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PROGRAMMATIC ENVIRONMENTAL ASSESSMENT OF MALARIA CONTROL PROGRAMS

VOLUME I - DECISION SUPPORT MANUAL

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Dear Reader:

This Manual and Guidebook are as current as our resources can make them by the issuance deadline. Obviously there are many omissions and we hope there are no more than a tolerable level of errors. We hope you find this new approach useful as well as challenging.

The work was set up with an open-ended design so that you might add operational procedures and literature at will.

In the future we expect to be making additions and corrections, and so we need feedback from you. Please send us the attached card if you are the ultimate user of these five volumes.

Sincerely,

Harvey I. Scudder, Ph.D.
Fred C. Roberts, M.A., R.S., R.P.E.

Dr. Scudder and Mr. Roberts:

As the user of your Malaria Control Manual and Guidebook, I should like to receive any future additions, corrections, or supplements as they may be issued.

Signed_____

Name Printed_____

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PLEASE NOTE:

This Manual and Guidebook do not constitute publications, as they have been written and compiled only for internal use within the Department of State's malaria control programs, as sponsored by the U.S. Agency for International Development. They are working documents, intended as a framework for periodic updating by AID and for casual additions by each program using them, in accordance with local country needs.

Harvey I. Scudder, Ph.D.

Fred C. Roberts, M.A., R.S., R.P.E.

PREFACE

During the past ten years the prospect of world-wide malaria eradication has changed considerably, with some developing countries experiencing serious epidemics and even a return to former high transmission levels.[1] Many reasons have been given to explain the complexity of problems besetting the various programs, but all agree that a number of revisions are necessary, from training to administration and to field operations.

Among the changes in program philosophy appearing is a strong component of environmental concern, with agreement that malaria programs have an impact that must be assessed, acknowledged, and dealt with on a regular basis. The U.S. Federal "Regulation 16", of June 1976, set forth environmental procedures[2] for the Department of State's AID Programs, with the stated purpose of providing environmental assessments which give "a comprehensive understanding of the reasonably foreseeable environmental effects of proposed actions and their reasonable alternatives, so that the expected benefits of development objectives can be weighed against any adverse short or long-term impacts upon the human environment or any irreversible commitment of resources." Furthermore, "it is essential that the sources of data used to identify, quantify or evaluate any and all environmental consequences be expressly noted". A revision and clarification of these regulations have been proposed on the basis of the past five years' experience.

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1. US/AID Audit Report #76-348 - Malaria Eradication Programs. 1976

2. Code of Federal Regulations, Title 22 - Foreign Relations, Chapter II, Part 216 - Environmental Procedures, 28 June 1976

The background of need for the present Manual and Guidebook was derived by AID from "an environmental seminar for concerned Asia Bureau Mission Personnel and host country counterparts, held in Pattaya, Thailand, during December 1978. One of the exercises was an analysis of alternative approaches for assessing environmental effects of malaria projects in Asia. As a result of the exercise, the group concluded that a comprehensive analysis of potential malaria control project interventions having worldwide application should be conducted for assessing the likely effects on the environment of malaria projects. Such an analysis would be usefully supplemented with a handbook of guidelines for project officers to assist them in anticipating and responding to potential adverse environmental effects."[1]

In his opening statement for the National Research Council's 1971 "Symposium on Pest Control Strategies for the Future", Dr. Donald S. Farner forecast the present Manual.

"In my view, there is a critical need for two developments: We must have an effective algebra of decision-making--an apparatus that can produce the best decision in light of an always deficient but always improving body of knowledge of the beneficial and deleterious effects of control practices. It must be an apparatus that works in terms of successive proximations as more knowledge and new options become available. The difficulties of fitting such a decision-making apparatus to a law-making process that, in this field, is sometimes chaotic is well known.

We must continue to evolve, through research and development, a much broader spectrum of control strategies to provide additional and optional inputs into the decision-making apparatus."[2]

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1. AID, 1979b. Excerpted from IQC Contract #AID/SOD/PDC-C-0163 of 30 August 1979. (Underlining has been added).

2. Farner, in NRC-NAS 1972, p. 2.

The Malaria Control Manual and Guidebook have been developed to assist all levels of personnel responsible for the planning, management, and administration of malaria control programs. These documents represent a new, and hopefully more successful, way of handling a most complex area of environmental management.

The essential decisions in malaria control must be based upon data derived from close monitoring of all the natural and human cultural factors which make up the malaria ecosystem, as interpreted by such diverse disciplines as biology, engineering, medicine, sociology, economics, and political science.

The wealth of variables involved in these essential decisions is very hard to integrate and resolve because of their number, diversity, difficulty in collection and evaluation, and because of the conflicts in the objectives they generate.

Not only must the key components in the malaria ecosystem, which are mosquito vector, the agent *Plasmodium*, and the human host, be modified or controlled, but all the other components, both natural and artificial must also be fully understood, managed, and very often redesigned. Profound changes in the physical, biological, and social environment must result. Not all of these changes will be favorable and not all can be carried out, so that cost/risk/benefit analyses must continually provide feedback for their direction.

The dominant areas upon which malaria control efforts most obviously impact are the water ecologies, where our expertise is still very young, in contrast to our far greater ability to handle the land ecologies.

In the past twenty years or so, we have developed an increased consciousness that the environment in which we live is not only very finite, but very sensitive to what we do, and that if we are to safeguard the future of mankind we must become fully aware of the ways our activities create ecological effects both

temporary and permanent, reversible and irreversible. Only with this consciousness guiding our judgment in making environmentally important decisions can we have a choice and also leave a choice for future generations.

So it is that these documents propose a very analytical approach to the control of malaria, since so many of the areas of the world where people are affected by this disease are also those whose natural environments have had but little study. Changes in such environments, even for so important an objective as disease control, should be done with care and understanding.

All program administrators need help in making decisions, rather than just compilations and analyses of data. Precisely the same administrative needs have been expressed in industry,[1] where management of increasingly complex technologies have sought new ways of coping with the endless variables which seem pertinent to their decisions. Major improvements in management decision making have had their origins in the logic and strict discipline developed for the mathematically-oriented computer sciences.

The authors therefore intend that this Manual will serve as a group of programs for people, using the same essential discipline as in programs for computers. The result is hopefully the successful introduction of a valuable new management technique, useful in the complex decision making of malaria control programs, both planning and operations, as well as for training.

The discipline of decision support[2] programming seeks to dissociate information into manageable pieces, remove all redundancy, reject all information not strictly pertinent to the decisions to be made, and to every extent possible, weigh (or quantify) the individual pieces. The decision process then

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1. Martino, 1968, p. 163.
2. Keen and Scott Morton, 1978.

becomes a series of programmable algorithms, a set of "do-able" step-by-step processes which permit analysis and justification. These can also be taught, audited, and incrementally revised. Very complex areas can be analyzed by the matrix approach, and those of lesser complication can be shown as branching sequences; all can be easily illustrated by flow-charts.

The Manual presents these flow-charts ("decision support systems" or algorithms) preceded in each instance by text which gives the relevant definitions, a discussion of the need for making environmentally and operationally sound decisions, instructions for the use of the particular flow-chart, and references to the Guidebook for additional information.

The Guidebook complements the Manual by adding detailed discussions where pertinent to the decision process, excerpts from key literature, the most useful reports available, additional bibliography, and annotated references to additional information which may be useful.

All of the material is tied to a decimal numbering system shown on the flow-charts and in the text of the Manual. Consequently, not only is quick reference facilitated, but both Manual and Guidebook can be easily amended or supplemented by new issuances to reflect program policy changes or technical findings.

The present work is general, and is intended for worldwide use. Applications for particular problems in individual countries may require supplements addressed to those particular problems. AID has considered producing such supplements, and the suggestion is made that these would be inserted directly into the present Manual and Guidebook as amendments or revisions.

ACKNOWLEDGEMENT

The inspiration to employ decision support systems in the present work really has its origins in the senior author's 1965-1966 association in DHEW with Mr. John R. Hall of Arlington, Virginia, a member of the Operations Research Society of America, and founder of its Health Applications Section. Largely through John Hall, the systems approach was rapidly introduced into Federal health programs of the U.S. Public Health Service.

When AID wished assistance in its analysis of environmental problems for international malaria programs, the newly formulated decision support systems approach seemed to hold the greatest promise for both the sorely needed analytical and training tools required.

We wish to thank Mrs. Jean Meneley Diers of Sunol, California for her excellent drafting of the algorithms and Mrs. Anita Durham for her tireless efforts in typing of the manuscript.

Valuable suggestions have also been made by Dr. Charles W. Hays of Worcester, Massachusetts, Mr. Richard C. Husbands of Sacramento, California and Dr. Eugene J. Gerberg of Insect Control and Research, Inc. of Baltimore, Maryland.

The first draft of the Malaria Control Manual and Guidebook was completed in 1980 under an AID contract with Insect Control and Research, Inc. of Baltimore, Maryland.

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CHAPTER 1 INTRODUCTION

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DSS 1.0 GENERALIZED DECISION SUPPORT SYSTEM FOR MALARIA CONTROL (VECTOR PROGRAM)

CHAPTER I - INTRODUCTION

SECTION 1.0 - CONCEPTUAL APPROACH TO ENVIRONMENTAL PROBLEMS

Environmental problems, regardless of their nature and specifics, must first be addressed with the following concepts in mind, if one is to deal with them equitably in the long run:

1. Recognition that the environment is vulnerable to our actions, even to our presence, has only recently developed in the overall conscience of mankind. This has led to a proliferation of controls over all kinds of environmental interventions, including vector control, often with unfortunate results, characterized by stop-gap measures and often a failure to understand the dynamics of a given ecology.

   What is really needed is management knowledge and the ability to apply it, so that we can become truly the husbandmen of our environment. Agriculture, as an example, owes its successes to comparable advances which moved it from a culture of hunter-gatherers to husbandmen with management expertise and skills.

2. Research must be done to provide this management expertise, so we may have the concepts, the data, and the abilities to manage the dynamics of the environments we invade, in order to insure desirable and stable systems in which, for example vector-borne disease is not a factor. We need a new discipline of applied ecology, which can become a part of all planning, operations, and maintenance, and be economically justifiable on a cost/risk/benefit basis in the long run. Within this new body of knowledge,

we can then control a given disease vector, and at the same time, know what else we are doing! In the less complex realm of agriculture, "integrated pest management" (IPM) seeks to and seems capable of achieving these ends.

3. Costs of control within a context of environmental management must be rigorously and carefully studied, in order that they may be clearly identified and quantitated; only then may they be justified in contrast to our usual short term, often drastic interventions with their long term implications for which costs must also be identified and computed. We must also identify and compute the probable costs of the unstable environmental systems we create by our short term solutions, out of which may arise the potential for surprise responses to our intrusions.

4. There must be public acceptance of the most economic level of control, even though this may mean some disease, some discomfort, some nuisance. Beyond such a point, some prophylactic measures of control may be economically feasible, or may need to be individually elected and carried out. We must thereby limit the economic burden to society at large.

5. Education of the general public to a point of understanding environmental responsibility must be achieved, in order that non-technical persons will not only be able and willing to support environmental decisions, but will help in their management. This education must be begun at the earliest elementary level, and continue throughout all higher education as a civic responsibility. Again, the parallel with health education is applicable, since this is really one's health ecology.

6. Effective restraints must be agreed upon in order to limit the progressive elimination of species and habitats, locally to internationally. Because of man's needs for food and living space, these must be tempered until population growth can be brought under control or substitute technologies can alleviate aspects of the problem.

7. Political problems which make the solutions to environmental management so difficult must be urgently studied. Part of this aspect would be greatly aided by environmental education, but part requires more attention to the economics of long term solutions, instead of the crisis vis-a-vis heroic effort.

   How does one secure support for a preventive measure or program, which would avoid the crisis: or, support for a maintenance phase, when the problem has little or no visibility?

This Manual has been built around a decision support system of flow-charted algorithms, backed up by a four-part Guidebook of the literature considered essential to making the decisions set forth in the algorithms. Together the Manual and Guidebook make up a Programmatic Environmental Assessment of Malaria Programs.

Testing of this new approach under field conditions and in training programs by AID is in the planning stages. Computer adaptation of the decision support system is envisioned, and ultimately, a tele-communications network to furnish the technical support and continuing update which the program should require.

This new approach to vector control with a built-in environmental assessment and monitoring systems, should have applicability to other environmental programs. Also it should provide a basis for simulation modelling.

SECTION 1.1 - ENVIRONMENTAL ASSESSMENT

1.11 - BACKGROUND

"Man cannot survive on this planet without utilizing its natural resources prudently. Every human action affects the world around us in some degree and the full effect is difficult to assess because of complex relations among living and nonliving things. Under the circumstances one can neither expect to restore the entire past nor preserve the entire present for future generations. However all can and should strive for proper balance between resource development and maintenance of pleasant surroundings.

"The Environmental Policy Act of 1969 and the reports on environmental assessment that it requires are aimed at insuring such a balanced approach. To be effective we must provide a system for relating large numbers of actions and environmental factors and for placing value judgments on impacts which are difficult to quantify."[1]

"The passage of the National Environmental Policy Act of 1969 in response to growing concern over protecting and enhancing the natural environment has made it mandatory for federal agencies to evaluate the environmental impacts of their projects and programs during the earliest stages of planning. Despite decades of experience in relating large-scale

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1. Morton, Rogers C.B. Foreword in Leopold et al. 1971.

construction projects to resultant physical, chemical, and biological changes in the environment, our ability to evaluate environmental impacts has not kept pace with the ability to design and construct larger and more complex projects. Thus, at the time of the National Environmental Policy Act, there existed a real gap between the need to perform environmental impact evaluations and our ability to do so."[1]

1.12 DEFINITION

"The environment represents the most complex system known to man for it truly represents the complete set of resources, physical and biological, that exist on earth, as well as the infinite interactions that occur among this set of resources."[2]

"Contemporary concern for the environment has been described as an 'environmental revolution'. Many of the elements of this revolution, which were proclaimed over the years by conservationists and only recently catapulted into public acclaim, have been translated into executive, legislative, and judicial action. In the process, it is clear that what may have begun as a revolution against thoughtless exploitation of natural resources of our physical environment has evolved into an environmental ethos that calls for the evaluation of the effects of human activities on the total environment of man. Thus, if contemporary environmentalism is, indeed, revolutionary, the revolution does not lie merely in our recognition that humans are but one kind of living thing on this planet. It also lies in our recognition of a more complex fact--that as a part of earth's ecology we both affect and

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1. Whitman et al., 1971, p. 1

2. Whitman et al., 1971, p.7

are affected by the ecology; that human social relationships have as much an environmental reality as does the habitat of black ducks; that the nutritional needs of a white-tail deer is as much an environmental reality as a job for a person; and that these are not isolated realities of the total environment, but realities that can interact with one another, influence one another, and even determine one another. People throughout the world who live in direct contact with the adversities of the physical environment know it. And it was not so long ago, before the advent of industrial society, that all people everywhere knew it.

The interdependence of social and physical components of the total environment is, therefore, not a new concept. A central issue in applying this concept is the inclusion of a total environmental perspective into the actual mechanisms of decision-making that are employed by complex, bureaucratic organizations.

Such an inclusion involved inputs from specialists as well as from the lay public, and a dynamic interaction between executive, judicial, and legislative branches of government. It is the quality of this involvement and these dynamic interactions that will determine the future quality of human life."[1]

The proposal by Erickson to put the total human environment into decision making is clearly set forth in the accompanying flow chart (Fig. 1).[2] In this introduction we have included under Section 1.5 (Demographic Responses to Malaria Control Programs) some of the very important reasons why the various components of the social environment must enter into any environmental assessment.

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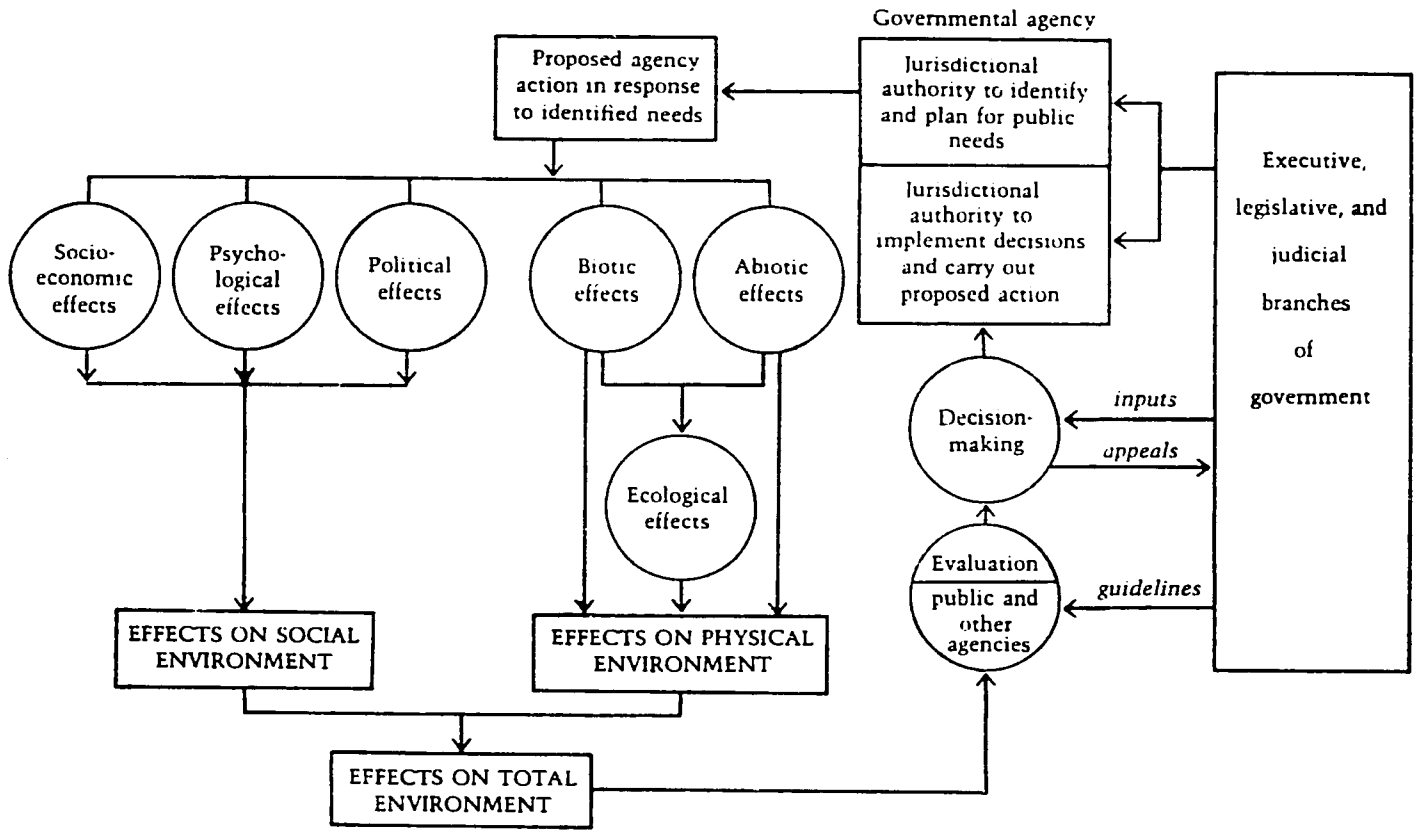
1. Erickson 1979, p. 17-19 (adapted).
2. Erickson 1979, p. 18.

FIGURE 1

OVERVIEW - PUTTING THE TOTAL HUMAN ENVIRONMENT INTO DECISION-MAKING [1]



1. Erickson, 1979, p. 18.

1.12

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1.13 PROCEDURE FOR CONDUCTING AN ENVIRONMENTAL ASSESSMENT (EA)[1]

"An environmental assessment procedure to be practical and effective, must greatly simplify the environment into a relatively small number of measurements and indicators that can be used to determine whether or not a proposed project has a significant impact upon the environment. An EA, to be of value, must be comprehensive and broad enough to include all relevant types of environmental measurements and indicators as determined through an interdisciplinary perspective. An EA, to be utilized in the program planning process, must be structured in an orderly and systematic framework that will enable replication from project to project and yet be flexible enough to be useful over a wide range of program alternatives. In short, EA must be an analytical tool that strikes a balance between too little detail and too much detail--a tool that can be valuable in the program planning process if used intelligently and honestly."[2]

The basic steps in conducting an EA are those shown in the flow chart (Fig. 2) adapted from Leopold et al.[3] Note that step (E) deals with alternatives, by which one attempts to fit the proposed actions (C) as closely as possible to the nature of the environment (D), as well as to the goals and objectives of the program (A).

In step (F) one determines the specific nature of the environmental changes (impacts) which may follow the proposed actions. An analysis of the significance (or specific effect of each) and its magnitude (extent) then determines its importance. These specific determinations are then collated in turn to form the basis of an environmental assessment (G), in

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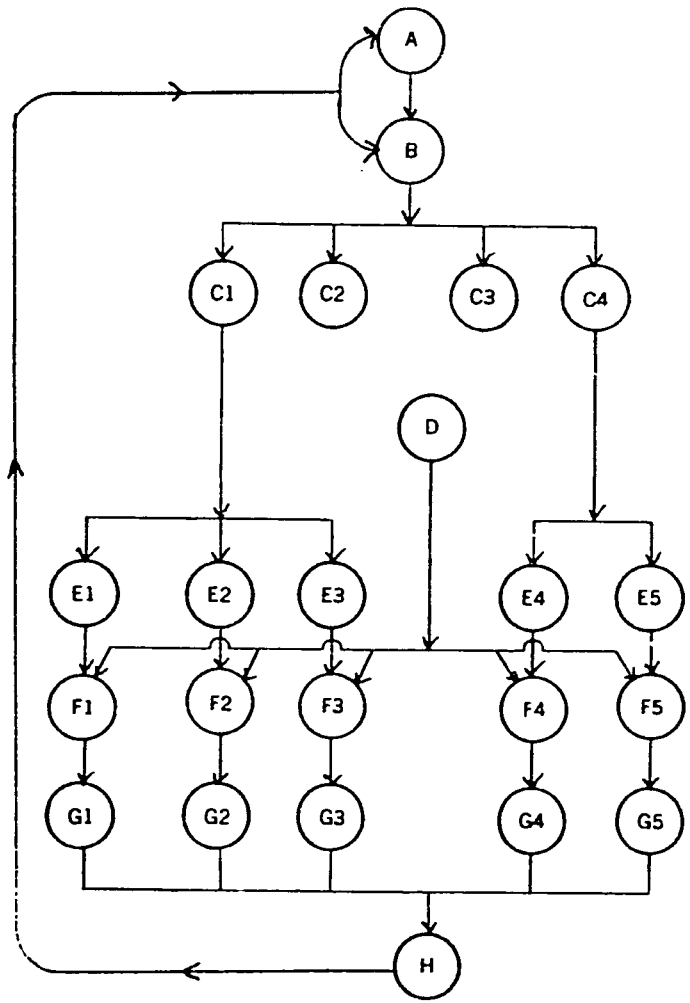
1. See Camougis, 1980; and also Rau & Wooten, 1980.
2. Whitman et al. 1971, (adapted)
3. Leopold et al. 1971

FIGURE 2

FLOW CHART FOR THE DEVELOPMENT OF AN ENVIRONMENTAL ASSESSMENT[1]



A. Statement of goals and objectives

B. Technologic possibilities for achieving objective.

C. Proposed actions and alternatives.

D. Environmental characterization report prior to initiation of action.

E. Alternative engineering and biological plans.

F. Identification of impact importance and analysis of its significance and magnitude.

G. Assessment of impact.

1. Adapted from Leopold et al., 1971, p. 3.

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which the interactions and estimate of future status of all the environmental changes are evaluated.

Recommendations for the program are made after making as many feedback iterations as would productively modify the original assumptions of (A) and (B) to give the best in a cost vs. benefit analysis of the proposed actions (C) represented in the definitive engineering and biological plans (E).

The final recommendations (H plus iterations) are then integrated into the overall program planning process so that balanced consideration can be given not only to human ecology but also to environmental values and resources in plans being formulated for disease control as the primary objective. All three of these categories must be optimized to prevent any one from invalidating any other. This is the essence of environmental management in man's best interest.

SECTION 1.2 - THE NATURE OF ECOLOGY

"Ecology is a relatively young discipline of science that has as its task the understanding of nature. More specifically, ecology is the study of the relationships of organisms with their environment. Thus, it is the science of functions and processes of operational nature. The functional relationships of nature range from simple growth of an individual as influenced by its genetic constituency and environment; to the complex situation of competition between species; to nutrient and energy budgets of the portion of the earth's mantle inhabited by organisms. The science is non-axiomatic--calling upon the many disciplines studied by the biologists, environmentalists, and human biologists for information and conceptualization. Thus, the science is strongly synthesizing in its development of concepts and principles pertaining to generalization and description of natural interaction processes.

In ecology, organisms are considered at the various levels of individuals, populations of species, and communities consisting of all species inhabiting any given area. The ecological environment is that environment and factors of the environment which impact on and are the natural influences usually experienced by organisms, which is affected by many of the parameters..." (see Section 11.62, 11.636, and 11.637 on environmental modifications, and contamination by insecticides) which relate to environmental contaminants.

"The study of entire natural systems, including all organisms inhabiting a given area and all of the environmental influences, is the study of ecosystems, which has recently contributed a great deal to our understanding of natural processes but is relatively insensitive to the effect of individual components or species. Because man's interest is with all aspects of the environment, the ecological portion of this study has attempted to develop a method giving equal consideration to all levels and disciplines.

A complicating attribute of natural systems is that no individual environmental or biological changes result in individual environmental or biological responses. In other words, nature is without boundaries in organization and responds as a total integrated unit with an infinite number of interacting attributes.

It should be pointed out that an organized and directed application of ecological principles to man-manipulated systems is still in its infancy, and in many cases, much of the desired information, principles, mathematics, and problem definition is not yet available for ready application."[1]

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1. Whitman et al. 1971, p. 11-12 (adapted).

SECTION 1.3 — ECOLOGICAL PARAMETERS

If we are to manage our environment successfully, we must know in advance what impacts our actions may have, and be able to make appropriate decisions on cost/risk/benefit basis. We must know the nature of these impacts in sufficient detail; where, how, and why they would occur; and have both the information and time sufficient for both the analyses and the making of rational choices.

Finally we must monitor the environment in relation to our decisions carefully and in depth in all the essential aspects, to both verify the validity of our projections and decisions and to safeguard against unforeseen consequences.

The immediate question is, obviously, what do we measure? What are these essential parameters which would tell us what we need to know, in order to make an environmental assessment and follow it up with a reasonable monitoring program? Even if we do all of this, how can we be sure that those who follow us in our structure will continue to acknowledge the responsibility and carry out the commitment?

"There is no simple set of ecology parameters for an EA. Similarly, there is no simple way of using ecology parameters to determine all which one needs to know about the ecological impacts of a control project."

"Consistent with the need to consider ecological impacts at several levels, three principal components of ecology have been selected for the EA: species and populations, habitats and communities, and ecosystems. Within these components, parameters have been selected which best represent the concerns for ecology which should be integrated into environmental analyses during project planning phases."[1]

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1. Whitman, et al. 1971 p. 12 (adapted).

1.31 - Species and Populations

The kinds and numbers of living things are the most likely parameters to reflect changes in the environment as integrations of both biotic and abiotic factors. Parameters based upon species and populations would vary with the many features of seasonal, climatic, and population dynamics, quite apart from those induced by a control program's impacts, so assessments and monitoring of these require a great amount of interpretation.

Species which are common in the various ecological situations or habitats under study may be selected for census as index species, and if these are diverse enough in the niches they occupy, may do well as sentinels, indicating by their numbers and population trends what is occurring, either positive or negative. They need to be selected to represent each recognized niche or subhabitat, aquatic or terrestrial, for activity during each season, and for a degree of convenience in census by informed biologists so that accurate data may be obtained.

Specialized parameters include the assessment and monitoring of rare and/or endangered species. Literature or the identity and range of such forms may be available, but in undeveloped countries (even in developed countries!) they may not have been studied, or documented for the area under consideration. A careful survey is needed to reveal such forms, particularly if major habitat changes or habitat elimination is part of a control program. One must be sensitive to the possibility that a form common in an area under study may be rare elsewhere, and that extinction could occur if its very localized but prime habitat is under impact. Assessments involving such questions may require assistance from specialists outside the control program.

Population parameters of index species, determined by census techniques, should reveal the direct effects of seasonal variations, different annual variations, natural catastrophes, or impacts of chemicals or other habitat alterations. These overt effects and the deduction of population trends may be very difficult to interpret. Data from years prior to the beginning of the control program, at least from one prior year, would be most helpful.

Program impacts may result from such actions as the introduction of the mosquito fish Gambusia, or of Tilapia which may cause drastic shifts in the species and populations of other fish, other aquatic animals, and plants.

1.33 - Habitats and Communities

A major part of any environmental assessment is a careful analysis of the different kinds of habitat included in the impact or control area, inclusive of subhabitats or niches, and the determination of how each might be affected, as well as the extent to which secondary effects might occur outside the area of direct impact. (For example, damming a river would have an effect downstream as well, but draining the swamp might not.)

If a portion of a habitat must be sacrificed, one must know what aliquot it represents of that kind of habitat in a region, and hence be the basis for estimating the magnitude, and hence importance, of the impact.

Such an assessment opens the need to consider mitigations, under which replacements in a nearby or adjacent area may be proposed to reduce the regional impact. Even if the aliquot damaged or destroyed is small, a policy of mitigation may be advisable. This may range from reserving an area of comparable habitat for perpetuity (if that can be done), or restoration of a formerly damaged or destroyed area to a level where it can once again function as the same kind of habitat it once was.

Effects on communities[1] follow alteration of a habitat, and major shifts in their species composition and populations will result.

Species diversity is a frequently used parameter for assessing communities, on the assumption that the number of different kinds of living things qualifies the complexity of trophic levels and broadly quantifies the overall energy exchange occurring in a habitat. Changes in this parameter may be used as a signal that investigation is needed, to explain what is occurring. For example, a body of water may become eutrophic, as in the instance of a surfeit of nutrients added by a sewer outfall, or oligotrophic, as the result of acid rain. In each instance there would be major changes in species diversity as well as in the index species and their populations.

1.36 - Ecosystems

Programs of source reduction have the greatest possibility of changing entire ecosystems.[2] Major drainage works or an impoundage may result in the disappearance of a marsh or swamp with profound changes in the ecosystems encompassed by these actions. Changes from natural to agricultural or residential uses of land areas may occur, and the nearly complete loss of native species of plants and animals would follow.

An impoundage, for example, creates a new ecosystem which would change the malaria vector picture entirely, but not necessarily for the better. If large populations of water weeds, such as Salvinia or Eichornia come in, a worse problem may be created, or if the impoundage is not properly designed and contoured, the shoreline may develop a wealth of Anopheles habitats. The impoundage may damage the entire biota of a region, and may even produce

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1. The assemblage of different species of living things which associate with each other.

2. The complexes of plant and animal species and their populations which associate with each other in a given area, together with all the physical and chemical factors which condition the various habitats.

changes in the climate. Forecasting such possibilities and making the best decisions about them requires expert engineering and biological knowledge and design. Outside assistance by specialists in such problems is highly recommended, because very profound errors are in evidence on most continents today.

1.380 - Procedure

The Manual and the Guidebook have been built around a core of environmental assessment policies and procedures for malaria programs, and the details are embodied in various chapters, of which Chapter 10 presents the legal base and Chapter 11 the control program. Environmental assessment and monitoring policy and procedures are set forth specifically in these Chapters, with cross-reference in monitoring in operations Chapters 17 and 19.

The reader should consult these major references which are given in the bibliography: Southwood, 1978; Welch & Croft, 1979; Ricklefs, 1979, Price, 1975.

SECTION 1.4 - FUNDAMENTAL CHANGES IN ECOLOGICAL SYSTEMS

1.41 - Human Ecology: Wherever and whenever malaria as a disease is important in the population, an effective malaria program has major impacts on the human ecology (economy):

a. Morbidity is reduced, and as a consequence, the productivity of labor increases. There may be an increase in the standard of living with this increased labor productivity.

b. Mortality drops, especially for those under age 14, and the population increases as a result of more persons reaching reproductive age. This in itself may not be favorable to the society.

c. Medical costs decrease because of the reduction in morbidity and mortality, and the quality of life improves as the health standards rise. The resources expended in the treatment of malaria can be utilized for other health problems.

1.42 - Agricultural Ecology: Malaria control by changing the water characteristics of land may permit a drastic change in land use, with a corresponding effect on the human economy.

a. Drainage operations for mosquito control may make land available which was formerly too wet for farming. With improvement of the land and removal of the risk of malaria, the land may be used for home sites and for agriculture. As unfortunately has happened, failure to maintain a control program at an effective level can lead to disease exposure of the population in its new location.

b. Impoundage* of streams makes new aquatic areas available for raising fish, water supply, ground water recharge, electric power, and recreation. In arid areas the availability of water for irrigation may have extensive effects over large land areas, the poor management of which can add to the problem of malaria vector production.

1.43 - Hydrologic Features: Since the management of water is of primary importance in mosquito control, the hydrologic features of the land are changed with intention as well as by accident.

a. Stream modifications* through channeling or impoundage may make major differences in the run-off characteristics of the land, affecting erosion, siltation, and water table.

b. Loss of tertiary treatment values occur with the elimination of wetlands and bodies of water which formerly allowed for the processing of biological or chemical pollutants. Pollution of streams may then proceed directly from the origins of run-off.

1.44 - Wildlife Ecology: Malaria control operations may have extensive impacts on wildlife because of the many ways in which they can alter the basic ecosystems.

a. Direct destruction of habitats may range from partial to total.

b. Intrinsic changes of habitat character such as water level and vegetation may cause upsets in the balance of existing species.

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* Both measures may create new and very favorable environments for mosquito vector production if not properly designed and managed.

c. Contamination of habitats by pesticides may mean short or long term die-off of species, depending on the acute toxicity, chronic toxicity, food web translations, rate of degradation, and overall, the pollutant load per unit of the habitat. Properly handled, the risk of insecticidal contamination by a malaria control program can be minimized to a very minor or unimportant level.

d. Plants or animals intrusive to the disturbed habitat may upset the balance of existing species by territory and food competition, or through factors of disease. Biological control agents may, unfortunately, fall into this category, so great care must be used in their deliberate introduction.

SECTION 1.5 - POPULATION RESPONSES TO MALARIA CONTROL PROGRAMS

1.51 - Population Increase: Malaria has long been conceded to be one of the major controlling factors in the population, so any reduction of malaria may have a direct effect in increasing the population.

A generalized flow (Fig. 3) chart adapted from Blankenship and Thomas[1] portrays the factors which must be considered in the impact dynamics "of introducing modern medicine to a subsistence-level agrarian population." Assumed is a progressive increase in population leading to a "crash".[2] This "simulation model has been devised to explore some of the consequences of introducing modern medical services.

"The model predicts that decreased mortality would initiate population growth. Some growth would be supported by changes in individual consumption patterns. But unless decreases in birth rate stabilized the population, it would increase beyond the level sustainable by local resources. Starvation or emigration would cause the population to crash. The model identifies several strategies for reducing birth rate sufficiently to avoid a population crash. Despite these strategies, increased equilibrium size of population would reduce per capita consumption. Since the population lives at the subsistence level, hardship, hunger, and even starvation could result. Thus, introduction of modern medical services could involve a trade-off between short-term improvement in health and long-term economic hardship for the population. The model suggests that improved well-being of the population

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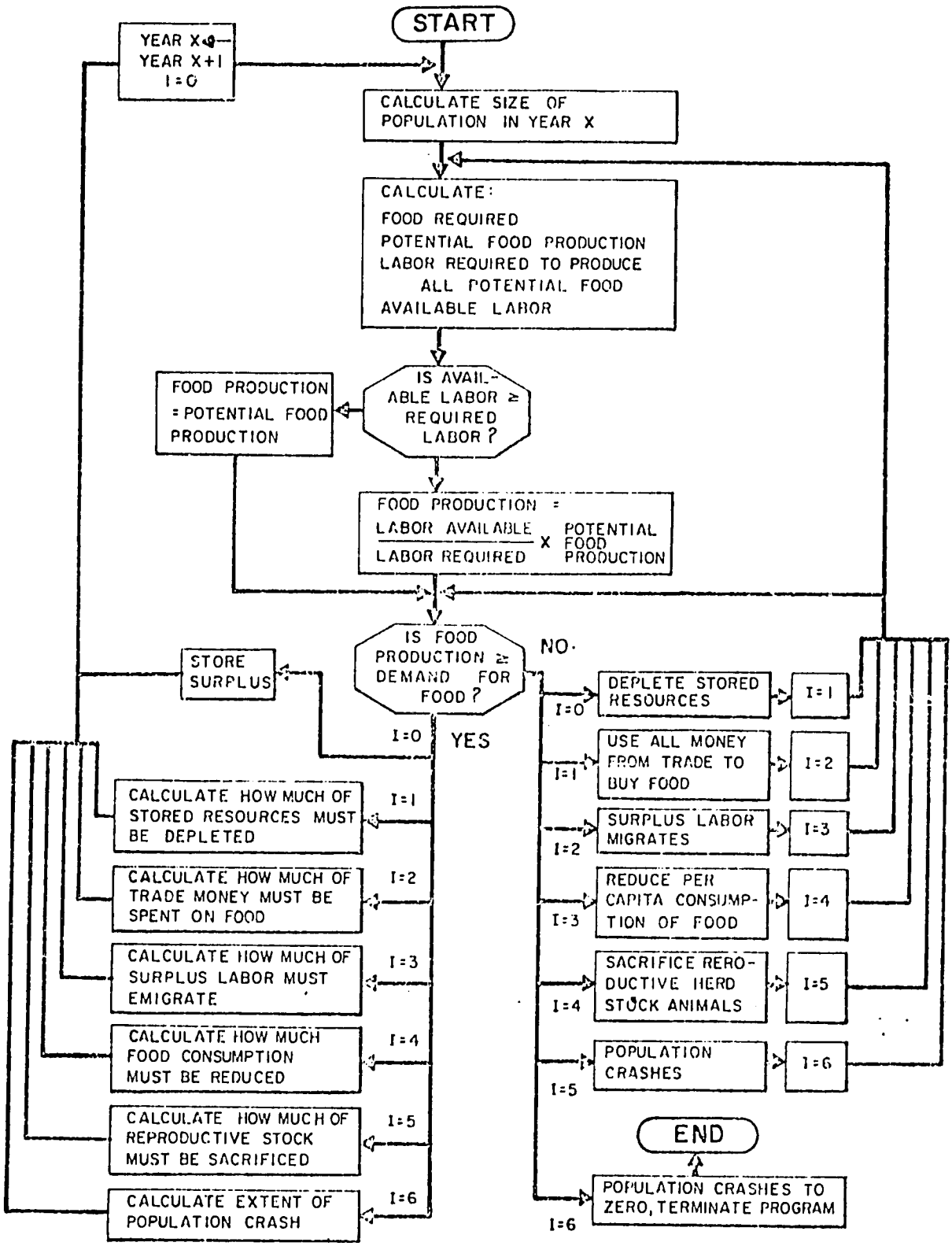
1. Blankenship and Thomas 1977, p. 403.
2. For an interesting counterview, see Simon, 1980.

FIGURE 3

FLOW CHART SIMULATION OF A SUBSISTENCE-LEVEL POPULATION FACED WITH A FOOD SHORTAGE DUE TO POPULATION GROWTH. NOTE THE INCREASING GRAVITY OF THE SITUATION WITH EACH SUCCESSIVE ITERATION.[1]

1.51



1. From Blankenship and Thomas. 1977. P. 405.

would require not only modern medical services but also (a) reduced birth rates; and (b) the improved technology necessary to increase food production."[1,2]

The effect of disease control on human population is a well-known but hardly predictable ecological force. It exempts no species in principle; whether man can devise feasible solutions to it is still a major ethical, economic, and of course, biological question. The question must be faced and answered everywhere the ecology of man is changed by such a factor as malaria control.

1.52 - Migration of population: In areas of the world where malaria control has been even temporarily successful, people have moved into formerly malarious areas where no one could live safely before. The assumption that there would be no further risk has been in error in the many regions where malaria has returned in force. The result has been a worse problem than in times past, because immigration has increased the population at risk. In addition, the new population has lost or never had the partial immunity present when malaria was prevalent, leading to greater severity of the resurgent disease.

1.53 - Immigration of malaria carriers to a malaria-free area: Failure to screen all persons entering a malaria-free region may undo the success of a former control program, especially if the primary thrust has been disease control rather than vector control. When these new carriers are exposed to an effective vector population, a malaria outbreak is imminent. Control measures such as screening, quarantine, and treatment of potential carriers should always be regarded as necessary to protect the gains made by malaria control programs.

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1. Blankenship and Thomas 1977, p. 401.
2. Taylor, 1970.

1.54 - Loss of program image and visibility: As a control program goes into a maintenance phase and therefore loses the priority it once enjoyed, both the citizen and bureaucratic support become more difficult to obtain. This is a classic behavioral picture of adaptation to a change in the human ecology, and must be assessed and dealt with effectively to maintain the program gains and to insure its continuation until all risk is past and a safe margin of time has been established. Certainly this response by the population has been of very major importance in causing the profound lapse of programs in the less developed countries in the past 15 or more years.

SECTION 1.6 - RESEARCH

1.61 - State-of-the-Art of Environmental Assessment

"The development of an EA--the primary objective of this study--represents a significant advance in assessing the ecological and environmental aspects of malaria control program planning. The EA recommended in the Manual is a synthesis of state-of-the-art knowledge, technical skill, the interdisciplinary approach and contemporary values into a comprehensive and systematic tool for evaluating environmental impacts of malaria control. The procedure used to develop the EA assures that this system reflects advanced concepts in measuring the environmental consequences of malaria control.

Anyone attempting to perform or devise analyses of environmental impacts of public projects, soon concludes that the needed data, values, concepts, and scientific knowledge just do not exist to the degree necessary to permit an accurate evaluation. Research in the fields of ecology, water management, and land use is slowly providing some of the analytical tools needed to measure the response of the natural environment to large-scale changes. The federal requirement for environmental impact evaluation, authorized by the Environmental Policy Act of 1969, is forcing the development and use of more rational systems of analysis, such as EA, and with them comes a need for more precise scientific knowledge of the important environmental processes. Thus, a continuation, and hopefully an increase, in the already high level of scientific research in this field can be anticipated in the next few years."[1]

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1. Whitman _et al_. 1971, p. 53 (adapted).

1.62 - Continuing Need for Environmental Assessment Research

The Manual and Guidebook represent the first attempts to offer a modern management tool for malaria control programs, based upon the current state-of-the-art. A strong recommendation is made at this point, that in the use of this tool, every program should feel a responsibility to develop and collate additional information, and to point out where research is needed to provide better concepts, data, and analyses for the conduct of environmental assessments.

SECTION 1.7 - USE OF THE MANUAL

1.71 - Purposes

The Manual purports to be a "decision support system[1]" utilizing a system of algorithms which would enable the program planner and the operations management to direct an orderly (and basically complete) process of environmental assessment for any given malaria control project. The Manual in its completed form is to be employed as an integral part of the planning, operating, monitoring, and feedback of the project, so it is intended to be useful in decision-making for all phases of project activity. In that way the responsibility for and execution of environmental assessment is built into the context of the entire program. If one accepts environmental responsibility as a program ethic, then there is no question about the need to make it a concurrent aspect of all program operations.

Such routine integration of environmental responsibility into program and operations prevents it from either becoming lost on one hand or ending up as an extraneous threat or polarized issue on the other. Many assessment activities have been eventually consigned to shelf status only, because they have been found inconvenient, inapplicable, without feasibility or rationality, isolated in time, or with no provision for feedback to an operating program. Such a situation represents a useless expenditure of resources, as well as a potential and perhaps irrational threat to the program at some future point.

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1. Keen and Scott Morton, 1978.

1.72 - The Decision Support Role of the Manual

In order to propose an assessment procedure which can become an integral part of the malaria program, it has been necessary to develop algorithms which cover the whole operation, and within which environmental assessment is then detailed. The authors have no intention of writing an operations manual at this point, but feel that environmental assessments done any other way cannot be responsibly produced. We have, therefore, attempted to set forth a complete logic system for malaria programs, and have undertaken to fill out those portions which deal with environmentally significant decisions and consequences.

1.73 - The Presumed Advantages of the Manual

These may be summarized as follows:

a. Each process and decision step composing a given program component are clearly identified and displayed in the appropriate algorithm, so that:

   1. Both the immediate and long range objectives of the program can be visualized, prioritized, and placed in proper perspective.

   2. Every person on the control program staff can be informed of where the program is in time, what it has pending, and what inputs, outputs, documentations, and decisions are expected at each step.

b. Responsibility for assignments can be clearly made, and both feedback and audit follow logically.

c. The algorithms so visualize the process and decision steps that errors and omissions can be easily seen, and the necessary corrections made quickly at any management level. The decimal system used throughout the Manual and Guidebook allows for quick insertion of new information as well as revision or deletion of present materials.

d. The steps in any process or decision can be further subdivided as experience directs, making each step small enough to be manageable.

e. Other aspects of the malaria control program can be "plugged in" as a part of the process, because the algorithm model is flexible and lends itself to easy revision.

f. The algorithms can be used as an outline for program proposals, and as a basis for budget justifications, job descriptions, or other program documents.

g. Updating the Manual and Guidebook by issuances of new or revised sections is foreseen as a constant need. The full participation in these revisions by all who use the Manual and the accompanying Guidebook would insure that these management tools progressively improve, and truly find maximum utility as a decision support system.

SECTION 1.8 - USE OF THE GUIDEBOOK

The Guidebook is intended as the primary resource volume for the environmental assessment procedures. To the extent that pertinent information can be made available, its contents are supportive of each step in the decision process. The decimal system used in the Guidebook corresponds directly with that in the Manual. For example, the Manual's Decision Support System #11.62 for specific source reduction measures has a detailed discussion of the environmental implications of source reduction in the Guidebook under 11.62: The specifics for shoreline contouring and maintenance of a lake or pond would be found under 11.626B as indexed in the algorithm.

SECTION 1.90 - GENERALIZED DECISION SUPPORT SYSTEM FOR MALARIA CONTROL (VECTOR PROGRAM)

Definitions:

Malaria control in its vector aspects is the reduction of the specific vector's population to a level below which transmission of malaria is improbable, and the maintenance of that level by a sustained effort until it can be made secure. At that time the control effort may be modified to a maintenance phase,[1] which must be continued as an insurance policy indefinitely, unless eradication with quarantine and drug suppression of all carriers can be achieved. Obviously if immunization against malaria can be made effective, the outlook for both maintenance programs and eventual eradication will be substantially changed.

In accordance with the integrated pest management concept (IPM)[2,3,4] the population of a pest (vector) is subjected to a diversity of control efforts, and for only for the time and intensity needed to bring its population below an economic threshold,[5] defined as a safe level below which cost/benefit analyses no longer favor control. Monitoring the situation then directs resumption of overt control efforts only when the pest population again moves up through the economic threshold, toward a level where once again the pest (vector) can cause damage (economic injury level).

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1. See Chapt. 22.
2. NRC-NAS, 1972.
3. Metcalf and Luckman, 1975.
4. Glass, et al., 1975.
5. Headley, p. 100-108, in: NRC-NAS, 1972.

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In anopheline control, the maintenance phase of the program would use only that amount of effort necessary to keep the mosquito population at the approximate economic threshold, safely below the economic injury level,[1] at which transmission of malaria could occur.

Environmental Concerns:

When a disease control effort, as a vector program, is directed at the environment, rather than at man himself, there will be modifications of the environment which will create temporary to permanent effects, both good and bad from human value standpoints (economic, social, esthetic, scientific). Since both the natural ecology and the social ecology of man will respond, the results are often very complex and difficult to anticipate as well as to analyze. Experience in our recent past, both accidental and experimental, has given us to an increasing degree the knowledge of what may happen and its significance, magnitude, and importance. Moreover we now are more and more capable of assessing impacts, have had some success in predicting them at this point, and so may be able to choose among courses of action in terms of their expected benefits, weighed against estimates of their potential risks and probable costs.

In the instance of malaria vector control, the most rational view of the present state-of-the-art is that it can be done on a very low risk/cost basis in terms of the natural ecology. The assumptions which accompany this are that:

1. Adequately educated and trained administrators and technical personnel will carry out the program.

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1. Glass, et al., 1975, p. 71.

2. Program management will stay well ahead of operations, to avoid emergency decisions and consequently desperate measures as much as possible, since these are often the basis for increased and unforeseen risks to the environment (as well as to operations!).
3. The anopheline target will be made as limited and as specific as possible, to reduce non-target impacts.
4. Highly sensitive periodic monitoring will be done, at a valid sampling level, providing program feedback to insure its effectiveness and efficiency, as well as the environmental safeguards ne ded.
5. The program will have adequate budget, priority, and political security.
6. Continued research and testing of new materials and methods, as well as technical support for integrated approaches, will make possible the consistent improvement in target restriction, accuracy of target impact, and reduction in non-target effects.

The net result should be such a minimal environmental liability that a negative determination is assured (See "Regulation 16")[1]. Nevertheless, the potential for real damage is always present when the factors assembled may include insufficiently trained personnel, poisonous materials, major engineering modifications or inadequate resources.

If one now turns to the artificial ecology of man, no such confidence in minimal liability is warranted. Here the epidemologist, the sociologist, and the demographer have major reasons for concern. Relief from a disease

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1. See Chapter 10.

which has been a major factor in governing the population level is an immediate and very great benefit, but without concomitant social and cultural changes to accomodate it, projects a high birthrate into a headlong confrontation with a limited and often marginal economy. This environmental impact is major, and its effects have been well documented. It is not within the purpose of this Manual and its present approach to deal with this highly sensitive issue, with its ethical, cultural, economic, and political impacts, but those who administer vector control programs certainly need to be well aware of this aspect of ecological disruption, as it can override all other considerations.

Use of the Algorithm:

The first algorithm (*DSS 1.0*) in the Manual presents the basic decision support system for all the others that follow and are subsets of it. From it there are derived the identity and numbering sequence[1] of the chapters in both the Manual and the Guidebook. This master algorithm sets forth in flow chart form only the major steps (2-23) in the vector control program, which are then expanded in the later chapters. Subset algorithms are given for all those process or decision steps where environmental concerns play a part, together with a text of instructions for each algorithm. Using a decimal system for reference, the Manual directs one to the Chapters and Sections of the Guidebook for further detail, compiled from a wealth of literature and reports.

The two volumes are intended to serve only the environmental concerns of the malaria program, but in doing this within the context of operations, they would also serve as a framework for a future operations manual.

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1. The chapters, sections, and subsections of the Manual and Guidebook are numbered in accordance with the numbers used in the algorithms (*DSS 1.0* sets up the numbers for the chapters).

Subset algorithms, identified by increasing decimal divisions, may show some redundancy when fitted to the major chapter algorithms from which they are derived, but it is felt this can be easily understood, and moreover, that it is actually helpful, and the redundant portion may show more detail and be more carefully worked out than is possible on the more major flow sheets.

Not all of the program steps can be easily placed in a linear sequence, and also many feedback operations are left out, but experience should fill these in. Also many feedbacks are repetitive adjustments, or iterations, which continue, often in rapid succession, until by such successive approximations the optimal stage or decision is reached.

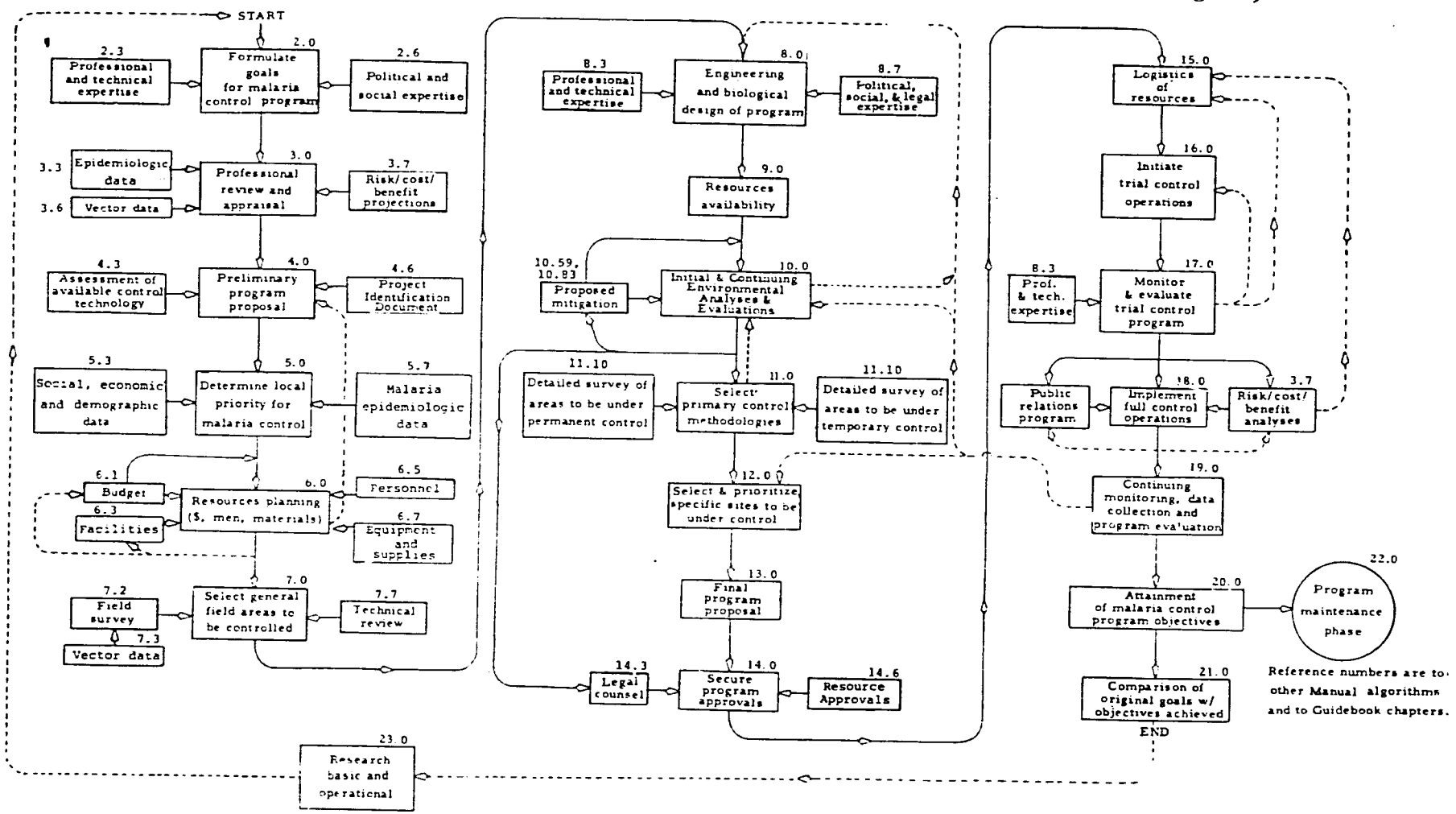
Changes in the form of additives, modifications and deletions, will improve these systems and their resource materials as experience in the field may direct. The form of the Manual and Guidebook lends itself to this growth and adaptability as potentials for improvement of these volumes.

Use of the Guidebook:

The Guidebook is intended as the field library and overall sourcebook for those persons directing vector control.

D.S.S. #1.0

Generalized Decision Support System for Malaria Control (Vector Program)



Reference numbers are to other Manual algorithms and to Guidebook chapters.

CHAPTER 2 MALARIA PROGRAM GOALS

SECTION 2.0 GENERAL

2.1 PROCEDURE

2.3 PROFESSIONAL AND TECHNICAL EXPERTISE
(See also Chapters 3 and 25)

2.6 POLITICAL AND SOCIAL EXPERTISE
(See also Chapters 3 and 25)

CHAPTER 3 - PROFESSIONAL REVIEW AND APPRAISAL

SECTION 3.1 - PROCEDURE

3.11 VECTOR CONTROL PROGRAM PRE-AUDIT

3.3 - EPIDEMIOLOGIC DATA

3.6 - VECTOR DATA

(See also 7.0)

3.7 - RISK/COST/BENEFIT PROJECTIONS

(See also Chapter 11, 11.939 and Chapter 18)

CHAPTER 3 - PROFESSIONAL REVIEW AND APPRAISAL

SECTION 3.1 - PROCEDURE

3.11 VECTOR CONTROL PROGRAM PRE-AUDIT

The Programmatic Environmental Assessment (PEA) is intended for worldwide use and therefore, by necessity, is general in nature. A complex environmental undertaking such as a malaria control program, however, will be affected by a wide range of factors that are specific to the environment of the host country. The algorithms of the PEA Manual have been designed to address these factors and therefore presuppose that information is available about these local factors. In fact, the effectiveness of the PEA, to a great extent, will depend upon the quantity and quality of information that will be provided locally.

The pre-audit is a tool designed to assist in obtaining required information about the vectors, malaria epidemology, environmental conditions and relevant socio-economic conditions in the host country. The audit takes the form of a comprehensive series of questions to be answered prior to using the algorithms. It can be expected that some questions may not be relevant, and some important questions may not be included, but the series of questions should provide a systematic examination and review process to generate most of the necessary local information.

The audit will also point out those areas where information is lacking and where corrective action should be taken to insure that the information is obtained. The resultant body of knowledge that is accumulated by the pre-audit will serve to facilitate use of the algorithms and increase the quality of the decisions.

SECTION 3.11 - MALARIA CONTROL PROGRAM PRE-AUDIT

(Initial Step of the Program Planning Process)

A. Program History:

1. What is the history of malaria control in the area under review?
2. Has an eradication program been part of the program? (Is it eradication or control?)
3. What control measures have been used?
   a. Residual spraying
   b. Space spraying
   c. Larviciding
   d. Physical control (source reduction)
   e. Herbiciding
   f. Biological control
   g. Special measures (insect growth regulators, genetic measures)
   h. Drug treatment
4. How effective was each program component?
   a. Were the goals reached?
   b. Why not?
5. What evaluation procedures were used?
6. What problems occurred in the program?
7. What is the budgetary history of the program?
8. What is the organizational structure of the Agency (Is an organizational chart available)?
9. Is information processing adequate to provide proper supervision and control, and to make appropriate modifications of the program?

B. Program Personnel:

1. What groups and numbers of personnel are now available (professional, technical, skilled, semi-skilled and untrained)?

2. What training facilities are available?

3. Are there staff specifically trained in:

   a. Malaria survey techniques (disease)?

   b. Malaria survey techniques (vector)?

   c. Environmental evaluation?

   d. Insecticide application?

   e. Chemical safety procedures?

   f. Resistance testing?

   g. Biocontrol inventories?

   h. Supervision

   i. Management

4. What is the personnel problem history (medical, administration, labor problems, and security)?

C. Facilities, Supplies and Services:

1. What housing and equipment are there for the program?

   a. Office

   b. Warehouse and shelters

   c. Vehicles

   d. Heavy equipment

   e. Small equipment and hand tools

   f. Spray machines

   g. Protective clothing and safety equipment

   h. Utilities

   i. Insecticide storage facilities

   j. Maintenance facilities (garage)

   k. Automotive repair equipment

   l. Aircraft (hangar and strip)

2. Is there a ready supply of insecticides, drugs, food, oil, gasoline and other basic materials to support the program?

3. How is material shipped and received?

   a. What delays have been experienced? (Is there any reason to suspect major problems with procurement and deliveries?)

4. Are personnel, equipment, supplies, and facilities (or else qualified independent services) available to serve as:

   a. Medical laboratory

   b. Biological laboratory

   c. Chemical laboratory

   d. Engineering shop

5. How secure are all of these facilities from theft, abuse and exposure?

6. Is there professional, medical, engineering, and biological support if needed?

7. Are firms available to contact for air or ground spray?

8. Is there a biomedical library available to the program?

9. Are the overall quality and quantity of program personnel, facilities, and resourses adequate for its success?

D. <u>Political Factors</u>:

1. Does the malaria problem extend beyond the political borders?

2. What priority is given to malaria prevention and control?

3. What priorities do health programs enjoy as evidenced by consistent level of support?

4. What has been the financial support of the program from local, provincial, national and international appropriations?

5. What is the enabling legislation affecting the program?

6. What legislation restricts the program?

   a. What are the regulatory agencies that effect the program?

7. Is malaria control part of the official health program structure or is it separate?

8. Is the program administered by a physician, engineer, or biologist?

9. Does the administrator ensure that these major program components are in balance?

10. What problems have occurred with political support?

11. How concerned are the political powers with health and disease, population pressure, environmental effects, and the specific political jurisdiction in which the program is located?

12. What agencies can provide direct or indirect support to the vector control program?

13. Is the program to be coordinated with allied agencies involved in land use planning, public works, health, agriculture, etc.?

E. Cultural Factors:*

1. How important is the malaria problem to the inhabitants themselves?

2. How much resistance is shown to policies which would change the use of water areas, agriculture, location and standards for housing?

3. Is there a problem in obtaining access to property and homes?

4. Does religion pose specific problems for the program?

5. Do migratory patterns of the local population or of emigrants influence the malaria problem?

6. Are there life style features which would create program problems?

F. Disease

1. Have the boundaries of the epidemic area been mapped?

2. What epidemiological data are available and what analyses have been done? Are there seasonal studies?

3. What is the epidemic-endemic nature of malaria in the area?

4. Have the endemic foci been located and mapped?

5. What priority ranking is given malaria on epidemiological basis?

6. What species of plasmodia occur in the area and what are their relative frequencies?

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* See also J.

7. What are the economic losses due to malaria (health costs, manpower losses, areas uninhabitable, loss of industries)?

8. What evaluations have been done on disease reductions by past programs?

9. How have disease levels been evaluated?

10. What is the nature, volume and effectiveness of drug use for prophylaxis and prevention?

11. Is there resistance to drugs?

    a. Which species of plasmodia?

    b. Which drugs?

12. Is usage of insecticides by the program being monitored? Is it coordinated with agricultural usage?

G. Vector:

1. How many species of Anopheles are recorded for the area and which ones are known vectors? How extensive and how valid are the records?

2. Have the vectors been specifically verified as transmitting disease in the control area and how was this done?

3. Can the vectors be ranked in order of importance? In what ways?

4. How many generations per year can be expected from each species?

5. Has any insecticidal resistance been noted?

6. Is there a recorded insecticide history on the vector species?

7. Have agricultural or other insecticidal usages impacted the vector species?

8. Where, how and by whom were the resistance tests conducted and on what species?

9. Where do the larvae of the vector species occur, in natural or artifical situations?

10. Are the adults seasonal in occurrence? Are density data available?

11. What is known of the biting habits of the vector species?

    a. Known hosts and preference for man?

    b. Time and location of biting (indoors, outdoors)?

    c. Do they rest indoors or outdoors?

12. Have flight range studies been carried out for the important vectors?

13. Do any of the vector species show specific shade or sunlight preference which may result from cultural practices in agriculture?

14. Do aquacultural practices contribute to vector problems?

15. Are aquatic or semiaquatic plants the basis for major control problems?

16. Does any vector species have specialized habitats (air plants, wells or cisterns, coconut shells, treeholes, leaves or hoof prints)?

17. What vector predators and pathogens have been recorded for the area?

18. Can "resting stations" and light traps be used to check on vector adult populations?

H. Climate:

1. What is the seasonal climate of the area and is there a marked wet and dry season? For what areas and time are rainfall data available?

2. Based on the mean daily temperatures, what is the average development time for the vectors?

3. Does this time period have a seasonal variation?

4. Are night temperatures ordinarily high enough to quarantee development of plasmodia in the vector?

I. Topography and Land Use:

1. Has the area been carefully mapped?

2. How accessible are all parts of the control area?

3. What is the nature and extent of wetlands and fully aquatic areas within 3 to 5 km. of the areas to be protected?

4. Has the topography been carefully evaluated for mosquito larval sources?

5. What is the nature of land use within 3 to 5 km. of the human areas to be protected, and what are the plot sizes?

6. Where is the drinking water obtained, sewage disposed of, and what areas are used for bathing and recreation?

7. Are there impoundages, drainage canals and ditches, or irrigation systems which may require mosquito control?

8. Can consultant assistance be obtained to conduct surveys and assessments of the physical environment?

9. Do current land use practises increase or decrease vector sources?

10. Are there future projects or land use plans or sanitation projects that will impinge upon the vector sources?

J. Areas to be Protected: *

1. What is the nature of housing inclusive of vector proofing and the quality of interior surfaces?

2. What is the density and distribution of homes in the control area?

3. What hours and where do the population expose themselves to potential vectors?

4. Are both work areas and habitation of importance in disease transmission?

5. What is the farm animal population, its density, distribution and housing?

6. Are there existing environmental or community health programs?

K. Biota: (Plants and animals of natural economic, scientific, cultural and esthetic value)

1. What records and study have been made of the species of plants and animals in the area?

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* See also E.

2. What ecological data are available and would apply locally?

3. Are any species in the area known to be endangered?

4. Are there local, provincial or national biologists available for environmental consultation or surveys?

5. Are there library facilities adequate for identification, life history data, ecological significance and survey methods for assessment of the biota?

6. What is the record of plant and animal introductions into the control area?

7. What species of aquatic or semi-aquatic vegetation exist in the area?

8. What legislative protection is there for the biotic environment and does this constitute an obstacle to control?

9. Does a regulatory agency or agencies exist specifically to protect the environment or wildlife?

L. Environmental Effects:

1. Is there a record of environmental or safety problems generated by past program activities?

2. Were these problems based on improper procedures, accumulative control measures or inadvertent impacts?

3. Have these problems been evaluated and preventive measure formulated?

4. Has the use of pesticides outside the malaria control area created major problems for people, farm animals, the environment (or even vector resistance)?

M. Program Evaluation, Audit and Liaison:

1. What outside program reviews have been made and are the reports available?

2. What is the quality of these reports, and was the work done by competent persons?

3. Has the program been provided consistent and longterm financial support?

4. Are adequate funds set aside for use in emergencies?

5. What support has been sought from outside agencies, and has any been obtained?

6. What agreements, understanding, and commitments have there been between the malaria program and local, provincial, national, or international agencies (both private and governmental)?

TABLE 1

MALARIA CASES REPORTED IN JANUARY-DECEMBER 1979, BY GEOGRAPHIC REGION AND COUNTRY[1]

Region and country or territory[a]	No. of cases reported
Africa South of the Sahara:	
Angola	522,358
Benin	122,405
Botswana	5,954
Burundi	94,049
Cape Verde	621
Central African Republic	167,346
Chad	94,545[b]
Comoros	30,352[c]
Congo	147,521
Djibouti	113[b]
Equatorial Guinea	37,454[d]
Ethiopia	31,658[e]
Gabon	16,776[f]
Gambia	51,993[g]
Ghana	413,319[h]
Guinea	52,210[b]
Guinea Bissau	160,931
Ivory Coast	349,046
Kenya	437,660[i]
Liberia	232,112
Madagascar	302,336
Malawi	23,237
Mali	180,176
Mauritania	24,899[b]
Mauritius	127
Mozambique	–
Namibia	–
Niger	384,029
Nigeria	1,021,331
Réunion	52
Rwanda	137,047
São Tomé and Príncipe	7,478
Senegal	508,010
Sierra Leone	79,991
Somalia	11,343
South Africa	2,007
Sudan	12,082
Swaziland	489[c]
Togo	294,562
Uganda	20,305
United Republic of Cameroon	31,585[b]
United Republic of Tanzania	485,956[b]
Upper Volta	217,146
Zaire	317,533[g]
Zambia	10,580
Zimbabwe	87,647[j]
Africa North of the Sahara:	
Algeria	73
Egypt	474
Libyan Arab Jamahiriya	134
Morocco	397
Tunisia	6[k]
Western Hemisphere:	
Argentina	936
Belize	1,391
Bolivia	14,712
Brazil	147,630
Canal Zone	0
Colombia	60,957
Costa Rica	307
Dominican Republic	3,080
Ecuador	8,207
El Salvador	77,976
French Guiana	604
Guatemala	69,039
Guyana	2,294
Haiti	41,252
Honduras	25,297
Mexico	20,983
Nicaragua	18,418
Panama	316
Paraguay	116
Peru	17,127
Suriname	903
Venezuela	4,705
Western Asia:	
Afghanistan	34,444
Bahrain	273
Democratic Yemen	4,083
Gaza Strip	1[b]
Iran	22,175
Iraq	4,012
Jordan	320
Oman	2,111
Pakistan	12,304
Qatar	168[b]
Saudi Arabia	3,192
Syrian Arab Republic	2,550
United Arab Emirates	2,502
Yemen	3,838[l]

[a]Countries or territories from which malaria has been eradicated are not included in this table.
[b]1978 data.
[c]1976 data.
[d]1971 data.
[e]Eight months' data.
[f]Five months' data.
[g]Fifty-two week period.
[h]1977 data.
[i]Six months' data.
[j]1974 data.
[k]January-September 1979 data.
[l]Tihama region only.
[m]Updated figure, breakdown by areas not available.

1. PAHO, 1981, p. 279-280.

TABLE 1 (Continued)

Region and country or territory[a]	No. of cases reported	Region and country or territory[a]	No. of cases reported
Central Asia:		Malaysia, West	10,543[m]
Bangladesh	49,776	Sabah	33,324
India	3,064,697	Sarawak	1,068
Maldives	329	Papua New Guinea	117,670
Nepal	12,131	Philippines	87,421
Sri Lanka	48,004	Solomon Islands	26,357
		Thailand	302,658[m]
Eastern Asia and Oceania:		Vanuatu	2,935
Burma	14,515	Viet Nam	40,782[k]
China	2,384,543		
East Timor	-	*Europe, Including Turkey and the USSR:*	
Indonesia	165,911	Turkey	29,323
Democratic Kampuchea	-	USSR	-
Republic of Korea	0		
Lao People's Democratic Republic	-		

TABLE 2

SPECIES OF ANOPHELES VECTORS OF PRIMARY IMPORTANCE IN THE TRANSMISSION OF MALARIA[1]

Species of Anopheles vectors of primary importance in the transmission of malaria

A. aconitus Dönitz, 1902
A. albimanus Wiedemann, 1821
A. albitarsis Lynch Arribalzaga, 1878
A. annularis van der Wulp, 1884
A. aquasalis Curry, 1932
A. atroparvus van Thiel, 1927
A. aztecus Hoffman, 1935
A. balabacensis Baisas, 1936
A. barbirostris van der Wulp, 1884*
A. bellator Dyar & Knab, 1908
A. campestris Reid, 1962
A. claviger (Meigen), 1804
A. cruzi Dyar & Knab, 1908
A. culicifacies Giles, 1901
A. darlingi Root, 1926
A. farauti, Laveran, 1902
A. fluviatilis James, 1902
A. freeborni Aitken, 1939
A. funestus Giles, 1902
A. gambiae Giles, 1902*
A. hispaniola (Theobald) 1903
A. hyrcanus sinensis Wiedemann, 1828
A. jeyporiensis s.l. James, 1902
A. koliensis Owen, 1942
A. labranchiae Falleroni, 1926
A. letifer Sandosham, 1944
A. leucosphyrus Donitz, 1901
A. maculatus Theobald, 1901
A. maculipennis Meigen, 1818*
A. mangyanus (Banks), 1906
A. melas Theobald,1903
A. messeae Falleroni, 1926
A. minimus s.l. Theobald, 1901
A. moucheti s.l. Evans, 1901
A. multicolor Cambouliou, 1902
A. nigerrimus Giles 1900
A. nili (Theobald), 1904
A. nuñez-tovari Gabaldon, 1940
A. pattoni Christophers, 1926
A. pharoensis Theobald, 1901
A. philippinensis Ludlow, 1902
A. pseudopunctipennis Theobald, 1901*
A. punctimacula Dyar & Knab, 1906
A. punctulatus Dönitz, 1901*
A. quadrimaculatus Say, 1824
A. sacharovi Favre, 1903
A. sergenti (Theobald), 1907
A. sinensis Wiedemann, 1828
A. stephensi s.l. Liston, 1901
A. sundaicus (Rodenwald), 1926
A. superpictus Grassi, 1899
A. umbrosus s.l. (Theobald), 1903
A. varuna Iyengar, 1924
A. vestitipennis Dyar & Knab, 1906

Note: According to the International Code of Zoological Nomenclature, in writing the full scientific name of a mosquito the genus may be abbreviated to one or more letters but should always start with a capital letter. The name of the species must not be capitalised, even if it is derived from an author's surname. In precise description the surname of the author who first described and named the species is added without an intervening comma; the year of the publication is separated from the previous word by a comma. If the new name of the species replaces a name given to it originally then the present author's name is given in brackets.

Some names of species given in Table 6 refer to groups of Anopheles that have been subdivided into sub-species and varieties; this is indicated by the abbreviation s.l. (*sensu lato*).

Some species which are now known to represent complexes of sibling species are indicated by an asterisk.

