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WATER POLLUTION CONTROL IN THE BANGKOK METROPOLITAN REGION

A Report Prepared for the
National Research Council, Royal Thai Government
in Cooperation with the
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Bangkok, Thailand
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By Harvey F. Ludwig

January 5, 1973

O U T L I N E

WATER POLLUTION CONTROL IN THE BANGKOK METROPOLITAN REGION

ABBREVIATIONS USED IN REPORT

AIT	Asian Institute of Technology
ASRCT	Applied Science Research Corporation of Thailand
BSDC	Bangkok Sewerage and Drainage Committee
ECAFE	Economic Commission for Asia and the Far East (United Nations)
EERI	Environmental and Ecological Research Institute (of ASRCT)
EEU	Environmental Engineering Unit (of EERI, ASRCT)
EGAT	Electric Generating Authority of Thailand
EPA	Environmental Protection Agency (USA)
NCEQC	National Committee on Environmental Quality Control
NCHE	National Committee on Human Environment
NEC	National Executive Council
NESDB	National Economic and Social Development Board
NRC	National Research Council
RID	Royal Irrigation Department
RTG	Royal Thai Government
SEAFDEC	Southeast Asian Fisheries Development Center
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organization
USOM	United States Operations Mission (US/AID,Thailand)
WHO	World Health Organization

I. INTRODUCTION

NATURE AND PURPOSE OF PROJECT

Interest in environmental pollution in Thailand, especially water pollution, has been steadily increasing over the past decade, particularly in the rapidly growing Bangkok Metropolitan Region, which is the only major urban complex in the country. As a result of this interest the RTG (Royal Thai Government), on the recommendation of the National Economic and Social Development Board (NESDB), established the Bangkok Sewerage and Drainage Committee (BSDC) in 1962. This Committee arranged for retaining engineering consultants for carrying out an engineering analysis of the pollution/drainage problems in the region, with the results presented in early 1968 in the report, "Master Plan/Sewerage, Drainage and Flood Protection Systems/Bangkok and Thonburi" (the "Master Plan Report") (Reference 8A).

Although this Master Plan Report represented a major achievement in sanitation/water pollution control history in the Bangkok Metropolitan Region, since 1968 little has been done to implement the report's recommendations, primarily because of the high construction costs involved, despite the continuing growth of population and industry and intensification of the water pollution problem. Nevertheless, public interest in the problem has continued to increase, resulting in establishment in 1970 by the RTG of a National Committee on Environmental Quality Control (NCEQC), headed by Dr. Pradisth Cheosakul, who is also Secretary-General of the National Research Council of Thailand (NRC), with the assignment of evaluating the environmental pollution situation in Thailand and of developing recommendations on desired steps to be taken by the Government (Reference 7B).

The present report is the result of a request by Dr. Pradisth to USOM to furnish the services of a short-term expert consultant on water pollution control, to assist NRC/NCEQC in evaluating the water pollution problem in the Bangkok Metropolitan Region and in developing suitable recommendations. In response to this request, USOM assigned to Dr. Pradisth the services of Dr. Harvey F. Ludwig over the period of three months, 6 October 1972 through 5 January 1973. The present report is a report of NRC/NCEQC, prepared by Dr. Ludwig together with the staff of NRC working under Dr. Pradisth's direction.

Early in 1972 the RTG established the National Committee on Human Environment (NCHE) (Reference 7C), which has been also busy in studying environmental pollution problems and in developing recommendations for consideration by the RTG. The NCHE has established a working group or Executive Committee headed by Mr. Renoo Suwansit, Secretary-General of NESDB. During the preparation of the present report, the NRC/NCEQC staff including Dr. Ludwig have met with Mr. Renoo and his staff in order to assist in the

Executive Committee's efforts. It is hoped that the present report will be of value to the NCHE, as well as to NRC/NCEQC, and will contribute to the common objective of arriving at decisions on desirable specific action programs to be undertaken by the RTG.

CONDUCT OF STUDY

The specific assignment carried out by the Special Consultant in furnishing assistance to the NRC/NCEQC included six items as follows:

(1) Reviewing existing technical reports relative to the extent and scope of water pollution in the Bangkok-Thonburi area.

(2) Reviewing existing laws, statutes and regulations on water quality and water pollution prevention and abatement.

(3) Reviewing present control and enforcement activities in this field by the various concerned RTG agencies.

(4) Assisting in the drafting of sound water quality standards and criteria.

(5) Assisting in the drafting of sensible and enforceable, laws, statutes and regulations in water pollution control.

(6) Providing recommendations regarding the formation or reorganization of a coordinated control agency or group of agencies required for effective water pollution control.

The approach to carrying out this assignment was based primarily: (1) on meetings and "work sessions" with key officials of the RTG having interests in water pollution, and also on meetings with other available persons interested in the subject and willing to help, including members of international agencies and of the local universities; (2) on review of available reports and publications relating to the subject; and (3) on several field visits to inspect conditions in the klongs and rivers and to review typical industrial waste treatment plants. Arrangements for most of these meetings were made by Miss Praparsri Thanasukarn of NRC (also Secretary of the NCEQC), who also attended most of them and otherwise assisted in the work of the Special Consultant.

Appendix I is a listing of persons who were interviewed and Appendix II is a listing of reports, publications, and other references which were considered. Supplemental Report I is a compilation of notes of the meetings, and Supplemental Report II is a compilation of brief abstracts of the significant references.

WATER POLLUTION PROBLEM IN BANGKOK REGION

The following is a general description of the pollution problem in the Bangkok Metropolitan Region, for the purpose of outlining the nature and extent of the problem as background for subsequent discussion.

The Bangkok Metropolitan Region, now comprising both the municipality of Bangkok on the east side of the river and the municipality of Thonburi on the west side, has been growing very rapidly (about 3.2 percent per year) and now has a population of approximately 4 million. It is the only metropolitan center in Thailand (the next largest municipality is Chiengmai, with a population of only about 100,000). The Bangkok Region is situated in the delta of the Chao Phraya River (the largest in Thailand), some 50 km up-stream from its point of discharge into the Gulf of Thailand, in an area which was previously rice paddies (Figure 2). The average elevation is only about one meter above sea level, hence the region is very flat and at best the natural drainage is very slow and poor. The drainage pattern is fixed by a system of man-made canals or klongs, built by excavating the earth (a tight clay) in the early history of the area, primarily to provide transportation and for military protection (Figure 4).

In earlier times the system of klongs together with the river into which the klongs discharge did serve to receive and dispose of the waste of the region in an acceptable manner, and the klongs contributed greatly to the aesthetic charm of the community. However, this system with its fixed capacity for assimilating wastes has become greatly overtaxed by the increasing community growth. Today the entire system of klongs and the river is heavily polluted from the sanitary wastes of the population, plus garbage and refuse thrown into the klongs and river from nearby dwellings and commercial establishments, plus discharges of wastes from industries scattered throughout the region.

Pollution in Klongs

There are no sanitary sewers in Bangkok, only street drains which receive surface runoff and also, by indirect flow, much of the effluents from septic tank systems serving individual buildings. Because of the tight clay type of soil, little of the septic tank effluent percolates downward and therefore finds its way into the drains and klongs. Also, because septic tanks do not effect much removal of organic material, most of the organic pollution from the entire population eventually reaches the klongs and the river.

The organic loadings reaching the klongs from septic tanks are supplemented by solid wastes from nearby buildings. Although

throwing refuse into klongs is illegal, many of these buildings are not serviced by the municipal refuse pick-up trucks because of access difficulties.

With the respect to industrial wastes, the Bangkok Region represents the largest concentration of industry in Thailand, and many of these produce wastes which create serious local pollution problems despite efforts to require industries to treat their own wastes. While some of the larger industries do create and intensify local pollution problems, the total organic heading produced by all of the industries is small, less than 5% of the total organic loading originating from people.

Owing to the flatness of the hydraulic gradient, considerable "in-klong" biological treatment takes place in the klongs on the way to the river. Hence the klongs serve not only for purposes of transportation, recreation, bathing, etc., but also as open sewers and as partial sewage treatment systems. Most of the klongs are septic (devoid of oxygen) most of the time, and often black in color and odor-producing and objectionable aesthetically. They are also heavily polluted from the public health point of view, with coliform concentrations almost always at high levels (such that, were the klongs in the USA, they would be quarantined and prohibited for public contact).

The sanitation problem in the klongs has been further intensified by a gradual decrease in the hydraulic capacity of the klongs over the years, due to numerous factors including regulation of the river (by dams upstream) which has tended to reduce or eliminate flushing of the klongs during high river flow, filling in of some of the klongs, and a gradual depreciation of the regular cleaning program. It is possible also that the level of the region is sinking due to pumping of ground water. Hence, the sanitation problems in the klongs are serious not only in the dry season but also in the rainy season due to a gradual worsening of the capability of the klong drainage system to remove surface waters following rains.

Chao Phraya River

The natural (unregulated) flow of the Chao Phraya River averages more than 1,000 cms (cubic meters per second), ranging from about 25 cms to about 4,000 cms. The critical period, with respect to pollution, occurs during the dry season.

The condition of the river, on reaching the Bangkok Region, may be described as "partially polluted", i.e. its oxygen content is appreciable but not at saturation levels, due both to waste discharges and surface runoff upstream. The effect of the pollution discharged from the Bangkok Region, during the dry season, is to use up most of the oxygen reserves of the river, resulting in a "sag" in the dissolved oxygen concentration below the region.

The critical point is about 10 km downstream from Bangkok (about 40 km from the river mouth), where the dissolved oxygen level is reduced to 1.0 mg/l or less, sometimes zero. However, due to regulation of the river by upstream dams, it appears probable that a minimum flow of 150 cms can be maintained in the future which will serve to alleviate the situation for the time being.

Downstream from the Bangkok Region another urban/industrial complex is developing, and it seems likely there will be a continuous metropolitan zone or megalopolis stretching along the river from Bangkok to the Gulf of Thailand and thence along the east coast of the Gulf, with an eventual population by 1990 or so of approximately 10 million. Hence, conditions in the river downstream from Bangkok can be expected to become progressively worse.

Marine Pollution

Another area of concern, in considering water pollution problems in the Bangkok Region, is the upper portion of the Gulf of Thailand, which is important both for recreational uses and commercial fishing especially shellfishing. The Upper Gulf is characterized by extensive estuarine zones (including extensive mud flats) which are the habitats of commercially important clam and mussel species and also of shrimp (the most important marine fishery of Thailand), and also are the breeding areas for commercially important finfish in the Gulf. Pollution from the Chao Phraya and the Mae Klong rivers (Figure 1) has already resulted in serious damage to shellfishing and likely also will have long-range implications on finfish. The Mae Klong River, due to industrial waste discharges (mostly sugar cane mill wastes) is heavily polluted every year during the dry season resulting in severe effects on the cockle clam industry in the vicinity of the river mouth.

MASTER PLAN REPORT

Because of mounting interest in the sanitation problem at Bangkok, the RTG, through the Bangkok Drainage and Sewerage Committee, retained a firm of consulting engineers (Camp, Dresser and McKee) to conduct a comprehensive preliminary engineering investigation over the period 1966-68. The results of this plan, prepared under the supervision of the Committee, were presented in February 1968 in the report, "Master Plan Sewerage, Drainage and Flood Protection Systems/Bangkok and Thonburi" (References 8A, 8B).

The Master Plan Report recommends a comprehensive program of construction of sewerage, drainage, and flood protection, covering a total area of 259 sq.km. (the Master Plan area), with the primary objective to clean up the klongs. The report

recommended delaying any efforts to clean up the river but recommended this need be further studied. Despite the high expectations from this effort, since the report was submitted little has been done to implement its recommendations and the quality of the klong and river water has become progressive worse.

ACKNOWLEDGEMENTS

A large number of individuals and agencies assisted in providing information and otherwise helping in the preparation of this report. Particular thanks are due the National Research Council, Applied Science Corporation of Thailand, Ministry of Public Health, the Municipality, the Ministry of Industry, the Department of Fisheries, the Department of Hydrography, the Bangkok Sewerage and Drainage Committee, the Ministry of Interior, the National Economic and Social Development Board, and of course USOM.

Special appreciation is due to Dr. Pradisth Cheosakul, Secretary General of NRC, for his sponsorship of the study, and to Miss Praparsri Thanasukarn of his staff who furnished continuing staff assistance throughout the project.

II. EVOLUTION OF WATER POLLUTION CONTROL

BASIC CONCEPT OF WATER POLLUTION CONTROL

The term water pollution traditionally has meant the impairment of the beneficial uses of natural waterways, such as rivers, lakes, and marine waters, to which waste effluents are discharged. The beneficial uses include transportation, irrigation, water supply, sanitation, fisheries and other wildlife reproduction, recreation, etc. The uses often represent conflicting interests, and it is the purpose of water pollution regulatory programs everywhere to provide needed protection for all those values which are essential for the continuing health and welfare of the developing community. The object of regulatory programs has been to maintain water quality standards in the waterways at the minimum levels necessary for perpetuation of the essential beneficial uses.

Over the past decade, in the industrialized countries, especially the USA, the concept of water pollution control has been enlarged in scope to include consideration of all environmental works or systems affecting water quality in addition to waste disposal. Hence many of the regulatory agencies in the USA and elsewhere are now termed "quality control" rather than "pollution control" agencies recognizing the impact of virtually all human activities on environmental quality. Waste disposal is still as important as ever, but the new realization is that waste disposal should be part of a planned comprehensive water quality control program (including land use controls and use of regional waste disposal systems), and not be carried out in the traditional manner of trying to clean up "after the fact" the individual pollutional effects of unregulated community activities.

DIFFICULTIES IN ACHIEVING EFFECTIVE REGULATION

Regulation of water pollution has proven to be very difficult to accomplish in all countries. No government anywhere to our knowledge has yet managed to establish an ideal program. However, a great deal of effort has been expanded in the industrialized countries especially in the USA over the past 20 years, in attempting to improve water pollution control programs, and the magnitude of this effort transcends all previous experience in the world. It is estimated that the expenditure in the USA on attempting to control water pollution over the past decade represents at least 90% of the total worldwide expenditure. This experience gained in the USA furnishes a very valuable background of information for guiding thinking here in Thailand. It is hoped that Thailand will profit from the lessons learned in the USA and elsewhere and in particular avoid costly mistakes

which have commonly occurred in the evolution of these programs.

Experience has shown that effective regulation of water pollution is very difficult to achieve, primarily for three reasons. First because control of water pollution is a "negative factor" conflicting with the economic desires of expanding population and industry. The entire history of water pollution control shows that generally no person or agency, whether individual, corporate, or public, is inclined to make any expenditures at all for controlling water pollution, and will make such expenditures only when made to do so by Government regulation. This is the main reason why, in the USA today, authority for control of water pollution is passing from the individual State Governments to the Federal Government. The record shows that most of the States simply have not been capable of realistic enforcement of water pollution control laws.

