weighed 3½ pounds.

It should be pointed out that mosquitoes are not always unbearable in this section. The severity of the problem varies with the temperature, tides, and rainfall. At times the density is low. High densities occur several times each year, following high tides or heavy rainfall, especially after an extended period of dry weather.

PRINCIPAL SPECIES OF MOSQUITOES AND CHARACTERISTICS. The principal species found in this area are *Aedes taeniorhynchus* and *Aedes sollicitans*, both of which are commonly referred to as salt-marsh mosquitoes. They do not lay their eggs on water, but rather on moist soil, which will at some time be flooded by tides or rainfall. Under favorable conditions, an immense number of eggs can be deposited and accumulate to hatch when flooded. Egg deposits have been checked as high as 50,000 per square foot in Florida. The flight range of the adult mosquito varies, but a distance of 10 to 12 miles is not uncommon, and they have been known to go at least 25 miles. Of the fresh-water species, *Psorophora confinnis* is the most prevalent. *Anopheles* and *Culex* species are also present to a lesser degree.

THE BREVARD MOSQUITO CONTROL DISTRICT PROGRAM. Brevard County has one of the largest budgets and programs for mosquito control in the State of Florida. Equipment consists of 6 Stearman airplanes equipped for aerial application, 16 ground aerosol fog machines on trucks, 7 draglines, 1 ten-inch hydraulic dredge, 2 bulldozers, 1 lowboy, a large number of trucks and miscellaneous vehicles, pumps, and 3 operational bases with mechanics and other personnel as required. The program is financed by local taxes, assistance from the Florida State Board of Health, and chemicals supplied by the Patrick Air Force Base (PAFB).

The Need for a Joint Cooperative Program. All of the remaining large salt-marsh mosquito breeding acreage to be eliminated in Brevard County lies within the area being acquired by NASA. The District has already eliminated breeding in 11,588 acres of this property, leaving approximately 14,262 acres to be completed. NASA is fully aware that this large amount of breeding area could produce enough mosquitoes, if not controlled, to seriously retard NASA's work program. NASA is also aware that the responsibility for controlling these mosquitoes is a joint responsibility and has suggested the possibility of providing financial assistance to the Brevard Mosquito Control District.

The District has been cooperating with PAFB for a number of years in the control of mosquitoes. PAFB has supplied insecticides, and the District, in turn, has provided airplanes and pilots as needed for temporary control and, in addition, has completed extensive dredge and dragline projects which have eliminated practically all the mosquito breeding areas on PAFB and surrounding areas. Permanent control of this magnitude would not have been possible without the aid received from PAFB. This arrangement has proved to be to the mutual advantage of both parties concerned. A somewhat similar arrangement with NASA would seemingly be to the mutual benefit of both NASA and the District.

If NASA should undertake, without the joint cooperation of the District, mosquito control measures on NMILA properties, it would be necessary for NASA to define the mosquito problem areas, perform an untold amount of engineering work, and purchase airplanes, ground fogging equipment for temporary control, and heavy machinery for permanent control measures, or in lieu thereof, to contract for such work. This would be a very time-consuming and costly process. The District has already defined the problem and formulated plans for the eventual construction of dikes and ditches for the control of mosquitoes in the remaining area. The District, at present, has four draglines working in this area and has the necessary additional equipment to carry on a long-range program. It is estimated that the District would require a minimum of 4½ years to complete the first phase of the proposed permanent improvement work with the amount of equipment now owned by the District.

Information available in regard to the development of the NMILA indicates that a high level of permanent control should be accomplished within 3 years and that a considerable amount of temporary mosquito control must be maintained within certain areas during and after this interval of time. Through a joint cooperative and mutual assistance program between NASA and the District, it is believed that considerable saving in time can be obtained and also that the program can be effectively and efficiently administered. Depending on the amount of assistance provided, the permanent control work can be accelerated to completion within the time limit desired by NASA.

Temporary Control. Immediate relief can come only from temporary control which consists of adulticiding and larviciding. It is not possible to initiate a permanent control program that would completely eliminate the need for temporary control measures. There will be need for some temporary control measures even after the permanent control work is completed.

Since this protection will be required at all hours of the day and particularly at night, and often on very short notice, NASA should be responsible for the ground adulticiding program. It is recommended that NASA make provisions for purchasing at least two thermal aerosol generators capable of dispensing 80 gallons of insecticide per hour. Each machine should be mounted on a 4-wheel drive truck of not less than 7500 pounds GVW rating. The insecticidal formulation, and application thereof, should be in accordance with recommendations of the

Florida State Board of Health. These machines should be ready for use by May 1, 1963. Additional units will possibly be required in 1964.

No temporary control work should be attempted without the aid of an adequate inspection program to determine when and where to treat. Considerable training will be involved plus constant supervision. Since the Range Contractor at Cape Canaveral already has a good working force plus an excellent entomologist, who has demonstrated his ability, it is recommended NASA have the range contractor perform the inspection and ground adulticiding measures. The District can supply at least one airplane to aid in this work when the mosquitoes are bad. Requests for this help should come from the entomologist mentioned.