1. Bruce-Chwatt, 1980, p. 109. (See also: Russell, Rozeboom, and Stone, 1943, for identification keys.)

TABLE 3

TWELVE EPIDEMIOLOGICAL ZONES OF MALARIA AND SOME OF THE IMPORTANT VECTORS[1]

Twelve epidemiological zones of malaria and some of the important vectors

Zone	Extension	Main malaria vectors
1 North American	From the Great Lakes to southern Mexico	*A. quadrimaculatus, A. freeborni* with *A. albimanus* as an incidental vector
2 Central American	Southern Mexico, the Caribbean islands, fringe of the South American coast	*A. albimanus, A. aquasalis, A. punctimacula, A. darlingi, A. aztecus*
3 South American	Most of the South American continent irregularly beyond the Tropic of Capricorn	*A. darlingi, A. aquasalis, A. pseudopunctipennis, A. bellator, A. cruzi*
4 North Eurasian	With the Palaearctic region excluding the Mediterranean coast of Europe	*A. atroparvus, A. sacharovi, A. maculipennis, A. messeae.* To the east *A. pattoni, A. sinensis*
5 Mediterranean	Southern coast of Europe, north-western part of Africa, Asia Minor and east beyond the Arab Sea	*A. labranchiae, A. sacharovi, A. superpictus, A. claviger, A. hispaniola, A. messeae*
6 Afro-Arabian	Africa north and south of the Tropic of Cancer including central part of the Arabian peninsula	*A. pharoensis, A. sergenti, A. multicolor, A. hispaniola, A. gambiae* (in part)
7 Afro-Tropical (formerly 'Ethiopian')	Southern Arabia, most of the African continent, Madagascar and the islands south and north of it	*A. gambiae* complex, *A. funestus, A. rufipes, A. moucheti, A. nili, A. pharoensis, A. d'thali*

1. Bruce-Chwatt, 1980, p. 111-112.

TABLE 3 (Continued)

Zone	Extension	Main malaria vectors
8 Indo-Iranian	North-west of the Persian gulf and east of it including the Indian sub-continent	*A. sacharovi*, *A. superpictus*, *A. culicifacies*, *A. stephensi*, *A. fluviatilis*, *A. annularis*
9 Indo-Chinese Hills	A triangular area including the Indo-Chinese peninsula, the north-western fringe beyond the Tropic of Cancer	*A. minimus*, *A. leucosphyrus*, *A. balabacensis*
10 Malaysian	Most of Indonesia, Malaysian peninsula, Philippines and Timor	*A. leucosphyrus*, *A. balabacensis*, *A. sundaicus*, *A. maculatus*, *A. sinensis*, *A. umbrosus*, *A. aconitus*, *A. philippinensis*, *A. minimus flavirostris*, *A. barbirostris*
11 Chinese	Largely the coast of mainland China, Korea, Taiwan, Japan	*A. sinensis*, *A. pattoni*, *A. sacharovi*
12 Australasian	Northern Australia, the island of New Guinea and the islands east of it to about 175° east of Greenwich, but excepting the malaria-free zone of the South Central Pacific	*A. koliensis*, *A. punctulatus*, *A. farauti*, *A. annulipes*, *A. bancrofti*

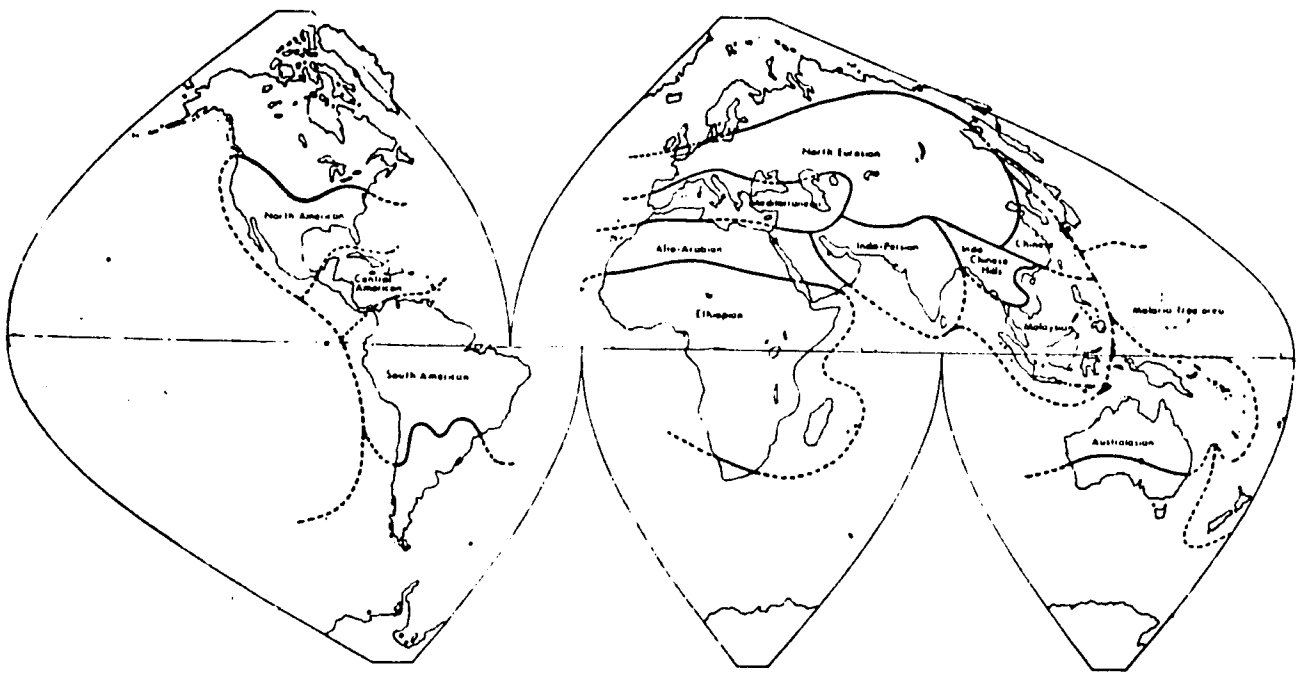
Notes:

1 The malaria-free zone of the south-central Pacific includes New Caledonia, New Zealand, the Caroline Islands, Marianas, up to Hawaian islands, east to Galapagos and Juan Fernandez and rejoining the southern tip of New Zealand.

2 This table represents only a crude approximation of the distribution of most important vectors of malaria. For indication of generic and sub-generic relationships of confirmed and suspected vectors of malaria Russell *et al.* (1963) 'Practical Malariology' should be consulted.

FIGURE 4

TWELVE EPIDEMIOLOGICAL ZONES OF MALARIA
ACCORDING TO THE CLASSIFICATION BY MACDONALD (1957)[1]



1. Bruce-Chwatt, 1980, p. 113.

CHAPTER 4 - PRELIMINARY PROGRAM PROPOSAL

SECTION 4.1 - THE PROPOSAL

4.3 - ASSESSMENT OF AVAILABLE CONTROL TECHNOLOGY

4.6 - PROJECT IDENTIFICATION DOCUMENT (PID)

(See also 10.0; Section 216.1(c)(6), and Section 216.3 (a) (1 and 2) of Regulation 16).

CHAPTER 5 - PRIORITY FOR MALARIA CONTROL

SECTION 5.1 - LOCAL PRIORITIES (LDC & PROVINCE)

5.3 - SOCIAL, ECONOMIC AND DEMOGRAPHIC DATA

5.7 - MALARIA PREVALENCE AND INCIDENCE

CHAPTER 6 - RESOURCES FOR MALARIA CONTROL

(See also Chapter 9)

SECTION 6.1 - BUDCET

6.3 -- FACILITIES

6.5 - PERSONNEL

6.7 - EQUIPMENT AND MATERIALS

CHAPTER 7 - SURVEY AND SELECTION OF CONTROL AREAS

(See also 3.6)

SECTION 7.1 - SELECTION PROCEDURE

7.2 - FIELD SURVEY[1]

7.3 - VECTOR DATA[2]

7.7 - TECHNICAL REVIEW

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1. See WHO, 1973a (Annex 3, p. 173-187).
2. See Service, 1976; and WHO, 1973a.

CHAPTER 8 ENGINEERING AND BIOLOGICAL DESIGN OF PROGRAM

SECTION 8.1 PROCEDURE

8.3 PROFESSIONAL AND TECHNICAL EXPERTISE
(See also Chapters 2 and 25)

8.7 POLITICAL, SOCIAL, AND LEGAL EXPERTISE
(See also Chapters 2 and 25)

CHAPTER 9 - RESOURCES AVAILABILITY[1]

(See also Chapter 6)

1. See Caswell *et al.*, 1981, p. 153-279 (Commercial Products Directory) of the Pesticide Handbook (Entoma).

CHAPTER 10 - INITIAL AND CONTINUING ENVIRONMENTAL ANALYSES AND EVALUATIONS

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Environmental Concerns
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SECTION 10.62 - EXAMPLES OF PRIOR ENVIRONMENTAL ASSESSMENTS FOR MALARIA CONTROL

10.62A Savannah River Wildlife Refuge

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10.62C Sri Lanka Malaria Control Project

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SECTION 10.64 - THE PROGRAMMATIC ENVIRONMENTAL ASSESSMENT (PEA)

SECTION 10.7 - SCOPING

DSS 10.7 *DETERMINE THE SCOPE OF THE ENVIRONMENTALLY SIGNIFICANT ISSUES TO BE ADDRESSED IN AN EA OR EIS*

SECTION 10.8 - PREPARE AN ENVIRONMENTAL ASSESSMENT (EA)

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DSS 10.8 *CONDUCT AN ENVIRONMENTAL ASSESSMENT (EA)*

SECTION 10.9 - PROCEDURE FOR AN ENVIRONMENTAL IMPACT STATEMENT (EIS)

DSS 10.9 COMPLETE AN ENVIRONMENTAL ASSESSMENT (EA) AND DETERMINE THE NEED AND PROCEDURE FOR AN ENVIRONMENTAL IMPACT STATEMENT (EIS)

CHAPTER 10 - INITIAL AND CONTINUING ENVIRONMENTAL ANALYSES AND EVALUATION

SECTION 10.0 - General

Background:

The regulatory requirements for the various analyses and reviews of environmental risks, costs, and benefits which must be conducted by the AID programs for malaria control are set forth in "Regulation 16", which was published on June 30, 1976,[1] and revised on October 23, 1980, as part of the U.S. Code of Federal Regulations[2] (22 CFR Part 216).

"These procedures have been revised on the basis of experience with AID's original environmental procedures adopted in 1976. They also incorporate elements of regulations issued by the President's Council on Environmental Quality and Presidential Executive Order 12114 requiring environmental reviews by U.S. Agencies operating overseas."[3]

"An important background reference is the two volume 'Environmental Impact Statement on the AID Pest Management Program.'"[4]

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1. Federal Register, 1976.
2. Federal Register, 1980.
3. Printz, 1981.
4. AID, 1977a.

"At the 1978 Asian Regional Workshops on environment and development, it was apparent that many AID personnel still [saw] satisfaction of our responsibility to the environment as both a possible impediment to project approval and a complicated, mystical analysis based on detailed data collected by ecologists. Neither view is correct. The environmental assessment is simply another means for evaluating potential implications and likely success that decision makers need to consider along with social, technical, and economic implications in determining whether, and how, a project should be initiated. It only entails an examination of the reasonably foreseeable impact of the project and alternative actions. It does not pass judgment. There are numerous ways of evaluating environmental impacts. Early definition of the principal problematic areas is the best means of ensuring the relevance of the evaluation and providing a basis for selecting the approach by which the evaluation is best accomplished.

"As we continue to gain experience in identifying reasonably foreseeable environmental impacts, it should be easier for missions to determine at early stages in the programming cycle those projects, that if approved for project design, would require detailed environmental analyses. This coupled with an early identification of the significant issues, alternatives, and impacts to be analyzed, will permit the assessment, when necessary, to be performed as a part of the project design rather than as an 'add on' analysis as is the usual case today. This approach should virtually eliminate the presently perceived time constraints in the project cycle for such an analysis."[1]

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1. AID, 1979a, p. 2

Definitions:

The definitions given here are excerpted from the AID Environmental Procedures[1] and are also repeated, where useful, in the text and in the Manual Glossary (Chapter 26).

A. Initial Environmental Examination (IEE)

An Initial Environmental Examination is an initial study of the reasonably foreseeable effects of a proposed action on the human environment. Its function is to provide the basis for a Threshold Decision as to whether an Environmental Assessment or an Environmental Impact Statement will be required. If an Environmental Assessment or an Environmental Impact Statement is required, the IEE will also provide the basis for its preparation. The IEE should identify and described where appropriate: (1) the nature, scope and magnitude of any reasonably foreseeable effects of an action or any part of an action on the human environment; (2) the reasonably foreseeable effects of any such environmental impact on organisms in the biosphere including human life; and, where an Environmental Assessment or an Environmental Impact Statement is required, (3) reasonable alternatives to the proposed action which will be studied in detail in the Environmental Assessment or draft Environmental Impact Statement. The IEE will be an integral part of the Project Review Paper or equivalent document which will be circulated to selected Federal agencies for comment, when an Environmental Assessment is to be prepared.

B. Threshold Decision

A Threshold Decision is a formal Agency decision which determines, based on an Initial Environmental Examination, whether a proposed Agency action is or is not an action which will have a significant effect on the human environment and, if so, whether an Environmental Assessment or an Environmental Impact Statement is required.

C. Environmental Assessment

An Environmental Assessment is a detailed study of the reasonably foreseeable environmental effects, both positive and negative, of a proposed action and its reasonable alternatives carried out within or affecting specific developing countries. To the extent practicable, the Assessment will be developed in close collaboration with the host country institutions and subject to recipient country review.

D. Environmental Impact Statement (EIS)

An Environmental Impact Statement is a detailed study of the reasonably foreseeable environmental impacts, both positive and negative, of a proposed AID action and its reasonable alternatives, prepared when major Agency actions

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1. Federal Register, 1980.

significantly affect: the global environment or areas outside the jurisdiction of any nation (e.g., the oceans); the environment of the United States; or as a matter of policy, other aspects of the human environment at the discretion of the Adminstrator.

E. Negative Determination

A Negative Determination is a formal written document based on a Threshold Decision that a proposed action is not a major action which will have a significant effect on the human environment and is, therefore, an action for which an Environmental Assessment or an Environmental Impact Statement will not be required.

F. Negative Declaration

A Negative Declaration is an official written Agency decision made by an Assistant Administrator which states that the Agency will not develop an Environmental Assessment or an Environmental Impact Statement for an action which the Agency has identified as being ordinarily covered by AID Environmental Procedures. The decision may be based on: (1) overriding considerations such as the provision of disaster relief; (2) the fact that a substantial number of Environmental Assessments or Environmental Impact Statements relating to similar activities have been prepared in the past; or (3) the fact that the Agency has previously decided to prepare a programmatic Assessment or Statement covering the activity in question.

Environmental Concerns:

"As a matter of policy, AID is now committed to careful consideration of the environmental implications of all AID-supported projects.

"Procedures for environmental evaluation of AID projects have now been developed under the title Regulation 16, Environmental Procedures. They stem from the U.S. National Environmental Policy Act of 1969 (NEPA) and from U.S. environmental procedures already in existence (Council on Environmental Quality Guidelines). Although NEPA is primarily focused on U.S. environmental concerns, it has influenced an approach to the study of environmental problems that is applicable to non-U.S. situations. The purpose of the AID Environmental Procedures is to insure that the environmental impacts of AID activities are given appropriate consideration, taking into account particular countries' stages of development, goals, and priorities."[1]

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1. AID, 1976b.

"It is important to realize that even if adverse impacts and/or irreversible commitments of resources are likely to occur as a result of the project, it does not mean the project or activity cannot go forward. The Environmental Assessments' role is to help 'decision makers' understand likely consequence of the activities, mitigating actions that might be taken, and alternative approaches to the end goals. Its purpose is to permit more informed decisions to be made in the context of the development priorities of the country. Environmental impact is only one of several factors to be taken into consideration in reaching the decision as to a project's worthiness. Our commitment is to ensure that we examine this factor in a responsible and defensible manner with the host country."[1]

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1. AID, 1979a, p.4.

Procedures:

"The procedures[1] introduce a great deal of flexibility in the environmental evaluation of projects and reduce the potential for delays in processing. They eliminate from the requirement for environmental review, categories of projects with little or no likelihood of environmental impact and conversely, the procedures identify the types of projects which most likely result in significant adverse impact and which will always need further environmental study. For these latter type activities, the procedures establish a means of predefining likely areas of significant adverse impacts to be fully evaluated and those of less significance but still of importance in reaching decisions on the activity. This 'Scoping' process encourages the involvement of host country expertise in reaching decisions on significant impacts and subsequent evaluations. Evaluations of impacts and alternative actions is now permitted as a component of Project Paper preparation.

General Approach:

"These procedures assume that all proposed actions can, for purposes of environmental review, be associated with one of the following categories:

"1 - Excluded from detailed environmental review requirements either categorically or by a decision reached through preparation of an Initial Environmental Examination.

"2 - Being of a certain class of project for which the use of approved 'Design Criteria' has been authorized, thereby excluding such project from formal environmental review. A following of the criteria will avoid a significant adverse impact on the environment.

"3 - Requiring an Environmental Assessment or an Environmental Impact Statement either because of being identified in the procedures as an activity normally requiring such evaluations or because of a decision reached through preparation of an Initial Environmental Examination."[2]

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1. Federal Register, 1980.
2. Printz, 1981.

Specific Approach:

"Category 1 - (Exclusion) The Project Identification Document (PID) should contain a Statement to the effect that the proposed activity meets the criteria for categorical exclusions or is being excluded from further review because of the Negative Determination reached in the Initial Environmental Examination (IEE). The Threshold Determination or the decision on categorical exclusion made by the Mission or Office submitting the PID is to be verified by the Bureau Environmental Officer before proceeding to Project Paper preparation.

"Category 2 - For all activities not fitting clearly into categories 1 or 3, a determination must be reached by the Mission as to the availability of 'approved' environmental design criteria/considerations. If and when these become available, the PID should state the intention of the design team to utilize the criteria in developing the project, thus avoiding any likely significant adverse environmental impacts.

"Category 3 - (Inclusion) Proceed at the earliest possible time to organize and conduct a 'Scoping' meeting to help identify the principal issues to be examined, the means and timing of the examination. An Environmental Assessment (EA) can be prepared by individuals on the design team and presented as a component of the Project Paper or as a separate document. Consulting or specialized organizations may also conduct the analysis of impacts and alternative actions.

"An Environmental Impact Statement (EIS), if required, is prepared in accordance with regulations of the Council on Environmental Quality. It is prepared instead of an Environmental Assessment when the impact is on the U.S. or an area not under the jurisdiction of another country. It follows a more involved public review process. The Environmental Coordinator and the Office of General Counsel have special roles in this type of examination."[1]

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1. Printz, 1981.

Use of the Algorithms:

Regulation 16 has been interpreted and illustrated by eight algorithms which follow in the text of this chapter:

D.S.S. #10.0 - *Select and initiate the appropriate environmental review procedure. (Exemptions and exclusions)*

#10.3 - *Conduct an initial environmental examination (IEE) and threshold decision (Requirement and procedures)*

#10.4 - *Determine the procedural requirements prior to conducting an initial environmental examination (IEE) for a proposed pesticide.*

#10.5 - *Conduct an initial environmental examination (IEE) for the use or procurement of a proposed pesticide.*

#10.6 - *Review proposal for a negative declaration.*

#10.7 - *Determine the scope of the environmentally significant issues to be addressed in an EA or EIS.*

#10.8 - *Conduct an environmental assessment (EA)*

#10.9 - *Complete an environmental assessment (EA) and determine the need and procedure for an environmental impact statement (EIS).*

These eight algorithms lead progessively from one to another, and refer back on completion to *D.S.S. #1.0 at 11.0*, for continuation of the program through selection of the various control methodologies and approval of the program proposal and project paper.

These algorithms, which direct the various levels of environmental inquiry and analysis, will be referred to in other algorithms as program planning and operations proceed. Accordingly one should refer back to them either to recheck one's current compliance with environmental standards or to conduct further inquiries and analyses as seem needed. This rechecking or re-running of algorithms, their iteration, should become a routine habit in program planning and operation. Not only is it possible to do a good internal audit in this way, but also one profits by the consequent feedback mechanisms which insure good management.

The user of this Manual should review all of Chapter 10 algorithms prior to proceeding with further program planning in detail, which is set forth in Chapter 11. Then one should proceed with Chapter 11, returning as directed to process the various program options through Chapter 10 and its algorithms. In this way the selection process reduces the amount of environments review to that actually necessary.

Use of the Manual:

This chapter is intended to make compliance with the regulations easier to follow through the algorithms as interpretive devices. The detail of control procedures is particularly addressed in the following Chapter 11, which deals in depth with the methodologies available for malaria vector control.

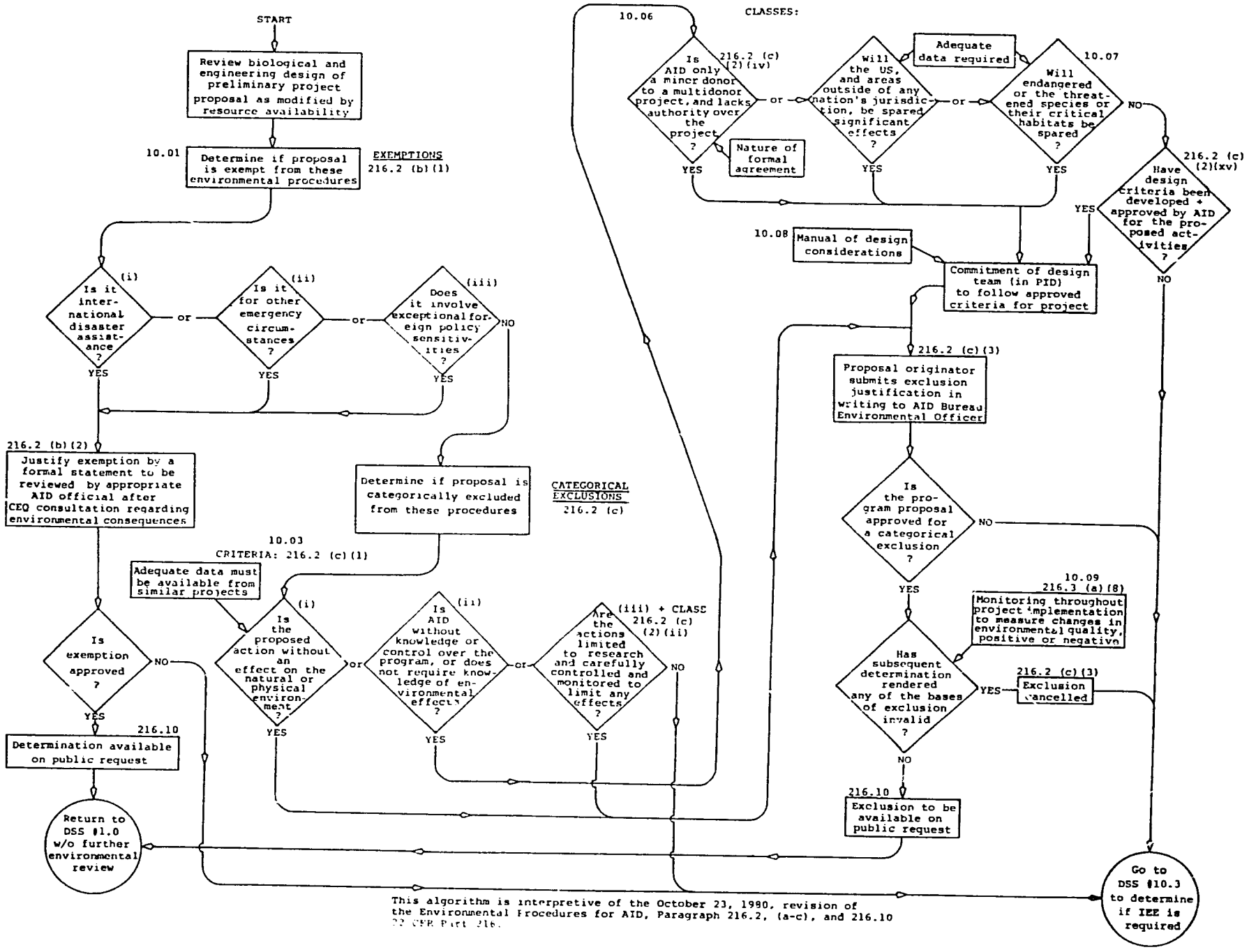
As one proceeds, it is well to refer back to this chapter to check or clarify points of compliance with the regulations.

Use of the Guidebook:

As supplemental information becomes available, it will be added to the corresponding Section 10 of the Guidebook, under the decimal reference system set up in the algorithms.

Select and Initiate the Appropriate Environmental Review Procedure (Exemptions and Exclusions)

D. S. S. #10.0



This algorithm is interpretive of the October 23, 1980, revision of the Environmental Procedures for AID, Paragraph 216.2, (a-c), and 216.10 22 CFR Part 216.

INTERNATIONAL DEVELOPMENT COOPERATION AGENCY [1]
Agency for International Development

22 CFR Part 216

Environmental Procedures

§ 216.1 Introduction.

(a) *Purpose.* In accordance with Sections 118(b) and 621 of the Foreign Assistance Act of 1961, as amended, (the FAA) the following general procedures shall be used by A.I.D. to ensure that environmental factors and values are integrated into the A.I.D. decision making process. These procedures also assign responsibility within the Agency for assessing the environmental effects of A.I.D.'s actions. These procedures are consistent with Executive Order 12114, issued January 4, 1979, entitled Environmental Effects Abroad of Major Federal Actions, and the purposes of the National Environmental Policy Act of 1970, as amended (42 U.S.C. 4371 et seq.) (NEPA). They are intended to implement the requirements of NEPA as they effect the A.I.D. program.

(b) *Environmental Policy.* In the conduct of its mandate to help upgrade the quality of life of the poor in developing countries, A.I.D. conducts a broad range of activities. These activities address such basic problems as hunger, malnutrition, overpopulation, disease, disaster, deterioration of the environment and the natural resource base, illiteracy as well as the lack of adequate housing and transportation. Pursuant to the FAA, A.I.D. provides development assistance in the form of technical advisory services, research, training, construction and commodity support. In addition, A.I.D. conducts programs under the Agricultural Trade Development and Assistance Act of 1954 (Pub. L. 480) that are designed to combat hunger, malnutrition and to facilitate economic development. Assistance programs are carried out under the foreign policy guidance of the Secretary of State and in cooperation with the governments of sovereign states. Within this framework, it is A.I.D. policy to:

(1) Ensure that the environmental consequences of A.I.D.-financed activities are identified and considered by A.I.D. and the host country prior to a final decision to proceed and that appropriate environmental safeguards are adopted;

(2) Assist developing countries to strengthen their capabilities to appreciate and effectively evaluate the potential environmental effects of proposed development strategies and projects, and to select, implement and manage effective environmental programs;

(3) Identify impacts resulting from A.I.D.'s actions upon the environment, including those aspects of the biosphere which are the common and cultural heritage of all mankind; and

(4) Define environmental limiting factors that constrain development and identify and carry out activities that assist in restoring the renewable resource base on which sustained development depends.

(c) *Definitions.*—(1) *CEQ Regulations.* Regulations promulgated by the President's Council on Environmental Quality (CEQ) (Federal Register, Volume 43, Number 230, November 29, 1978) under the authority of NEPA and Executive Order 11514, entitled Protection and Enhancement of Environmental Quality (March 5, 1970) as amended by Executive Order 11991 (May 24, 1977).

(2) *Initial Environmental Examination.* An Initial Environmental Examination is the first review of the reasonably foreseeable effects of a proposed action on the environment. Its function is to provide a brief statement of the factual basis for a Threshold Decision as to whether an Environmental Assessment or an Environmental Impact Statement will be required.

(3) *Threshold Decision.* A formal Agency decision which determines, based on an Initial Environmental Examination, whether a proposed Agency action is a major action significantly affecting the environment.

(4) *Environmental Assessment.* A detailed study of the reasonably forseeable significant effects, both beneficial and adverse, of a proposed action on the environment of a foreign country or countries.

(5) *Environmental Impact Statement.* A detailed study of the reasonably foreseeable environmental impacts, both positive and negative, of a proposed

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1. Federal Register, 1980

A.I.D. action and its reasonable alternatives on the United States, the global environment or areas outside the jurisdiction of any nation as described in § 216.7 of these procedures. It is a specific document having a definite format and content, as provided in NEPA and the CEQ Regulations. The required form and content of an Environmental Impact Statement is further described in § 216.7 infra.

(6) *Project Identification Document (PID).* An internal A.I.D. document which initially identifies and describes a proposed project.

(7) *Program Assistance Initial Proposal (PAIP).* An internal A.I.D. document used to initiate and identify proposed non-project assistance, including commodity import programs. It is analogous to the PID.

(8) *Project Paper (PP).* An internal A.I.D. document which provides a definitive description and appraisal of the project and particularly the plan or implementation.

(9) *Program Assistance Approval Document (PAAD).* An internal A.I.D. document approving non-project assistance. It is analogous to the PP.

(10) *Environment.* The term environment, as used in these procedures with respect to effects occurring outside the United States, means the natural and physical environment. With respect to effects occurring within the United States see § 216.7(b).

(11) *Significant Effect.* With respect to effects on the environment outside the United States, a proposed action has a significant effect on the environment if it does significant harm to the environment.

(12) *Minor Donor.* For purposes of these procedures, A.I.D. is a minor donor to a multidonor project when A.I.D. does not control the planning or design of the multidonor project and either (i) A.I.D.'s total contribution to the project is both less than $1,000,000 and less than 25 percent of the estimated project cost, or (ii) A.I.D.'s total contribution is more than $1 000,000 but less than 25 percent of the estimated project cost and the environmental procedures of the donor in control of the planning of design of the project are followed, but only if the A.I.D. Environmental Coordinator determines that such procedures are adequate.

§ 216.2 Applicability of procedures.

(a) *Scope.* Except as provided in § 216.2(b), these procedures apply to all new projects, programs or activities authorized or approved by A.I.D. and to substantive amendments or extensions of ongoing projects, programs, or activities.

(b) *Exemptions.* (1) Projects, programs or activities involving the following are exempt from these procedures:

(i) International disaster assistance;

(ii) Other emergency circumstances; and

(iii) Circumstances involving exceptional foreign policy sensitivities.

(2) A formal written determination, including a statement of the justification therefore, is required for each project, program or activity for which an exemption is made under paragraphs (b)(1) (ii) and (iii) of this section, but is not required for projects, programs or activities under paragraph (b)(1)(i) of this section. The determination shall be made either by the Assistant Administrator having responsibility for the program, project or activity, or by the Administrator, where authority to approve financing has been reserved by the Administrator. The determination shall be made after consultation with CEQ regarding the environmental consequences of the proposed program, project or activity.

(c) *Categorical Exclusions.* (1) The following criteria have been applied in determining the classes of actions included in § 216.2(c)(2) for which an Initial Environmental Examination, Environmental Assessment and Environmental Impact Statement generally are not required;

(i) The action does not have an effect on the natural or physicial environment;

(ii) A.I.D. does not have knowledge of or control over, and the objective of A.I.D. in furnishing assistance does not require, either prior to approval of financing or prior to implementation of specific activities, knowledge of or control over, the details of the specific activities that have an effect on the physicial and natural environment for which financing is provided by A.I.D.;

(iii) Research activities which may have an affect on the physicial and natural environment but will not have a significant effect as a result of limited scope, carefully controlled nature and effective monitoring.

(2) The following classes of actions are not subject to the procedures set forth in § 216.3, except to the extent provided herein;

(i) Education, technical assistance, or training programs except to the extent such programs include activities directly affecting the environment (such as construction of facilities, etc.);

(ii) Controlled experimentation exclusively for the purpose of research and field evaluation which are confined to small areas and carefully .. onitored;

(iii) Analyses, studies, academic or research workshops and meetings;

(iv) Projects in which A.I.D. is a minor donor to a multidonor project and there is no potential significant effects upon the environment of the United States, areas outside any nation's jurisdiction or endangered or threatened species or their critical habitat;

(v) Document and information transfers;

(vi) Contributions to international regional or national organizations by the United States which are not for the purpose of carrying out a specifically identifiable project or projects;

(vii) Institution building grants to research and educational institutions in the United States such as those provided for under Section 122(d) and Title XII of Chapter 2 of Part I of the FAA (22 USCA §§ 2151 p. (b) 2220a. (1979));

(viii) Programs involving nutrition, health care or population and family planning services except to the extent designed to include activities directly affecting the environment (such as construction of facilities, water supply systems, waste water treatment, etc.)

(ix) Assistance provided under a Commodity Import Program when, prior to approval, A.I.D. does not have knowledge of the specific commodities to be financed and when the objective in furnishing such assistance requires neither knowledge, at the time the assistance is authorized, nor control, during implementation, of the commodities or their use in the host country.

(x) Support for intermediate credit institutions when the objective is to assist in the capitalization of the institution or part thereof and when such support does not involve reservation of the right to review and approve individual loans made by the institution;

(xi) Programs of maternal or child feeding conducted under Title II of Pub. L. 480;

(xii) Food for development programs conducted by food recipient countries under Title III of Pub. L. 480, when achieving A.I.D.'s objectives in such programs does not require knowledge of or control over the details of the specific activities conducted by the foreign country under such program;

(xiii) Matching, general support and institutional support grants provided to private voluntary organizations (PVOs) to assist in financing programs where A.I.D.'s objective in providing such financing does not require knowledge of or control over the details of the specific activities conducted by the PVO;

(xiv) Studies, projects or programs intended to develop the capability of recipient countries to engage in development planning, except to the extent designed to result in activities directly affecting the environment (such as construction of facilities, etc.); and

(xv) Activities which involve the application of design criteria or standards developed and approved by A.I.D.

(3) The originator of a project, program or activity shall determine the extent to which it is within the classes of actions described in paragraph (c)(2) of this section. This determination shall be made in writing and be submitted with the PID, PAIP or comparable document. This determination, which must include a brief statement supporting application of the exclusion shall be reviewed by the Bureau Environmental Officer in the same manner as a Threshold Decision under § 216.3(a)(2) of these procedures. Notwithstanding paragraph (c)(2) of this section, the procedures set forth in § 216.3 shall apply to any project, program or activity included in the classes of actions listed in paragraph (c)(2) of this section, or any aspect or component thereof, if at any time in the design, review or approval of the activity it is determined that the project, program or activity, or aspect or component thereof, is subject to the control of A.I.D. and may have a significant effect on the environment.

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(d) *Classes of Actions Normally Having a Significant Effect on the Environment.* (1) The following classes of actions have been determined generally to have a significant effect on the environment and an Environmental Assessment or Environmental Impact Statement, as appropriate, will be required:

(i) Programs of river basin development;

(ii) Irrigation or water management projects, including dams and impoundments;

(iii) Agricultural land leveling;

(iv) Drainage projects;

(v) Large scale agricultural mechanization;

(vi) New lands development;

(vii) Resettlement projects;

(viii) Penetration road building or road improvement projects;

(ix) Powerplants;

(x) Industrial plants;

(xi) Potable water and sewerage projects other than those that are small-scale.

(2) An Initial Environmental Examination normally will not be necessary for activities within the classes described in § 216.2(d), except when the originator of the project believes that the project will not have a significant effect on the environment. In such cases, the activity may be subjected to the procedures set forth in § 216.3.

(e) *Pesticides.* The exemptions of § 216.2(b)(1) and the categorical exclusions of § 216.2(c)(2) are not applicable to assistance for the procurement or use of pesticides.

§ 216.3 Procedures.

(a) *General Procedures*—(1) *Preparation of the Initial Environmental Examination.* Except as otherwise provided, an Initial Environmental Examination is not required for activities identified in § 216.2(b)(1), (c)(2), and (d). For all other A.I.D. activities described in § 216.2(a) an Initial Environmental Examination will be prepared by the originator of an action. Except as indicated in this section, it should be prepared with the PID or PAIP. For projects including the procurement or use of pesticides, the procedures set forth in § 216.3(b) will be followed, in addition to the procedures in this paragraph. Activities which cannot be identified in sufficient detail to permit the completion of an Initial Environmental Examination with the PID or PAIP, shall be described by including with the PID or PAIP: (i) an explanation indicating why the Initial Environmental Examination cannot be completed; (ii) an estimate of the amount of time required to complete the Initial Environmental Examination; and (iii) a recommendation that a Threshold Decision be deferred until the Initial Environmental Examination is completed. The responsible Assistant Administrator will act on the request for deferral concurrently with action on the PID or PAIP and will designate a time for completion of the Initial Environmental Examination. In all instances, except as provided in § 216.3(a)(7), this completion date will be in sufficient time to allow for the completion of an Environmental Assessment or Environmental Impact Statement, if required, before a final decision is made to provide A.I.D. funding for the action.

(2) *Threshold decision.* (i) The Initial Environmental Examination will include a Threshold Decision made by the officer in the originating office who signs the PID or PAIP. If the Initial Environmental Examination is completed prior to or at the same time as the PID or PAIP, the Threshold Decision will be reviewed by the Bureau Environmental Officer concurrently with approval of the PID or PAIP. The Bureau Environmental Officer will either concur in the Threshold Decision or request reconsideration by the officer who made the Threshold Decision, stating the reasons for the request. Differences of opinion between these officers shall be submitted for resolution to the Assistant Administrator at the same time that the PID is submitted for approval.

(ii) An Initial Environmental Examination, completed subsequent to approval of the PID or PAIP, will be forwarded immediately together with the Threshold Determination to the Bureau Environmental Officer for action as described above.

(iii) A Positive Threshold Decision shall result from a finding that the proposed action will have a significant effect on the environment. An Environmental Impact Statement shall be prepared if required pursuant to

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§ 216.7. If an impact statement is not required, an Environmental Assessment will be prepared in accordance with § 216.6. The cognizant Bureau or Office will record a Negative Determination if the proposed action will not have a significant effect on the environment.

(3) *Negative Declaration.* The Assistant Administrator, or the Administrator in actions for which the approval of the Administrator is required for the authorization of financing, may make a Negative Declaration, in writing, that the Agency will not develop an Environmental Assessment or an Environmental Impact Statement regarding an action found to have a significant effect on the environment when (i) a substantial number of Environmental Assessments or Environmental Impact Statements relating to similar activities have been prepared in the past, if relevant to the proposed action, (ii) the Agency has previously prepared a programmatic Statement or Assessment covering the activity in question which has been considered in the development of such activity, or (iii) the Agency has developed design criteria for such an action which, if applied in the design of the action, will avoid a significant effect on the environment.

(4) *Scope of Environmental Assessment or Impact Statement*—(i) *Procedure and Content.* After a Positive Threshold Decision has been made, or a determination is made under the presticide procedures set forth in § 216.3(b) that an Environmental Assessment or Environmental Impact Statement is required, the originator of the action shall commence the process of identifying the significant issues relating to the proposed action and of determining the scope of the issues to be addressed in the Environmental Assessment or Environmental Impact Statement. The originator of an action within the classes of actions described in § 216.2(d) shall commence this scoping process as soon as practicable. Persons having expertise relevant to the environmental aspects of the proposed action shall also participate in this scoping process. (Participants may include but are not limited to representatives of host governments, public and private institutions, the A.I.D. Mission staff and contractors.) This process shall result in a written statement which shall include the following matters:

(*a*) A determination of the scope and significance of issues to be analyzed in the Environmental Assessment or Impact Statement, including direct and indirect effects of the project on the environment.

(*b*) Identification and elimination from detailed study of the issues that are not significant or have been covered by earlier environmental review, or approved design considerations, narrowing the discussion of these issues to a brief presentation of why they will not have a significant effect on the environment.

(*c*) A description of (*1*) the timing of the preparation of environmental analyses, including phasing if appropriate, (*2*) variations required in the format of the Environmental Assessment, and (*3*) the tentative planning and decision making schedule; and

(*d*) A description of how the analysis will be conducted and the disciplines that will participate in the analysis.

(ii) These written statements shall be reviewed and approved by the Bureau Environmental Officer.

(iii) *Circulation of Scoping Statement.* To assist in the preparation of an Environmental Assessment, the Bureau Environmental Office may circulate copies of the written statement, together with a request for written comments, within thirty days, to selected federal agencies if that Officer believes comments by such federal agencies will be useful in the preparation of an Environmental Assessment. Comments received from reviewing federal agencies will be considered in the preparation of the Environmental Assessment and in the formulation of the design and implementation of the project, and will, together with the scoping statement, will be included in the project file.

(iv) *Change in Threshold Decision.* If it becomes evident that the action will not have a significant effect on the environment (i.e., will not cause significant harm to the environment), the Positive Threshold Decision may be withdrawn with the concurrence of the Bureau Environmental Officer. In the case of an action included in § 216.2(d)(2), the request for withdrawal shall be made to the Bureau Environmental Officer.

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(5) *Preparation of Environmental Assessments and Environmental Impact Statement.* If the PID or PAIP is approved, and the Threshold Decision is positive, or the action is included in § 216.2(d), the originator of the action will be responsible for the preparation of an Environmental Assessment or Environmental Impact Statement as required. Draft Environmental Impact Statements will be circulated for review and comment as part of the review of Project Papers and as outlined further in § 216.7 of those procedures. Except as provided in § 216.3(a)(7), final approval of the PP or PAAD and the method of Implementation will include consideration of the Environmental Assessment of final Environmental Impact Statement.

(6) *Processing and Review Within A.I.D.* (i) Initial Environmental Examinations, Environmental Assessments and final Environmental Impact Statements will be processed pursuant to standard A.I.D. procedures for project approval documents. Except as provided in § 216.3(a)(7), Environmental Assessments and final Environmental Impact Statements will be reviewed as an integral part of the Project Paper or equivalent document. In addition to these procedures, Environmental Assessments will be reviewed and cleared by the Bureau Environmental Officer. They may also be reviewed by the Agency's Environmental Coordinator who will monitor the Environmental Assessment process.

(ii) When project approval authority is delegated to field posts, Environmental Assessments shall be reviewed and cleared by the Bureau Environmental Officer prior to the approval of such actions.

(iii) Draft and final Environmental Impact Statements will be reviewed and cleared by the Environmental Coordinator and the Office of the General Counsel.

(7) *Environmental Review After Authorization of Financing.* (i) Environmental review may be performed after authorization of a project, program or activity only with respect to subprojects or significant aspects of the project, program or activity that are unidentified at the time of authorization. Environmental review shall be completed prior to authorization for all subprojects and aspects of a project, program or activity that are identified.

(ii) Environmental review should occur at the earliest time in design or implementation at which a meaningful review can be undertaken, but in no event later than when previously unidentified subprojects or aspects of projects, programs or activities are identified and planned. To the extent possible, adequate information to undertake deferred environmental review should be obtained before funds are obligated for unidentified subprojects or aspects of projects, programs or activities. (Funds may be obligated for the other aspects for which environmental review has been completed.) To avoid an irreversible commitment of resources prior to the conclusion of environmental review, the obligation of funds can be made incrementally as subprojects or aspects of projects, programs or activities are identified; or if necessary while planning continue, including environmental review, the agreement or other document obligating funds may contain appropriate convenants or conditions precedent to disbursement for unidentified subprojects or aspects of projects, programs or activities.

(iii) When environmetal review must be deferred beyond the time some of the funds are to be disbursed (e.g. long lead times for the delivery of goods or services), the project agreement or other document obligating funds shall contain a covenant or covenants requiring environmental review, including an Environmental Assessment or Environmental Impact Statement, when appropriate, to be completed and taken into account prior to implementation of those subprojects or aspects of the project, program or activity for which environmental review is deferred. Such convenants shall ensure that implementation plans will be modified in accordance with environmental review if the parties decide that modifications are necessary.

(iv) When environmental review will not be completed for an entire project, program or activity prior to authorization, the Initial Environmental Examination and Threshold Decision required under § 216.3(a)(1) and (2) shall identify those aspects of the project, program or activity for which

environmental review will be completed prior to the time financing is authorized. It shall also include those subprojects or aspects for which environmental review will be deferred, stating the reasons for deferral and the time when environmental review will be completed. Further, it shall state how an irreversible commitment of funds will be avoided until environmental review is completed. The A.I.D. officer responsible for making environmental decisions for such projects, programs or activities shall also be identified (the same officer who has decision making authority for the other aspects of implementation). This deferral shall be reviewed and approved by the officer making the Threshold Decision and the officer who authorizes the project, program or activity. Such approval may be made only after consultation with the Office of General Counsel for the purpose of establishing the manner in which conditions precedent to disbursement or covenants in project and other agreements will avoid an irreversible commitment of resources before environmental review is completed.

(8) *Monitoring.* To the extent feasible and relevant, projects and programs for which Environmental Impact Statements or Environmental Assessments have been prepared should be designed to include measurement of any changes in environmental quality, positive or negative, during their implementation. This will require recording of baseline data at the start. To the extent that available data permit, originating offices of A.I.D. will formulate systems in collaboration with recipient nations, to monitor such impacts during the life of A.I.D.'s involvement. Monitoring implementation of projects, programs and activities shall take into account environmental impacts to the same extent as other aspects of such projects, programs and activities. If during implementation of any project, program or activity, whether or not an Environmental Assessment or Environmental Impact Statement was originally required, it appears to the Mission Director, or officer responsible for the project, program or activity, that it is having or will have a significant effect on the environment that was not previously studied in an Environmental Assessment or Environmental Impact Statement, the procedures contained in this part shall be followed including, as appropriate, a Threshold Decision, Scoping and an Environmental Assessment or Environmental Impact Statement.

(9) *Revisions.* If, after a Threshold Decision is made resulting in a Negative Determination, a project is revised or new information becomes available which indicates that a proposed action might be "major" and its effects "significant", the Negative Determination will be reviewed and revised by the cognizant Bureau and an Environmental Assessment or Environmental Impact Statement will be prepared, if appropriate. Environmental Assessments and Environmental Impact Statements will be amended and processed appropriately if there are major changes in the project or program, or if significant new information becomes available which relates to the impact of the project, program or activity on the environment that was not considered at the time the Environmental Assessment or Environmental Impact Statement was approved. When on-going programs are revised to incorporate a change in scope or nature, a determination will be made as to whether such change may have an environmental impact not previously assessed. If so, the procedures outlined in this part will be followed.

(10) *Other Approval Documents.* These procedures refer to certain A.I.D. documents such as PIDs, PAIPs, PPs and PAADs as the A.I.D. internal instruments for approval of projects, programs or activities. From time to time, certain special procedures, such as those in § 216.4, may not require the use of the aforementioned documents. In these situations, these environmental procedures shall apply to those special approval procedures, unless otherwise exempt, at approval times and levels comparable to projects, programs and activities in which the aforementioned documents are used.

(b) *Pesticide Procedures*—(1) *Project Assistance.* Except as provided in § 216.3(b)(2), all proposed projects involving assistance for the procurement or use, or both, of pesticides shall be subject to the procedures prescribed in

§ 216.3(b)(1) (i) through (v) below. These procedures shall also apply, to the extent permitted by agreements entered into by A.I.D. before the effective date of these pesticide procedures, to such projects that have been authorized but for which pesticides have not been procured as of the effective date of these pesticide procedures.

(i) When a project includes assistance for procurement or use, or both, of pesticides registered for the same or similar uses by USEPA without restriction, the Initial Environmental Examination for the project shall include a separate section evaluating the economic, social and environmental risks and benefits of the planned pesticide use to determine whether the use may result in significant environmental impact. Factors to be considered in such an evaluation shall include, but not be limited to the following:

(a) The USEPA registration status of the requested pesticide;

(b) The basis for selection of the requested pesticide;

(c) The extent to which the proposed pesticide use is part of an integrated pest management program;

(d) The proposed method or methods of application, including availability of appropriate application and safety equipment;

(e) Any acute and long-term toxicological hazards, either human or environmental, associated with the proposed use and measures available to minimize such hazards;

(f) The effectiveness of the requested pesticide for the proposed use;

(g) Compatibility of the proposed pesticide with target and nontarget ecosystems;

(h) The conditions under which the pesticide is to be used, including climate, flora, fauna, geography, hydrology, and soils;

(i) The availability and effectiveness of other pesticides or nonchemical control methods;

(j) The requesting country's ability to regulate or control the distribution, storage, use and disposal of the requested pesticide;

(k) The provisions made for training of users and applicators; and

(l) The provisions made for monitoring the use and effectiveness of the pesticide.

In those cases where the evaluation of the proposed pesticide use in the Initial Environmental Examination indicates that the use will significantly effect the human environment, the Threshold Decision will include a recommendation for the preparation of an Environmental Assessment or Environmental Impact Statement, as appropriate. In the event a decision is made to approve the planned pesticide use, the Project Paper shall include to the extent practicable, provisions designed to mitigate potential adverse effects of the pesticide. When the pesticide evaluation section of the Initial Environmental Examination does not indicate a potentially unreasonable risk arising from the pesticide use, an Environmental Assessment or Environmental Impact Statement shall nevertheless be prepared if the environmental effects of the project otherwise require further assessment.

(ii) When a project includes assistance for the procurement or use, or both, of any pesticide registered for the same or similar uses in the United States but the proposed use is restricted by the USEPA on the basis of user hazard, the procedures set forth in § 216.3(b)(1)(i) above will be followed. In addition, the Initial Environmental Examination will include an evaluation of the user hazards associated with the proposed USEPA restricted uses to ensure that the implementation plan which is contained in the Project Paper incorporates provisions for making the recipient government aware of these risks and providing, if necessary, such technical assistance as may be required to mitigate these risks. If the proposed pesticide use is also restricted on a basis other than user hazard, the procedures in § 216.3(b)(1)(iii) shall be followed in lieu of the procedures in this section.

(iii) If the project includes assistance for the procurement or use, or both of:

(a) Any pesticide other than one registered for the same or similar uses by USEPA without restriction or for restricted use or the basis of user hazard; or

(b) Any pesticide for which a notice of rebuttable presumption against reregistration, notice of intent to cancel, or notice of intent to suspend has been issued by USEPA,

The Threshold Decision will provide for the preparation of an Environmental Assessment or Environmental Impact Statement, as appropriate (§ 216.6(a)). The EA or EIS shall include, but not be limited to, an analysis of the factors identified in § 216.3(b)(1)(i) above.

(iv) Notwithstanding the provisions of §§ 216.3(b)(1) (i) through (iii) above, if the project includes assistance for the procurement or use, or both, of a pesticide against which USEPA has initiated a regulatory action for cause, or for which it has issued a notice of rebuttable presumption against reregistration, the nature of the action or notice, including the relevant techni-

cal and scientific factors will be discussed with the requesting government and considered in the IEE and, if prepared, in the EA or EIS. If USEPA initiates any of the regulatory actions above against a pesticide subsequent to its evaluation in an IEE, EA or EIS, the nature of the action will be discussed with the recipient government and considered in an amended IEE or amended EA or EIS, as appropriate.

(v) If the project includes assistance for the procurement or use, or both of pesticides but the specific pesticides to be procured or used cannot be identified at the time the IEE is prepared, the procedures outlined in §§ 216.3(b)(i) through (iv) will be followed when the specific pesticides are identified and before procurement or use is authorized. Where identification of the pesticides to be procured or used does not occur until after Project Paper approval, neither the procurement nor the use of the pesticides shall be undertaken unless approved, in writing, by the Assistant Administrator (or in the case of projects authorized at the Mission level, the Mission Director) who approved the Project Paper.

(2) *Exceptions to Pesticide Procedures.* The procedures set forth in § 216.3(b)(1) above shall not apply to the following projects including assistance for the procurement or use, or both, of pesticides.

(i) Projects under emergency conditions.

Emergency conditions shall be deemed to exist when it is determined by the Administrator, A.I.D., in writing that:

(*a*) A pest outbreak has occurred or is imminent; and

(*b*) Significant health problems (either human or animal) or significant economic problems will occur without the prompt use of the proposed pesticide; and

(*c*) Insufficient time is available before the pesticide must be used to evaluate the proposed use in accordance with the provisions of this regulation.

(ii) Projects where A.I.D. is a minor donor, as defined in § 216.1(c)(12) above, to a multi-donor project.

(iii) Projects including assistance for procurement or use, or both, of pesticides for research or limited field evaluation purposes by or under the supervision of project personnel. In such instances, however, A.I.D. will ensure that the manufacturers of the pesticides provide toxicological and environmental data necessary to safeguard the health or research personnel and the quality of the local environment in which the pesticides will be used. Furthermore, treated crops will not be used for human or animal consumption unless appropriate tolerances have been established by EPA or recommended by FAO/WHO, and the rates and frequency of application, together with the prescribed preharvest intervals, do not result in residues exceeding such tolerances. This prohibition does not apply to the feeding of such crops to animals for research purposes.

(3) *Non-Project Assistance.* In a very few limited number of circumstances A.I.D. may provide non-project assistance for the procurement and use of pesticides. Assistance in such cases shall be provided if the A.I.D. Administrator determines in writing that (i) emergency conditions, as defined in § 216.3(b)(2)(i) above exists; or (ii) that compelling circumstances exist such that failure to provide the proposed assistance would seriously impede the attainment of U.S. foreign policy objectives or the objectives of the foreign assistance program. In the latter case, a decision to provide the assistance will be based to the maximum extent practicable, upon a consideration of the factors set forth in § 216.3(b)(1)(i) and, to the extent available, the history of efficacy and safety covering the past use of the pesticide the in recipient country.

§ 216.4 Private applicants.

Programs, projects or activities for which financing from A.I.D. is sought by private applicants, such as PVOs and educational and research institutions, are subject to these procedures. Except as provided in §§ 216.2 (b), (c) or (d), preliminary proposals for financing submitted by private applicants shall be accompanied by an Initial Environmental Examination or adequate information to permit preparation of an Initial Environmental Examination. The Threshold Decision shall be made by the Mission Director for the country to which the proposal relates, if the preliminary proposal is submitted to the A.I.D. Mission, or shall be made by the officer in A.I.D. who approves the preliminary proposal. In either case, the concurrence of the Bureau Environmental Officer is required in the same manner as in § 216.3(a)(2), except for PVO projects approved in A.I.D. Missions with total life of project costs

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less than $500,000. Thereafter, the same procedures set forth in § 216.3 including as appropriate scoping and Environmental Assessments or Environmental Impact Statements, shall be applicable to programs, projects or activities submitted by private applicants. The final proposal submitted for financing shall be treated, for purposes of these procedures, as a Project Paper. The Bureau Environmental Officer shall advise private applicants of studies or other information foreseeably required for action by A.I.D.

§ 216.5 Endangered species.

It is A.I.D. policy to conduct its assistance programs in a manner that is sensitive to the protection of endangered or threatened species and their critical habitats. The Initial Environmental Examination for each project, program or activity having an effect on the environment shall specifically determine whether the project, program or activity will have an effect on an endangered or threatened species, or critical habitat. If the proposed project, program or activity will have the effect of jeopardizing an endangered or threatened species or of adversely modifying its critical habitat, the Threshold Decision shall be a Positive Determination and an Environmental Assessment or Environmental Impact Statement completed as appropriate, which shall discuss alternatives or modifications to avoid or mitigate such impact on the species or its habitat.

§ 216.6 Environmental assessments.

(a) *General Purpose.* The purpose of the Environmental Assessment is to provide Agency and host country decision makers with a full discussion of significant environmental effects of a proposed action. It includes alternatives which would avoid or minimize adverse effects or enhance the quality of the environment so that the expected benefits of development objectives can be weighed against any adverse impacts upon the human environment or any irreversible or irretrievable commitment of resources.

(b) *Collaboration with Affected Nation on Preparation.* Collaboration in obtaining data, conducting analyses and considering alternatives will help build an awareness of development associated environmental problems in less developed countries as well as assist in building an indigenous institutional capability to deal nationally with such problems. Missions, Bureaus and Offices will collaborate with affected countries to the maximum extent possible, in the development of any Environmental Assessments and consideration of environmental consequences as set forth therein.

(c) *Content and Form.* The Environmental Assessment shall be based upon the scoping statement and shall address the following elements, as appropriate:

(1) *Summary.* The summary shall stress the major conclusions, areas of controversy, if any, and the issues to be resolved.

(2) *Purpose.* The Environmental Assessment shall briefly specify the underlying purpose and need to which the Agency is responding in proposing the alternatives including the proposed action.

(3) *Alternatives Including the Proposed Action.* This section should present the environmental impacts of the proposal and its alternatives in comparative form, thereby sharpening the issues and providing a clear basis for choice among options by the decision maker. This section should explore and evaluate reasonable alternatives and briefly discuss the reasons for eliminating those alternatives which were not included in the detailed study; devote substantial treatment to each alternative considered in detail including the proposed action so that reviewers may evaluate their comparative merits; include the alternative of no action; identify the Agency's preferred alternative or alternatives, if one or more exists; include appropriate mitigation measures not already included in the proposed action or alternatives.

(4) *Affected Environment.* The Environmental Assessment shall succinctly describe the environment of the area(s) to be affected or created by the alternatives under consideration. The descriptions shall be no longer than is necessary to understand the effects of the alternatives. Data and analyses in the Environmental Assessment shall be commensurate with the significance of the impact with less important material

summarized, consolidated or simply referenced.

(5) *Environmental Consequences.* This section forms the analytic basis for the comparisons under paragraph (c)(3) of this section. It will include the environmental impacts of the alternatives including the proposed action; any adverse effects that cannot be avoided should the proposed action be implemented; the relationship between short-term uses of the environment and the maintenance and enhancement of long-term productivity; and any irreversible or irretrievable commitments of resources which would be involved in the proposal should it be implemented. It should not duplicate discussions in paragraph (c)(3) of this section. This section of the Environmental Assessment should include discussions of direct effects and their significance; indirect effects and their significance; possible conflicts between the proposed action and land use plans, policies and controls for the areas concerned; energy requirements and conservation potential of various alternatives and mitigation measures; natural or depletable resource requirements and conservation potential of various requirements and mitigation measures; urban quality; historic and cultural resources and the design of the built environment, including the reuse and conservation potential of various alternatives and mitigation measures; and means to mitigate adverse environmental impacts.

(6) *List of Preparers.* The Environmental Assessment shall list the names and qualifications (expertise, experience, professional discipline) of the persons primarily responsible for preparing the Environmental Assessment or significant background papers.

(7) *Appendix.* An Appendix may be prepared.

(d) *Program Assessment.* Program Assessments may be appropriate in order to assess the environmental effects of a number of individual actions and their cumulative environmental impact in a given country or geographic area, or the environmental impacts that are generic or common to a class of agency actions, or other activities which are not country-specific. In these cases, a single, programmatic assessment will be prepared in A.I.D./Washington and circulated to appropriate overseas Missions, host governments, and to interested parties within the United States. To the extent practicable, the form and content of the programmatic Environmental Assessment will be the same as for project Assessments. Subsequent Environmental Assessments on major individual actions will only be necessary where such follow-on or subsequent activities may have significant environmental impacts on specific countries where such impacts have not been adequately evaluated in the programmatic Environmental Assessment. Other programmatic evaluations of classes of actions may be conducted in an effort to establish additional categorical exclusions or design standards or criteria for such classes that will eliminate or minimize adverse effects of such actions, enhance the environmental effect of such action or reduce the amount of paperwork or time involved in these procedures. Programmatic evaluations conducted for the purpose of establishing additional categorical exclusions under § 216.2(c) or design considerations that will eliminate significant effects for classes of actions shall be made available for public comment before the categorical exclusions or design standards or criteria are adopted by A.I.D. Notice of the availability of such document shall be published in the **Federal Register.** Additional categorical exclusions shall be adopted by A.I.D. upon the approval of the Administrator, and design consideration in accordance with usual agency procedures.

(e) *Consultation and Review.* (1) When Environmental Assessments are prepared on activities carried out within or focused on specific developing countries, consultation will be held between A.I.D. staff and the host government both in the early stages of preparation and on the results and significance of the completed Assessment before the project is authorized.

(2) Missions will encourage the host government to make the Environmental Assessment available to the general public of the recipient country. If Environmental Assessments are prepared on activities which are not country-specific, the Assessment will be circulated by the Environmental Coordinator to A.I.D.'s Overseas Missions and interested governments for information, guidance and comment and will be made available in the U.S. to

interested parties.

(f) *Effect in Other Countries.* In a situation where an analysis indicates that potential effects may extend beyond the national boundaries of a recipient country and adjacent foreign nations may be affected, A.I.D. will urge the recipient country to consult with such countries in advance of project approval and to negotiate mutually acceptable accommodations.

(g) *Classified Material.* Environmental Assessments will not normally include classified or administratively controlled material. However, there may be situations where environmental aspects cannot be adequately discussed without the inclusion of such material. The handling and disclosure of classified or administratively controlled material shall be governed by 22 CFR Part 9. Those portions of an Environmental Assessment which are not classified or administratively controlled will be made available to persons outside the Agency as provided for in 22 CFR Part 212.

§ 216.7 Environmental impact statements.

(a) *Applicability.* An Environmental Impact Statement shall be prepared when agency actions significantly affect:

(1) The global environment or areas outside the jurisdiction of any nation (e.g., the oceans);

(2) The environment of the United States; or

(3) Other aspects of the environment at the discretion of the Administrator.

(b) *Effects on the United States: Content and Form.* An Environmental Impact Statement relating to paragraph (a)(2) of this section shall comply with the CEQ Regulations. With respect to effects on the United States, the terms environment and significant effect wherever used in these procedures have the same meaning as in the CEQ Regulations rather than as defined in § 216.1(c) (12) and (13) of these procedures.

(c) *Other Effects: Content and Form.* An Environmental Impact Statement relating to paragraphs (a)(1) and (a)(3) of this section will generally follow the CEQ Regulations, but will take into account the special considerations and concerns of A.I.D. Circulation of such Environmental Impact Statements in draft form will precede approval of a Project Paper or equivalent and comments from such circulation will be considered before final project authorization as outlined in § 216.3 of these procedures. The draft Environmental Impact Statement will also be circulated by the Missions to affected foreign governments for information and comment. Draft Environmental Impact Statements generally will be made available for comment to Federal agencies with jurisdiction by law or special expertise with respect to any environmental impact involved, and to public and private organizations and individuals for not less than forty-five (45) days. Notice of availability of the draft Environmental Impact Statements will be published in the Federal Register. Cognizant Bureaus and Offices will submit these drafts for circulation through the Environmental Coordinator who will have the responsibility for coordinating all such communications with persons outside A.I.D. Any comments received by the Environmental Coordinator will be forwarded to the originating Bureau or Office for consideration in final policy decisions and the preparation of a final Environmental Impact Statement. All such comments will be attached to the final Statement, and those relevant comments not adequately discussed in the draft Environmental Impact Statement will be appropriately dealt with in the final Environmental Impact Statement. Copies of the final Environmental Impact Statement, with comments attached, will be sent by the Environmental Coordinator to CEQ and to all other Federal, state, and local agencies and private organizations that made substantive comments on the draft, including affected foreign governments. Where emergency circumstances or considerations of foreign policy make it necessary to take an action without observing the provisions of § 1506.10 of the CEQ Regulations, or when there are overriding considerations of expense to the United States or foreign governments, the originating Office will advise the Environmental Coordinator who will consult with Department of State and CEQ concerning appropriate modification of review procedures.

§ 216.8 Public hearings.

(a) In most instances AID will be able to gain the benefit of public par-

ticipation in the impact statement process through circulation of draft statements and notice of public availability in CEQ publications. However, in some cases the Administrator may wish to hold public hearings on draft Environmental Impact Statements. In deciding whether or not a public hearing is appropriate, Bureaus in conjunction with the Environmental Coordinator should consider:

(1) The magnitude of the proposal in terms of economic costs, the geographic area involved, and the uniqueness or size of commitment of the resources involved;

(2) The degree of interest in the proposal as evidenced by requests from the public and from Federal, state and local authorities, and private organizations and individuals, that a hearing be held;

(3) The complexity of the issue and likelihood that information will be presented at the hearing which will be of assistance to the Agency; and

(4) The extent to which public involvement already has been achieved through other means, such as earlier public hearings, meetings with citizen representatives, and/or written comments on the proposed action.

(b) If public hearings are held, draft Environmental Impact Statements to be discussed should be made available to the public at least fifteen (15) days prior to the time of the public hearings, and a notice will be placed in the FEDERAL REGISTER giving the subject, time and place of the proposed hearings.

§ 216.9 Bilateral and multilateral studies and concise reviews of environmental issues.

Notwithstanding anything to the contrary in these procedures, the Administrator may approve the use of either of the following documents as a substitute for an Environmental Assessment (but not a substitute for an Environmental Impact Statement) required under these procedures:

(a) Bilateral or multilateral environmental studies, relevant or related to the proposed action, prepared by the United States and one or more foreign countries or by an international body or organization in which the United States is a member or participant; or

(b) Concise reviews of the environmental issues involved including summary environmental analyses or other appropriate documents.

§ 216.10 Records and reports.

Each Agency Bureau will maintain a current list of activities for which Environmental Assessments and Environmental Impact Statements are being prepared and for which Negative Determinations and Declarations have been made. Copies of final Initial Environmental Examinations, scoping statements, Assessments and Impact Statements will be available to interested Federal agencies upon request. The cognizant Bureau will maintain a permanent file (which may be part of its normal project files) of Environmental Impact Statements, Environmental Assessments, final Initial Environmental Examinations, scoping statements, Determinations and Declarations which will be available to the public under the Freedom of Information Act. Interested persons can obtain information or status reports regarding Environmental Assessments and Environmental Impact Statements through the A.I.D. Environmental Coordinator.

(22 U.S.C. 2381; 42 U.S.C. 4332)

Dated October 9, 1980.

Joseph C. Wheeler,

Acting Administrator.

Important Changes in Regulation 16 [1]
Environmental Procedures

- Significant Effect 216.1(c)(11) - This term was not defined previously in the Regulations, but was perceived to include significant impacts on the environment, either adverse or beneficial. The Executive Order 12114, entitled Environmental Effects Abroad of Major Federal Actions, defined "significant effect" in the context of an action that does significant harm to the environment. A.I.D. has taken this definition from the Executive Order, believing it is not necessary to require by regulation, a formal environmental assessment in order to study more beneficial alternatives. Other A.I.D. studies conducted in the process of project selection and design are intended to accomplish that purpose.

- Categorical Exclusions 216.2(c) - Numerous specific activities have been excluded from the requirements of environmental review. (An IEE, EA or EIS are generally not required.) In addition, the three basic criteria used in determining these classes of actions are included in the regulations to assist activity originators in reaching decisions as to the extent any proposed activity is likely to have a significant adverse impact.

- Activities Requiring Environmental Analysis - 216.2(d) - For those activities listed, it is no longer necessary to prepare an Initial Environmental Examination. It has already been determined that there is sufficient likelihood of significant adverse impact to require an environmental assessment or impact statement. Since this is known as soon as the activity is proposed, an early examination of the likely consequences (Scoping) will permit the issues to be addressed during project design where alternatives can be appropriately considered.

- Use of Design Considerations - 216.2(c)(2)(xv) - The procedures now recognize the appropriateness of using design criteria for activities with predictable impacts or requiring a straight forward environmental review. This approach has potential for reducing paperwork while assuring environmental soundness. No design criteria are presently approved but the documentation for activities in rural roads, small scale irrigation, rural electrification,

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1. Printz, 1981.

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water supply and small industries has been readied for trial use. Other material is under preparation. The Office submitting the PID will make the Threshold Determination subject to the concurrence of the Bureau Environmental Officer.

- Delayed Environmental Review - 216.3(a)(1) and 216.3(a)(7)(i) Two additions were made to provide more flexibility in instances where insufficient information is known about the activity or its subparts at the time of the Initial Environmental Examination or project authorization. These procedures are quite specific and require consultation with the Bureau's Environmental Officer and in some situations, with the Office of the General Counsel.

- Scoping of Issues - 216.3(a)(4) - This concept is an adaptation of the approach required in U.S. Environmental Impact Statements by the regulations of the Council on Environmental Quality. Its purpose is to identify and focus on the important environmental issues and to eliminate from formal review, those that are not. This approach also encourages participation of local and host government expertise in the issue defining process. It is such a logical step in project formulation it is possible that it is already being followed in some Missions on major projects.

  The participation of local or host government expertise will provide an excellent opportunity to identify appropriate local individuals or organizations that can carry out the evaluations as part of the design effort. This approach is encouraged.

  The appropriate Bureau Environmental Officer will review and approve the resulting statement from the Scoping exercise and make a judgement regarding its circulation to other U.S. federal agencies for comment.

- Pesticide Use or Support - 216.3(b) - The only change to existing procedures was one of a technical nature. It is recommended however, that A.I.D. personnel once again review this part of the regulations. Experience has shown that the procedures are quite workable and present no impediment to project implementation. A.I.D. is encouraging other donor organizations to adopt similar reviews of requested chemicals before financing and will soon have available additional descriptions of this process and examples of how they have been applied effectively.

- Private Applicants - 216.4 - This section has been added to clarify the applicability of the procedures to programs supported by A.I.D. Note that the Bureau Environmental Officer has an approving role except for activities having life of project costs under $500,000.

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- Endangered Species - 216.5 - This section requires an EA whenever there are endangered species or habitat within the project area. Each Mission should, therefore, prepare an inventory of people or organizations in the country that might be knowledgeable about the existence and range of such species. This information may be difficult to document but needs to be pursued in connection with assistance projects, especially those which could have direct impacts on habitat (irrigation, resettlement, etc). Assistance should be sought from the Bureau Environmental Officer until more specific guidance and other materials can be provided to all Missions.

- Environmental Assessments -(EA) - 216.6 - The new format adopted from the CEQ regulations is intended to enhance the use of an EA for purposes of decision making. The EA will be analytic rather than encylopedic and focused on major issues derived from the Scoping statement. The procedures still encourage collaboration with the affected nation(s). Separate documents prepared by outside contractors in the style of U.S. Environmental Impact Statements are still permitted, but discouraged except in unusual circumstances. By following the elements of the EA described in this section, alternatives can be examined and consequences of actions presented as a component of the Project Paper, thus eliminating much of the duplication that occurs when assessments are prepared and presented as separate documents.

SECTION 10.3 - INITIAL ENVIRONMENTAL EXAMINATIONS (IEE)

General:

"A. The format of the [following IEE Guideline] was prepared as guidance to help focus on likely impacts; its use is not mandatory. If there are other checklists or summary techniques that better relate to the project under consideration, these should be used.

"B. The IEE for projects clearly having no significant impact on the natural and physical environment need consist only of simple factual information supporting that decision in the PID. A record of the environmental issues having been considered is needed but the checklist approach is unnecessary for obvious activities such as: training, research, food storage, fertilizer distribution improvement, family welfare centers, population planning, and etc.

"C. The identification of the important possible impacts at the PID and IEE stage will help determine the significance of likely impacts, the means by which any required assessment should be conducted, and keep the Assessment focussed on the principal issues. This 'Scoping' of principal issues can be done at the mission by staff and host country personnel having adequate diverse experience and backgrounds. Included for example, might be AID specialists in health, social science, agriculture or engineering collectively discussing the project with others knowledgeable of the countries' geology, forests, wildlife, fisheries, or archaeology. Other disciplines might be utilized wherever more appropriate.

"D. Decisions on the need for further environmental analysis are to be made on the basis of reasonably foreseeable impacts on the natural and physical environment as ideally determined by the process of 'C'. Likely social or economic impacts (e.g. expected future industrial growth in an area) in the absence of any direct significant impacts on the natural and physical environment from a project (e.g. none occurring from the upgrading of existing railroads alignments) do not usually lead to the need for an Assessment. If direct impacts are, however, significant enough to require an Assessment, any likely social and economic impacts must also be evaluated in the Assessment.

"E. If some likely environmental consequences are recognized in the IEE process, but an Assessment is not needed because the effect is not judged to be significant, the identified questions of impacts should still be addressed by someone with environmental expertise on the project design team, thus helping ensure a more sound project."[1]

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1. AID, 1979a, p.2-3.

INITIAL ENVIRONMENTAL EXAMINATION (IEE) GUIDELINE[1]

The following format should be used for the presentation of an Initial Environmental Examination (IEE):

Face Page, showing:

INITIAL ENVIRONMENTAL EXAMINATION

Project Location:

Project Title:

Funding (Fiscal Year and Amount):

Life of Project:

IEE Prepared by: Date:

Environmental Action Recommended:
(Environmental Assessment, Negative Determination, etc. Cite page where Recommendation for Environmental Action is fully stated in body of IEE.)

Concurrence: Date:
(By Mission Director or other appropriate official)

Assistant Administrator's/Director's Decision: Date:
(Approval/Disapproval of Environmental Action Recommended in the IEE. The Assistant Administrator/Director of the responsible Bureau or Independent Office reviews the IEE concurrently with the PRP or equivalent document.)

Contents of Initial Environmental Examination

I. Examination of Nature, Scope, and Magnitude of Environmental Impacts

Description of Project

Identification and Evaluation of Environmental Impacts
(See Impact Identification and Evaluation Form.)

II. Recommendation for Environmental Action

1. AID, 1976b.

Preparing the Examination of Nature, Scope, and Magnitude of Environmental Impact

A. Description of Project

The description of the project should include enough information to give readers a clear understanding of the proposed action and its relation to the environmental setting, which is not usually covered in the PRP. The location or the general area affected by the proposed action should be identified; and its major land and water forms, land use, population, and socioeconomic characteristics should be included in the description. Any special cultural features likely to be affected by the proposed action should be described. The description should be based on readily available maps and published information. Surveys and development of technical data for the specific project are not recommended for preparation of this section.

B. Identification and Evaluation of Environmental Impacts

1. General

The AID program represents a wide spectrum of activities, ranging from emergency assistance to longer-term assistance, from capital projects to technical assistance, from commodity assistance to training; etc. The characteristics of the project determine the kind and extent of environmental evaluation required.

All projects must undergo examination to identify the nature, scope, and magnitude of environmental impact. This examination will enable the reviewer to weigh relative effects on the environment and to arrive at a recommendation as to whether an Environmental Assessment or an Environmental Impact Statement is required or whether a Negative Determination is appropriate.

There are some AID projects which by their general nature ordinarily have little or no impact on the environment and therefore usually do not require the preparation of an Environmental Assessment (or an Environmental Impact Statement). These are:

- Education or training programs not directly affecting the environment

- Controlled experimentation exclusively for the purpose of research which is confined to small areas and carefully monitored

- Analyses, studies, academic or investigative research, workshops and meetings

IEE Guideline

- Projects where AID is a minor donor* to a multidonor project and there are no potential effects upon the environment of the U.S. or areas outside any nation's jurisdiction. (The determination of minor donor will have to be made on a case-by-case basis.)