The second main difficulty in establishing an effective regulatory program is the fact that water pollution activities are of interest to many of the traditional branches of government, such as public health, industry, commerce, agriculture, irrigation, fisheries, etc., so that in nearly every country the tendency is for each branch to develop its own area of activities. This has inevitably led to an unworkable situation of confusion and division of responsibilities. In all countries and States of the USA where effective control has been accomplished, this has been possible only through assigning to a single agency the real power for exercising control over all sources of water pollution. This agency sometimes is controlled by a board which includes representation from the traditional branches of government which are interested and affected.

The third main difficulty is the fact that a water pollution control program to be meaningful must deal with an entire river basin or drainage basin, and not be limited in authority to only a portion of such a basin. However, the traditional structures for political subdivisions of Government are not organized by drainage basins; hence it is necessary, somehow, to provide regulatory control throughout the basin. Experience has shown that this is virtually impossible to achieve through cooperation among the traditional political subdivisions. If effective control of water pollution is desired, the control agency must have juridiction over the entire basin. The total national program then becomes the combination of these individual basin programs.

HISTORICAL EVOLUTION OF WASTE DISPOSAL SYSTEMS

The history of waste treatment and disposal in all countries shows a close correlation between the extent of population and industrial growth and the efforts expended for waste handling facilities. While the water resources of an area remain fixed

in extent, and hence have limited capacity for absorbing wastes, the pollution loadings increase with growth and it is only after detrimental effects on environment are clearly apparent that public policy requires expenditures for waste treatment.

Because waste treatment and water pollution control efforts are more advanced in the USA than elsewhere (in terms of expenditures made), it is useful to review the history of the development of waste disposal philosophy in the USA as a guide for other nations not yet so advanced in industrialization. For this purpose waste disposal history in the USA may be divided into basically five categories:

(1) First Phase/Collecting Sewers: In early USA history, say up to about 1910-20 in most communities, the primary object of waste disposal systems was to remove the wastes from town. Hence the design provided for sewers to collect the wastes and remove them from the town to the nearest available water course. There was little if any consideration of treatment.

(2) The Second Phase, that of "Primary Treatment", came about with the advent of public travel by automobiles (up to about 1930-40). Primary treatment meant holding the waste quiescent for a period of 1 to 2 hours, allowing the sludge to settle and grease to float, with removal of the sludge and grease for separate digestion. While removing only about one-third of the total organic content, primary treatment met the needs of the times by preventing nuisances due to formation of sludge banks and grease mats in the receiving waters.

(3) The Third Phase, "Secondary Treatment" (1940-70), meant biological oxidation of the effluent from the primary treatment system, resulting in removal of another one-third or more of the organic load. This was done essentially to maintain oxygen levels in receiving waters at levels (say 4 ppm) sufficient to prevent immediately observable adverse effects, namely fish kills and odor nuisances.

(4) The Fourth Phase, "Advanced Waste Treatment": Over the period of the past two decades, it has been realized that conventional secondary treatment in itself would not meet the needs of the future (because of increasing loadings discharged to fixed waterways), hence exphasis has been placed on improving secondary treatment to achieve overall removals of BOD of 90 percent or more. Also, it became recognized that, even with high-level secondary treatment, the apparently clean effluent still contained concentrations of toxicants and of biostimulants. While apparently small and exerting no immediately observable adverse effects, these materials nevertheless tended to accumulate in the receiving waters and over prolonged periods (sometimes decades) result in significant depreciation of the natural ecology. The adverse effects are indicated, for example,

by eutrophication (including algal blooms) and by a gradual depreciation in species diversity. Concern with the need for achieving higher levels of removal of organics and for removing toxicants and biostimulants has led to a whole new concept of waste treatment, called "advanced" or "tertiary" treatment, now being rapidly implemented in the USA despite the high costs compared with conventional secondary treatment.

(5) A Fifth Stage appears in the offing in the USA with the advent of the new Federal legislation of October 1972, which sets "no discharge" as a national goal by 1985. This objective is based on the concept that the effluents from advanced waste treatment processes will necessarily be of such high quality that they can be recycled (reused as water supply, hence need not be discharged to streams). The cost of realizing such a goal by 1985 would probably require Federal expenditures of the magnitude of $100 billion (plus state, local, and industrial expenditures).

At this time Thailand is only now beginning to have to deal with water pollution, and the general situation resembles Phase I in the USA - Communities are yet to be sewered. In due time Thailand will face problems similar to those described above, and increasing investments in waste disposal will be made accordingly. It will be important to tailor these efforts to meet the peculiar needs of Thailand (and not simply "copy" the methods used elsewhere, as is already tending to be done), and especially to take advantage of the lessons learned, so that costly mistakes can be avoided. Thailand has a big advantage in having such experience to draw upon.

HISTORICAL EVOLUTION OF WATER POLLUTION REGULATION

In the early history of waste disposal (the early phases noted above), the primary factor motivating construction of waste disposal facilities was concern for public health. Hence governmental health agencies usually played the leading role in stimulating construction of facilities, and these agencies also exercised the regulatory role for controlling pollution. In this era the human health factor was the primary factor in water pollution regulation.

Following World War II, it was recognized in the USA that the problem of industrial wastes had reached a magnitude equal to that of sanitary wastes, and moreover that the pollutants from both sanitary and industrial wastes were creating serious adverse effects on all sorts of receiving water values, particularly wildlife conservation and enjoyment of outdoor environment for recreation and aesthetics. As a result in many of the States of the USA authority for water pollution regulation has been transferred from the State Health Department to a new and independent State

agency. Often this new agency took the form of State Board, with representation on the Board from all of the traditional interested State agencies (health, water, resources, fish and game, etc.). In other States a new State Department has been created (e.g. Pennsylvania, Maryland), amounting to a department of environmental resources. In no State was it found feasible to achieve progress through cooperation among the traditional departments.

This same change in jurisdiction occurred in the Federal Government in the 1960's with the transfer of the Federal Water Pollution Control Program from the U.S. Public Health Service, to become a constituent in the Department of Health, Education and Welfare; then to be further transferred to the Department of Interior; then finally to become part of the New Environmental Protection Agency (EPA).

Another very significant change in philosophy of jurisdiction for water pollution in the USA has evolved over the past decade with the gradual transfer of authority from the States to the Federal Government. Over the past few years the Federal role has emerged "supreme" with the States now functioning virtually as arms of the Federal Government. This came about because most of the States simply could not cope with the problem (political constraints prevented most States from establishing regulatory programs sufficiently rigorous to suit public needs). There were some exceptions, e.g. California, but these were too few to change the national trend.

Figure 3 is a schematic representation of the trend of events in the USA, which may be helpful as a guide for Thailand.

ELEMENTS OF COMPETENT REGULATORY PROGRAM

As has been pointed out, experience elsewhere over the past several decades has shown conclusively that, if satisfactory progress is to be made in regulating pollution, there must be established a single governmental agency having firm responsibility and authority for establishing and operating the regulatory program, that the regulations must be developed to be comprehensive for entire drainage basins, that the regulatory agency have the power of the highest level of government, and that the national government must establish a sufficiently high priority for water pollution control to enable the regulatory agency to carry out its mission.

In order to carry out an effective regulatory program the Regulatory Agency must have authority and resources to perform the following functions (either with its own staff, or by contract with other public or private agencies):

(1) Basin Planning

(a) Beneficial Uses: Determination of beneficial uses of the receiving waters in the basin, and assignment of priorities as to their relative importance with respect to continuing development of the regional and national economy. (This is a matter of top-level government policy and establishes the basis for the entire water pollution control regulatory program.)

(b) Water Quality Standards: Determination of levels of water quality ("water quality standards") to be maintained in the various streams or portions of streams in order to protect the essential beneficial uses. (This follows from Item a.)

(c) Engineering Planning: Sponsoring of engineering studies for development of a master plan of waste disposal which is comprehensive for each basin, which determines the most efficient combinations of waste collection, treatment, and disposal systems which can maintain the desired levels of water quality.

(2) Monitoring: Continuing monitoring of the quality of the receiving waters in the basin, including periodic sampling and analysis, for establishing the characteristics of these waters (physical, chemical, and biological) and for determining changes in these characteristics due to waste discharges or other causes. This information is essential for obtaining quantitative knowledge of the water quality characterists including information on fish and other aquatic wildlife, for continuing assessment of the effectiveness of the waste disposal operations, and for developing recommendations on how the waste disposal and other control operations can be improved.

(3) Permits

(a) Permit Administration: Administration of the procedures for issuing permits authorizing waste disposal systems to operate, including:

(1) Preparing guidelines on how permit applications are to be prepared, and preparing information releases for the waste dischargers explaining governmental policies on pollution control.
(2) Review of permit applications, including necessary hearings or reviews, and fixing of effluent quality requirements (which in turn fix the level of treatment required), review of plans for construction of treatment and disposal, and field checking to ensure proper construction.

(3) Issuing of permits specifying the works to be constructed, constraints on operation, and the required program for continuing sampling and analysis of the effluent.

(4) Periodic inspection of the waste treatment and disposal facilities to ensure compliance.

(b) Enforcement: Administration of legal procedures as needed for taking enforcement action against waste dischargers not complying with the law (including assessment of fines and other penalties).

(4) Research: Sponsoring of research on methods of waste treatment and on effects of wastes on receiving water ecology, to furnish basic information needed for basin planning.

(5) Coordination: Maintenance of water quality at the desired levels requires continuing close collaboration with the other interested agencies of government, not only for obtaining concensus on the priorities for beneficial uses, but for developing joint approaches for preserving water quality through programs other than waste treatment. Examples are salinity control and use of stored water for augmentation of streams during periods of low flows.

(6) Education: The Regulatory Agency should take leadership in conducting educational programs for the general public, evaluating and supporting the academic resources available for training of desired professional skills, sponsoring trainees and fellowships, and conducting regional or national conferences.

An important point relating to water quality standards is that meaningful standards can hardly be set without first setting the priorities for beneficial uses, and until this is done there is little if any value in the "copying" of "average standards" used elsewhere.

Another important lesson from past experience is the need for comprehensive basin-wide engineering planning (Item 1c). The traditional approach of regulatory agencies has usually limited its interest to establishing water quality standards and has not been concerned with the numbers and locations of treatment plants. This policy usually leads to a proliferation of many plants, which not only cost much more to build and operate than systems serving a number of communities and industries, but also do a much less effective job in protecting environment. Hence the Regulatory Agency needs to exercise leadership in generating such comprehensive plans, either by contract with private consulting firms or through utilization of the environmental engineering capabilities of other branches of the Government. Sponsorship of this type of planning is

a relatively new concept, and is only now being carried out in some of the states of the USA, notably California and Maryland. The State of California has underway the first comprehensive program for such planning or all of the river basin areas of the State. There is probably no better investment that a Regulatory Agency can make than to sponsor this type of planning. Without basin planning the wastage in monies expended in constructing works following inefficient concepts is relatively huge (Reference 13A).

Another essential task of the Regulatory Agency is to carry out a continuing program for monitoring of the quality of the waters of the basin (Item 2). Again, this is a new activity in most places, but experience again has shown that without such monitoring the Regulatory Agency cannot know what is happening to the waters, especially with respect to long-range effects, and therefore the Regulatory Agency cannot be in a position to evaluate the effectiveness of its own program. In Thailand the Water Pollution Section of the Ministry of Public Health has a going capability in monitoring which can be expanded to manage this activity.

With respect to research, again experience has shown the Regulatory Agency should take leadership in sponsoring needed research, simply because no other branch of Government has this responsibility. Usually it is possible to have the needed research carried out by contract with private or public agencies. The Environmental Engineering Unit of ASRCT has the nucleus for meeting this need, working in close cooperation with the interested universities particularly AIT (Asian Institute of Technology).

PROBLEM IN THAILAND

With respect to Thailand (or any other country) it seems clear that, if real progress is to be made in regulating environmental pollution, an independent regulatory agency must be established. Moreover the agency must have the power of the highest level of the national government behind it in order to be meaningful, i.e., must be above the Ministry level.

The major problem in Thailand today is how to bring this authority into reality within a reasonable period of time. Time is of the essence because of difficulty in correcting environmental degradation after it occurs. Experience elsewhere has shown very clearly that in the field of environment an ounce of prevention is in fact worth more than a pound of cure. Whereas in the industrialized nations it has taken decades to generate public support for strong regulatory action, hopefully in Thailand this time period can be reasonably compressed and a positive program got underway during the current decade.

REFERENCE MATERIALS

The experiences in the USA have produced a number of references which may be valuable in guiding the development of water pollution regulation in Thailand, including:

(1) A model water pollution control law, "Suggested State Water Pollution Control Act, Revised", prepared by the U.S. Federal Government to assist individual States in developing State laws incorporating consideration both of national and local needs (Reference 3E), included in this report as Supplemental Appendix B.

(2) A statement on policy for water quality control issued by the State of California, "State Policy for Water Quality Control" (Reference 3A), included in this report as Appendix E. This is an excellent statement of the philosophy guiding Governmental regulation of water quality, which is as applicable to Thailand as California.

(3) A compilation of the activities of State regulatory agencies in the USA (Reference 3F), which summaries the types of activities conducted by these agencies and magnitude of resources expended (included in this report as Supplementary Appendix C).

(4) A description of the water pollution control plan for the marine waters of the State of California, "Water Quality Control Plan, Ocean Waters of California", which is a model for this type of work, and the associated publication on methodology, "Guidelines for Preparation of Technical Reports on Waste Discharges to the Ocean and for Monitoring Effects of Waste Discharges to the Ocean", both included as Supplemental Appendix D.

III. EXISTING WATER POLLUTION CONTROL ACTIVITIES

At the present time there is no national agency in Thailand having comprehensive responsibilities in water pollution control, nor in other aspects of environmental pollution. The situation resembles that in most States of the USA about 30 years ago, with a variety of responsibilities distributed among a number of the traditional arms of the RTG, and with their efforts supplemented by a variety of special committees. The activities being carried out by the governmental agencies and related activities by international and private agencies, are reviewed as follows:

MINISTRY OF PUBLIC HEALTH

The Public Health Act of B.E. 2404 (1941) (Reference 2A) gives the Ministry of Public Health broad responsibilities, working through the local authorities, for protecting human health including power for control of nuisances or other situations which may endanger health, including wastes of all types. From a practical point of view, however, the local authorities are scarcely in a position to enforce improvement of community sanitary conditions for a number of reasons - because of the absence of community waste collection and disposal systems, because the general soil conditions do not permit septic tank effluents to leach into the ground, and because, with respect to industrial wastes, the final authority for permits or licenses for industrial operations rests with the Ministry of Industry.

The Municipal By-Laws for the Municipality of Greater Bangkok require, for example, that sewage from buildings must be treated to the satisfaction of the Municipality before discharge to a public waterway. In practice this usually means disposal to some sort of holding or septic tank, with the effluent finding its way via drains or otherwise to reach the klongs and the river.