It is recommended that a diligent attempt be made to prevent the emergence of all large broods of mosquitoes within 5 miles of any concentration of people. This can be done most effectively by larviciding with paris green pellets. The District can furnish one airplane with a special hopper and spreader for this purpose, and will assume responsibility for the larval inspection work. In order to inspect the large area involved, the District proposes to purchase a new Bell, or similar type, helicopter to be used primarily for the purpose of checking the areas to determine when and where and to what extent breeding is beginning to occur. Normally, there is a period of 3 to 4 days after the eggs have hatched when larviciding with paris green pellets will be effective in preventing the emergence of the brood. The helicopter would also be available to the base entomologist, or his designated personnel, upon request. The purchase of this equipment is contingent upon the approval of the suggested working agreement between the District, NASA, and Patrick Air Force Base.

PERMANENT CONTROL. The permanent solution to the problem is to alter the mosquito breeding areas so they are biologically unfit to meet the requirements of the life cycle of the mosquito. This is known as permanent control and consists of mechanical measures—filling, draining, ditching, and impounding. Draining and ditching are the most commonly known methods of eliminating mosquito breeding areas. It has been proven, however, that these are not the best methods for this particular area. Most of the breeding areas are not high enough to drain, and it is not practical to construct enough ditches to provide for adequate minnow access. Also, a large amount of ditches could create sandfly breeding areas.

Since filling by either dragline or dredge is too slow and expensive, impounding is the method that best meets all the requirements of permanent mosquito control on the thousands of acres of breeding area within the NMILA. A dike is constructed around the breeding area and the marsh land is covered with water most of the year, so that the *Aedes taeniorhynchus* and *Aedes sollicitans* mosquitoes do not have a suitable place for oviposition. The rather constant water level maintained results in a very high minnow population that contributes a great deal toward mosquito control.

In order to accomplish mosquito control as rapidly as possible, this work can be done in two phases. Phase I will include diking the river's edge, only. Numerous dirt spillways can be constructed to prevent flooding of higher ground. After Phase I is completed, Phase II can be planned and constructed to provide drainage for upland areas that might suffer from poor drainage. The same process was used on most of the area already eliminated on NMILA and practically no flooding occurred even though some of the homes involved were only three feet above sea level.

DIKING AND DITCHING. It is recommended that the District be delegated the responsibility for planning and constructing the permanent types of control, with close liaison being continually maintained with the base entomologist and any other NASA or PAFB personnel that may be designated. The permanent types of control will consist of constructing with drag-

lines an estimated 555,500 feet of dikes averaging 4′ high by 18′ wide, and impounding water over 13,850 acres to an average depth of one foot. In addition, some 412 acres will be ditched with a dragline requiring some 141,700 lineal feet of ditches averaging 4′ deep by 10′ wide. Some of the islands proposed for improvements will possibly have to be worked with a barge-mounted dragline with clamshell. The District can furnish such a barge and machine. If the District continues to receive aid from PAFB, at least four of the District draglines will be working in the NMILA until the work is completed. As previously stated, this will require at least 4½ years with present equipment.

In order to complete the proposed permanent control program in 3 years, it is requested that NASA furnish the District two ¾ yard draglines and one D-6 bulldozer to aid in this work. Since the work in the marshes requires a different type of dragline from one used on high and dry land, it is recommended that the draglines and tractor be purchased in accordance with the District's specifications. In order to avoid the cost of management, engineering, and the high cost of contracting work of this nature, it is suggested that this equipment be leased to the District for $1.00 per year.

Conclusion. Due to the lack of time, and the obvious advantage of a cooperative program compared to any other way of accomplishing mosquito control on the NMILA, the District has not prepared a detailed breakdown showing the benefits that would be received by NASA in relation to cost. This information can be supplied at a later date, if required.

Detailed studies of the above proposal were made by NASA and the Air Force, and the proposal has been accepted almost in its entirey. The initiation of this cooperative mosquito control plan has been hailed as an outstanding example of cooperation between federal, state, and local agencies.

SPECTRUM OF CROSS-RESISTANCE TO INSECTICIDES IN THE MOSQUITO FISH, *GAMBUSIA AFFINIS* [1]

CLAUDE E. BOYD and DENZEL E. FERGUSON

The first reported case of insecticide resistance in a fish involved DDT-resistance in mosquito fish from Mississippi cotton-growing areas (Vinson, Boyd, and Ferguson, 1963). Subsequently, the same population of fish was shown to be resistant or highly tolerant to endrin, aldrin, dieldrin, toxaphene, heptachlor, BHC (lindane), and DDD (Boyd and Ferguson, 1963). In an effort to further document this broad spectrum resistance to chlorinated hydrocarbon compounds, many of which have not been used extensively in cotton insect control, the following insecticides were tested: Thanite (a thiocyanate compound), Dilan, methoxychlor, Kelthane, Perthane, chlordane, and Strobane.

Resistant fish were collected April 1, 1963 near Sidon, Leflore County, Mississippi, brought to State College, and released in a pond known to be free of insecticide contamination. Fish derived from this stock were tested during late July through early September, 1963, as were non-resistant mosquito fish collected near State College, Oktibbeha County, Mississippi.

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