- Document and information transfers

- Contributions to international, regional, or national organizations by the U.S. which are not for the purpose of carrying out a specifically identifiable project or projects

- Disaster and emergency relief activities

- U.S. institution-building grants, as provided for under Section 211(d) of the Foreign Assistance Act

- Program loans and other loans or grants to intermediate credit institutions and/or regional development banks, including financial transfer type projects, where the third party actions are unknown, nonspecific or lack significance in terms of their environmental impact

- Loans or grants for core support to private voluntary organizations and international or interregional organizations

On the other hand, some AID projects ordinarily will require preparation of an Environmental Assessment (or an Environmental Impact Statement). Examples are:

- Certain chemical programs, including those involving insecticides, herbicides, and rodenticides and other similar programs directed towards species suppression or genetic modification

- Certain large-scale, on-the-ground research activities such as pilot tests involving hazardous substances, large area land transformation, or extensive treatment of sizable areas

- Regional development programs that include comprehensive development plans and endorsement of specific work projects

- Irrigation systems designed to serve large areas

- New and rebuilt road systems or segments of systems, including improved but unpaved roads, and road maintenance and repair programs

*Minor Donor - AID is a minor donor for purposes of these Environmental Procedures when its total contribution to a multidonor project will not exceed $1,000,000 or 25% of the estimated project cost, provided, that AID does not, under the terms of the agreement governing its contribution, control the planning or design of the multi-donor project.

IEE Guideline

- Major public utilities and infrastructure such as dams, power plants, rural electrification, water supply and sanitary sewer systems

- Selected commodities when the end use is known

2. Use of Impact Identification and Evaluation Form

The attached Impact Identification and Evaluation Form is intended to help the person preparing the IEE to identify impacts that may be inherent in different kinds of projects. It has been devised to enable the reviewer not only to identify impact but also to allow for evaluation of the degree of impact. This form is not meant to be all-inclusive; impacts which are not included in the form but which are relevant because of particular environmental setting should be considered along with those highlighted in the form.

When identifying possible impacts suggested in the Impact Identification and Evaluation Form, it will be necessary to use information, technical and otherwise, that is readily available; to obtain host country expert opinion and participation, or other expertise if required; and to exercise reasonable judgment in impact identification.

In using the form, it is important to think in terms of <u>significant</u> effect. While it is difficult to state exactly what <u>significant</u> means, even in the U.S. context, it can be interpreted to mean "impacts that will result in important consequences or changes." It should be kept in mind that changes need not be large to be important and significant. It should also be noted that, even though there may be many beneficial impacts as a result of the project, a few significant adverse impacts could have serious or disadvantageous effect on the environment.

The Impact Identification and Evaluation Form should be cited in the section on Examination of Nature, Scope, and Magnitude of Environmental Impacts and should be attached as a reference.

Recommendation for Environmental Action

A. Recommendation for Threshold Decision

The completion of Section I of the IEE should establish the information needed and the basis on which to make a Threshold Decision. There are three recommendations that can be made, as follows:

IEE Guideline

1. That the project will not have a significant effect on the environment, and therefore a Negative Determination is appropriate. A Negative Determination, to repeat, is a formal written document based on a Threshold Decision that a proposed action is not a major action which will have a significant effect on the human environment and is, therefore, an action for which an Environmental Assessment or Environmental Impact Statement will not be required.

2. That the project will have a significant effect on the environment, and therefore an Environmental Assessment is required. An Environmental Assessment is a detailed study of the reasonably foreseeable environmental effects, both positive and negative, of a proposed action and its reasonable alternatives carried out within or affecting specific developing countries.

3. That the project will have a significant effect on the environment, and that an Environmental Impact Statement is required. This is appropriate for a project which will significantly affect:

- the global environment or areas outside the jurisdiction of any nation (e.g., the oceans);

- the environment of the United States; or

- as a matter of policy, other aspects of the human environment at the discretion of the Administrator.

While both beneficial and adverse impacts are to be considered in arriving at a recommendation, fundamentally it is adverse environmental impacts that indicate need for more careful study to assure that project design and implementation is done in such way as to eliminate or minimize them. It should be noted, however, that an Environmental Assessment (or Environmental Impact Statement) is required when significant impact is determined, regardless of whether the effects are presumed to be beneficial or adverse.

The reviewer should summarize the reasons leading to the recommendation. This summary, taken together with the completed Impact Identification and Evaluation Form (which includes a Discussion of Impacts), should fully justify the recommendation made.

If an Environmental Assessment or an Environmental Impact Statement is recommended, the reviewer should also provide the basis for its preparation. That is, he should recommend that the EA or EIS (1) should address in detail the implications of particular impacts and (2) should search for best solutions for minimizing or eliminating any adverse impacts inherent in the project.

IEE Guideline

In addition, if an EA or an EIS is recommended, the reviewer should discuss reasonable alternatives to the proposed action. Since all the parameters of a project are not established at the PID or PRP stage, alternatives will of necessity have to be viewed from a very broad standpoint. However, these should be pointed out to allow for their inclusion as a part of the EA or EIS.

B. The Use of Negative Declaration in Limited Cases

A Negative Declaration is an official written Agency decision made by an Assistant Administrator which states that the Agency will not develop an Environmental Assessment or an Environmental Impact Statement for an action which the Agency has identified [by an IEE] as being ordinarily covered by AID Environmental Procedures. The decision may be based on: (1) overriding considerations such as provision of disaster relief; (2) the fact that a substantial number of Environmental Assessments or Environmental Impact Statements relating to similar activities have been prepared in the past; or (3) the fact that the Agency has previously decided to prepare a programmatic Assessment or Statement covering the activity in question.

To further explain provision (3), the programmatic approach may be used for broad programs which include a variety of specific activities, or for certain types of projects which are generally applied on a regional and/or worldwide basis, when the environmental impacts of all the activities are substantially similar. Examples of activities which might be suitable for programmatic approach are: pest management programs which may be environmentally acceptable over a broad area or on a worldwide basis (an AID programmatic EIS is being prepared for this activity, 1976); large-scale development programs; fertility control programs; introduction of new crops; certain commodities.

A programmatic approach is useful in developing overall Agency policy regarding certain groups of activities and has the advantage of permitting the analysis of cumulative effects of a series or group of actions. The disadvantage may be lack of specificity when applied to individual country or program components. In general, the programmatic approach should be considered when initiating new programs, when making major changes in existing programs, or when major policy determinations are under study.

If a project lends itself to a programmatic approach and if a programmatic evaluation is being developed and will be applied to the project, a recommendation for a Negative Declaration is appropriate. The findings and recommendations of the programmatic EA or EIS must be included in the project design for the specific project. If for some reason the programmatic evaluation will not be made, separate evaluation for the project must of course be considered.

IEE Guideline

If a Negative Declaration is recommended, the reviewer should specify the basis for the decision, i.e. provision (1), (2), or (3); and he should provide ample explanation and justification in support of this choice.

Concurrence of Mission Director or Other Appropriate Official

The recommendation should have the concurrence of the Mission Director or other appropriate official. This should appear on the face page of the IEE.

Assistant Administrator's Decision

The Assistant Administrator of the responsible Bureau or the Director of the Independent Office will review the IEE concurrently with the PRP or equivalent document and will make the Threshold Decision (or Negative Declaration if applicable). A line for his decision (approval or disapproval of the environmental action recommended in the IEE) should be included on the face page.

It might be noted here that when preparation of an EA is recommended, the PRP or equivalent document, including the IEE, will be forwarded to other U.S. Federal agencies having an interest in the kinds of environmental impact involved. The reason for this is that these agencies may have technical expertise that could be helpful in advising on environmental evaluation. The appropriate Bureau or Independent Office will be responsible for circulation to other Federal agencies.

Attachment:
Impact Identification and Evaluation Form

1 1

IMPACT IDENTIFICATION AND EVALUATION FORM

Impact Areas and Sub-areas 1/	Impact Identification and Evaluation 2/
A. LAND USE	
1. Changing the character of the land through:	
a. Increasing the population	_____
b. Extracting natural resources	_____
c. Land clearing	_____
d. Changing soil character	_____
2. Altering natural defenses	_____
3. Foreclosing important uses	_____
4. Jeopardizing man or his works	_____
5. Other factors	
_____	_____
_____	_____
B. WATER QUALITY	
1. Physical state of water	_____
2. Chemical and biological states	_____
3. Ecological balance	_____
4. Other factors	
_____	_____
_____	_____

1/ See Explanatory Notes for this form.

2/ Use the following symbols:
N - No environmental impact
L - Little environmental impact
M - Moderate environmental impact
H - High environmental impact
U - Unknown environmental impact

---

1. AID, 1976 b.

IMPACT IDENTIFICATION AND EVALUATION FORM 2

C. ATMOSPHERIC

1. Air additives ---------- _____

2. Air pollution ---------- _____

3. Noise pollution ---------- _____

4. Other factors

_____ _____

_____ _____

D. NATURAL RESOURCES

1. Diversion, altered use of water ---------- _____

2. Irreversible, inefficient commitments ---------- _____

3. Other factors

_____ _____

_____ _____

E. CULTURAL

1. Altering physical symbols ---------- _____

2. Dilution of cultural traditions ---------- _____

3. Other factors

_____ _____

_____ _____

F. SOCIOECONOMIC

1. Changes in economic/employment patterns ---------- _____

2. Changes in population ---------- _____

3. Changes in cultural patterns ---------- _____

4. Other factors

_____ _____

_____ _____

IMPACT IDENTIFICATION AND EVALUATION FORM

Explanatory Notes [1]

The following is provided for guidance in completing this form.

I. Identification of Impacts

The human environment includes both natural and man-made environments. The Impact Identification and Evaluation Form is a checklist for identifying and measuring significant environmental impacts. Major areas of impact addressed are:

A. LAND USE

B. WATER QUALITY

C. ATMOSPHERIC

D. NATURAL RESOURCES

E. CULTURAL

F. SOCIOECONOMIC

G. HEALTH

H. GENERAL

Section IV below, Description of Possible Impacts, delineates the kinds of impacts that may be identified in each of these areas and their sub-areas. This Description is keyed by letter, number, and abbreviated title to the entries in the Impact Identification and Evaluation From.

This is not an exhaustive list of impacts. It should serve to highlight possible impacts and to stimulate identification of additional environmental impacts that may appear in particular projects or programs.

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1. AID, 1976 b.

II. Evaluation of Impacts

Each impact identified should also be evaluated. These evaluations will allow the reviewer to focus on the more significant environmental impacts. The gradings and symbols for impacts are:

N - No environmental impact

L - Little environmental impact

M - Moderate environmental impact

H - High environmental impact

U - Unknown environmental impact

An Unknown impact is one where no knowledge is at hand or available to make a determination; it is not to be used for an impact whose full extent may be difficult to measure.

It should be noted that impact evaluation is a judgmental process which should be made in view of all the relevant conditions and circumstances that surround the project.

III. Discussion of Impacts

A Discussion of Impacts section should be attached to the Impact Identification and Evaluation Form (this Discussion will be referred to in the body of the Initial Environmental Examination). In this section the reviewer should individually address each sub-area in which an environmental impact is identified or in which the impact is unknown. The information given should be germane and brief yet sufficient to indicate the basis on which each evaluation was made. Where the expected impacts are high, fuller discussion should be made.

Attention is drawn to the impacts listed in the last area, H. GENERAL. These are most important considerations and should be used in the analysis of every sub-area.

Some areas in the form overlap others. It is difficult to avoid this problem, which individually may be solved by appropriate cross-referencing of the discussions.

It should be stressed that the Impact Identification and Evaluation Form is simply a guide to identify environmental impacts of programs and projects and to allow the reviewer to indicate his evaluation of their degree of significance. The form should be used and expanded to meet the needs of individual program managers and analysts. On the basis of information developed by use of the form and amplified in the accompanying Discussion of Impacts, a Threshold Decision can be recommended.

IV. Description of Possible Impacts*

A. LAND USE

Land should be prudently used for the management and conservation of the resources needed for the health and safety of man. Alterations of land forms or depletion of some of their natural defenses often take place over a period of years; nature's reactions usually take even longer. Therefore, analyses of proper land use tend to stress the long-term considerations over the short-term.

Some lands are affected relatively rapidly and irreversibly by seemingly small changes in an ecosystem. These areas are the particularly fragile ones such as rain forests, islands, and coastal lands.

Almost every development involves some use of land. Strip mining clearly changes the shape of the land. Other actions appear to retain the character of the land yet can have far-reaching deleterious effects. Therefore analysts should look into the role land plays in contributing to or conserving the health of a people or an area. Some of the land-use environmental impacts may involve:

1. Changing the character of the land through:

a. Increasing the population of people or animals in an area. Stress is put on the land through additional requirements for water, waste-disposal facilities, use of ground cover by grazing animals, roads, agricultural land, abodes, and a varied number of community services such as power and sanitation.

b. Extracting natural resources such as minerals or water. The baring of land for minerals can cause high erosion; moreover, the process water used in many mining operations can result in the discharge of volumes of highly acidic or alkaline waters, and of heavy metals. These discharges can pollute surface and ground waters, and prevent for a long period the use of any "downstream" land for agricultural purposes. The extraction of water from wells can lower the water table, causing subsidence of the land or, if the area is near the sea, salt water intrusion--i.e., salt water mixing with fresh to yield a brackish drinking or irrigating water.

c. Land clearing. The removal of ground cover takes place through almost every use of land. In addition to the impacts already noted, special problems may exist in tropical areas; for example, the clearing away of a tropical forest often reveals infertile soil, which is almost impossible to cultivate more than a season or two even with the help of fertilizers.

*These are not listed in order of precedence.

d. Changing the character of the soil. Slash-and-burn agriculture can destroy the replenishments of nutrients to the soil. Irrigation water can leach out needed trace elements in the soil. Erosion can take away the topsoil and increase a population's encroachment on forested areas. Overgrazing can remove ground cover, which in an arid and infertile area might never recover and lead to desertification.

2. Altering some of the significant natural defenses provided by an area. A wooded area such as a forest prevents flooding of lower or adjacent areas. Sand dunes and their grasses help maintain the stability of the landward areas. Long reaches of beach lessen the impact of the sea on the land; coral reefs act the same way. Mangrove forests prevent the sea from claiming more land; in fact, such forests build land.

Trying to stem some of the actions of nature could exacerbate a situation: groins built to maintain a beach could denude others; seawalls or breakwaters sometimes hasten shore erosion, or prevent the building of land on the leeward side of a barrier island or spit. Moreover, a mountain road poorly designed can direct waters from a flash storm in flood volume into lower lands or valley; or can take away just enough ground cover from the side of the mountain to cause erosion of the lower portion of the land.

3. Foreclosing important and perhaps better uses of the land. Scarce agricultural land may be flooded by a dam or partially lost to a roadway or airport. A marshland or mangrove lagoon, which are spawning grounds for many fish, may be filled for land developments. Other habitats for animals or other organisms which are used for food or are members of endangered species of worldwide importance may be destroyed. An aquifer recharge area may be eliminated by developments that could be put elsewhere.

4. Jeopardizing man or his works because either is put into a zone of potential disaster. A development may be planned for a flood-plain, near an active volcano, in an earthquake area, in the path of frequent typhoons or hurricanes, or in an area subject to locust or other plagues. The foregoing are natural disaster areas. There are also potential man-made disaster areas where land may be in the path of a weakly built dam, or an increasing load of water pollution.

5. Other factors. (Please describe and evaluate.)

v

B. WATER QUALITY

Water is the solvent for many of man's waste products. It also is the vehicle for growth of all life on this planet.

The use of water for public water supplies, agricultural waters, industrial water supplies, recreational tourism, and as media for fishing and transportation depends intimately on the chemical, biological and physical states of the water. Overloading the capacity of water to absorb waste products, or altering its composition, will affect man's ability to use the water, sometimes critically. The impacts may involve:

1. Changing the physical state of the water. Increased siltation or sediment loads change the physical state of water. Activities bringing this about include: erosion runoff from new roads or near shore construction sites or resulting from deforestation or removal of ground cover; irrigation projects; dredging; discharge of solid wastes from processors such as sugar mills, pulp mills, refineries, steel mills, and such.

Changing the physical state of a water body usually changes the chemical and biological states; when sediments lessen the amount of light that penetrates a water body, photosynthesis is slowed down or stopped, thereby altering the ecological balance of the water body and bringing about associated biological and chemical changes.

Raising the temperature of receiving waters, say by the effluent of an electricity generating plant, changes the physical state of water. Similarly, dumping solid wastes such as construction debris will bring physical changes to a water body, as will the discharge of sewage sludge and garbage.

2. Changing the chemical or biological states of the water. A pollutant by definition causes deleterious changes in the state of water, usually of a chemical or biological nature. Pollution is introduced by sewage, leaking septic tanks, animal wastes washed into a stream or percolating into ground water, fertilizer similarly finding its way into ground or surface waters, and herbicides and pesticides contaminating the same waters.

Other sources of water pollution may stem from industrial discharges of wastes directly into surface waters, or into ground waters by injection of the wastes into deep wells or by allowing the wastes to seep down to the ground waters; spills or leaks of toxic materials such as oil; and the leaching into waters of accumulated salts from dumps and landfills, or from other substances subject to the dissolving power of the rain.

Even the dumping of wastes seemingly far from any influence on the shorelands can, through unfortunate currents, bring some of the pollutants back to the land.

3. Changing the ecological balance of a water body, thereby changing its chemical and biological balance. For example, implanting alien organisms into a water body can bring about profound changes in that body: Newly introduced plant forms could proliferate and clog or eventually eutrophy a waterway; the addition of some predator fish could destroy the population of less aggressive fish which in turn might have kept an insect population under control.

Introducing toxics into a water body, especially a small one, could destroy much of the life there. Similarly, a habitat or ecosystem would be altered forever through land reclamation; e.g., by filling a swamp or marshland. These areas might be the feeding and nesting places for fish and animals which may play an essential part in the ecology of the region; these areas might also be one of the natural defenses of the area, such as a mangrove swamp.

4. Other factors. (Please describe and evaluate.)

C. ATMOSPHERIC

Airborne pollutants and some allegedly benign additives in sufficient concentrations and quantities can harm and destroy animal and vegetable life and cultural artifacts such as buildings, tapestries, and statues. In addition, airborne pollutants can alter the chemical characteristics of rain. Moreover, air pollution, by changing the reflectivity (albedo) of the atmosphere, can modify the weather and even climate of an area and possibly make the area more arid. Other intrusions into the atmosphere such as high levels of noise can modify and destroy a human community or a wildlife habitat.

Accordingly, atmospheric impacts may be grouped as follows:

1. Air additives. Spraying of herbicides and pesticides into the air--from aircraft or land-based dispensers--can harm or destroy life other than that targeted. Moveover, the additives can affect ground and surface waters, and eventually become concentrated in fish and thus in man in areas many miles from the source of spraying.

2. Air pollution. Particles and gases that can cause pollution may enter the atmosphere through industrial processes, engine exhausts, and the burning of solid wastes. Major air pollutants include: suspended particulates such as dust, pollen, ash, soot, metals, and various chemicals; sulfur dioxide; carbon monoxide, nitrogen dioxide; hydrocarbons; and the photochemical oxidants that are generated by the action of sunlight on chemical precursors.

120'

The effects of these pollutants include the aggravation of respiratory and cardiovascular diseases, reduced growth of plants and premature drop of their fruit and leaves, and the deterioration of building materials and other surfaces.

A particularly hazardous air pollution comes from the generation of dust during an industrial, construction, or mining process where workers are not protected from the particulates. In these instances, severe occupational diseases can be anticipated.

3. Noise pollution. Excessive noise—that is, noise that can impair hearing and some bodily and psychological functions, may be introduced by an industrial process or by vehicles. A riveting machine and a nearby jet plant takeoff make about the same painful noise; a heavy truck and a pneumatic drill make highly discomforting noise, about the same as a New York subway train pulling into a station.

4. Other factors. (Please describe and evaluate.)

D. NATURAL RESOURCES

Exploitable natural resources are those that can be taken from the sea, from the surface of the land or from beneath the ground, or extracted from the atmosphere. A major consideration from a community's viewpoint is the benefit expected from exploiting one of its natural resources. However, another consideration becomes one of determining the environmental effects of the resource's removal or diversion.

Natural resource environmental impacts may come from:

1. Diversion, storage or increased use of water. Dams, irrigation systems, watercourse diversion or channelization can profoundly affect people, animals, and other organisms that depended on the original sources of water. Entire species of organisms, and others that depended on them, could be harmed or destroyed. At the same time, other less desirable species could be encouraged. Far-reaching effects include the erosion of land, the spreading of desert lands, and the dissemination of diseases such as schistosomiasis.

2. Irreversible or inefficient commitments of natural resources. A plentiful natural resource might be taken without foreknowledge of the ecological role it plays. For example, sand might be extracted offshore without the realization that this sand may replenish a downstream beach; thus, a coastal area could be left defenseless. Precious coral could be extracted by primitive dredging methods, thereby destroying future crops and possibly a new industry. Animals such as goats or sheep could be released for pasture in an isolated area only to result in the destruction of the ground cover and also other perhaps

valuable life there. Forests could be cut down for pulp without the realization of the role the forests may play in stemming floods, in protecting animal life, in storing water in a landform possibly adaptable for the hydroelectric generation of power.

3. Other factors. (Please describe and evaluate.)

E. CULTURAL

An activity may depreciate or seriously harm the culture or cultural heritage of a people. Culture may be defined in terms of the values a people hold, the consequent behavior patterns the people follow, and the knowledge and beliefs they have distilled from their forebears. Evidences of culture may be ensconced in (1) sacred or otherwise important waters and lands, historic and archeological sites, buildings and other artifacts, or other physical symbols; or in (2) a people's mythology, lore, ethics, history, teachings, activities, ethnology.

There are international conventions that now exist dealing with protection of the world cultural and natural heritage and with protection of endangered species. These conventions will ultimately indicate in each of the signatory countries those cultural and natural heritages and endangered species that need protection. Host country experts who are now a part of these activities should be consulted to obtain their views on possible impacts in this area.

Cultural impacts, although often subtle, can be pervasive and may involve:

1. Altering or destroying important physical symbols of a culture; e.g., monuments, sacred ground, ancient shrines, etc.

2. Diluting a culture, possibly through methods such as introducing alien cultures, or dispersing or otherwise adulterating the indigenous culture. For example, a forced mixture of populations could introduce alien ideas, as perhaps could direct TV broadcasts containing culturally erotic material. Resettlement of a population could break important cultural ties and thereby weaken a society dependent on site and on historic leaders.

It is recognized that cultural impacts and changes may be critically needed to help conserve the society.

3. Other factors. (Please describe and evaluate.)

F. SOCIOECONOMIC

Socioeconomic impacts arise out of the striving of a people to earn a livelihood and to achieve a quality of life that provides a measure of food, housing and health. Thus, socioeconomic impacts may involve:

1. Changes in patterns of economic growth and employment. For example, a labor-intensive industry may move into a rural area because of the training and cheapness of labor there; or move out because these attributes of labor are offered elsewhere. Marginal agricultural land may be brought into production, bringing with it not only increased employment but also increased need for services such as water and roads. A marginal mineral deposit may be found whose exploitation could change the socioeconomic pattern of the area.

The factors that bring about economic changes are endless but often highly significant in socioeconomic impact analyses.

2. Movement, resettlement, or changes in population. This element is related to the use of land and community services, but the stress here is on the extent of change expected in the socioeconomic relationships among the people and between the people and their community.

3. Changes in cultural patterns that could affect socioeconomic patterns in a major way. For example, the persuasion of women to work, or the removal of children from the labor market would affect family income and relationships. Similarly, the eating of healthful but formerly taboo foods, which may be plentiful, or of unfamiliar food additives such as fish protein concentrate, could have large quality-of-life impacts on a people.

4. Other factors. (Please describe and evaluate.)

G. HEALTH

Impacts related to health broadly pertain to man and to the organisms and environments needed in large diversity and profusion to sustain man on the planet. These impacts may involve:

1. Altering or destroying a natural environment. Such changes coul' come about through the addition of chemicals to an environmental system to get rid of selected vectors of disease. For example, a copper compound can be added to a fresh water body to poison the int mediate (snail) host of schistosomiasis, but the poison will also kill other organisms. Similarly a larvacide could be used to help

eliminate the onchocerciasis (River Blindness) vector. Bush clearing or barricades could be used to destroy a tsetse fly colony but at the same time could jeopardize other organisms.

2. Eliminating an element in an ecosystem. The killing of coyotes to prevent crop destruction could give rise to the proliferation of the rodents that coyotes feed on. The destruction of mangroves to eliminate mosquitoes and other pests could give rise to the destruction by wave action of a coastline (see Item A2).

3. Other factors. (Please describe and evaluate.)

H. GENERAL

Some impacts are of overriding international interest and concern. Others, while not immediately apparent, may accrue to an overall program of which the proposed activity is a part, or an early step. Thus, general impacts may involve:

1. Activities that will affect the United States or other nations, directly or indirectly, now or at some later time. The agent for such impacts could be the ocean, the atmosphere, or carriers such as man, birds, or other organisms.

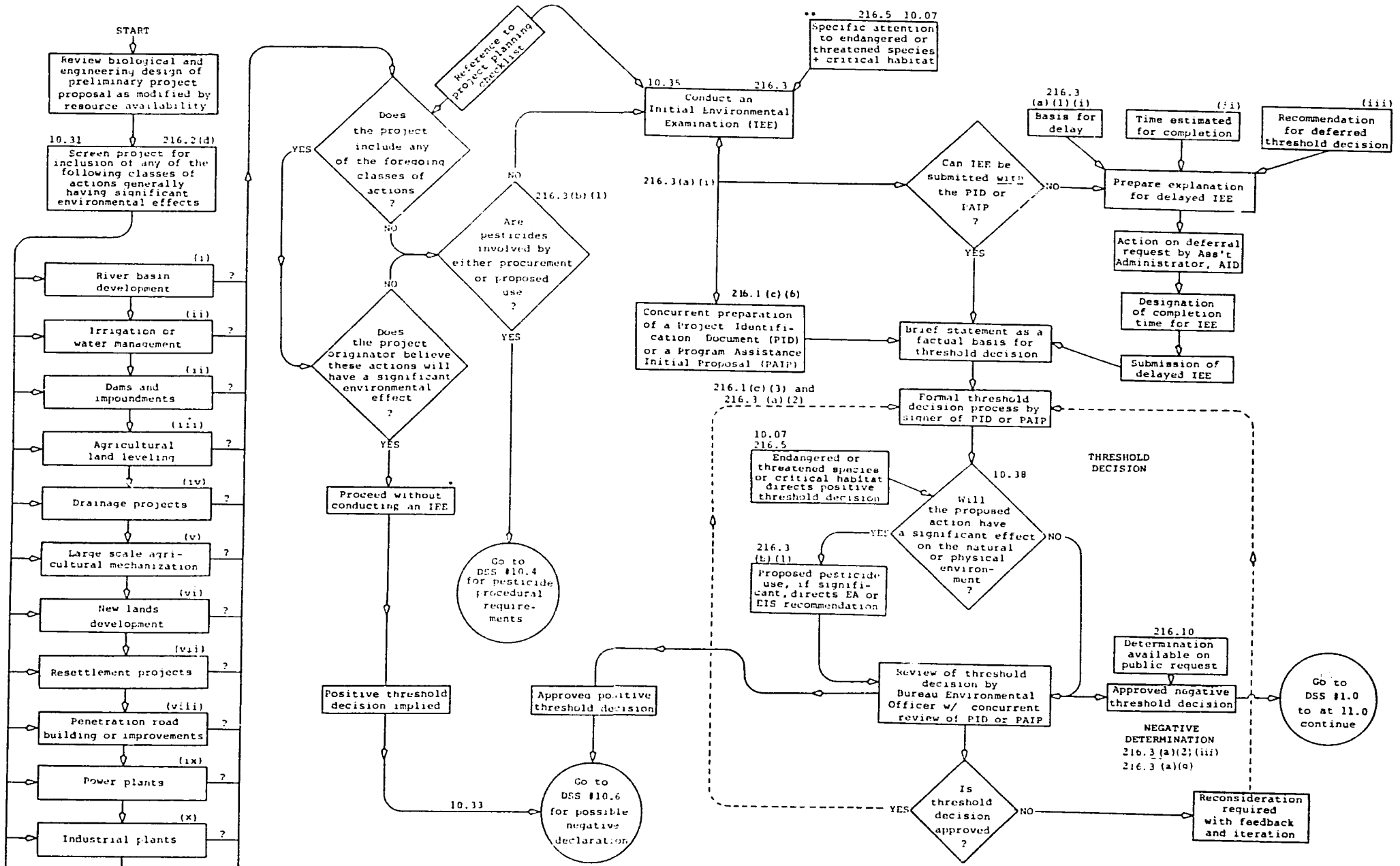
2. Activities that are matters of controversy locally, nationally, or globally.

3. Activities that are part of a larger program, or intended to be part of a larger program, whose total effect would require an appraisal of environmental impacts. If the activity fits this category, then use the present form for the appraisal of the entire and overall program.

4. Other factors. (Please describe and evaluate.)

Conduct an Initial Environmental Examination (IEE) and Threshold Decision (Requirement and Procedures)

D. S. S. #10.3



*Proceed with scoping process as soon as practible (See D.S.S.#10.7 and 216.3(a)(4))

** See Manual text section 10.35 for IEE procedure, including impact identification and evaluation form, guideline, and format.

This algorithm is interpretive of the October 23, 1980, revision of the Environmental Procedures for AID, Paragraphs 216.2(d), 216.3(a)(1) & (2), and 216.10, 22 CFR Part 216.

SECTION 10.38 - THRESHOLD DECISION

General:

The environmental threshold decisions, as specified in Regulation 16 (215.1(c)(3) and 216.3(b) and (c), are actions to be taken early in program planning. These decisions are made on the basis of Initial Environmental Examinations (IEE) which are to reveal whether or not any proposed program action would be likely to have a significant effect on the human environment. They are therefore very important in recognizing the environmental responsibility and liability of the program and need to be well documented (see the sample form which follows).

Detailed plans and procedures for environmental surveys are given under Chapter 11 - Selection of Primary Anopheline Control Methodologies and in the corresponding Guidebook Section 11.

Whenever, in either planning or operations, a new policy or procedure is selected, the program manager should, as emphasized in Section 10.0 under Use of Algorithms, run an iteration of these threshold procedures to see if such decisions are needed.

ENVIRONMENTAL THRESHOLD PROCEDURE

POLICY ASSUMPTIONS

1. All projects (plans, actions proposed and carried out) are to be in compliance with Federal Regulation No. 16.

2. AID's Manual of the Programmatic Environmental Assessment of Malaria Control Programs, specifically Chapter 10, shall be used as the guide for compliance with Regulation 16.

3. The procedures for carrying out Initial Environmental Assessments are set forth in the Manual under Chapter 11 - Selection of Primary Control Methodologies, illustrated by algorithms which should be used to check off the progress and course of the procedures. Copies of these algorithms with routes and completion dates may accompany the IEE Report.

4. Compliance with these procedures should result in a Negative Determination for all but the most unusual circumstances.

5. Such exceptions as may occur require a detailed Environmental Assessment (EA), under which resulting program revisions would ordinarily merit the project a Negative Determination or Negative Declaration in a second Threshold Decision.

6. For all but the most unusual malaria programs planned in accordance with the Manual, an Environmental Impact Statement (EIS) would not be considered necessary.

   Outside consultation on project plans, management and staffing, and re-assessment of cost/risk/benefit factors should be contemplated if an EIR is indicated.

7. The project should continue the environmental assessment as the control program gets underway, and use monitoring to determine the continuing validity of the assumptions made under the Initial Environmental Examination in order to keep the program within compliance with Federal Regulation 16.

U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT

i

OFFICE OF HEALTH

MALARIA PROGRAMS

ENVIRONMENTAL THRESHOLD PROCEDURE

PART I. Project Identification* Project No._____

Title:

Location:

Current Status:

Project Elements and Proposed Actions with Environmental Significance:
(List of Control Procedures)

☐ Preliminary Project Proposal has been submitted as of _____.

☐ Pre-Audit (Manual Chapter 1) has been conducted.**

Exceptions:

Comment:

For the Project:_____

Position and Unit:_____

Date and Place:_____

---

* Attach written description of project, complete with maps.

** AID Programmatic Environmental Assessment Manual, 1981.

PART II. Determination of Foreseeable Environmental Effects

☐ An Initial Environmental Examination (IEE) has been conducted and submitted for the Project in accordance with Manual Chapter 11, to determine the effects of those Project actions listed under Part I and the significance and magnitude of each such effect. Exceptions are:

☐ The findings of the ITT for this Project have been evaluated by cost/risk/benefit criteria, and also, where appropriate, enhancements and mitigations of environmental factors have been proposed, with the following exceptions:

Comment:

☐ Report submitted_____by_____

☐ Attached

For the Program_____

Position and Unit_____

Date and Place_____

PART III. Recommendation for Environmental Threshold Decision

The determination of the environmental effects of proposed actions under this project (Part II) have been found to fall within the acceptable parameters for AID Malaria Control Programs (Manual Chapter 11), and also such enhancements and mitigations as have been proposed are feasible, with the following exceptions:

Comment:

Recommendation (Manual Chapter 10)

- ☐ A Negative Determination be approved for this project.
- ☐ An Environmental Assessment (EA) be conducted.
- ☐ An Environment Impact Statement (EIS) be prepared.
- ☐ A Negative Declaration be approved for this project.

Comment:

For the Program_____

Position and Unit_____

Date and Place_____

PART IV. Decision on the Environmental Threshold

Based upon the Determination (Part II) and Recommendation (Part III) set forth for this Project, I/we hereby approve the following threshold decision:

with these exceptions:

Comment:

Compliance of all parts of this procedural document with the Manual provides adequate environmental safeguards for the preliminary planning stages and initiation of the Project.

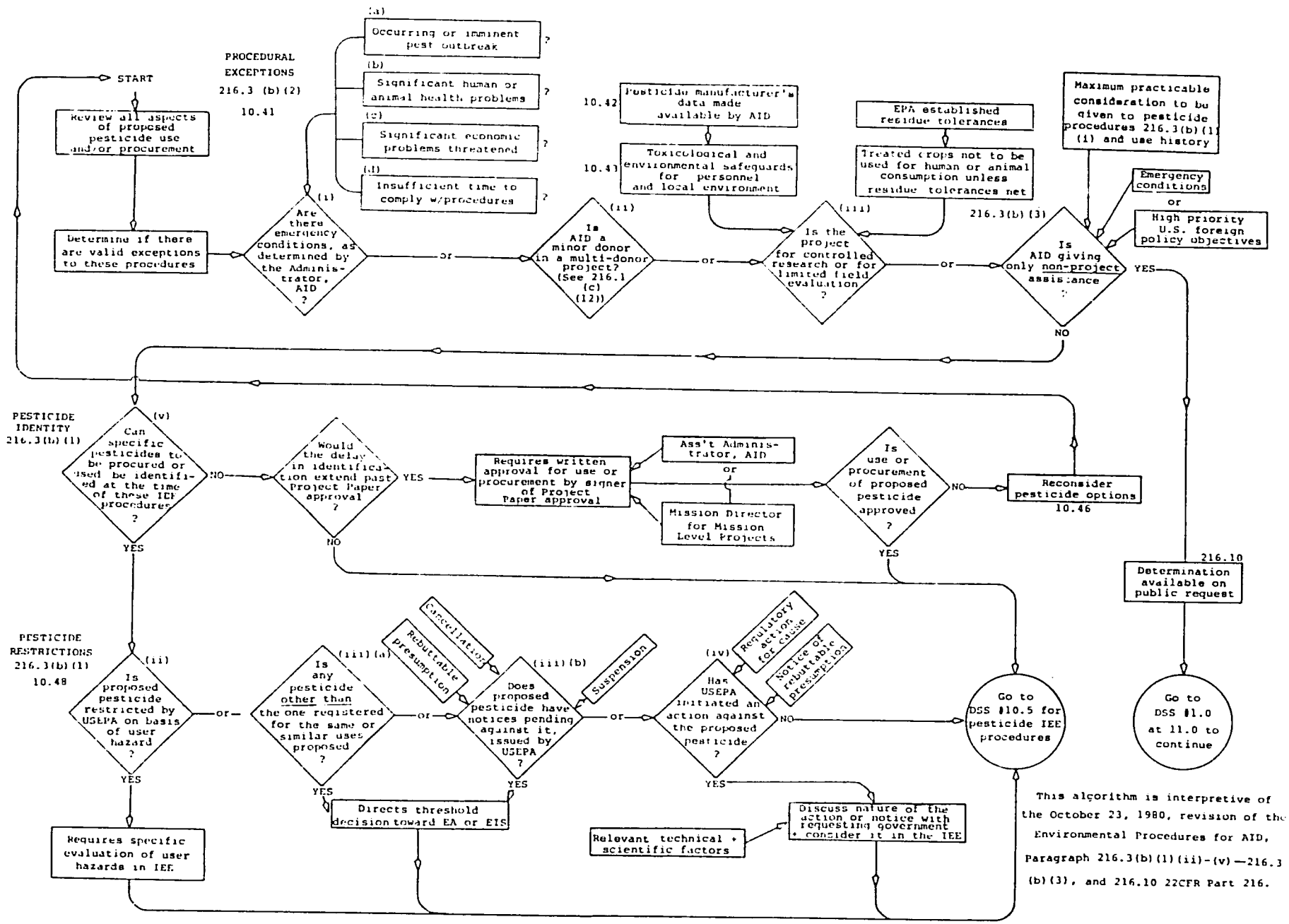
For the Program_____

Position and Unit_____

Date and Place_____

(In the completion of this document, note the accompanying policy statements, and follow the procedures set forth in the AID Manual for the Programmatic Environmental Assessment of Malaria Programs, 1981)

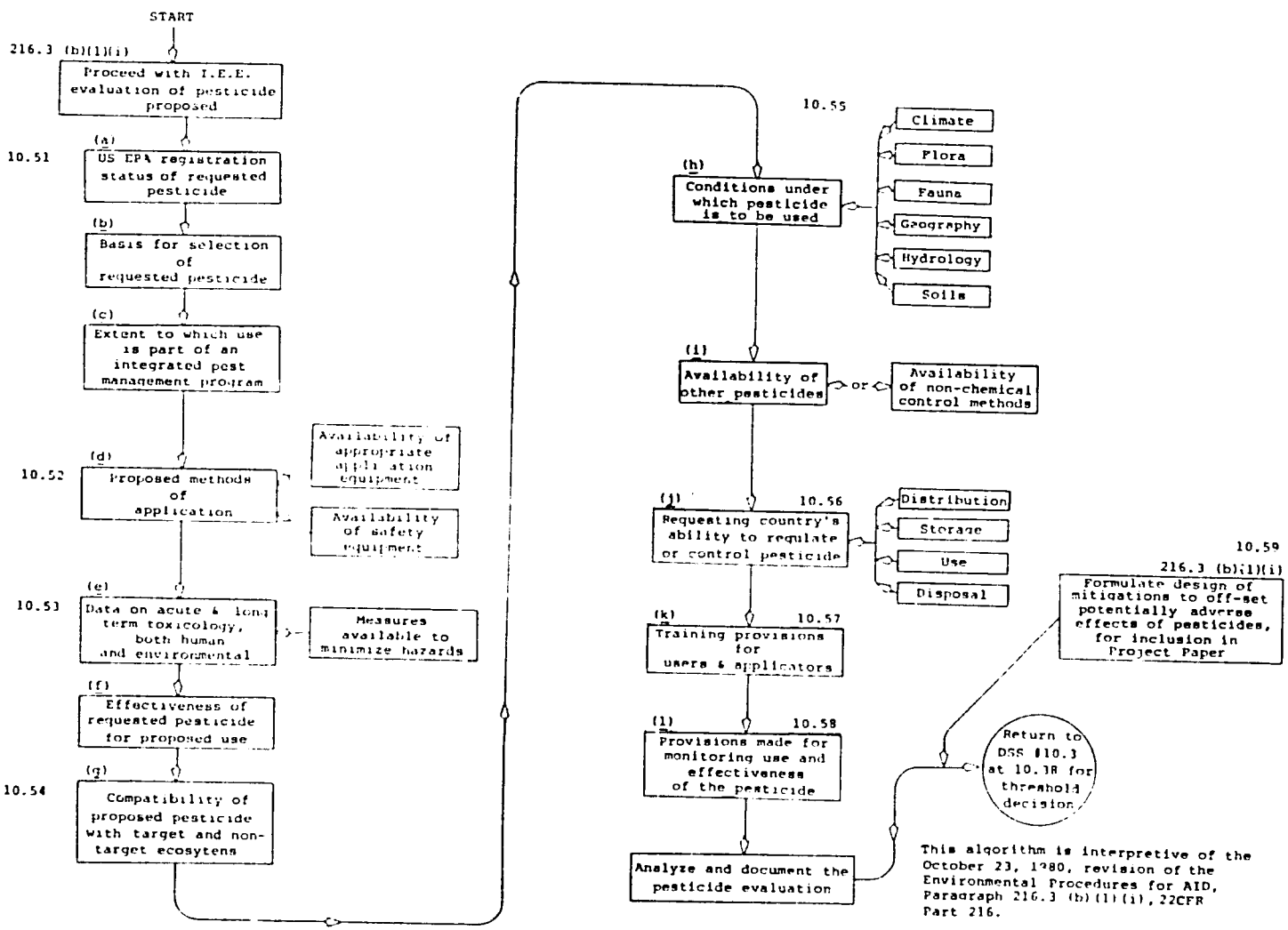
Determine the Procedural Requirements Prior to Conducting an Initial Environmental Examination (IEE) for Proposed Pesticide



This algorithm is interpretive of the October 23, 1980, revision of the Environmental Procedures for AID, Paragraph 216.3(b)(1)(ii)-(v)—216.3 (b)(3), and 216.10 22CFR Part 216.

Conduct an Initial Environmental Examination (IEE) for the Use or Procurement of a Proposed Pesticide

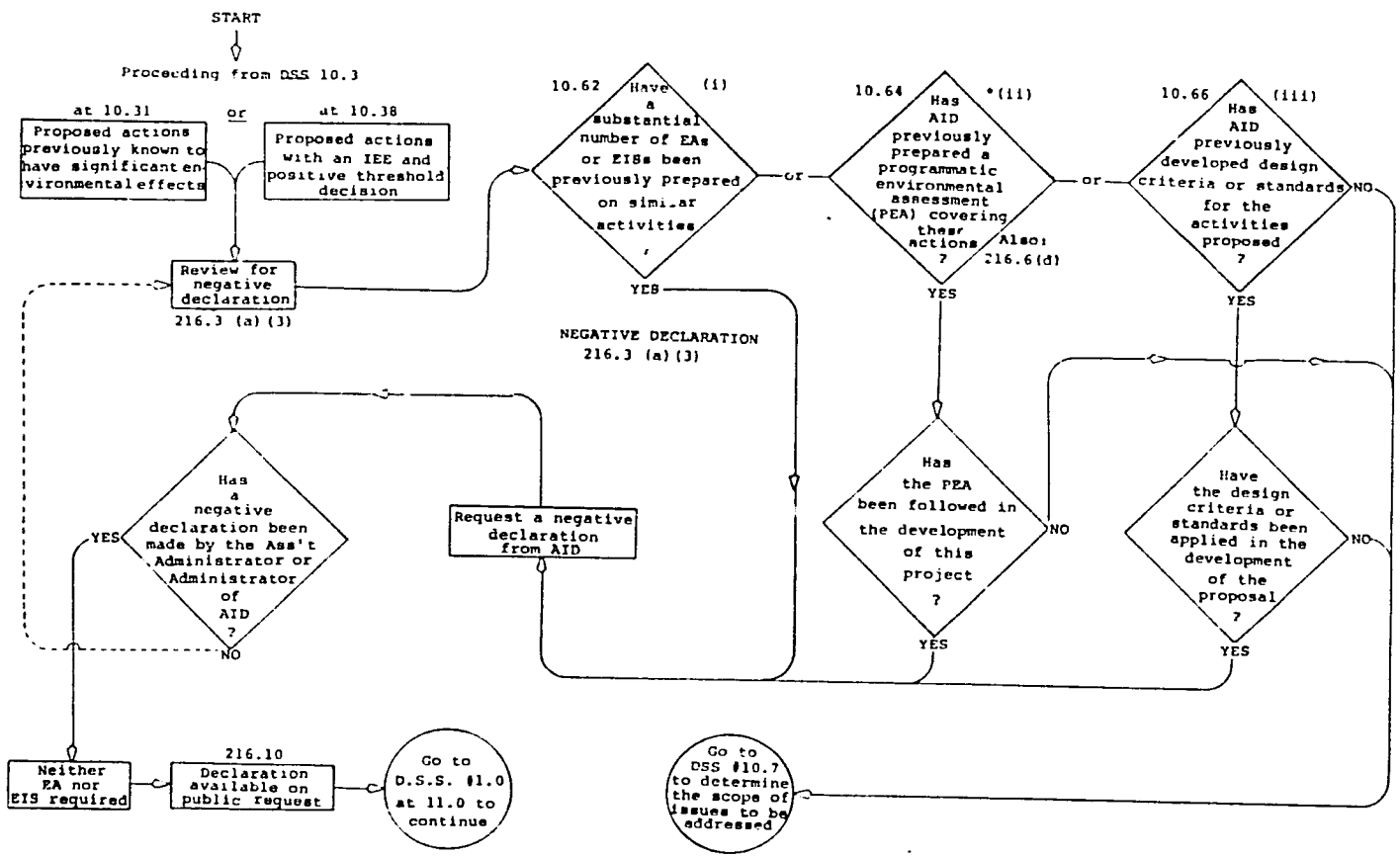
D.S.S. #10.5



This algorithm is interpretive of the October 23, 1980, revision of the Environmental Procedures for AID, Paragraph 216.3 (b)(1)(i), 22CFR Part 216.

D.S.S. # 10.6

Review Proposal for Negative Declaration



*This Manual, as approved by AID, serves as the official PEA for the vector control procedures to be followed in malaria control programs.

This algorithm is interpretive of the October 23, 1980, revision of the Environmental Procedures for AID, Paragraph 216.3 (a) (3), 216.6(d), and 216.10 22 CFR Part 216.

SECTION 10.62 - EXAMPLES OF PRIOR ENVIRONMENTAL ASSESSMENTS FOR MALARIA CONTROL

10.62A - Savannah River Refuge (DDT) by the CDC, USPHS:

Tarzwell, 1947

Erickson, 1947

Bishop, 1947

Scudder and Tarzwell, 1950

10.62B - Pakistan (DDT and Malathion) by the AID:

AID, 1972

10.62C - Sri Lanka (Malathion) by the AID:

Gerberg and Willcox, 1977

Hays, Berry, and Ford, 1978b

10.62D - Thailand (DDT) by the AID:

Gerberg and Graham, 1978

10.62A - Savannah River Wildlife Refuge, Jasper County, S.C.[1,2,3,4]

In 1945-47, a detailed ecological study and analysis of mosquito larviciding with DDT was conducted by scientists of the Technical Development Laboratories, Communicable Disease Center, U. S. Public Health Service, Savannah, GA. A fresh water coastal marsh of 815 acres, with both hammocks and diked permanent water areas, was utilized, and the terrestrial and aquatic assessments were made both prior to and during weekly airplane treatments over a two year period (16-17 in 1946 and 20 in 1947).

An application rate of 0.1 lb/acre of DDT as a 20% solution in a methylated naphthalene was used, and showed a ground level DDT deposit averaging 0.046 lb/acre. Some ground applications of DDT-dust and DDT-fuel oil were also made.

"Routine applications of DDT as a dust caused little apparent damage to surface organisms, as indicated by gross observations". DDT-fuel-oil solutions killed the large surface insects such as Dytiscidae, Gyrinidae, Hydrophilidae and Corixidae at concentrations as low as 0.025 pound of DDT per acre. However, the kills resulting from applications of 0.05 or 0.025 pound of DDT per acre were proportionately much less than those resulting from applications at the rate of 0.1 pound per acre. As was true for treatments with dust, few significant changes occurred due to any single treatment. The seasonal effects of routine DDT treatments, as indicated by a comparison of the population of surface organisms in the treated and check ponds, were quite marked." "Insects as a group decreased in number in the treated ponds, with the largest decrease occurring among the Chironomidae."

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1. Tarzwell, 1947.
2. Erickson, 1947.
3. Bishop, 1947.
4. Scudder and Tarzwell, 1950.

"The net results of these changes are difficult to evaluate, but it appears that there is some reduction in the available supply of fish food. Although the forms which increased in numbers often occur in great abundance, they are much smaller than the forms which are reduced in number, and in general they are not as readily taken by the fish. Reductions noted to date, however, have not been sufficient to affect the breeding stock, and since treatment is in localized areas, it is probably not sufficient to seriously limit the fish population by restriction of the food supply."[1]

"DDT had no apparent effect on the birds of the sprayed area." "The fluctuations of birds on both sprayed and unsprayed areas were similar and apparently DDT had no measurable effect on the population from week to week." "DDT had no detected effect on the cotton rat or house mouse population of the sprayed area." "Daily sight operations were made on cottontail rabbits, cotton rats, and raccoons on sprayed and unsprayed areas...Calculated on a weekly basis the fluctuations in the number of observations on the two areas roughly paralleled one another, indicating that DDT had no effect on the mammals of the sprayed area."[2]

"The detrimental influence of DDT, as used for the control of malaria vectors upon the plankton organisms of smaller ponds, is indicated by these studies to be so slight in comparison with the larger variations due to climatic and other ecological factors, as to be relatively unimportant in upsetting the biological balance." "No drastic killing of any specific group of organisms occurred from DDT treatment during the course of these experiments. Even though a few groups did show a slight reduction in number in the treated ponds over the control, in no instance were they wiped out or reduced to any marked degree."

"It appears that the use of DDT as a mosquito larvicide will be restricted more by its potential danger to the fish and the higher forms of life than by any harmful effects on the plankton organisms as a group."[3]

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1. Tarzell, 1947, p. 553-4.
2. Erickson, 1947, p. 1261-2.
3. Bishop, 1947, p. 1268.

"Mosquitoes, deer flies, and sand flies were reduced in numbers by the routine larvicidal treatments; however, for other than these forms, no over-all effect of the treatments was observed. Observations in check and treated areas showed only those differences in general insect numbers and activity which could be considered to be due to differences in the respective ecological situations."

"Experimental beehives kept under observation during the first season of treatment showed no over-all adverse effects and produced a crop of honey normal for the year. During the two succeeding years of treatment, beekeepers kept many colonies in treated areas with no reported adverse effect, indicating that routine DDT mosquito larviciding is not detrimental to honey production."

"Light trap catches in treated and check areas during two seasons' treatment showed no significant over-all reduction in the insect population of areas adjoining those routinely larvicided with DDT as 0.1 pound per acre with the possible exception of the Trichoptera."[1]

The general conclusion of all these studies was that the use of DDT for routine mosquito larviciding at an application rate of 0.1 pound/acre was not significantly hazardous to wildlife.

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1. Scudder and Tarzwell, 1950, p. 86-87.

10.62B - Pakistan Malaria Control Project[1]

In 1972, AID examined the evidence of a quarter of century of DDT use and concluded that "There is little risk to the general population from the use of DDT, the most persistent of the synthetic insecticides in malaria control and eradication programs, and that application of insecticides to the interior surface of houses poses little danger to fish and wildlife." Because of the proposed increasing use of ULV malathion instead of DDT, "small risks to the population and to fish and wildlife associated with DDT in a malaria program should decrease even further."

The use of oil, or oil and insecticides, were recommended for breeding areas and were considered to "present few, if any, environmental hazards, in the amounts used for larval control, and should improve the environment by reducing the numbers of nuisance as well as malarial mosquitoes."

"The introduction of a exotic larvivorous fish such as Gambusia affinis poses no known danger to human beings. It may, however, pose a serious danger to local, native fish, both small and large."

"The net effect of the proposed Pakistan Malaria Control Program on human health and the environment in the broad sense is positive. Any possible risks are greatly outweighed by the benefits arising from properly controlled use of insecticides in the program."

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1. AID, 1972.

10.62C - Sri Lanka Malaria Control Project[1,2]

The use of malathion for residual spraying of houses followed the appearance of DDT resistance in 1969, and an epidemic of malaria in 1972 because of the failure of DDT.

"Malathion after twenty years of use for a variety of pest control conditions, has produced no apparent adverse effects on the environment." "It appears that under field conditions, malathion residues are unlikely to migrate to any significant extent through ecosystems by environmental transport mechanisms."

"The anticipated impact on the natural environment is negligable. House spraying is a contained activity and there is no interaction between the domestic environment and the natural environment."

"Most of the anticipated unfavorable impacts of the malaria program on man, are potential rather than actual. There is a potentially hazardous impact on spraymen, transport workers, and storekeepers (warehousemen) from the use of the pesticide, malathion. Malathion is one of the least toxic to humans of the organo-phosphate insecticides, but like all pesticides, must be used properly and with care." "The calculated exposure in spray operations is less than 0.01% of the toxic dose."

"A potential for adverse effects on the natural environment exists in the transport and storage of malathion. As malathion is well tolerated by most species of wildlife (birds and mammals) the adverse effect should be minimal with proper cleanup and decontamination precautions taken. However, if the release should occur near water, the potential for damage to endemic fish populations exists, as malathion is toxic to most species of fish and fish food organisms."

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1. Gerberg and Willcox, 1977, p. 72-87.
2. Hays, Berry and Ford, 1978b.

"If any larvacidal operations are undertaken, then there definitely could be an anticipated unfavorable impact on water quality." "The area that might be treated (if at all) would be minuscule compared to the overall program. The unfavorable impact implications, however, would be the toxicity to fish, and some non-target aquatic invertebrates. There would be no expectations for a build-up in the food chain. Though water that collects in pools in the dried up river beds may be used for drinking water by man and animals, it is unlikely that sufficient malathion would accumulate to create a hazard. In addition the use of these pools by man and animals is not common in urban areas."

"In conclusion the anti-malaria program should not have any significant effect on the environment, except improvement of health conditions."[1]

Comments on the Sri Lanka assessment[2] suggest that some portions are transferable to other programs and some are not. "Devoting less than twenty pages to the EA itself and approximately twenty-five pages to "background" seems to us to be an unwise division of resources. We recommend that one-third to one-half of an EA document should focus on the actual environment."

"The major negative impacts of the project cited in the EA relate to the effects on spraymen and householders. This section de-emphasized the potential dangers of malathion which were clearly demonstrated in the problems which had previously arisen in Pakistan. The section, in minimizing the harmful impacts, seems to skim over the potential adverse effects. The report states that malathion is well tolerated by most species of wildlife but does not back this up well. The problem of disposal of malathion containers is not mentioned though adverse conditions can arise from careless disposal."

The effect of the pesticide on air and water quality is described as negligible but little evidence is provided for this conclusion. We believe there could be significant adverse impacts, especially on water quality, if the

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1. Gerberg and Willcox, 1977, p. 54, 73, 78-81, 83, 84.
2. Hays, Berry, and Ford, 1978b.

10.62D - Thailand Malaria Control Project[1]

"At present, the use of DDT has not presented any environmental problems." "If the program switches to malathion or fenitrothion due to resistance of the vector to DDT, there could be some potentially hazardous impacts on spraymen, mixers, transport workers and warehousemen."

"Carelessness of indoor spraying could lead to contamination of food, water and feed products, however, there have been no reported cases of injuries or sickness due to DDT poisoning."

"If the program continues with the residual spraying of DDT wettable powder to walls and ceilings of houses, there will be no measurable effect on the air quality."

"It is difficult to envisage any adverse effects on the natural environment from [indoor house spraying of DDT in] this operation. Some non-target organisms in the house may be effected but at this time there is considerable resistance to DDT in these non-target organisms."

"A potential for adverse effects on the environment exists in the transportation and storage of DDT."

"A theoretical adverse environmental effect could result from a massive spill of DDT into a water system. Though improbable, if it occurred there could be an adverse effect on non-target insects and various aquatic invertebrates and vertebrates.

"Except for the possible use of [temephos] Abate® as a larvicide, it is expected there will be no effect on the water quality. The small amount of DDT that falls on the soil in rural house spraying, would have no impact, favorable or unfavorable, on water quality."

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1. Gerberg and Graham, 1978, p. 82-89.

insecticide is not handled carefully."

"In summary, we see that the undue brevity of the report on potential negative impacts seems to underestimate the potential problems of the project. Therefore, the EA does not send a sufficiently cautious message to project managers, both those employed by AID and the host country counterparts."[1]

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1. Hays, Berry, and Ford, 1978b, p. 189-191.

"The anticipated unfavorable impacts are minor, more potential than actual. The use of DDT presents no known hazard to operational personnel or to the occupants of the habitation that are sprayed. "House spraying is a contained activity and there is essentially no interaction between the domestic environment and the natural environment.

"In conclusion, the malaria control program should not have any significant effect on the environment, except improvement of health conditions.[1]

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1. Gerberg and Graham, 1978, p. 82, 84-87, 88.

SECTION 10.64 - THE PROGRAMMATIC ENVIRONMENTAL ASSESSMENT (PEA)

Consistent with Regulation 16, paragraph (216.6 (d), Program Assessment)[1], the Agency has supported the production of this Manual and Guidebook, with the hope that, as finally revised and officially adopted, these documents would serve as the PEA for malaria vector control, and guide compliance of programs with the provisions of Regulation 16 for "environmental procedures". The intent is to assess those environmental impacts generic (or common) to malaria control as one or more classes of Agency actions which are not country specific. Thereby this would be "an effort to establish additional categorical exclusions or design standards or criteria for such classes that will minimize adverse effects of such actions, enhance the environmental effect of such action or reduce the amount of paperwork or time involved in these procedures."

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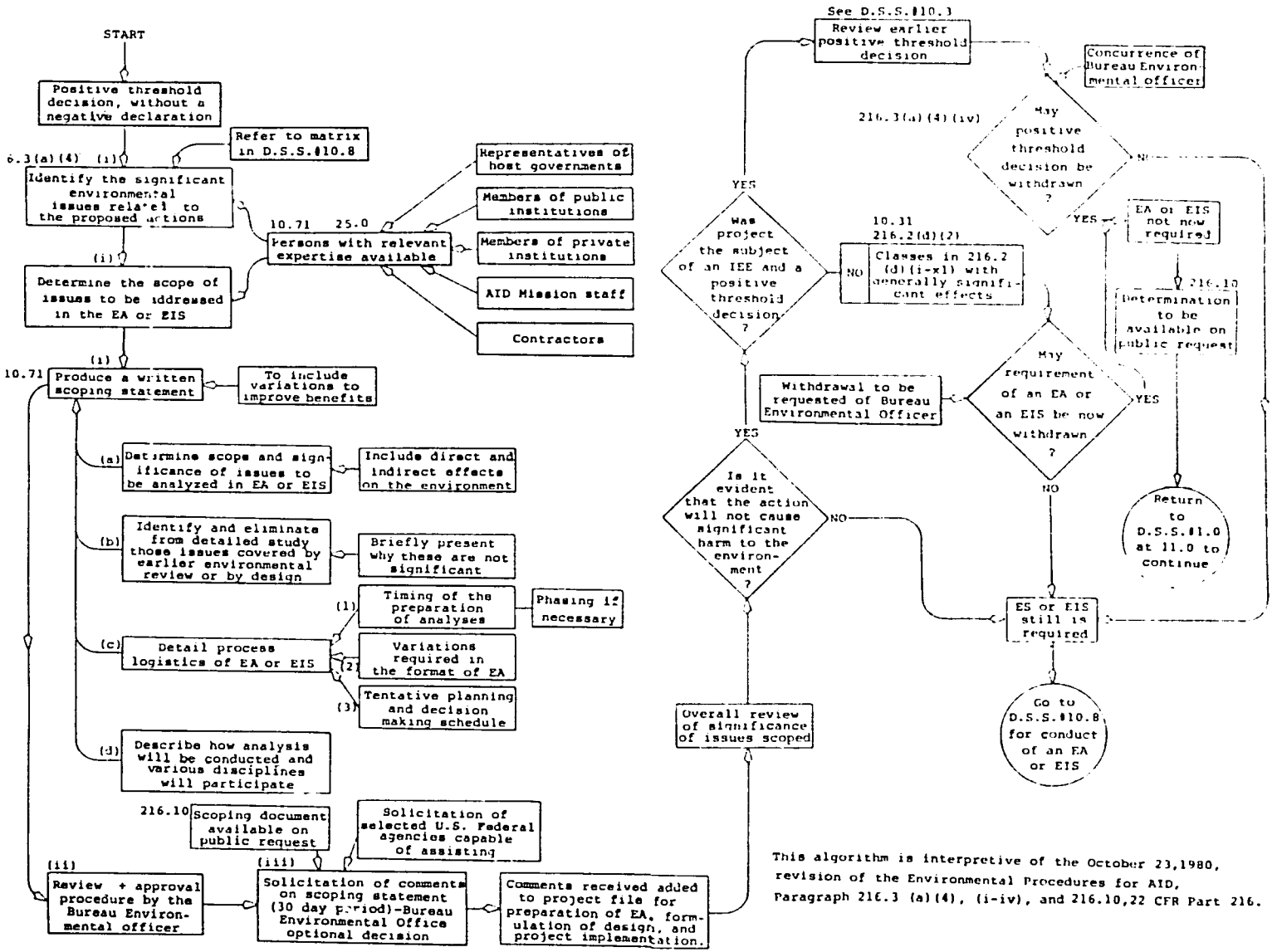
1. Federal Register, 1981. (Also included in this Manual under Special Tab, "Regulation 16", p. 11.

Determine the Scope of the Environmentally Significant Issues to be Addressed in an EA or EIS



This algorithm is interpretive of the October 23,1980, revision of the Environmental Procedures for AID, Paragraph 216.3 (a)(4), (i-iv), and 216.10,22 CFR Part 216.

SECTION 10.8 - PREPARE AN ENVIRONMENTAL ASSESSMENT (EA)[1]

Background and Definition:

In a search for EA's as examples, the authors have found several reports[2] which provide a useful history of the development of assessments and give some useful guidance. All fall far short of the idealized guidelines which are set forth in "Regulation 16", and which have been shown graphically in the algorithm DSS #10.8. This does not mean these EA's failed to serve their purpose, or are no longer useful, but rather that they were attempts to meet the needs in each specific program.

The purpose of the algorithms and the supporting content in this Chapter, the greater detail given in Chapter 11, and in the Guidebook under the corresponding decimal references is not to exact a given and uniform level of performance, but rather to present all the factors and decision components potentially involved, so that informed choices may be made by the program managers and staff. They may then proceed with some greater understanding to prepare an EA which is tailored to the individual situation. The nature and completeness of an EA must be determined by what is found to be of significance, magnitude, and importance[3] in each program component, subject to the program constraints and resources. What one does not want, is that it be subject to a lack of informed procedure and thereby end in gross error!

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1. See Camougis, 1980; also Rau & Wooten, 1980.
2. See Special Tab, "Prior EAs", earlier in this chapter under 10.62.
3. See Chapter 1 at 1.13

"The environmental assessment does not need to be a separate document. It can be an identifiable part of the Project Paper (as is the case for economic, technical and social analyses), Feasibility Study, or other Agency prepared or assisted document.

"Alternative means exist for acquiring the skills needed for preparation of EA's, including but not limited to:

"- Use of one or more appropriately skilled individuals working with qualified host country officials/citizens.

"- Specialists selected to participate on a project design team.

"- Contracting with qualified host country individuals and/or firms to assess the predefined issues or impacts.

"- Selection of a multi-disciplinary team from a U.S. firm appropriate to the issues to be examined. (Six IQC firms will soon be available for use in the environmental/natural resource area).

"- Use of other qualified individuals already in and knowledgeable of the country, i.e., Peace Corps personnel, mission staff, expatriates, etc.

"Highly technical and specialized data and analyses should be limited to that required for an effective review of environmental consequences and alternatives. Simple language defining issues, reasonable foreseeable impacts and alternative or mitigating actions should be utilized. The amount of detail should be commensurate with the extent and expected impact of the action and with the amount of information required at the particular level of decision making."[1]

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1. AID, 1979a, p. 3-4.

Accordingly the form and content of EA's to date have not shown any standardization, but the authors believe the current development of the Manual and Guidebook may be of great help in their future preparation.

Some excellent ideas and assistance may be derived from these points[1]:

> "Is it possible for a single environmental assessment (EA) to anticipate the potential environmental impact of many malaria control programs? The concept is intriguing. If a universal EA can be prepared for all malaria programs, much time can be saved. Moreover, funds currently set to assess environmental impacts could be expended directly on malaria control activities."
>
> "Three conceptual principles [are offered] as basic to the development of AID environmental policy with respect to malaria programs. These three working concepts are:
>
> 1. Environmental Uniqueness. Every malaria control program interacts within the context of a unique social and physical setting. Assessments of the impact of each project must be made in terms of these unique characteristics. We do not recommend a universal malaria program environmental assessment.
> 2. Transferability. In spite of local environmental uniqueness, there are a number of elements in environmental assessment which are common to many malaria projects. These common elements can be incorporated into operating manuals which can be used to guide project managers and to assist EA teams.

1. Hays, Berry, and Ford, 1978a, p. 3-4.

3. Monitoring. Even with excellent environmental assessments and well prepared operating manuals, AID's current procedures do not assure that potential problems will be followed throughout the full life of the project. Thus, our third operating principle is that assurance of environmental quality must involve the continuing monitoring mechanism as an integral part of every malaria control project."

The authors wish to emphasize this last point, that monitoring,[1] which provides program with essential feedback in all its aspects, must be provided for in the environmental sector on a continuing basis. In the press of an operational program it can easily be forgotten or given a low priority.

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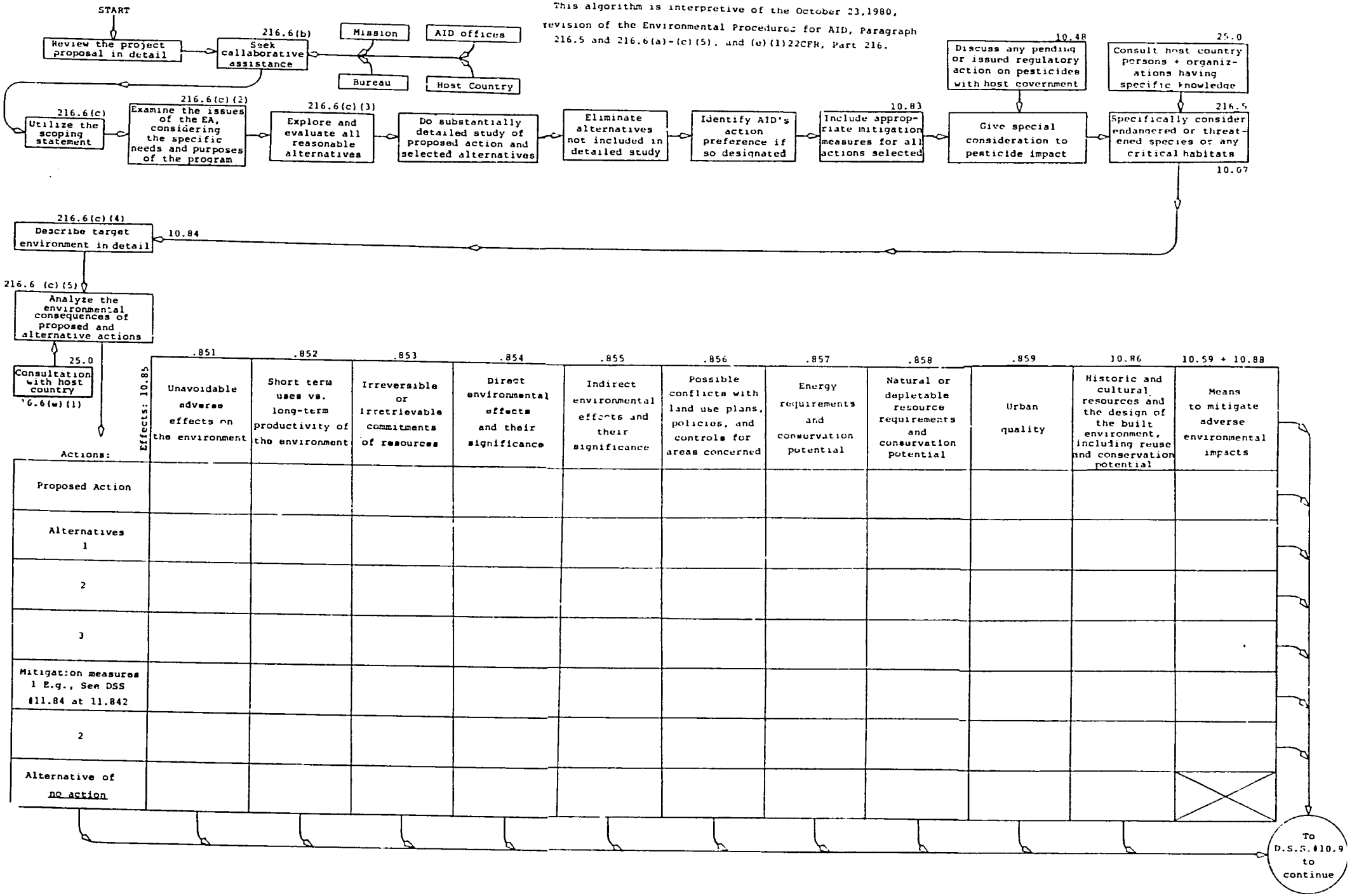
1. See Welch & Croft, 1979.

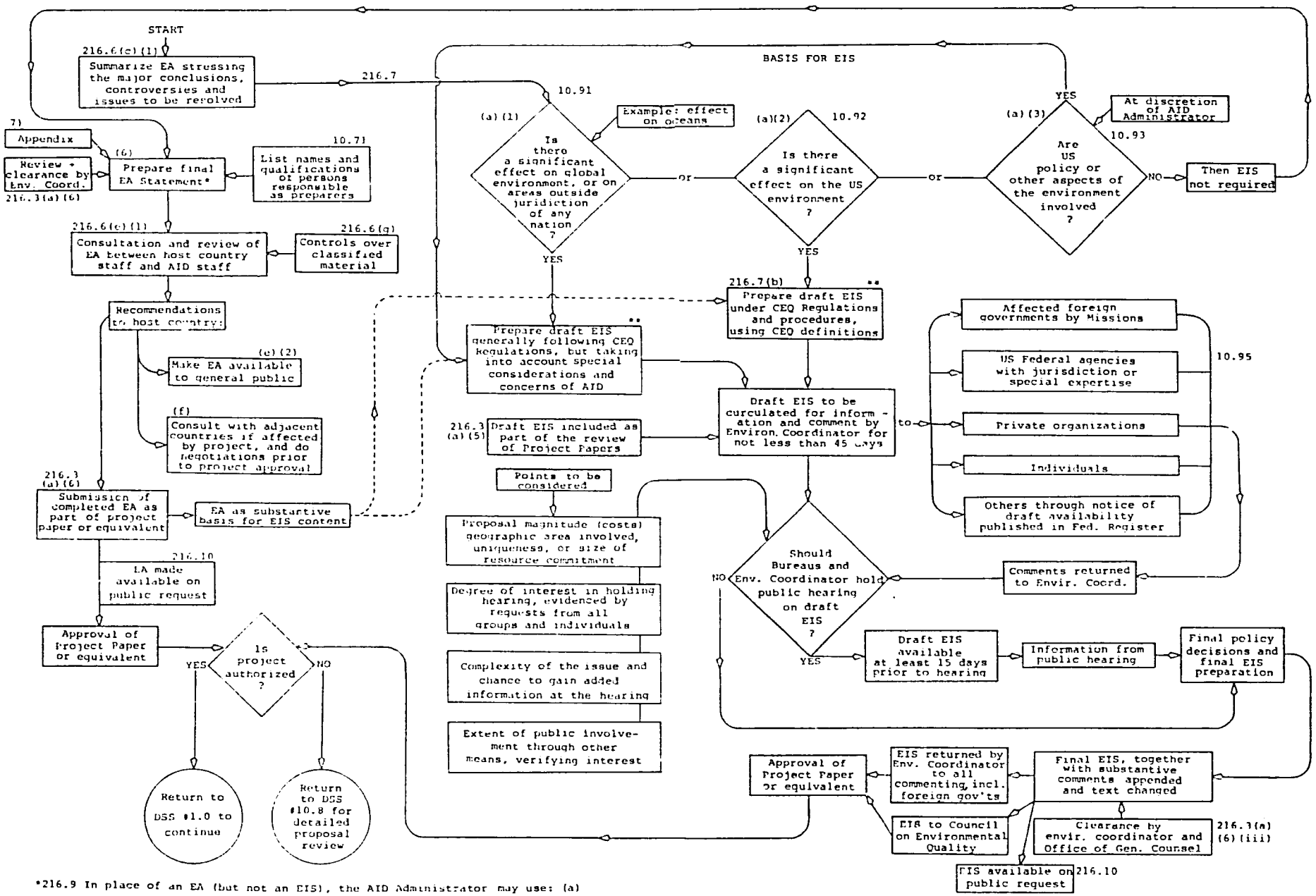
Conduct an Environmental Assessment (EA)

D.S.S. #10.8

This algorithm is interpretive of the October 23,1980, revision of the Environmental Procedures for AID, Paragraph 216.5 and 216.6(a)-(c)(5), and (e)(1)22CFR, Part 216.



Complete an Environmental Assessment (EA) and Determine the Need and Procedure for an Environmental Impact Statement (EIS)



*216.9 In place of an EA (but not an EIS), the AID Administrator may use: (a) certain bilateral or multilateral environmental studies, or (b) concise reviews of the environmental issues involved.

**CEQ Regulations. See Federal Register 43 (230), November 29, 1978.

This algorithm is interpretive of the October 23,1980, revision of the Environmental Procedures for AID, Paragraph 216.3(a)(6), 216.6, 216.7 216.8, 216.9, and 216.10, 22CFR Part 216.