Most of the activities of the Ministry of Public Health relating to water pollution are carried out by the Water Pollution Control Section of the Division of Sanitary Engineering in the Department of Health. This Section, established in 1969, has a annual budget of only about 1.0 million baht, enough to support a small professional staff of about four engineers and scientists. However, the Water Pollution Control Section can draw upon the resources of the Sanitary Engineering Division (about 50 engineers, mostly working on rural water supplies), with its Laboratory Section (staff of 12 including 5 scientists) equipped to handle 1,000 samples per year for analysis of some 11 water quality parameters.

In addition to the above, the Sanitary Engineering Division's program in water pollution control has included the activities of several short-term WHO consultants, working mostly on problems in the Bangkok Metropolitan Region.

The activities of the Water Pollution Control Section in 1971 have been summarized in six categories (Reference 28) as follows:

(1) Surveillance of quality of rivers and other water resources: This comprised eight projects including studies of the Chao Phraya River in the vicinity of Bangkok and of two of the major klongs. The current program includes monthly sampling of the river at eight stations in the Bangkok Region, and plans are being developed (in collaboration with ASRCT) for expanding this program to make possible more precise projections as to future quality of the river.

(2) Development of recommendations for a comprehensive program of water pollution control to be carried out by the Department of Health's regional sanitary engineering centers. Preliminary recommendations were developed for desirable water quality standards for rivers and for desirable effluent standards for waste discharges (Reference 28), also an application for a USOM sponsored project (in the amount of $92,900 plus local contributions) was prepared for expanding the Water Pollution Control Section's activities over a five year period (1972-1977).

(3) Design of waste collection and disposal systems when requested by public agencies (some 11 systems were designed, mostly for public institutions).

(4) Investigation of water pollution nuisance situations (20 investigations were made, for various industrial waste discharges throughout the country).

(5) Professional contributions in water pollution control (included 14 lectures, publications, and manuals).

(6) Design of industrial waste disposal systems, for advancing technology applicable in Thailand, or at the request of industries (two such systems were designed in 1971, one for a condensed milk factory, another for a paper and pulp mill).

Considering the few years of its existence, the Water Pollution Control Section has made a good start in building up a reservoir of facts on water pollution in the Bangkok Region and elsewhere - most of the available facts have come from this source. Also, the Sanitary Engineering Division has made good progress in building up a small staff of engineers and scientists having graduate training in water pollution control. Although only about 10 in number, this group is a good nucleus for growth for further expansion.

The main problem for the future appears to be the difficulty of obtaining budget appropriations and commensurate powers which would enable the Department of Health, through its Sanitary Engineering Division and Water Pollution Control Section, to move ahead in implementing a national water pollution control program. There appears to be little evidence of such support being generated in the near future.

MINISTRY OF INDUSTRY

(a) Waste Disposal Permits

The Factory Act, B.E. 2512 (1969) (Reference 4A) authorized the Ministry of Industry to require industries producing liquid wastes to provide for proper waste treatment, as part of the licensing operations administered by the Ministry. Because the program has been underway only a short time it is difficult yet to assess the extent of its effectiveness; also, the Ministry has not made available any reports sufficient to permit an evaluation. No compilations are available as to types of plants built, sizes, processes used, operating performance, etc.

Responsibilities for handling waste discharge permits in the Ministry has been assigned to the Factory Control Division but recently transferred to the Department of Industrial Works. The professional staff involved has been limited to a few engineers (mostly without graduate training in waste processing), but supplemented by the group of engineer inspectors involved in field checking of overall factory installation including waste treatment facilities. Also, the Department of Science of the Ministry (including a staff of about 10 scientists) serves as a consulting arm by furnishing services for sampling and analysing the wastes of an industry seeking a permit, for evaluating the situation, and for preparing a preliminary engineering design of a suggested treatment system for consideration by the industry.

Usually the requirements to be imposed on the industry have been set by a Working Committee within the Ministry of Industry; however, for certain industries manufacturing foods and drugs an interagency board known as the Food Quality Control Board (Appendix I), has been involved in preparing recommendations on the degree of treatment needed. While this Board has prepared such recommendations for a number of industries, the final decisions have been made by the Ministry of Industry.

In administering the program, the Ministry includes the handling of waste disposal as part of the processing of the overall application by the industry for a license to operate. After agreement between the industry and the Ministry as to the type of treatment required, the Ministry's field inspectors ascertain that the system has been installed. There is no monitoring of performance, and dependence is placed on complaints from the public to indicate whether performance is satisfactory. Significant complaints (maybe 20 per year) are received by either the Ministry of Industry, the Ministry of Public Health, or by the Municipality. When complaints are received, the Ministry of Industry then checks the situation, but no statistics are available on these operations.

As previously noted, the Water Pollution Control Section of the Ministry of Public Health has investigated numerous complaints and has prepared reports for consideration by the Ministry of Industry, but there appears to be little effective communication between the two groups and no doubt there is considerable duplication of effort.

It is estimated some 10,000 industries are located in the Bangkok area, but of these probably only about 200 produce the bulk of the wastes, and of these 200 perhaps only 20 are major sources of wastes (over 100 cms flow or over 100 kg/day BOD). Of these 20 perhaps 10 now have waste disposal systems under operation.

The requirements promulgated by the Ministry, in the form of Annexes to the Factory Act (Reference 48, Appendix K) are mostly of the subjective type (there shall be nothing "bad" in the waste effluents), but do set numerical limits of 20 ppm for BOD and 30 ppm of Suspended Solids as the maximum values to be generally allowed in waste effluents. This is hardly realistic in terms of general performance elsewhere (even if these limits were set as averages they would be difficult for most plants to meet).

The effluent requirements of the Ministry were reviewed in 1970 by a team of special consultants from UNIDO (Reference 5E) (Supplememtal Appendix F). Their report presented suggested specific standards for three selected industries (soap, breweries, paper/pulp) plus general effluent criteria for all industries. These proposals recognize the need for more flexibility than allowed in the existing requirements, and provide for separate consideration of industrial wastes, sanitary wastes, cooling wastes, and storm drainage; hence they represent an improvement over the present overly simplistic requirements. Even so they hardly begin to recognize the real complexity of the subject. Industrial wastes very greatly in nature and only by specialized study and effort can be the proper requirements for a particular industry be established. Even in the USA, where large sums have been expanded in attempting to set up efficients limitations for particular industries, only very recently (Reference 3K) has a competent set of technical guides been produced which are sufficiently detailed and comprehensive to enable a regulatory agency to set standards for a particular industry with reasonable confidence that the requirements specified are indeed reasonable. This type of work is one of the most complex in the entire technology of water pollution control.

As has been shown by experience elsewhere, proper handling of industrial wastes involves a comprehensive analysis of the overall processing operations to be sure the design takes maximum advantage of opportunities for recycling and for using processes which minimize waste production, as well as providing for treatment of the "irreducible" residuals contained in the plant effluent.

To sum up, although the Ministry of Industry does have its waste control program underway, it is difficult to evaluate its effectiveness because of the lack of information on waste treatment systems built and on operating performance. Experience elsewhere shows almost invariably that operating performance is poor without periodic monitoring. The reports of the Ministry of Public Health, on complaint investigations, indicate there are plenty of problems. The effluent requirements, as promulgated, have the advantage of simplicity but hardly represent tailored attention to individual factory needs either with respect to the nature of the waste or the receiving water conditions in the vicinity. Also, assignment of this responsibility to the Ministry of Industry seems hardly realistic in that regulatory interests for controlling industrial wastes often conflict with those for promoting the growth of industry. Also, experience elsewhere has shown it is not realistic for a regulatory agency to participate in the design of waste treatment systems which must meet performance requirements established by the same agency. Much more attention must be paid to the problem of controlling industrial wastes, both in design of treatment facilities and in monitoring their performance, before there can be assurance that the sizeable investments being made by industry are in fact providing the degree of protection to environment which should be expected.

With respect to the Mae Klong River, where pollution from 8 sugar mills and one pulp and paper mill has seriously impaired commercial fisheries for many years, both in the river and in the Upper Gulf, the Ministry's program for abatement of pollution is moving very slowly because these factories are the major employers in the area. At this time not one of these 9 plants is known to have an effective treatment and disposal system.

(b) Department of Mineral Resources

The Departmental of Mineral Resources of the Ministry of Industry is involved both in mining waste problems and in ground water development:

(1) Mining Wastes: The Minerals Act, B.E. 2510 (1967) (Reference 4C) requires the Ministry of Industry to establish a limit on the concentration of suspended matter to be allowed in mining wastes (now set at 6 grams/liter), and also specifies that such wastes not contain toxic materials harmful to people, wildlife, or property. Thus far there seem to be few problems although the Department of Fisheries is concerned about possible effects on shrimp farming in the Gulf of Thailand from tin mining.

(2) Ground Water: The Ground Water Division of the Department has been studying effects of pumping on water quality in the groundwater basin of the Bangkok Region and has a manual under preparation on the subject. Because of continuing overpumping the groundwater levels have been dropping drastically (as much as 3

meters/year in the most critical area), and suffering depreciation in quality from inflows from nearby groundwaters which are high in salinity. In some zones the chloride levels have already reached levels of 200 ppm or more, causing wells to be abandoned. The situation indicates the need for laws to control pumping, not only to reduce the draft but to require pumping from deeper strata. Also, some alleviation may be possible by recharging through spreading of floodwaters. The Division has proposed a project for modeling the basin to permit determination of effects of alternative schemes and thus furnish the basis for effective controls.

MUNICIPALITY

The Municipality, the local government for the Metropolitan Region of Bangkok-Thonburi, includes three divisions with responsibilities relating to water pollution control, namely planning, public works (design), and sanitation (operation and maintenance).

(a) Division of Public Works: This Division, which is represented on the BSDC (Bangkok Sewerage and Drainage Committee), participated in supervising preparation of the Master Plan Report and has been primarily responsible for followup activities for attempting to implement the plan. Also, the Division is represented on the recently established Committee on Klong Dredging.

(b) Division of Planning: The Planning Division has worked closely with the Division of Public Works on strategy for implementing the Master Plan; has headed up the Municipality's pilot program over the past several years to establish "set-backs" along the klongs to permit access by trucks to collect solid wastes; has also considered collection of refuse along klongs by boats; and is developing zoning proposals by which industries will hopefully be concentrated in industrial zones thus simplifying pollution control.

(c) Division of Sanitation: This Division has responsibility for maintenance of drainage ditches and of klongs, and for collection and disposal of solid wastes including operation of trucks for collecting refuse along streets and of truck-pumpers for collecting sludge from individual septic tanks (now disposed of by lagooning). The major problem of the Division over the years has been a progressively smaller budget for sanitation activities per capita of population serviced, resulting in a gradual depreciation in services rendered. With respect to cleaning of klongs, for example, the present budget is barely sufficient for "minimal maintenance" and includes next-to-nothing for remedial repairs and dredging (as recommended in the Master Plan) which are needed together with routine cleaning to form a balanced economical klong maintenance program.

To sum up, it appears that the Municipality is suffering on all fronts from lack of sufficient monies to keep up with the needs of rapid urban growth, both for construction and for operation and maintenance (a problem common to most rapidly growing urban centers everywhere). The consensus of the Municipality officials is that, while the Master Plan recommendations for sewerage, drainage, and flood protection appeared reasonable when formulated in 1968, subsequent history indicates the levels of funds needed for implementing the plan, even for the core area of Bangkok, are far more than will likely be made available in the foreseeable future and hence re-analysis of the entire subject is in order. Also, experience since 1968 indicates public concern with drainage problems (flooding of streets and yards during and after rains) commands a significantly higher priority than concern about sanitation.

MINISTRY OF INTERIOR

Various branches of the Ministry of Interior have responsibilities relating to water pollution control:

(a) Electric Generating Authority of Thailand (EGAT): This is the national power authority, whose interests touch upon the water pollution similar to RID's. Coordination of EGAT's water resource development projects with those of RID is accomplished through close working collaboration. In most instances EGAT has primary responsibility for construction and operation of the dams, and RID for construction and operation of diversion works, with decisions on allocation of storage made jointly.

A major new dam project is now being planned for the Quai Yai River (a main tributary of the Mae Klong), with World Bank financing, and for this project EGAT has under preparation an environmental impact statement (the first in Thailand), with assistance from AIT. A nuclear power plant also is scheduled later in the decade.

(b) Office of Town and Country Planning: This agency has responsibility for urban planning throughout the country including developing long-range plans for the Bangkok Metropolitan Region in collaboration with the Municipality. The Department's current plans envision an enlarged metropolitan region stretching down the river to the Gulf, and believes considerable revisions are needed in the Master Plan for Sewerage, Drainage, and Flood Protection because of changes in circulation (highway) patterns over the past four years. The Office proposes new industries generally not be located in the vicinity of Bangkok but at three additional industrial zones at Nakorn Pathom (50 km west), Samutsakorn (30 Southwest), and Chonburi.

(c) Planning and Policy Bureau: This is a new agency set up recently to advise the RTG on needed policy changes, and could exercise significant influence on future RTG divisions on what to do about environmental pollution control problems. A number of the key staff of this

Bureau are also leaders in the activities of the Society for Conservation of National Treasures and Environment.

(d) Public Welfare Department: This Department is constructing Thailand's first community sewerage system, for the Huey Kwang Housing Project (design population of 25,000) at Bangkok, including collecting sewers and treatment and disposal works. This is intended as a model for demonstrating how sewage can be properly handled in the new growth communities being developed in the Bangkok Region. While the collecting sewers are certainly in order, expenditure of about $1 million for treatment and disposal, although a commendable project, raises questions in view of the scarcity of monies for higher-priority needs in advancing sanitation and water pollution control in the region. For example, $1 million would fund the operation of a National Environmental Pollution Control Secretariat for several years.

MINISTRY OF AGRICULTURE

(a) Department of Fisheries: The Department of Fisheries is beginning to become much more involved in water pollution problems, due primarily to effects of pollution in the Mae Klong River on both fresh water and marine fisheries. The Department maintains a series of experiment stations around the country, which in the future will include pollution studies in their programs. The concern of the Department at present is not so much with sanitary wastes but with industrial wastes.

The main problem at present is the damage to shrimp and mollusk fishing in the upper portion of the Gulf (References 10E, 11A), due to pollution in the Mae Klong mostly from wastes from cane sugar mills during the dry season. Despite heavy complaints for many years (especially serious in 1970 because of a molasses spill from one of the mills), the Department sees little relief so far from the Ministry of Industry's waste treatment program. The shrimp industry in the Upper Gulf furnishes 10,000 tons/year for export (worth 700 million baht), and Government policy is to expand this business (see NESDB).

The Department's budget (60 million baht) has no allowance at present for pollution work, but the planned first step is to collect the facts on shellfish damage. The Department is represented on the National Committee on Human Environment by the Under-Secretary of the Ministry of Agriculture. The Department has no effective arrangements at the working level for collaboration with other agencies of the RTG, and agrees a national coordinating authority of some sort is in order. It was suggested that the Department cooperate with the Division of Oceanography of the Royal Thai Navy in carrying out the pending marine pollution monitoring program in the upper portion of the Gulf of Thailand.

(b) Royal Irrigation Department (RID): The RID's interests are essentially devoted to irrigation, but in planning for utilization of the nation's rivers, through construction of dams, diversion work, etc., the RID is concerned with assisting in developing multi-purpose projects which consider all beneficial uses of water resources including low flow augmentation for assisting in waste disposal. The RID's interest in Klongs and their maintenance is limited to klongs built or used primarily for irrigation purposes. The RID has been involved in klong operations in the Bangkok urban area only in lending assistance to the Municipality through loan of pumping equipment during floods. With respect to the Chao Phraya, two major dams (Bhumipol in 1964 and Sirikit in 1972) make it feasible to maintain a minimum dry weather flow of 150 cms (but this was prompted primarily for salinity control to keep the river suitable for water supply rather than to help maintain an aerobic condition in the river). No dams have been built yet on the Mae Klong River (only diversion works, which intensify the low flow problem), but a major dam planned on the Quai Yai River tributary will include allowances for low flow augmentation.

(c) Plant Industry Division: The Plant Industry Division operates a "Project for Strengthening Plant Protection Service" sponsored by the UNDP Special Fund. The Project is carrying out a broad research program including research on agricultural chemicals. While the program does not include research on water pollution, it was agreed a real problem exists but the likely answers will be generated by programs in the industrialized countries (especially the USA) for changing the compositions of these materials so they will be biologically degradable.

METROPOLITAN WATER WORKS AUTHORITY (MWWA)

While the primary interest of MWWA is in furnishing the water supply for the Bangkok Region, the MWWA is concerned with the problems of salinity control in the Chao Phraya River and with salt water intrusion in the groundwater basin from which a significant portion of the community water supply is still obtained. Also, it is likely that a local authority for administering sewerage, drainage, and flood protection measures will be formed sooner or later, similar in nature to MWWA, and that this will be accomplished by adding this responsibility to MWWA. While MWWA (and everyone involved) seems to agree with the concept of assigning this added responsibility to MWWA, there is little consensus on when to do this because of the difficult problems MWWA already has in managing its current responsibilities. MWWA's position is that it can take on the additional assignment only if also given enough additional budget support to do the added job.

BANGKOK SEWERAGE AND DRAINAGE COMMITTEE (BSDC)

This Committee was established in 1962 under sponsorship of the

NESDB (Appendix H). It has since served as the focus of responsibility for policy-level decisions in the Bangkok Region on sewerage, drainage, and flood control. The Committee's primary assignment was to implement and to supervise the preparation of a "Master Plan Report of Sewerage, Drainage, and Flood Protection" (prepared for the Committee by the consulting engineering firm of Camp, Dresser and McKee) (References 8A, 8B; Supplemental Appendix A). The Master Plan Report was submitted early in 1968 and presents a comprehensive program of public works improvements, costing some $500 million, to be carried out in stages over a period of the next 20 years or so (see Chapter IV).

Preparation of the Master Plan Report involved a number of policy decisions as to appropriate levels of expenditures which might be made available for construction for implementing the report's recommendations. One of the basic decisions was to employ separate systems for handling sanitary works and surface drainage, despite the extra costs, because of the advantages of the separate system for cleaning up the klongs. The report places a higher priority construction on sanitary sewers than on drainage facilities. Since 1968, for many reasons (including an economic recession), very little has been done to implement the report's recommendations, and what has been done (completion of the Rama IV scheme, at a cost of about $4 million) has been prompted by desires to improve drainage rather than concern with sanitation.

At this time the prospects for implementing the report's recommendations in any comprehensive fashion seem as elusive as ever, and most of those interviewed agree, reluctantly, that the levels of expenditures proposed simply transcend reality and hence a critical reassessment of the entire concept is in order. One conclusion which seems to be emerging is that the public is more concerned with drainage improvements (to alleviate flooding of yards and streets) than with sanitation problems, suggesting that the overall sewerage/drainage concept be reexamined and perhaps recast to accommodate the adjusted levels of priorities.

Another of the report's recommendations, for forming a metropolitan authority for drainage, sewerage, and flood protection, through enlargement of MWWA's role, still appears to be a sound concept and perhaps will be achieved before long.

Since submittal of the report the BSDC has striven to obtain funding for one of the recommended high priority projects, in order to demonstrate the feasibility of the overall sewerage/drainage concept, and thus help establish a firm basis for obtaining a major loan from the World Bank for implementing construction of a major portion of the plan. It appears that construction of this first project (without the sanitary sewers), for the "Construction-Government" area (which is the center of the older portion of Bangkok), will begin in 1973. The construction cost is estimated at about $20 million.

The BSDC continues to function and is in the unfortunate position (with its limited resources) in continuing to have primary responsibility for policy decisions.

NATIONAL ECONOMIC AND SOCIAL DEVELOPMENT BOARD (NESDB)

The NESDB is part of the Office of the Prime Minister and has primary responsibility for advising the RTG on allocation of resources; hence is vitally concerned with problems of sanitation and water pollution control because of the magnitude of expenditures involved in implementing control programs. As previously noted, NESDB sponsored formation of the BSDC which exercised significant influence in developing policy decisions for guiding preparation of the Master Plan. However, the costs involved for implementing the plan have since appeared to be prohibitive in terms of the country's total resources and priorities and little has been done to face up to the problem. The Third Plan of the NESDB, for the period 1972-76 (References 12A, 12B), does include about $20 million for proceeding immediately with construction of drainage improvements as recommended in the Master Plan for the First-Phase Project (the Padung Krung-Kasem Project in the Construction-Government area). The Third Plan also notes it will be RTG policy to promote ocean fisheries, especially coastal shrimp farming, and also recognizes in principle the need for making progress in achieving increased national efforts in regulating water pollution control.

The NESDB is currently involved in the work of the National Committee on Human Environment, and Mr. Renoo Suwansit, Secretary General of NESDB, is also chairman of the Executive Committee of the National Committee.

DIVISION OF OCEANOGRAPHY (ROYAL THAI NAVY)

The Division of Oceanography, Department of Hydrography is engaged in implementing Thailand's participation in the world-wide marine pollution monitoring program sponsored by the World Meteorological Organization and Intergovernmental Committee on Oceanography. The first field survey, to be carried out early in 1973, will collect and analyse samples from the upper portion of the Gulf of Thailand. The Department of Marine Science of Chulalongkhorn University is serving as consultant on the project.

Suggestions were made to the Division on planning the program, especially for developing data on effects of pollution on marine fisheries, and in broadening the program to include collaboration by the Department of Fisheries and by AIT.

NATIONAL RESEARCH COUNCIL (NRC)

The National Research Council has been involved in studying and evaluating environmental pollution problems in Thailand for many years, and sponsored preparation of Thailand's contribution to the Stockholm

Conference in the summer of 1972. The report included description of water pollution problems in Thailand including the Bangkok Region and set the stage for the present report.

The NRC sponsored formation of the ASRCT, including the Environmental and Ecological Research Institute of the ASRCT, and the Institute's Environmental Engineering Unit. Also, Dr. Pradisth Cheosakul, Secretary General of NRC, has served as Chairman of the National Committee on Environmental Quality Control and as a member of the Advisory Committee on Family Planning and Environment of the NEC. He is also a member of the National Committee on Human Environment and a member of the Board of Directors of the International Institute of Environmental Affairs. The present study and report came about through his initiative as a result of discussions between NRC and USOM.

APPLIED SCIENCE RESEARCH CORPORATION OF THAILAND (ASRCT)

The ASRCT was established in 1963, under sponsorship of NRC, as a nucleus of scientific and engineering talent which, working under corporate status, can assist public and private agencies of Thailand in applying scientific findings in promoting the continuing development of the country (Reference 7A). In 1971 an Environmental Engineering Unit (EEU) was established in ASRCT, as part of the Environmental and Ecological Research Institute, which has focused its efforts on water pollution control problems.

Although only just getting started, the EEU has contributed to developing new concepts (in cooperation with AIT) of converting waste organic materials to fish production, which appear to have real potential for application in tropical developing nations. The Unit is presently engaged in preparing proposals for research grants (including proposals to international agencies) on water pollution research projects which could materially help solve problems in the Bangkok Region. These include projects for critical evaluation of pollution in the klongs and river, for development of a package waste treatment plant for use by smaller industries, and for developing economical solutions to treating cane sugar mill wastes for use in the Mae Klong River Basin (References 1C,1D). The EEU has potentials for making increasingly valuable contributions but needs much more support in the generation of projects, especially from branches of the RTG interested in water pollution control which might look to ASRCT for furnishing specialized technological assistance. At present the Unit appears to have good working rapport with the Ministry of Public Health but is otherwise somewhat "isolated" from other branches of government. The EEU is in an excellent position of course to carry out research contracts for a national environmental pollution control agency should such an agency be established.

UNIVERSITIES

(a) Asian Institute of Technology (AIT): The AIT operates a graduate program in environmental engineering with a faculty of three doctorate engineers (from England, the USA, and Canada), which has established a good reputation for capability and has made significant contributions to new technology especially in the water field including pollution control. These contributions include development of water quality standards suited to streams in tropical developing countries (References 6C, 6D, 6E), development of waste treatment methods suited to these countries, evaluation of pollution in the Chao Phraya River (References 6A, 6B), and a current project for assessing pollution loadings discharged to the Gulf of Thailand from Chonburi Province and for assessing environmental impact of proposed river impoundments. The AIT group has cooperated on projects with the Environmental Engineering Unit of ASRCT and like the EEU represents a valuable resource for continuing to assist in solving Thailand's water pollution control problems.

(b) Chulalongkorn University: This is the primary source of undergraduate engineers in Thailand, and considerable numbers of the graduates have pursued graduate training in environmental engineering, usually in the USA or England or at AIT. The present Rector and former Dean of Engineering, Professor Aroon Sorathesn, is the "Senior Engineering Professor" of Thailand, has been a member of virtually all Governmental committees dealing with environmental pollution problems (and has been chairman of many), and is Thailand's representative on the Board of Directors of the International Association on Water Pollution Research.

(c) Mahidol University: The Mahidol University complex includes a Faculty of Public Health which is the primary center for public health training in Thailand, including interests in sanitation. Although not thus far particularly active on water pollution problems, Mahidol represents a valuable potential especially for research on public health aspects.

In addition Thailand's system of universities includes a number of additional schools of science and engineering located at provincial capitols, all of which have interests in developing capabilities in environmental science and engineering. It is estimated that the academic resources of Thailand will be able to meet the needs for manpower, at the undergraduate level, for engineers and scientists needed for work in environmental pollution control. Graduate study (on specialized fields) can best be handled, as in the past, by study abroad or at AIT.

INTERNATIONAL AGENCIES

Various international agencies have rendered assistance to agencies of the RTG on water pollution matters. These include WHO's assistance to

the Ministry of Public Health in establishing and furthering the activities of the Water Pollution Control Section, assistance by UNIDO to the Ministry of Industry for special consulting on industrial waste effluent criteria, and assistance by USOM to the Ministry of Public Health and to the NRC. Also, ECAFE's Mekong Committee has under consideration demonstration projects for constructing waste disposal facilities at selected cities.

The International Agency most involved in water pollution problems at Bangkok is the World Bank, who has had continuing interested in improving drainage and sanitary conditions at Bangkok for the past decade. A World Bank team visited Bangkok in 1964 to evaluate the question, "Does Bangkok really need a sewerage system?" (References 5G, 8A). The World Bank is still very much interested in improving drainage conditions in Bangkok, and the current World Bank loan for expansion of the metropolitan waterworks includes an understanding that the Government will made a positive effort to begin solving the drainage problem. The big difficulty, of course, is money; however, should MWWA be expanded to include responsibility for drainage as well as sewerage and flood protection, perhaps revenues for such works can be obtained by "add-ons" to the water bills. While difficult to achieve, this type of financing has proven effective elsewhere, might be the only feasible source of funds, and would establish a firm basis for World Bank loans.

SOCIETY FOR CONSERVATION OF NATIONAL TREASURES AND ENVIRONMENT

The Society for Conservation of National Treasures and Environment ("SCONTE") is believed to be the only private association which has attracted public attention to problems of environment. It is headed by Dr. Mayura Viseskul (of the Planning and Policy Bureau of the Ministry of Interior). It comprises representatives of student action committees from eight universities and has been very active this past year in efforts to generate public support for action on pollution control. The Society was a primary sponsor of a public action program entitled, "Week for Cleanliness and Better Environment" held in November 1972 including a "Conference on Polluted Environment" on 20 - 21 November. The Conference included participation of a number of senior officials of Government. The Society has also sponsored special programs including enlistment of student help for klong cleaning demonstrations and has prepared TV "spots" and programs. The object of this activity is hopefully to hasten recognition by the RTG to the seriousness of environmental degradation and to take preventive actions recognizing that correction of degregation after the fact is often unmanageable. The November Conference, the first of its kind, no doubt was valuable for many reasons, certainly for bringing together many diverse interests and focusing attention on the paucity of communications and collaboration between them.

SPECIAL AD HOC COMMITTEES

(a) Committee on Klong Dredging: A number of special ad hoc committees appointed by the NEC are involved in water pollution control matters, including the Committee on Nightsoil Disposal and the Committee on Klong Dredging.

One of the controversies stimulated by concerus what can be done to remove materials from the Bangkok klongs to improve their sanitary and hydraulic condition. Whereas the Master Plan recommendations of 1968, which included construction of gates and pumping plants as well as dredging, have not been implemented (presumably because of high cost), it is alledged that adequate cleaning can be accomplished without gates and pumping by "top flushing", i.e. stirring up the top layers of bottom sediments so these materials will be flushed to the river. A Committee on Klong Dredging, headed by Professor Aroon Sorathesn, was recently established to evaluate these alternatives. While it is unlikely there is any easy solution to dredging the klongs, the controversy serves to draw attention to the importance of the problem.

(b) Committee on Septic Tank Sludge Disposal: This committee, also established in 1972 and also headed by Professor Aroon, is reviewing methods for disposing of the sludge ("nightsoil") collected by the Municipality from septic tanks of individual buildings. Presently the sludge is disposed of by lagooning. A possibility suggested to the Committee is to consider disposal of the sludge by composting together with solid wastes at the existing municipal composting plant.

NATIONAL ADVISORY COMMITTEES

Because of the increasing interest in environment, three different committees, established by the NEC over the past two years, have been evaluating the problems and developing recommendations for consideration by the NEC:

(a) Advisory Committee on Family Health and Environment:
Established in March 1972, this Committee, headed by Professor Chamras Chayapong, is preparing its a report and recommendations (Appendix J), including a recommendation that a national environmental Secretariat be established in the Office of the Prime Minister.