CHAPTER 11 - SELECTION OF PRIMARY ANOPHELINE CONTROL METHODOLOGIES

SECTION 11.0 - GENERAL

Background and Definitions
Factors in Anopheline Vector Effectiveness
Environmental Concerns
Use of the Algorithm
Use of the Guidebook

DSS 11.0 SELECT PRIMARY ANOPHELINE CONTROL METHODOLOGIES (IPM APPROACH)

SECTION 11.60 - SELECT LARVAL CONTROL METHODOLOGY

Background and Definitions
Environmental Concerns
Use of the Algorithm
Use of the Guidebook
Special Note (WHO Larval Control Manual)

DSS 11.60 SELECT LARVAL CONTROL METHODOLOGY

SECTION 11.61 - DEVELOP SOURCE PREVENTION REVIEW PROCESS

Background and Definitions
Environmental Concerns
Use of the Algorithm
Mosquito Source Prevention Checklist and Flow Chart

SECTION 11.62 - SELECT SPECIFIC SOURCE REDUCTION MEASURES FOR EACH BREEDING AREA

Background and Definitions
Environmental Concerns
Use of the Algorithm
Use of the Guidebook

DSS 11.62 SELECT SPECIFIC SOURCE REDUCTION MEASURES FOR EACH BREEDING AREA

SECTION 11.627 - ASSESS THE ENVIRONMENTAL EFFECTS OF PROPOSED SOURCE REDUCTION MEASURES ON NATURAL AQUATIC AND WETLAND AREAS

Definitions
Background
Environmental Concerns
Use of the Algorithm
Use of the Guidebook

DSS	*11.627*	*ASSESS THE ENVIRONMENTAL EFFECTS OF PROPOSED SOURCE REDUCTION MEASURES ON NATURAL AQUATIC AND WETLAND AREAS*
SECTION	11.63 -	SELECT CHEMICAL LARVICIDE METHODOLOGY Background Definitions Environmental Concerns Selected Insecticides Suitable for Larvicidal Application Use of the Algorithm Use of the Guidebook
DSS	*11.63*	*SELECT CHEMICAL LARVICIDE METHODOLOGY*
SECTION	11.64 -	SELECT BIO-CONTROL METHODOLOGY Definitions Environmental Concerns Five Stage Screen for Bio-control Agents Use of the Algorithms Use of the Guidebook
DSS	*11.64*	*SELECT A BIOLOGICAL CONTROL AGENT*
DSS	*11.646*	*SELECT LARVIVORE OR HERBIVORE FISH*
DSS	*11.6463*	*DETERMINE SUITABILITY OF BIOLOGICAL CONTROL AGENT*
SECTION	11.64639 -	EVALUATE ENVIRONMENTAL EFFECTS OF LOCAL BIOLOGICAL AGENT SELECTED Background Environmental Concerns Use of the Matrix
Matrix	*11.64639*	*EVALUATE ENVIRONMENTAL EFFECTS OF LOCAL BIOLOGICAL CONTROL AGENT SELECTED*
SECTION	11.647 -	SELECT MICROBIAL PATHOGEN, PARASITE OR INVERTEBRATE PREDATOR Definitions Environmental Concerns Use of the Algorithm Use of the Guidebook

DSS	*11.647*		*SELECT MICROBIAL PATHOGEN, PARASITE OR INVERTEBRATE PREDATOR*
SECTION	11.70	–	SELECT ADULT RESIDUAL CONTROL METHODOLOGY Definitions and Background Insecticides Suitable Environmental Concerns Use of the Algorithm Use of the Guidebook
DSS	*11.70*		*SELECT ADULT RESIDUAL CONTROL METHODOLOGY*
SECTION	11.80	–	SELECT ADULT SPACE TREATMENT METHODOLOGY Definitions and Background Environmental Concerns Use of the Algorithm Use of the Guidebook
DSS	*11.80*		*SELECT ADULT SPACE TREATMENT METHODOLOGY*
DSS	*11.84*		*DO INITIAL ENVIRONMENTAL EXAMINATION TO ASSESS THE POTENTIAL EFFECTS OF ADULT SPACE TREATMENT*
SECTION	11.90	–	EVALUATE CANDIDATE INSECTICIDE AND DETERMINE ITS FEASIBILITY Definitions and Background Insecticide Resistance in <u>Anopheles</u> Environmental Concerns Use of the Algorithms Use of the Guidebook
DSS	*11.90*		*EVALUATE CANDIDATE INSECTICIDE AND DETERMINE ITS FEASIBILITY*
SECTION	11.934	–	ANALYZE HUMAN SAFETY PROVISIONS AGAINST HAZARDS OF A CANDIDATE INSECTICIDE Definitions and Background Use of the Algorithm Use of the Guidebook
DSS	*11.934*		*ANALYZE HUMAN SAFETY PROVISIONS AGAINST HAZARDS OF A CANDIDATE INSECTICIDE*
DSS	*11.9341*		*REVIEW PROBLEMS WITH QUALITY OF A CANDIDATE INSECTICIDE*

SECTION 11.936 – ASSESS THE ENVIRONMENTAL EFFECTS OF A CANDIDATE INSECTICIDE ON NATURAL AQUATIC AND WETLANDS AREAS

Background and Definitions
Environmental Concerns
Use of the Algorithm
Use of the Guidebook

DSS 11.936 ASSESS THE ENVIRONMENTAL EFFECTS OF A CANDIDATE INSECTICIDE ON NATURAL AQUATIC AND WETLANDS AREAS

CHAPTER 11 - SELECTION OF PRIMARY ANOPHELINE CONTROL METHODOLOGIES

SECTION 11.0 - GENERAL

Background and Definitions:

Historically the control of malaria vectors consisted of antilarval measures such as drainage, the use of oil or Paris Green, and of antiadult measures ranging from repellents and bed nets to pyrethrum house sprays. With the advent of DDT a single approach became dominant, the use of the residual spray, directed at the endophilic adults. With this miracle insecticide and concurrent use of drugs for the human host, the global concept of eradication was born, only to be beaten down in time by a complex of factors.[1,2] Still eradication was achieved in much of the affluent world before the acknowledgement that it was no longer a viable concept for less developed countries.

With the resurgence of malaria in so many countries, the reconstruction of malaria vector control programs along the more traditional lines[3] of the pre-DDT days has become imperative. The return to a more complex control effort brings us as a consequence into full consideration of the potential environmental effects, a new social and political ethos. By source reduction we would now permanently modify not only more of the environment, but would need in doing so to provide for protection of a much larger and more dynamic population; in chemical control we would greatly increase the magnitude of the treated areas and often employ materials far more toxic to both man and other non-target organisms; in biological control we are tempted to introduce exotic species whose new roles are hard to predict; and in the latest special methods we are tinkering with the physiology and even the DNA of the vector target.

To direct the control measures more specifically at the target, with less effect on non-target species; to increase their effectiveness on the vector, though no one control component alone holds the promise DDT once did; to

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1. Jeffrey, 1976, p. 365-366.
2. Harrison, 1978, p. 244-255.
3. Harrison, 1978, p. 258-259.

keep risks/costs within the benefits to be realized; and to provide insurance against the many factors of failure, we now look toward a management objective which has proved itself in agriculture, namely, the integrated pest management[1] concept. Basic to the understanding of this concept is comprehension of an actuarial scheme, the life table,[2] used as a standard analytical method for the life insurance business. In this the reproductive potential of the target population is analyzed for its every vulnerable point from birth to death at ultimate maturity. So must it be for control of a vector population and its vectoring potential.

"Endemic and epidemic malaria result from the interplay of many factors, chief of which are man, mosquito, and plasmodium, the last named depending upon each of the others, in turn, for completion of its life cycle. The following formula epitomizes the complex science of malaria epidemiology by focusing attention on the principal variables of which malaria is a function.

$$(X + Y + Z)\ bepti = \text{MALARIA INCIDENCE}$$

X = the human carrier	b = bionomics
Y = the mosquito vector	e = environment
Z = the human victim	p = plasmodium
	t = treatment or control
	i = immunity

"To each factor there are several aspects, the more important of which may be grouped as follows:

Bionomics, human	- race, age, sex, occupation, housing, literacy, economic state, agricultural practice, migration, aggregation, quarantine, war.
Bionomics, mosquito	- species, strain, biting behavior, food and egg-laying tropisms, adult habitat, flight capabilities, seasonal distribution, hibernation, transportation.
Environment	- temperature, relative humidity, rainfall, wind, topography, water table, water types, flora, fauna, soil, altitude, man-made breeding places.

1. EPA, 1980; Flint and van den Bosch, 1981.
2. Southwood, 1978, p. 356-387.

Plasmodium	- species and strain.
Treatment	- therapeutic, suppressive.
Control	- man and mosquito.
Immunity	- natural, acquired, tolerance, premunition."[1]

The malaria formula provides an overview, but it is a group of many summarized assumptions. Since control measures must have specific and characterized targets or objectives, each element of the formula must be analyzed for its potential value in furnishing points of vulnerability which may be useful in controlling vector effectiveness and efficiency. At the same time one is struck by the number and variety of environmental interventions called for, which requires excellent field surveys and monitoring to reveal control progress, as well as environmental effects.

To assist in visualizing the complex biological and physical factors and their interacting dynamics which are involved in malaria transmission or its failure the following tabulation (Table 4) is offered. In its review, note the many points, at each of which a single unfavorable factor could reduce the vectoring potential. Consider then that each such change in probability be geometric or exponential, not simply additional (incremental). Any feasible method of control may make a significant contribution even if its effect is small.

The points for malaria control programs to attack are clearly numerous, and range over extensive environmental, vector, vector-host, and host areas. Exploration of ways to utilize these points of vulnerability is far from being complete, and the exploitation of many of these which might give tangible effectiveness has not been done on a proper scale.

As our knowledge of ecological factors and our ability to analyze their interactions have increased, so has our ability to manage these factors which is, of course, the basic objective of a control program. This is the essence of the integrated pest management concept[2,3], by which a selection of diverse controls are brought to bear in an integrated fashion upon the full bionomics of the pest, with the actuarial result or lowering its population below the "economic injury threshold," in this instance, the level and circumstances under which malaria can be successfully transmitted.

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1. Russell *et al*. 1946, p. 340.
2. Glass *et al*. 1975
3. CEQ, 1972.

TABLE 4 - FACTORS IN ANOPHELINE VECTOR EFFECTIVENESS, CONTRASTED WITH POTENTIAL VULNERABILITY

To be effective, the mosquito (from egg stage forward) must succeed in:	While not being subject to:
1. Acquiring a female sex factor in its DNA (as a fertilized egg).	1. The male factor (1:1 ?).
2. Fertilization of the egg.	2. Absence of potent males, or inadequate mating conditions.
3. Being deposited as an egg in a favorable place for larval development.	3. Egg trap situations, inclusive of a modified environment (source reduction or an insecticide).
4. Surviving as an egg and hatching successfully.	4. Unfavorable climate, predation, loss of water medium (natural, or source reduction).
5. Development to maturity as a larva.	5. Source reduction, larviciding, disease, parasitism, predation, exposure to usual growth regulators (IGR), flushing or sluicing of breeding area.
6. Pupation and emergence.	6. All of No. 5 (plus differences in aspects of disease and predation), and unfavorable climate.
7. Swarming and mating.	7. Unfavorable climate and predation. (See also #2 above).
8. Searching for and finding a blood host.	8. Predation, shortage of hosts, adulticide treatment of environment in host area.
9. Selection of human host.	9. Zoophilism (genetic selection of animal preference, or opportunism), lack of human host exposure, lack of attraction factors by human host.
10. Feeding on human host to at least partial repletion.	10. Death by host's defenses, interrupted feeding at an early point, use of repellents by host, use of barriers by host (nets, screens). Use of sprays or aerosols while host is available.

TABLE 4 - FACTORS IN ANOPHELINE VECTOR EFFECTIVENESS (Cont'd)

To be effective, the mosquito (from egg stage forward) must succeed in:	While not being subject to:
11. Ingestion of an infective dose of plasmodial gametocytes along with host blood.	11. Disease-free human hosts, or hosts under suppressive drugs.
12. Escape from human host to a safe resting place to assimilate blood meal.	12. Endophilism (which is basic to risk of death from residual insecticides, interior space aerosols, other sprays), and predation.
13. Survival over sufficient incubation time for plasmodial sporozoites to develop.	13. (As in No. 11), also unfavorable climatic factors.
14. Production of viable sporozoites and their transfer to its salivary glands.	14. Genetic strain problems in vector efficiency (physiology) which diminishes its support of plasmodial reproduction, also low temperature in resting place which inhibits sporozoite development.
15 and	15. and
16. Repeat of No. 8 and 9.	16. Repeat of No. 8 and 9.
17. Feeding on susceptible human host at least to point of salivary injection of viable sporozoites.	17. Repeat of No. 10, aborting salvary injection, insusceptibility of human host (sporozoite or other malarial immunity), and prophylactic drug level in host.

With this concept in mind, one should make variable selection from all of the diverse arsenal of vector control to meet points of ecological vulnerability for the vector as precisely and effectively as possible by use of:

Source reduction
Chemical control
Biological control
Special methods of control (genetic, hormonal, etc.)

In addition the vector program should be correlated with modifications of host factors (drugs, immunity, behavior, housing, etc.).

The chance to abuse any system increases with its complexity--hence the environmental concerns, yet on the other hand with its proper use, the opportunity to increase the specificity of control with target emphasis and minimal or no tangible environmental damage is a perceivable advantage. Reduction of cost may accompany increasing target accuracy and efficiency. The disadvantage is in its degree of sophistication, its demand for excellent training of the project personnel in each aspect of the program and for each project undertaken. The overriding benefit is its potential for success with a pluralistic approach. This approach reduces the impact of such changes as the loss of insecticide effectiveness upon development of vector resistance, or the failure of a residual spray because of the existence or development of exophilism. If one component of the strategy fails, others are in place to continue the impact upon the vector.

Environmental Concerns:

Conscientious and periodic monitoring and analysis, with feedback to an adequately trained, staffed, and equipped malaria control program, using the IPM approach, could serve as a model of successful environmental management, and that is what a disease control program should be. At the same time its level of success as well as its environmental risk/cost/benefit ratio would be far more acceptable than that of most current mosquito control programs which relay upon simplified or monolithic approaches.

Since the natural environment is so very complex the task is not easy compared to an IPM approach in the artificially simplified environment of an agricultural crop with its pests.

Attempts to employ an IPM approach without adequate monitoring is first of all highly susceptible to failure, and secondly could result in environmental risks or adverse effects (costs).

Whenever the program planner or manager has access to earlier detailed environmental studies and analyses which are of good quality, using these to the extent they pertain to the current control area may avoid their repetition. Such studies may have been done in, or adjacent to, the area now being considered, or may have been done elsewhere in essentially the same ecology.

Consequently, the common reference to environmental assessment should not be interpreted as meaning a full IEE, EA, or EIS as set forth in Chapter 10 is needed in each instance, but only when the proposed control area, procedure, or material is unique and has never been studied in the context in which it is to be used.

Please note that the "environmental analysis and evaluation" step 11.40 of the algorithm DSS #11.0 has its counterparts in more detail in the text and algorithms of DSS #11.62, 11.627, Matrix #11.64639, and DSS #11.936. These, together with the Guidebook Section 11 should give a clear idea of how to meet environmental concerns. In addition, check for new literature and reports to be made available.

Use of the Algorithm:

This simpler algorithm emphasizes review of the environment in which control is to take place, and formulation of all feasible control measures as an integrated pest management approach. Continue to the subset algorithms for each of the primary methodologies.

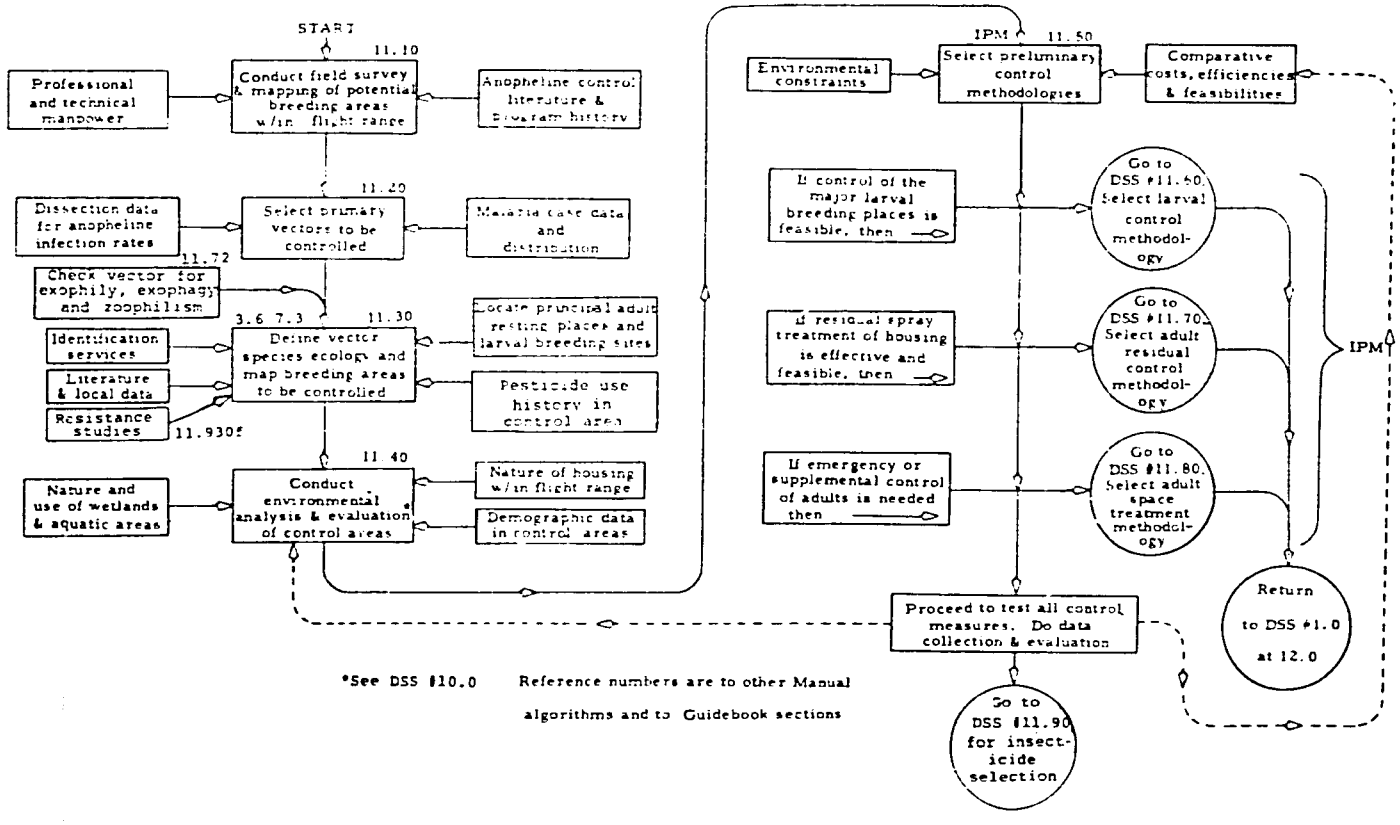
As instructed under the use of the eight algorithms in Chapter 10, the user is now directed to return to Chapter 10 and then back again to this chapter as an iterative process in order to utilize both sets of algorithms together, since the legal compliance set forth in Chapter 10 must be at all steps integrated with Chapter 11, which considers the program by itself.

Use of the Guidebook:

Examples of successful IPM programs in agriculture and their beginnings in vector control are given as basic to understanding and use of IPM. See the Guidebook Sections indicated for additional resource material.

D.S.S. #11.0

Select Primary Anopheline Control Methodologies (IPM Approach)



*See DSS #10.0 Reference numbers are to other Manual algorithms and to Guidebook sections

SECTION 11.60 - SELECT LARVAL CONTROL METHODOLOGY[1]

Background and Definitions:

Larval control is the use of any measure which prevents, or interrupts the development of mosquito larvae and pupae, to the extent that adults are reduced in number to a projected control level within the treatment area. The measures used vary greatly in cost, effectiveness, and personnel training required for the program. Constant field survey and vigilance, coupled with good technical supervision, are required for successful control. Even so, areas overlooked or new breeding areas may suddenly account for increases in vector populations. Sophisticated knowledge of larval ecology is needed, not only for each species under control, but also those other species which might under certain circumstances become surprise vectors.

Combinations of control measures are often the best strategy, rather than reliance on a single approach. The concept of integrated pest management[2] employs chemical, biological, and physical controls to the best advantage of each.

Source reduction should be considered to lessen the long-term costs by investment in permanent or semi-permanent alteration of breeding sites, with much of these costs than being non-recurring.

Past and current investigations of biological control by predators, parasites, or pathogens[3] show many limitations, but some good prospects. Some of these, such as mosquito fish, have been very effective in specific situations. Particular caution must be taken in the introduction of exotic agents, because of their potential for serious disruption of native biota.

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1. WHO, 1973a, is recommended as an operational manual.
2. EPA, 1980; Flint and van den Bosch, 1981.
3. Williams, 1977, suggests "biorational" agent in place of "pathogen, infectious agent, or toxin" to avoid legal and public misinterpretation.

Special methods of control by genetic means, hormonal interference with growth and development, and the use of pheromones seem to be showing great potential.

Larval control has often been omitted in favor of adult control measures, but insecticide resistance of the adults, or a behavioral change to exophilism has often threatened a program based on adult control alone. An integration of methods to include larval control would give far more assurance of success.

Environmental Concerns:

Physical alteration, chemical treatment, or the introduction of exotic biological control agents, or other control measures, may damage or completely destroy the economic, ecologic, or esthetic (human interest) values of aquatic or wetland areas. These potential effects must be contrasted against the projected public health gains from the use of larval control. Environmental assessments with risk/cost/benefit analyses are necessary. Proper training and supervision of control personnel may go far to limit or even prevent such harmful effects. Although the public health advantages of control may be so great as to obscure the program costs, the damage to the environment may produce long term and expensive consequences. A well-conceived and well-operated program maintains careful monitoring of the environmental effects and adds these as feedbacks along with operational data to insure the continued effectiveness and environmental consciousness of the program.

Use of the Algorithm:

Note that emphasis on larval control methodology selection is on a strategy of several methods, the integrated pest management concept. The first priority consideration should always be source reduction, to cut back the size of the control problem so that the routine control costs (which must be continued into the future) can be minimized. The problem then remaining should be

handled by a combined strategy of chemical, biological, and special measures. In each instance, an assessment of the projected environmental effects must be done and an analysis made of the cost-benefit effects.

Overall, because of the intimate relationship of the larval control measures and the environment, a more detailed knowledge is required of all levels of program personnel. The advantages of a better malaria control strategy through larval control make the additional cost of training, survey, and evaluation worth the investment.

Use of the Guidebook:

Consult the Guidebook under Section 11.60 for discussion of the integrated pest management concept, but for more specific considerations go on to the sections for each control methodology selected.

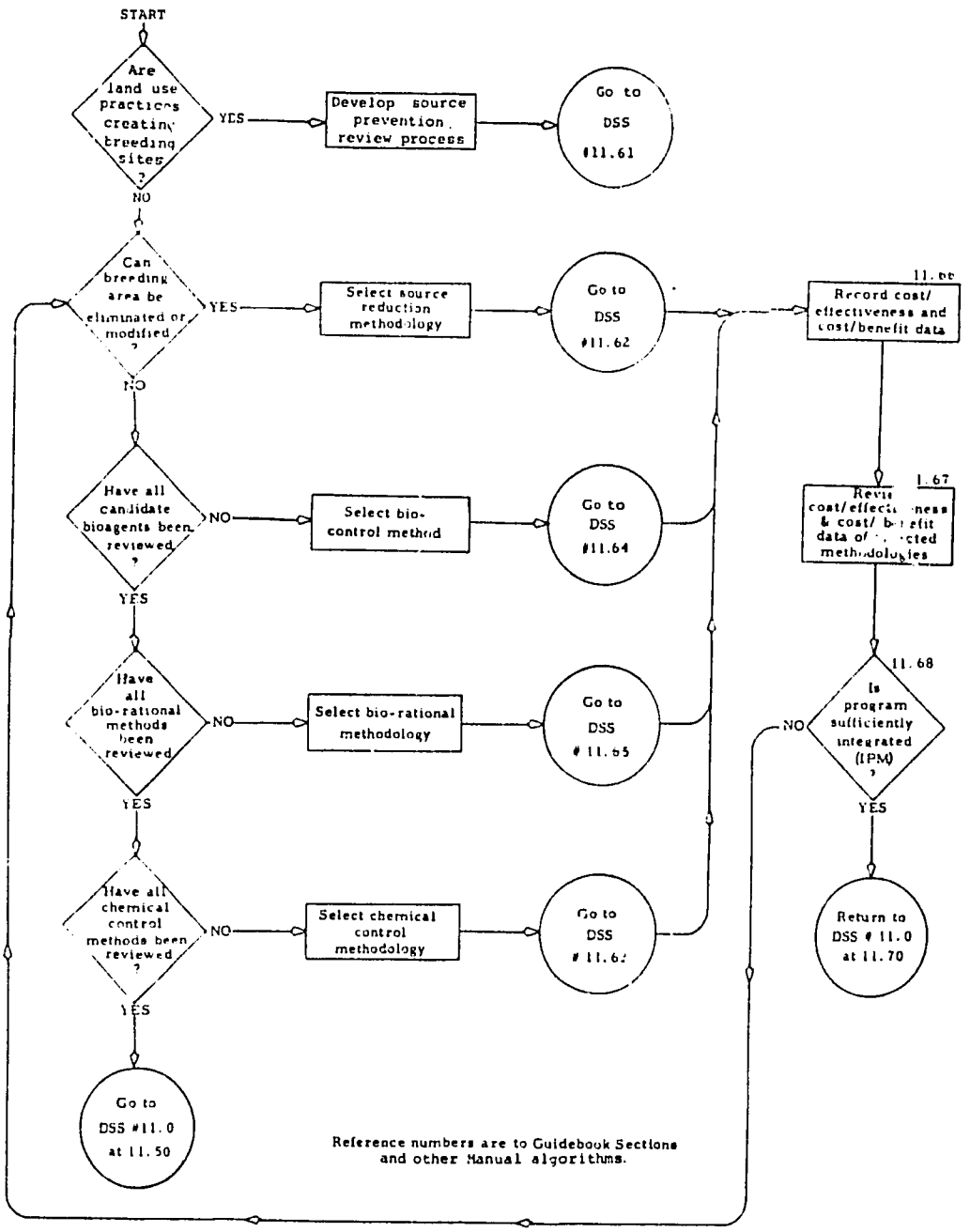
Special Note:

Each operating program should have a reference copy of the WHO[1] "Manual on Larval Control Operations in Malaria Control Programmes". Offset Publication No. 1. WHO Geneva, Switzerland. VI + 199 p. (Paper). This extensive publication has a chapter on each of the following: Naturalistic Control, Source Reduction, Chemical Control of Mosquito Larvae and in addition has five Annex Sections of very useful data and procedures.

1. WHO, 1973.

Select Larval Control Methodology

D.S.S. #11.6



SECTION 11.61 - DEVELOP SOURCE PREVENTION REVIEW PROCESS

Background and Definitions:

"Source" in this context refers to the wide variety of water collections or run-off in which the various species of anopheline larvae may develop successfully.

Environmental conditions or sources conducive to the production of anopheline mosquitoes and to malaria transmission have often been created, or enhanced, by the activities of man. There are many examples, and their potential runs from that of a new dam for hydroelectric power,[1] to an influx of persons carrying malaria, or to a failure in proper maintain of a drainage system. Potential sources may be controlled or eliminated in some instances, or prevented in others, but the program must always be alert to such changes in the environment and be able to act as fast as resources and the situations permit.

Algorithm DSS #11.61 has been designed to assist in developing a procedure to prevent creation of aquatic sources of anopheline mosquitoes by activities of man. (Ultimately the procedure may be expanded to man-caused environmental changes that increase malaria transmission rates through other mechanisms.)

An effective source prevention review process provides opportunities to avoid creating conditions that are conducive to anopheline production. The procedures would include (1) reviewing existing planning, (2) implementing specific design and management recommendations when necessary to avoid vector problems and (3) monitoring the results. If man-created environmental factors significantly influence anopheline production in a project area, and if a viable planning

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1. FSA and TVA, 1947.

process is in existence, an effective source prevention program could avoid high costs of malaria control associated with repetitive chemical applications or with costly remedial measures.

Environmental Concerns:

Standard design and management recommendations that are formulated in a source prevention program may incorporate physical, biological or chemical measures. These measures should be evaluated to determine the impact that they might have upon the environment. Algorithms *DSS 11.627*, *11.64639*, and *11.936*) may be utilized to assess the environmental impact of the proposed preventive measures.

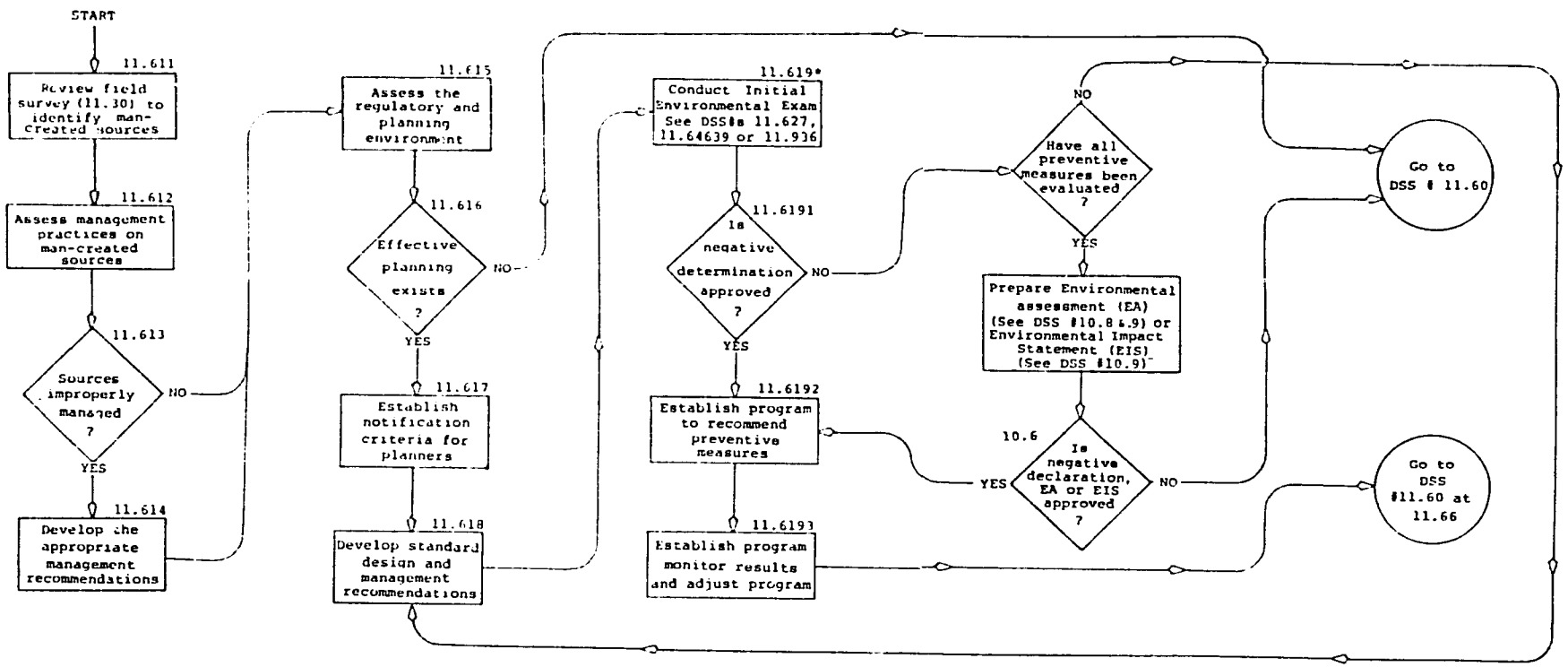
Use of the Algorithm:

The first step in establishing a source prevention review process is the identification of man-created environmental factors that are conducive to vector production. (Fig. 5 - Mosquito Source Prevention Checklist). The completion of Step 11.30 in *DSS 11.0* defined the ecology of the vector species and created a map of the breeding sites. Man-created conditions that are favorable to vector production should have been identified at that time. The development of a source prevention review process also requires an assessment of existing management practices on man-created anopheline sources to determine if the practices are conducive to the production of vectors.

A most essential ingredient in a source prevention review process is the existence of effective land-use planning. The planning may be accomplished by either regulatory or planning agencies. Their usefulness in the source prevention process is directly related to extent to which they effect properly planned modifications of the environment. Staff of these agencies should be made aware of the kinds of activities of man that influence vector production.

Develop Source Prevention Review Process

D. S. S. #11.61



Reference numbers are to other Manual algorithms and to Guidebook sections.

*See also DSS #10.0 through 10.9 for more detailed procedure beyond this point.

FIG. 5 - MOSQUITO SOURCE PREVENTION CHECK LIST[1]

(FOR ANALYSIS OF FIELD SURVEYS AND THE DESIGN OF PREVENTION PROGRAMS)

If a field survey, agency, or personal contact shows that any of the following items are in planning, already being done, or being expanded, they should be checked as potential anopheline sources, and source prevention measures put into effect. All may require continuing monitoring, with informal or formal agreements with the other agencies, private owners or managers.

	POTENTIAL SOURCE DESCRIPTION, IDENTITY AND LOCATION	EVALUATION of POTENTIAL[2]	DATES CHECKED and BY WHOM
A. AGRICULTURE			
1. Heavily irrigated crops, such as:			
a. Pasture			
b. Cotton			
c. Sugar			
d. Other			
2. Aquatic culture, such as:			
a. Fish			
b. Shrimp			
c. Rice			
d. Other			
3. Land use expansion or change with:			
a. Clearing or other shade removal in wetlands areas			
b. Changes in topography			

1. Based on a form designed by the Source Reduction Committee, California Mosquito Control Association, 1974.
2. Significance of all situations reviewed requires careful consideration of mosquito flight range and larval biology for each potential vector.

	POTENTIAL SOURCE DESCRIPTION, IDENTITY AND LOCATION	EVALUATION of POTENTIAL	DATES CHECKED and BY WHOM
c. Creation of an erosion potential			
d. Modification of the borders (B), location (L), or extent (E) of:			
(1) Streams			
(2) Lakes or ponds			
(3) Marshes			
(4) Swamps			
(5) Estuaries			
(6) Inland marine waters			
B. DRAINAGE SYSTEMS/WATER DISTRIBUTION SYSTEMS			
1. Construction			
2. Modifications			
3. Additions			
4. Changes or need for:			
a. Maintenance nature/design			
b. Maintenance schedule			
c. Weed control			
d. Regrading/rechanneling			
e. Seepage control			
C. WATER COLLECTION, PROCESSING OR STORAGE SYSTEMS			
1. Construction with:			
a. Elimination of shallow areas			
b. Shoreline contouring			

	POTENTIAL SOURCE DESCRIPTION, IDENTITY AND LOCATION	EVALUATION of POTENTIAL	DATES CHECKED and BY WHOM
2. Modifications			
3. Additions			
4. For purposes of:			
a. Power			
b. Water supply			
c. Irrigation			
d. Flood prevention			
e. Fish culture			
f. Recreation			
g. Ground water recharge			
h. Waste disposal (oxidation)			
5. Changes in or need for:			
a. Shoreline maintenance nature/design			
b. Shoreline maintenance schedule, including water level management			
c. Weed control			
(1) Shoreline (marginal/emergent)			
(2) Floating			
d. Seepage control			
e. Stocking with mosquito fish			
f. Levees, with:			
(1) Vehicle access			
(2) Wave protection			

	POTENTIAL SOURCE DESCRIPTION, IDENTITY AND LOCATION	EVALUATION of POTENTIAL	DATES CHECKED and BY WHOM
D. HOUSING			
1. Construction			
2. Modifications			
3. Additions			
4. Changes in or need for:			
a. Mosquito proofing			
b. Residual spraying			
5. Location			
a. Resettlement in non-malarious areas			
b. Migration into and settlement of areas potentially malarious			
E. POPULATION EXPOSURE			
1. Use of activity areas in the open during evening or night hours for:			
a. Work			
b. Social events			
c. Recreation			
d. Training/education			
2. Use or need for:			
a. Bed nets			
b. Repellents			
c. Space spraying			

	POTENTIAL SOURCE DESCRIPTION, IDENTITY AND LOCATION	EVALUATION of POTENTIAL	DATES CHECKED and BY WHOM
F. HIGHWAYS			
1. Construction, resulting in:			
a. Borrow pits			
b. Roadside ditches			
c. Drainage blocking			
d. Other			
2. Modifications			
3. Changes in or need for:			
a. Maintenance design/nature			
b. Maintenance schedule			
c. Related drainage			
d. Other			
G. GROUND WATER LEVEL			
1. Changes			
a. Raising			
b. Lowering			
H. OTHER ENVIRONMENTAL CHANGES			

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	POTENTIAL SOURCE DESCRIPTION, IDENTITY AND LOCATION	EVALUATION of POTENTIAL	DATES CHECKED and BY WHOM
I. VEHICULAR ACCESS 1. In problem areas identified in A to H, is there provision for access by control equipment, including vehicles/boats?			

They will then be able to recognize which projects require the expertise of staff of the malaria control program to prevent malaria problems.

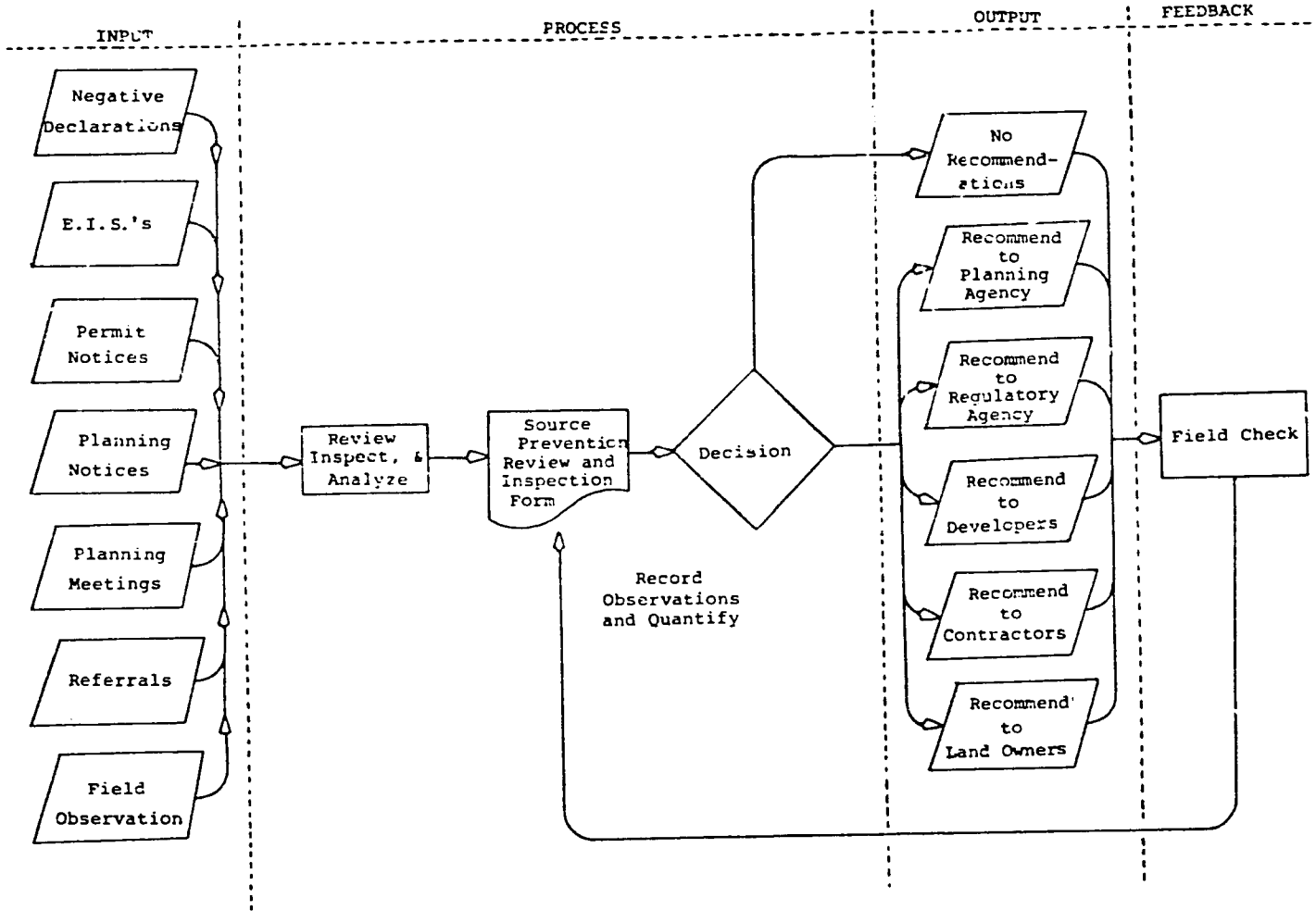
The staff of the malaria control program must provide effective design and management recommendations to planners in order to prevent man-created vector sources. These recommendations may be standardized and made available for recurring types of projects or they may be specifically formulated for unique projects. An example of standardized design and management recommendations is provided by the document "Standard Recommendations to Prevent Mosquito Problems Associated with Gravel Harvesting Operations."[1]

The final step of an effective source prevention review process is the evaluation of the effectiveness of the program in order to make required adjustments. This step will depend upon the establishment of a monitoring system to collect and document data to measure the effectiveness of the prevention efforts. An example of a document to collect source prevention data is provided by the "Source Prevention Review and Inspection Form."[2] Periodic evaluations of the review process will indicate where the program can be modified to increase effectiveness. A first example is provided with the inclusion of an information flow chart (Figure 6) showing the complete source prevention process in a mosquito abatement district.

1. Alameda County, California, 1975, in Section 11.61 of the Guidebook.
2. Alameda County, California, 1977, in Section 11.61 of the Guidebook.

FIGURE 6

SOURCE PREVENTION PROGRAM FLOW CHART[1]



1. Prepared by Alameda County Mosquito Abatement District, Oakland, California, 1977.

SECTION 11.62 -- SELECT SPECIFIC SOURCE REDUCTION MEASURES FOR EACH BREEDING AREA[1]

Background and Definitions:

Source reduction is the physical or biological modification, management, or elimination of potential breeding areas, often by engineering techniques, so that mosquito larvae can no longer be produced there. Examples are rechanneling a stream or ditch to eliminate residual pools during low flow, shore line maintenance of an impoundage to prevent the encroachment of marginal vegetation, drainage ditching to eliminate standing water in a wetland or irrigated area, and reshaping lake or impoundage banks by fill or deepening to eliminate shallow areas.

The diversity of source reduction methods is very great, and their choice is tied to the value or use made of the aquatic or wetland area, the economics of the operation which may involve major engineering work, and the impact of the changes on the environment, which may have positive or negative values far beyond the malaria control objectives.

Both biological and engineering studies are essential to the choice of method, its operation, the maintenance which must be assumed, and the evaluation of the cost versus benefit achieved. The results at the very best may be permanent and with no maintenance costs, or adversely they may create costly, extensive and difficult problems which are almost impossible to overcome.

Source reduction, by minimizing the routine control problems, often represents the best long term investment but may require a high initial outlay, especially if major engineering modifications are involved.

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1. See FSA & TVA, 1947, for impounded water;
WHO, 1973a, Manual on larval control operations, p. 15-64, CH II.
WHO, 1980, for environmental management, and
new WHO manual on source reduction and chemical control, in preparation by Husang Rafatjah in 1982.

Emphasis on source reduction is part of a basic public health concept of prevention or "building out" the health problem by altering the physical or biological design of man's environment, in this case aquatic or wetland areas. Success in doing so may mean an end to the repetitive, and in the long run expensive, chemical treatments for mosquito control.

The design of effective source reduction measures requires detailed surveys, both engineering and biological, to disclose all possible factors such as hydrologic, topographic, biologic, and climatic which are basic to mosquito production and which are of environmental concern. If the area is already fully committed to human use, then wildlife or special ecological values may no longer be present or require consideration, however the problems may still be very complex. Creation of an elaborate drainage system or an impoundage may lead to major responsibilities for maintenance, for which planning and future commitment of personnel and budget are required.

In planning for source reduction, one must take into account every ecological requirement of a vector species and analyze these for points of attack. At the same time each countermeasure must be analyzed in terms of whether or not it would favor a minor or intrusive vector species, unless of course the water ecology would be eliminated. Where there is more than one potential vector, the control measures taken may inadvertently tip the balance in favor of a new prime vector.

Environmental Concerns:

Source reduction methodology commonly creates major environmental impacts, which must be carefully assessed, and wherever possible minimized, avoided, or mitigated. The modified or eliminated breeding sites may represent extensive changes in the former values of these lands, ranging from great increases in value to great losses, to be weighed against or

with the projected gains in malaria control. Lands formerly of no direct value to man may become available for agriculture, home sites, or lakes. Areas which originally had but moderate problems have developed major problems through poor planning and execution of source reduction measures.

The potential for long term effects of source reduction is very great, so that considerable care must be used in designing these measures and in anticipating these effects.

The interdependence of all biotic and physical factors demand well qualified personnel for investigation, decision, and execution of source reduction measures. Each individual situation will be unique.

Use of the Algorithm:

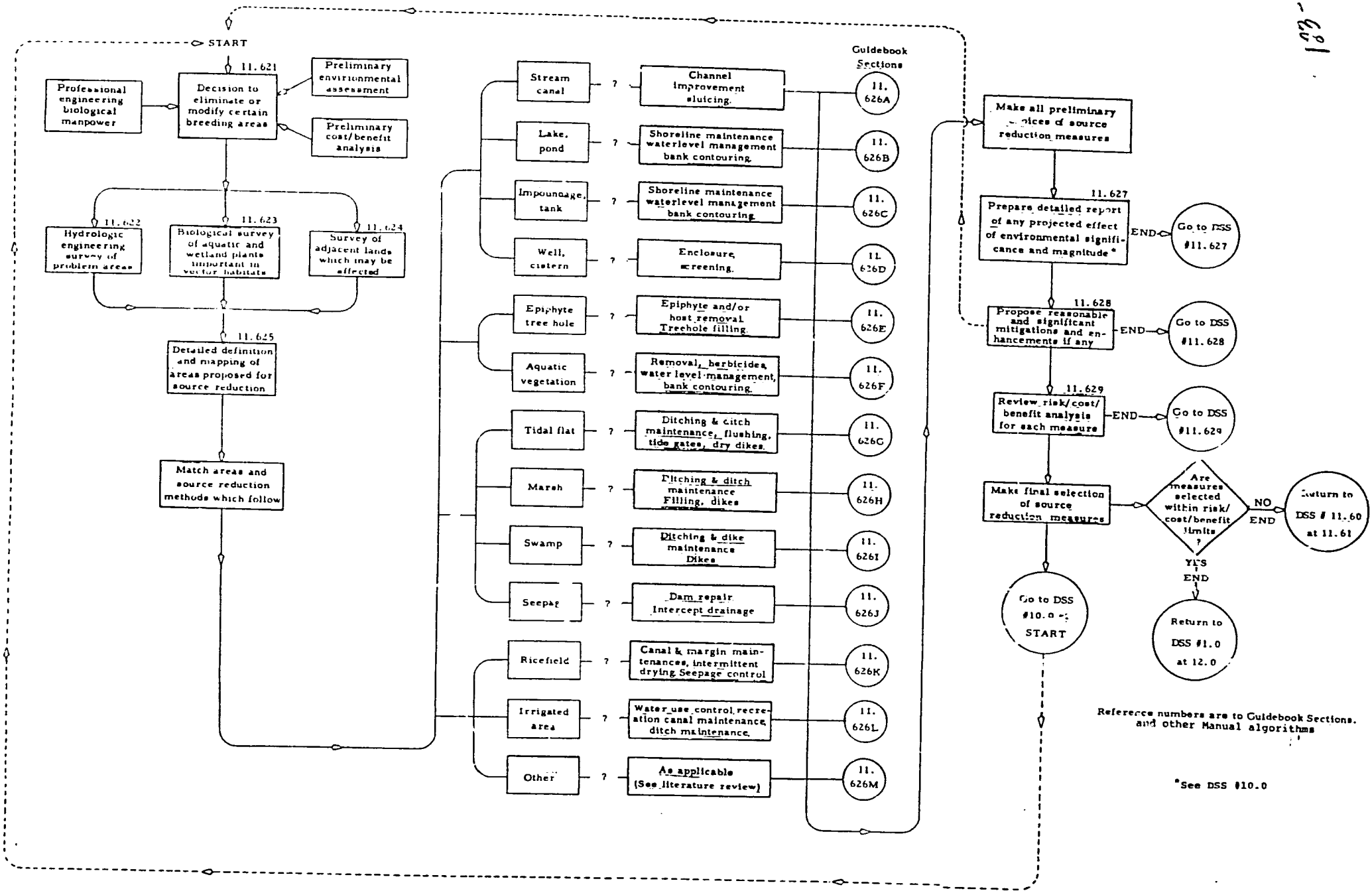
The major task beyond the basic field surveys is to choose for each problem area the most feasible method of reducing the problem. The algorithm presents a dozen potential kinds of problem areas and poses conventional measures for dealing with them. Beyond the design stage their feasibility depends on having adequate resources of professional and technical manpower, the necessary equipment, the labor to carry out the work, plus a commitment for whatever maintenance becomes necessary.

Use of the Guidebook:

Available literature and discussion of the problems cannot substitute for field experience in a particular situation, in a particular country, but it is a beginning. More extensive support is desirable, and may be furnished in future additions to the Guidebook. See the Section 11.62.

Select Specific Source Reduction Measures for Each Breeding Area

D.S.S. #11.62



SECTION 11.627 – ASSESS THE ENVIRONMENTAL EFFECTS OF PROPOSED SOURCE REDUCTION MEASURES ON NATURAL AQUATIC AND WETLAND AREAS

Definitions:[1]

Aquatics and wetlands may be defined as the whole spectrum of water-dominated land, including:

a. Aquatic: with semipermanent or permanent flooding. Water may be fresh, brackish, or saline. Vegetation is marginal or floating.

b. Flatland: with seasonal or periodic flooding, and with little or no vegetation (less than 25% cover).

c. Marsh: with more than 25% cover by herbaceous plants, but less than 40% by woody plants.

d. Swamp: with more than 40% cover by woody plants.

Hydrologic features may be defined as:

a. Marine: the ocean, or salty to brackish bodies of water marginal to the ocean, such as bays, lagoons and adjacent land areas subject to tidal action.

b. Estuarine: the complex of the river mouth area, where fresh and salt water intermingle before reaching the ocean's margin, and the marginal land of the adjacent areas subject to tidal and fresh water flooding.

1. Waterways Exp. Sta., 1978, p. 15-16.

c. Riverine: the river and stream-dominated lands, such as flood plains or "bottom" lands.

d. Lacustrine: the margins of lakes or ponds, and the marginal lands under domination by such a water area.

e. Palustrine: land areas (such as marshes and swamps) dominated by a high water table, but not by bodies of water.

(Figure 7 gives a more detailed classification).

Source reduction may be defined as the application of physical control measures which so change the nature of aquatic and wetland areas as to eliminate or modify those habitats specifically required by the malaria vector. Reproduction of the vector is thereby prevented or reduced. Desirable objectives of such measures are to limit the changes produced to just those necessary for vector control in order to minimize both the operational costs and the environmental damage. Concurrent concerns are that new or additional habitats are not being created for other vectors or pests, that the habitat changes effected can be economically maintained, mitigated by habitat replacement elsewhere, or assumed as a rational and logical program cost.

A major advantage of source reduction is its cost saving, over that of repetitive temporary measures such as chemical application. Major disadvantages are the greater sophistication needed in professional and technical help, the common need for heavy equipment, and often high initial operational costs, even though many are non-recurring and so may be more economical in the long run.

Environmental Concerns:

Water-dominated lands which are not usable or marginal for agriculture, aquaculture, industrial, or residential purposes are often erroneously thought to have little or no intrinsic value. To the contrary, the complex nature

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11.6271

FIGURE 7 CLASSIFICATION OF WETLANDS AND DEEPWATER HABITATS[1]

Key to the Systems

1. Water regime influenced by oceanic tides, and salinity due to ocean derived salts 0.5 ‰ or greater.
   2. Semi-enclosed by land, but with open, partly obstructed or sporadic access to the ocean. Halinity wide-ranging because of evaporation or mixing of seawater with runoff from land ..... ESTUARINE
   2. Little or no obstruction to open ocean present. Halinity usually euhaline; little mixing of water with runoff from land 3
      3. Emergents, trees, or shrubs present. ..... ESTUARINE
      3. Emergents, trees, or shrubs absent ..... MARINE
1. Water regime not influenced by oceanic tides, or if influenced by oceanic tides, salinity less than 0.5‰.
   4. Persistent emergents, trees, shrubs, or emergent mosses cover 30% or more of the area ..... PALUSTRINE
   4. Persistent emergents, trees, shrubs, or emergent mosses cover less than 30 percent of substrate but non-persistent emergents may be widespread during some seasons of year 5
      5. Situated in a channel; water, when present, usually flowing ..... RIVERINE
      5. Situated in a basin, catchment, or on level or sloping ground; water usually not flowing 6
         6. Area 8 ha (20 acres) or greater ..... LACUSTRINE
         6. Area less than 8 ha 7
            7. Wave-formed or bedrock shoreline feature present or water depth 2 m (6.6 feet) or more ..... LACUSTRINE
            7. No wave-formed or bedrock shoreline feature present and water less than 2 m deep ... PALUSTRINE

Key to the Classes

1. During the growing season of most years, areal cover by vegetation is less than 30%.
   2. Substrate a ridge or mound formed by colonization of sedentary invertebrates (corals, oysters, tube worms) ..... REEF
   2. Substrate of rock or various sized sediments often occupied by invertebrates but not formed by colonization of sedentary invertebrates 3
      3. Water regime subtidal, permanently flooded, intermittently exposed, or semipermanently flooded. Substrate usually not soil 4
         4. Substrate of bedrock, boulders, or stones occurring singly or in combination covers 75% or more of the area ..... ROCK BOTTOM
         4. Substrate of organic material, mud, sand, gravel, or cobbles with less than 75% areal cover of stones, boulders, or bedrock. ..... UNCONSOLIDATED BOTTOM
      3. Water regime irregularly exposed, regularly flooded, irregularly flooded, seasonally flooded, temporarily flooded, intermittently flooded, saturated, or artificially flooded. Substrate often a soil 5
         5. Contained within a channel that does not have permanent flowing water (i.e., intermittent subsystem of Riverine System or intertidal subsystem of Estuarine and Marine Systems). ..... STREAMBED
         5. Contained in a channel with perennial water or not contained in a channel. 6
            6. Substrate of bedrock, boulders, or stones occurring singly or in combination covers 75% or more of the area ..... ROCKY SHORE
            6. Substrate of organic material, mud, sand, gravel, or cobbles; with less than 75% of the cover consisting of stones, boulders, or bedrock ..... UNCONSOLIDATED SHORE
1. During the growing season of most years, percentage of area covered by vegetation 30% or greater.
   7. Vegetation composed of pioneering annuals or seedling perennials, often not hydrophytes, occurring only at time of substrate exposure.
      8. Contained within a channel that does not have permanent flowing water ..... STREAMBED (VEGETATED)
      8. Contained within a channel with permanent water, or not contained in a channel ..... UNCONSOLIDATED SHORE (VEGETATED)

1. Cowardin et al., 1979, p. 46-47.

FIGURE 7 CLASSIFICATION OF WETLANDS AND DEEPWATER HABITATS

(continued)

7. Vegetation composed of algae, bryophytes, lichens, or vascular plants that are usually hydrophytic perennials.
    9. Vegetation composed predominantly of nonvascular species.
        10. Vegetation macrophytic algae, mosses, or lichens growing in water or the splash zone of shores ..... AQUATIC BED
        10. Vegetation mosses or lichens usually growing on organic soils and always outside the splash zone of shores ..... MOSS-LICHEN WETLAND
    9. Vegetation composed predominantly of vascular species.
        11. Vegetation herbaceous
            12. Vegetation emergents ..... EMERGENT WETLAND
            12. Vegetation submergent, floating-leaved, or floating ..... AQUATIC BED
        11. Vegetation trees or shrubs 13
            13. Dominants less than 6 m (20 feet) tall ..... SCRUB-SHRUB WETLAND
            13. Dominants 6 m tall or taller ..... FORESTED WETLAND

of ecology as currently understood provides the following list of possible values for such aquatic and wetland areas:[1]

a. Esthetic and scientific values of a wildlife perserve including diverse species supported,

b. Hydraulic functions of water storage, erosion control, water treatment, and groundwater recharge,

c. Cycling of nutrients, including detritus production, collection, and decomposition.

Source reduction measures are aimed at habitat modification and/or destruction, and may produce environmental damage in the prevention of vector breeding and survival. Such measures can permanently alter the nature of aquatic and wetland areas, and so effect major biotic and physical changes. These changes should be recognized, evaluated, and carefully considered in a cost/benefit analysis of any vector control program. Necessarily, in addition to vector control, other beneficial effects may be produced: land may be made suitable for human use or converted to alternative ecologies. The original values need to be determined by assessment, the impact of control measures weighed against these, and the cost/benefit yield to society calculated. Wherever feasible these environmental impacts should be minimized, or mitigated by conserving or restoring other areas in substitution for those permanently eliminated or altered.

Use of the Algorithm:

For this section, a two-stage matrix is provided so that the aquatics and wetlands may first be classified into any of 20 basic types (4 x 5) and then characterized by any of 140 procedure-effect combinations (10 x 14), to

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1. Erickson, 1979, p. 138.

yield a potential choice of 2800 situations (20 x 140) which could result from the application of source reduction measures. As with most matrices, many of these situations may never be encountered, but the concept of a checklist is a valuable one in any environmental assessment procedure.

Next, one evaluates each situation for significance, or meaning, which is the degree of impact for each specific environmental component affected.[1]

Then evaluate the magnitude, or the size, scope or span of an effect across space and time Together these two analyses lead to a potential spectrum of environmental effects, from a highly significant effect such as causing mortality of a given animal, to a barely significant effect such as causing a minor, non-threatening reduction in its food supply; from an effect of great magnitude, such as destroying the only existing population of that species of animal, to a small magnitude effect of destroying only a very small (non-threatening) aliquot of its population.

The final criterion, that of importance of an environmental effect, is the evaluation of its significance times its magnitude.

An effect of low significance, but of high magnitude would have an impact of great importance as it accumulates over space and time. Progressive lowering of the water table, or a small change in microclimate, would serve as examples. Such effects might be easily overlooked at the time of their origin.

An effect of high significance, but of low magnitude, might well have a level of importance well below that of the successful control of a major disease such as malaria. An example would be the creation of an impoundage which could be successfully maintained without mosquito production by destroying a local marsh which was a malaria control problem. If one

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1. Leopold et al., 1971, p. 2 (adapted with a change in terms used).

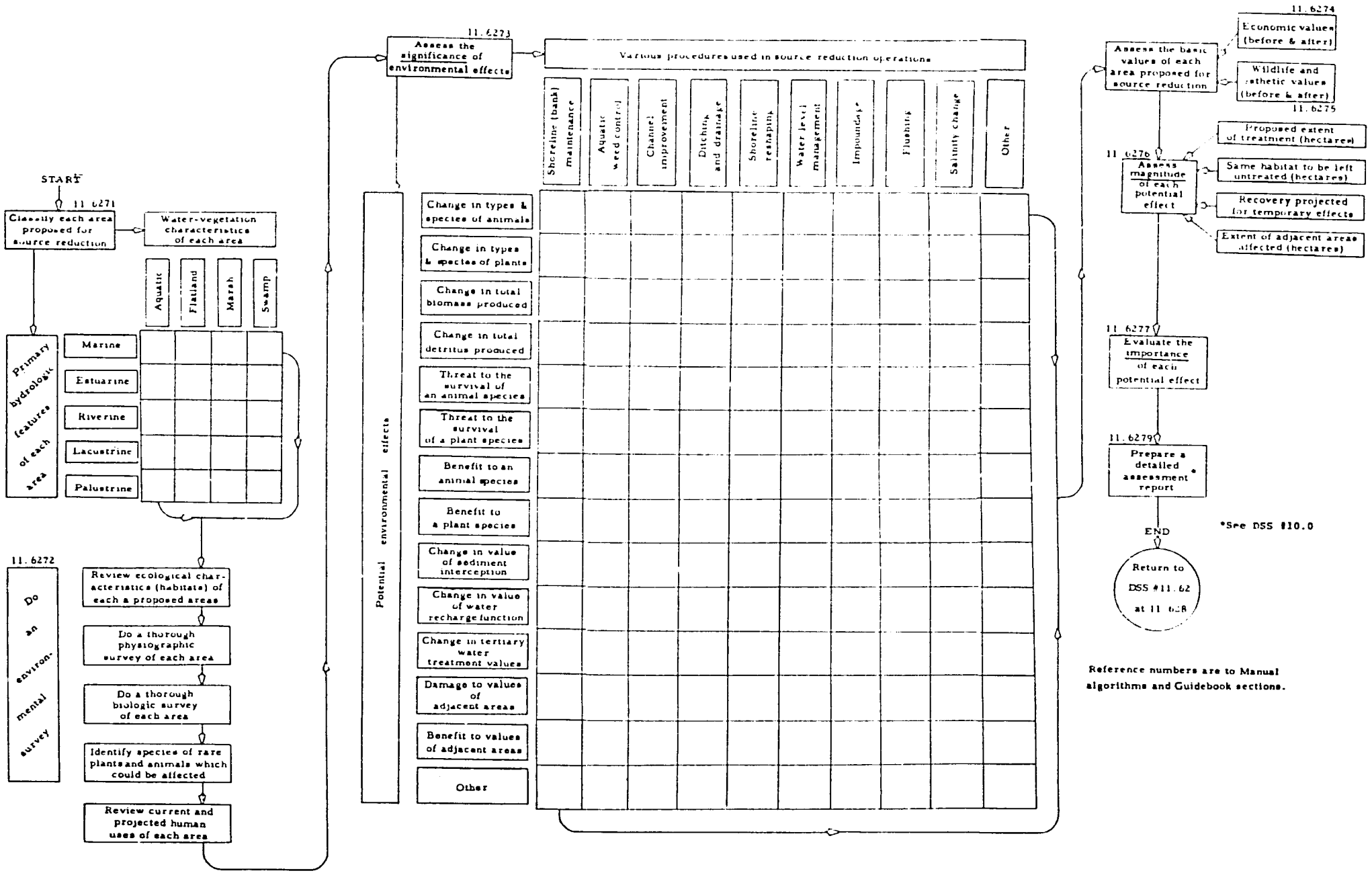
balanced the complete destruction of the local marsh habitat against more extensive untouched areas of comparable marsh elsewhere, beyond vector flight range, then the low magnitude of this very significant environmental effect would argue for the impoundage, as justified for disease control and perhaps for water storage or other uses.

Obviously an error in either the estimate of significance or of magnitude would render invalid the evaluation of importance for a given environmental effect.

Use of the Guidebook:

Useful discussions of the steps required in the algorithm, further references, and suggestions for preparation of the assessment report are given under the corresponding Guidebook Section 11.627.

Assess the Environmental Effects of Proposed Source Reduction Measures on Natural Aquatic and Wetlands Areas



SECTION 11.63 - SELECT CHEMICAL LARVICIDE METHODOLOGY[1,2]

Background:

"Since the pre-World War II era there have been relatively few antimalaria programs in which anti-larval measures played a significant role. In the early part of the century, before development of the residual insecticides, larvicides played a central role in many anti-mosquito and antimalaria campaigns, in combination with source-reduction methods. The work of Gorgas in Havana and Panama with oils, and the use of Paris Green by workers in the United States are outstanding examples. Brown, et al. have summarized the more recent applications of larvicides in malaria control campaigns of field trials, particularly in the Middle East, Nigeria and El Salvador.[3] It may be anticipated that larviciding, with the safe, biodegradable pesticides now available, such as temephos (Abate), will play an increasing role in antimalaria campaigns. So, too, may some of the more economical of the available oils. It must be reemphasized here, however, that application of larvicides demands a much more sophisticated approach than residual spraying of domiciles, and a much higher level of training for field personnel and supervisors than has heretofore been available. Even with the very safe larvicides now available, the application to aquatic habitats makes it essential that trained entomologists exercise at least frequent supervision. Where AID supports or cooperates in a country program involving pesticides, particularly larvicides, it is important that a trained professional be available for rapid consultation."[4]

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1. See WHO, 1973a, Manual on larval control operations, Ch. III, p. 65-140.
2. See a new WHO manual on source reduction and chemical control in preparation by Husang Ratfajah for 1982.
3. Brown et al. 1976.
4. AID - Asia Bureau Malaria Strategy Study 1977, p. 64.

Definitions:

Chemical larvicidal control refers to the application of a chemical to the larval sources of mosquitoes to effect mortality at one or more of the immature, aquatic stages of the target species (eggs, larvae, pupae). A larvicide is the particular chemical that is introduced to cause the mortality. An example of chemical larvicidal control would be the properly timed application of fenthion at predetermined field strength and application rates, to the surface of the aquatic habitat of a target anopheline species to kill the susceptible stages of the immature mosquitoes.

The selection of larvicidal control has, as its strongest advantage, the prevention of the emergence of a brood of adult mosquitoes. When larviciding is successful, one then avoids having to deal with a population of adults which may be difficult to locate, hard to control, and can pose a potential disease threat as they enter areas of human work or habitation where they may serve as malaria vectors.

Larviciding should be used as a component of an integrated pest management (IPM) approach, in which all four primary control methodologies are employed to the extent practicable (source reduction, chemical control, biological control, and diverse special methods, inclusive of insect growth regulators, inhibitors, and genetic controls).

Whenever field surveys find larval breeding sources well enough delineated, accessible, and feasible for control operations, then the use of a larvicide is indicated. The decision to use a larvicide may not prove practical because of a lack of trained personnel or appropriate equipment, inaccessibility of the breeding area, or concern over a potential high risk to the environment.

The objective in applying a larvicidal chemical is to treat and to cover the water surface wherever larvae are located, since the larvae feed on the surface film as well as hang from it. Since the larva feeds by sweeping the film into its mouth, insecticides as a part of the film are ingested. The larva's contact with the film also makes possible the direct penetration of the insecticide through the larval cuticle or its respiratory system.

Effective application of a larvicide depends upon achieving as complete coverage of the larval habitat as possible, and repeating this at those intervals which will catch every brood well before its pupation time.

Chemical larvicidal control methodologies appear deceptively simple when in fact their successful use requires thoughtful planning, precise implementation and continuing analyses of results. For a malaria control program in its early stages, larvicidal control may provide immediate and dramatic results at relatively low initial costs.

A number of pitfalls are inherent in the larvicidal approach, however, and should be considered:

1. Larvicidal control programs require sensitive monitoring systems and timing of the application is often critical to success.
2. Larvicides may be toxic to humans, potentially endangering both control personnel and the public.
3. Larvicides may also affect non-target organisms resulting in environmental disruptions or even disruption of natural mosquito control mechanisms.
4. Since larvicidal control is short lived, repetitive applications are required and may become quite costly over the long term.
5. Prolonged use of larvicides can be expected to result in the selection of a strain of resistant mosquitoes.

Although the risks of resistance must be a dominant consideration, the long term cost/effectiveness of a larvicidal program can be prolonged by both the sophisticated use of larvicides[1,2] and by integration of the control program to sufficient level to forestall resistance and obtain the benefits of long term control methodologies.[3]

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1. Georghiou, 1979.
2. Zboray and Gutierrez, 1979.
3. Smith, 1971.

Failure of larviciding may be due to any of the following reasons:

1. Inadequate survey which failed to designate important sources.
2. Incomplete coverage due to an application which missed important sources.
3. Appearance of breeding areas since the field survey, and their escape from treatment. Temporary water areas will present this problem if they are vector habitats.
4. Vegetation coverage of an aliquot of the water surface, so that the surface film does not actually receive treatment.
5. Current and wind forces which strip off the treated surface film.
6. Loss of the insecticide through degradation.
7. Development of resistance by the larvae to the chemical selected.
8. Improper application or poor formulation of the dilute materials used in the treatment.
9. Faulty materials.

The form of the insecticide upon application is either a dust which floats as particles on the surface film, or as oil droplets or an emulsion which mixes into the film.

The means of application may range from spraying or dusting a water surface to the use of a delayed delivery mechanism such as pellets, capsules, or a slow-drip device.

The amount of insecticide used for malaria control has ranged from 25 gallons of #2 diesel fuel per acre[1] in the past, through one pound of Paris Green[2] to 0.05 lb/acre[3] by an ultra-low volume delivery system.

Larviciding operations may present particular hazards to program personnel so that safety training in all aspects of insecticide handling and security is very important.

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1. Russell et al., 1946, p. 421.
2. Disease Vector Ecology & Control Center, USN, 1976, p. 53-54.
3. Brown 1978, p. 186.

A number of larvicides that vary widely in characteristics are available for use in larval control programs.[1] (See Table 5). The selection of an appropriate larvicide requires careful consideration of many factors that bear upon the suitability of a candidate larvicide, including but not limited to the following:

1. Market characteristics of larvicides--costs, supply (availability), shelf life, formulation.
2. Biocidal and physical characteristics of the insecticides--toxicity (LD 50), specificity, biological and physical degradability.
3. Characteristics of the target species--susceptibility (LC 50), most susceptible developmental stage, generations-per-year, rate of development.
4. Characteristics of the aquatic habitat of the target species--accessibility of application equipment, the non-target organisms present, susceptibility of NTOs, food chain characteristics, natural mortality factors operating on the aquatic stages of the target anophelines, utilization of the source by the public.
5. Characteristics of work force--supply, skill level, literacy.

Environmental Concerns:

As the toxicities and specificities of insecticides have increased, and the application technology has become more and more capable of achieving a uniform coverage with less and less material, there has in general been less environmental damage done by larviciding. Another major factor has been the restriction of treatment to just those areas which are the actual sources for the vector to be controlled. A further refinement, basically for the economics of the program, has been to limit treatment, on the basis of flight range of the vector, to only those selected areas which support disease transmission in human habitation, recreational (social) and work areas.

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1. Rathburn, 1979.

TABLE 5

SELECTED INSECTICIDES SUITABLE FOR LARVICIDAL APPLICATION IN MOSQUITO CONTROL[1]

Selected insecticides suitable for larvicidal application in mosquito control

Insecticide	Dosage per hectare	Remarks
Diesel oil (fuel oil) and other petroleum oils	140–190 l in open ponds to cover water surface	With an addition of a spreading agent the amount can be decreased 5 times or more
Larvicidal oil	19–47 l (with special spreading agents)	Various proprietary formulations
Paris green	ca 800–1000 g of pure toxicant diluted at 1–5% in dust	Pellets containing 5% of Paris green may be applied at about 17 kg per hectare using ground based machines or aircraft
DDT HCH (Lindane) Dieldrin	ca 200 g ca 110 g ca 110 g	Outdoor application of chlorinated hydrocarbons is not advised. In some conditions a limited use may be permissible as oil or water emulsion formulations on waters with little vegetation. Granular formulations are available
Malathion	200–700 g	Usually as emulsion concentrate. Avoid overdoing which may injure fish
Temephos (Abate)	50–200 g of pure compound. 2 kg–20 kg of granular formulation	As emulsion concentrate or granular formulation. The latter are available in 1%, 2% and 5% concentration and higher dosages are used for polluted waters
Fenitrothion Fenthion	200–300 g 20–100 g	Not to be applied to waters containing fish

1. Bruce-Chwatt, 1980, p. 246.

Beyond these considerations, poorly conducted larviciding operations may themselves become the primary reason for any environmental damage or hazard to people and wildlife.

The development and use of degradable materials as insecticides has meant that no residual toxicant is left in the environment to produce damage by their accumulation or migration through food chains.

If larviciding is handled by a competent program staff equipped properly, environmental effects and risk may be so minimal that they are of no consequence. (See Section 10.62 for discussion of prior environmental assessments, especially 10.62A).[1,2,3,4]

Use of the Algorithm

DSS 11.63 allows one to make a qualified decision about the use of a larvicide, and if this control measure is in order, directs one to DSS 11.90 and its subset algorithms to select and evaluate a specific chemical for its potential advantages and disadvantages, together with the operational support needed for its successful use.

If these decisions are carried out successfully, one is then directed to return to the general program algorithm DSS 1.0.

Use of the Guidebook

Many valuable papers have been excerpted for the Guidebook, to provide an adequate field library for this important area. Should additional literature resources be needed, an extensive bibliography is also given in Chaper 24 of the Guidebook.

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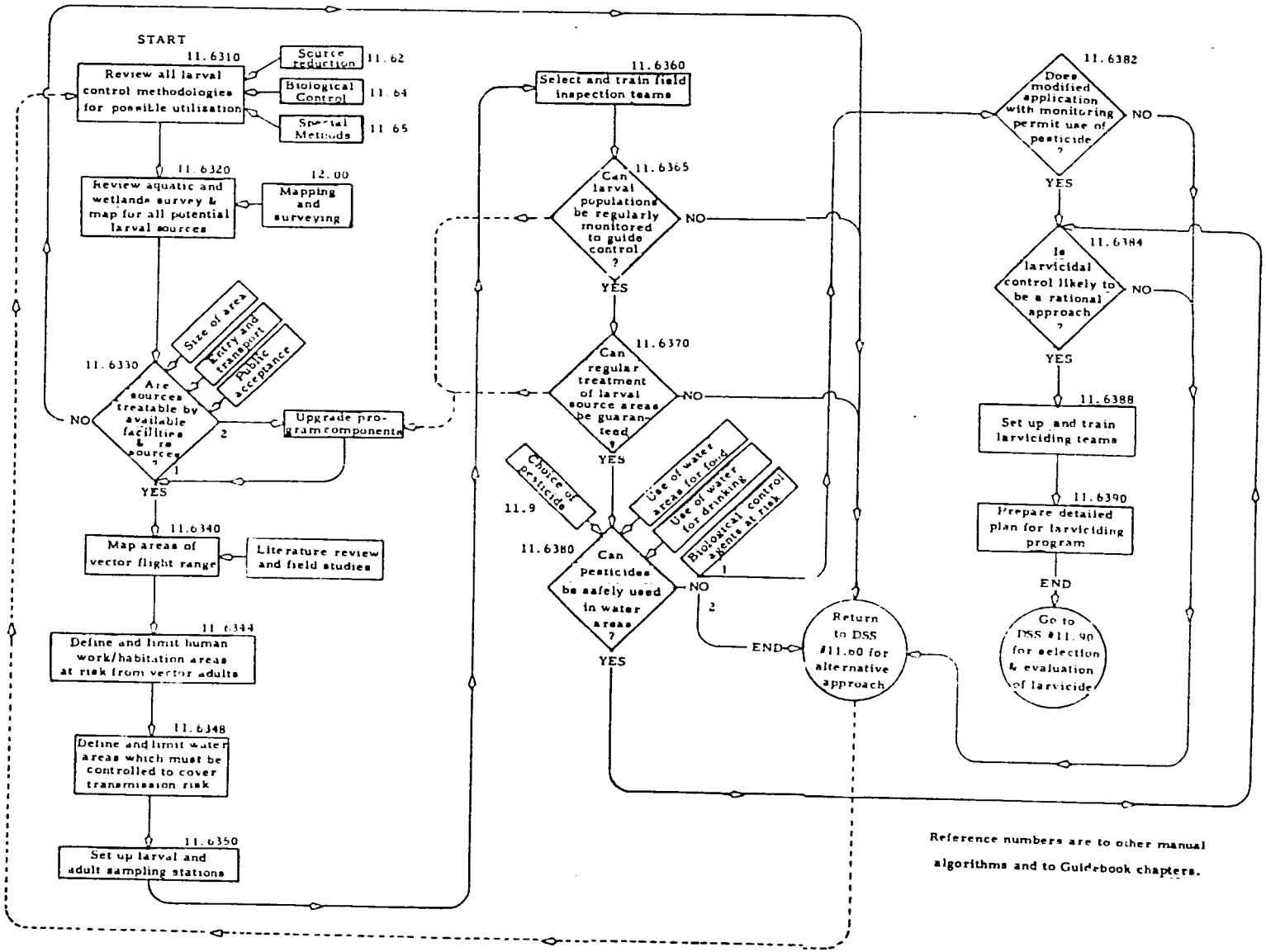
1. Tarzwell, 1947.
2. Erickson, A.B., 1947.
3. Bishop, 1947.
4. Scudder and Tarzwell, 1950.

Select Chemical Larvicide Methodology

D.S.S. #11.63



Reference numbers are to other manual algorithms and to Guidebook chapters.

SECTION 11.64 - SELECT BIO-CONTROL METHODOLOGY [1]

Definitions:

Biological control in this paper refers to the reduction or elimination of mosquito larval populations by the enhancement of native or introduction of exotic plant or animal species, inclusive of pathogenic organisms and viruses. Examples would be the introduction of mosquito fish, *Gambusia affinis*, to prey upon larvae, which upon establishment of the predator fish, would provide long term control. Another example would be the introduction of the pathogen, *Bacillus thuringiensis*, variety *israelensis*, to provide an immediate short term kill of the larvae. The introduction of aquatic plants known to limit anopheline populations would also be considered biological control.

Biological control may well offer a vital element to an anopheline control program. The control program should be sufficiently integrated with physical, biological and chemical control methodologies to reduce insecticide pressures and forestall the eventuality of insecticide resistance. In spite of the fact that a biocontrol agent may provide relatively low larval mortality rates (20-30%), the addition of one or more biocontrol agents may be a decisive factor in insuring long term control.

1. See WHO, 1973a, Manual on larval control operations, Chapter I, p. 7-14.

The analysis of the cost-effectiveness of proposed biological control agents will undoubtedly vary widely. An agent that is easily obtained, easily transported and establishes itself could result in significant savings when compared to repetitive insecticide applications. On the other hand, an agent in short supply, not easily used, or unable to establish itself may require excessive expenditures of resources to obtain an insignificant increment of effectiveness.

The effective use of biocontrol agents to control anopheline mosquitoes will be dependent upon a thorough knowledge of the ecological requirements of the vector species as well as the proposed biocontrol agents. The direct and indirect effects of the agent has upon other species in the biotic community are also of concern.

Environmental Concerns:

There are major environmental and economic risks associated with the introduction of an exotic agent to provide biological control. An exotic organism that establishes itself, unlike a once-used pesticide, could conceivably create adverse economic and/or ecological impacts in perpetuity. For this reason the decision support system has been programmed conservatively to avoid unnecessary introductions of exotic species that could become established.

Local biological control agents are given first consideration in the algorithms because they are unlikely to present the dangers inherent in exotic introductions. Ideally, a thorough inventory of existing local biocontrol agents would be made preceding the selection of a biocontrol agent. The World Health Organization has provided support in biocontrol inventories and has established an international reference center headed by Dr. John Briggs, Ohio State University, Columbus, Ohio. Technical assistance by identification and study of vector pathogens and parasites may be provided upon request.

The algorithm also gives strong consideration to the five stage scheme established by the World Health Organization for screening and evaluating the efficacy and safety of biocontrol agents.[1] When a biocontrol agent has passed the fifth stage, its efficiency, safety and impact on non-target organisms should be well defined. Sufficient knowledge should be available about an agent having passed stage five to be able to determine whether a detailed environmental assessment should precede its introduction. (See Table 6).

Use of the Algorithms:

The successful utilization of the algorithms will be dependent upon the availability of the specific information required at each step. The user will need information about the candidate biocontrol agents, the vector sources, the vector control agency, and the socio-economic system of the host country.

The user of the algorithm is in the best position to provide the information about the vector control agency, the vector sources and the socio-economic system. Basic information on the vector sources will have already been obtained at Steps 11.3 and 11.4 of algorithm DSS 11.0. Additional information on vector sources will be accumulated to complete Step 11.642 of algorithm DSS 11.64. As indicated in the algorithm, the information would be expected to be derived from local literature, local expertise, or actual field studies. Additional information of a local nature will also be required as certain steps are reached in the algorithms. Information about local regulations on exotic introductions, and the environmental or economic significance of the vector sources are further examples of required information.

The Decision Support System provides the user with the most recent information on the efficacy of the candidate biocontrol agents. The information, or guidance on obtaining the information, can be found in the Guidebook Sections numbered to correspond to the algorithm step numbers.

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1. WHO, 1975a.

TABLE 6 PRELIMINARY SCHEME FOR SCREENING AND EVALUATING THE EFFICACY AND SAFETY OF BIOLOGICAL AGENTS FOR CONTROL OF DISEASE VECTORS[1]
(World Health Organization, 1975)

STAGE I	*STAGE II*		*STAGE III*	*STAGE IV*		*STAGE V*
Laboratory	*Laboratory*		*Preliminary field trials*	*Laboratory*		*Large scale field trials*
A. Identification and characterization [a] B. Assessment against selected target vectors C. Preliminary evaluation of ease of rearing in quantity	A. Mammalian infectivity tests to ensure safety to laboratory & field personnel [b] B. Preliminary assessment against certain non-target species	RESULTS OF REVIEW OF STAGES I AND II	Strictly regulated pond tests under WHO supervision [c] to determine efficacy against disease vectors under natural conditions	More detailed tests on mammalian infectivity, using appropriate techniques *Laboratory & field trials* Detailed studies on non-target range—especially other fauna in habitats where Stage V trials may be conducted	REVIEW OF STAGES I, II, III AND IV BY INFORMAL CONSULTATION GROUP	To be conducted under WHO auspices. Not presently defined, and will vary according to target vector, habitat(s), mode of application, etc.

[a] This study may vary from routine taxonomic determination (fish, nematodes, predatory insects) to the detailed serotyping necessary for microorganisms, especially viruses.

[b] Not required in predator–prey situations, but more detailed tests on effects on non-target organisms could be substituted in trials of larvivorous fish, predatory insects, etc.

[c] Especially where the biological control agent is not indigenous.

1. Briggs, 1977, p. 10. (See also WHO, 1975a, p. 24, 30).

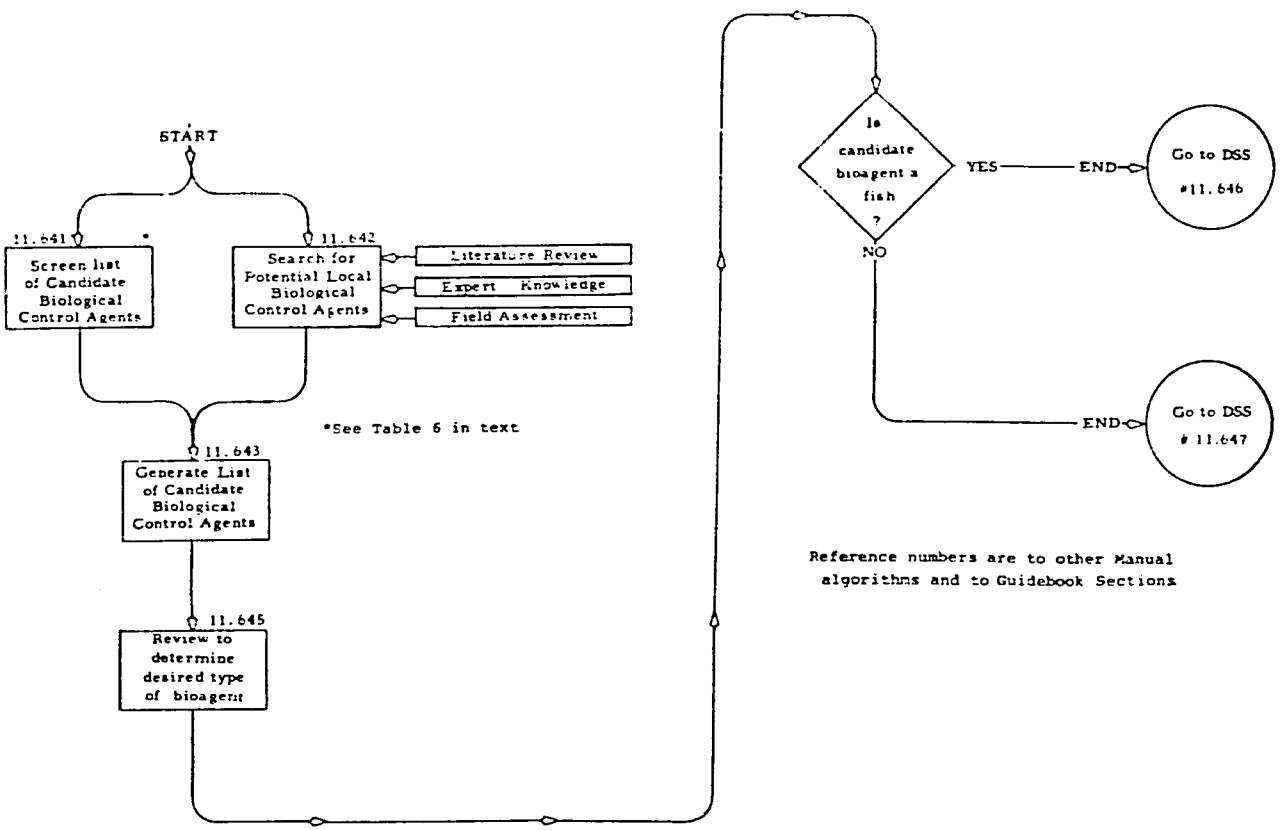
11-44
11.641

Once the essential information has been gathered by the user, the utilization of the algorithms should proceed rapidly toward selection of appropriate biological control methodologies.

Use of the Guidebook:

The Guidebook provides information available to date on the various candidate biological control agents. A bibliography is included to enable further research.

Select A Biological Control Agent D.S.S #11.64



Reference numbers are to other Manual algorithms and to Guidebook Sections

D.S.S. 11.646 SELECT LARVIVORE OR HERBIVORE FISH

Definitions and Background

Mosquito-eating fishes are to date the most effective biological control agents of anopheline larvae and pupae. The effectiveness of fish in the natural control of mosquitoes has long been recognized and fish have been utilized in mosquito control operations since the early 1900's. Gerberich and Laird[1] have listed over 200 species of fish used for mosquito control in a comprehensive annotated bibliography. The mosquito fish, *Gambusia affinis*, a fish indigenous to Central America, is now nearly worldwide in distribution because of its use in mosquito control.

Because fish have been utilized effectively for a relatively long period of time, a good deal of useful information is available on operational techniques. The California Mosquito and Vector Control Association provides a valuable publication[2] outlining the operational techniques of biological control by fishes including holding systems, capturing equipment and methods, transportation equipment and methods and aquacultural techniques. Utilization of fish in anopheline control programs may require significant expenditure for equipment, facilities and training. The benefits of effective biological control by a larvivore or herbivore fish may easily outweigh these costs, however, and would justify the effort expended in finding a successful fish.

Fish utilized in mosquito control commonly provide control by one of two ways. The fish may prey directly on the mosquito larvae (larvivores) or they may graze on the aquatic vegetation (herbivores) that serves as a refuge for the mosquito larvae. The herbivorous fish cause larval mortality indirectly

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1. Gerberich and Laird, 1966.
2. Coykendall, 1980.

as they expose the larvae to biological and/or physical control agents that are able to operate more effectively as the vegetation is reduced. In general, an effective larvivore or herbivore fish should possess the following characteristics:

1. High predation rates on anophelines or high grazing rates on vegetation used as refuge.
2. Ability to establish and reproduce in sufficient numbers in the anopheline sources.
3. An adaptive range of tolerances to salinity, temperatures and pollutants consistent with the sources.
4. Ease in handling (collection, transporation, stocking, rearing, etc.).

Environmental Concerns:

The introduction of exotic fishes for the purpose of anopheline control may have disastrous environmental consequences. For this reason it is extremely important to learn as much as is practicable about the biological characteristics of the candidate fish and the structure and function of the aquatic ecosystem into which the fish will be introduced. Introduced fish may directly affect important animal or plant species by their feeding. They may also indirectly effect other fish species by competing with them for food. Indeed, the introduction of an exotic fish may alter the aquatic ecosystem dramatically by way of its impact as a predator or herbivore, as a source of food to the next trophic level, or possibly even by physical changes in the water resulting from its activities (i.e. turbidity). The mosquito fish, Gambusia affinis, unfortunately

provides an excellent example of an effective mosquito predator that has a history of out-competing indigenous fishes in some of its introductions.[1]

Use of the Algorithm:

Algorithm D.S.S. #11.646 is designed to assist in selecting a larvivore and herbivore fish that will provide effective control and avoid adverse environmental problems by first assessing local species of larvivore and herbivore fishes existing in the sources. If they are present, environmental modifications such as ditching or vegetation removal may enhance the effectiveness of predation by the indigenous fish. If predatory fish are not found at the sources, the next step in the algorithm leads to the assessment of native fishes from the same drainage area. The introduction of a native fish common to the drainage area also requires careful consideration since the fish is to be introduced to a new aquatic system. However, the risks may well be reduced, and more practically, the host country may have less stringent regulations concerning the possession, transportation and introduction of native species.

The algorithm D.S.S. #11.646 only considers the introduction of exotic fishes after the native species have been assessed. In this way, the considerable environmental risks associated with the introduction of exotic species may be avoided.

Use of the Guidebook:

Several papers on fish have been excerpted for the Guidebook, and a large number of other references are given. Titles of the latter indicate research on the effect of chemical larvicides on fish as well as the ecological significance of such fish.

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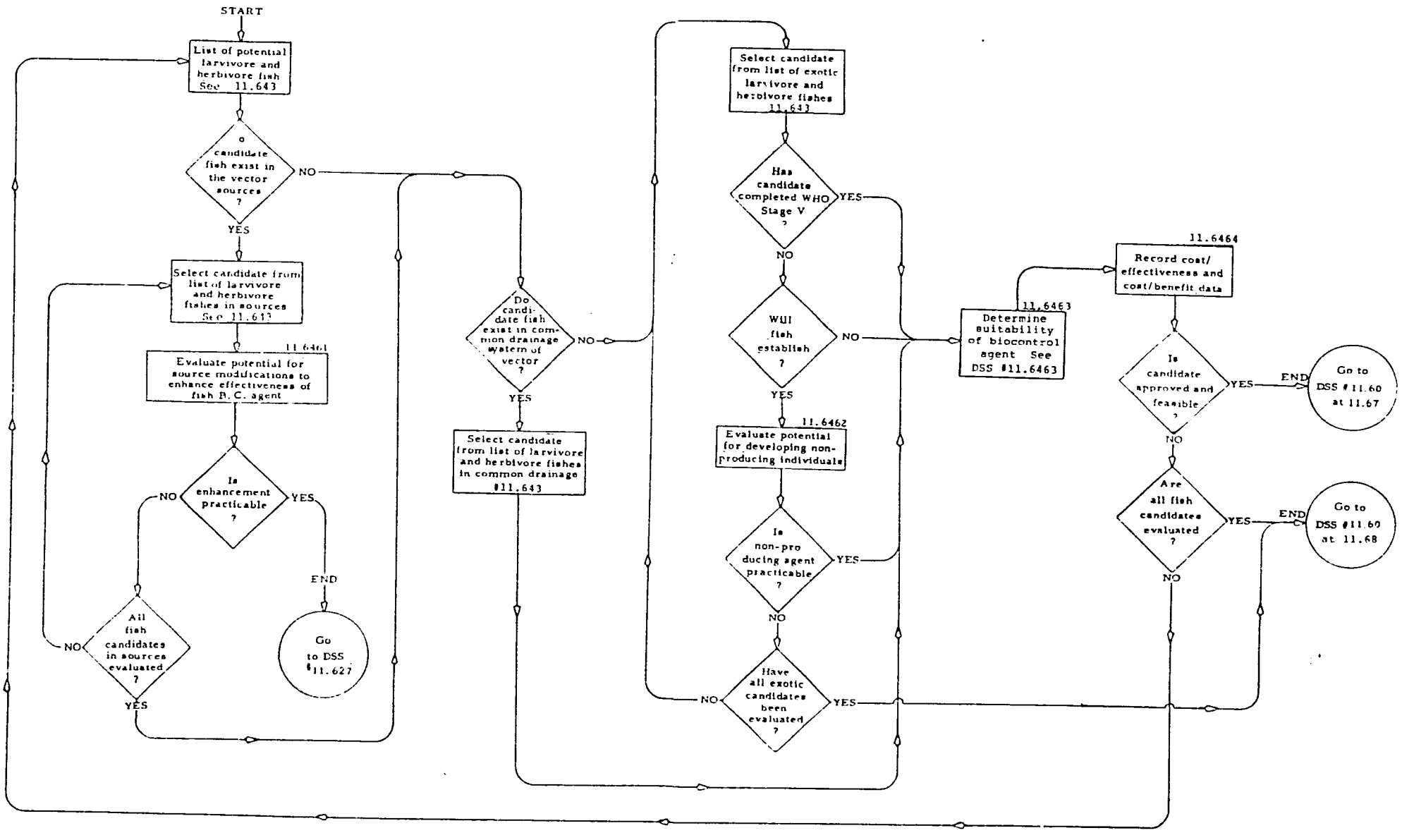
1. Bay, 1972 (see excerpt in Guidebook under 11.6461).

D.S.S. #11.646

Select Larvivore or Herbivore Fish



SECTION 11.647 - SELECT MICROBIAL PATHOGEN, PARASITE OR INVERTEBRATE PREDATOR

Definitions:

Microbial pathogens and parasites of mosquitoes include viruses, rickettsiae, bacteria, protozoa, fungi, flatworms, and nematodes. Their use in mosquito control has been limited in the past, but recent advances in research and development offer promise that they will contribute significantly to future malaria control efforts.

It follows that since microbial pathogens and parasites span a wide range of the biological world that the techniques utilized in microbial control also vary widely. At one end of the spectrum the microbes may be used in repeated applications to suppress the vector populations. This strategy of control is perhaps best illustrated by use of the endotoxin of *Bacillus thuringiensis* var. *israelensis* (BTI). A number of formulations of BTI are now available, including wettable powders, emulsions, and sand granules, any one of which may be applied as an insecticide, using conventional spray equipment and techniques. As with many insecticides, the products degrade rapidly and currently provide very little residual activity.

At the other end of the spectrum of potential control strategies is the use of organisms that upon introduction would establish themselves and effect permanent control of the target populations. The mermithid nematode, *Romanomermis culicivorax* for example, has been found to establish and reproduce after its introduction. Since techniques of mass rearing of the nematodes have advanced markedly in recent years, this species may well offer promise of long term control of anophelines.

In certain circumstances, invertebrate predators of anophelines may be found to provide a significant contribution to their natural mortality. These predators include a variety of nematodes and aquatic arthropods (mites, spiders, insects). Although little has been accomplished in the development of mass rearing and planting techniques for invertebrate predators, there appears to be some potential for their effective use in malaria control programs of the future. For now, perhaps the most important consideration is that the selected malaria control strategy does not disrupt an existing natural control component provided by invertebrate predators. For this reason it is important that initial environmental investigations detect and define the existence of any effective natural control that is being provided by invertebrate predators, and that control measures selected and implemented are complementary rather than disruptive of this natural level of control.

Environmental Concerns:

Introductions of exotic microbial pathogens, various parasites, and invertebrate predators carry the risks of creating adverse environmental impacts and should be given careful consideration. Considerable caution should guide use of those agents that are not highly selective for anophelines and would establish themselves. Again, the algorithm has a principal safety factor built in through reliance upon the rationale provided by the WHO Five Step Scheme.[1]

Use of the Algorithm:

The effectiveness of the algorithm will depend upon the availability of information on potential microbial pathogens, parasites and invertebrate predators. The Guidebook provides information on various candidate organisms, but local field and literature evaluations will be necessary to assess the presence

1. See Table 6.

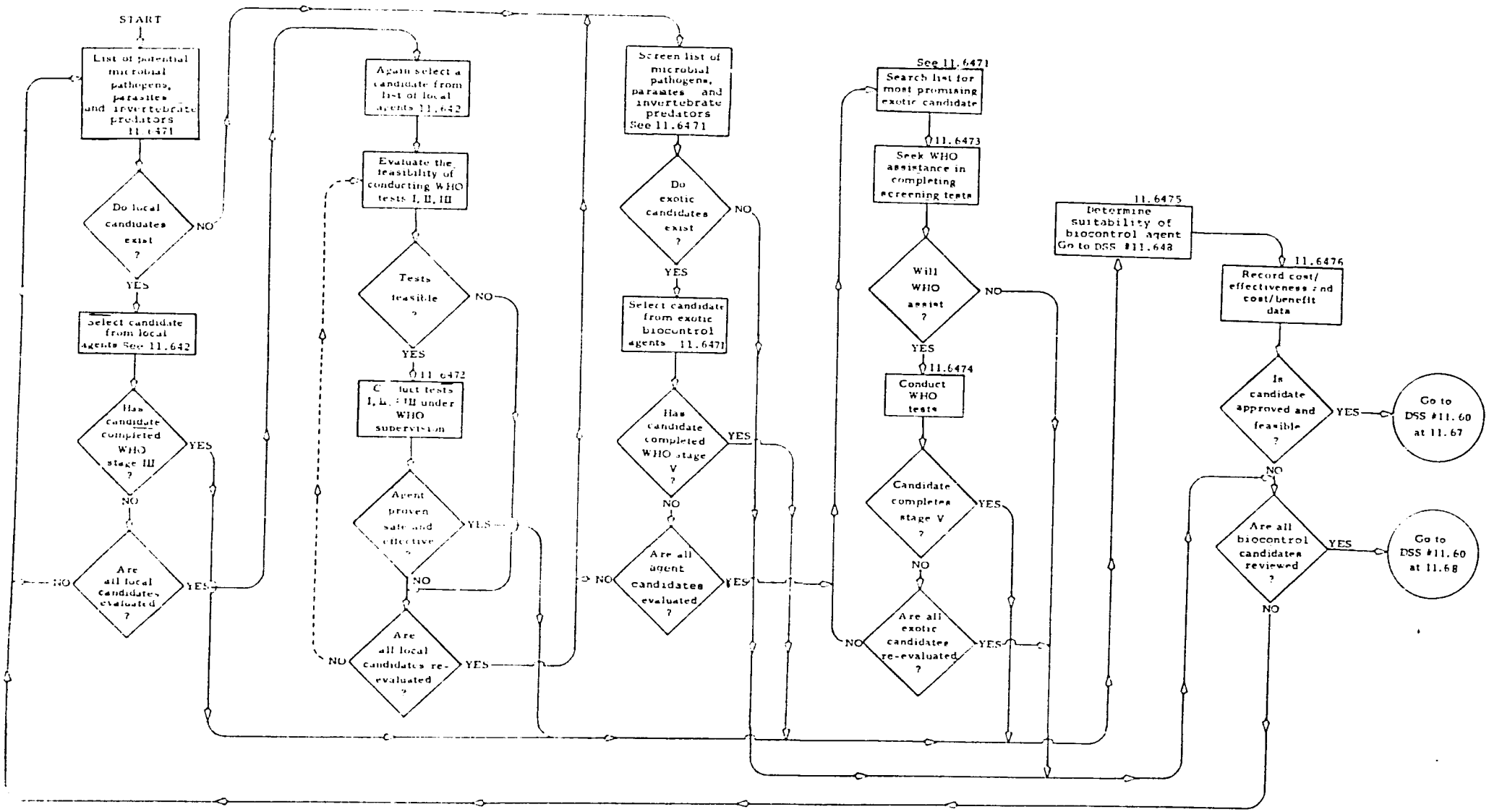
and effect of local organisms. The current ratings of potential control agents in the Five Step Scheme may be obtained from Dr. John P. Briggs, Entomology Department, Ohio State University, 1735 S. Neil Avenue, Columbus, Ohio, 43210.

Use of the Guidebook

The Guidebook has a number of articles selected as excerpts and also lists a large number of additional references which may be consulted for guidance in this area (see also Guidebook material under Section 11.6463).

D.S.S. #11.647

Select Microbial Pathogen, Parasite or Invertebrate Predator



Reference numbers are to Guidebook Sections.

SECTION 11.648 DETERMINE SUITABILITY OF A BIOLOGICAL CONTROL AGENT

Definitions and Background:

Having selected and tentatively approved the use of a potential biological control agent, the program's next series of steps is to explore the practicality of the agent and the risks attendant upon the use of it. This series can be resolved first of all into the program's successful culture and production of the agent, which require special resources and trained personnel, unless these services can be purchased, economically, as with the microbial agents or their toxins. The next task is the scheduled transport, introduction and distribution of the agent on the field, with whatever ecological modification (enhancement) may be needed to guarantee the successful establishment and effectiveness of the agent. The third task is to do careful, often extensive monitoring of the agent in the field in its new and/or enhanced role, not only to protect the agent, but also to discover and limit the extent of its unfavorable impact for protection of the environment.

A local agent, to become a more effective controlling factor than in its original state, must be enhanced by some cultural advantage furnished by the program. A local agent may require augmentation, that is, harvesting and transplanting, or rearing. It may require enhancement, that is, physical or biological changes in the environment of the mosquito sources to enhance its effectiveness. An example would be the removal of a certain species of vegetation (e.g. *Myriophyllum* spp.) to enhance the effectiveness of predation by mosquito fish.

The advantage of an exotic biocontrol agent which has completed the WHO Five Stage Scheme is that it has been thoroughly screened to meet requirements of safety to humans and non-target organisms. The information should be readily available to enable the evaluation of risks and benefits of the agent in the proposed vector sources.

Exotic biocontrol agents that have not completed the WHO Scheme should be given consideration only under special circumstances. For instance, funds for testing biocontrol agents at Stage IV or V may be available for a promising exotic agent. The host country could then become the site and stimulus for completion of the final tests.

Environmental Concerns:

The introduction of an exotic agent, or the enhancement and/or augmentation of the role of a preexisting or local agent always has the potential for a serious environmental impact. Therefore a very carefully controlled introduction (and/or ecological modification) is the rule, with monitoring which could reveal any potential disruption of the ecology in time to reverse the process and prevent the risk of a large scale disaster. The impact of the enhancement measures should always be monitored to allow for the withdrawal of the measures in the event significant negative environmental effects are detected. When the field data are adequate and favorable enough to permit the large scale use of the agent, only then should its use be made more extensive. Ecological change will always occur, for that is implied, at the very least, for the successful control of the anopheline target. Its monitoring is then normal to a good control operation. The impact should be evaluated and defended on the basis of cost/risk/benefit considerations to the program.

One major advantage of a local agent is that it is already adapted to the target or host species, and to the ecological parameters of the area. Another major advantage is that its effect on the local environment is to an extent already observable and, not likely to create environmental problems. In contrast, a newly introduced exotic agent, unless carefully screened, may well become a dramatic and unwelcome surprise of high risk to the local environment.

Use of the Algorithm:

The two algorithms, *D.S.S. #11.646* and *11.647*, which are used for the selection of biological control agents give the highest priorities to the use of local agents, or if they cannot be made effective, to exotic agents which have passed the WHO Five Stage Scheme (see Table 6). The next step for the program is to determine in all its aspects the suitability of the agent chosen. *D.S.S. #11.648* sets forth the basic tests and decisions needed in preparation for the actual approval and subsequent use of the agent chosen. The possibility that the formal processes of environmental assessment and impact (Chapter 10 of the Manual) may be required cannot be ruled out, but care in conducting this phase of the decision process should in general avoid these complications. The algorithm has therefore included the elements of these processes and refers the user to Chapter 10 for the greater detail.

Use of the Matrix:

The matrix, *11.6484 - Evaluate Environmental Effects of Each Biological Control Agent Selected* is to be used to determine whether environmental risks exist at a level that would require a full-fledged environmental assessment (EA)

or an environmental impact statement (EIS). Each candidate biological control agent should be processed through this matrix to detect potential effects of environmental significance.

The horizontal elements of the matrix represent a division of the anopheline sources into elements of ecologic or economic significance that could be impacted by the biological control agent. Most of the information specifically required to define the elements has probably been gathered in preceding studies of the sources.

Each biological control agent should be evaluated for significance and magnitude as defined in 11.627. Values ranging from zero to ten for significance and magnitude may be assigned according to the best judgment of the user. The importance of each potential environmental effect is significance time magnitude. The scores resulting from the evaluation of importance should be placed in each box of the matrix. These analyses could lead to a spectrum of environmental effects. A highly important environmental effect, such as the potential elimination of a rare and endangered species (significance = 10) found only in the vector sources (magnitude = 10), would score high (importance = 10 x 10). An unimportant environmental impact, however, as with a rare and endangered species (significance = 10) of which only a minute aliquot of its population would be impacted (magnitude = 1), would result in a relatively low score (importance = 1 x 10).

An accumulative effect of the candidate biocontrol agent may be assessed by totalling the value measuring the importance of each of the potential impacts indicated in the matrix. If the evaluation indicates no significant environmental effects, the user should proceed with the negative determination to

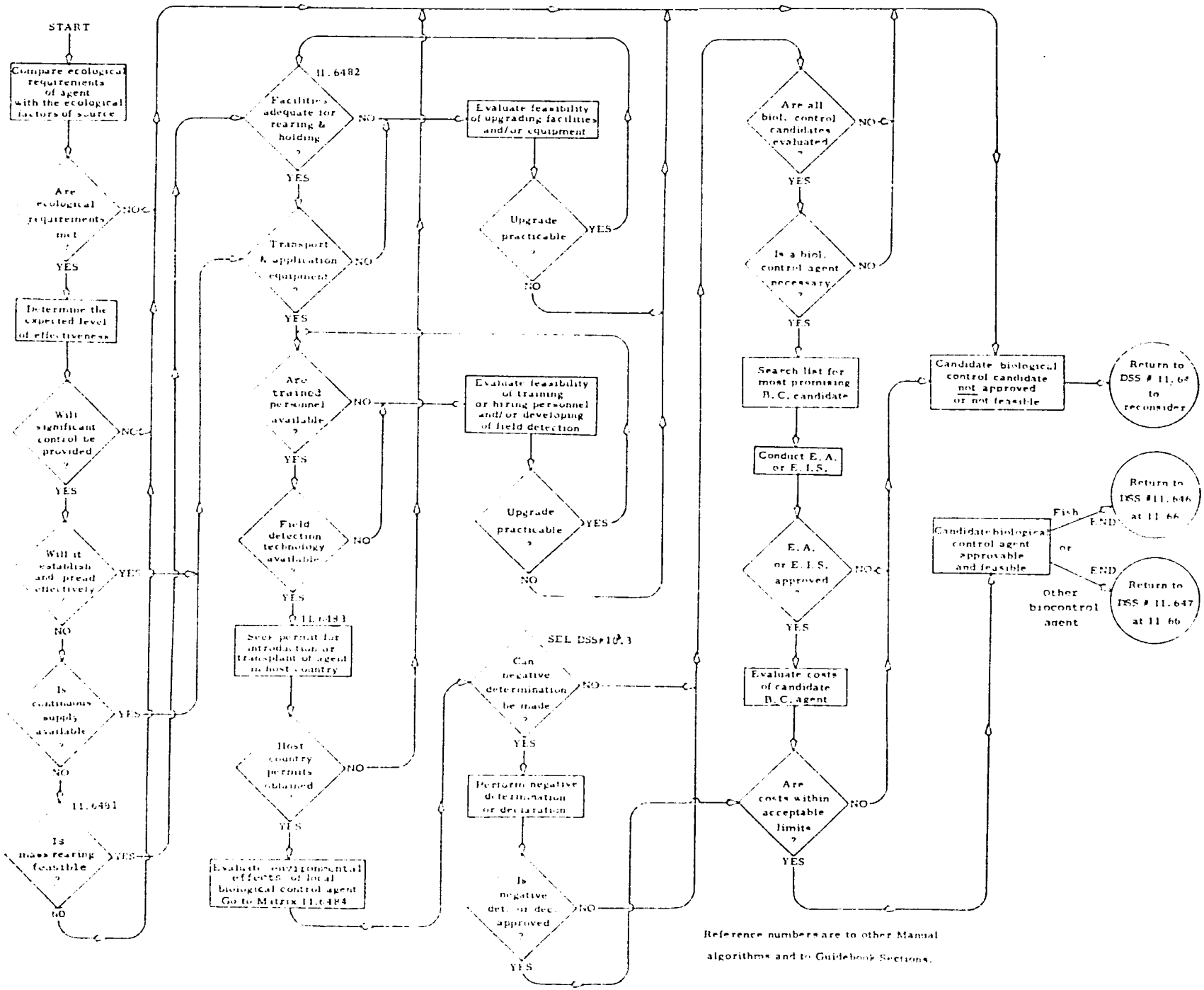
clear the agent for use.

The matrix may well clearly contraindicate use of a particular biocontrol agent. In the event there is doubt whether it should be introducted because of insufficient information, a trial introduction may be required to determine the impact of the agent on selected local species and representative food chain(s). The introduction should be permitted by the host country, conducted in a closed water system of manageable size, and proper safeguards should be incorporated to prevent escape of the agent.

Use of the Guidebook:

Guidebook Section 11.648 provides documented interactions of candidate biocontrol agents in the environment. The information may be incomplete, however, and it is necessary that the ecological requirements of the agent be as thoroughly understood as possible to enable accurate prediction of the effects of the agent in the anopheline sources.

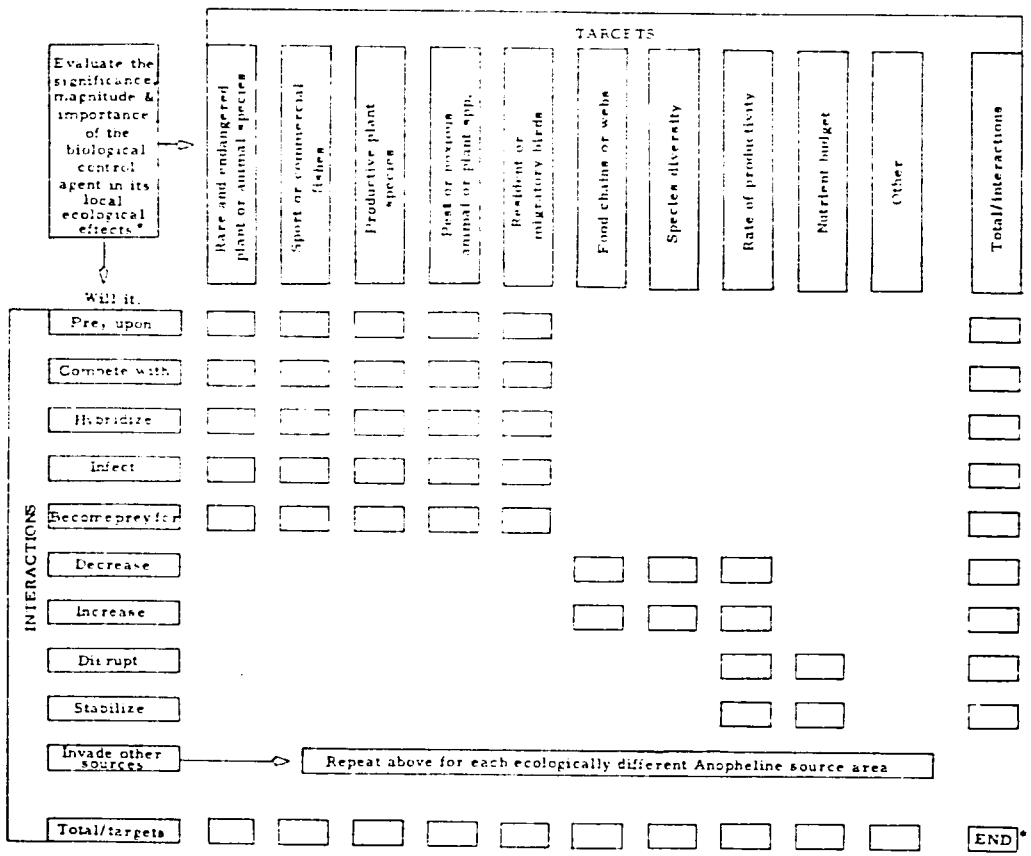
Determine Suitability of Biological Control Agent



Reference numbers are to other Manual algorithms and to Guidebook Sections.

Matrix #11.6484

Evaluate Environmental Effects of Each Biological Control Agent Selected



*See DSS #10.0

Reference numbers are to Guidebook Sections.

*Return to DSS #11.648 at 11.6484

SECTION 11.70 - SELECT ADULT RESIDUAL CONTROL METHODOLOGY[1]

Definitions and Background:

Residual insecticides kill by contact when applied to interior and exterior surfaces where mosquitoes rest. The insecticide penetrates the external surface of insects through pores, nerve endings, and membranes. Some insecticides exert a combined contact and fumigant (vapor) action, although the effective lethal period of the latter disappears long before the contact effect. (See a list of examples in Table 7).

In selecting a residual insecticide, the toxicity or biological activity against the vector, and safety to humans and domestic animals are primary considerations. Normally high insect toxicity and low human hazard should take priority. The importance of other factors such as insecticidal persistence, odor and cost will vary according to the special conditions and needs of the area. Costs should be based on the material as applied and not on the purchase price of the chemical.

In general, residual insecticides are formulated as water-dispersible powders (WDP) or as emulsion concentrates (EC) to which water is added to obtain the desired concentration for spraying. For the majority of residual spraying purposes the WDP formulations are the most effective against adult mosquitoes. They are usually packaged as 40%, 50% and 75% active ingredients (AI) to be suspended in water to obtain a final suspension of from 1% to 5% depending on the recommended dosage rate to be applied. On porous wall surface the WDPs deposit more insecticide on the surface than do emulsion and oil formulations.

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1. Fontaine, 1978.

TABLE 7

INSECTICIDES SUITABLE AS RESIDUAL SPRAY APPLICATIONS FOR CONTROL OF ANOPHELES VECTORS OF MALARIA[1]

Insecticides suitable as residual spray applications for control of Anopheles vectors of malaria

Insecticide	Dosage in grams per m^2	Average duration of effectiveness in months	Remarks
DDT	2.0	6–12	In some conditions $1.0 g/m^2$ may be used
HCH (Lindane)	0.5	3	In special conditions
Dieldrin	0.5	6–12	Now rarely used
Malathion	2.0	3	Widely used
Propoxur	2.0	3	More expensive than other compounds
Fenitrothion	2.0	3	Reasonably safe when usual precautions are observed. Expensive.

1. Bruce-Chwatt, 1980, p. 249.

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The target dosage for residual insecticides is 2 g/m^2 of active ingredient.

Efficiency in controlling adult anophelines with residual treatments is dependent upon the extent to which these factors operate:

1. The mosquitoes are both endophagic and endophilic, that is, they not only prefer to feed indoors, but also prefer to rest indoors after they have obtained a blood meal. Spraying interior walls of homes and other buildings is thereby effective as a control measure. Studies of vector behavior are necessary, with occasional monitoring to perceive any drift away from this behavior pattern, such as has occurred by force of insecticide selection.
2. The insecticide has a low vapor pressure and is not lost from the surface treated. Tests can be run with time and temperature factors.
3. The treatment operation is successful in covering all the surfaces used by the resting mosquitoes.
4. The surface does not absorb or destroy the insecticide applied. Laboratory tests are necessary, using samples of the actual surfaces treated.
5. The insecticide adheres well to the surface treated, and does not flake or spall off.
6. The adult anophelines are not repelled or irritated by the sprayed surface, to the extent that they make only a brief contact or none at all and fly off.

7. The residual insecticide layer is very slow to degrade chemically, and remains effective over a period of months. Tests should be run in the laboratory.
8. The residual layer is not covered up by deposits of material (soil, paint, grease, etc.).

Environmental Concerns:

A good residual insecticide properly applied with routine safety precautions observed, both for the operators and the inhabitants of the structures treated, has essentially no environmental impacts other than to kill certain non-target species which inhabit buildings. DDT has killed geckos (wall lizards) and mice, as well as various insect pests such as flies and cockroaches.

Since residual insecticides, as applied or as residues within structures, do not have an impact on the open environment, one is chiefly concerned with the level of care used in following safety recommendations for the protection of operators, residents, and domestic animals during the spray application, and for the protection of household contents, particularly water supplies and foodstuff, against insecticide contamination.

The remaining hazard of any residual insecticide lies in how safely the concentrated materials are stored and handled, how properly one proceeds with the disposal of any unused insecticide, empty containers and other refuse, and finally the cleaning of equipment, and contaminated clothing, gloves and shoes.

Specifically, the transport of the insecticide into the open environment could occur on the clothing and footwear of persons involved in mixing, spraying or equipment cleaning operations. This would ordinarily be of minor importance but the possibilities include both the contamination normal

to insecticide handling as well as accidental spillage. The latter could be very important. All clean up operations from the spray equipment to the cleaning of clothing and footwear, should be so handled that none of the wash water contaminates natural waters or drinking water sources.

Use of the Algorithm:

DSS 11.70 serves as a guide in the decision process which would determine whether or not a residual spray material is feasible for malaria control in any given situation.

To initiate a program without rather extensive knowledge of the vector's behavior is foolish indeed. Control failures have occurred when anophelines were gradually selected for exophily (preference for staying out-of-doors) and exophagy (for feeding out-of-doors), even though the insecticide still showed a good toxicity level in laboratory tests against the vector.

Because residual spraying must be done within homes, it affords the greatest opportunity for direct contact of the residents with the insecticide. Safeguards must be emphasized, beginning with the quality of the insecticide, to be sure that highly toxic compounds are not used improperly, or that dangerous impurities are not included in the technical product, or that dangerous degradation products are not present or develop in the insecticide stocks.

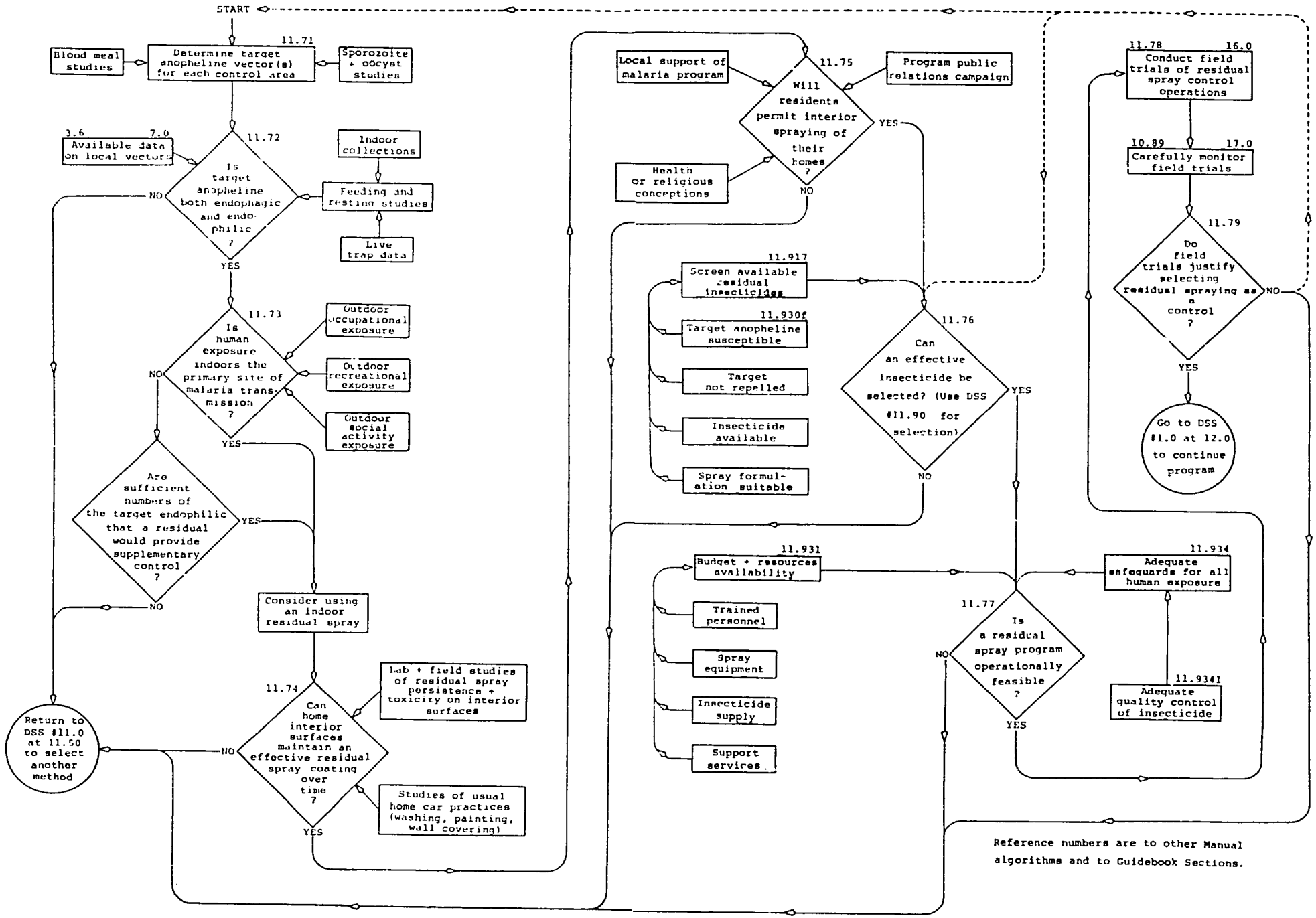
The algorithm assures that these and other problems can be kept under consideration in the decision process. As with all proposals for use of chemicals, the reader should also proceed to comply with *DSS 10.4* and *11.90* which deal generally with reviews of pesticides.

Use of the Guidebook:

Candidate insecticides are discussed in the Guidebook, and extensive literature given under Section 11.90 and following subsections.

Select Adult Residual Control Methodology

D.S.S. #11.70



Reference numbers are to other Manual algorithms and to Guidebook Sections.

SECTION 11.80 - Select Adult Space Treatment Methodology

Definitions and Background:

Adult space treatment in this Manual refers to the dispersal of insecticides, by ground equipment or aircraft, in droplets of appropriate size to remain suspended in air and impinge upon adult anopheline mosquitoes. An example would be the periodic applications, by truck-mounted equipment, of ultralow Volume (ULV) dosages of malathion in a city and suburban area to kill adult anopheline mosquitoes and reduce malaria transmission.

Adult space spraying may provide an important element of an integrated malaria control program. The approach has proven successful in a variety of circumstances, providing in some cases significant reductions in rates of malaria transmission. Although it was considered effective, as early as the 1930's, the method was little used in malaria control programs following the advent of DDT and its use as a residual wall spray.[1] With the development of insecticide resistance, and the subsequent failure of many wall spraying programs, space spraying has received renewed interest.

Fortunately space spraying was utilized in mosquito control programs during the DDT years and the technology continued to advance. Today, highly effective truck-mounted equipment is available to efficiently disperse ultralow volumes (ULV) of undiluted insecticides (cold foggers).[2]

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1. Hobbs, 1976.
2. Mount, 1972.

Under certain circumstances, applications of adult space sprays may provide a critical element of a malaria control program. For example, when a malaria control program is first being established, space spraying may be called upon to provide immediate reduction of malaria transmission in designated suburban and urban areas. The program could then be phased out as effective measures are applied to the vector sources. Space treatment may also be temporarily utilized when an outbreak of malaria has occurred or is anticipated because of a breakdown in other elements of an integrated control program (i.e., resistance to larvicides). It is also conceivable under certain circumstances that anticipated costs of a program directed to the vector sources would be so high that adult space spraying would be necessitated.

The success of adult space spraying programs will depend upon the collection and processing of various kinds of information. Epidemiological information is essential to the selection of areas to be targeted for spraying. Entomological information must be gathered to insure that the timing and location of space spraying will maximize the adult anopheline mortality and the reduction of malaria transmission. A monitoring system to evaluate the effectiveness of the program is also essential to monitor levels of malaria transmission and adult anopheline mosquitoes.

Space spraying has some major drawbacks that should be given consideration. First, the approach by itself does nothing to change the environmental conditions that create the adult anopheline mosquitoes. Secondly, repetitive applications of insecticide may lead to the development of insecticide resistance. Finally, although the insecticide in use may be safe and applied in extremely low volume, the applications nevertheless are made in the human environment, and result in at least some risk to humans. For these reasons, the use of space spray under most circumstances, should be recognized as a tool to be utilized <u>temporarily</u> until long term control measures can be applied to the vector sources,

Environmental and Human Safety Considerations:

Adult space treatment can be safely used if appropriate chemicals are selected and properly applied. On the other hand, the potential for environmental damage and human injury is high if inappropriate chemicals are applied, or if chemicals are applied improperly. Because space treatment will enter the human environment, human safety should be given the highest consideration. Because the space spray will likely contact a wide variety of susceptible insects in the spray area, consideration should also be given to the impact of the spray on beneficial insects. For example, significant problems could be caused if spray were to drift into areas where bees are being maintained for agricultural purposes.

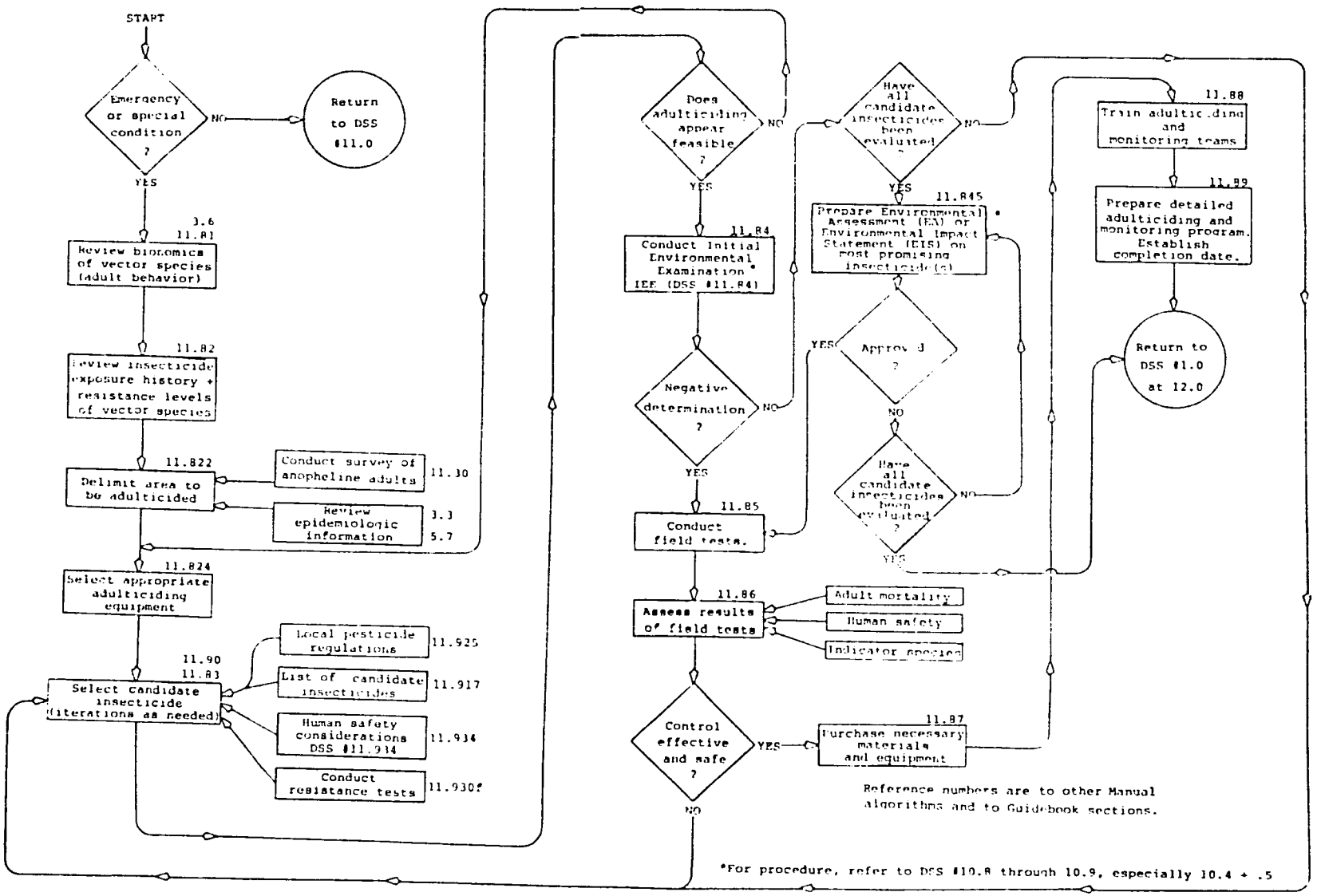
Use of the Algorithm:

The algorithms covering space spraying are designed to lead to the selection of the most appropriate space spray program under the existing circumstances and, at the same time, avoid the requirements of an Environmental Assessment or Environmental Impact Statement. Under certain circumstances the algorithm may help the user detect a need for an EA or an EIS, or the algorithm may even lead to a decision to reject adult space spraying as a viable approach to the problem.

Use of the Guidebook:

The Guidebook provides background information to assist in completing the steps of the algorithm. Much of the required information, however, will have to be gathered by the user of the algorithm.

Select Adult Space Treatment Methodology D. S. S. # 11. 80

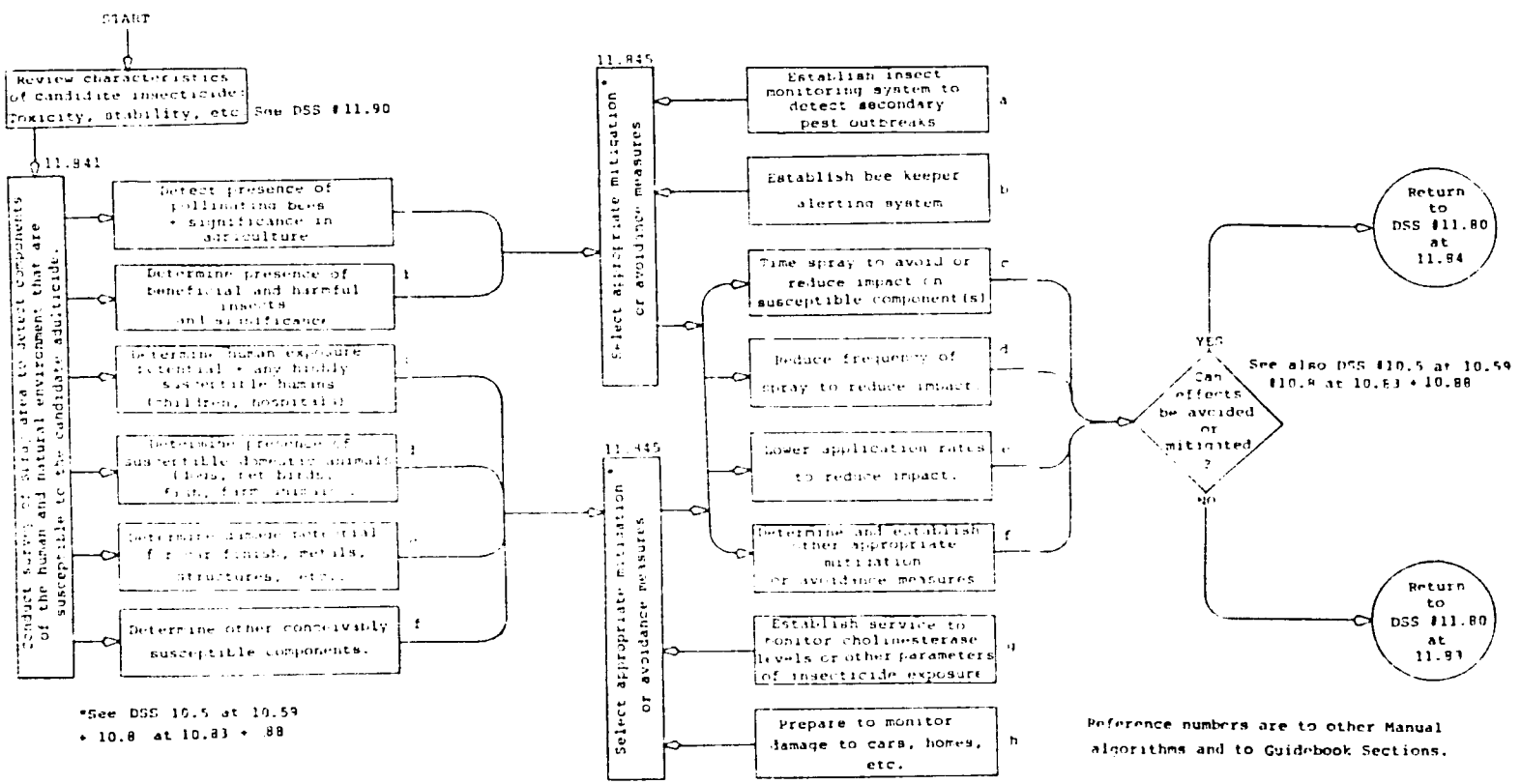


Reference numbers are to other Manual algorithms and to Guidebook sections.

*For procedure, refer to DSS #10.8 through 10.9, especially 10.4 + .5

D.S.S. #11.84

Do Initial Environmental Examination to Assess the Potential Effects of Adult Space Treatment



SECTION 11.90 – EVALUATE CANDIDATE INSECTICIDE[1] AND DETERMINE ITS FEASIBILITY[2]

Definitions and Background:

The use (and abuse) of chemicals represents, at one and the same time, both the greatest opportunity to advance the interests of mankind and also to do the greatest environmental damage, to the detriment and even the extinction of mankind and all other biotic components of this planet. Decisions as to the use of potentially hazardous materials must therefore be taken with full consideration of all risks and benefits which can be anticipated as real, probable, and important.

The use of chemicals for the control of anopheline adults and larvae must fall within this area of decision. Basic to this consideration are the nature and effectiveness of the chemical selected, the competence and adequacy of the operational program, especially its personnel, and the characteristics and response of the environment which may be effected by the use of the chemical.

Although a number of pesticides have been withdrawn from the market upon finding that they represent unacceptable hazards, the most common problem has been the loss of effectiveness of pesticides through the development of resistance by pests.[3,4] Each year resistance has rendered formerly valuable pesticides progressively useless, and research has attempted to thwart this

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1. For lists and descriptions of insecticides, see Worthing, 1979; and Caswell et al. 1981, p. 103-125: Consolidated list of approved common names of insecticides; and p. 127-146: Insecticide reference standards of the Entomological Society of America.

2. For specifications, see WHO, 1979b; and see Guidebook at 11.90 for the WHO seven-stage evaluation and testing program for new insecticides, established in 1960, as reported by Wright, 1971. P. 14-22.

3. WHO, 1976.

4. Watson and Brown, 1977.

genetic process somehow, but so far the gains are not impressive. In the Central Valley of California, for example, where intensive mosquito control has been carried on since the early 1940's, common pest mosquitoes are generally resistant to all ordinary chemical controls.

The WHO Expert Committee on Insecticides has for many years guided resistance testing of mosquitoes, and made available the WHO Test Kit (standardized procedures and test materials) to control programs throughout the world.

Local resistance testing is therefore recommended as a routine procedure, to insure against purchase of ineffective insecticides or to explain a drop in control effectiveness of an insecticide which has heretofore been effective.

Table 8 shows WHO data on anopheline resistance through 1976. The situation continues to worsen, and alternative methods of control become more attractive and should be explored by each program.

A list of suspended and cancelled pesticides with full annotations is given in the 29th edition of Entoma[1], as well as a list of new chemicals registered.[2]

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1. Caswell _et al_., 1981, p. 77-99.

2. Ibid, p. 100-101.

TABLE 8

INSECTICIDE RESISTANCE IN SOME IMPORTANT SPECIES OF ANOPHELES VECTORS OF MALARIA AS REPORTED BY THE WHO IN 1977[1]

Insecticide resistance in some important species of Anopheles vectors of malaria as reported by the WHO in 1977

Species	DDT	Dieldrin-HCH	Organophosphorus compounds	Carbamates
A. aconitus	+	+	–	–
A. albimanus	+	+	+	+
A. albitarsis	+	+	–	–
A. annularis	+	+	–	–
A. aquasalis	–	+	–	–
A. atroparvus	–	+	–	–
A. culicifacies	+	+	+	–
A. farauti	–	+	–	–
A. flavirostris	–	+	–	–
A. fluviatilis	+	+	–	–
A. funestus	–	+	–	–
A. gambiae	+	+	–	–
A. hyrcanus	+	+	+	–
A. labranchiae	+	+	–	–
A. messeae	+	+	+	–
A. minimus	–	+	–	–
A. multicolor	+	+	–	–
A. pharoensis	+	+	–	–
A. philippinensis	+	+	–	–
A. pseudopunctipennis	+	+	–	–
A. pulcherrimus	+	+	–	–
A. quadrimaculatus	+	+	–	–
A. sacharovi	+	+	+	+
A. sergenti	–	+	–	–
A. sinensis	+	+	+	–
A. stephensi	+	+	+	–
A. subpictus	+	+	–	–
A. sundaicus	+	+	–	–
A. vagus	+	+	–	–

Note: This list based on the data provided in the WHO Technical Report Series No 585 (1976) refers only to the most important Anopheles species, vectors of malaria. It should be remembered that in each of species quoted the phenomenon of resistance and its degree do not cover the whole geographical area of distribution of the species concerned.

1. Bruce-Chwatt, 1980, p. 263.

Environmental Concerns:

As has been stated in 11.63 for larviciding, "environmental effects and risks may be so minimal that they are of no consequence."

This presumption is valid only for a well-disciplined effort by competent, well-informed program staff, equipped properly, and given good management. Other than this, the hazards, as set forth in these algorithms, may be many. Chemicals are very valuable pesticides, and may range from the only practical control measure to a valuable supporting one. With further development of other control technologies they may be in some instances minimized or even eliminated, but need to be retained as valuable insurance. The burden of responsibility is on the program management, and these algorithms help define the problems and their solutions.

From the standpoint of environmental concerns, there is no element of a malaria control program that will stir more controversy than one employing chemicals. Pesticides used in mosquito control programs have been implicated in fish and wildlife losses,[1] target mosquito resurgence, disruption of natural biological control,[2] and secondary pest outbreaks.[3] Careful selection of candidate insecticides, full knowledge of their potential environmental impacts and their prudent implementation is required to avoid the environmental risks described above.

In the final analysis, one must weigh all factors which can be reasonably evaluated, and make a decision on a risk/cost/benefit basis.

Use of the Algorithms:

These algorithms require careful analyses of three major program aspects: the insecticide, the operation, and the environmental hazards. Note that these hazards may result from innate qualities of the insecticide, or of the operation, or of the resultant of these two. Additional algorithms

1. Hunt, 1971.
2. Hoy, et al., 1972.
3. Luck and Dahlsten, 1975.

will be developed to assist in the exploration of all four matrix categories of *DSS 11.90* which introduce the hazard categories. Essential at this point is to realize their intimate inter-relationship, though for convenience the attempt is made to categorize them.

The algorithms are designed to evaluate candidate insecticides, allowing the selection of the insecticide(s) that will maximize effectiveness and benefits while minimizing costs and associated risks. *DSS 11.936* should assist the user in determining the level of environmental documentation that will be required to clear the larvicide for use, *DSS 11.9341* is designed to assist the user in avoiding quality problems associated with pesticides, and *DSS 11.934* directs the safeguarding of people who may be exposed to these materials.

At the completion of these steps, one returns either to *DSS 11.0* to evaluate other control measures, or to *DSS 1.0* to continue the program with pesticides as an integral component.

Use of the Guidebook:

Supportive information is available in the Guidebook to assist the user of the algorithms. Both excerpted literature and additional references are provided.[1]

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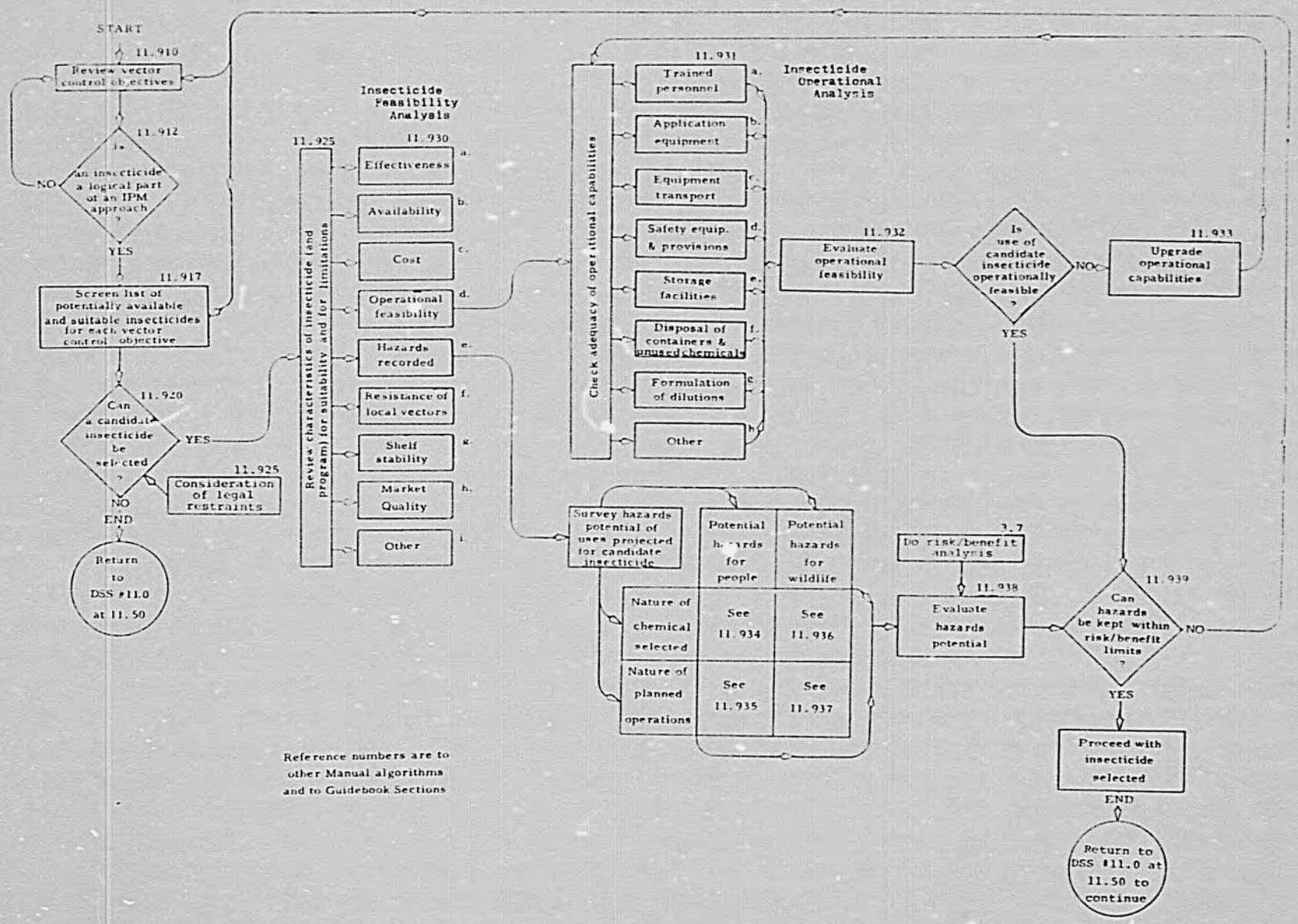
1. Note especially the brochure, "Insecticides for the control of insects of public health importance", issued in 1981 by the Vector Biology and Control Division, CDC, PHS, U.S. Department of Health and Human Services, Atlanta, GA. iii + 37 p.

Evaluate Candidate Insecticide And Determine Its Feasibility D.S.S. #11.90



Reference numbers are to other Manual algorithms and to Guidebook Sections

SECTION 11.934 - ANALYZE HUMAN SAFETY PROVISION AGAINST HAZARDS OF A CANDIDATE INSECTICIDE[1]

Definitions and Background:

Human safety provisions against hazards of insecticides are those measures taken by personnel of a malaria control program to protect program personnel and the general population from hazards of insecticides used in the program. The actions include proper selection, testing, storage, handling and application of insecticides. Safety provisions also include monitoring of exposure and pesticide poisoning symptoms in the personnel, and the public if necessary. Finally, it includes establishing procedures to properly clean up pesticide spills and to correctly treat persons displaying symptoms of pesticide exposure.

Hazards associated with the use of insecticide stem mainly from their acute and chronic toxicity, although flammability must also be considered. Acute oral and dermal toxicities are measured by the amount of active ingredients taken orally or absorbed through the skin that is required to kill 50% of the test animals. The measurement is called the LD 50 (lethal dose) and is expressed in milligrams/kilogram of body weight. Acute inhalation toxicity is the concentration of active ingredients that, when inhaled, kills 50% of the test animals. This measurement is called the LC 50 (lethal concentration) and is usually measured in parts per million. The LD 50's and LC 50's of candidate insecticides provide convenient measurements to compare the hazards of acute toxicity of candidate insecticides.

Chronic toxicity refers to the level of toxicity resulting from repeated or continuous exposure to insecticides (oral, dermal, or inhalation). An example of chronic toxicity is the depression of cholinesterase by organophosphate and carbamate insecticides by accumulated exposures. Cholinesterase is an

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1. See WHO, 1973a, Annex 4 (p. 187-193); and Hayes, 1982.

enzyme that is essential to normal functioning of the nervous system.

Use of the Algorithm:

The algorithm is designed to assist the user in establishing appropriate safety provisions to be employed for each candidate insecticide.

Use of the Guidebook

The use of pesticides in the United States is regulated according to the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) of 1972. Because of the strict requirements of FIFRA, much valuable information has been developed describing the characteristics of insecticides and their effect on humans. Standard testing procedures determine effectiveness, toxicity, residual qualities, breakdown properties and the effect of insecticides on the environment. In order to meet registration requirements of FIFRA, the insecticide must be effective without being unacceptably hazardous to pesticide applicators or the general public. The insecticide must also prove not excessively harmful to non-target species. The Guidebook provides much of the valuable information about pesticides that have completed the registration process in the United States. It also contains information on safety procedures and equipment. The Guidebook supplies the required background information for the most common pesticides now in use in malaria control programs.