(b) National Committee on Environmental Quality Control (NCEQC):
Established in February 1971, and headed by Dr. Pradisth Cheosakul (also Secretary General of the NRC), the NCEQC (Appendix F) has held seven meetings involving all aspects of environment. The Committee assisted in preparation of Thailand's participation in the UN Stockholm Conference and has made a number of recommendations to the RTG including a proposal for expediting promulgation of the City Planning Act as a basic step necessary for all environmental control programs.

As a part of the work of preparing the current report, a meeting was held on 26 October 1972 between Dr. H.F. Ludwig and Miss Praparsri Thanasukarn representing NRC/NCEQC, with Mr. Renoo Suwansit, Chairman of NCHE, together with other members of the National Committee on Human Environment (NCHE), including Mrs. Valapa Chartprasert (Secretary), Miss Uratip Tunskul (Assistant Secretary), and Mr. Praphorn Charuchandr (Assistant Secretary). It was agreed Dr. Ludwig, Miss Praparsri, Miss Uratip, and Mr. Praphorn should constitute a "Working Group" for preparing draft materials for consideration by the NCHE's Executive Committee. An initial draft of a preliminary contribution was prepared on 3 November and reviewed by the Working Group on 13 November 1972 (Reference 7D). The present report, it is hoped, will be useful in the deliberations of the sub-committees of the Executive Committee, which should get under way early in 1973.

(c) National Committee on Human Environment (NCHE): The NCHE (Appendix G) comprises a Main Committee for policy matters and an Executive Committee as the working group. Its first meeting was held 14 November 1972. Three sub-committees were appointed, one on water, one on air and noise, and one on soils/land. Further meetings are scheduled to begin early in 1973 .. The NCHE is in a good position to make a real contribution by generating recommendations on realistic steps the RTG should take to move ahead on programs for protection and conservation of environment.

IV. BENEFICIAL WATER USES

Beneficial uses of the waterways of Thailand include transportation, irrigation, fisheries, sanitation, recreation, wildlife reproduction, and waste assimilation. The objective of water pollution regulation is to control waste discharges and other projects or activities affecting water quality, in order to insure necessary protection of the important beneficial uses. Hence, before meaningful requirements for waste treatment can be specified, it is necessary to determine the levels of water quality which must be maintained to protect the important beneficial uses. For each drainage basin in the country the important beneficial uses need to be stated for each important water body, or portions of these, and then the level of quality determined as needed to preserve the important values.

The levels of quality needed for sustaning beneficial uses vary widely for different uses. Requirement for waste treatment are generally very much higher for preserving wildlife and for providing an aesthetic environment than for most other uses. Transportation and irrigation, at the other extreme, are hardly affected by existing organic pollution. Irrigation use in fact may be enhanced through the nutrients contained in the organic wastes.

Unfortunately there is no easy answer to establishing proper beneficial uses and the related water quality standards. They must be literally tailored to suit the developing economy and hence will be different for different rivers and stretches of the rivers. Unfortunately little can be gained by following beneficial use/water quality standards concepts developped in the industrialized nations because of the great differences in the economy, geography, social values, etc. The best work to date in attempting to develop water quality standards for the developing tropical countries of South East Asia is that by Pescod of AIT (Reference 60). Appendix D is a summary of his suggested values for standards according to the controlling beneficial use.

As noted by Pescod, for the South East Asian countries usually the most important use needing protection is commercial fishing. Also, experience in Thailand and elsewhere in South East Asia has shown that waste assimilation is often the most important water use.

BANGKOK METROPOLITAN REGION

For the Bangkok Region of immediate concern, an estimate of the effects of pollutants on beneficial uses is as follows:

(1) Water Supply: Although the primary source of the water supply for Bangkok is river water, dependence is placed on treating the raw water to produce a safe and satisfactory product. The present

program of expansion of the Bangkok Region's water system, now underway, can be expected to produce a good water despite existing and projected pollution in the river. In the long run it may be necessary to control industrial wastes to limit discharges of toxicants and similarly to control use of agricultural products such as herbicides and pesticides, but this is not believed to pose any problem for the foreseeable future. Construction of the metropolitan sewerage system, even if treatment were included, would not significantly alter the situation on water supply.

(2) Sanitation: The klongs of course are the "core" of community life in Thailand, being the source of water, receipient of wastes, place for washing and bathing, for recreation especially by children, etc. Because of the discharge of fecal materials into the klongs of the Bangkok Region, they are very heavily polluted with very high coliform concentrations. If standards such as those used in California (where the coliforms cannot exceed 10 per milliliter for water contact activities) the klongs would all be quarantined and public contact with them prohibited. However, it is questionable that any regulatory program would much affect the traditional way-of-life along the klongs. Moreover, even if the proposed sewerage system were to be built, the coliform concentrations in the klongs would remain high. Moreover, the significance of the existing public health hazard is itself very debatable here in Thailand. The most important means for protecting public health along the klongs appears to be in boiling of drinking water taken from the klongs, and this likely will continue to be the case until the klongs are no longer depended upon as the source of family water supply.

(3) Fisheries: Commercial fisheries make a significant contribution to the GNP of Thailand, but most of this (90%) is from estuarine and marine fisheries and only about 10% from the rivers. However, "subsistence fishing" from the rivers, klongs, paddies, etc. is considered to be an essential part of the food supply for rural populations. Most of the subsistence fishing species are very hardy types (some are surface breathers) which can tolerate high levels of organic pollution. For the Bangkok Region, which is urbanized, the extent of organic pollution has already greatly depreciated the fresh water fisheries, all the way to the Gulf, but it is questionable whether this loss in fresh water fisheries is really important compared to waste assimilation. The pollutants in the Chao Phraya River are discharged of course into the Gulf where their effects may really be serious in affecting shellfish and reproduction of finfish.

(4) Recreation: It is believed that the Chao Phraya River is not used for recreational purposes to any significant extent. The recreational centers are located on the Gulf (Pattaya etc.) and are as yet scarcely affected by pollution from the Bangkok Region.

(5) Wildlife Conservation: The reduction in dissolved oxygen concentration in the Chao Phraya River has no doubt greatly altered the natural ecology of the river, i.e., has altered the natural fish-food chains and hence the distribution of fish and other aquatic species over the affected portion of the river. No doubt the changing ecology favors the tougher fish species, but it is doubtful this has much practical significance for the foreseeable future.

(6) Aesthetics: This is believed to be the only critical problem in the Bangkok Region, namely the depletion of oxygen resources to the point where portions of the river become septic and foul smelling during the dry season. The situation is already marginal and it can be expected that the incidences of septicity and of foul odors will progressively increase as organic loadings increase. Sooner or later fish kills can be expected when periods of septicity become prolonged. Experience elsewhere indicates that until such situations reach "crisis" proportions there usually is little done because of the very high costs of corrective measures. As was pointed out by the World Bank Team report of 1964, "the rate at which investment should be made in sewerage and drainage systems will principally be established by the outraged aesthetic sense of the inhabitants of Bangkok".

(7) Waste Assimilation: Waste assimilation has been traditionally regarded as a legitimate "secondary" use of water resources, to the extent that such use does not impair the primary beneficial uses. In very recent years in the USA an idealistic concept of "anti-degredation" has evolved as a matter of national policy, which means in effect that no legitimate assignment can be made for use of water resources for waste assimilation. This means no discharge of pollutants to water courses, and the new Federal legislation enacted in October 1972 sets zero discharge as a national goal to be achieved by 1985. There is good reason for such goals in the USA, where tremendous industrialization has created an accompanying huge problem of wastes, so that to reduce loading to levels that can be satisfactory absorbed by the nation's water courses will require progressively higher levels of treatment, and eventually recycling with little of any discharge can become feasible. For Thailand, however, the pollutant loadings are still small with respect to the extent of the nation's water courses, and it is only in a few areas where the water resources are overstressed. Generally speaking, it can be expected that waste assimilation can continue to be a legitimate use of water resources in Thailand, for decades to come, provided such use is properly regulated.

One of the first real public confrontations between beneficial uses in water pollution history in Thailand is now developing in the Bangkok area, namely the conflict between aesthetics and waste assimilation in the Klongs and in the Chao Phraya River. Whether the factor of aesthetics (odors, fish kills) in the Chao Phraya will be given a sufficiently high priority to force implementation of a

metropolitan waste treatment system, which will reduce the organic pollutants from sanitary sources to levels which can be managed by the river, is yet to be resolved. The situation is analogous to that along the eastern shore of San Francisco Bay following World War II when construction of a freeway brought the public for the first time in close proximity to obnoxious conditions along the shore. It was this aesthetic factor, rather than other arguments including public health, that led to construction of a regional waste disposal system.

Historically in most situations the arguments for installing metropolitan waste disposal systems have been much stronger than now exist at Bangkok. Usually the prime motivating factors have been public health and aesthetics, both of which have as yet to be assigned high priorities in the Bangkok Region or elsewhere in Thailand.

UPPER GULF OF THAILAND

As will be discussed later, the pollutants discharged to the upper portion of the Gulf of Thailand from the Chao Phraya and other major rivers, including the Mae Klong, have already caused severe damage to marine fisheries, and the likely continuing increase in pollution as the Bangkok megalopolis grows will pose a very serious problem. It is obvious that the conclusions on the need for sewage treatment at Bangkok should be based not only on correction of the sanitation/aesthetics problem in the Bangkok Region but also on the overall needs of the Upper Gulf for protection of fisheries. The pollution problem in the Upper Gulf thus far is attributed mostly to organic loadings and their effects on oxygen reserves, but sooner or later the problem of toxicants reaching the Gulf from industrial wastes and agricultural chemicals will have to be considered.

The most advanced work to date in establishing water quality standards for protecting marine waters for conservation of fisheries and aesthetics is that described in publications of the California State Water Resources Control Board (References 3B, 3C), which are included in this report as Supplementary Appendix D. These publications list the standards and associated waste effluent limitations adopted by the State in 1972, together with methodology for sampling and analysis. The parameters employed include bacteriological characteristics, physical characteristics, chemical characteristics, biological characteristics, toxicity, and radioactivity.

V. ASSESSMENT OF EXISTING POLLUTION

POLLUTION IN KLONGS OF BANGKOK REGION

(a) Master Plan Report

The Master Plan Report (References 8A, 8B) included the first systematic study attempting to estimate pollution in the klongs and the Chao Phraya River. From August 1961 through July 1966 analyses were made of water samples collected once a week from 17 locations in the klongs and 3 in the river. The main parameters used were BOD (biochemical oxygen demand), DO (dissolved oxygen), and MPN (most probable concentration of coliforms). These studies confirmed the existence of gross pollution in many of the klongs, with worst conditions occurring at low tide. Of the klongs studied, those in central Bangkok were in worst condition, e.g., the BOD in Klong Padung Krung Kasem at low tide was about 80 mg/l, which is representative of weak sewage rather than of a surface water. Klongs Lord and Ong Ang were similarly polluted, showing high BOD, often zero DO, and coliform counts in excess of 100,000/ml. The report states that pollution in the klongs "constitutes a definite health hazard" and a "substantial aesthetic nuisance".

The coliform counts are especially indicative of the level of pollution when compared to existing sanitation standards elsewhere. In California, for example, the maximum allowable average coliform concentration for recreational waters is 10/ml.

The Master Plan Report points out how the sanitation problem in the klongs is compounded by the flatness of the terrain and the corresponding poor drainage throughout the region. The stormwater drainage system (which also receives sanitary wastes) was constructed as roads were built and not in accordance with any drainage plan, with the drains laid at practically no slope in order to avoid pumping, resulting in continuing deposition of silt and trash. Practically all the drains in Bangkok are at least partially submerged some part of the day. A major conclusion of the report is that the long tradition of trying to accomplish drainage without pumping must be changed.

The recommendation of the Master Plan Report was to construct new works described as three different systems, namely a wastewater sewerage system, storm-water drainage system, and flood protection system. They are described briefly as follows:

(1) Wastewater Disposal System: This consists (Figure 4) of a network of 55 km of tunnels reaching throughout the Master Plan area plus a system of smaller sewers for picking up sewage from buildings, plus a single main terminal pumping plant located at Thonburi.

(2) Flood Protection System: This includes low-level embankments around the Master Plan area with a system of gates and locks to separate internal klongs from external klongs and the river, plus pumping stations wherever the external water levels are higher than internal, plus rehabilitation and dredging of most of the existing klongs.

(3) Storm-Water Drainage System: This includes a new system of drains (incorporating existing drains whenever possible), discharging to the klongs, with the klongs continuing to serve as the main drainage conduits of the city. Assuming completion of the flood protection system the level in the klongs can be maintained sufficiently low to allow the drains to function by gravity.

The report notes that anyone of the three systems can be constructed without constructing the other two, but the new drains would be of limited use until after the flood protection works are built. The report assigns the highest priority to the wastewater sewerage system (in order to reduce health hazards and alleviate aesthetic conditions throughout the city), the next priority to the flood protection system (not only for flood protection but to establish the basis for the drainage system), and third priority to the storm-water drainage system (to alleviate local flooding during heavy rainfall).

The report also assigns priorities for projects according to areas most needing relief. The oldest portion of Bangkok, between Klong Padung Krung Kasem and the river, plus the Government area to the north, called the "Construction-Government Area", is recommended for the first stage of construction, followed by the Thonburi area for the second stage, the Sathorn Triangle area for the third, the Pathum Wan area fourth, and the Bangkapi area fifth. Additional priorities would be established later to suit the developing growth.

The estimated construction costs for providing these five priority areas with all three systems (sewerage, drainage, and flood protection) totals about 1,052 million baht for sewerage, 458 million for drainage, and 693 million for flood protection, or 2,203 million baht ($106 million) total. For the entire Master Plan area (the metropolitan area as envisioned in 1968) the costs by systems are 3,900 million baht ($188 million) for sewerage; 3,500 million baht ($168 million) for drainage; 3,900 million baht ($188 million) for flood protection; totalling 11,300 million baht ($544 million). The report suggests the systems for the five priority areas be completed within a period of 14 years, and that the remainder of the region be provided with sewerage facilities by the year 2000. To carry out the program for sewerage and flood protection would require capital expenditures of about $6 million per year for 14 years, then about $9 million per year for 11 years.

The report recommends a metropolitan authority like MWWA be established to administer the program, preferably by enlarging MWWA. Such an authority is needed primarily to insure revenue collections sufficient for financing loans.

(b) Water Quality Impact of Proposed Sewerage System

While there can be little argument that the Bangkok region needs a sewerage system of some kind, in order to achieve a decent condition of cleanliness throughout the region, the construction of a sewerage system represents only part of the total problem. As noted in the Master Plan Report (Figure 5), even if the proposed sewerage system were to be constructed as scheduled, it would require many years before the bulk of the population would be connected to the system. Even by the year 2000 only about three-fourths of the population would be served. Considering increasing growth, the magnitude of sanitary wastes continuing to reach the klongs would remain high. This is not an argument against the need for sewers; rather, without sewers the conditions in the klongs likely will become increasingly worse.