A list of suspended and cancelled pesticides with full annotations is given in Entoma (29th edition),[1] as well as a list of new chemical registrations.[2]

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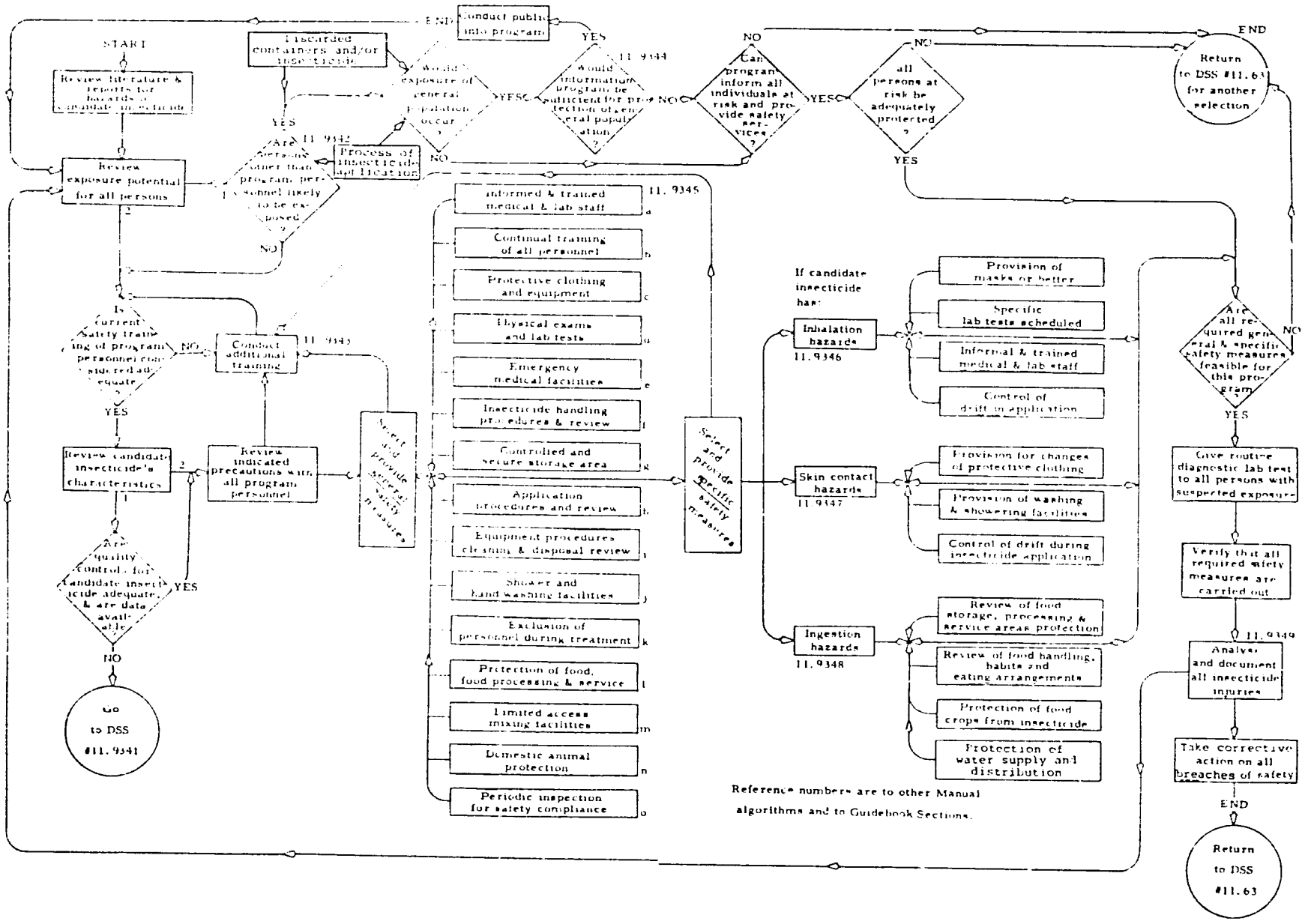
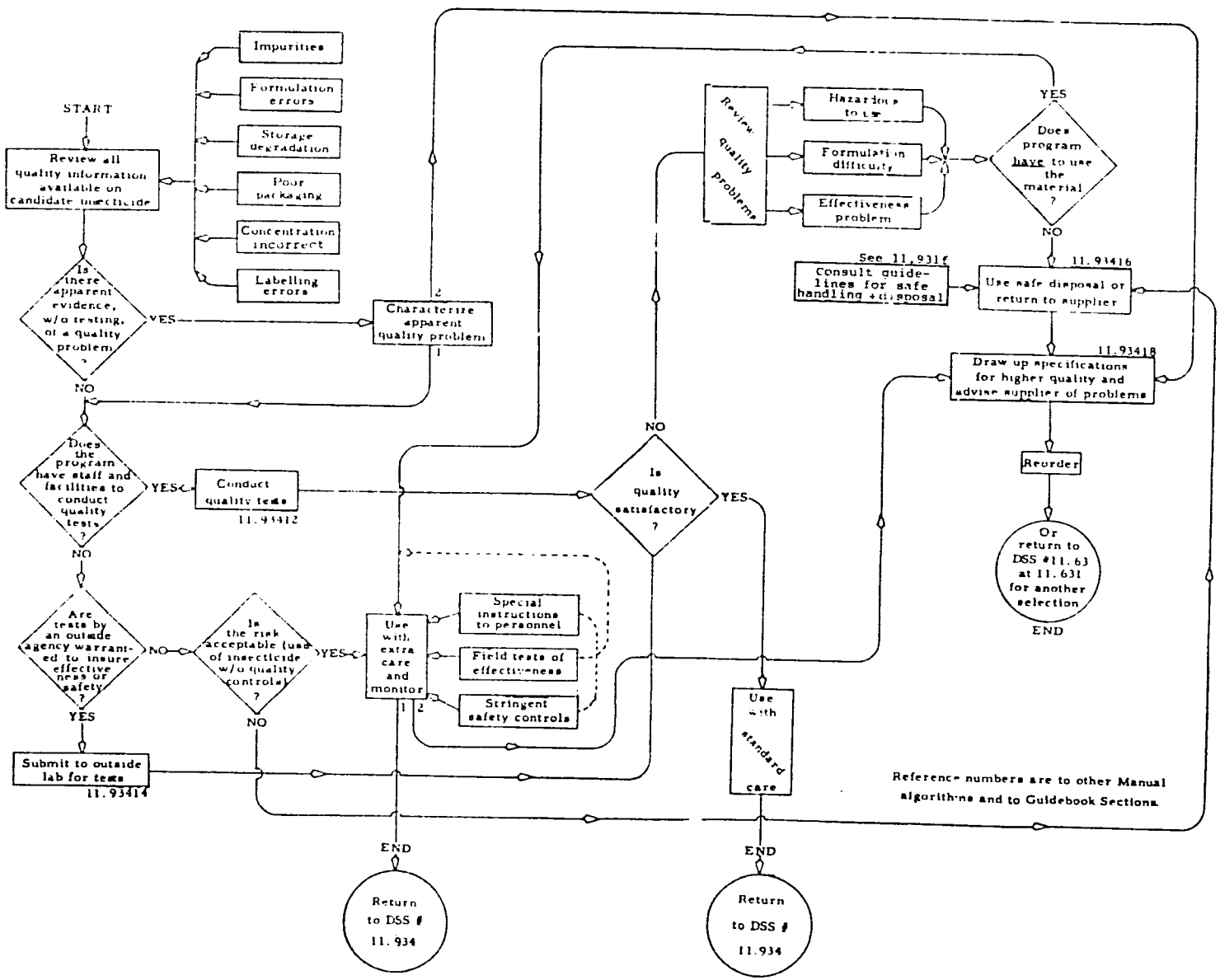
1. Caswell et al., 1981, p. 77-99.
2. Ibid, p. 100-101.

Analyze Human Safety Provisions Against Hazards of a Candidate Insecticide



Review Problems With Quality of a Candidate Insecticide

DSS #11.9341



SECTION 11.936 - ASSESS THE ENVIRONMENTAL EFFECTS OF A CANDIDATE INSECTICIDE ON NATURAL AND WETLANDS AREAS

Background:

Until the revelation that DDT had caused environmental damage, concern for hazards to wildlife was essentially non-existent for pesticide use. Particularly with DDT, there has never been any demonstrated basis for concern with its ordinary use in mosquito control, for which very low dosage (0.1 lb/acre) prevailed for larviciding and for which residual spraying presented no tangible environmental risks. The basis for environmental concerns came with the high dosage and extensive area usage of DDT for agricultural and forest pest control. Fortunately DDT is a low toxicity compound, whose low price and effectiveness promoted its widespread use in time to teach very valuable lessons about the food web transport and accumulation of low-biodegradable chemicals in nature. With other more toxic chemicals, the tuition for such lessons could have been high indeed.

Unfortunately for mosquito control, for which DDT should still be used, the concern over the impact of chemicals on the environment became a political issue, so that once a ban was established for other areas of pest control, there was apparently no way of allaying the fears generated, even with the evidence which mosquito control programs could well document. The story of DDT chronicles this with great clarity.

The foregoing argument is a strong basis for supporting the use of a programmatic environmental assessment (PEA), by which mosquito control (and

vector control generally) could be viewed separately and rationally for its own use of pesticides and its own environmental impacts of various kinds, independent of the very different and more extensive control programs of forestry and agriculture. The addition of the short and long term benefits to be achieved in public health also justify such separate cost/risk/benefit considerations of vector control.

Environmental Concern:

The history of malaria control by pesticides, as conducted under reasonable professional direction and with adequately trained staffs has rarely if at all given any basis for environmental concern, but the introduction of new and highly toxic pesticides does introduce new risk factors which must be carefully evaluated, not only for wildlife, but for people exposed. Until one has more pesticides which are target-specific, or nearly so[1], one must respect their potential for serious damage, even though applications may be properly controlled. Every new material, and every new usage must be assessed and then monitored over time to determine its hazard potential for wildlife as well as for man.

This area is one for which the use of consultants is always in order, because of its complexity (see Chapter 25).

The several studies done on the use of DDT for malaria control from 1945 to 1947 by the U.S. Public Health Service scientists in South Carolina are still valid (see Section 10.62A) though more theory and quantitative ecological methods have been developed since. Such studies are very expensive and time-consuming, and if well done, can justify a PEA, under which they need not be

1. See *Bacillus thuringiensis* (Section 11.647 and Glossary), whose endotoxin has high target specificity.

repeated, but have a general application. This does not, however, obviate the necessity for monitoring, which should be an intrinsic part of all programs. Failure to monitor removes a very important "feed-back" mechanism which serves to protect a control program from surprise factors.

Use of the Algorithm:

DSS 11.936 presents an idealized procedure for the environmental assessment of an insecticide. Its use must be coordinated with the *DSS 10.0* series as required by Regulation 16, particularly *DSS 10.4* and *10.5* which are specifically concerned with pesticides.

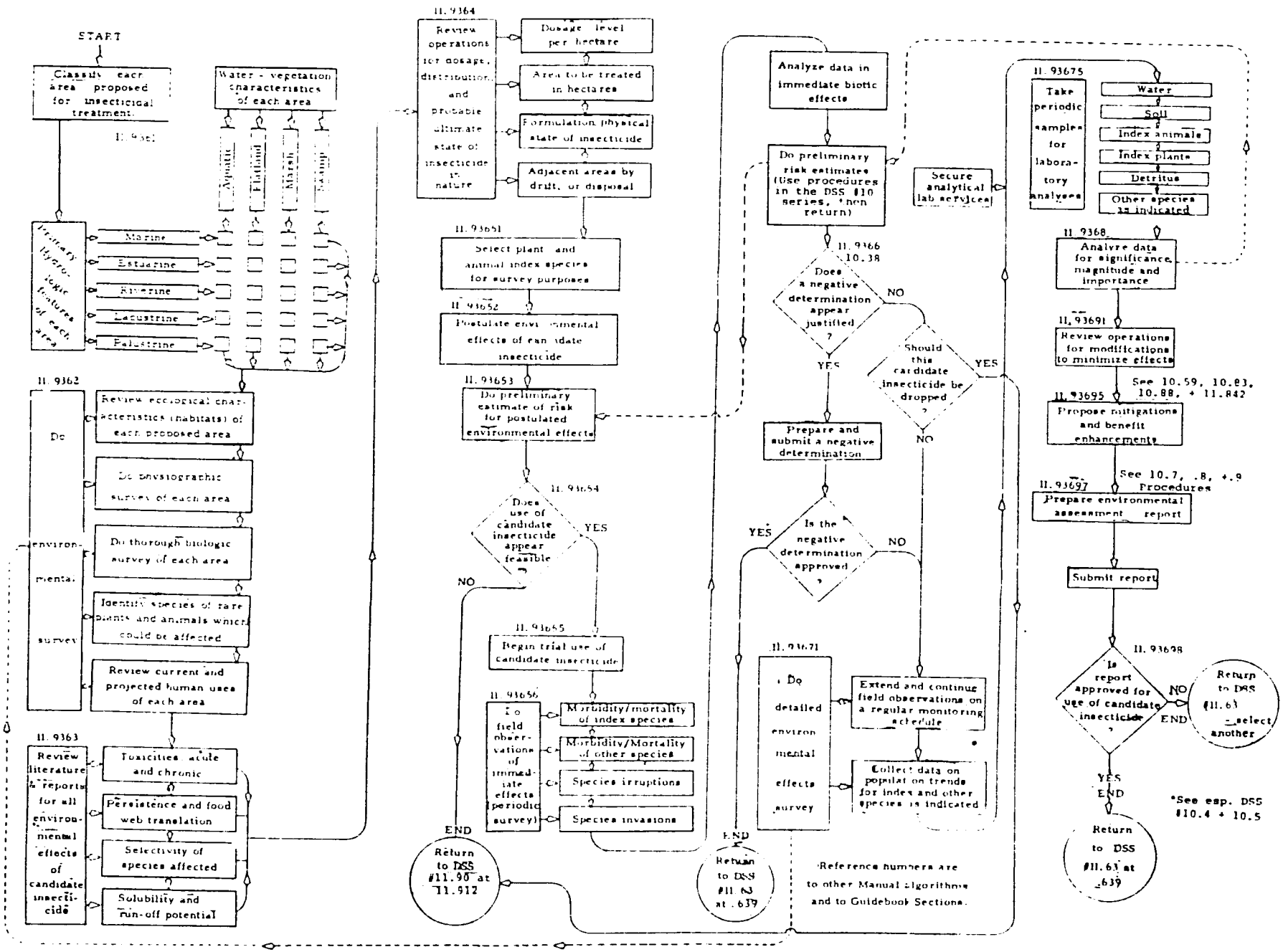
The matrix in *DSS 11.90* sets forth four algorithms on pesticide hazards of which two, *11.934* and *11.936* have been completed. The missing two, *11.935* and *11.937*, which deal with the hazards inherent in operations, rather than in the pesticide itself, have not yet been completed at this stage of the Manual.

Use of the Guidebook:

The Guidebook includes under Section 11.936 a large number of key literature excerpts as well as an extensive list of additional papers to be consulted for guidance in this area.

Also Section 25 as well as Chapter 25 of the Manual has compilations of consultants who may be utilized.

Assess the Environmental Effects of a Candidate Insecticide* on Natural Aquatic and Wetlands Areas



CHAPTER 12 - SELECTION OF SPECIFIC CONTROL SITES

(See also Chapter 7)

CHAPTER 13 — FINAL PROGRAM PROPOSAL

CHAPTER 14 - PROGRAM APPROVALS[1]

SECTION 14.1 - APPROVAL PROCESS FOR PROJECT (Project Paper)

SECTION 14.3 - LEGAL COUNSEL

SECTION 14.6 - RESOURCES APPROVAL

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1. See Manual Chapter 10 in its entirety.

CHAPTER 15 - LOGISTICS OF RESOURCES

CHAPTER 16 - INITIATION OF TRIAL CONTROL OPERATIONS

CHAPTER 17 - MONITORING[1] AND EVALUATION OF TRIAL CONTROL OPERATIONS

(See also Chapter 10, 10.89, and Chapter 19)

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1. See especially: Camougis, 1980; Southwood, 1978; and Welch & Croft, 1979.

CHAPTER 18 - FULL CONTROL OPERATIONS[1]

SECTION 18.1 - IMPLEMENTATION OF FULL CONTROL OPERATIONS

SECTION 18.6 - PUBLIC RELATIONS PROGRAM

SECTION 18.7 - RISK/COST/BENEFIT ANALYSES

(See also Chapter 3, 3.7; and Chapter 11, 11.939).

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1. See selected bibliography in Chapter 24, as Section 24.23 - Comprehensive monographs on Malaria Control, Mosquitoes, and Mosquito Control.

CHAPTER 19 - CONTINUING MONITORING,[1] DATA COLLECTION, AND PROGRAM EVALUATION (OPERATIONAL)

(See also Chapter 10, 10.89; Chapter 17; and Chapter 19).

1. See especially Camougis, 1980; Southwood, 1978; and Welch & Croft, 1979.

CHAPTER 20 - ATTAINMENT OF MALARIA CONTROL OBJECTIVES

CHAPTER 21 - COMPARISON OF GOALS AND OBJECTIVES ACHIEVED

CHAPTER 22 - PROGRAM MAINTENANCE PHASE

CHAPTER 23 - RESEARCH

CHAPTER 23 RESEARCH

Background

The material excerpted[1] in the following pages is a summary of recommendations to AID of research needed in vector biology and control. It was produced by a 4 day workshop, on "Comprehensive Vector Control - Current Status", held under the auspices of the Insects Affecting Man and Animals Research Laboratory, U. S. Department of Agriculture, Gainesville, FL, on April 13-16, 1982.

This overview of research should serve as a stimulus to all control programs, encouraging them at least to point out, and hopefully to participate in or conduct, investigative inquiries essential to malaria control operations.

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1. AID/USDA, 1982, p. 2 - 22.

Research Recommendations for Vector Biology and Control [1]

Several points were brought out in the discussions at the meeting and are included here since they are general in nature and apply to all of the sections of the report.

A system of data storage and retrieval is needed for AID and other agencies that would make information readily available on: (a) vector control or research projects in existence in all parts of the world indicating location, funds, objectives, personnel, and duration; (b) institutions available for training or research in medical entomology and vector control; and (c) maintenance and updating of a World Directory of vector control and research specialists.

Increasing research capabilities and conducting vector control depends on training for individuals. Training activities are extremely important and need to be developed particularly for vector control activities. There is still a need for supervision of overseas projects in vector research and control. There is also a need for continued interagency coordination.

In the future, USAID may wish to consider convening working groups to consider specific areas of importance within the general area reviewed in this report.

Research and operational fund support is limited and it will be necessary to accomplish as much as possible by cooperative research. New vector control methods, particularly nonpesticidal approaches, will depend upon institutions rather than industry for their development. New approaches to control may be more costly to develop but in the long run may be equally cost effective. When possible, new technology should be tested by conducting limited operations within the framework of an established program.

Operational programs require careful monitoring and flexibility in conduct to assure optimum results from resources available. Improved and more efficient monitoring methods are needed to plan and evaluate programs and deal with the problem of resistance, vector density, and disease level.

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1. USDA / AID, 1982, p. 2 - 22.

3. INSECTICIDES

3.1. Residual Sprays

3.1.1. General Status

Residual spraying, especially in dwellings, was the sole method of malaria control for many years, and in some places produced results that achieved or approached eradication. Throughout most of the area where malaria control programs are in place, it still remains the main line of defense, although in other places problems such as exophily or exophagy of the vectors, or inappropriate types of housing, virtually preclude its use. Even where residual sprays remain the most effective method of control, widespread difficulties are being encountered, primarily because of the development of insecticide resistance and the refractory behavior of certain vectors. When alternate insecticides are introduced to control the resistant strains, resistance to them may develop also, and cross-resistance may occur. The new compounds are usually quite expensive, and recently there has been a serious reduction in the number of new compounds available for evaluation. It is therefore crucial to develop ways to preserve the usefulness of the compounds we now have, to delay the development of resistance, and to find ways to obtain the maximum effectiveness with the least amount of the new, more expensive, materials.

There is an additional problem in the potential for improper use of new materials and methods, as when ULV (ultralow volume) formulations are misused as residual sprays, increasing the expense and hazards.

3.1.2. Recommendations

The following recommendations and the priority rank that has been assigned to each are based largely on consideration of the aforementioned widespread difficulties that are being encountered in the use of residual sprays. Some of the recommendations presuppose an adequate state of knowledge of the ecology and ethology of the target populations. In this regard, it is considered highly desirable that an annotated bibliography of all malaria vectors be prepared. The bibliography should include information on the susceptibility and habits of the different malaria vectors as they affect their exposure to residual spray applications; where pronounced exophily or exophagy occurs, additional (or alternative) control measures would need to be included in malaria control programs.

3.1.2.1. Laboratory Research

The first priority in laboratory research is still the evaluation of new compounds. The chemical industry has a dominant role in the synthesis, development, toxicological testing, and registration of new insecticides. Although the number of new compounds has decreased in recent years, it is still of primary importance to assure that all new compounds that become available be evaluated for their effectiveness in

vector control. Compounds synthesized previously should also be reexamined to determine which insecticides are minimally affected by existing resistance mechanisms.

Promising compounds should be studied to determine the potential of the principal vector species to develop resistance to them, the mechanisms of such resistance, the consequent cross-resistance spectra, and the genetic dominance of resistance.

The second priority in laboratory research is the development of improved formulations. The following recommendations apply to space sprays and larvicides as well as to residual sprays. Research is needed to (a) optimize insecticide toxicity on various types of surfaces and environments, including water, and (b) to provide, through microencapsulation, UV (ultraviolet) shields or other means, the capability of controlling the rate of insecticide release and of chemical decay according to desired specifications.

A third priority consists of studies of insecticide usage strategies aimed at inhibiting the development of resistance. Possible subjects for research include the following: (a) studies with admixtures of chemicals to provide for: the development of criteria for choice of chemicals for use in mixtures; research on the role of synergistic combinations; search for negatively correlated cross-resistance, and its validation through laboratory selections of representative populations; (b) studies to develop criteria for the use of specific chemicals in rotation, and their validation through laboratory selection experiments; and (c) studies on the order of use of specific chemicals to develop criteria for selection and testing of the most appropriate sequences under laboratory conditions. Promising results from this research must subsequently be tested under field conditions (see 3.1.2.2).

Insecticide repellency studies constitute a fourth priority. The repellency of existing and future compounds should be examined, and the consequences of repellency on the extent of man-vector contact should be evaluated.

Improved diagnostic techniques for early detection of resistance in field populations are also needed. Bioassay tests at discriminating dosages (dosages that distinguish between susceptible and heterozygous resistant individuals) are useful but they lack certainty where resistance occurs at a low frequency. There is need for more sensitive, simple biochemical marker tests to detect unequivocally the presence of specific resistance genes in populations. A recently developed esterase test for organophosphorus resistance in *Culex quinquefasciatus* shows promise.

3.1.2.2. Field Research

The first four of the following recommendations concern application procedures aimed at reducing insecticide costs. All are of equal importance and first priority; the other recommendations are listed in descending order of priority.

(a) Evaluations are needed on the effectiveness of partial coverage of wall surfaces and/or selective spraying of structures (human habitations, animal shelters, etc.). Such research requires the availability of chemicals possessing vapor or particulate action, and/or knowledge of peculiarities in the resting and biting habits of the target population.

(b) Studies on reduced rates of insecticide application should be undertaken to determine the cost effectiveness of different rates of application as related to the desired length of protection.

(c) The effectiveness of seasonal application of insecticides should be determined, since the need for insecticide deposits may be limited to periods of transmission activity of the vector. In certain areas, agricultural insecticides may so strongly reduce mosquito density that residual house spraying may be temporarily postponed.

(d) Consideration should be given to the possibility of assigning spray priorities to certain localities. Horizontal stratification of country according to disease transmission potential may permit spray activities to be concentrated where need is highest.

(e) Field tests should be made to follow up any promising results obtained in laboratory tests under 3.1.2.1. on the use of admixtures of insecticides, rotation of insecticides, or optimal sequence of use of insecticides to delay the development of resistance, or to follow up on promising results of such studies which are already available.

Each study should include at the minimum the collection of information on: effect on resistance and cross-resistance, control efficacy, operator and resident safety, economics, and logistics.

(f) Sociological and/or other research on means of improving the acceptability of house spraying to residents is needed. Acceptability studies might emphasize the following: deodorized insecticide formulations; employment of local people on spray teams; means of enhancing community involvement; and reduction of visible spray residues on walls.

(g) There is a need to replace the use of human baits by other means of assessing vector population density and biting rates. Research on alternatives might include the use of animals, light traps, attractants, or other means (see also Section 5).

3.2. Larvicides and IGR's

3.2.1. General Status

There are many choices available to those who wish to use larvicides: oils, IGR's (insect growth regulators), synthetic

organic compounds, monolayer films, and microbial insecticides. These materials are formulated in many ways, such as emulsifiable concentrates, wettable powders, granules, and slow release formulations.

Because of the diversity of larvicides and their formulations, their uses will be dictated by the ecological conditions of the breeding places and biological characteristics of the vector species.

It should be pointed out that best results in terms of vector control programs are obtained when mosquito larvicides are employed in conjunction with other control strategies. Source reduction and habitat management should precede the use of larvicides in area-wide mosquito control programs. No single strategy will yield the desired results in a large and sustained vector control program. Similarly, biological control measures should be exploited whenever possible and supplemented with larvicidal applications if and when necessary.

Larvicides provide many more choices for the selection of safe and environmentally acceptable compounds than adulticides, and in some cases they are more efficient and economical to use. Among the many groups of insecticides there are some compounds that are developed only for mosquito control, which reduces the chance that resistance will develop in mosquito populations from agricultural uses.

Some of the conditions under which larvicides may be especially suitable and yield satisfactory results include the following: when the seasonal activity of the mosquito vectors is of limited duration; where breeding sources are confined and accessible for treatment, and residual sprays are not accepted; where exophily of the vector makes residual house sprays ineffective; and to supplement the manipulation of larvivorous fish until the predators have increased to sufficient levels to effect adequate control of larvae.

3.2.2. Recommendations

Chemical larvicides offer a wide range of options for the control of mosquitoes and other vectors in the aquatic stages. To further develop larvicides and larvicidal formulations for use in global vector control programs, and to provide training in their uses, the following research is recommended.

(a) All promising larvicides should be screened and evaluated against larvae and pupae of major disease vectors. Standardized testing techniques for assessing the activity of quick- and slow-acting compounds and methods for assessing novel modes of action should be developed under laboratory conditions.

(b) Research on the development of suitable and effective formulations should be stressed. The efficacy of different types

of formulations such as granules, slow-release preparations, wettable powders (WP), emulsifiable concentrates (EC), and micro-encapsulated formulations should be evaluated in the laboratory. Priority should be given to the development of formulations to reduce the frequency of application and accompanying labor costs.

(c) Promising larvicides and their formulations should be extensively evaluated under simulated field conditions and further evaluated in small-scale field trials for the assessment of efficacy, suitability, and longevity of formulations. Special emphasis should be placed on field entomological observations.

(d) Those larvicides and formulations which show promise in small-scale field trials should be subjected to large-scale field trials under a variety of conditions. Epidemiological and entomological observations in the trial area should be carried out, including assessment of the possible development of resistance, and additional observations on possible toxic effects to the applicators and acceptability by people in the trial area should be made.

(e) Impact on nontarget organisms and wildlife should be studied under laboratory and field conditions. Since larvicidal formulations are to be applied repeatedly to aquatic habitats, it is essential that adequate information on their impact be obtained during the course of their evaluation in vector control programs.

(f) There are many aquatic plants and plant products which induce high mortality in the immature stages of mosquitoes. Research is needed to identify such plants and plant products and to develop ways in which such options can be exploited in vector control programs.

(g) The research recommended in Section 3.1.2.1. on strategies to retard the development of resistance in the use of residual sprays is also applicable to larvicides.

3.3. Space Sprays

3.3.1. General Status

Space spraying has been used successfully in some situations against vectors of malaria, yellow fever, and dengue as well as other arboviruses. Present usage consists of ULV (ultralow volume) sprays and thermal fogs. Aerosols of diluted insecticides and dusts are used to a lesser extent. Space sprays are applied both from the ground and from the air.

Because space sprays can be applied rapidly to large areas, they are particularly attractive for use during outbreaks of mosquito-borne diseases, especially viral diseases. The use of space sprays against malaria or endemic viral diseases during periods of low level transmission may have some utility in some

situations. However, serious questions remain about just how effective space sprays are in reducing transmission of disease. One problem of major importance is the determination of the time of application. Space sprays (aerial ULV) are frequently used for the control of arboviral epidemics. However, spraying operations are often begun too late in the epidemic to have an impact. This is an epidemiological problem which deals with our inability to recognize the developing epidemic early enough to mount a large-scale space spray effort.

Equipment used to generate space sprays falls into two main categories, namely, ULV sprayers and thermal foggers. Each has its advantages and disadvantages. The thermal foggers produce smaller droplets and are advantageous when penetration into dense foliage or into buildings is desired. The dense fogs produced can be undesirable, particularly when applied in populated areas. Another disadvantage is the requirement that the pesticides must be diluted in costly petroleum solvents prior to use in this type of equipment. ULV sprayers produce an aerosol using liquid insecticides in highly concentrated form. ULV sprays are barely visible to the naked eye.

Thermal foggers may be hand carried or truck mounted. ULV sprayers may be mounted on trucks or aircraft or may be hand carried or mounted on the backs of spraymen (back pack sprayers). Most back pack sprayers and small hand-held sprayers have serious deficiencies. Some disadvantages are (a) excessive weight, (b) high noise levels, (c) high vibration, (d) short service life, (e) nonuniform droplet size, and (f) safety problems.

3.3.1.1. Insecticides Used as Space Sprays

The following compounds have been used experimentally or in large-scale vector control programs: organophosphorus compounds--malathion, fenitrothion, naled, dichlorvos, iodofenphos (jodfenphos), chlorpyrifos, and pirimiphos-methyl; carbamates--propoxur, bendiocarb; pyrethroids--pyrethrum, resmethrin, permethrin, and deltamethrin. Of the above compounds, only malathion, naled, and pyrethrum (and resmethrin in several states) are registered for aerial ULV in the USA.

3.3.1.2. Formulations Used in Space Sprays

As mentioned above, one of the advantages of ULV sprays is the use of concentrated pesticides, without the need for the extra weight and expense of diluents. However, there may be some advantages to using diluted products. Recent work suggests a probable improvement in penetration using increased volumes for ULV application. Also, solid pesticides must be dissolved in solvents prior to use. Some products are so toxic to insects that only a few grams per acre need to be used, and with these compounds solvents (diluents) must be used to provide adequate volumes of spray for dispersal.

3.3.2. Recommendations

Recommendations for research on the use of space sprays in order of suggested priority are as follows:

(a) Additional evaluation is needed on the effectiveness of space sprays in reducing a vector population in its natural habitat and on the impact of such a reduction on the disease.

(b) The advantages and disadvantages of space spray methods and equipment should be compared under different conditions of climate, topography, and environmental factors such as vegetation and buildings.

(c) The quality of operational space spray applications should be evaluated in developing countries where equipment has not been tested for droplet size and distribution, where the flow rate may not have been determined since the equipment was first used, and where training and guidelines for use are considered less than adequate. The evaluation should include determination of droplet size and distribution, flow rates, dosage actually applied, and time of day of application.

(d) Simpler, less expensive equipment that can be more easily repaired in remote areas should be developed. Investigations should include the possibility of mounting ULV units on farm tractors or on trailers pulled by the tractors, and/or utilizing the power take-off of the tractor to replace the engine of the ULV unit.

(e) Research should be conducted on pesticidal chemicals and formulations other than those listed above to determine their effectiveness. In particular, the use of other carbamates and newer synthetic pyrethroids should be pursued. Research should also be conducted on the formulation of pesticides for ULV application to determine the most effective and economical products and the optimum volume of spray for field use. Attention should be paid to safety aspects of space spray application, taking into consideration the exposure of workmen and the environment to toxic chemicals.

(f) New equipment and methodology should be developed for indoor use. Currently available power units for ULV or thermal fog generators are not appropriate for indoor use.

(g) Suggested additional studies include (1) determination of the value of space spray applications to reduce malaria transmission among migratory human populations, and (2) determination of the accumulative effects of space spray applications in reducing adult or larval vector populations or in development of resistance to the insecticide being used.

4. SOURCE REDUCTION, WATER AND WEED (HABITAT) MANAGEMENT

4.1. General Status

Although these broad categories of vector control have been available for many years, they have not been utilized as widely or as well as possible.

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Training in and promotion of the use of these methodologies should be given a high priority. It is highly recommended that all vector control directors give serious consideration to the utilization of source reduction as a basic part of their control measures.

Demonstration projects should be funded in tropical areas to show the efficacy of those methodologies and to formulate specific applications.

An increased level of research is urgently needed in both water and weed management.

4.2. Recommendations

Research, training, and other activities that are needed to improve and extend the use of source reduction technology, water management, and weed management are summarized in the following paragraphs.

4.2.1. Source Reduction

(a) It is important to determine which vector species are amenable to source reduction techniques.

(b) Literature on source reduction and its effectiveness and economics is available and well documented. Because many of these publications are no longer widely available they should be collated and reprinted to make them more available for use in current programs.

(c) Training in source reduction methodology is required in order for vector control programs to utilize it. Commonly the people without such specific training view source reduction only as the use of rather massive equipment in large projects, and tend to reject it out-of-hand as neither economic nor manageable, yet source reduction in many cases can be done with minor equipment, even with hand equipment and ordinary labor.

(d) Major problems in source reduction are compounded by the requirement for environmental assessments and environmental impact statements, which tend to inhibit or actually to prevent source reduction programs. Further research should be implemented on major ecosystems and their nontarget organisms (for example, to show the effects of source reduction on tidal lagoons, mangrove swamps, and major freshwater and saltwater aedine habitats).

(e) The scope of any major source reduction project should always be limited by the documented extent and severity of the vector problem. Very careful collection and analysis of epidemiological and entomological data should be made before, during, and after the conduct of source reduction projects in order to provide the basis for the evaluation of the effectiveness of such projects.

(f) The planning, construction, and operation/maintenance of all multi-use water projects should involve review by vector

a person well trained in source reduction methodology to maintain liaison with those donor agencies (such as AID, UNDP, international banks, etc.) planning and funding projects of potential concern to vector control. Liaison must further be maintained with the contractors and ultimate users during construction and operation of any such project.

(g) Vector control programs should be involved in the planning, construction, and operation/maintenance of all projects that incidentally change the rate of water movement either by blocking its drainage or changing its flow pattern (for example, highway construction and storm water management).

(h) Data derivable from remote sensing (LANDSAT) should be exploited to determine the nature and extent of larger areas eligible for source reduction and for the evaluation of past and present projects.

4.2.2. Water Management

(a) Investigation should be carried out in tropical countries to determine whether or not impoundments create vector problems. If so, research should be done on the problems.

(b) Research should be done in tropical countries to determine if the Tennessee Valley Authority (TVA) four-phase water level and shore line management systems are feasible under those conditions.

(c) Joint research projects should be established with agricultural experts to develop methods of mosquito control which are compatible with the specific crop or culture (for example, rice, fish, shrimp, etc.).

(d) Major research is required on irrigation distribution systems from a source reduction standpoint.

4.2.3. Weed Management

(a) An urgent need exists for research on plant-associated vector problems. Each situation may require a separate investigation.

(b) Once a plant-vector association is established, methods must be developed to eliminate the problem without causing or creating additional or secondary problems.

5. SURVEILLANCE, ATTRACTANTS, AND REPELLENTS

5.1. General Status

Surveillance is a critical component of any vector-borne disease study or control operation. Chemical attractants can play a part in surveillance, and can also be used in connection with protection and control. Vector repellents have the potential to offer protection from disease.

The worsening situation for control of malaria in most endemic areas of the world has occurred at a time of diminishing support for studies of vector taxonomy and ecology, as well as

routine entomological surveillance. Consequently, large and expensive control programs have been initiated, or simply perpetuated year after year, and sometimes terminated, often without an entomological assessment of program effectiveness. Certainly we must realize that a precursor to any entomological assessment or field study is a clear understanding of the taxonomy of the target organism(s). This need can be met only if there is continual and increased support for biosystematic research.

The basic methods for collecting critical surveillance data and for conducting vector ecology studies are available and there should be priority support and funding for the field application of these methods. However, there is a need to improve the established surveillance techniques, to improve analysis and interpretation of data, and to develop and introduce new and innovative surveillance methods, e.g., development of a trap baited with a chemical attractive to anopheline mosquitoes. An examination of the uses of chemical attractants in surveillance, or repellents to provide protection from vector species, reveals a very basic lack of information on the physiological/biochemical mechanisms of attractancy and repellency in mosquitoes.

Another area of research that has received limited attention concerns the search for materials, other than repellents, which have a beneficial mode of action through the modification of vector behavior. Such materials might be effectively used to reduce the incidence of disease transmission.

5.2. Recommendations

The following recommendations are presented in descending order of priority.

(a) Research should be conducted to improve conventional surveillance techniques and hardware, with particular emphasis on malaria vectors. Examples of problems and approaches to improvements are as follows: (1) attempts should be made to develop new or improved trapping methods, in combination with effective chemical attractants adequate to replace the current use of human bait; (2) existing age-grading techniques are difficult and labor intensive and should be simplified and improved; (3) application of new serological methods for host blood meal identification should be evaluated; and (4) improved field techniques for the mass isolation and identification of malaria sporozoite infectons in mosquito salivary glands should be developed.

(b) More research is needed on vector biology and the application of new knowledge to design and to interpret surveillance techniques.

(c) The level of support for biosystematic research to delineate vector species complexes should be expanded. These studies should include a multidisciplinary approach, e.g.,

classical taxonomic, cytogenetic, and chemical studies. Consideration should also be given to developing techniques for the rapid identification of vector species by use of serologic or electrophoretic methods.

(d) The physiology of avidity in haematophagous arthropods needs additional study. Since 1970, less than five efforts have been conducted in this area and none are underway at present. Until the physiological processes of host attraction are understood, our understanding of structure-activity relationships of host emanations to attractancy or repellency will be very shallow. Such an understanding requires both physiological and chemical research on host attraction.

Variations between mosquito species in response to different hosts, based on empirical evaluations, indicate that mixtures of sensors are involved in the response. Thus, different mixtures of materials are likely to be active in different mosquito species.

(e) Research is needed on new methods of use of existing insect repellent materials, or new formulations, to reduce cost, increase persistence, increase effectiveness, and improve user acceptability. For example, an innovative method that requires additional research is the concept of area protection with treated netting.

(f) Additional chemicals (including those of plant origin) should be screened for insect repellency action. This screening should also include tests to identify materials, not necessarily repellents, that suppress, inhibit, or interrupt hematophagous behavior of arthropods.

(g) The application of microcomputer technology to surveillance data collection, storage, and analysis should be investigated. Computer simulation and mathematical models of various components of vector-borne disease systems will play increasing roles in disease prediction, prevention, and control. These models are dependent upon valid surveillance data input. Microcomputers have great potential for data compilation, storage, and analysis and can provide not only ease of handling data, but also data of higher quality. Even simple programs can be used as parts of decision support systems and can have direct application to field control situations.

(h) The use of various remote sensing techniques such as radar, LANDSAT satellite imagery, and conventional aerial photography for vector habitat surveillance and analysis should be explored. These areas of research offer tremendous potential for development of practical techniques for surveillance of vector breeding over large areas. Such surveillance should be especially

valuable in areas where transportation facilities (roads, etc.) are poorly developed, and where ecological changes result from drought, dam construction, and other factors. The primary advantage of remote sensing, however, is high cost effectiveness, once the research investment has been made.

(i) Research on the identification of chemical attractants is urgently needed. Carbon dioxide has been shown to be attractive to mosquitoes when released in large quantities from traps, and plant and flower-produced attractants for several species of mosquitoes have been demonstrated. None of the latter have been identified and made available for use and no projects are presently underway. Surveillance and control methods could be greatly assisted by deployment of a practical chemically-based material that would attract blood-seeking mosquitoes to a trap. Such a material can only be obtained through sustained basic chemical research on human- or animal-generated skin, body, or excretory emanations, including isolation, identification, synthesis, and formulation efforts. One research effort is presently being conducted on the chemistry of animal-generated attractants for avid mosquitoes. Since 1968, only one effort has been conducted on human-generated emanations, while less than five efforts looked at mosquitoes from the sensory physiology viewpoint. None are now being conducted.

(j) An intensive search should be made to identify semiochemicals (signalling agents) in mosquitoes. Demonstrations of the existence of semiochemicals in adult mosquitoes of four species have appeared in the literature, but none since 1975. No chemicals have been identified, and no work is presently underway. Materials useful in survey and control may be identified through basic research. This situation is very different from that in agricultural insects, where behaviorally active chemicals have been isolated, identified, and synthesized for almost 300 species, and some practical applications are in current use.

6. ENVIRONMENTAL PROBLEMS[1]

For this broad topic one is referred to the current "Regulation 16"[2] which directs the development of environmental examinations, assessments, and impact statements, to be set forth in the Malaria Manual and Guidebook by Scudder and Roberts, 1982.

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[1] See the two supplementary statements by Scudder presented at this meeting and the proposal to use flow-charted algorithms to guide management through environmental problem areas.

[2] Federal Register 45 (207). October 23, 1980. Rules and Regulations, 22 CFR Part 216 Environmental Procedures (for ICA, Agency for International Development).

7. GENETIC CONTROL AND STERILE INSECT TECHNIQUE

7.1. General Status

The successful genetic control campaign waged against the screwworm over the past 20 years provides a model and an incentive for the development of similar autocidal control techniques for other insect pests, especially the most important vectors of disease.

There are essentially two choices available for genetic control. For the sterile insect technique (SIT), the rationale for control is in the use of inundative releases of males sterilized by ionizing radiation or chemosterilants. This method has been tested in field experiments against a few species of mosquitoes, but no operational programs have ever been attempted. The other option involves the assembly of genetic control systems composed of heritable chromosomal aberrations and lethals or desirable traits, e.g., lack of vector competence and insecticide susceptibility. A few small-scale experiments have been conducted, but these had only limited objectives such as measuring competitiveness of the type bearing a chromosome aberration.

The synthesis of genetic control methods has been characterized by many entomologists as too complex and sophisticated for the practical purpose of vector control. Actually, there are precedents in the literature for almost every genetic mechanism that has been proposed for genetic control. The technology and methodology for the synthesis of genetic mechanisms already exist, but there is not sufficient support for this type of research. A sustained effort will be required to fully evaluate the possiblility of a genetic control system for any species, and the cost of developing and implementing genetic control may appear to be higher than the investment required for a pesticide, for which industry bears the brunt of the expense. However, limited resources should not impede the goal of choosing a few important vectors to serve for the development of genetic control methods. The species chosen should be amenable to control by this method in accordance with theoretical considerations.

7.2. Recommendations

In the recommendations listed below, an effort was made to present an orderly progression of how the steps in the development of a genetic control system would be done. Most of the recommendations are directed toward the use of heritable chromosomal aberrations; however, many of the items are applicable to a refinement of SIT. The present status of research on SIT and the genetic mechanisms for the control of vectors, as summarized by R. H. Baker and D. A. Dame, is included in Attachment 4.

(a) Initiation or continuation of studies on the cryptic genetic variability in vectors is needed, using the available

technology (e.g., isozymes, chromosomes, biometrics, cuticular hydrocarbons, etc.) to identify species complexes and to select species for genetic control studies. Several complexes are known for anopheline mosquitoes, and similar situations undoubtedly exist for other species.

(b) Additional studies on the formal genetics and cytogenetics of selected species are recommended to provide the chromosome and linkage maps that are necessary for the synthesis of genetic control mechanisms and the analysis of populations.

(c) Evaluation of the genetic changes that occur during the process of colonization of a species should be investigated by the use of isozyme and chromosome analysis. A better understanding of colonization may improve the general fitness of released insects.

(d) Additional research is needed on the induction and isolation of heritable genetic control mechanisms (e.g., homozygous translocations, compound chromosomes, and conditional lethals) as well as on nonheritable mechanisms (e.g., dominant lethality).

(e) The inheritance of innocuous traits (e.g., lack of vector competence and capacity, diapause, pesticide susceptibility, and autogeny) should be determined, and genetic engineering research should be conducted to transfer the genes transmitting such traits into genetic control systems.

(f) Genetic control systems or strains for SIT should be improved through selective breeding schemes, which should include the improvement of the performance of genetically-altered mosquitoes under field conditions.

(g) Investigations of the cryptic variability in predators and parasites and evaluation of the effect of polymorphism on the efficiency of these biological control agents are needed.

(h) Genetic systems for the efficient separation of male and female mosquitoes for SIT are urgently needed.

(i) Evaluations of SIT for the control of *Anopheles albimanus*, *An. gambiae*, and *An. culicifacies* should be made as a part of an operational program or in a large-scale, integrated management trial in an isolated area.

(j) The environmental impact of chemosterilant residues inside sterilized mosquitoes should be determined, and the search for nonhazardous compounds should be continued.

(k) International centers should be established to preserve special genetic stocks and to provide training in rearing mosquitoes and genetic techniques.

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8. BIOLOGICAL CONTROL

8.1. General Status

Comprehensive vector control utilizes all means available for the interruption of transmission of disease agents in such a way that the different techniques complement rather than conflict with each other. Chemical control is usually the easiest, cheapest and most readily effective method of vector control when it can be used, but unless it provides complete interruption of disease transmission and eradication of the etiological agent, chemical control is repetitive, expensive in the long run, and almost certainly will lead eventually to insecticide resistance. In some instances, as where vectors are exophilic and breeding places are scattered, chemical control may not be possible. It is therefore important to identify natural sources of mortality in vector populations and to explore alternative natural control factors which might be used to augment normal mortality to decrease the size or longevity of vector populations.

Biological control is a method which is usually so host-specific that it will not adversely affect the environment. It is labor intensive rather than capital intensive, which is particularly advantageous in developing countries. Many of the parasites and predators can be produced locally, which avoids problems in monetary balances. The cost/benefit and cost effectiveness may be very high. In addition, the development of resistance to biological control agents is less apt to become a serious operational problem than resistance to insecticides.

No single biocontrol agent is likely to have widespread applicability relative to vector species and habitats. Therefore, the efficacy of a biocontrol agent cannot be decided on the basis of a single test, however large, in one environment against one vector species. Because of a variety of biological, physical, and chemical factors, an organism might either have a temporary larvicidal effect or cycle and persist to exert more permanent control in a restricted habitat range. In light of our incomplete knowledge of the limiting factors, potential biocontrol agents need to be evaluated against as wide a variety of susceptible vectors in as many different habitats as possible.

There have been notable successes with biological and conventional techniques without prior extensive knowledge of the biology, ecology, or dynamics of the systems involved. It can be argued that these successes were in some way responsible for the attitude that an appreciation of basic biologies was not essential to vector control. However, it is becoming increasingly apparent that present efforts in all areas are hampered by an inadequate foundation of basic information. It is clear that the type of

information required for biological control is fundamentally different from that required for conventional suppression strategies. If biocontrol is to play a role in the suppression of disease, a great deal of basic research is required. A research philosophy relying substantially on serendipity and the wholesale screening of biologicals will not be as fruitful ultimately as one employing a mixed and more balanced strategy that includes basic research.

Many mosquito pathogens have not reached the stage of field testing because basic questions are unanswered. For example, knowledge is needed as to how horizontal transmission of some types of microsporidia is accomplished before their biocontrol potential can be evaluated. New techniques for the evaluation of the results of field applications are needed for those biocontrol agents which exert their effect over the whole lifespan of the vector. The activity of even those pathogens which have already been proven to be efficacious might be enhanced with a more thorough knowledge of the dynamics of filter feeding in vector *Nematocera*.

8.2. Recommendations

The following recommendations for research on biological control methods have been grouped into two categories: general recommendations dealing with broad areas of research and specific recommendations concerning a few of the more important species.

8.2.1. General Recommendations

(a) Biocontrol agents contribute to suppression of mosquito populations throughout the world. Every locality has specific situations unique to the area. Generally the search for biocontrol agents has been insufficient, and additional exploration should be supported. When fish predators are considered, emphasis should be on the feasibility of using native species, particularly those that offer promise for food or bait.

(b) A major limiting factor in the commercial production of biological control agents is the present general inability to mass produce them. With present technology, living organisms (hosts or prey) are required for the mass culture of most of these agents. A few of the promising biocontrol agents can be produced in vitro, and for the most part those are the ones that have reached the level of commercial production. Therefore, much more research is needed on the development of technology for production of other promising agents such as nematodes, fungi, and fish.

(c) Formulation of biocontrol agents can make the difference between success and failure. For instance, bacterial and microsporidian spores must remain in the larval feeding zone long enough for the mosquitoes to acquire a lethal dose. Different formulations are required to penetrate vegetative canopies and reach larval breeding sites.

Short shelflife is one of the most important potential deterrents to the marketability of biocontrol agents. It is imperative that these products remain viable at relatively high tropical temperatures for extended time periods. Research is desperately needed to resolve these problem areas of formulation and shelflife.

(d) Two strategies for biological control are inundative and inoculative releases. These involve quite different approaches an are appropriate to different vectors and biocontrol agents.

The concept of inoculative release is based on the establishment, persistence, and cycling of the agents in the habitat where control is desired. Knowledge of the various parameters that permit or influence cycling will provide background on the feasibility of using certain agents in specific habitats, determining optimal application times and rates, and may enable enhancement of the cycling phenomenon through formulation.

8.2.2. Specific Recommendations

(a) Large-scale trials of the efficacy of *Bti* (*Bacillus thuringiensis israelensis*) in interrupting disease transmission should be carried out. Such tests should be done with such species as *Anopheles albimanus*, *An. culicifacies*, *An. sundaicus*, or *An. sacharovi*.

(b) The question of whether, to what extent, and under what conditions, cycling of *Bacillus sphaericus* takes place after application should be examined, since the persistence of the organism in the field depends on such cycling.

(c) Carefully designed field trials with various species of *Toxorhynchites* in various habitats should be conducted with the intention of providing information on the mechanisms responsible for the level of suppression obtained.

(d) One factor limiting the utility of *Romanomermis culicivorax* is its inability to cycle in the field under some conditions. This limitation appears to be related to water quality and substrate. It is strongly suggested that research be funded that would characterize potential breeding sites in such a way that probable cycling could be predicted before this agent is used in a suppression effort.

9. POPULATION DYNAMICS AND COMPUTER SIMULATIONS

Modelling is a useful and powerful tool that has application in many fields of biological science. All models include assumptions that attempt to represent a segment of the real world. In most cases increased realism is obtained by increasing model complexity. In any use of models the structure and complexity will depend upon the objectives and ultimate use of the

model. Models provide insight into the behavior and interactions between different components in a system. As such, models are useful research, planning, and training tools.

Modelling research and use of models have had and will continue to have a great impact on understanding disease-vector interactions and development of comprehensive control strategies. Recent improvements in vector-disease models and availability of low-cost computer systems will increase the potential usefulness of modelling systems in field research and operational programs.

9.1. General Status

Modelling of malaria transmission and of vector population dynamics already has a long history, and is currently an active field of investigation (see working papers by Molineaux and by Weidhaas and Haile, Appendix 4).

9.1.1. Models of Vector Population Dynamics

The current emphasis on vector control includes the potential of combining various methods of control into comprehensive control. The complexity of the problem has resulted in the development of models which interact the effect of control methods with the dynamics of populations by following density trends with or without control. The existing models are largely theoretical, but based on a large body of data on the biology, ecology, and life history of vectors. The models have been adapted to computer methodology. Vector models are all based on the life history of the vector involved, but have generally been developed along three main approaches: (a) quantification or computer simulations of descriptive life cycles; (b) mathematical models; or (c) a combination of both general approaches. To date these models have been useful in synthesizing biological and control data, studying the relationship of control to the dynamics of the population and planning research and field experiments. One vector model has been extended to include a model of falciparum malaria in the human and vector population.

Currently, the major accomplishments of these models and computer simulation techniques have been the synthesis of existing data into reasonably quantified models describing the problem theoretically. Such models have improved planning of research and field experiments for control. For example, vector models were used to plan two sterile male release experiments with *Anopheles albimanus* in El Salvador and then to analyze the results of these programs. Theoretical models have been used to study the potential of biological control agents, genetic mechanisms, and attractants as well as the use of insecticide treatments.

There is a need to improve the existing models and simulation techniques and to verify their validity in conjunction with ongoing or new field trials. Such needs include: (a) the development of additional quantitative data on the biological and population parameters which control population dynamics; and

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(b) the inclusion of environmental factors (e.g., rain, temperature, humidity, and water level) which also affect population dynamics. There is also a need to develop field methods for measuring the various population parameters to be used in these models. For example, simpler methods of estimating total or absolute numbers of the different stages of the vector, the survival of the various stages under natural conditions and the development times of the various stages and forms are needed.

9.1.2. Models of Malaria Transmission

Malaria transmission models started with Ross as early as 1911, and have been reviewed by Bruce-Chwatt. The evolution of malaria models may be illustrated through three examples.

Ross' model divides the human population into negatives and positives and allows transfers in both directions; superinfection has no effect (the recovery rate is constant) and there is no immunity; he identified the factors that determine transmission as (a) the vector's density, (b) the rate of contact with man and longevity, (c) the incubation period in the vector, and (d) the number of positives. The first four factors are the components of a contact rate later called vectorial capacity. The best known malaria model is Macdonald's, which is Ross' model with some changes, not all fortunate. He assumes that superinfection delays recovery; his formula for this, which makes multiple infections queue before being disposed of, may have gone beyond his intention. He took into account that not all parasitemias are infective, and defined the important concept of basic reproduction rate, which includes the vectorial capacity plus the duration of infectivity. The Garki model of Dietz et al. has seven human states, and takes into account the acquisiton and the parasitological effects of immunity.

Modelling the interface between human and vector populations involves at least three decisions. The first concerns superinfection in the vector; in some models (Macdonald) it does not increase infectivity, in others (Garki) it does; numerically this is probably unimportant. The second decision concerns man-vector contact; past malaria models have assumed uniform contact. The third decision concerns the effect of infection on the vector; past malaria models have assumed that it has none.

Malaria transmission models and vector population models seem to originate in two ways. Some modellers start with a system of equations and give high priority to mathematical analysis with the purpose of making the assumptions explicit, removing ambiguities and contradictions, and possibly, reaching some general laws (e.g., the existence and definition of critical levels). Other modellers start with a straightforward translation of what is presumably known about the biological aspects of the problem into a computer simulation model, and study the model's behavior. It appears that both approaches have something to contribute.

The usefulness of a model could presumably be measured by three criteria: (a) insights provided into the problem; (b) ability to simulate realistically the epidemiology of malaria, making the model more valid for planning and/or teaching; and (c) actual utilization in planning control programs.

The examples cited above may illustrate these criteria. Ross' model provided three important insights, namely the existence of a threshhold (e.g., a critical vector density) below which malaria could not maintain itself, the tendency of malaria to return to the same level after temporary disturbances, and the nonlinear relationship between the entomological situation (e.g., vector density) and the endemic level (the practical implication for control, namely that the same effective vector control may interrupt transmission in one situation, but have almost no impact in another, was clearly drawn only in 1961 by Moshkovsky). The Garki model of Dietz et al. is reasonably realistic in simulating some important aspects of the epidemiology of malaria (see the working paper by Molineaux and the relevant references). Macdonald's model contributed significantly to the decision to embark on global malaria eradication (some implicit assumptions about the uniformity of the vector's behavior in terms of exposure to residual insecticides, and about the uniformity of human behavior in terms of participation in mass drug administration, may have contributed to generate an exaggerated optimism concerning the possibility of eradication).

9.2. Recommendations

The first of the following recommendations is broad in scope and takes first priority; the other three concern different aspects of computer modelling in vector control and are of equal secondary priority.

(a) Projects are needed to include the use and development of disease-vector models in conjunction with operational control programs. This will provide support for planning and operation of the control programs as well as the opportunity to improve and validate modelling procedures and to collect more adequate data for model input.

(b) Models must be developed to simulate vector population dynamics and the effects of important control measures that are currently in use or that are under investigation.

(c) Continued development is needed to provide malaria transmission models that will realistically simulate (1) drug resistance and the effects of alternative drug policies, (2) natural immunity and administration of potential vaccines, (3) morbidity and mortality rates, and (4) serological data.

(d) New and more precise field methods to measure key vector population parameters must be developed.

CHAPTER 24 REFERENCES AND BIBLIOGRAPHIES

SECTION 24.1 REFERENCES TO LITERATURE CITED IN THIS MANUAL

24.2 SELECTED BIBLIOGRAPHIES[1]

24.21 Literature on Decision Support Systems and Algorithms in General

24.22 Literature on Disease Algorithms

24.23 Comprehensive Monographs on Malaria Control, Mosquitoes, and Mosquito Control

24.5 SELECTED JOURNALS

24.51 Journals for Environmental Toxicants, Analyses, and Management

24.52 Journals for Malaria and Mosquito Control

24.53 Journals for Weed Control

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[1] For additional bibliographies on special topics, see Section 24 of the Guidebook.

CHAPTER 24 - REFERENCES AND BIBLIOGRAPHIES

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What is being done at the University. P. 138 - 145 in: Swift, J.E. (Editor) Agricultural chemicals - harmony or discord for food, people and the environment. Proc. of Symposium, February 16 - 17, 1971, Sacramento, CA. Division of Agr. Sciences, Univ. California Davis, Davis, CA 151 p. (Paper).

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Ecological methods with particular reference to the study of insect populations. 2nd edition. Chapman & Hall, London. XXIV + 524 p.

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The effects on surface organisms of the routine land application of DDT larvicides for mosquito control. U.S. Public Health Reports 62: 525 - 554.

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Manual on larval control operations in malaria programmes. WHO Offset Pub. #1. WHO Division of Malaria and Other Parasitic Diseases. World Health Organization, Geneva, Switzerland. VI + 199 p. (Paper).

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Specifications for pesticides used in public health: insecticides, molluscid repellents, methods. 5th edition. WHO Expert Commitee on Vector Biology & Control. World Health Organization, Geneva, Switzerland. 327 p.

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Environmental management for vector control. 3rd Report, WHO Expert Committee on Vector Biology and Control. Tech. Rep. Ser. #649. World Health Organization, Geneva, Switzerland. 75 p. (Paper).

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Pesticide management and insecticide resistance. Academic Press, New York. 656 p.

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The importance of malaria in the world. P. 1 - 93 in: Kreier, Julius P. (Editor), Malaria, Vol. 1 - Epidemiology, chemotherapy, morphology, and metabolism. Academic Press, New York. XVII + 416 p.

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Toward guidelines on the selection of specialist-oriented vs. user-oriented system design. P. 175 - 183 in: Proc. 13th Hawaii International Conference on System Sciences, Vol. 2, 3-4 January 1980, Ralph H. Sprague, Jr. (Editor), University of Hawaii, Honolulu. VIII + 215 p. (Paper).

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Decision support systems, an organizational perspective. Addison-Wesley, Reading, Mass. XIV + 269 p.

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Design of decision support systems. P. 1 - 8 in: Proc. 13th Hawaii International Conference on System Sciences, Vol. 2, 3-4 January 1980. Ralph H. Sprague, Jr. (Editor), University of Hawaii, Honolulu. VIII + 215 p. (Paper).

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A symposium on human malaria, with a special reference to North America and the Caribbean region. Publication No. 15. American Association for the Advancement of Science, Washington, D.C. VII + 398 p.

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A quarterly journal for full length articles in English describing original experimental or theoretical research work dealing with any scientific aspect of environmental contamination, including chemistry, toxicology, degradation, mode of action, analysis, monitoring, etc., of impurities that get into the ecosystem. Published by Springer-Verlag, 175 Fifth Avenue, New York, NY 10010.

Bulletin of Environmental Contamination and Toxicology. Vol. 1, 1966.
Monthly journal, two volumes annually, of short reports drawn from all disciplines which in any way shed light on the introduction, presence, and effects of toxicants on the total environment. Descriptions of new methods, procedures, and techniques are sufficiently detailed so that other researchers can readily adopt them. Published by Springer-Verlag, 175 Fifth Avenue, New York, NY 10010.

Environmental Entomology. Vol. 1, 1972.
A bimonthly journal devoted to the research on the behavior of insects and their interaction with the biological, physical, and chemical constituents of the environments. Published by The Entomological Society of America, 4603 Calvert Road, College Park, MD 20740.

Environmental Management. Vol. 1, 1977.
An international journal for decision makers and scientists. Published bimonthly by Springer-Verlag, 175 Fifth Avenue, New York, NY 10010.

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Published quarterly by D. Reidel Publishing Co., Box 17, 3300 AA, Dordrecht, Netherlands.

Journal of Environmental Management. Vol. 1, 1973.
Published bimonthly by Academic Press, Inc., 111 Fifth Avenue, New York, NY 10003.

Journal of Environmental Quality. Vol. 1, 1972.
Published quarterly by the American Society of Agronomy (jointly with the Crop Science Society of America, and the Soil Science Society of America), 677 South Segoe Road, Madison, WI 53711.

Journal of Environmental Sciences. Vol. 1, 1957.
Official bimonthly publication of the Institute of Environmental Sciences, a professional society of engineers, scientists and educators simulating and testing in the environments of earth and space, for the betterment of mankind and the advancement of industry and science. Contains technical articles and reports on the researching, simulating, testing and teaching of environmental sciences and technologies. Published by The Institute of Environmental Sciences, 940 E. Northwest Highway, Mt. Prospect, IL 60056.

Journal of Wildlife Management. Vol. 1, 1937.
Published quarterly by the Wildlife Society, Suite 611, 7101 Wisconsin Avenue, NW, Washington, D.C. 20814.

Pesticides Monitoring Journal. Vol. 1, 1967.

A quarterly journal whose principal sources of data and articles are from the pesticide monitoring activities of the U.S. Federal Government, particularly in those agencies represented on the Monitoring Panel, which participate in the operation of the National Pesticides Monitoring Network. Pertinent data in summarized form, together with discussions are invited from the Federal and non-Federal sources, including those associated with state and community monitoring programs, universities, hospitals and non-governmental research institutions, both domestic and foreign. Results of studie in which monitoring data play a major or minor role or serve as support for research investigation also are welcome, however, the Journal is not intended as a primary medium for the publication of basic research. Published by the Federal Working Group on Pest Management, U.S. Environmental Protection Agency. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Pesticide Science. Vol. 1, 1970.

Bimonthly journal providing an international forum for research material on all aspects of the production, use, metabolism, degradation and toxicology of synthetic and naturally occurring insecticides, fungicides, herbicides and growth regulators for agricultural, veterinary and public health use. Published for the Society of Chemical Industry by Blackwell Scientific Publications, Ltd., Osney Mead, Oxford OX2 OEL, England.

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24.52 - Journals for Malaria and Mosquito Control

American Journal of Public Health and the Nation's Health
Vol. 1, 1911, Washington, D.C.

American Journal of Tropical Medicine & Hygiene
Vol. 1, 1951, Lawrence, KS.

Aquatic Weeds
Vol. 1, 1979, Lisse, Netherlands.

British Medical Journal
Vol. 1, 1857, London, England.

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Vol. 1, 1910, Farnham Royal, Slough, England.

Bulletin of Entomology, Entomological Society of India
Vol. 8, 1967, Delhi (formerly privately published in Madras).

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An annual publication. CMCA Press, 197 Otto Circle,
Sacramento, CA 95822.

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A semiannual journal covering all aspects of malariology
(fundamental, applied, and field). Published by the Malaria
Research Center, 22 Sham Nath Marg, Delhi, 110054, India.
(Formerly by the Malaria Institute in Calcutta)

Journal of Economic Entomology
Vol. 1, 1908, College Park, MD.

Journal of Medical Entomology

Vol. 1, 1964, Honolulu, HI.

A bimonthly journal concerning all phases of medical entomology and medical acarology, including systematics of insects and mites of public health and veterinary significance. Published by the Department of Entomology, Bishop Museum, Honolulu, HI.

Journal of Tropical Medicine & Hygiene

Vol. 1, 1898, Oxford, England.

Mosquito News

Vol. 1, 1940, American Mosquito Control Association, Fresno, CA.

New Jersey Mosquito Extermination Association, Proceedings

Vol. 1, 1914, Trenton, NJ.

Pest Control

Vol. 1, 1933, New York, NY.

(formerly Pests and Their Control)

A monthly journal for the pest control industry, member, National Pest Control Association. Every issue contains some lengthy discussion, some quick observations and chatty news items. A twelve-month seminar on the industry. Published by Harcourt Brace Jovanovich Publications, 757 Third Avenue, New York, NY 10017. (Pest Control Circulation Department, P.O. Box 6215, Duluth, MN 55806).

Philippine Entomologist

Vol. 1, 1968, Laguna, PI.

Revista Brasiliera de Malariologia e Doenças Tropicais.

Vol. 1, 1949, Rio de Janeiro.

Riviste di Malariologia

Vol. 1, 1922, Rome.

Royal Society of Tropical Medicine & Hygiene, Monographs

Vol. 1, 1936, London.

Royal Society of Tropical Medicine & Hygiene, Transactions

Vol. 1, 1907, London.

Société de Pathologie Exotique, Bulletin
Vol. 1, 1908, Paris.

Tropical and Geographical Medicine
Vol. 1, 1949, Amsterdam, London, New York.

Tropical Diseases Bulletin
Vol. 1, 1912, London.

WHO, Bulletin of the
Vol. 1, 1947, Geneva.

WHO, Bulletin Supplement
Vol. 1, 1952, Geneva.

WHO Chronicle
Vol. 1, 1947, Geneva.

WHO Technical Report Series
Vol. 1, 1950, Geneva.

WHO Monograph Series
Vol. 1, 1951, Geneva.

24.53 - Journals for Weed Control

Aquatic Weed Control. Vol. 1, 1975.

A monthly newsletter on recent developments in the control of aquatic weeds. Published by the Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, FL 32611. (Available from: Agricultural Research & Education Center, 3205 SW College Avenue, Ft. Lauderdale, FL 33314).

Journal of Aquatic Plant Management. Vol. 1, 1962.

Issued once or twice yearly. Includes papers on all aspects of aquatic vegetation, management, field operations, research, and regulation; also review articles. Published by the Aquatic Plant Management Society, Inc., P.O. Box 06005, Ft. Meyers, FL 33906.

Weed Research. Vol. 1, 1961.

A bimonthly international journal in English, French, and German, concerned with the study of weeds and their control, and related topics. Sponsored by and is the official journal of the European Weed Research Society. Papers on work carried out in any part of the world, including tropical and sub-tropical regions, are welcomed. Reviews of technical conferences and symposia are also published. Published by Blackwell Scientific Publications, Ltd., Osney Mead, Oxford OX2 OEL, England.

Weed Science (Formerly "Weeds"). Vol. 1, 1951.

The bimonthly official publication of the Weed Science Society of America. Articles are included on weeds, herbicides, growth regulators, or related topics. Published by the Weed Science Society of America, 309 West Clark Street, Champaign, IL 61820.

CHAPTER 25 – MALARIA CONTROL CONSULTANTS

CHAPTER 25 – MALARIA CONTROL CONSULTANTS

General Statement:

Because of the complexity of malaria control, especially of the attendant environmental, sociological and economic issues, any program may profit from the appropriate use of outside expertise on a short term problem-solving and planning basis. These needs may cut across many disciplines:

Sociology

Economics

Anthropology

Public Health

Epidemiology

Clinical Science

Laboratory Science

Entomology

Parasitology

Engineering (both sanitary and civil)

Pesticide Chemistry

Toxicology

Natural History (many fields)

Environmental Sciences

SECTION 25.5 - SOURCES OF CONSULTANT ASSISTANCE

In order to avoid endorsement of any one individual or corporate consultant, the following sources are suggested:

1. Malaria Programs, Office of Health
   Bureau for Science and Technology
   U.S. Agency for International Development
   Department of State
   Washington, D.C. 20523
   (703) 235-8926

2. Division of Vector Biology and Control
   World Health Organization
   1211, Geneva 27
   Switzerland
   (41-22) 91-38-45

3. International Health Program
   American Public Health Association
   1015 Fifteenth Street, N.W.
   Washington, D.C. 20005
   (202) 789-5708

4. Parasitic Diseases and Vector Control
   Pan American Health Organization
   525 Twenty-Third Street, N.W.
   Washington, D.C. 20037
   (202) 861-3200

5. "Directory of North American Entomologists and Acarologists" by W.B. Hull and G.C. Odland (Editors).
1979. 189 p. (Paper).

Contains alphabetical, geographical and discipline listing on nearly 5,000 professionals in the field. Includes important supplementary data such as telephone number, languages other than English, national professional registries, academic degrees, etc.
Available from the:

Entomological Society of America
P. O. Box 4104
Hyattsville, MD 20781
(301) 864-1334

6. "World Directory of Vector Research and Control Specialists" compiled by Eugene J. Gerberg, Ph.D. for the AMCA.
Available from the:

American Mosquito Control Association
5545 E. Shields Avenue
Fresno, CA 93727
(209) 292-5329

(A copy is furnished for Section 25.0 of the Guidebook)

7. Individual authors of papers, given as references in the Manual and Guidebook, may be potential consultants, if direct contact is made with them.

CHAPTER 26 GLOSSARY[1]

General Considerations:

The glossary in this Manual is a compilation of glossaries from thirteen publications, plus the authors' additions and amendments.

The reader should consider that the field is so very multidisciplinary that it is not conceivable for one to cover it. No glossary can manage a range of disciplines which extend through medicine, biology, engineering, chemistry, agriculture, economics, and sociology, yet we are confident the glossary presented here will be of value. As with all sections of this Manual, additions by the reader are encouraged.

Excerpts have been selected and edited from the following sources:

AID, 1977a, Vol. 2, p. 146.
Bruce-Chwatt, 1980, p. 235-242.
Cowardin *et al.*, 1979, p. 42-43.
Federal Register, 1980, 22 CFR Part 216, para. 216.1(c).
Foote and Cook, 1959, p. 151.
Gerberg and Graham, 1978, p. 96-102.
Knuth, 1977, p. 63.
Mulhern, 1975, p. 15.6-1 to 15.6-11.
Myers, 1955.
Ricklefs, 1979, p. 864-882.
WHO, 1963, p. 91-124[2].
WHO, 1975a, p. 24, 30.
Weinsdorfer, *in* Kreier, 1980, Vol. 1, p. 47-50.
Wright, 1971, p. 14.

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1. See also these glossaries:
   Harbach and Knight, 1980, "Taxonomist's glossary of mosquito anatomy", a definitive work.
   Foote, 1977, "Thesaurus of entomology", a thorough listing.
   Berg, 1982, "Farm chemicals handbook", (includes a "pesticide dictionary).

2. This WHO glossary forms an important base for the present work.

CHAPTER 26 GLOSSARY

AAT®. See Parathion.

abate. To abolish; to eliminate; to reduce in amount; to diminish. The California Health and Safety Code provides a procedure by which landowners may be required by the courts to "abate" man-made mosquito nuisances.

Abate®. See Temephos.

Abbott's formula. Formula used in applied entomology for correction of insect mortality figures in observations where any significant mortality (over 5%) occurs among controls. The corrected proportion is $(x-y)/x$, where x is the proportion surviving among the controls and y that surviving among the test insects. See also check mortality.

abiotic. Not biological; relating to non-living things, or non-living factors affecting life.

abiotic mosquito control. Control of mosquitoes by non-living factors, such as: evaporation, salinification, shading, exposure to sunlight, etc.

absorption. Process of attraction of one substance into the mass of another. The basic physical forces involved are those of osmosis and diffusion. See also sorption.

Accothion® See fenitrothion.

acid. Term applied to water with a pH less than 5.5.

acre foot. Quantity of water that would cover 1 acre 1 foot deep. An acre-foot is a volume measurement and is equivalent to 43,560 cubic feet.

Actellic® See pirimifos-methyl.

Actellifog® See pirimifos-methyl.

active case detection. Active case detection is a part of surveillance activities in which the formal malaria project actively searches for malaria cases through the collection of blood slides and epidemiological investigations.

adjuvant. An ingredient which is added to an insecticide formulation to modify or enhance the action of the principal active ingredient.

adsorption. Adhesion which takes place at the surface of a solid or a liquid in contact with another medium (solid, liquid or gas) resulting in an accumulation or increased concentration of molecules from that medium in the immediate vicinity of the surface. See also sorption.

adulticide. In mosquito control, any chemical used to kill the adult (imago) stage. Loosely applied also to repellents. Synonym: imagicide.

aerosol. Suspension of solid or liquid particles in air or gas, ranging in size from 0.1 to 50μ. An insecticidal liquefied-gas aerosol is one produced by the extremely rapid volatilization of a liquefied or compressed gas, serving as a propellant for a non-volatile oil solution of an insecticide.

As the liquefied gas volatilizes, it propels the oil solution in the form of an aerosol of very fine droplets. The size of the droplets varies with the product but must be less than 50μ in diameter. The gases used are generally dichlorodifluoromethane (Freon-12) or trichlorofluoromethane (Freon-11) which do not involve a toxic hazard to warm-blooded animals.

aestivation. State of survival of mosquitos by means of behavioural and physiological changes during periods of high temperature and drought.

age, epidemiologically dangerous. Minimum age at which a female mosquito can transmit sporozoites in the prevailing climatic conditions.

age, physiological. Number of gonotrophic cycles undergone by a female mosquito.

age composition. Frequency distribution of ages in a population or a specified fraction of it.

age-grading. Classification of female mosquitoes according to their physiological age (number of gonotrophic cycles) or simply as nulliparous or parous.

age groups. Sections of a community classified by age.

Agrothion®. See fenitrothion.

alga (pl. algae). Mostly chlorophyll-containing plants, the majority of which are aquatic. The smallest are microscopic unicellular plants and the largest contain millions of cells and may be several hundred feet in length. Algae grow in saline and fresh waters, sometimes very densely in polluted water.

algorithm. A set of rules or directions for getting a specific output from a specific input. All vagueness must be eliminated; the rules must describe operations as simple and well defined, and they must terminate after a finite number of steps. (Knuth, 1977 p. 63).

alkali. In chemistry, any substance having marked basic properties.

alkali soil. A soil with a high degree of alkalinity (pH 8.5 or higher), or with high exchangeable sodium content (15% or more of the exchange capacity), or a soil that contains sufficient alkali (sodium) to interfere with the growth of most cultivated plants.

alkaline. Term applied to water with a pH greater than 7.4.

alkaline soil. A soil that is alkaline in the portion occupied by plant roots, although the term is commonly applied to the surface layer or horizon having pH value greater than 7.0; practically, a soil having pH above 7.3.

Alkron®. See parathion.

Alleron®. See parathion.

allethrin. See pyrethroids.

alluvial. Related to deposits of soil made by flowing water.

Altosid®. See methoprene.

analog. In chemical terminology, one of a group of substances having similar properties or showing similarity or agreement with regard to certain characteristic features. The term should be qualified according to the type of analogy.

animism. Animism is the belief that all natural objects and the universe itself possess a soul which may exist apart from their material bodies.

Annual Parasite Incidence (API). Annual Parasite Incidence (API) is the proportion of cases of malaria detected on an annual basis in relation to the unit of population in which malaria occurs.

Anopheles. Genus (or subgenus) of mosquitos of the subfamily Anophelinae.

Anophelinae. Subfamily of the Culicidae which includes the genus Anopheles.

Anopheline density. The anopheline density is the number of female anophelines in relation to the number of specified shelters or hosts (e.g., per room, per trap, or per person) or to a given time period (e.g., overnight or per hour), specifying the method of collection.

anophelism. Presence of anophelines in a locality, irrespective of the presence of malaria.

antenna (pl. antennae). Paired segmented sensory organs located on each side of the head, sometimes referred to as feelers.

anterior. Situated in front; before; in Diptera, that face of the leg which is visible from the front when the leg is laterally extended.

anthropophilic. Showing a preference for feeding on man even when non-human hosts are available. A relative term requiring qualification so as to indicate the extent of this preference.

anthropophilism, anthropophilic. A feeding habit in which the blood of man is preferred over that of other animals. See zoophilism.

Aphamite® See parathion.

apical. Situated at, near or pertaining to the apex (that part of any joint or segment opposite the base by which it is attached).

application rate. The average volume or weight of the field formulation of chemical material (including both toxicant and diluent) which is applied per unit of area or volume treated.

aprocarb. See propoxur.

aquatic. Growing or living in, or frequenting water.

aquifer. A porous underground layer permitting waterflow, often leached away to form caverns and channels; water-bearing stratum.

arboreal. Tree inhabiting.

arthropod (Arthropoda). An animal characterized by having a hard exoskeleton; body with a number of segments arranged longitudinally; with paired and jointed appendages. The phylum Arthropoda includes insects, spiders, mites, ticks, scorpions, crabs, lobsters, shrimp, etc.

assimilation. Incorporation of any material into the tissues, cells, and fluids of an organism.

assimilation efficiency. A percentage expressing the proportion of energy ingested that is absorbed into the blood stream.

attack. 1. Period of acute (overt) illness consisting of a single paroxysm or of several separate paroxysms. The first attack following the incubation period is called the "primary attack". 2. In malaria eradication terminology, the phase during which antimalarial measures applicable on a large scale and aiming at the interruption of transmission are applied on a total-coverage basis in an operational area. This phase is sometimes called the period of total-coverage spraying.

attack phase (3-4 years). Attack phase interrupts malaria transmission, mainly by DDT domiciliary spraying. In early attack, malariometric surveys provide evaluation and guidance of operations. In late attack (after reduction of malaria prevalence to less than 5%), total coverage by case detection and treatment services (surveillance) is established. This phase ends when malaria incidence is reduced to .01% and other criteria are met. General spraying coverage is then withdrawn.

attractant. That which attracts; specifically, anything used to attract insects or other animals. The lure can be light, sound, temperature, contact, or chemical. The attractant can stimulate positive behavior relating to food, egg laying, or mating. An older word is attrahent.

augmentation. The biological control technique of artificially increasing the population density of a predator, parasite, or pathogen by 1) mass rearing and release, or 2) providing food supplements to maintain its population at an artificially high level.

autochthonous. Term applied to malaria contracted locally.

autogenous mosquitoes. Those which can produce viable eggs without obtaining a blood meal.

average enlarged spleen. This is the weighted average spleen size of those subjects with a palpably enlarged spleen in a specified age group of the population sample examined. This index is obtained by multiplying the number of individuals in each arbitrary classification of enlarged spleen by class number, adding the products, and dividing the total by the number of individuals whose spleen is palpable. For the purpose of splenometry the classification of Hackett (1944), in which spleen size ranges between grade 0 (not enlarged) and grade 5, has become the generally accepted standard.

Ayurvedic medical practitioner. Ayurvedic medical practitioner is the "traditional doctor" was believes that the cause of illness is due to imbalances of bodily forces.

BHC. Abbreviation and common name of benzene hexachloride, a chlorinated hydrocarbon insecticide comprising essentially a mixture of isomers of 1,2,3,4,5,6 hexachlorocyclohexane in the form of whitish to light-brown granules, flakes, or powder. The gamma-isomer is the most active constituent. The grades of BHC commercially available are distinguished according to their gamma-isomer content as follows: technical BHC: 12%-16%; refined BHC: 16.1% - 98.9%; lindane: 99% - 100%. See also lindane.

BP 511.® See Actelic.®

BTI or B.t.i. (Bactimos,® Teknar,® Vectobac®). An endotoxin concentrate derived from Bacillus thuringiensis var. israelensis, that is highly specific to mosquito and blackfly larvae and harmless to animals and man. It is formulated in wettable powder form and applied as a larvicide. The bioagent kills rapidly and disappears within a few days.

Bacillus thuringiensis. See B.t.i.

back-cross. The mating, in the laboratory, of insects from one colony or strain with the progeny of a cross-mating between that strain and another.

bacterium (pl. bacteria). A large group of one-celled microorganisms. Some are disease producing; some cause decay; some are active in fermentation, or in conversion of dead organic matter into soluble food for plants; some fix atmospheric nitrogen.

Bactimos.® See B.t.i.

balance of nature. The tendency of populations of all living species to maintain a more or less consistent or predictable numerical relation to each other, due to interaction with each other and with the environment. The balance is not static or fixed, but variations in population densities tend to fall within certain typical limits.

bar. An elongated landform generated by waves and currents, usually running parallel to the shore, composed predominantly of unconsolidated sand, gravel, stones, cobbles, or rubble and with water on two sides.

barrier spraying. See under barrier spraying.

basal. Situated at or pertaining to the base or point of attachment to or nearest the main body.

basin flooding (basin irrigation). The application of irrigation water to the land in basins formed by ridges or dikes of soil which confine the water to the area irrigated. The ridge or dike surrounds a nearly level area of land.

batch. Eggs deposited by a single female mosquito at any one oviposition.

Bay 41831.® See fenitrothion.

Baycid.® See fenthion.

Baygon.® See propoxur.

Baytex.® See fenthion.

beach. A sloping landform on the shore of larger water bodies, generated by waves and currents and extending from the water to a distinct break in landform or substrate type (e.g., a foredune, cliff, or bank).

bendiocarb (Ficam®). A carbamate insecticide of moderately high toxicity (Type II). Has residual spray uses as a wettable powder and is also available as a dust.

benign tertian. Colloquial name for vivax malaria.

berm. (1) The space left between the upper edge of a cut and the toe of an embankment. (2) A horizontal strip or shelf built into an embankment to break the continuity of an otherwise long slope.

binomial nomenclature. Having two names, tne generic name and the specific name used in zoological nomenclature, as Culex tarsalis.

bioassay. In applied entomology, the experimental testing of the biological effectiveness of an insecticide by deliberately exposing insects to it. Each series of bioassay tests requires specification of the test mosquito species, their age, sex, and physiological condition, the concentration of the insecticide per unit of surface or of air volume, the age of the deposit, the type of material on which the insecticide has been applied, the time of exposure of the insects, and the temperature and humidity at the time of testing.

bioassay mortality. Mean mortality of a sample of test mosquitos employed in a uniform series of bioassay tests.

biological control. Use of a virus or any living form, from a microorganism to a vertebrate, to control the population of a vector, pest animal, or pest plant (weed).

biological mosquito control (biocontrol). The action of natural enemies; i.e., predators, parasites, pathogens, and competitors in maintaining the population of another organism at a lower average than would occur in their absence. This term has been applied to 1) the control or generally in this manual, to the deliberate use, or the manipulation by man, of introduced or native natural enemies to increase their effectiveness. The first process may or may not directly benefit man; the second process is used to achieve a desired level of pest control. Biological control may be accomplished by the introduction of natural enemies; by augmentation of the existing populations of natural enemies; or by conservation of the existing population through preventing damage by the application of pesticides or other harmful influences. Biological control is a part of natural control or naturalistic control.

biological sealing. The action of various organisms found in the soil, usually at or close to the surface, which cements soil particles or fills voids or pores and reduces infiltration of water into the soil.

bionomics. Bionomics is the study of organisms in relation to their environment.

biorational control. Use of a viral or microbial agent to control a vector, other animal, or a plant (weed) without risk to desirable species. Term is used to avoid the legal and popular connotation of "infectious agent" or "pathogen".

biota. The animals and plants of a given habitat or area.

Biothion®. See temephos.

biotic. Pertaining to living organisms; biological.

biotic factor. A living organism, animal or plant, that affects the development of mosquitoes either adversely or favorably.

biotic insecticide. Microorganisms or their by-products that can be applied like a chemical insecticide, at regular intervals and effective dosage rates, to suppress a local insect pest population.

biting-capture. Collection of mosquitos caught in the act of feeding on a human or animal host.

biting cycle. Regular variations in the amount of blood-feeding activity exhibited by populations of mosquito species during each 24-hour day-and-night period.

biting rate. Biting rate is the proportion of female mosquitoes caught biting on a bait at certain stated times during 24 hours.

black spores. Dark banana-shaped or round bodies occasionally observed on the midgut wall of the mosquito in association with oocysts and thought to be the result of the secretion of chitin around tracheoles or foreign bodies.

blackwater fever. Fever, often severe or fatal, characterized by acute intravascular haemolysis with haemoglobinuria; believed to be due to repeated infection with falciparum malaria and often precipitated by the taking of quinine. Sometimes called "haemoglobinuric fever".

Bladan®. See parathion.

Blattanex®. See propoxur.

Blex®. See pirimifos-methyl.

blood meal. Ingestion by a female mosquito of the blood obtained from a vertebrate host; also the ingested blood.

border; border levee. An earth ridge built to guide water down a slope or to hold irrigation water within prescribed limits in a field; a small levee.

border ditch. A ditch on the edge or border of a plot or check to be irrigated. Sometimes used as a combination of field ditch and border strip irrigation where the field ditches form the borders of the border strips.

border strip irrigation. See strip check.

botanical insecticides; botanicals. Insecticides derived from plants. Plant derived substances used to control insects, such as pyrethrins (from chrysanthemum).

boulder. Rock fragments larger than 60.4 cm (24 inches) in diameter.

brackish. Marine and estuarine waters with mixohaline salinity. The term should not be applied to inland waters.

breed. To produce offspring, to propagate, as to breed dogs, fish, or insects. Synonym: generate, reproduce, beget, propagate.

breeding. The propagation or reproduction of animals or plants. (Mosquito breeding - a term often applied to the aquatic stages, principally the larvae and pupae of mosquitoes.)

breeding place. A location, usually on or near water, where female mosquitoes lay eggs and in which immature stages (larvae and pupae) develop. Some workers prefer the term "mosquito source" and use it synonymously for "breeding place".

breeding potential. See reproductive potential.

broad-leaved deciduous. Woody angiosperms (trees or shrubs) with relatively wide, flat leaves that are shed during the cold or dry season; e.g., black ash (*Fraxinus nigra*).

broad-leaved evergreen. Woody angiosperms (trees or shrubs) with relatively wide, flat leaves that generally remain green and are usually persistent for a year or more; e.g., red mangrove (*Rhizophora mangle*).

bromeliad malaria. See under bromeliad malaria.

brood. Parasites belonging to the same generation and at about the same stage of development.

caking. Phenomenon which sometimes occurs in water-dispersible powder concentrates of insecticides during storage under conditions of relatively high humidity and temperature and/or under pressure, causing formation of solid lumps which may adversely affect the suspensibility of the powder. An anti-caking agent is sometimes added to water-dispersible powder.

calcareous. Formed of calcium carbonate or magnesium carbonate by biological deposition or inorganic precipitation in sufficient quantities to effervesce carbon dioxide visibly when treated with cold 0.1 normal hydrochloric acid. Calcareous sands are usually formed of a mixture of fragments of mollusk shell, echinoderm spines and skeletal material, coral, foraminifera, and algal platelets (e.g., Halimeda).

calibration of pesticide application equipment. The adjustment of the equipment to apply a pesticide formulation at a desired application rate. Accurate calibration requires determination of the equipment's swath width, ground speed, and output rate for various operational settings of the controls or other adjustments, for various readings of gauges or other measuring instruments with which the machine is equipped, and for each combination of nozzles and formulations used.

capture station. Site selected for periodic sampling of the mosquito population of a locality. It may be any place where adult mosquitos rest. Such stations are often used for checking fluctuations in mosquito densities.

carbamate. A group of newer insecticides, derivatives of carbamic acid, having an anti-cholinesterose action similar to that of the organophosphates in interfering with nerve impulse transmissions; however their action is reversible, so symptoms of poisoning in man are more transient. They have a wide range of toxicity, are not magnified in the food chain, break down relatively quickly, and so have low environmental persistence. See carbaryl, propoxur, bendiocarb.

carbaryl, carpolin. (Sevin,® Sevinol,® Sevidol,® Septene,® tricarnam,® Hexavin,® Karbaspray®). A carbamate insecticide of moderate toxicity to man. The product shows some promise as a residual house spray.

carbofos. See malathion.

carpolin. See carbaryl.

carrier. 1. Person harbouring malaria parasites with or without clinical evidence of infection. In malaria eradication terminology the carrier state is considered as a type of malaria case. 2. Finely ground inert mineral added to the technical product in the formulation of insecticide dusts and water-dispersible powders to facilitate their use. The most important inert carriers, or diluents, are the silicates of aluminum and magnesium (e.g., talcs, pyrophyllites, bentonites, clays) and the diatomaceous earths.

carrying capacity. The ordinary upper limit of numbers of individuals which a habitat (or niche) can support.

case. An occurrence or instance of infection or disease. The word is so vague that the type of case should always be specified, as, for instance, a malaria case or a fever case.

case, collateral. In malaria eradication terminology, a case occurring in the immediate vicinity of a malaria case which has been the subject of an epidemiological investigation (may be specified as collateral fever case, collateral suspected case, etc.). This is the equivalent of the epidemiological term "contact" used in many infectious diseases, which would be inaccurate in malaria where infection does not spread by contact.

case suspected. In malaria eradication terminology, a case other than a fever case believed to be one of malaria infection. It may be convenient in some programmes to introduce a subclassification of this category according to the reliability of the source of information regarding the suspected case.

case detection. In malaria eradication terminology, one of the activities of surveillance operations concerned with the continuous search for malaria cases in a community. The purpose of case detection is to identify malaria-infected persons, treat them and furnish the necessary data for assessment of the malaria situation. Case detection is a screening process, using as its indicator either the symptom of fever or specific epidemiological attributes. It differs from the malariometric survey in the following respects: (a) the screening covers the entire population at risk without any age discrimination; (b) the criteria for selection are of a clinical or an epidemiological nature; and (c) the process is continuous, while malariometric surveys are based on sporadic random-sample surveys of the younger age groups. Active case detection is the process of case-finding by visiting, at regular intervals, all houses of a malarious area and taking blood specimens of any inhabitants who have, or have recently had, fever. The house-to-house visits are made by the staff of the malaria eradication service or by other designated official health personnel. Passive case detection is the finding of malaria cases through notification by medical or other collaborating personnel to whom fever cases and other suspected cases are reported. Malaria detection posts are the main sources of notification, but other medical and paramedical personnel may contribute to passive case-detection operations and in some instances constitute the only source. In order to qualify for inclusion in the general organization of passive case detection, such notification must be accompanied by a blood slide. See also malaria detection post.

case follow-up. Periodic re-examination with or without treatment. In malaria eradication terminology the term implies that a blood film is examined and treatment given if appropriate. It may involve, for example, anti-relapse therapy at the beginning of the transmission season. Case follow-up is a part of surveillance.

categorical exclusions. In Regulation 16: 216.2(c), classes of environmental actions for which an Initial Environmental Examination (IEE), Environmental Assessment (EA), or Environmental Impact Statement (EIS) generally are not required. See Manual, Chapter 10.

channel. An open conduit either naturally or artificially created which periodically or continuously contains moving water, or which forms a connecting link between two bodies of standing water.

channel bank. The sloping land bordering a channel. The bank has steeper slope than the bottom of the channel and is usually steeper than the land surrounding the channel.

charmers. Charmers are "medical practitioners" who believe that the cause of illness is supernatural and prescribe ritual appeasements to the "god" causing the illness.

check. (1) A structure designed to raise or control the water surface in a canal or ditch. (2) In irrigation terminology, an area of land enclosed or bordered by levees to control the irrigation water.

check irrigation. A modification of the border-strip method of irrigation in which earth ridges or checks are constructed at intervals across a border strip to pond water on the soil surface behind each check as the water flows down the strip.

check mortality. Mortality of a smaple of mosquitos which, in tests of an insecticide, are kept as controls, being submitted to the same conditions as the test mosquitos except for the toxicant itself. Also known as "control mortality", "comparison mortality". See also Abbott's formula.

chemical control. The use of chemicals (insecticides or pesticide, and herbicides) for control of vectors, pests, or weeds, as opposed to use of other methods such as source reduction, physical control, or biological control.

chemical mosquito control. The use of chemicals to control mosquito eggs, larvae, pupae, or adults (imagos).

chemoprophylaxis. Protection from or prevention of disease by chemotherapeutic means (the use of drugs before infection).

chena. Chena refers to an agricultural area that has been carved out of the jungle by slashing and burning the forest. These areas are typically used for 2-4 years then abandoned by the farmer.

chlorinated hydrocarbon insecticides. Synthetic organic insecticides, also called organo-chlorines, characterized by attachment of chlorine to a basic carbon-hydrogen framework. Persistent chlorinated hydrocarbons, such as DDT, accumulate in the bodies of animals and are passed up the food chain, becoming lethal to predators at the top of the chain.

chlorpyrifos (Dursban®, Lorsban®, Dowco 179®). An organophosphate insecticide used as a larvicide for mosquito control. It is moderately toxic to man, highly toxic to bees and may affect fish, birds and other wildlife.

cholinesterase. An enzyme in the blood that is normally present and necessary for proper nerve functions. Excessive exposure to organophosphate and carbamate insecticides reduces cholinesterase levels.

chromatin. Nuclear material of the malaria parasite or of other cells having a characteristic staining reaction.

Chrysron®. See pyrethroids.

circumneutral. Term applied to water with a pH of 5.5 to 7.4.

claypan. A dense compact layer in the subsoil with a higher clay content than the overlaying material. Claypans are usually hard when dry and plastic and sticky when wet. They usually impede the movement of water and air. With adequate fertility they often do not impede the plant roots. See hardpan.

clone. Generations of individual organisms descended by asexual reproduction from a single individual (ancestor).

cobbles. Rock fragments 7.6 cm (3 inches) to 25.4 cm (10 inches) in diameter.

codominant. Two or more species providing about equal areal cover which in combination control the environment.

colloids. Extremely fine particles of a material. Clay colloids have great influence on the chemical and physical properties of soil. They carry a negative charge and are capable of attracting cations. The laboratory for chemical and physical investigations of soils, U.S. Department of Agriculture, defines clay colloids as those clay particles smaller than 0.001 mm. in diameter.

colony. Self-contained population of a mosquito species maintained in a laboratory through one or more generations.

community. The organisms inhabiting a common environment; all of the populations occupying a given area.

community follow-up. In malaria eradication terminology, the intensification of normal surveillance operations, including periodic examination of a large part of the population, in remaining or new malaria foci.

competition. Use or defense of a resource by one individual that reduces the availability of that resource to other individuals.

competitive exclusion principle. The hypothesis that two or more species cannot coexist on a single resource that is scarce relative to the demand for it.

completed locality. In malaria eradication terminology, a sprayed locality in which every possible effort has been made to spray all sprayable houses, including those previously classed as pending.

comprehensive mosquito control. Scientifically planned, continuing, carefully executed programs aimed at insuring the effective control of mosquitoes of all species which may bring disease or "dis-ease" to mean and domestic animals. All of the known technology is to be applied as appropriate, including preventive measures, naturalistic control, source reduction and chemical larviciding and/or adulticiding. "Comprehensive mosquito control" includes all other forms of mosquito control. See also "integrated pest management" and "integrated mosquito control".

concentrate. A form of commercial pesticide preparation which generally requires further dilution to decrease the concentration of its active ingredient before it is applied.

concentration. The amount of toxicant or other active ingredient in a pesticide formulation per unit of volume or weight of the formulation. Concentration may be expressed as weight per volume (pounds per gallon) or percent by weight (%). Synonym: strength.

concentration, median lethal. That concentration of an insecticide (utilized to impregnate the absorbent papers used in tests) sufficient to kill 50% of the mosquitos of a sample exposed to the insecticide during a specified period. Abbreviated LC_{50}.

conduit. A general term for any channel intended for the conveyance of water, whether open or closed.

congener. In chemical terminology, one of a group allied in origin, i.e., all belonging to the same chemical group and derived from the same parent compound; thus the 4-aminoquinolines are congeneric with, or congeners of, one another. The fact that two compounds belong to the same chemical group does not necessarily imply that they have the same type or degree of activity.

consolidation. In malaria eradication terminology, a 3-4 year phase that follows the attack phase; it is characterized by active, intense and complete surveillance, with focal remedial measures for each discovered case, with the object of eliminating any remaining infections and proving the eradication of malaria. It ends when the criteria for eradication have been met (no indigenous cases for three consecutive years).

constant-pressure valve. Synonym of pressure regulator.

consumptive use. The quantity of water transpired by plants plus that evaporated from the soil surface, or snow, in a given area in a given time. Does not include deep percolation losses or surface runoff losses.

continuous flow irrigation. A system by which each irrigator receives his alloted quantity of water at a continuous rate. Usually inefficient on small farms where the flow of water is small.

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contour checks. Areas of a field separated by borders which follow the contours.

contour ditch. An irrigation ditch which follows the contour of the land.

contour irrigated pasture. A grazing field prepared for irrigation that has earthen contour levees to guide water along strips or checks which follow the contour of the land.

control mortality. Synonym of check mortality.

convectional rainfall. Convectional rainfall is localized precipitation that occurs due to the evaporation of water from land masses with subsequent saturation of the air (clouds) and eventual release back to the ground.

coordinates (maps). Intersecting lines (such as longitude and latitude) which determine specific points on the earth's surface.

Corothion®. See parathion.

corrugations. Small graded channels or furrows so spaced that an adequate lateral spread of water is obtained by the time the desired amount of water enters the soil. Normally used for drilled crops and surface flooding.

cost/benefit/analysis. A comparison of the overall projected costs of the program with the projected benefits to be derived. The costs and benefits would be quantified monetarily when possible and would include a qualitative description of intangible costs and benefits. (Examples: costs = expenditures for control, demographic impacts, environmental impacts, etc.; benefits = reduction of rates of malaria, environmental improvement, sociological benefits, etc.)

cost/benefit ratio. Used to help decide if a malaria program should be implemented and to help decide the type of program.

cost/effectiveness. The monetary costs of control program compared to a measurable unit of effectiveness produced.

cost/effectiveness ratio. Used to measure the progress of a control program in order to increase effectiveness and reduce costs.

creaming. Phenomenon occurring when the dispersed phase of an emulsion rises to the top to form a more concentrated layer (e.g., cream layer in milk).

crenation. Formation of a notched or wavy edge at one or both ends of an oval red blood cell infected with *Plasmodium ovale*.

crepuscular. Active during twilight hours.

crescent. Common term for the gametocytes of *P. falciparum* and *P. reichenowi*.

cross. In genetics, the mating, in the laboratory, of members of two colonies or strains of the same species, or the product of such a mating, which may be fully fertile, incompletely fertile, or sterile. (The term "cross" is sometimes incorrectly applied to hybrid offspring of a mating between distinct species.)

cross-resistance, insecticide. Resistance to an insecticide developed in a mosquito population by selection pressure from another insecticide belonging to the same group (e.g., the DDT-methoxychlor group or the dieldrin-BHC group.) Not to be confused with double resistance to an insecticide. See resistance.

cryptozoite. Exoerythrocytic stage of malaria parasites arising directly from sporozoites in the tissues of the vertebrate host. Term limited at present to avian malaria parasites.

cubic feet per second. Sometimes called "second-foot". Commonly abbreviated "cfs". The number of cubic feet of water passing each second a given location in a conduit or structure. One cfs equals 448.8 gallons per minute (gpm). One cfs flowing for 1 hour equals approximately 1 acre-inch. One cfs flowing for 1 day equals approximately 2 acre-feet.

cure, clinical. Relief of symptoms of a malaria attack (e.g., by chemotherapeutic action against asexual erythrocytic parasites) without complete elimination of the infection.

cure, radical. Complete elimination of the malaria parasite from the body so that relapses cannot occur. Radical cure may be brought about by natural means in the absence of specific medication (natural or spontaneous cure), by radical treatment, or by suppressive cure.

cure, suppressive. Complete elimination of the parasite from the body by means of continuous suppressive treatment.

cuticle. A thin, multilayered tissue on the exterior of the integument covering insects and other arthropods. The outside layer (epicuticle) is composed of proteins, waxes and "cement", while layers of the procuticle beneath contain chitin along with proteins and waxes penetrated by numerous pores and glands.

Cytel® See fenitrothion.

Cythion® See malathion.

cytogenetics. Cytogenetics is the study of hereditary transmission and behavior of chromosomes.

cytomere. Island of cytoplasm in a growing schizont; usually uninucleated first and later multinucleated, giving rise finally to merozoites.

cytoplasm. Cell substance other than nuclear material and special organelles.

DDT. A chlorinated hydrocarbon insecticide used widely in the past as a residual wall spray in malaria eradication programs. The development of resistance and environmental considerations have sharply reduced its usage. Technical DDT should contain a minimum of 70% by weight of p,p -isomer having a minimum melting point of 104 C.

DDVP. Abbreviation for dimethyldichlorovinyl phosphate (dichlorvos).

death rate. The percentage of newborn dying during a specified interval (ecological term).

decamethran. See pyrethroids.

deciduous stand. A plant community where deciduous trees or shrubs represent more than 50% of the total areal coverage of trees or shrubs.

decision support system (DSS). The support of unstructured management decision-making by a variety of means, including computer hardware and software.

deep percolation loss. Excess irrigation water which percolates to a depth below the root zone and cannot be used by plants.

demographic. Concerned with the statistical data of populations, their dynamics, and the analyses of such data.

density, anopheline. Number of female anophelines in relation to the number of specified shelters or hosts (e.g., per room, per trap, or per person) or to a given time period (e.g., overnight or per hour), specifying method of collection.

density, average infective. Average number of female anophelines of a species that are found with sporozoites in the salivary glands per standard collecting unit (room or person) per unit of time.

density, parasite. See parasite density.

density, dependent. Having a degree of influence on individuals in a population that varies with the level of crowding in that population, e.g., food supply.

density, independent. Having a degree of influence on individuals in a population that does not vary with the level of crowding the population, e.g., temperature.

depot preparation. Synonym of repository drug.

depressional rainfall. Depressional rainfall occurs normally during the inter-monsoon season when the barometric pressure falls causing winds containing saturated ocean air to blow over the island dropping their precipitation.

deviation, animal. Increase in the proportion of mosquitos feeding on non-human hosts, with consequent reduction in the proportion feeding on man.

diapause. Temporary interruption in the development of insect eggs, larvae, or pupae usually associated with a dormant period during unfavorable seasons of cold or dry weather.

diazinon. An organophosphorus residual insecticide. Technical diazinon should contain at least 85% by weight of O,O-diethyl O-(2isopropyl-4-methyl-pyrimidinyl-6) phosphorothioate.

Dibrom® See naled.

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dichlorvos (Vapona®). Organophosphorus insecticide (0,0-dimethyl 2,2-dichlorovinyl phosphate, abbreviated DDVP) which kills mosquitos by fumigant action.

dieldrin. A highly toxic chlorinated hydrocarbon insecticide occasionally used as a residual wall spray. Technical dieldrin should contain at least 76.5% by weight of HEOD.

diflubenzuron (Dimilin®). An insect growth regulator (IGR) of mosquitoes, acting to inhibit chitin synthesis, thereby preventing normal development. It is characterized by its specificity for mosquitoes and its rapid biodegradability.

dike. An embankment to confine or control water, especially one built along the banks of rivers to prevent overflow of low lands; a levee.

diluent. The material, usually water or oil, which is mixed with a concentrate to dilute it to field strength.

dilution (dilute). The adjustment of the quantity of active ingredient in a pesticide formulation from a higher concentration to a lower (desired) concentration. A concentrate is diluted by mixing it with a diluent.

disease. A condition in which bodily health is impaired; sickness; illness; a malady; an ailment; a condition which adversely affects survival. (An archaic form, "dis-ease", means discomfort.)

dispersion. Movement of organisms away from their place of development or from centers of population density. Mosquito dispersion may be active or passive. See also migratory flight; pre-hibernation flight.

distribution. Geographical, seasonal, ecological or topographical range of an organism.

distribution system. (1) The system of ditches, and their appurtenances, which conveys irrigation water from the main canal to the farm units. (2) Any system which distributes water to users.

ditch. An artificial channel, usually distinguished from a canal by its smaller size.

diurnal. Active by day.

diversity. The number of species in a community or region. Alpha diversity refers to the diversity of a particular habitat, beta diversity to the species added by pooling habitats within a region. Also, a measure of the variety of species in a community that takes into account the relative abundance of each species.

dominant. The species controlling the environment.

dormant. A state of arrested or reduced metabolic activity; a sleep-like condition; a period of quiescence or inactivity. See diapause.

dormant season. That portion of the year when frosts occur, or the dry season.

dorsal. Situated on or belonging to the upper surface or body portion.

dosage. 1. Amount of a drug to be given for the treatment of a particular condition; usually graded in accordance with the age and weight of the recipient. 2. Average amount of insecticide discharged per unit of surface sprayed, expressed in grams of technical product (gamma-isomer, for BHC) per square metre (nozzle dosage). Since some proportion of spray does not reach or does not remain on the target, this dosage is always higher than the actual amount deposited.

dose. Prescribed amount of a drug to be taken at one time or within a given period of time. The amounts of antimalarial drugs should be expressed in terms of the base (when applicable) and in fractions of a gram or milligram.

dose, adult. Amount of a drug to be given to an adult person (all persons over the age of 14 years may be considered adults).

dose, daily. Amount of a drug to be taken every 24 hours.

dose, discriminating. Amount of an insecticide (usually expressed as the concentration per standard period of exposure) which in a sample of mosquitos containing resistant individuals distinguishes between phenotypes and determines their respective proportions. Where the genetic factor for resistance is either dominant or recessive, only one discriminating dose operates. Where it is semi-dominant, two such doses may operate: a lower discriminating dose killing susceptibles only and an upper discriminating dose dilling both susceptibles and heterozygous (but not homozygous) resistant individuals.

dose, loading. Initial dose of a drug, higher than that regularly used, given with the objective of rapidly providing an effective drug concentration.

dose, maximum tolerated. Largest dose that can be taken without harm within a stated period of time.

dose, median lethal. Amount of a toxicant sufficient to kill half the individuals of the sample tested. In applied entomology, the amount of insecticide, usually applied by topical application, found sufficient to kill 50% of the mosquitos treated. Abbreviated LD_{50}.

dose, minimum effective. Smallest dose found to produce a stated effect.

dose, single. Quantity of a drug prescribed to be taken on a single occasion and intended to produce an effect without further medication.

Dowco 179®. See chlorpyrifos.

drain. A channel or pipeline for carrying off surplus ground or surface water.

drain tile. Pipe made of burned clay, concrete, etc., usually in short lengths, used for constructing drains. See tile drain.

drainage. (1) The process of removing surplus ground or surface water by artificial means. (2) The manner in which the waters of an area are removed.

drainage basin. The area from which water is carried off by a drainage system; a watershed or catchment area.

drug. Substance or mixture of substances intended to be used in the prevention, mitigation or treatment of disease or of an abnormal physical state or the symptoms thereof in human beings or animals.

drug, causal prophylactic. Synonym of primary tissue schizontocide.

drug, repository. Sparingly soluble drug or drug preparation which, on being injected intramuscularly or subcutaneously, forms a local depot from which the active principle is gradually released into the circulation. Also known as "depot preparation".

drug association. Simultaneous administration of two or more drugs, either in separate or in compound preparations.

drug failure. Absence or insufficiency of drug action after administration of a normally effective dose. It is important to discriminate between such causes of drug failure as deficient absorption, unusual rate of degradation or excretion of the drug, and resistance of the parasite.

drug interference. Inhibition or diminution of the effect of one drug by another.

Dugesia. See flatworms.

Dursban® See chlorpyrifos.

EA. See environmental assessment.

EE. Abbreviation for exoerythrocytic.

EIS. See environmental impact statement.

ecdysis. Casting of the successive larval skins.

eclosion. Emergence of the imago from the pupal case; hatching of the larva from the egg.

ecological efficiency. Percentage of energy in the biomass produced by one trophic level that is incorporated into biomass produced by the next highest trophic level.

ecological parameters. Scientific measurements of specific aspects of an environmental state, taken as quantitative determinants of its condition and trends, obtained by monitoring and analyses of various biotic and abiotic components of the ecology under study. See Manual 1.3.

ecology. The interrelationships of living organisms to one another and to their environment, or the study or science of such interrelationships (EPA definition).

economic injury level. The lowest population density at which the damage caused by a pest will exceed the cost of artificial control measures to prevent it.

economic threshold. The lowest density of pests which requires that control measures be implemented to prevent an increasing pest population from reaching the economic-injury level.

ecosystem. Ecosystem is the relationship and interaction between the organisms (the living components) of an area to each other and to their environment (the non-living components - climate, geology, etc.).

ecotype. A genetically differentiated subpopulation that is restricted to a specific habitat.

effectiveness. As applied to an insecticide, its ability to kill mosquitos or other insects against which it is directed. To be distinguished from persistence.

embryo. An immature animal before leaving the body of the parent or before emerging from the egg.

embryology. The science or study of the formation and development of embryos.

emergence. Synonym of eclosion but used mainly with regard to the adult insect coming out of the pupal case.

emergent hydrophytes. Erect, rooted, herbaceous angiosperms that may be temporarily to permanently flooded at the base but do not tolerate prolonged inundation of the entire plant; e.g., bulrushes (Scirpus spp.), saltmarsh cordgrass.

emergent mosses. Mosses occurring in wetlands, but generally not covered by water.

Emmatos® See malathion.

emulsifiable concentrate. Monophase liquid system containing an insecticide together with one or more surface-active agents having the property of forming an emulsion on dilution with water.

emulsion. Two-phase system, having a reasonable degree of stability, in which a liquid is dispersed in droplets ("dispersed phase") within a second liquid ("continuous phase"). Commonly an oil or oil solution divided into a mass of microscopic droplets suspended in a watery liquid. Usually contains an added "emulsifying agent" to help keep the droplets suspended in the water. Emulsifiable insecticides supplied as concentrates can be diluted by adding water.

encephalitis. Inflammation of the brain. This condition can be brought about in a number of ways. Some viruses that produce encephalitis are transmitted by arthropods.

endemic. Said of a disease that is native to, or peculiar to, a district or a class of people or animals and is within predictable case numbers and limits. Broadly, any entity indigenous to a certain region. See epidemic.

endemicity. Malaria is endemic in a particular area when there is a constant measurable incidence of natural transmission over a succession of years. Based on the spleen rates of children and adults, endemicity is classified in the following degrees:

Hypoendemic:	Spleen rate (children 2-9 years) 0-10%
Mesoendemic:	Spleen rate (children 2-9 years) 11-49%
Hyperendemic:	Spleen rate (children 2-9 years) constantly over 50%; adult spleen rate also high.
Holoendemic:	Spleen rate (children 2-9 years) constantly over 75%; adult spleen rate low.

endogamous. Endogamous is a term meaning marrying within the tribe or social plane.

endophagy. Tendency of mosquitos to feed indoors.

endophilism, endophilic. A condition in which mosquitoes prefer to rest and feed indoors.

energy budget. In ecological studies, the total energy available to each trophic level, modified in turn by the extractive efficiency and by the productivity of the organisms of that level.

enhancement methods. The means used to favor the establishment and population growth of a biological control agent, such as massive rearing and release, artificial feeding, and increasing the "carrying capacity" of the environment.

Entex.® See fenthion.

entomology. The science which treats of insects.

environment. 1. The sum of all the physical, chemical, and biological factors of an area; 2. A major habitat type, as marine, desert, or forest. See habitat.

environmental assessment (EA). A detailed study of the reasonably foreseeable environmental effects, both beneficial and adverse, of a proposed action and its reasonable alternatives. Used within agencies to guide management decisions. See Regulation 16: 216.1(c)(4), 216.3(a)(4 & 5), and 216.6 in Manual, Chapter 10.

environmental impact statement (EIS). A specific legal document, originated by the National Environmental Policy Act of 1969, containing an environmental assessment having definite format and content, and which is circulated in draft for comment or review by governmental agencies and the general public. Public hearings may be required to complete the process. See Regulation 16: 216.1(c)(5), 216.3(a)(4 & 5), and 216.7 in Manual, Chapter 10.

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environmental importance. The evaluation of an environmental effect by the combination of its significance (what it does) times its magnitude (its size and extent). See Manual 1.13.

environmental magnitude. The quantitative extent in time, area, or other measure, of an effect or impact of an action on the environment. See Manual 1.13.

environmental significance. The specific effect or, identity of an effect, of an action having an environmental impact of any kind or level. See Manual 1.13.

environmentalist. One who is interested in all the external conditions and influences affecting the life and development of man and other organisms.

enzyme. Complex proteinaceous substance that accelerates (catalyzes) specific transformations of materials (metabolism) such as digestion of foods, or other biochemical processes.

epidemic. An unusual number of cases or an unusual spread of a disease within an area. Disease beyond a predictable level. See endemic.

epidemicity. Malaria is considered epidemic when the incidence of cases in an area rises rapidly and markedly above its usual level, or when it occurs in an area where it has been absent.

epidemiological investigation. In the broad sense, the study of the environmental, personal and other factors that determine the incidence of disease. Consideration is given in these studies to (1) the causative agent and its biology; (2) the identification, habits, and relative importance of the vector; (3) the susceptibility and proximity to vectors of the affected human population; and (4) presence and possible importance of intermediate hosts. In malaria eradication it is a part of surveillance operations and is concerned with ascertaining the origin and means of infection in any malaria cases discovered; determining, by localized mass blood examinations (epidemiological survey), the existence and nature of any malaria foci in the neighbourhood; and seeking, by entomological and other means whenever necessary, to establish whether transmission is taking place and, if it is, its source.

epidemiology. Epidemiology in a broad sense is the study of the environmental, personal and other factors that determine the incidence of disease.

equilibrium model. Any hypothetical or actual representation of a system in which two balancing forces act to maintain stability in the system.

erythrocytic. Developing within red blood cells; applied to stages of the malaria parasite.

estivation (aestivation). An inactive state in which some animals pass through adverse summer conditions. For example, animals that require much moisture estivate during extremely dry periods. See hibernation.

estuarine. Of, or pertaining to, the river mouth complex at sea level and the surrounding wetlands, its mixture of fresh and salt water, subject to tidal action.

ethylparathion. See parathion.

Etilon® See parathion.

eutrophic. Referring to rapid or high level of organic growth in a body of water, often caused by sewage and runoff from fertilized agricultural land.

eutrophic lake. Lakes that have a high concentration of plant nutrients such as nitrogen and phosphorus.

evaluate. To appraise: example - to determine the effect of an application of insecticide upon a mosquito population.

evaporation. The process whereby a liquid is changed to a gas. An example is the change of liquid water to vapor.

evergreen stand. A plant community where evergreen trees or shrubs represent more than 50% of the total areal coverage of trees and shrubs. The canopy is never without foliage; however, individual trees or shrubs may shed their leaves.

excito-repellency. Property in an insecticide of stimulating irritability in insects.

exflagellation. Extrusion and liberation of microgametes (flagella) by male gametocytes.

exoerythrocytic. Developing in tissues outside the red blood cells; applied to stages of the malaria parasite in the vertebrate host. Abbreviated EE.

exophagy. Tendency of mosquitos to feed outdoors.

exophilism, exophilic. A condition in which mosquitoes prefer to rest and feed out of doors.

exotic. Said of an organism that has been introduced from another area.

exploitation efficiency. The percentage of potential prey or food plants that are consumed by predators and herbivores.

exponential rate of increase (r). Rate at which a population is growing at a particular instant, expressed as a proportional increase per unit of time.

extender effect. Delayed degradation or excretion of a drug (or of its active metabolite) brought about by concurrent administration of another substance.

extreme high water of spring tides. The highest tide occurring during a lunar month, usually near the new or full moon. This is equivalent to extreme higher high water of mixed semidiurnal tides.

extreme low water of spring tides. The lowest tide occurring during a lunar month, usually near the new or full moon. This is equivalent to extreme lower low water of mixed semidiurnal tides.

facultative. Being able to live under different conditions or to respond to particular conditions in a variety of ways.

falciparum malaria. Falciparum malaria is a severe type of malaria (malignant tertian) caused by Plasmodium falciparum, a species of malaria parasite.

fat-body. Tissue which partially fills the body cavity of an insect and plays a many-sided role in its metabolism; in particular it serves as a place for the accumulation of reserve substances in overwintering female mosquitos.

fauna. Fauna is the animal life of an area.

fecundity. Rate at which an individual produces offspring, usually expressed only for females.

feedback. The return of information, energy, or products of a system back into the system in such a way as to modify (control) the inputs or outputs (processes or decisions) of that system. Such factors may be positive or negative in effect, and tend to stabilize or "correct" the system if it can respond adaptively. The term "feedback loop" is often used diagrammatically.

fenitrothion (Sumithion®). An organophosphate insecticide used as a residual wall spray.

fenthion (Baytex®, Entex®, Lebaycid®, Tiguron®, Baycid®, Spotton®, Mercaptophos®, Queletox®). A moderately toxic organophosphate insecticide commonly used as a larvicide and sometimes as an adulticide to kill mosquitoes. It is highly toxic to bees and may effect marine organisms - shrimp, crayfish crabs. Smells slightly of garlic.

fever. Increase of body temperature in response to infection. It may be classified as (a) continuous, (b) remittent (characterized by decreases but without a return to normal temperature), or (c) intermittent (interrupted by periods of normal temperature).

fever case. In malaria eradication terminology, an occurrence of fever, which is classified as (a) actual (current) - i.e., existing at the time of examination or during the previous four days; or (b) recent - i.e., occurring since the preceding visit of a surveillance agent or in the four weeks before examination exclusive of the four immediately preceding days.

Ficam®. See bendiocarb.

field capacity. The amount of water retained in a well-drained soil against the forces of gravity at any specific time (usually about 2 to 3 days) after thorough wetting.

field ditch. A ditch constructed within the field to be irrigated, usually on a contour or slight grade.

field formulation (field strength formulation). The chemical formulation which is applied in the field to control a pest. It requires no further dilution and may be purchased as a field strength commercial preparation or it may be produced by diluting a concentrate. Synonym: finished spray, final mix, field strength dilution.

field shelter. Non-movable living quarters temporarily housing agricultural or other workers who normally reside elsewhere. Field shelters are called by a variety of names in different countries: "farm huts", "crop huts", "rice kitchens", etc.

fimbriation. Synonym of crenation.

"Five-Stage Scheme." See W.H.O. "Five-Stage Scheme".

flashboard. A plank, or slab, generally held horizontally in vertical slots on the crest of a dam or check structure, or in a spillway, to control the upstream water level.

flat. A level landform composed of unconsolidated sediments - usually mud or sand. Flats may be irregularly shaped or elongate and continuous with the shore, whereas bars are generally elongate, parallel to the shore, and separated from the shore by water.

flatland. Level areas of land regardless of the kind of vegetation. Commonly produced by stream or lake deposition of sediments.

flatworms (Platyhelminthes: Turbellaria). Predatory worms which devour mosquito larvae in aquatic habitats. Species known to provide biological control are found in the genera: Dugesia, Microstomum, Mesostoma, and Phagocata. Relative ease of rearing adds to their potential.

flight, migratory. Directional flight of a group of mosquitos, not subject to the ordinary laws of dispersion.

flight, pre-hibernation. Dispersion or migration of mosquitos occurring before and in relation to hibernation, often to greater-than-normal distances.

flight range, effective. Distance from a breeding place that the females of a given species of mosquito travel in numbers sufficient to maintain endemic malaria or to cause an epidemic.

floating plant. A non-anchored plant that floats freely in the water or on the surface; e.g., water hyacinth (Eichhornia crassipes) or common duckweed (Lemna minor).

floating-leaved plant. A rooted, herbaceous hydrophyte with some leaves floating on the water surface; e.g., white water lily (Nymphaea odorata), floating-leaved pondweed (Potamogeton natans). Plants such as yellow water lily (Nuphar luteum) which sometimes have leaves raised above the surface are considered floating-leaved plants or emergents, depending on their growth habit at a particular site.

floodplain. Flat expanse of land bordering an old river.

flora. Flora is the vegetation or plant life of an area.

flow chart. A diagram of the order in which certain events occur in arriving at a final state or step in some larger scheme. Commonly a display of processes, decisions, and results showing their interrelationships by connecting arrows or other symbols.

focal spraying. Focal spraying is residual insecticide house spraying around a malaria focus.

focus, malaria. See under malaria focus.

Folidol® See parathion.

Folithion® See fenitrothion.

food chain. An abstract representation of the passage of energy through populations in a community.

formula, parasite. See under parasite formula.

formulation. Physical form in which a pesticide is prepared. Examples are solutions, emulsions, granules, and wettable powders.

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fresh. Term applied to water with salinity less than 0.5% dissolved salts.

freeboard. The distance left between the normal operating water surface and the top of the sides in an open channel, the crest of a dam, etc., to prevent the water overtopping the structure as a result of wave action, floating debris, or any other condition or emergency.

fumigant. Any product, such as an insecticide, which exerts a toxic effect through its vapour.

fungus. Any of a group of thallophytic plants including molds, mildews, rusts, smuts, and mushrooms. They contain no chlorophyll and reproduce mainly by means of asexual spores.

furrow. A small ditch constructed to guide the flow of water across the land being irrigated. The water soaks into the soil from the furrow. Used to irrigate row crops.

Fyfanon® See malathion.

Gambusia affinis, mosquitofish. A small mosquito-eating fish used widely in malaria control because of its proven effectiveness in control of anopheline larvae, high reproductive potential, and adaptability to a wide variety of aquatic habitats.

gamete. Mature sexual form, male or female. In malaria parasites the female gametes (macrogametes) and male gametes (microgametes) normally develop in the mosquito.

gametocyte. Parent cell of a gamete. In malaria parasites, the female gametocytes (macrogametocytes) and male gametocytes (microgametocytes) develop in the red blood cell. Very young gametocytes cannot usually be distinguished from trophozoites.

gametocyte rate. This is the percentage of individuals in a given population whose blood contains sexual forms of malaria parasites.

gametocytocide. Drug which destroys the sexual forms of malaria parasites.

gametocytogenesis. Formation of gametocytes.

gamma BHC. See lindane.

gamma HCH. See lindane.

general equilibrium position (level). A term used by students of population dynamics to mean the average value above and below which a population density fluctuates over a long period of time and in the absence of permanent environmental change.

generation time. Average age (Tc) at which a female gives birth to her offspring, or average time (T) for a population to increase by a factor equal to the net reproduction rate.

genetic mosquito control. The use of any condition or treatment that can reduce the reproductive potential of mosquitoes by altering or replacing hereditary material. The desired end result is a reduction or a change in the composition of the insect population that will benefit man. This has not yet been developed into a practical method of mosquito control.

geographical reconnaissance. In malaria eradication terminology, the operation which provides the basis for the choice of field centres and depots, for detailed schedules and itineraries of spraying and surveillance personnel, for the final deployment of transport, and for numerical control of the completeness of work accomplished. It includes collection of information on the number, type, location and means of access of all houses and field shelters, as well as on communications, health units, vehicle-repair facilities, population movements and other relevant factors.

geometric rate of increase (λ). Factor by which the size of a population changes over a specified period.

gland infection. See salivary gland infection.

gonotrophic concordance. Trophic activity in the female mosquito (e.g., blood ingestion) with gonadal development.

gonotrophic cycle. This is one complete round of ovarian development in the mosquito, often stated in reference to the period of time required for its completion. Since one blood meal normally suffices for the maturation of one egg batch, except possibly the first, the biting cycle and gonotrophic cycle are usually parallel.

gonotrophic dissociation. Trophic activity in the female mosquito (e.g., blood ingestion) without gonadal development. Also known as "gonotrophic discordance".

gravel. A mixture composed primarily of rock fragments 2 mm (0.08 inch) to 7.6 cm (3 inches) in diameter. Usually contains much sand.

gravity water. (1) Water that moves through the soil under the influence of gravity. (2) A supply of water which flows into the distribution system under the force of gravity, as distinguished from a pumped supply.

gross production. The total energy or nutrients assimilated by an organism, a population or an entire community.

gross production efficiency. The percentage of ingested food utilized for growth and reproduction by an organism.

ground water. Water in soil below the ground surface, usually under conditions where the pressure in the water is greater than atmospheric pressure and the soil voids are substantially filled with the water.

growing season. The frost-free period of the year or the wet season, when plants may grow.

guidebook. A practical and easily usable compilation of procedural information, serving to advise on the way some process or enterprise should be successfully conducted.

guppy. See *Poecilia reticulata*.

gut infection. The presence of malaria parasites on the gut wall of a female mosquito.

habitat. The natural region or abode which an organism inhabits. The term as applied to particular surroundings may be made more specific or critical by adding qualifying expressions. For example; sand dune habitat, flood plain habitat, pasture habitat, and rice field habitat. The place where the organism lives; "address". Habitat is not equivalent to niche.

haematin. Ferrihaemic acid, found in malaria pigment.

haemoglobinuric fever. Synonym of blackwater fever.

haline. Term used to indicate dominance of ocean salt.

hand-capture. Method of collecting individual mosquitos resting on a surface by the use of a simple test-tube or a suction device and, generally, a source of light.

hardpan. A hardened layer in the subsoil caused by cementation of soil particles with organic matter or with materials such as silica or calcium carbonate. Moisture does not change the hardness. See claypan.

hatching. Emergence of the larva from the egg.

head. (1) The height of water above any point or plane of reference. (2) Sum of the energy which a body of water possesses by virtue of its velocity, pressure and position, expressed as height to which the water would rise above a given datum if all the energy were converted to potential (position) energy. (3) Rate of flow used in irrigation. See: irrigating head.

head ditch. Ditch across upper end of field, used for distributing water to furrows or checks.

head gate. Gate structure at upper end of a ditch to control the flow of water into the ditch.

herbaceous. With the characteristics of an herb; a plant with no persistent woody stem above ground.

herbicide. A pesticide used to kill plants. Synonym: weedicide.

herbivore. An organism that consumes living plants or their parts.

Hexavin® See carbaryl.

hibernation. State of survival, by means of behavioural or physiological changes to a lethargic, inactive, or torpid state, during periods of cold. Animals becoming temporarily and occasionally active during such periods are said to be in a state of partial hibernation. See: estivation.

histosols. Organic soils.

hormone. A substance, especially a product of the cells of one part, transported in the body fluid or the sap of an organism and producing a specific effect on the activity of cells remote from its source; chemical messenger; exciter. A "juvenile hormone" used to control mosquitoes disrupts development of the organism. Since it is not, strictly speaking, a hormone produced by the mosquito, it is preferable to call it an insect growth regulator.

host. Living animal or plant harbouring or affording subsistence to a parasite; also a cell in which a parasite lodges ("host cell"). An individual preyed upon.

host, definitive. Host in which sexual reproduction of the malaria parasite occurs. The mosquito is often described as being the definitive host of the malaria parasite, but it is preferable to use the more specific term "invertebrate host".

host, intermediate. Host in which only asexual forms of the malaria parasite develop. Man is often described as being the intermediate host of human malaria parasites, but it is preferable to use the more specific term "vertebrate host".

host preference. Preference of mosquito for a particular type of host, e.g., human or animal; to be distinguished from mere readiness to feed on a particular type of host when no other is available.

house. In malaria eradication terminology, any structure other than a tent or mobile shelter which serves as a dwelling. For purposes of measuring the progress of spraying operations, houses are continuously reported as sprayed or as pending and the numbers of these compared with the number originally designated for spraying ("sprayable houses"). See also house-numbering.

house-numbering. Designation by serial numbers of houses within specified geographic limits which are subject to visits by personnel of the malaria eradication service for the purpose of house-spraying, surveillance, inspections, etc. From an operational standpoint a house to be numbered as a unit consists of a structure or a group of contiguous structures, including the living rooms and dependencies, which is occupied continuously or periodically by a single family and consequently accessible for spraying or inspection upon a single request.

house-spraying. In malaria eradication terminology, application of a residual insecticide in liquid form to specified (mostly interior) surfaces of buildings. House-spraying is the primary method of attack in most malaria eradication programmes. The spraying is (a) total, when all dwellings designated to be sprayed receive the insecticide; (b) complete, when all the surfaces to be sprayed are thoroughly treated; (c) sufficient, when the prescribed dosage is applied; and (d) regular, when the spraying cycles needed to interrupt transmission are maintained.

house-to-house visiting. In malaria eradication terminology, the primary process of active case detection in which a surveillance agent or other member of the malaria eradication staff (or of the general health services) visits every household in a locality (village, town, etc.) in order to search for fever cases, take a blood slide in each such case and administer presumptive treatment.

house resting density. House resting density is an entomological tool to assist the epidemiologist to determine the effect of insecticides on vector populations.

human blood index. The human blood index is the proportion of freshly fed anophelines found to contain human blood. Precipitation tests permit the specific differentiation of human and animal blood, and subgrouping of the latter.

hydric soil. Soil that is wet long enough to periodically produce anaerobic conditions, thereby influencing the growth of plants.

hydrophyte. Any plant growing in water or on a substrate that is at least periodically deficient in oxygen as a result of excessive water content (plants typically found in wet habitats).

hyperendemism, hyperendemic. A situation in which all susceptible individuals in an area eventually contract a disease. Transmission usually takes place the year around without seasonal interruption. A constant high level of malaria existing in an area with the spleen-rate in children of 2-9 years constantly over 50%. See also endemism.

hyperhaline. Term to characterize waters with salinity greater than 40%, due to ocean-derived salts.

hypersaline. Term to characterize waters with salinity greater than 40%, due to land-derived salts.

hypoendemic. Hypoendemic is a term that means the normal incidence is low, i.e., there is a constant low level of malaria existing in this area with the spleen-rate in children 2-9 years from 0-10%.

IPM. See integrated pest management.

imagicide. Insecticide used for destroying insects in the adult stage. See also adulticide.

imago. Completely developed stage of the insect, often termed "adult".

immunity. All those natural processes which prevent infection, reinfection or superinfection, or which assist in destroying parasites or in limiting their multiplication, or which reduce the clinical effects of infection. Immunity may be natural and independent of previous infection - for example, man is naturally immune to avian malaria; or it may be acquired, either passively or actively. There is some evidence of human passive immunity to malaria by maternal transfer during the first months of life in malarious areas ("congenital immunity" or "neonatal immunity"; the latter term is preferred by immunologists). Active malarial immunity is acquired as a result of previous infection.

immunity, concomitant. Synonym of premunition.

immunity, infection. Synonym of premunition.

immunity, residual. Immunity consequent on infection and persisting after its termination.

impervious soil. A soil through which water, air, or roots cannot penetrate. No soil is impervious to water and air all the time. (Soils which take water very slowly are often said to be "impervious".)

impoundment. An artificial body of water, as a reservoir, pit, dugout, or sump. Also impoundage.

incidence. Number of cases of disease occurring during a given time period in relation to the unit of population in which they occur (a dynamic measurement). This allows an estimate of the monthly, quarterly, or yearly (or any other time period) incidence per any chosen unit of population, e.g., in percentage, but requires a precise mechanism for continuous, reliable parasitological examination over the chosen time period and in the selected universe. Not to be confused with prevalence.

incidence, annual parasite. Number (per thousand of a population) of microscopically confirmed malaria cases detected during one year. The epidemiological value of the annual parasite incidence depends entirely on whether the population to which this figure relates was covered by an adequate system of case detection. May be abbreviated as API.

incubation interval. Period elapsing between the occurrence of infective gametocytes in a human subject and their appearance in an infective form in a secondary case deriving from the first case. The term includes one parasite cycle in the mosquito and one or several in man; it is also called "infection cycle".

incubation period. 1. Time elapsing between the initial malarial infection in man and the first clinical manifestations. When the time is extended to many times its normal length it is known as a protracted incubation period; this may occur in *P. vivax* infections in the autumn in some temperate climates, where the infected person may show no clinical signs until the following spring. 2. Time needed for the completion of sporogony in the mosquito up to the infecting stage (known as the extrinsic incubation period).

index.[1] 1. Figure indicating the proportion which one happening or number bears to another; a measurement of one type of value used to indicate another. 2. Token or sign indicating (but not measuring) a quantity or value. 3. Loosely, a rate.

index, anthropophilic. Synonym of human blood index.

index, host preference. Figure indicating the proportion of freshly fed anopheles giving a positive precipitin reaction for any specified host in the particular conditions in which capture has been made.

index, human blood. Figure indicating the proportion of freshly fed anopheles found to contain human blood.

index, infestation. Figure indicating the proportion of houses or places found to contain a specified insect. The use of this term with regard to the degree of malaria parasitaemia is not recommended.

index, maxillary. Mean number of teeth per maxilla of female mosquitos.

index, parasite-density. Mean parasite count among those persons found positive in a sample of the population; calculated either as the geometric mean or as the weighted average of the individual parasite counts divided into arbitrary classes.

indicator district. Selected part or selected number of villages of the malarious area of a country in which the results of periodic surveys or case detection, or both, are used for assessment of the effectiveness of the eradication measures applied in the attack phase of malaria eradication. Such an area must represent the overall condition of the entire malarious area of the country or of the particular epidemiological zone from which it is chosen. The selection of an indicator district (also called "index area") and the initial survey must take place in the preparatory phase, at the latest.

indigenous. Said of an organism that is native, not introduced, in an area.

indirect competition. Exploitation of a resource by one individual that reduces the availability of that resource to others.

infected anopheles. Female anopheles with oocysts of malaria parasites on the midgut wall (with or without sporozoites in the salivary glands). To be distinguished from infective anopheles.

infection. Entrance, establishment or maintenance in a host of a parasite, generally involving its multiplication; also the resulting condition in the host.

infection, mixed. Malaria infection with more than one species of Plasmodium.

infection immunity. Synonym of premunition.

infection interval. Period elapsing from the time an individual is infected until he himself becomes infectious to others. In malaria the infection interval is the period from the inoculation of a human being with sporozoites until the appearance of gametocytes potentially infective to mosquitos. To be distinguished from incubation interval and incubation period.

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1. Terms entered here as indices may be called "rates" by some authors and vice versa; both entries should be consulted for such terms.

infection rate. The number of salivary gland- and/or gut-infected mosquitoes expressed as a percentage of the total number examined for parasites (see salivary gland infection and gut infection). This rate is not expressed in units of time.

infectious. Capable of transmitting infection; term commonly applied to the human host.

infective. Capable of transmitting infection; term commonly applied to the parasite (gametocytes, sporozoites, etc.) or infecting agent.

infective anopheles. Female anopheles with sporozoites in the salivary glands (with or without oocysts in the midgut). To be distinguished from infected anopheles.

infestation. Relationship of ectoparasites to the host or of vermin or pests such as mosquitos to an environment in which they are numerous. The term has been loosely used in malaria literature in the following senses: (a) "acute infestation": early state of infection among children who have high parasitaemia and acute illnes; (b) "immune infestation": the stage of infection following "acute infestation", characterized by low parasite density and the development of tolerance. Such uses of "infestation" to refer to malarial parasitaemia are not recommended.

infiltration. The process of water soaking or moving into the soil through the soil surface. Not the same as percolation.

initial environmental examination (IEE). The first review of the reasonably foreseeable effects of a proposed action on the human or natural environment, leading to a threshold decision as to whether or not an environmental assessment (EA) or an environmental impact statement (EIS) will be required. See "Reg. 16" 216.1(c)(2) and ?16.3(a) in Manual, Chapter 10.

inorganic. Chemical substances that usually do not contain carbon atoms in the molecule.

insect growth regulator (IGR). Natural and synthetic products which prevent normal development or cause delayed mortality of insects by disrupting a natural physiological process. IGR's interfere with normal molting processes of the larvae, and prevent emergence of adult mosquitoes. Examples: Altosid®, Dimilin®. See: diflubenzuron and methoprene.

insecticide. Any substance or preparation used to kill insects. See also ovicide, larvicide, pupicide, and adulticide or imagicide.

insecticide, contact. Insecticide which exerts a toxic action when its particles come into contact with the insect's cuticle.

insecticide, fumigant. Insecticide which acts through the release of vapour from a volatile substance.

insecticide, residual. Insecticide which, when suitably applied on a surface, maintains for a considerable time its insecticidal activity by either contact or fumigant action.

insecticide avoidance. Development, in a strain of insects, of the ability to avoid contact with an insecticide. This term is preferred as more truly descriptive than "behaviouristic resistance", the term used by the WHO Expert Committee on Insecticides (1957 and 1960) mainly because it has been generally accepted.

insecticide common name. The name approved by the Entomological Society of America to be used in referring to insecticides by a common name. Example: dichlorvos, not DDVP, is the approved common name for Vapona®.

insecticide resistance. The ability of an insect population to withstand doses of an insecticide which were generally effective against earlier populations. Insects may withstand a toxicant through physiological-biochemical processes after it enters the body (physiological resistance), or by avoiding contact with it (behavioristic resistance). Also includes a natural ability to tolerate a chemical substance by an insect population as compared with a developed resistance.

insecticide trade name. The name under which an insecticide is marketed. The symbol ® is a part of the trade name and means that the product is registered. Example: Vapona®.

inspection. A looking into; careful investigation; critical examination.

instar. The form assumed by insects between larval molts. Mosquitoes develop through four larval instars. The first is formed when the larva issues from the egg, the second follows the first molt, the third larval instar follows the second molt, and the fourth instar occurs prior to and ceases to exist when the pupa is formed.

integrated mosquito control. 1. Applied mosquito control which combines and integrates any two or more measures which tend to suppress or destroy mosquitoes. For example, source reduction and chemical control (the term is often used in this way); 2. The manipulation of pest or vector populations taking advantage of natural occurring mortality; the integration of all suitable management techniques with the natural regulating and limiting elements of the environment; 3. Modified FAO definition - a pest management system that combines and coordinates natural limitations and naturalistic control elements in the most compatible manner possible with chemical suppression, when necessary, to keep mosquito populations below a defined tolerance level. Various other more complex and technical definitions have been advanced, mainly relating to the control of agricultural pest insects and implying the judicious use of pest management techniques to supplement natural limiting factors so that acceptable control can be had with minimum use of pesticides. See also IPM.

integrated pest management (IPM). For pest animal, weed or vector control, the choice of the best blend of control options from chemical, physical, biological, or cultural methodologies, based upon monitoring the problem to maximize the control advantage, while achieving the best cost/risk/benefit.

intensity. Vague term often loosely applied in malariology with reference to the degree of severity of symptoms, the level of parasite density, morbidity or parasite rates, vector densities, etc. Should preferably be replaced by a precise term indicating the relevant measurement.

interruption of transmission. Cessation of transference of malaria by mosquitos from one person to another. In malaria eradication terminology, refers exclusively to the cessation of transference secured by antimalarial measures at any stage before eradication is achieved.

interspecific competition. Competition between individuals of different species.

intraspecific competition. Competition between individuals of the same species.

intrinsic rate of increase. Expotential growth of a population with a stable age distribution.

invertebrate. An animal without a backbone or spinal column.

inverted siphon. A pipeline crossing over a depression or under a canal, road, etc. The term is common but not correct since no siphoning action occurs.

irrigating head. (1) The flow (quantity of water flowing per unit of time) used for irrigation of a particular tract of land. (2) The flow of water distributed at a single irrigation, or the flow in a single farm lateral. (3) The flow rotated among a group of irrigators.

irrigation requirement. The relation between the area of land served and the quantity of irrigation water used per unit of time. It may be expressed as the area irrigated with a given flow for a given period of time, rate of flow per acre for a particular time, or the amount of water applied in acre-feet or acre-inches per acre each year. It is a measure of the use of water and may be distinguished as head gate or gross duty, lateral duty, farm duty, net duty, or crop duty for different crops.

irrigation water management. The use and management of irrigation water where the quantity of water used for each irrigation is determined by the water-holding capacity of the soil and the need of the crop, and where the water is applied at a rate and in such a manner that the crop can use it efficiently and significant erosion does not occur.

irritability. Readiness of mosquitos to take flight in response to external stimuli.

irritant. Insecticidal or other substance which disturbs resting mosquitos and stimulates them to fly.

isotherm. A line connecting points on the earth's surface having the same temperature at a given time or the same mean temperature over a given period.

itinerary. In malaria eradication terminology, the listed work sequence of a spraying squad, a surveillance agent or other mobile operational unit, showing localities and target dates, usually with an accompanying map.

invert. The floor, bottom, or lowest part of the internal cross section of a channel or pipe.

James's stippling. Fine, evenly distributed granulations brough out by suitable staining in red cells infected with *P. ovale*.

Karbaspray® See carbaryl.

Karbofos® See malathion.

key, taxonomic. List of distinguishing morphological characters so arranged as to facilitate identification of species. The commonest form is the dichotomous key, in which the characters are displayed as pairs of alternatives ("couplets").

key factor analysis. A statistical treatment of population data designed to identify factors most responsible for change in population size.

knockdown. Rapid immobilization of an insect by an insecticide without necessarily causing early death.

Kop-Thion® See malathion.

Kypfos® See malathion.

lacustrine. Of, or pertaining to, a lake or pond, or other body of water not part of the ocean, and its associated margins.

larva (pl. larvae). The immature form, between the egg and the pupa, of insects which have complete metamorphosis. As the larva grows it molts several to a few times, depending on the insect family or order (mosquito larvae molt four times). In insects the larva usually appears quite different and lives in a different habitat than the adult. See also nymph and naiad.

larval control. Control of the immature feeding stages of an invertebrate vector or pest. In malaria control, the measures used to reduce the mosquito population through attacks upon its aquatic feeding stages (wigglers).

larvicide. Substance used to kill aquatic larvae by ingestion, contact, respiratory blockage, etc. Modern larvicides are applied in the form of oils or emulsions, or as small pellets or granules of inert material such as bentonite, impregnated with insecticide, which is released gradually when they are placed in water.

latent period. Stage during which malarial infection in the vertebrate is not evidenced clinically by any symptoms of disease; occasionally used for the condition in which few or no parasites can be detected by microscopic examination. There is normally a latent period preceding the primary attack ("incubation latency") and a period or periods of latency between the relapses following the primary attack, when the erythrocytic forms have disappeared from the blood but infection persists.

lateral. Pertaining, or attached, to the side.

lateral. (1) A channel or pipeline diverting water from a main channel or pipeline for delivery to farm ditches. (2) A secondary ditch.

latitude. Distance measured in degrees north and south of the equator.

Laverania. Generic (or subgeneric) name applied by some authors to P. falciparum and P. reichenowi.

LC_{50}. Abbreviation for median lethal concentration.

LD_{50}. Abbreviation for median lethal dose. The dosage lethal to 50% of test organisms treated.

leaching (drug). Solution in water and subsequent unequal distribution or loss ("leaching out") of a water-soluble drug mixed with crude, hygroscopic common salt that has absorbed water.

leaching (soil). Washing out unwanted soluble materials from the soil by the application and drainage of water.

Lebaycid®. See fenthion.

leaping weir. A narrow ditch made of concrete, so constructed across a stream at a drop in its grade that it carries away all or part of the stream's normal flow, but none of its sediment-laden storm flow, since the latter has high enough velocity to leap across the weir and not fall into it.

legal enforcement mosquito control. Control of mosquitoes through the enactment of legislation that enforces control measures or imposes regulations, to prevent the production, introduction, or spread of pests.

levee. An embankment of earth constructed to divert or confine the flow of water. Usually applied to large embankments, but may be used to describe small ridges or borders.

life cycle (of the mosquito). The complete development of a mosquito, from fertilization of the egg through all life stages to maturity, mating, and eventual death of the individual.

life table. A summary by age of life expectancy, survivorship, and fecundity of female individuals in a population.

limiting factor. An environmental factor that exerts a limiting influence, despite the favorable nature of the remainder of the environment. It controls a population by its scarcity or overabundance, thereby exceeding the biological limits of tolerance of the organism.

lindane, gamma BHC, gamma HCH (Lindane^{+N}). A chlorinated hydrocarbon insecticide of moderate toxicity used as residual wall spray in malaria control programs.

loam. Soil material containing 7-27 percent clay, 28-50 percent silt, and less than 52 percent sand.

logistic equation. Mathematical expression for a particular sigmoid growth curve in which the percentage rate of increase decreases in linear fashion as population size increases.

longitude. A system of measuring distance in degrees from the Prime Meridian; lines spaced equal distances apart which divide the earth into equal segments from pole to pole.

longitudinal. Situated or running lengthwise; in the direction of the long axis.

Lorsban.® See chlorpyrifos.

low volume insecticide application. An arbitrary term meaning an application rate of more than 16 but less than 64 fluid ounces per acre. Very low volume (16 fluid ounces per acre or less) is sometimes called ultra low volume (ULV).

M and P®. See fenitrothion.

macrogamete. Female gamete.

macrogametocyte. Female gametocyte.

macrophytic algae. Algal plants large enough either as individuals or communities to be readily visible without the aid of optical magnification.

maha season. Maha season refers to the southwest monsoon season characterized by high rainfall during May through September.

maintenance phase. In malaria eradication terminology, period which begins when the criteria of malaria eradication have been met in an operational area and which will continue until world-wide eradication has been achieved. During this period vigilance is exercised by the public health services to prevent the spread of malaria imported from across the borders of the area concerned.

Malamar®. See malathion.

malaria. A disease caused by a protozoan parasite (Plasmodium) which multiplies in man and destroys red blood cells. The parasite is transferred from man to man by the bite of an anopheline mosquito.

malaria, benign tertian. Synonym for vivax malaria.

malaria, bromeliad. Malaria transmitted by species of Anopheles that breed in certain bromeliaceous plants in South and Central America.

malaria case. In malaria eradication terminology, occurrence of malaria infection in a person in whom, regardless of the presence or absence of clinical symptoms, the presence of malaria parasites in the blood has been confirmed by microscopic examination. During surveillance, every malaria case detected is classified, according to the origin of the infection, as indigenous or as imported, introduced, relapsing or induced.

malaria case, imported. Case in which the infection was acquired outside the area in which it is found, implying that its origin can be traced to a known malarious area.

malaria case, indigenous. Case that is natural to an area or country, i.e., not introduced. The term is applied to cases whose origin from local transmission cannot be disproved. In malaria eradication terminology relapsing cases are not classified as indigenous.

malaria case, induced. See under induced malaria.

malaria case, introduced. In malaria eradication terminology, a case in which it can be proved that the infection is the first step (direct secondary) of local transmission subsequent to a proved imported case.

malaria case, relapsing. In malaria eradication terminology, the classification used for a case shown by the history of the subject to be a probable relapse if careful epidemiological investigation shows that the infection was contracted before the interruption of transmission was claimed in the locality and if there are no epidemiologically related malaria cases in the neighbourhood.

malaria, cerebral. Form of pernicious malaria associated with cerebral symptoms and due to infection with Plasmodium falciparum.

malaria, chronic. Colloquial term for the state of ill-health associated with prolonged and repeated malaria infection. Its use is not recommended.

malaria, congenital. Malaria infection directly transmitted from mother to child; such infection is relatively rare and usually takes place in utero through the placenta (prenatal or true congenital malaria), but it is believed that it may also occur at delivery. The term "hereditary malaria" is not recommended.

malaria control. Operations aimed at reducing the prevalence of malaria to a level at which it is not a major public health problem.

malaria detection post. In malaria eradication terminology, a unit or person, forming part of the apparatus of passive case detection, by whom blood slides are taken in all fever cases (not only in suspected malaria cases) and to whom the service responsible for malaria eradication gives regular supervision (as well as making arrangements for the preparation, transport and examination of blood slides and checking the results). Unsupervised persons or institutions from whom notifications are received, with or without supporting blood slides, are not regarded as detection posts, even though their activities may be of value in the case-detection system. Most frequently the designation applies to a rural health centre or dispensary or to a voluntary collaborator, but it may also apply to, for example, a hospital or a medical practitioner.

malaria eradication. "The ending of the transmission of malaria and the elimination of the reservoir of infective cases in a campaign limited in time and carried to such a degree of perfection that, when it comes to an end, there is no resumption of transmission" (WHO Expert Committee on Malaria, 1957, page 4). This objective does not necessarily include the eradication of the vector mosquitos. The concept of malaria eradication must be distinguished from malaria control, which aims at reducing the disease to a low level and is of indefinite duration.

malaria eradication board. Term used in some countries for a high-level coordinating body set up to formulate policy and in some cases to exercise technical and administrative direction of the country's malaria eradication programme.

malaria eradication pilot project. Operation intended to provide evidence as to whether certain single or combined antimalaria measures will, if properly applied, bring about the interruption of transmission, and if so, within what period. Within this framework it is possible in a special type of field project to study the most economical, effective and speedy technical means of eradicating malaria.

malaria eradication programme. Operation aimed at achieving malaria eradication. The phases of a malaria eradication programme are: preparatory, attack, consolidation, and maintenance.

malaria, falciparum. Malaria infection caused by *Plasmodium falciparum*.

malaria focus. In malaria eradication terminology, a defined and circumscribed locality situated in a currently or formerly malarious area and containing the continuous or intermittent epidemiological factors necessary for malaria transmission: a human community, at least one source of infection, a vector population and the appropriate environmental conditions. The use of the term to mean a "focus of infection", i.e., one or more persons having parasites in their blood capable of infecting mosquitos, is not recommended. It should be noted that during the attack and consolidation phases, when malaria transmission has already been interrupted in the area around the focus by the appropriate operations, transmission can take place in the focus itself but not in its contiguous environment. Malaria foci may be classified as residual or new.

malaria, holoendemic. Degree of malaria endemicity in an area characterized by a spleen rate in children (2-9 years) constantly over 75% but a low adult spleen rate.[1] Another characteristic of holoendemicity is the high tolerance of the adult population.

malaria, hyperendemic. Degree of malaria endemicity in an area characterized by a spleen rate in children (2-9 years) constantly over 50% and also a high adult spleen rate.[1] In areas of hyperendemicity the parasite rates are usually high not only in children but also in adults.

malaria, hypoendemic. Degree of malaria endemicity in an area with a spleen rate in children (2-9 years) of 10% or less.*

malaria, imported. See under imported malaria case.

malaria, indigenous. See under indigenous malaria case.

malaria, induced. Malaria infection properly attributable to the effect of a blood transfusion or other form of parenteral inoculation, but not to normal transmission by the mosquito. The course of the infection may be different from that observed in the normal case. Induced malaria may occur accidentally or may be produced deliberately for therapeutic or experimental purposes.

malaria, introduced. See under introduced malaria case.

malaria, malariae. Malaria infection caused by Plasmodium malariae. The term "quartan malaria" is preferable.

malaria, man-made. Malaria resulting from human activities, often constructional or agricultural, which have provided a local environment suitable for the proliferation of vector mosquitos.

malaria, mesoendemic. Degree of malaria endemicity in an area with a spleen rate in children (2-9 years) between 11% and 50%.[1]

malaria, ovale. Malaria infection caused by Plasmodium ovale.

malaria parasite. Colloquial term for any of the protozoan organisms causing malaria infections, including the infection of animals by parasites of the order Haemosporidia.

malaria, pernicious. Malaria infection with severe symptoms, usually due to Plasmodium falciparum.

malaria pigment. Compound of haematin (ferrihaemic acid) and protein occurring in the cytoplasm of erythrocytic forms of malaria parasites through the decomposition of haemoglobin by the parasite. The pigment is detectable in the organs and tissues following destruction of the parasites, and in ookinetes and oocysts. The terms "melanin" and "haemozoin" are not recommended.

malaria, quartan. Colloquial name for malaria infection caused by Plasmodium malariae. This term is preferred to "malariae malaria".

malaria, refractory. Term used by some authors to describe persistence or slow and gradual reduction of the amount of malaria despite total-coverage spraying.

malaria, relapsing. See under relapsing malaria case.

malaria, responsive. Term used by some authors to describe malaria that is rapidly reduced in amount by total-coverage spraying soon after the beginning of the attack phase.