In addition to sanitary wastes, solid wastes thrown into the klongs continue to be a major problem. While the Master Plan Report does not cover this problem, it is recognized that it must be solved and various proposals have been suggested as previously discussed.

(c) Developments Since Master Plan Report

Since 1968, for a variety of reasons, very little has been done to implement the recommendations of the Master Plan Report. The MWWA has had so many problems in developing the new metropolitan water supply system (agreed by all to represent a commanding priority) that it has hardly been ready to take on major additional responsibilities. The only significant funds allocated for construction of sewerage/drainage/flood protection facilities were about 70 million baht for completing the Rama IV tunnel and pumping scheme, a flood protection project already underway when the Master Plan Report was being prepared.

While it is of course difficult to ascertain why the RTG has not taken more action, it does seem clear that the levels of expenditures recommended in the report, although seemingly reasonable at the time, now appear to be more than can be realistically expected. The Third Year Plan recently prepared by NESDB (References 12A, 12B), although recognizing in principle the importance of the problem and stating that MWWA will be assigned responsibilities for sewerage, drainage, and flood protection, nevertheless shows only an allocation of about $20 million (for the entire five year period), enough only for proceeding this

year with the flood protection and drainage features of the first-phase project (for the Construction-Government Area). The sanitary sewers are not included. Also, the Third Plan notes, "generally drainage will receive higher priority than sewerage, since there will be direct tangible improvements and visible savings by reduction in damage to public and private property".

The conclusion must be made that the priority assigned by the RTG to solving the problem of sanitation/aesthetics due to pollution in the klongs still remains lower than other commanding priorities. Perhaps the best hope for financing sewerage construction in the future will be in sewer revenues collected along with the water bill. This does appear possible once MWWA has solved the problem of collecting water revenues. Such sewer rentals would furnish a sound basis for World Bank financing.

(d) Industrial Wastes

The industries of the Bangkok Region are distributed throughout the region. Appendix C is a current tabulation of information on waste loadings. The primary impact of individual discharges in the Bangkok Region is in their organic content which intensifies oxygen depletion in the receiving water in the vicinity of the discharge. Even though the total BOD loading from all the industries is small, compared to the sanitary wastes, the industrial discharges create serious local nuisances judging by the complaints received and investigated.

Although the total number of industries in the region is large (about 10,000), relatively few are large enough to create serious nuisances and effective control of these is feasible. As indicated in earlier discussion, this will require a more systematic approach, with tailored attention to each major industry to develop a plan of treatment which represents the minimum investment required for meeting the local water quality requirements. Also, a systematic monitoring program is essential to insure that the industrial waste disposal facilities are being competently operated.

In the future it is hoped that new industries will be located in definite industrial zones, which would greatly simplify the problem of waste treatment by permitting use of systems serving groups of industries. This will become increasingly important should the future industries be of types producing wastes containing sizeable amounts of toxic materials.

(e) Present Condition of Klongs

Despite the importance of the subject, very little work has been done since 1968 to "get the facts" on the actual conditions in the klongs. A modest program of field work was conducted by

the Ministry of Public Health, as part of a study aimed primarily at assessing conditions in the river (Reference 2E). The report reviews all earlier studies including the Master Plan Report plus results of field investigations over the period June 1969 - May 1970 including sampling of 12 major klongs (at their mouths) over 24 hour periods. The odors in the klongs were observed to be worse in Klong Padung Kasem, Ong Ong, and Bang Lam Poo in the immediate vicinity of markets and boat congregations. The BOD concentrations in the klongs ranged from 30 to 206 ppm. The total BOD discharge from the klongs to the river was about 77,000 kg/day in a total flow of about 15 cms, and the total sanitary waste discharge to the klongs was estimated at 6.7 cms. The klongs remove about 49% of the BOD by in-klong treatment, hence installation of separate sewers would significantly increase the total BOD discharged to the river. Also, where gates are employed detention times in the klongs are increased resulting in greater BOD removals (89% in Klong Lord).

These data generally confirm that the klongs continue to become gradually more polluted as community growth continues. Recently there have been evidences of real public concern, e.g., the current controversy on how to "get going" on klong dredging. While there is concensus that the quality of water in the klongs is depreciating, nevertheless the impact of this on community livings continues to be limited to concern about the public health hazard and about aesthetics, neither of which has yet become severe enough to create an action-demanding crisis. While water-borne communicable diseases account for about 5% of the deaths in the region, this has "always" been the case. Regarding aesthetics, despite the objectionable appearance of the klongs and associated smells, a great deal of the "mai pen rai" attitude still exists.

(f) Need for Critical Evaluation

Considering the importance of the klongs in the overall sanitation/water quality picture in the Bangkok Region, there are surprisingly few facts available as to their actual condition as related to waste loadings and as to improvements to water quality which would accrue from proposed engineering improvements. The few water quality studies made thus far, including those in the Master Plan Report, represent only very limited efforts and most of this concerned the quality in the river rather than the klongs. This despite the concensus that klong water quality is much more important.

What is needed is a mass balance of the wastes entering the klong from all sources (sanitary, solid wastes, industry), and of their fate in the klongs on the way to the river, including effects on water quality, together with predictions on improvements to klong water quality which could be expected from any

proposed engineering improvement. With such facts in hand the RTG would be able to compare the extent to which proposed improvements and their costs (such as separate vs combined sewerage systems, solid waste collection proposals, industrial waste treatment, etc.) would contribute to improving klong water quality. Through such comparisons a clear picture can be expected to emerge as to desirable standards of water quality for the klongs. Although recommendations have been made from time to time on desirable water quality standards for the klongs (References 2B, 8A), these have not been supported by firm evidence of the costs involved to achieve them. Setting of water quality standards on the basis of standards used elsewhere are not likely to be implemented if this requires heavy costs without strong evidence that the proposed standards are really the essential minimums suiting the country's developing needs.

In summary, the entire klong water quality picture needs to be quantified, through use of mathematical modelling to permit reliable prediction of the effects of any proposed measure. Until this is done the situation will remain confused with a host of "experts" advocating a variety of schemes.

POLLUTION IN CHAO PHRAYA RIVER

(a) Master Plan Report

Virtually all the wastes from the Bangkok Region are discharged to the Chao Phraya River resulting in heavy impact on river water quality. Although the Master Plan Report does not recommend construction of waste treatment facilities, the report presents a preliminary evaluation of river water quality. This includes the results of sampling and analysis from field surveys, representing the first significant study of the problem. The study concluded that waste assimilation is the most important and proper use of the Chao Phraya River in the Bangkok Region, that the organic loadings from the Bangkok Region use up most of the oxygen reserves of the river during the dry season, but nevertheless the river's potential for waste assimilation is sufficient to accommodate continuing growth (without creating any "crisis" conditions in the river) until about 1975. The Report recommended that in-depth studies be made to determine the best course of action so that construction of an appropriate waste treatment facility could be started about 1972 and finished by 1975. The report notes that, if a sewage treatment plant were to be considered for treating the collected wastes prior to discharge to the river, an allowance of about 150 million baht ($7.2 million) would be reasonable for purposes of financial planning. The report notes an activated sludge system for handling the design flow of 3 cms (1985) would cost

about 540 million baht but perhaps satisfactory treatment could be obtained through use of ponds for as little as 75 million baht.

Since submittal of the report in 1968, little further attention has been given to the subject except for a modest study carried out by the Ministry of Health in 1969-70 (Reference 2D) to supplement the Master Plan Report information.

(b) Ministry of Public Health Studies

The Ministry of Public Health report (Reference 2D), which reviews all earlier studies as well as presenting findings from the 1969-70 field surveys, attempts to make an oxygen balance between the supply of oxygen in the river on reaching Bangkok, plus augmentations from reaeration and photosynthesis (very slight) and from tidal flushing (also very slight), and the demands for use of oxygen from waste discharges directly into the river or from klongs. This study clearly shows the paucity of the total data available to date, which is sufficient only to confirm the generalized conclusion that the oxygen reserves in the river are mostly depleted during the dry season, with actual septicity occurring from time to time at the low ("sag") point below Bangkok about 40 km from the mouth of the river. Considering the importance of the subject it is clear that a much better evaluation of the river water quality needs to be carried out, including mathematical modelling, for the purpose of establishing a reliable quantification of the oxygen balance in the river and the impact on this balance of proposed engineering improvements including sewage collection and treatment facilities. The Ministry of Public Health together with ASRCT is now considering undertaking such a program.

(c) Regional Plan for Waste Treatment and Disposal

The study program for quantifying the oxygen balance in the river should include the entire stretch of river from Bangkok to the Gulf, recognizing the fact that the metropolitan region is inevitably extending down the river to reach the Gulf (and beyond). Because of the continuing growth of this "megalopolis", the problem of maintaining a reasonable oxygen balance will extend progressively down the river; hence, with respect to sewage treatment needs, the situation has changed significantly since the Master Plan Report of 1968. A new study is in order, namely to develop a master plan for a regional system of treatment and disposal covering the entire megalopolis zone, which will not only maintain suitable oxygen levels in the Chao Phraya but also consider protection of the marine fisheries, especially shellfish and finfish reproduction in the extensive shallow estuarine and mud flat areas along the north part of the Gulf.

In the development of the regional plan, a key aspect will be determination of the importance of marine fisheries versus

the extra costs for conserving them. While maintaining an oxygen reserve in the river may suffice to meet sanitation/nuisance/aesthic needs in the Bangkok Region, the problem of protecting wildlife reproduction in the shallow estuarine areas may be much more difficult because of toxic materials from industrial wastes, from land runoff (agricultural chemicals), and even from sanitary sewage.

POLLUTION IN UPPER GULF

The "molasses incident" of 1970, caused by the spill of molasses from a sugar cane mill into the Mae Klong River, attracted public attention to the growing problem of damages to marine fisheries due to pollution from the major river systems discharging into the upper portion of the Gulf. The molasses spill temporarily "wiped out" fishlife in the river and also had drastic effects on the extensive cockle clam farming industry covering several thousand acres of mud flats near the mouth of the river. About two years elapsed before conditions in the farming area returned to normal.

While incidents such as spills are spectacular, the greater hazard is in the gradual accumulation of toxicants and other pollutants in estuarine and other shallow marine waters, which are the habitats not only for shellfish such as shrimp and clams but also are the reproduction areas for major finfish species commercially fished in the Gulf of Thailand. While statistics are lacking, the fisheries authorities estimate the reduction in clam and mussel production may be as much as 50% over the past 10 years. Over this same span of time species such as the macrobrachium prawn and certain crabs, which formerly were common near the mouth of the Chao Phraya, are now rarely found.

The seriousness of this pollution is indicated by the value of the marine fisheries in the Gulf, which account for almost 4% of the GNP (gross national product). This represents about 1.25 million tons of catch annually, including about 60,000 tons of shrimp which accounts for almost half the value of the total catch and for considerable foreign exchange (about 10,000 tons/year are exported). The NESDB Third Plan (References 12A, 12B) recognizes the potentials for the national economy in greatly increasing shrimp production and export, and has assigned 800,000 rai of shallow coastal area to be devoted to shrimp production. Much of this is outside the Upper Gulf zone not affected by the main river discharges, but already the Fisheries Department is apprehensive about potential pollution to the new shrimp areas from emerging new industries.

The Fisheries Department recognizes that the first step in getting on top of the pollution problem is to ascertain the

facts by establishing an adequate data collection and analysis program, and moreover believes that to achieve an effective regional pollution control program will require establishment of some type of independent national agency clearly having responsibility for coordinating the interests of all branches of government.

With respect to monitoring of marine water quality, the pending program of the Division of Oceanography of the Royal Thai Navy, under sponsorship of UN affiliates (the WMO and IOC), is intended to obtain periodic information on water quality characteristics in the upper part of the Gulf. This program presents an opportunity for continuing assessment of the long-range effects of pollution on marine fisheries in this area, and arrangements have been made through the NRC to assist the Division of Oceanography through a Technical Advisory Committee including representatives of the Department of Fisheries and of AIT as well as Chulalongkorn's Department of Marine Science (who are serving as the project consultants). The problem of pollution in the upper portion of the Gulf involves problems to be found all over South East Asia; hence it should be possible to obtain research grants for expanding the initial monitoring program into a full-fledged investigation which could be of great value and credit to Thailand.

VI. CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The purpose of this study is to develop guidelines which might assist the Royal Thai Government in solving water pollution problems, particularly in the Bangkok Metropolitan Region. Regulation of water pollution in rapidly growing metropolitan areas is an especially difficult problem for governments because any solution is expensive and is in competition for funds with many other pressing needs. Also, the main objective of water pollution control is preservation of environmental values, including aesthetic and other intangibles such as preservation of wildlife species; hence development of a competent water pollution regulatory program involves social and political as well as economic and technological factors to an unusually high degree. The approach of this study was to review the history of water pollution control activities in the Bangkok Metropolitan Region, and to compare this with experiences elsewhere (especially in the USA) where similar problems have occurred and brought under control. From this evaluation the following conclusions have been developed:

(1) Developments Since Master Plan Report

Since submittal of the Master Plan Report in 1968 (Master Plan of Sewerage, Drainage and Flood Protection for Bangkok and Thonburi), the pollution situation in the Bangkok Metropolitan Region has significantly changed, with respect to both the internal situation (cleaning up the klongs) and the external situation (cleaning up the Chao Phraya River):

(a) On the internal situation (cleaning up the klongs) the Master Plan Report recommended a program of construction, including a system of separate sanitary sewers, which has proven to be much too expensive, i.e., the construction costs appear to transcend the amounts of monies likely to be available. As a result very little has been done to implement the overall program of construction, and nothing on the separate sewers. At this time it can be concluded the entire concept for the program needs critical review, leading to modified program which is phased to suit the economic/financing realities, and which recognizes the paramount interest in drainage (as compared with sanitation per se) in the planning of an integrated sewerage/drainage system.

(b) On the external situation (cleaning up the rivers) the Master Plan Report recommended delaying construction of any treatment plant but recommended in depth studies to determine treatment needs, noting that the oxygen reserves of

the river could be expected to handle the waste loadings until about 1975, and that design of a suitable treatment plant should be underway by 1972. Since 1968 it has become apparent, due to the projected growth of the Bangkok Region into a megalopolis stretching all the way to the Gulf and beyond, that the problem of maintaining aerobic conditions in the river requires consideration of the entire river zone down to the Gulf and moreover must also consider treatment needs for protecting marine fisheries in the Upper Gulf - which now appears to be one of the most important water pollution problems in Thailand.