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1. Based on Classification of Malaria Conference in Equatorial Africa (World Health Organization, 1951).

malaria, simian. Malaria naturally occurring in apes and monkeys. Some simian species of Plasmodium have been experimentally transmitted to man.

malaria, simple tertian. Synonym for vivax malaria.

malaria, stable. Epidemiological type characterized by steady prevalence which does not show great change during one transmission season, or from one season to another, except as the result of extreme changes in the environmental factors affecting transmission. Epidemics are unlikely; the affected population often shows a high degree of immunity. This condition is usually linked with the presence of vectors enhibiting pronounced man-biting habits and longevity.

malaria, subtertian. Synonym of falciparum malaria.

malaria survey. Investigation carried out in an area with the object of determining the main features of malaria under the existing circumstances and thus ascertaining the most suitable antimalaria measures.

malaria, tertian. Synonym of vivax malaria.

malaria, tropical. Synonym of falciparum malaria. Also known under the obsolescent name of "aestivo-autumnal malaria".

malaria, unstable. Epidemiological type characterized by very variable prevalence, typically showing great changes from one part of the transmission season to another and from one year to another. Epidemics are common and often attributable to minor causes; the population usually shows little immunity. This condition is usually linked with the presence of vectors which do not exhibit very pronounced man-biting habits or great longevity.

malaria, vivax. Malaria infection caused by Plasmodium vivax.

malariogenic potential. Malariogenic potential is the degree to which an area is conducive to malaria based on cumulative epidemiological data collected from each area regarding the parasite load, vector density, water logging, climatic conditions, population movement and factors causing man-made malaria.

malariometric survey. Investigation conducted in selected age-group samples of a population in randomly selected localities in order to assess the degree of malarial endemicity. Such a survey is concerned with the measurement of the prevalence of malaria as indicated by spleen and/or parasite rates in random samples of the population. It is used in pre-eradication operations and in the preparatory and early attack phases of malaria eradication programmes. Later, when the amount of malaria has been considerably reduced, the indices furnished by malariometric surveys are no longer sentitive enough to measure further progress.

malariotherapy. Treatment of certain diseases, notably neurosyphilis, by deliberately infecting the patient with malaria. See also induced malaria.

malarious area. Area in which transmission of malaria is taking place, or in which it has been present during the preceding four years; or, in malaria eradication terminology, an area where transmission has apparently or actually ceased but where final eradication has not been proved.

malathion, mercaptothion, carbofos, maldison (Cythion®, Emmatos®, Fyfanon®, Karbofos®, Kop-Thion®, Kypfos®, Malamar®, Malaspray®, Malathion®, Malatol®, Zithion®, others). A slightly toxic organophosphate insecticide commonly used as an adulticide in mosquito control programs, often in urban areas. Field strength malathion has had little or no effect on birds or mammals, however, fish and bees have been susceptible.

Malatol®. See malathion.

maldison. See malathion.

malignant tertian. Obsolescent term for falciparum malaria.

manual. A ready reference text for any operation, detailing "how to do it". Synonym: handbook.

marine. Of, or pertaining to, the sea or to marginal waters and shores of lagoons and bays. In malaria control, the diverse shoreline and inland areas reached by salt to brackish water, subject to tidal action.

marsh. A category of wetlands, usually very open in character, water-dominated if not permanently flooded, having more than 25% cover by herbacious plants, but less than 40% by woody plants (scrub and/or forest).

mass blood examination. Examination of the blood of all persons in a unit of the population, which may be repeated at certain intervals. Blood specimens are commonly obtained during house-to-house visits. Unlike other case-detection methods, mass blood examinations are used to discover all persons harbouring malaria parasites, even those who have no clinical symptoms; they thus supplement the routine methods in special problem areas and are useful in demonstrating the proportion of asymptomatic carriers present in the community examined. They form a part of case-detection activities and must be distinguished from malariometric surveys, which are carried out on a sampling basis in selected groups. Mass blood examinations have sometimes been called "mass blood surveys", but this term should be avoided in the interest of clarity.

mass drug administration. Distribution of a specified drug to every member of a population. The frequency of distribution depends on the purpose, the nature and dosage of the drug, and local conditions. Although the intention is that the drug shall reach every member of the population, the practical difficulties of ensuring this may be considerable.

maturation. Final stage in the formation of the macrogamete, by which it is prepared for union with the microgamete.

Maurer's spots. Irregular granulations (spots, clefts or stippling) brought out by special staining in erythrocytes parasitized by Plasmodium falciparum.

mean high water. The average height of the high water over 19 years.

mean higher high tide. The average height of the higher of two unequal daily high tides over 19 years.

mean low water. The average height of the low water over 19 years.

mean lower low water. The average height of the lower of two unequal daily low tides over 19 years.

mean tide level. A plane midway between mean high water and mean low water.

mechanical mosquito control. Control of mosquitoes by mechanical means such as window screens and screened covers over potential sources.

median. Situated in or at the middle; of or pertaining to the middle.

medicated salt distribution. Distribution of common salt containing an antimalarial drug in such a proportion that every user will obtain with his regular food a daily amount of the drug sufficient to eliminate malaria parasites from the blood stream. Also know as "Pinotti's method".

meiosis. Process involving reduction division in a diploid nucleus. In malaria parasites it was originally thought to take place during the maturation of the macrogamete by the extrusion of polar bodies; today meiosis is believed to take place in the first division of the nucleus of the zygote (in the oocyst).

Mercaptophos®. See fenthion.

Mercaptothion. See malathion.

merozoite. Product of segmentation of a tissue schizont, or of an erythrocytic schizont before entering a new host cell. Merozoites are found either separated from or contined in the original schizont.

mesoendemic. Mesoendemic is a term that means the normal incidence is median, i.e., there is a constant middle level of existing malaria in the area with the spleen-rate in children (2-9 years) of 11-50%.

mesohaline. Term to characterize waters with salinity of 5 to 18%, due to ocean-derived salts.

mesophyte. Any plant growing where moisture and aeration conditions lie between extremes. (Plants typically found in habitats with average moisture conditions, not usually dry or wet.)

mesosaline. Term to characterize waters with salinity of 5 to 18%, due to land-derived salts.

Mesostoma. See flatworms.

metacryptozoite. Exoerythrocytic stage of the malaria parasite arising from the cryptozoite and occurring prior to the invasion of erythrocytes. Term limited at present to avian malaria parasites.

metamorphosis. The series of changes that an insect goes through during its growth from the egg through the larva and pupa to the adult. It is complete metamorphosis (Holometabola) when the larvae are distinctly different from the pupae and the pupal stage does not feed.

metaxenous, metoxenous. Term applied to parasite that requires two or more host species for completion of its life cycle.

methoprene (Altosid®). An insect growth regulator used to prevent the emergence of adult mosquitoes from aquatic sources. The product is highly specific to dipteran insects especially mosquitoes, shows little effect on other non-target organisms and is relatively non-toxic to man. Specifically an analog of juvenile hormone, it inhibits emergence of the adult mosquito from the pupa. It is rapidly biodegradable.

microbial mosquito control. The use of pathogens by man to reduce populations of mosquitoes.

microclimate. Conditions of temperature, humidity, and other factors in the immediate environment of an organism, as opposed to the general environment.

microgamete. Mature male gamete.

microgametocyte. Male gametocyte.

micron. One one-thousandth of a millimeter, or one one-millionth of a meter. Signified by the Greek letter μ.

Microstomum. See flatworms.

migrate. Commonly considered to mean the movement of animal populations from one region to another as affected by climatic, feeding, or breeding needs, or as a consequence of catastrophic conditions. Disperse is a more descriptive term for movements of mosquitoes.

migration (of mosquitoes). A mass movement.

mineral soil. Soil composed of predominantly mineral rather than organic materials.

mist. Suspension in air of droplets generated by condensation of a fluid from the gaseous to the liquid state or by the breaking up of a liquid by atomization. Mists may be produced by high-pressure pumps, atomizers, or high-speed mechanical rotors; their droplets range in size from 50 to 100 μ.

mixohaline. Term to characterize water with salinity of 0.5 to 30%, due to ocean salts. The term is roughly equivalent to the term brackish.

mixosaline. Term to characterize waters with salinity of 0.5 to 30%, due to land-derived salts.

moisture equivalent. An arbitrary moisture value used as a estimate for the field capacity of soils. It is the weight of water remaining in a soil sample (expressed as percentage of the dry weight of soil) after the soil has been saturated and subjected for thirty minutes to a centrifugal force 1,000 times gravity.

molt. In insects, to cast off the outgrown skin or cuticula in the process of larval growth; the period of transformation when the larva or nymph changes from one instar to another; the cast off skin.

monsoonal rainfall. Monsoonal rainfall is seasonal precipitation and wind that blows from the southwest in summer and northeast in winter.

montane. Montane is the lower vegetation belt on mountains.

morbidity. Disease rate, expressed as the percentage of cases of sickness in a given population in a specific period of time irrespective of deaths, such as the number of malaria cases per 1000 population (unlike other diseases where morbidity is calculated on the basis of 100,000 population).

mortality. Death rate, expressed as the percentage of deaths in a given population in a specific period of time, such as the number of deaths from malaria per 100,000 population during one calendar year or one epidemiological year.

mosquito control (vector control). Usually refers to the programmed efforts of local mosquito abatement districts or other governmental agencies to eliminate the sources of, or to suppress the populations of, the target insects to a level which can be tolerated. Less frequently refers to natural suppression. See also mosquito control under the following headings: abiotic, biological, chemical, comprehensive, genetic, integrated, legal, mechanical, microbial, natural, naturalistic, physical.

mosquito source. (Literally, the source of mosquitoes) persistent site where eggs, larvae, or pupae of mosquitoes are found (and from which adults have emerged); larval habitat. See also breeding place.

mosquito source reduction. See physical mosquito control.

mud. Wet soft earth composed predominantly of clay and silt--fine mineral sediments less than 0.074 mm in diameter.

multiparous. Term describing female mosquito that has oviposited more than once.

multivoltine species. A species that has several generations annually.

naiad. The aquatic, immature stage of the Odonata (dragonflies and damselflies), Ephemeroptera (Mayflies), and Plecoptera (stoneflies).

naled (Dibrom®). A moderately toxic organophosphate insecticide used as an adulticide for mosquito control. It is toxic to fish, birds and other wildlife and highly toxic to bees.

natural mosquito control (natural limitation). The maintenance of a fluctuating population density within definable upper and lower limits over a period of time by the combined action of abiotic and biotic elements of the environment. Manipulation by man of these elements of the environment is excluded from this classification, since the operation is no longer "natural", but is instead "naturalistic", or similar to natural. See also balance of nature.

naturalistic mosquito control. Measures without primary dependence on chemical, mechanical (physical) measures or water manipulation, which deliberately extend or intensify natural limiting factors such as shade, sunlight, pollution, and certain plants and predatory animals. Naturalistic control is similar to "natural limitation" except that man has helped the natural factors by slight modification of the environment without changing its basic character. See also integrated control, pest management and biological mosquito control.

needle-leaved deciduous. Woody gymnosperms (trees or shrubs) with needle-shaped or scale-like leaves that are shed during the cold or dry season; e.g., bald cypress (Taxodium distichum).

needle-leaved evergreen. Woody gymnosperms with green, needle-shaped, or scale-like leaves that are retained by plants throughout the year; e.g., black spruce (Picea mariana).

negative declaration. An official written agency decision suspending the development of an environmental assessment (EA), or an environmental impact statement (EIS) for an action ordinarily requiring such, either because the agency is already covered by a prior EA or EIS, or because there are overriding considerations, or because the agency has previously decided to prepare a programmatic EA or EIS to include the action under consideration. See Regulation 16: 216:3(a)(3) in Manual, Chapter 10.

negative determination. A decision that a proposed program action is not a major action which will have a significant effect on the human or natural environment, and will therefore not require an environmental assessment (EA) or an environmental impact statement (EIS). See Regulation 16: 216.3(a)(2)(iii) and 216.3(a)(9), in Manual, Chapter 10.

negative feedback. See feedback.

neutral equilibrium. The particular state of a system that either has no forces acting upon it, or all are equally balanced by each other.

niche. All the localized and distinctive components of a particular habitat with which a given organism or its population interacts, inclusive of that organism's place in it (i.e., the "job" it performs). Not just equivalent to habitat or microhabitat.

Nisan® See parathion.

nonpersistent emergents. Emergent hydrophytes whose leaves and stems break down at the end of the growing season so that most above-ground portions of the plants are easily transported by currents, waves, or ice. The breakdown may result from normal decay or the physical force of strong waves or ice. At certain seasons of the year there are no visible traces of the plants above the surface of the water; e.g., wild rice (Zizania aquatica), arrow arum (Peltandra virginica).

notification, compulsory. Reporting of detected cases of malaria by all medical units and medical practitioners, to either the health department or the malaria eradication service, as laid down by law or regulation. Usually this is restricted to clinical or microscopically confirmed cases and does not include suspected cases. Compulsory notification in a country supplements passive case detection or, under certain conditions, replaces it.

Novathion® See fenitrothion.

nozzle liquid distribution. Liquid discharge rate from a nozzle upon each element of a sprayed surface. For the flat-spray nozzles used in house-spraying, the nozzle liquid distribution is expressed as a curve whose ordinates show the variations in dosage at different points between the edges of a swath. Graphs obtained for a given type of nozzle are used to determine its suitability for house-spraying at different nozzle pressures and to indicate the amount of overlap of successive swaths needed to produce uniformity of dosage. A routine liquid-distribution test of new and used nozzles is carried out with appropriate laboratory apparatus to determine their suitability. In the field the liquid distribution of a nozzle is often tested by observing the uniformity in speed of drying of different parts of a swath sprayed on a smooth, porous wall. Not to be confused with nozzle spray pattern.

nozzle output. Synonym of nozzle discharge rate.

nozzle spray pattern. Instantaneous pattern produced by liquid discharged from a nozzle against a flat surface perpendicular to the centre line of the jet. Patterns may be open cones, solid cones, or flat fans. Flat-spray nozzles are commonly used for house-spraying. A nozzle-spray-pattern test is used to determine the pattern of the impinging liquid by observing it from the dry side of a sprayed pane of glass. Not to be confused with nozzle liquid distribution.

nuisance. An annoying, unpleasant, or obnoxious thing or practice.

nulliparous. Term describing female mosquito that has never oviposited.

numerical response. Change in the population size of a predatory species as a result of a change in the density of its prey.

nutrient budget. In ecological studies, the availability of a limiting inorganic element, such as nitrogen or phosphorus at each trophic level, as modified by the extractive efficiency and the productivity of the organisms at that level. In some ecosystems the nutrient budget, not the solar energy budget, is the prime limiting factor.

Nuvanol® See fenitrothion.

nymph. The growing stage of insects that have gradual metamorphosis, with visible evidence of wings (if any) on the outside of the body wall. Nymphs usually look like the adult, have most of the features of the adult, such as compound eyes or mouth parts, and live in the same habitat as the adult.

obligate hydrophytes. Species that are found only in wetlands--e.g., cattail (*Typha latifolia*) as opposed to ubiquitous species that grow either in wetland or on upland--e.g., red maple (*Acer rubrum*).

oil larvicides. Petroleum oils such as kerosene, diesel oil or others utilized to kill mosquito larvae in their aquatic sources.

oligohaline. Term to characterize water with salinity of 0.5 to 5.0%, due to ocean-derived salts.

oligosaline. Term to characterize water with salinity of 0.5 to 5.0%, due to land-derived salts.

oligotrophic. Referring to a body of water with low nutrient content and productivity.

oocyst. Fertilized female cell (zygote) after encystment, developing in malaria parasites from the ookinete.

ookinete. Motile vermicule stage of the malaria parasite, following fertilization of the macrogamete and preceding oocyst formation.

opportunistic species. A species that takes advantage of temporary or local conditions. (Populations of opportunistic species usually flucuate markedly)

organic. Chemical substances that always contain carbon atoms in the molecule.

organic soil. Soil composed of predominantly organic rather than mineral material. Equivalent to Histosol.

organism. Any living thing.

organophosphate insecticides. A group of synthetic insecticidal compounds consisting of mixed esters of phosphoric acid, with many containing sulfur. They are usually rapidly degradeable by biological or physical processes. See such materials as malathion, diazinon, fenthion, dichlorvos, and fenitrothion. They act by inhibiting a variety of esterases, such as cholinesterase.

Orthophos®. See parathion.

outfall. The point where water flows from a channel or pipeline, the mouth of drains and sewers.

output rate. The amount of the finished or field formulation which the application equipment dispenses per unit of time. Synonym: discharge rate and (less properly) flow rate.

ovarian stages. In the mosquito, the progressive changes in the ovary and ovarioles during oogenesis, representing degrees of development of the oocytes and variously classified by different authors.

ovariole. Tapered follicular tube in which oogenesis takes place. The ovary of the mosquito is composed of numerous ovarioles. In parous mosquitos the thin membranous wall of the follicular tube usually shows a dilatation at the position of a former follicle. The number of such dilatations indicates the number of completed gonotrophic cycles and thus the physiological age of the mosquito.

overwintering. Survival through the winter, irrespective of the means by which this is achieved.

ovicide. Any chemical applied to kill the eggs of arthropod pests.

oviposition. The act of depositing the egg. Act of laying eggs.

ovulation. Passage of an oocyte from its follicle to the point where it is fertilized just before the egg is laid.

ovum. Cell produced in the female reproductive organ which, after maturation and fertilization, is capable of developing into an organism.

oxidation. In chemistry, to combine a substance with oxygen.

palpus (pl. palpi). Five-segmented paired structures in mosquitoes consisting of appendages projecting from the base of the proboscis. Sexual variations and generic modifications of palpi are useful in classification.

palustrine. Of, or pertaining to, marsh or swamp wetlands.

Panthion® See parathion.

Paramar® See parathion.

Paraphos® See parathion.

parasite. A plant or animal living in, on, or with some other living organism (its host) at whose expense it obtains food and shelter. A parasite usually attacks a single host and remains with the host to complete all or part of its development. It can but does not necessarily harm its host. A pathogenic parasite harms its host.

parasite clearance time. Time elapsing from the first drug administration to the first occasion on which no parasites can be demonstrated in the blood.

parasite count. Number of parasites per cubic millimetre of blood on a given slide.

parasite density. The parasite density, an epidemiological index, is the collective degree of parasitemia in a population, calculated by the use of either the geometric mean or the weighted frequencies of the individual parasite counts; e.g., by using a frequency distribution based on a geometric progression with the factor 2, as employed by Bruce-Chwatt (1958). In the former case the parasite density is expressed as a numerical value, and in the latter as a parasite density index.

parasite formula. This is a statement of the relative prevalence of each species of human malaria parasite found in a group of positive slides, e.g., the percentage of each species in the total number of infections. When slides show a mixed infection, each species is counted separately. To be distinguished from species infection rate.

parasite rate. The parasite rate is the percentage of persons in a defined age group showing, on a given date, microscopically detectable malaria parasites in the peripheral blood. The parasite rate should always be defined in terms of the age group examined.

parasitemia. Condition in which malaria parasites are present in the blood. If this condition in the human subject is not accompanied by pyrexia or other symptoms of malaria except for a possible enlargement of the spleen, it is known as asynptomatic parasitemia, and the person exhibiting the condition is known as a symptomless parasite carrier. Asymptomatic parasitemia may be primary (occurring before primary-attack symptoms) or secondary.

Parathene® See parathion.

parathion, thiophos (Ethyl parathion®, AAT®, Alkron®, Alleron®, Aphamite®, Corothion®, Etilon®, Folidol®, Nivan®, Orthophos®, Panthion®, Paramar®, Paraphos®, Parathene®, Parawet®, Phoskil®, Rhodiatox®, Sopathion®, Stathion®, Bladan®). A highly toxic organophosphate insecticide with broad spectrum taxicity on bees, fish, shrimp, crabs, birds and other wildlife. Once used commonly as a larvicide for mosquito control until less toxic pesticides were produced.

Parawet®. See parathion.

Paris green. Copper aceto-arsenite, first used as a mosquito larvicide in 1921. Used as microcrystalline powder, applied so its fine particles, floating on the surface, would be fed upon by Anopheles larvae. Well tolerated by fish, other natural enemies of Anopheles domestic animals and crops. Usable on domestic water supplies.

parous. Term describing female mosquitos that have oviposited at least once.

parous rate. Parous rate is an entomological term describing the proportion of female mosquitoes in a population which have laid one or more egg batches, i.e., have fed at least once.

paroxysm. Cyclic manifestation of acute illness in malaria characterized by a rise in temperature with accompanying symptoms; usually caused by invasion of the blood by a brood of erythrocytic parasites.

passive case detection. Passive case detection is a part of the surveillance activities in which the public health and medical services other than the regularly constituted malaria service, assist surveillance activities by actively searching for malaria cases by the collection of blood slides and epidemiological investigations.

patent period. Stage during which malarial infection in the vertebrate is evidenced by the presence of parasites in the blood. A subpatent period is sometimes distinguished during which parasites are believed to be present in the blood in very small numbers but are not detectable by normal microscopic examination.

pathogen. Any organism causing disease.

pending houses. In malaria eradication terminology, any sprayable houses reported as partially or completely unsprayed at any time before the end of the current spraying operations, often classified for operational convenience as "refused" or "closed".

perched water table. The upper surface of an isolated body of saturated soil held above the main body of ground water by an impervious layer and separated from the main body of ground water by an unsaturated zone in the soil.

percolation. Downward movement of water through small passages in a body of material, as through the pores and cavities of soil.

perennial house spraying. Perennial house spraying involves the spraying of dwellings on an every three months schedule or four times per year.

periodicity. Recurrence at regular intervals of symptoms in malaria, characterized clinically by paroxysms and resulting from the invasion of the blood by new generations of parasites. Periodicity may be quotidian, tertian, quartan or double-quartan according to the intervals between paroxysms.

peripheral spraying. Synonym of barrier spraying.

permeability. The specific property of a porous medium (such as soil) which is a measure of the readiness with which the medium transmits fluid under standard conditions. Permeability is usually expressed as a velocity and for agricultural purposes can be conveniently expressed in inches per hour.

persistence. As applied to an insecticide, its enduring presence after its application. In house-spraying, generally expressed as the proportion of the insecticide deposit that remains, at any given time after application, either on or below the treated surface in an active or potentially active form. To be distinguished from effectiveness.

persistent emergent. Emergent hydrophytes that normally remain standing at least until the beginning of the next growing season; e.g., cattails (Typha spp.) or bulrushes (Scirpus spp.).

pest. Any organism (usually a plant or animal species) that is unacceptably abundant.

pest management. Good pest management is an advanced form of integrated control which involves complex ecological principles, that has as its objective the reduction of losses inflicted by pests. It is concerned with all population regulating forces and their interaction. See also integrated control and population dynamics.

pesticide. Any chemical substance used in the control of noxious animals or plants including insects and other arthropods.

Phagocata. See flatworms.

phanerozoite. Exoerythrocytic stage of malaria parasite in the vertebrate host arising in blood-induced infections or appearing later than the infection of erythrocytes. Term limited at present to avian malaria parasites.

phase, extrinsic. That part of the life cycle of Plasmodium occurring in the vector.

phase, intrinsic. That part of the life cycle of Plasmodium occurring in the vertebrate host.

Phosril®. See parathion.

photic zone. The upper water layer down to the depth of effective light penetration where photosynthesis balances respiration. This level (the compensation level) usually occurs at the depth of 1% light penetration and forms the lower boundary of the zone of net metabolic production.

physical mosquito control. Frequently called "mosquito source reduction". Making a major physical or environmental change in a mosquito breeding place by physical or mechanical means, to make it unsuitable for the production of mosquitoes. Examples: Draining the water out of a pond so that the pond no longer exists; filling a swamp so that it becomes dry ground instead of a swamp; regrading a pasture so that pools of water no longer remain after irrigation is complete; draining and recirculating excess irrigation water before mosquito adults can emerge from it.

physiological. Pertaining to physiology.

physiology. The branch of biology dealing with the phenomena of life and living organisms; the study of functions of the organs and parts during life.

Pinotti's method. Synonym of medicated salt distribution.

pioneer plants. Herbaceous annual and seeding perennial plants that colonize bare areas as a first stage in secondary succession.

pirimiphos-methyl (Actellic®, Actellifog®, Blex®, Silosan®). An organophosphorus insecticide of low mammalian toxicity, Type III, which is active against a wide range of insects including malathion-resistant strains. Formulated as an emulsion concentrate, aerosol, dust, or ultra-low volume spray. Toxic to fish.

pit shelter. Pit dug in the ground and used for collection of mosquitos resting in it, in order to obtain information on outdoor resting density. It is used for estimating density changes or changes in resting habits.

Plasmodium. The generic (genus) name of the protozoan that causes malaria, a red blood cell parasite; several species cause malaria of corresponding kinds.

Poecilia reticulata, the guppy. A small fish used to control mosquito larvae. It is able to withstand more polluted water than Gambusia.

poison. Any chemical agent which produces an injurious or deadly chemical effect in an organism into which it is introduced. Synonym: toxicant.

polyhaline. Term to characterize water with salinity of 18 to 30%, due to ocean salts.

polysaline. Term to characterize water with salinity of 18 to 30%, due to land-derived salts.

population. A group of individual organisms that occupies a given area. Usually, a population is considered to be composed of individuals of the same species, but it is sometimes used more broadly, such as "the mosquito population".

population density. The number of individuals of a given species within a given geographical area, such as 100 larvae per square foot. Synonym: abundance.

population density, index of. An objective measurement of a sample of a population, giving a relative idea of population density. Examples: 10 mosquitoes/trap night; 10 larvae/dipper; 100 adults/pant leg. Synonym: index of abundance.

population dynamics. The factors which govern fluctuation of numbers within populations, such as variations of growth, reproductive rates, mortality rates, migrations, age distribution, or other biotic or abiotic reasons other than the application of control measures; or the study of such factors.

porosity. The fraction of the soil volume not occupied by soil particles; the ratio of the volume of pores to the total volume of the soil.

positive feedback. See feedback.

positive threshold decision. See threshold decision.

posterior. Situated behind; hindmost; opposite of anterior.

precipitin test. A method for determining the source of a mosquito blood meal by comparing reactions with specific antisera.

predator. An animal that attacks another animal in order to feed upon it. An animal that preys on another and usually consumes more than one individual host (prey). Predators of mosquitoes are usually birds, fish, or insects that catch and devour their prey. Rarely a plant.

predatory insects (Odonata-dragonflies and damselflies, Gerridae-waterstriders, Notonectidae-backswimmers, Belostomatidae-giant waterbugs, Hydrophilidae-water scavenger beetles, and Dytiscidae-predaceous diving beetles). Found in aquatic habitats, these prey upon mosquito larvae. Adult Odonata prey on adult mosquitoes.

pre-eradication programme. Preliminary operation undertaken in a country whose general administrative and health services have not yet reached a level which would enable it to undertake a malaria eradication programme.

pre-eradication survey. Operation aimed at the collection of accurate da a on the malaria situation, preliminary to drafting a complet plan of operations for a malaria eradication programme. The undertaking of the survey presupposes the existence of evidence that transmission can be interrupted by the use of methods commonly employed in malaria eradication and the existence of

basic operational facilities. The pre-eradication-survey period ends when the plan of operations has been prepared.

pre-erythrocytic. Existing before the infection of erythrocytes; applied to exoerythrocytic stages of Plasmodium developing directly from the sporozoites. See also exoerythrocytic schizogony.

premunition. State of resistance, in a host harbouring a parasite, to superinfection by a parasite of the same species; this state is dependent on the continued survival of parasites in the body and disappears after their elimination. May be complete or partial.

preparatory phase. One to two years in malaria eradication terminology, time devoted to establishing the antimalarial organization in preparation for the attack operations. It ends when the epidemiological and geographical reconnaissance in the operational area are completed, the central and peripheral stations and essential services established, the staff recruited and trained, and the logistic and reporting systems organized.

prepatent period. Early stage of malarial infection in the vertebrate, before the invasion of erythrocytes is microscopically detectable.

pressure regulator. Mechanism in a sprayer which maintains a pre-set pressure at an outlet despite variations in pressure at the inlet. Also called "constant-pressure valve".

presumptive treatment. Presumptive treatment is initial drug treatment given in a suspected malaria case at the time when a blood sample is taken for examination.

prevalence. Number of cases of disease or infection existing at any given time in relation to the unit of population in which they occur (a static measure). Depending on the seasonality and the stability of the disease, the prevalence data of the same population may differ considerably at various time points. Malaria prevalence can be established on a single malariometric survey, whereas malaria incidence, which is a dynamic measure, requires a method of repetitive or continuous search.

primary productivity. Rate of assimilation (gross primary productivity) or accumulation (net primary productivity) of energy and nutrients by green plants and other autotrophs which capture solar energy in their accumulation of biomass.

prime meridian. A line drawn from pole to pole on the surface of the earth from which longitude is counted both east and west. (Meridian of Greenwich, London).

proboscis. An extended mouth structure of insects; the piercing mouth parts of a female mosquito which is made up of a sheathlike structure (labium) which encloses piercing and sucking structures. The male proboscis is modified and cannot be used to obtain blood from hosts.

productivity. Rate of production of biomass by the organisms at each trophic level. See primary productivity and secondary productivity.

propagation. Act of propagating as (1) continuance by generation or successive production, (2) the spreading abroad of anything.

prophylaxis. Any method of protection from or prevention of disease; when applied to chemotherapy (pills) it is commonly designated "drug prophylaxis" or "chemoprophylaxis".

prophylaxis, causal. Complete prevention of erythrocytic infection by the administration of drugs that destroy either the sporozoites or the primary tissue forms of the malaria parasite.

prophylaxis, clinical. Synonym of suppressive treatment.

propoxur, aprocarb (Baygon®, Unden®, Blattenex®, Suncide®). A moderately toxic carbamate insecticide used as residual house spray.

public nuisance. Anything that causes annoyance to the public, usually resulting in complaints.

pupa (pl. pupae). Stage between the larva and the imago in the development of the mosquito, during which it is aquatic and active but does not feed. When the larva undergoes metamorphosis into a pupa ("pupation") the fourth and last larval skin is cost. The larval characteristics are lost and the tissues of the body change to those of the adult insect which then emerges from the pupa.

pupicide. Any chemical used to eliminate or destroy the pupal stage.

Pynamin®. See allethrin.

pyrethrin. Insecticides derived from chrysanthemum flowers of high toxicity to insects and low toxicity to man and animals.

pyrethroids. A number of synthetic pyrethrin insecticides (pyrethroids) of potential use in malaria control, including allethrin (Pynamin®), decamethrin, and resmethrin (Chryson®, Synthrin®, SBP-1382®). In general they are highly toxic to insects and only slightly toxic to man and animals. Allethrin and resmethrin may be used as an adulticide, decamethrin has shown promise as a residual wall spray.

pyrogenic level. Estimated least quantum of parasites causing pyrexia (fever); varies greatly with the strain and species of parasite and the tolerance of the individual.

quartan. Recurring every third day (every 72 hours). Recurrence on two successive days, with one-day free intervals, is known as double-quartan periodicity. See also quartan malaria.

Queletox®. See fenthion.

quotidian. Recurring daily.

®. Registered trade name. See insecticide trade name.

r and k selection. Alternative expressions of selection on traits that determine fecundity and survival to favor rapid population growth at low population density (r) or competitive ability at densities near the carrying capacity (k).

race. Genetically distinct mating group within a species. To be distinguished from a subspecies, which is geographically isolated as well as being genetically distinct.

radical treatment. Radical treatment is treatment to completely eliminate the parasite from the body so that relapses cannot occur.

rate.[1] Proportion which one happening or number bears to another. In malaria eradication terminology, proportion of a group in which a specified characteristic has been demonstrated by examination either of the whole group or of an adequate sample.

rate, annual blood examination. In malaria eradication terminology, number of blood slides examined during a year in relation to the population covered by case detection. The annual blood examination rate refers to the number of blood slides and not to the number of persons examined (the latter figure may be smaller, as some persons are examined more than once during the year). It is not a fever rate, since it also includes slides collected in non-febrile cases during mass blood examinations and in epidemiological investigation.

rate, anopheline infection. Percentage of female anophelines of a given species found, by dissection within 24 hours of capture, to contain malaria parasites either as sporozoites in the salivary glands or as oocysts on the midgut wall.

rate, biting. Average number of mosquito bites received by a host per unit of time, specified according to host and mosquito species.

rate, gametocyte. Percentage of individuals in a given population whose blood contains sexual forms of malaria parasites.

rate, inoculation. Number of individuals per unit of population receiving infective inocula in a given unit of time. This rate may be estimated from (a) study of the frequency of infection in infants (parasitologically estimated rate) or (b) the relative infective density of the vectors (entomologically estimated rate).

rate, malaria morbidity. Number of recorded clinical cases of malaria per unit of population over a certain period. The malaria morbidity rate is too imprecise to be of value in malaria eradication.

rate, malaria mortality. Number of recorded deaths from malaria per unit of population over a certain period.

rate, nozzle discharge. Amount of liquid passing under pressure through the nozzle of a sprayer in a unit time. It is dependent on the pressure, the viscosity of the liquid, and the characteristics of the nozzle. In the standard nozzle-discharge-rate test, the result, expressed in millilitres per minute at a specified pressure, is obtained by measuring the amount of water passing in unit time through a nozzle which has been previously cleaned.

rate, oocyst. Percentage of female anopheles caught in nature and found, on dissection within 24 hours of capture, to contain oocysts in the midgut.

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1. Terms entered here as rates may be called "indices" by some authors and vice versa; both entries should be consulted for such terms.

rate, parasite. Percentage of persons in a defined age group showing, on a given date, microscopically detectable parasites in the peripheral blood. The parasite rate should always be defined in terms of the age group examined.

rate, reproduction. Estimated number of malarial infections potentially distributed by the average non-immune individual in a community where neither mosquitos nor persons were previously infected. When conditions are static the rate can be estimated if the sporozoite rate, the probability of mosquito survival and the time of extrinsic development of the parasite are known.

rate, slide positivity. Percentage of slides found positive, usually computed for a stated period of case-detection activities.

rate, species infection. Percentage of individuals found infected with a given species of malaria parasite in a sample of population (e.g., P. falciparum infection rate). To be distinguished from parasite formula.

rate, spleen. Percentage of persons (usually children) showing palpable enlargement of the spleen at a given time. If the spleen rate is investigated in adults, it should be specified as "adult spleen rate".

rate, sporozoite. Percentage of female anopheles caught in nature and found, on dissection within 24 hours of capture, to contain sporozoites in the salivary glands.

rate of coverage. The area treated per unit of time, such as acres per minute. Rate of coverage can also be thought of as the treatment time per unit of area treated, such as minutes per acre. The time measured is only that time during which the application equipment is dispensing the pesticide.

ratio, nulliparous. Proportion of a population of female mosquitos which has not laid eggs.

ratio, parous. Proportion of a population of female mosquitos which has undergone at least one gonotrophic cycle.

reach. A comparatively short length of a stream or channel.

recovery, spontaneous. Clinical or radical cure brought about by nature, in the absence of specific medication.

recrudescence. Renewed manifestation of infection (short-term relapse) believed due to survival of erythrocytic forms. Not to be confused with recurrence.

recurrence. Renewed manifestation of infection (long-term relapse) believed due to reinfection of erythrocytes from exoerythrocytic forms. Not to be confused with recrudescence.

refractory. Unresponsive to stimuli including administration of chemicals or drugs. Resisting ordinary treatment. Resistant to infection by genetic, rather than immune, protection.

Regulation 16. Federal regulations (US) setting forth the environmental procedures with which the International Development Cooperation Agency, U. S. Agency for International Development (AID) must comply. Referred to as Title 22, Code of Federal Regulations, Part 216 (22 CFR Part 216), adopted June 30, 1976, and revised effective October 23, 1980.

reinfection. Establishment of a fresh infection after a previous similar infection has died out or has been eliminated by treatment.

relapse. Renewed manifestation (of clinical symptoms and/or parasitaemia) of malarial infection separated from previous manifestations of the same infection by an interval greater than those due to the normal periodicity of the paroxysms. Relapses are sometimes classified as recrudescences and recurrences; they can be either clinical or parasitic, the latter being evidenced only by the reappearance or increase in number of the parasites in the blood. The qualifications "short-term" and "long-term" may be used to designate relapses following the primary attack after intervals of less than two or more than six months, respectively.

relative abundance. Proportional representation of a species in a sample or a community.

relative humidity. Relative humidity is the ratio of the amount of water vapor in the air versus the total amount of water vapor that the air could hold at the same temperature when saturated.

relict pool. Relict pool is a small body of water left behind when the water level of a river or stream recedes.

relief drainage. The use of drains to remove excess water from the soil to lower the water table and reduce hydrostatic pressure.

repellent. Any substance which produces a negative response in mosquitos, causing them to avoid a close approach such as alighting on the skin of the animal host or entering a room sprayed with the substance.

repository drug. See under repository drug.

reproductive potential. The maximum reproduction possible for a species population. To attain this maximum, a species would have to exist under ideally optimal ecological and genetic conditions, a condition which is probably never realized by a natural population. Species, such as mosquitoes, with a high reproductive potential characteristically have a great toll taken by death, while those with a lower reproductive potential have a smaller death toll. Synonym: biological potential.

residual deposit. Deposit of a residual insecticide, i.e., one remaining on sprayed surfaces after the solvent, emulsifier or carrying fluid has evaporated.

residual insecticide. Residual insecticide is an insecticide which when suitably applied on a surface, maintains for considerable time its insecticidal activity by either contact or fumigant actions, i.e. DDT.

resistance. 1. Ability of a parasite strain to multiply or to survive in the presence of concentrations of a drug that normally destroy parasites of the same species or prevent their multiplication. Such resistance may be relative (yielding to increased doses of the drug tolerated by the host) or complete (withstanding maximum doses tolerated by the host). 2. Ability in a population of insects to tolerate doses of an insecticide which would prove lethal to the majority of individuals in a normal population of the same species; developed as a result of selection pressure by the insecticide. Simultaneous resistance to one or more insecticides of two different groups is known as double insecticide resistance (not to be confused with insecticide cross-resistance).

resistance, behaviouristic. Synonym of insecticide avoidance.

resistance, physiological. In mosquitos, all forms of resistance to insecticides other than so-called "behaviouristic resistance".

Resmethrin (Chrysron®). See pyrethroids.

resting place. See vector resting place.

Rhodiatox®. See parathion.

ring form. Annular form of young trophozoites of malaria parasites in blood cells.

riparian. Pertaining to the banks of a body of water; a riparian owner is one who owns the banks; a riparian water right is the right to use and control water by virtue of ownership of the bank or banks.

risk/benefit. A comparison of the risks associated with a particular control methodology with the benefits derived. (Examples: risks = environmental disruptions, demographic impacts, etc.; benefits: reduced rates of malaria, reclaiming land, etc.)

risk/benefit ratio. Used to help decide upon alternative methods of control that have significant environmental or sociological impacts.

riverine. Of, or pertaining to, the wetlands directly associated with streams and their margins, such as flood plains and bottom lands.

Romanomermis culicivorax. A parasitic nematode of mosquito larvae that has shown great promise in control of larval mosquitoes, including Anopheles spp.

Romanovsky stain. Mixture of eosin, methylene blue and methylene azure which stains differentially the various elements of malaria parasites.

root zone. That part of the soil invaded by plant roots.

rosette. Colloquial name for some types of mature schizont.

run, length of. 1. The distance water must run in furrows or over the surface of a field from one ditch to another, or to the end of the field. 2. The period of time that one irrigator is allowed the irrigating head, in the system of rotation deliveries.

runoff. 1) Surface drainage; the portion of precipitation which appears as flow in streams. It may reach a stream through surface or groundwater flow. 2) In irrigation - the portion of applied irrigation water which does not soak into the soil but runs off as waste water.

S5660®. See fenitrothion.

SBP-1382®. See pyrethroids.

saline. General term for waters containing various dissolved salts. This term is restricted to inland waters where the ratios of the salts often vary; the term haline is applied to coastal waters where the salts are roughly in the same proportion as found in undiluted sea water.

salinity. The total amount of solid material in grams contained in 1 kg of water when all the carbonate has been converted to oxide, the bromine and iodine replaced by chlorine, and all the organic matter completely oxidized.

salivary gland infection. The presence of malaria parasites in the salivary glands of a female mosquito.

salting. A term used locally to refer to the action of soluble salts carried in irrigation water which may interfere with soil structure and crop growth.

sand. Composed predominantly of coarse-grained mineral sediments with diameters larger than 0.074 mm and smaller than 2 mm.

savanna. Savanna is an area of grassland in which are scattered trees or shrubs but little or no breaks in the continuity of grassland cover.

schizogony. Asexual process in the malaria parasite involving the production of erythrocytic or exoerythrocytic schizonts. The stages of schizogony occurring in cells other than erythrocytes in the vertebrate host ("exoerythrocytic schizogony") are divided into (a) primary EE forms ('pre-erythrocytic stages", "primary tissue forms"), in which EE forms are present before the erythrocytes are normally invaded; and (b) secondary EE forms ("exoerythrocytic forms sensu stricto" "para-erythrocytic stages", "secondary tissue forms"), in which EE forms are present after the erythrocytes are normally invaded.

schizont. Intracellular asexual form of the malaria parasite, developing either in tissue or in blood cells. The nuclei of schizonts show evidence of schizogonic division. The schizonts are qualified as mature when the nuclei and the cytoplasm are fully divided so that the merozoites have taken shape; erythrocytic schizonts are then called "segmenters" or (colloquially) "rosettes".

schizontocide. Drug which destroys the asexual forms of malaria parasites. Schizontocides are distinguished as blood schizontocides and tissue schizontocides. When "schizontocide" is used alone, it usually refers to a blood schizontocide, i.e., one which acts on the erythrocytic asexual parasites. Tissue schizontocides are those drugs which destroy the exoerythrocytic stages of the parasite. If they act on the primary exoerythrocytic forms they are referred to as primary tissue schizontocides ("causal prophylactic drugs"); if on the secondary forms, as secondary tissue schizontocides.

Schuffner's dots. Fine, evenly distributed granulations brough out by suitable staining in red cells infected with P. vivax and P. ovale. The granulations seen in Plasmodium ovale infections are better known as James's stippling.

scoping. A process, adopted from the Council on Environmental Quality regulations, which attempts to focus analytical attention on the significant issues to be addressed in an Environmental Assessment (EA) or an Environmental Impact Statement (EIS), thereby eliminating unnecessary detail and improving the usefulness of those documents in decision making. See Regulation 16: 216.3(a)(4) in Manual, Chapter 10.

seasonal house spraying. Seasonal house spraying involves the spraying of homes only when the expected population of mosquitoes would be high.

secondary productivity. Rate of production of new biomass at consumer trophic levels, by repackaging the biomass of organisms below each trophic level.

seepage. The slow movement of water into, through, or from the soil to form a pool on the surface. Seepage into a body is referred to as influent seepage; that away from a body as effluent seepage.

segmentation. Schizogonic division of malaria parasites leading to the formation of merozoites.

segmenter. Mature erythrocytic schizont.

selection pressure. In applied entomology, any selective effect of an insecticide favouring survival of those individual insects which carry a particular hereditary factor or factors, while those which do not carry these factors are killed.

selective insecticide. An insecticide which while killing the pest individuals spares much or most of the other fauna, including beneficial species, either through differential toxic action or through the manner in which the insecticide is utilized (formulation, dosage, timing, etc.).

semiarid. A term applied to a country or climate with precipitation ranging from about 10 to 20 inches per year.

Septene®. See carbaryl.

"Seven-Step Scheme". See W.H.O. "Seven-Stage Scheme".

Sevidol®. See carbaryl.

Sevimol®. See carbaryl.

Sevin®. See carbaryl.

shrub. A woody plant which at maturity is usually less than 6 m (20' feet) tall and generally exhibits several erect, spreading, or prostrate stems and has a bushy appearance; e.g., speckled alder (*Alnus rugosa*) or buttonbush (*Cephalanthus occidentalis*).

Silosan®. See pirimifos-methyl.

silt. Soil particles ranging from 0.002 to 0.05 mm. in diameter (U.S. Department of Agriculture classification).

siphon. A tube or pipe, usually bent in the shape of an inverted "U" by which water can be transferred from an upper level, over an obstruction, to a lower level. Atmospheric pressure forces the water up the shorter, or upper, leg of the siphon while the excess weight of the water in the longer, or lower, leg causes flow. Small siphons are commonly used to divert water from ditches to furrows or checks. Their use eliminates the need for cutting the ditch banks, which is often a distinct advantage.

slug dosage. The introduction at one point in a body of water of a sufficient amount of insecticide to treat the entire body of water. This system depends upon currents to disperse the insecticide throughout the body of water.

smoke, insecticidal. Insecticide particles produced and distributed in the air by smoke generators. The particles in insecticidal smokes of pyrethrum, rotenone and arsenicals range between 0.3 and 2 u in diameter.

smoke generator. Apparatus used to produce insecticidal smoke, as from slow-burning pellets, canisters, fumigant candles, etc., in which the insecticide is mixed with some inflammable material which is ignited.

social heterogeneity. Social heterogeneity is having unlike beliefs or customs pertaining to the life and relation of human beings in a community.

solution. A single-phase liquid system in which the particles of dissolved solid, liquid, or gas are molecules or ions. Insecticide formulations used in mosquito control which are solutions include mainly the oils.

Soprathion®. See parathion.

sorption. Term covering the phenomena of adsorption and absorption which occur when an insecticide deposit rests on a pervious surface; the action takes place partly from the vapour phase but mostly by direct diffusion from the crystals over the surface, with further diffusion inside the underlying layers. It generally results in progressive inactivation of the insecticide deposit.

sound. A body of water that is usually broad, elongate, and parallel to the shore between the mainland and one or more islands.

source of infection. Person harbouring malaria parasites infectious to a vector mosquito, who may have clinical symptoms of malaria or may be a symptomless parasite carrier. Any person with parasitaemia should be considered a potential source of infection.

source of mosquitoes. See breeding place and mosquito source.

source reduction. Use of preventive control measures against a vector or pest, by which its habitat is changed or eliminated. In malaria control, the drainage of a swamp, management of water level, or elimination of water plants. See Manual 11.62.

space-spraying. Spraying of a given space (not a surface) in or out of doors.

species. Group of organisms capable of exchanging genetic material with one another and incapable, by reason of their genetic constitution, of exchanging such material with any other group of organisms. The limits of species are indicated by the comparative study of morphological and other characters.

species complex. Group of closely related organisms, the exact specific status of which is uncertain, although they resemble some well-recognized type species.

species-group. An assemblage of co-ordinate categories, viz., species and subspecies.

species eradication. Complete elimination from a territory of one or more species of malaria vectors.

species infection rate. The percentage of individuals found to be infected with any given species of Plasmodium is the species infection rate for the species, e.g., the vivax infection rate.

spiracle (pl. spiracles). The breathing pore in some animals, the openings in the thorax and/or abdomen of an insect body through which respiration usually takes place.

spleen, average. Weighted average spleen size determined in all subjects of a specified age group in an examined sample of the population, including those whose spleens are not palpably enlarged. (This index is rarely used.)

spleen, average enlarged. Weighted average spleen size of those subjects with a palpably enlarged spleen in a specified age group of the sample of population examined. This index is obtained by multiplying the number of individuals in each arbitrary classification of enlarged spleen by the class number, adding the products, and dividing the total by the number of individuals whose spleens are palpable.

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spleen measurement. Determination of spleen sizes in a group of persons, usually children 2-9 years of age, as a basis for classification, usually into arbitrary classes numbered from 0 to 5. From the results the average-enlarged-spleen value is calculated.

spleen rate. The spleen rate is the percentage of persons (usually children of 2-9 years) showing palpable enlargement of the spleen at a given time. If the spleen rate is assessed in other age groups, this should be specified, e.g., adult spleen rate if it is measured in adults.

spoil bank. During the construction of a ditch or canal, the excavated material, or "spoil" is usually piled on one or both sides of the excavation. The resulting embankments are called "spoil banks".

sporadic. Term applied to malaria when autochthonous cases are too few and scattered to cause any appreciable effect on the community. These cases are often due to relapses of a previous infection: for purposes of epidemiological classification by origin of infection, the term "relapsing" is then preferred.

sporogony. Process of development occurring in the mosquito which follows sexual union of gametes and ends with the formation of sporozoites.

sporontocide. Drug which, when given to the malaria-infected vertebrate host, prevents or interrupts the development of the parasite in mosquitos feeding on that host. Also know as "antisporogonic drug".

sporozoite. Final stage of sporogony of Plasmodium in the mosquito; the infective form of the malaria parasite occurring either in a mature oocyst before its rupture or in the salivary glands of the mosquito.

sporozoite rate. This is the percentage of female anophelines of a given species caught in nature and found, on dissection within 24 hours of capture, to contain sporozoites in the salivary glands.

sporulation. Strictly, production of spores by multiple cell fission; incorrectly used for schizogony.

Spotton®. See fenthion.

sprayable. In malaria eradication terminology, designated (or of a type designated) for spraying.

sprayable surface. Parts of a sprayable house and its furnishings which are designated for spraying. The mean estimated area of the sprayable surfaces expressed in square metres (or square feet) per house or per inhabitant is termed the "average sprayable surface".

spray-capture. Collection of mosquitos which are knocked down by a quick-acting insecticidal spray within a closed space.

sprayed houses. In malaria eradication terminology, those structures designated for spraying in which all sprayable surfaces are reported as completely sprayed by the end of the current spraying operations. See also house-spraying.

sprayed locality. In malaria eradication terminology, a locality in which all sprayable structures have been sprayed during the current spraying operations except for pending houses.

sprayer. Apparatus used for applying liquid insecticides, herbicides and fungicides, in solution, emulsion or suspension, sprayable surfaces (also called "spray pump"). The three types usually used in malaria eradication programmes are the compression sprayer, the stirrup-pump sprayer and (rarely) the knapsack sprayer.

sprayer, bucket-pump. Synonym of stirrup-pump sprayer.

sprayer, compression. Pneumatic, pre-pressurized sprayer (also known as "pneumatic sprayer"). The pressure is normally furnished by a hand-operated pump incorporated in the apparatus, but it may be supplied from an independent source. The tank is usually circular in shape, with a working capacity of approximately 7½-15 litres (2-4 US gal). The sprayer is fitted with one or two straps for convenience in carrying.

sprayer, knapsack. Sprayer designed to be carried on the back by two straps passing over the shoulders of the operator. A continuous discharge is achieved by the constant operation of a pump incorporated within the tank. The tank may be shaped to the contour of a man's back or may be provided with a contoured shield.

sprayer, pneumatic. Synonym of compression sprayer.

sprayer, stirrup-pump. Sprayer held within a bucket or similar container by an adjustable foot-stirrup or fitted into a tank (also known as "bucket-pump sprayer"). Single- and double-barrelled types are available; the basic principle is the same in both. The single-barrel type consists of a barrel, a hollow plunger-shaft moving within the barrel (which acts as an air chamber), a plunger, and the necessary valve assembly. In the double-barrelled type the main barrel forms the air chamber, with the pump and plunger in a second barrel alongside. The plunger in both cases is operated manually by an up-and-down movement within the barrel.

spraying, barrier. Spraying in an area of predetermined shape and size to protect the population living in and beyond the sprayed area.

spraying, focal. House-spraying carried out in strictly localized areas such as one house or a group of dwellings; or in localities classified as either residual or new foci of malaria. During the consolidation phase focal spraying is an activity of surveillance operations.

spraying, residual. Spraying of a residual insecticide.

spraying cycle. Repetition of spraying operations at regular intervals; often designated in terms of the interval between repetitions, e.g., a six-month spraying cycle, one in which spraying is repeated after a six-month interval. Not to be confused with spraying round.

spraying frequency. Number of regular insecticide applications per house per year.

spraying interval. Time elapsing between successive applications of insecticide.

spraying round. Single spraying of all sprayable houses in an area over a period of time. Not to be confused with spraying cycle.

spraying squad. In malaria eradication terminology, the basic operational unit for spraying operations, composed usually of two to six spraymen under a leader.

sprayman. In malaria eradication terminology, the employee responsible for identifying and spraying the sprayable surfaces in the houses assigned to him by the squad leader and for correct utilization and maintenance of his equipment.

sprayman workrate. Average work output of a sprayman, usually expressed as the number of houses or the number of square metres sprayed per working day.

sprinkler irrigation. A method of irrigation in which the water is sprayed, or sprinkled, over the surface of the ground. Ideally, the water is applied at the rate at which it will soak into the soil so that no standing water remains. This method is particularly advantageous on uneven ground where leveling is impossible or very expensive, or on sandy soils where other irrigation methods result in excessive deep percolation losses.

spring tide. The highest high and lowest low tides during the lunar month.

staff gage. A linear scale located on a staff, plank, pier wall, etc., extending into the water, by which the elevation of the water surface may be read.

stage. Any definite period in the development of an insect; e.g., egg, larva, pupa, adult.

stagnant. Not flowing; not running in a current or stream; motionless; hence, foul from want of motion; as a stagnant pond, stagnant blood, air. Aged or stale.

standpipe. A vertical, open-ended pipe or tank connected to a pipeline to release air from the system and to prevent the development of excessive pressure by surges within the system.

Stathion®. See parathion.

stippling. See under James's stippling; Maurer's spots; Schuffner's dots; Ziemann's stippling.

stirrup pump. See under stirrup-pump sprayer.

stomach infection. See gut infection.

stone. Rock fragments larger than 25.4 cm (10 inches) but less than 60.9 cm (24 inches).

strain. Population of the same stock descended from a common ancestor or derived from a single source. Strains behaving in a similar manner are homologous; those behaving dissimilarly are said to be heterologous.

strip check (border strip irrigation, bordered check, strip irrigation). The area of land bounded by parallel earthen levees or ridges that guide irrigation water from the point of application to the end of the strip. The land between levees is level, the strip is gently sloped lengthwise, and irrigation is by flooding.

subirrigation. 1. Watering plants by applying the water below the ground surface. 2. Irrigation by raising and lowering the water table within or near the root zone, often under control.

submergent plant. A vascular or nonvascular hydrophyte, either rooted or non-rooted which lies entirely beneath the water surface, except for flowering parts in some species; e.g., wild celery (Vallisneria americana) or the stoneworts (Chara spp.).

subsoil. The material lying below the surface soil, generally devoid of humus or organic matter.

subspecies. Population of organisms originally belonging to the same species but so isolated by geographical barriers from other populations of the species as to have undergone taxonomically significant genetic divergence. Forms accorded the rank of subspecies are distinguished in nomenclature by a third name, so that the full designation is trinominal.

Sumithion®. See fenitrothion.

Suncide®. See propoxur.

superinfection. Fresh infection brought about in a host while a previous infection with a parasite of the same species is still present.

suppression. See under suppressive treatment.

surface-active agent. Substance which, when present even in very low concentration, lowers the surface tension of its solvent. Typical effects of surface-active agents, or "surfactants" (also known as "wetting agents"), are the functions of wetting, foaming, dispersion, emulsification and detergence.

surface area. In the application of insecticides, the area treated with finished spray or dry formulation. Can be the surfaces of bodies of water, buildings, walls, fences, or soil, surface area can be expressed as square feet and acres, or as square meters and hectares.

survey (engineering). The operation of finding and delineating the contour, dimensions, position, etc., as of any part of the earth's surface, whether land or water; as, a land or a hydrographic survey; also, a measured plan and description of any portion of country, or of a road or line through it. To determine and delineate the form, extent, position, etc., as of a tract of land, a coast, harbor, or the like, by taking linear and angular measurements, and by applying the principles of geometry and trigonometry.

survey (general or biological). A critical examination, inspection, or exact measurement often of an official character, for an implied or specified purpose; an ascertaining of facts regarding condition or conditions, to provide exact information, especially to those responsible or interested; often, a study of a given area with respect to a certain condition, or its prevalence. The act of examining something with reference to its condition.

surveillance. Oversight, close supervision, close watch. The continuing or repetitive investigation and collection and analysis of data to reveal current trends which are expected to change. In malaria eradication terminology, that part of the programme aimed at the discovery, investigation and elimination of continuing transmission, the prevention and cure of infections, and the final substantiation of claimed eradication. The individual functions of surveillance are case detection, parasitological examination, antimalarial drug treatment, epidemiological investigation, entomological investigation, elimination of foci by either residual spraying or mass drug administration, case follow-up and community follow-up.

survival, probability of. Mathematical expression of the likelihood of a female anopheline remaining alive for a specified period of time.

susceptibility. 1. Liability in a population of insects to be killed by a particular insecticide. The average susceptibility of a species or population of mosquitos is usually measured in terms of the median lethal concentration (LC_{50}). 2. Liability of a species of mosquito to become infected when fed on a person known to be infectious; usually measured in relation to the liability of infection of another species fed at the same time on the same person. 3. Liability of a person to become infected. The lower the immunity, the higher the susceptibility.

suspected case. See under suspected case.

suspensibility. Ability of a substance to enter into and remain in suspension. The suspensibility of an insecticidal water-dispersible powder is measured by the amount of insecticide which remains in suspension for a given time under specified conditions after having been submitted to a treatment simulating tropical storage.

swamp. A wetland (water-dominated) with more than 40% cover by woody plants (scrub or forest).

swarming. Nuptial flight or dance in which males of some species of mosquito gather together on the wing, usually at dusk or in dim light, in the open, moving up and down without horizontal progression; the females fly into the swarm of males, and copulation takes place in the air.

swath. Strip or band of fluid produced on a surface by the use of a sprayer. In house-spraying, a swath may be applied while the sprayman stands still and moves the lance vertically ("vertical swath") or (less commonly) while the sprayman walks parallel to the wall holding the lance at a given height ("horizontal swath").

swath, width, effective. Distance between centre lines of successive properly sprayed swaths; it is equal to the swath width minus the overlap.

sylvatic. Living in forested areas.

synergism. Joint action of non-antagonistic substances. As applied to drugs, there are two main types of synergism: addition, in which the combined effect of the drugs is equal to the sum of their separate effects, and potentiation, in which the combined effect exceeds the expected sum of their separate effects.

Synthrin®. See pyrethroids.

tail water. 1. The water, in a river or channel, immediately downstream from a structure. 2. The excess irrigation water which reaches the lower end of a field.

tank charge. Quantity of insecticide formulation (water-dispersible powder, emulsifiable concentrate or technical product) required for each filling of a sprayer. For water-dispersible powder, the insecticide tank charge should be weighed and distributed in paper, plastic or cloth bags. The amount of liquid charge is usually between one-half and three-quarters of the total capacity of the tank.

target organism. The object of a control effort.

Teknar®. See B.t.i.

temephos (Abate®, Biothion®). A slightly toxic organophosphate insecticide used as a larvicide in mosquito control. It is relatively non-toxic to fish, but bees, shrimp, crabs and birds may be affected.

temporary equilibrium position. The average density of a population over a large area temporarily modified by a procedure such as continued use of insecticides.

tenue form. Appearance characteristic of certain strains of P. falciparum, brought out in rapidly dried thin films.

terrigenous. Derived from or originating on the land (usually referring to sediments) as opposed to material or sediments produced in the ocean (marine) or as a result of biologic activity (biogenous).

tertian. Recurring every other day (every 48 hours). See also tertian malaria.

thiophos. See parathion.

threshold decision. A formal decision by an agency, based upon an initial environmental examination (IEE), as to whether a proposed agency action will or will not have a significant (important[1]) effect on the human or natural environment, and if negative, whether an environmental assessment (EA) or an environmental impact statement (EIS) is required by law. See Regulation 16: 216.1(c)(3), 216.3(a)(2) and 216.3(a)(4)(iv) in Manual, Chapter 10.

Tiguvon®. See fenthion.

Tilapia spp. Herbivorous fishes used in aquatic weed control, thereby enhancing the effectiveness of physical and biological control of mosquito larvae.

tile drain. A drain constructed by laying drain tile, with unsealed joints, in the bottom of a trench which is refilled after the tile is laid. Tile drains are installed to remove excess water from the soil.

tissue stages. Schizogonic stages of malaria parasites occurring in cells other than erythrocytes in the vertebrate host. See also exoerythrocytic schizogony.

tolerance. 1. Effect characterized by a lessened response to a given quantum of infection, of a toxicant or of a drug. 2. In insects, the characteristic ability of some species, on first exposure to an insecticide, to survive higher dosages of it than other zoologically related species which are normally susceptible. Increased insecticide tolerance may be seasonal, e.g., related

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1. See environmental importance as defined in this Manual, 1.3.

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to pre-hibernation, or may be due to a general increase in vigour affecting susceptibility to any insecticide ("vigour tolerance"). It may also at times be a sign of incipient physiological resistance to an insecticide.

tolerance level. The lowest population density at which a vector will cause economic loss, transmit disease, or exceed human tolerance. See economic injury level.

tolerance threshold. The population density at which control measures should be implemented to prevent an increasing vector population from reaching an intolerable level. See economic threshold.

tolerate. To endure or resist the action of (as an insecticide) without grave or lasting injury.

total coverage. 1. In case detection, activity in an area under surveillance which covers every locality and every household with adequate efficiency throughout the year or during the time when transmission occurs. 2. In mass drug administration, general distribution of drugs to a population in such a way as to assure the continuous maintenance of an effective drug concentration in the blood of every individual. 3. In spraying operations, application of insecticide during one spraying cycle to all sprayable surfaces in all sprayable houses within a given operational area.

total spray coverage. Total spray coverage is the application of residual insecticide during one spraying cycle to all sprayable surfaces in all sprayable houses within a given operational area.

toxicant. See poison.

toxicology. The science which treats of poisons, their action, antidotes, and uses.

transmission, natural. Process by which a vector mosquito transfers the parasite from an infectious subject to a susceptible recipient. From an epidemiological standpoint, natural transmission may be perennial (when transmission occurs throughout the year without great variation of intensity), subperennial (when it occurs throughout the year with peaks of markedly greater intensity in some months) or seasonal (when it occurs only during some months and is totally interrupted during other months). From an operational standpoint transmission continuing during eradication measures may be either residual (when it still persists in spite of the application of interruptive measures) or renewed (when there is recurrence of transmission in areas where it had been previously interrupted).

transmission season. Period of the year during which natural transmission of malaria infection can normally take place.

transpiration. The process by which water vapor is released to the atmosphere by the foliage or other parts of a living plant.

transverse. Broader than long; running across; cutting the longitudinal axis at right angles.

trap breeding place. Artificial breeding place constructed with the purpose of collecting mosquito eggs or larvae.

trap hut. Structure adapted for trapping mosquitos attracted by bait (human or animal) placed inside it. Its purpose is either to collect a representative portion of the incoming mosquitos or to test the effectiveness of an insecticide. It is usually a hut of simple design, often built of the same material as the local habitations, provided with trapping devices--usually one or more window traps so that mosquitos may be trapped as they enter or leave.

treatment, anti-relapse. Treatment aimed at the prevention of relapses, particularly long-term relapses.

treatment, presumptive. Administration of an antimalarial drug or drugs, usually in a single dose, in suspected malaria cases before the results of blood examinations are available. Its principal objectives are relief of clinical symptoms and prevention of transmission.

treatment, radical. Treatment adequate to achieve radical cure. In vivax, malariae and ovale infections, this implies the use of drugs which destroy the secondary tissue stages of the parasite.

treatment, suppressive. Treatment aimed at preventing or eliminating clinical symptoms and/or parasitaemia by early destruction of erythrocytic parasites. It does not necessarily prevent or eliminate the infection, and overt malaria may develop after drug withdrawal.

treatment schedule. Scheme of administration of a drug.

tree. A woody plant which at maturity is usually 6 m (20 feet) or more in height and generally has a single trunk, unbranched to about 1 m above the ground, and a more or less definite crown; e.g., red maple (*Acer rubrum*), northern white cedar (*Thuja occidentalis*).

Tricarnam®. See carbaryl.

trophic level. Position of any living thing in the food chain, determined by the number of energy-transfer steps to that level. The commonly conceived minimum levels are: plant (energy producer); and herbivore, carnivore, and detritivore (energy consumers).

trophozoite. Strictly, any asexual and growing parasite with undivided nucleus. In malaria terminology, generally used to indicate intracellular erythrocytic forms in their early stages of development. Trophozoites may be in either a ring stage or an early amoeboid or solid stage, but always have the nucleus still undivided.

Turbellaria. See flatworms.

turnout. A structure used to divert water from a canal to a farmer's lateral.

ultra low volume (ULV) spraying. Ultra low volume (ULV) spraying is a method of insecticide dispersion by special air or ground equipment using very small amounts of finely dispersed particles of insecticide.

Unden®. See propoxur.

unicameral. Unicameral refers to having a single assembly or legislature.

unit. A single thing, such as a magnitude or number. Example: the expression, "per unit of area", means per each single acre or square foot or other unit of area measurement.

unit head. The amount of water turned into each furrow or border check during irrigation.

unstable malaria. Unstable malaria refers to those areas where there are frequent outbreaks with the general incidence remaining at low levels.

vacuole. Portion of the young parasite, usually near the centre, showing very faint staining or none and surrounded by a circle or semicircle of cytoplasm.

Vapona®. See dichlorvos.

variety. A mosquito that possesses a slightly different character or variety of characters than is wholly characteristic of the population of which it is a member. "Variants" appear at random and do not seem to be associated with geographical or ecological variations in habitat. Mosquitoes possessing these characters do not represent distinct subgroupings within the population.

Vectobac®. See B.t.i.

vector. In medical and veterinary entomology, any organism (such as an insect or other arthropod) which 1) transports and transmits a parasite (including disease-causing pathogens) from one host to another, 2) causes direct harm or injury without transmitting a parasite, or 3) causes significant annoyance to humans and/or animals. In malaria, any species of mosquito in which the plasmodium completes its sexual cycle in nature and which is thus able to transmit the disease.

vector, conditional. Species of mosquito known to transmit malaria but presumed to be incapable of maintaining endemic malaria in the absence of more efficient vectors.

vector, principal. Species mainly responsible for transmitting malaria in any particular circumstances. Principal vectors may overlap or may alternate seasonally.

vector, secondary. Species thought to play a minor role in transmission in association with a principal vector and to be capable of maintaining malaria only at a reduced level in the absence of the latter.

vector control. Measures of any kind directed against a vector of disease and intended to limit its ability to transmit the disease.

vector density. Vector density is the number of female Anopheline mosquitoes in relation to the number of specified shelters or hosts or to a given time period specifying the method of collection.

vector efficiency. Ability of a mosquito species, in comparison with another species in a similar climatic environment, to transmit malaria in nature. A rough estimate of relative efficiency may be made by comparison of sporozoite rates taken in comparable conditions.

vector resting place. Vector resting place is the surfaces on which mosquitoes rest before or after blood meals, i.e., walls, ceilings, thatch, etc.

vector susceptibility. Vector susceptibility represents the degree to which a species of mosquito develops resistance to the effects of insecticides.

ventral. Situated on or belonging to the lower surface; opposite of dorsal.

vermicule, travelling. Obsolescent term for ookinete.

vertebrate. An animal with a segmented spinal column or a primitive form in which the backbone is represented by a notochord.

vigilance. In malaria eradication terminology, a function of the public health service during the maintenance period, consisting in alert watchfulness for any occurrence of malaria in an area in which it had not existed or from which it had been eradicated, and the application of the necessary measures against it.[1]

vigor tolerance. General increase in the ability of a mosquito species to survive exposure to many types of insecticide, i.e., a decline in the normal susceptibility depending on a non-specific defense mechanism.

virus. A particle visible only with the electron microscope, exhibiting living traits and producing disease in plants and animals, hence an infectious agent.

vivax malaria. Vivax malaria is recurring type of malaria caused by Plasmodium vivax, a species of malaria parasite. Vivax malaria is characterized by paroxysms on alternate days (tertian malaria).

volume. Space occupied as measured by cubic units; hence a mass or bulk; cubic inches, cubic feet, cubic centimeters (milliliters), gallons, liters.

volumetric. Relating or pertaining to the measurement of volume.

voluntary collaborator. Person belonging to and permanently present in the community who is not a paid staff member of the malaria eradication service but who co-operates voluntarily in surveillance activities such as case detection, notification and treatment. For operational purposes voluntary collaborators are regarded as malaria detection posts.

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1. In Spanish-speaking countries vigilancia is used to express the activities both of surveillance and of vigilance proper.

W.H.O. "Five-Stage Scheme". A procedure designed by the World Health Organization (1975a) for screening and evaluating the efficiency and safety of biological agents for control of disease vectors. See Manual 11.641.

W.H.O. "Seven-Stage Scheme". A procedure designed by the World Health Organization (1960) for the screening, evaluation, testing, and field trials of candidate insecticides for vector control. See Manual 11.90.

wasteway. 1. A channel which conveys or discharges excess or waste water from a canal or river.

water application efficiency. The fraction of the water delivered to the farm that is stored in the root zone for use by the crop, expressed as percent.

water-dispersible powder. Insecticidal formulation consisting of the insecticide, together with suitable carrier(s) and surface-active agent(s), designed for suspension in water.

water management. Water management involves the reduction or elimination of sources of mosquito breeding through filling, draining, diking, changes in water level, flushing, canal trimming and other engineering methods. See also irrigation water management, source reduction, and physical mosquito control.

water right. A legal right to the use of water.

water spreading. The artificial application of water to lands for the purpose of recharging ground waters for subsequent withdrawal.

water table. The elevation at which pressure in unconfined ground water equals atmospheric pressure; the elevation at which water stands in a hole dug down to the water table. The upper surface of a zone of saturation. No water table exists where that surface is formed by an impermeable body.

weir. 1. A dam across a stream for diverting the flow into a canal. 2. A device for measuring the flow of water.

wettable powder. Colloquial term for water-dispersible powder.

wetting agent. Synonym of surface-active agent.

window trap. Type of removable screened insect trap fitted to an opening of a typical inhabited or experimental hut and used for collection of incoming ("inlet trap") or outgoing ("outlet trap") mosquitos.

woody plant. A seed plant (gymnosperm or angiosperm) that develops persistent, hard, fibrous tissues, basically xylem; e.g., trees and shrubs.

xenodiagnosis. Exceptional method of diagnosing malaria in the suspected vertebrate host by feeding vector mosquitos on him and subsequently examining the mosquitos for the presence of sporogonic stages of the malaria parasite.

xerophyte, xerophytic. Any plant growing in a habitat in which an appreciable portion of the rooting medium dries to the wilting coefficent at frequent intervals. (Plants typically found in very dry habitats.)

yala season (Thailand). Yala season refers to the northeast monsoon season characterized by high rainfall during December through February.

Ziemann's stippling. Granulations brought out by special staining in erythrocytes infected by Plasmodium malariae.

Zithion®. See malathion.

zone. In malaria eradication terminology, a territorial and administrative operational unit responsible for the operation, evaluation and administration of the field programme in its area, which often coincides with an administrative division of the country. The zone office is normally under the direction of a senior professional officer, responsible for execution of all operations and routine evaluation of results in the zone.

Zoological Nomenclature, International Code of. Code of rules established by the International Commission on Zoological Nomenclature and periodical ised.

zoology. The science which treats of animals.

zoonosis. Disease or infection common to man and other vertebrates turally transmitted between these hosts.

zoophilic, zoophilism. Term applied to mosquitoes showing a relati erence for non-human blood, such as cattle, even when human hosts are re vailable.

zygote. Product of the union of the male and female gamete; term f used incorrectly to designate the oocyst.

CHAPTER 27 INDEX

(None prepared for this draft)