(2) Basic Studies for Determining Treatment Needs

Despite the importance of pollution in the klongs in the Bangkok Region, in the Chao Phraya River, and in the Upper Gulf, the total effort for establishing the scientific facts, needed for justifying costly construction programs, has been very small (including the studies done by the Bangkok Sewerage and Drainage Committee and the Ministry of Public Health). Even if the program of construction recommended by the Master Plan Report, or any other improvement program, were to be implemented, reliable predictions cannot be made as to the improvements to be expected in water quality. Most of the Master Plan Report effort was allocated to engineering design, with only a beginning limited effort on quantifying conditions of water quality in the klongs or Chao Phraya River:

(a) Bangkok Region Klongs: While there can be little question (based on experience elsewhere) that some sort of system for collecting sanitary wastes must be constructed as a key measure in cleaning up the community, even if such a collection system were built it is not now possible to predict the resulting effects on klong water quality, nor to predict the effects of proposed measures for handling solid wastes, nor of industrial waste treatment operations. A mathematical modelling program needs to be undertaken which establishes the relationships between present waste discharges to the klongs and existing water quality, and which can predict effects on water quality of any proposed improvement (e.g., separate versus sanitary sewers, klong dredging versus klong flushing, different levels of solid waste pick up, different levels of industrial waste treatment, etc.). Until such information is available the RTG will not be in a position to make policy decisions on proceeding with costly large-scale improvement measures.

Generally, such decisions, involving expenditures of 10's and 100's of millions of dollars for constructing works or systems allegedly for protecting environment, should not

be made until a reasonable investment (say 1% of the estimated costs for engineering and construction) has been made in basic studies relating to the impact of the systems on environment and proving if constructed they will in fact achieve the desired levels of protection. For example, with respect to the proposed sewerage system, the main objective of which is cleaning up the klongs, involving an ultimate cost of about $200 million, the total expenditures to date "to get the facts" are estimated to be of the order of magnitude of less than $50,000 (about 1/4 of 1/10 of 1%). With the needed basic information in hand, it will be possible to reexamine the overall concept of sewerage/drainage/flood protection for the Bangkok Region and to develop a modified program suited to the reality of the local situation. While everyone agrees the klongs are badly polluted and becoming steadily more polluted, until this basic information is available the situation will remain confused with a variety of committees, "instant experts", and others continuing to contribute to the confusion. Looking back, the question examined by the visiting World Bank team in 1964, "Does Bangkok really need a sewerage system?", is still a good one.

(b) Chao Phraya River: Similarly, very little scientific work has been done for quantifying water quality parameters in the river, not even on dissolved oxygen, which thus far has been the only major factor of concern. Again, a mathematical model of the river is needed, for the entire stretch from Bangkok to the Gulf, which quantifies the existing relationship between loadings and water quality and can predict the effects of various feasible alternatives for treatment and disposal of sanitary and industrial wastes from the developing megalopolis zone. The key parameters to be considered should include dissolved oxygen (to permit maintaining aerobic conditions in the river), floatables (including oils and grease), and toxicity (with respect to impact on aquatic species). On the basis of this information it will be possible to evaluate the entire problem of treatment and disposal throughout the megalopolis zone, including delineation of essential beneficial uses and of minimum water quality standards, and to develop a comprehensive regional plan of treatment and disposal (including reclamation and reuse) which will maintain aesthic conditions in the river and also provide necessary protection to marine fisheries in the Upper Gulf and estuary.

(c) Upper Gulf: Over the past decade the value of the marine fisheries in the Gulf, including shellfish (clams, shrimp) from the estuarine areas and ocean water finfish which reproduce in the estuarine areas, has steadily increased due to the expanding Bangkok regional market and to export opportunities, but at the same time damage from

pollutants in the discharges of the major rivers (especially the Chao Phraya and Mae Klong) has increased to alarming proportions. Unfortunately, again, there are few pertinent statistics or scientific evaluations of the long-range effects of pollution. The need now is to initiate a program of study, including sampling and analysis, to collect the facts on a continuing basis to permit quantification of pollutional discharges (including organic loadings and toxicity) from the major rivers and their effects on biological values.

The program now being implemented by the Division of Oceanography with consulting assistance from Chulalongkorn University (hopefully in collaboration with the Department of Fisheries, AIT, and Kasetsart University) can be a beginning step in this direction. Also, because the upper gulf zone represents a "textbook" situation for studying effects of pollution of estuarine and marine ecology, with the results being applicable throughout South East Asia, it should be possible to obtain grants for generating a comprehensive study on this subject (extending over, say, a five-year period). As this type of information becomes available it will then be possible to examine the water pollution control needs in the entire upper gulf zone and tributary drainage basins and in turn to develop conclusions on reasonable limits for discharges of toxicity and other pollutants from the major rivers. In other words, it will be possible to establish firm water quality standards and to develop a comprehensive coordinated plan of waste treatment and disposal covering the entire upper gulf zone including the drainage basin areas of the four major tributary rivers.

(3) Governmental Activities

(a) General Situation: At this time, in evolution of water pollution activities in the RTG, responsibilities and interests in water pollution control are distributed among many agencies of Government and there is virtually no coordination between them (the situation resembles that in California, for example, 30 years ago). The most significant programs are those carried on by; (1) the Ministry of Public Health, through the Water Pollution Control Section of the Division of Sanitary Engineering, which has a very modest budget for surveillance of effects of pollutional discharges into the klongs and river; (2) the Ministry of Industry, which initiated a permit program in 1969 for controlling wastes from individual industries (throughout the country), which is of questionable effectiveness for a variety of reasons (primarily conflict of interest and lack of adequate staff); (3) ASRCT, which has a small Environmental Engineering Unit (in the Environmental and Ecological

Research Institute) which has potentials for carrying out needed research but thus far has obtained very few funds to support its activities; (4) the Bangkok Sewerage and Drainage Committee, whose efforts led to development of the Master Plan Report and which has since continued in a role of general surveillance of sewerage, drainage, and flood protection matters; (5) the Municipality, which is concerned with designing, building, and operating and maintaining the community public works systems; (6) the Department of Fisheries, which is now beginning to consider studies on pollution; (7) the National Research Council, which has been studying environmental pollution problems for several years (and which sponsored this present report); (8) the Division of Oceanography of the Royal Thai Navy, which is implementing Thailand's participation in a global program for monitoring pollution effects on marine waters; and (9) a number of special committees, such as those on klong dredging and nightsoil disposal, working on specific problems. In addition the universities in the Bangkok Region, especially AIT, have carried out some specific studies and research. The sum total of all this effort, however, hardly resembles any kind of coordinated or comprehensive program; rather the situation is one of continuing confusion as to the real status of the seriousness of water pollution and what should be done.

(b) Upper Gulf Project: A beginning effort on a coordinated water pollution study is now underway for monitoring the marine waters of the Upper Gulf to assess effects of pollution. Through the efforts of the NRC, a Technical Advisory Committee has been appointed to work with the Division of Oceanography of the Royal Thai Navy to modify and expand the Division's pending program for sampling and analysis of the Upper Gulf to provide additional information relating directly to effects of pollution on marine fisheries. The enlarged program, involving the collaboration of the Division of Oceanography, Department of Fisheries, the Department of Science of Chulalongkorn University, AIT, and Kasetsart University as well as NRC and ASRCT, could make an important contribution and be the first step in establishing the necessary comprehensive program for evaluating pollution in the Upper Gulf (See Conclusion 2c).

(c) ASRCT/EEU: The activities of ASRCT's Environmental Engineering Unit (EEU) could be markedly enhanced through a much closer cooperation with the environmental pollution research activities of AIT (headed by Prof. M. B. Pescod). The interests of the two groups are complementary, not competitive, and AIT, through their regular working associations with international agencies, is in an excellent position to assist the EEU in developing grants for major study

projects (including those described in Conclusion 2). AIT is not set up to have primary responsibility for carrying out such major projects, but ASRCT is; however, AIT can participate and can play a very key role in helping generate the project grants.

(d) Ministry of Public Health: The activities of the Ministry of Public Health's Water Pollution Section should be strengthened to permit the Section to contribute much more effectively in evaluating water quality in the klongs and Chao Phraya River as discussed in Conclusion 2. The Section should give primary attention to the problems of sanitary wastes (which amount to more than 95% of the total organic waste loadings in the region), and should seek a much closer working relationship with the Ministry of Industry for assisting the Ministry of Industry on industrial waste disposal problems without deplication of effort.

(e) Ministry of Industry: The present program of the Ministry for controlling industrial wastes would be greatly enhanced by making available to the Ministry the full-time services of one expert in industrial waste treatment aspects of water pollution control. The main problem with the existing program is the lack of such an individual, who is needed to coordinate, organize, and strengthen the program to make it much more effective and meaningful. This need cannot be met by part-time inputs from visiting experts. It is believed that funds for financing such a position, say for a period of two years, can be obtained through one of the existing assistance programs managed by DTEC (Department of Technical and Economic Cooperation). In addition, a Thai engineer should be selected for training in industrial waste treatment and regulation technology (say, in the USA), who has career potentials for heading up this activity in the RTG.

(4) Coordinating Committees

In any effort to achieve some concensus of the diversified interests on a desirable program of action for controlling environmental pollution, over the past few years the RTG has established a number of national advisory committees including (a) the Advisory Committee on Family Health and Environmental, (b) the National Committee on Environmental Quality Control, and most recently (c) the National Committee on Human Environment (NCHE), which now has primary responsibility for developing a plan of action for consideration by the RTG. One of the main values of the present report, hopefully, will be its usefulness to the NCHE.

The NCHE, through its Executive Committee, has recently appointed working sub-committees including a sub-committee on water problems. It is suggested that these sub-committees

provide for participation and contributions from locally available individuals not working in the RTG who have expertise in the specialties concerned (e.g. from AIT).

(5) Technology Transfer

(a) Although governmental interests in water pollution control have evolved over the period of a century, the experience in the USA over the past several years is unique in representing a relatively vast level of effort and expenditures on all phases of the problem including research to develop new technology, planning to achieve more efficient regional systems, construction, and enforcement. A great deal has been learned from this effort, which furnishes a valuable base for guiding policy decisions in Thailand.

(b) One of the biggest problems in achieving progress in water pollution control in Thailand is the lack of senior-level experience in this field of work in the RTG. Most policy decisions are made by committees whose entire membership is from Government, hence the process is similar to "trying to squeeze blood out of a turnip". Recognizing the principle that one doesn't become expert at something by not doing it, there are no individuals in the RTG with extensive experience in research and development studies relating effects of works or systems to ecological impact, nor on the planning of water pollution control systems, nor on the design of treatment systems for processing sanitary or industrial wastes, nor on the regulatory aspects of water pollution control (including setting of beneficial uses, water quality standards, and waste treatment effluent criteria). There is expertise in the civil engineering aspects, only limited experience in monitoring (limited essentially to public health and dissolved oxygen considerations, only two of the important parameters), and only beginning efforts in research. The committee activities of Government should include active participation by individuals who have significant backgrounds of experience in the specialized fields under consideration. Also, should an Environmental Secretariat be established, its success in water pollution control will depend critically on having available at least one full-time individual with senior-level experience in water pollution control plus the help of selected consultants on a per diem basis.

(c) Assuming that the projects recommended above (Item 2), for conducting basic scientific studies and for preparing regional waste disposal plans, are to be implemented, it will be necessary to seek support from outside sources including technological expertise from private firms. It

is important in the organization of such projects, that provision be made for utilization of local personnel and agencies, public and private, so the projects are in effect joint ventures and will be conducted so as to build up in Thailand an increasing reservoir of expertise on water pollution technology. In other words, the projects should incorporate training in advanced technology much moreso than has been done in the past. While apparently adding to the costs of particular projects, in the long run the only economical manner by which Thailand can design and manage advanced technological systems will be through generation of local capabilities. In such projects full use should be made of local resources.

(d) Assuming establishment of an Environmental Secretariat (Item 7), a key task of the Water Pollution Control Division will be to keep track of research and development findings from work in the industrialized nations, especially the USA (whose budget for research and development now represents more than 90% of the total for the world), and to design Thailand's programs to take advantage of these findings. For example, the solution to the problem of water pollution from agricultural chemicals, which must be accomplished at the "source", will likely come from programs now sponsored by EPA in the USA.

(6) Time Element

Considering the factor of time, the main problem in achieving progress in water pollution control is how to move the regulatory situation (resembling that in California, say, 30 years ago) to a modern one (capable of carrying out a comprehensive program of water pollution control including planning, research, sponsoring establishment of waste control systems, monitoring, and permit operations) without waiting for 30 years to go by. What Thailand needs today is a going national regulatory authority having the scope of duties noted above and the supporting budget, but it is recognized that the best means for achieving this will likely be to proceed "one step at a time", beginning with the establishment of an office or secretariat sufficient to develop basic information necessary for making sound policy decisions. The Secretariat's initial assignment would be to function as the staff arm of the NCHE and thus greatly enhance the resources available to NCHE.

In attempting to get a competent regulatory authority established in Thailand it is necessary to recognize the fact that in no country yet has an effective regulatory program been established until after serious environmental degredation has occurred. The problem for the RTG is how to "pioneer" a bit and to move ahead with a program featuring prevention rather than cure. Pioneering is always difficult,

but should be feasible in that the experience of the industrialized nations is available as a guide, and is really essential if environmental values are to be preserved to the maximum degree consistent with continuing growth. The main lesson from the industrialized countries is that pollution can be controlled at reasonable costs as part-and-parcel of growth, but that correction after the fact (especially for industries) is often prohibitively expensive.

(7) Environmental Secretariat

Assuming an Environmental Secretariat is to be established, it should be located in the Office of the Prime Minister, in order to have the authority necessary for coordinating the action programs to be carried out by various Ministries.

The Secretariat should be funded sufficiently to have its own staff, to make frequent use of expert consultants, and to contract with other agencies for completion of specific tasks. In considering staffing, based on the current experience in the USA where State Governments staffs in water pollution control average about 17 persons per million population, a reasonable staffing for Thailand would be about 60 to 70 persons (to be achieved through build-up over a period of years). (Note that such an effort would be modest compared to regulatory operations in the USA, where the bulk of the budget today is in the Federal Government, not in the States.)

The Secretariat's main role in the immediate future would be planning, to determine and delineate specific programs to be done, and to sponsor these programs, i.e., arrange for the work to be carried out by the existing agencies of Government or otherwise, and to furnish necessary guidance and supervision for such projects. The Secretariat would collect, collate, and evaluate all pertinent information relating to water pollution control on a continuing basis, and from these evaluations develop recommendations on needed new programs for consideration by the RTG.

The Secretariat should include a water pollution control division with primary responsibility for water pollution control assigned to the division, and with the higher level of the Chief of the Secretariat engaged in overall policy and not in trying to "integrate" water pollution control activities with those of air, noise, etc. Such an approach (trying to achieve integration of environmental pollution control) has yet to succeed anywhere but has effectively used up budget in administrative work without

accomplishing much control. The water pollution control division must be permitted to do its job; hence the efforts of its staff must be focused on water pollution control.

The management of the water pollution control division should include a chief, skilled in RTG operations, and a deputy chief skilled in water pollution regulation.

Tasks which can be undertaken by the Water Pollution Control Division in its initial operations could include; (a) delineation of programs for obtaining necessary basic data and related engineering planning of waste disposal systems, plus development of financing for this work including outside support; (b) evaluation of the efficacy of the present industrial waste permit system, and development of recommendations for needed improvements (with particular attention to problems in the Mae Klong River basin), including establishment of realistic waste effluent criteria and monitoring programs; (c) monitoring of the klongs and Chao Phraya River for continuing evaluation of changes in water quality; and (d) provision of communications and coordination between various branches of the RTG involved in water pollution control, especially at the working level.

RECOMMENDATIONS

The RTG should take the following steps:

(1) Establish and conduct basic studies for quantifying water quality parameters in the klongs, in the river, and in the Upper Gulf, and, as this information becomes available, establish the essential beneficial uses of these water and the associated minimum water quality standards.

(2) Based on the information from Item 1, (a) prepare comprehensive plans for water pollution control in the klongs of the Bangkok Region (revise the existing plan), (b) prepare comprehensive water pollution control plans for the Chao Phraya River covering the new megalopolis area from Bangkok to the Gulf, and (c) develop guidelines for coordinated control of wastes within the entire drainage areas of the four major river systems draining to the Upper Gulf, as needed to protect marine fisheries in the estuarine and ocean waters of the Gulf.

(3) Furnish a full-time expert on industrial wastes to assist the Ministry of Industry in improving its program for control of industrial wastes, preferably through one of the international assistance programs. This expert should have responsibility for assisting in strengthening the existing program to insure competency, including prepara-

tion of periodic progress reports presenting the pertinent facts on waste treatment systems built and monitoring of waste treatment systems to insure performance. In addition, arrangements should be made for training of a Thai engineer in the USA, on industrial waste treatment and regulatory technology, who has career potentials for heading up this activity in the RTG.

It is especially important that individual industries make their investments in competent waste handling systems, otherwise they will have to make them twice (in the long run) with resulting extra strain on their competitive position. While industrial wastes in the Bangkok Region and elsewhere have posed mostly problems of septicity from organic loadings resulting in local nuisances, with resulting little economic damage, in the future competent control of industrial wastes will be a "must" for protection of marine fisheries.

(4) Proceed with the enlargement of the scope of duties of MWWA to include responsibility for sewerage, drainage, and flood protection, including carrying out of needed new engineering studies as noted above and cooperating and participating i the studies for obtaining basic scientific data.

(5) Consider establishment of an Environmental Secretariat or Office, in the Office of the Prime Minister. The Secretariat, with an appropriate budget (say $200,000/year) could undertake the programs noted above, under policy guidance from the Committee, using both in-house staff and contracts with outside agencies including ASRCT, AIT, and private firms. The Secretariat would also help obtain grants to assist in financing research.

Establishment of the Secretariat would be the first step in achievement of an eventual National Environmental Pollution Control Agency. One of the assignments for the Secretariat would be to develop plans by which the national authority can be achieved, and to work toward that end. It would be up to the Secretariat to demonstrate its capability to move ahead.

VII. FIGURES

FIGURE 1

CHAO PHRYA DRAINAGE AREA

(From Master Plan Report of 1968)

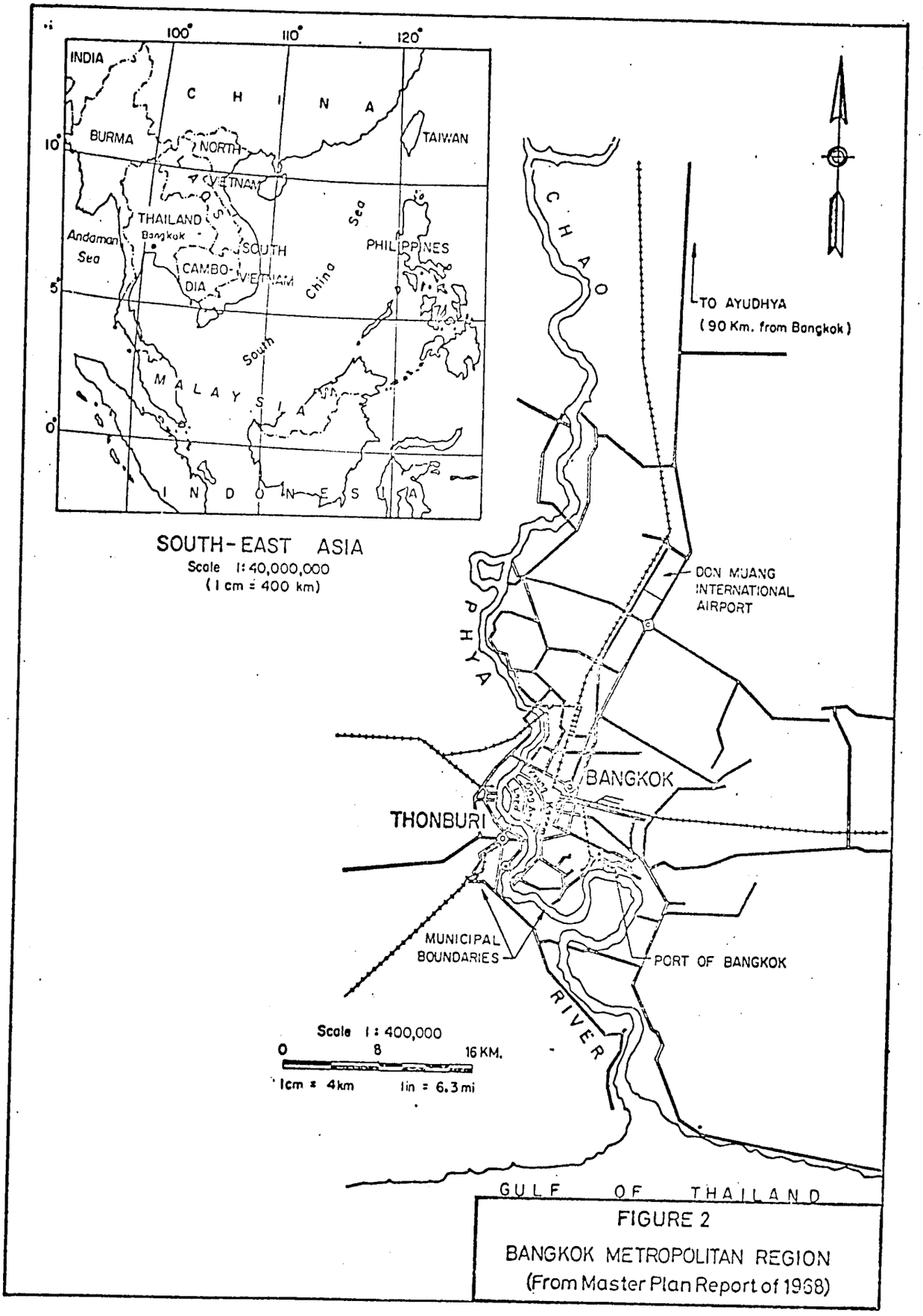

FIGURE 2

BANGKOK METROPOLITAN REGION
(From Master Plan Report of 1968)

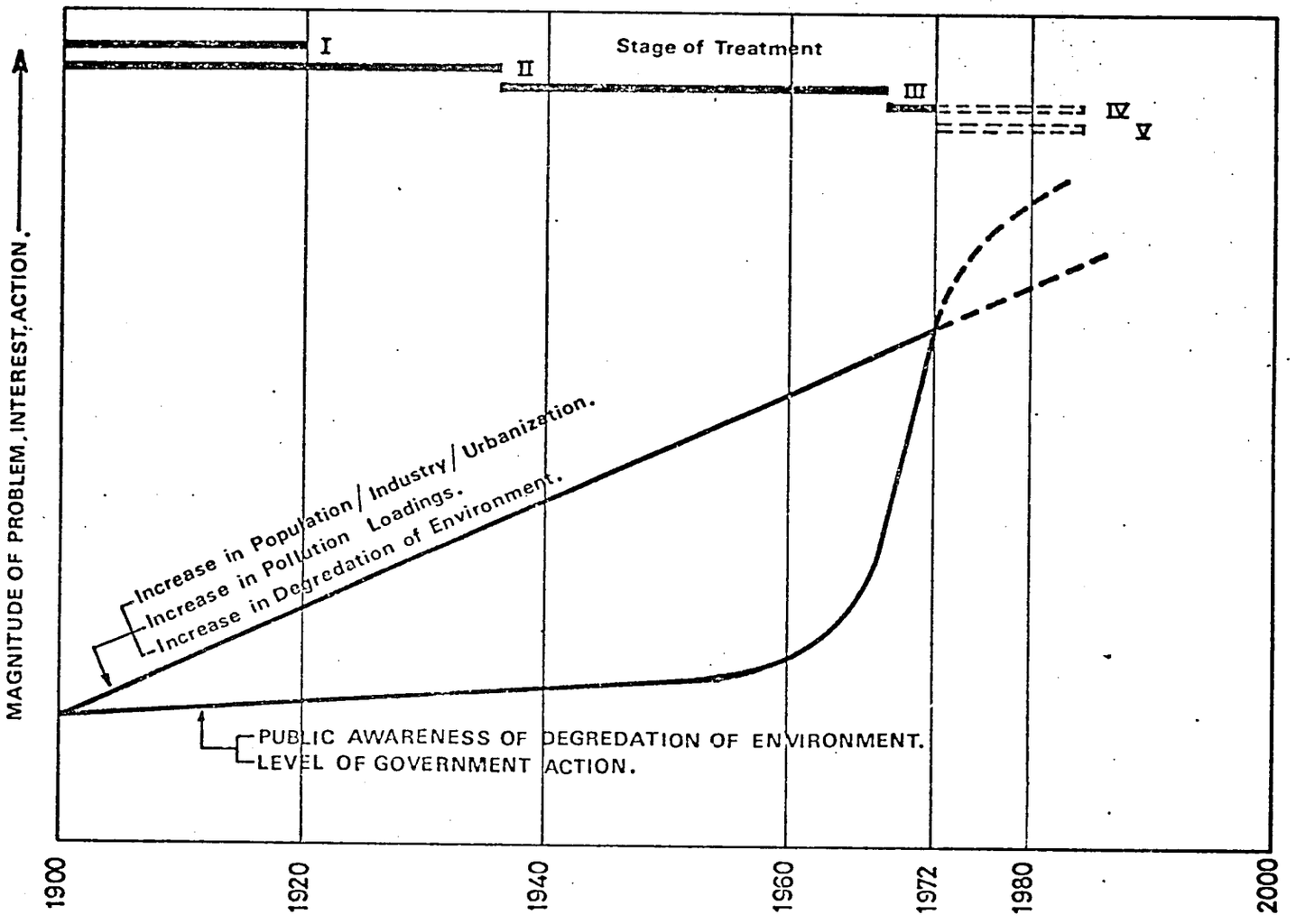

FIGURE 3 SCHEMATIC REPRESENTATION OF EVOLUTION OF POLLUTION CONTROL IN UNITED STATE OF AMERICA.

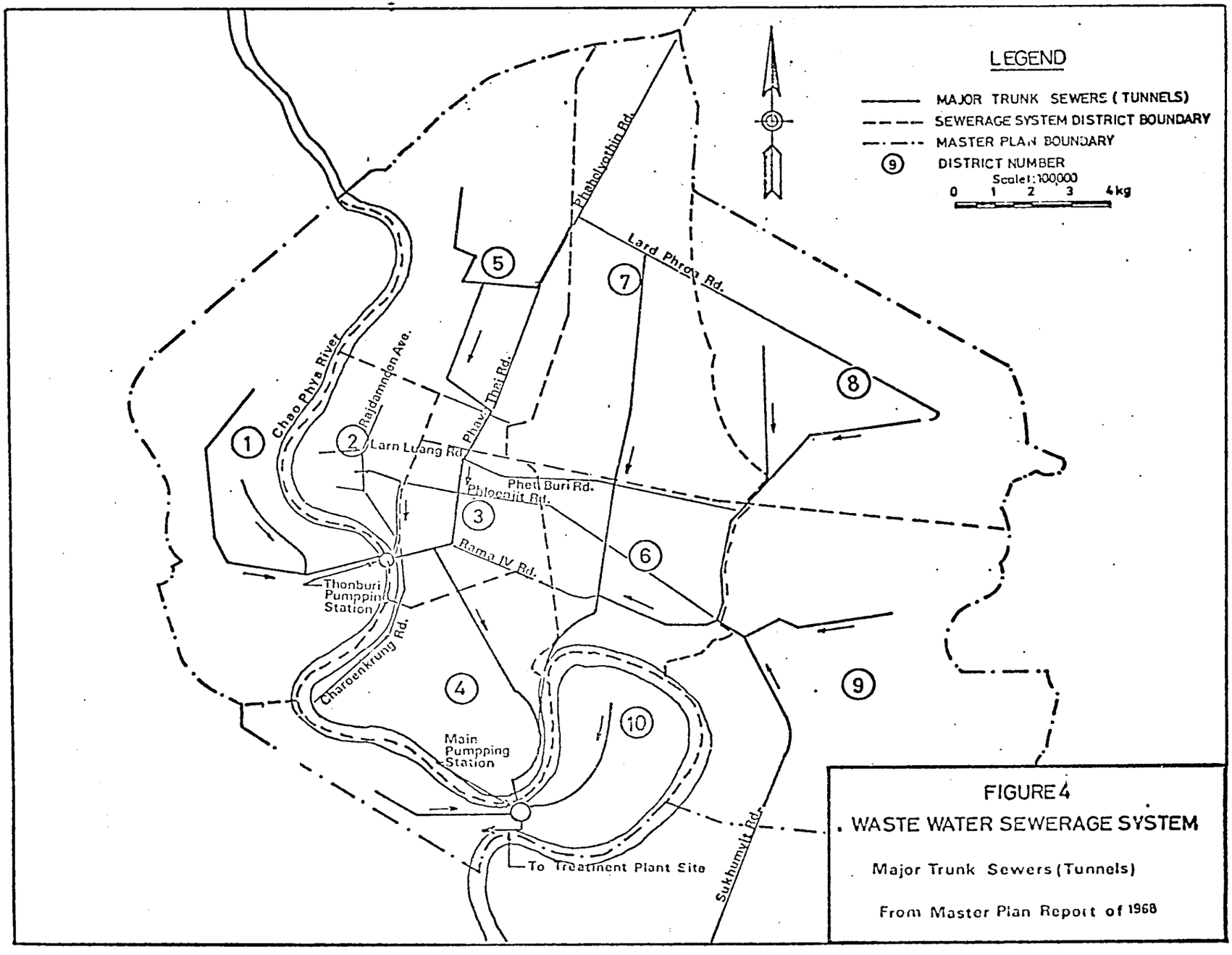

FIGURE 4

WASTE WATER SEWERAGE SYSTEM

Major Trunk Sewers (Tunnels)

From Master Plan Report of 1968

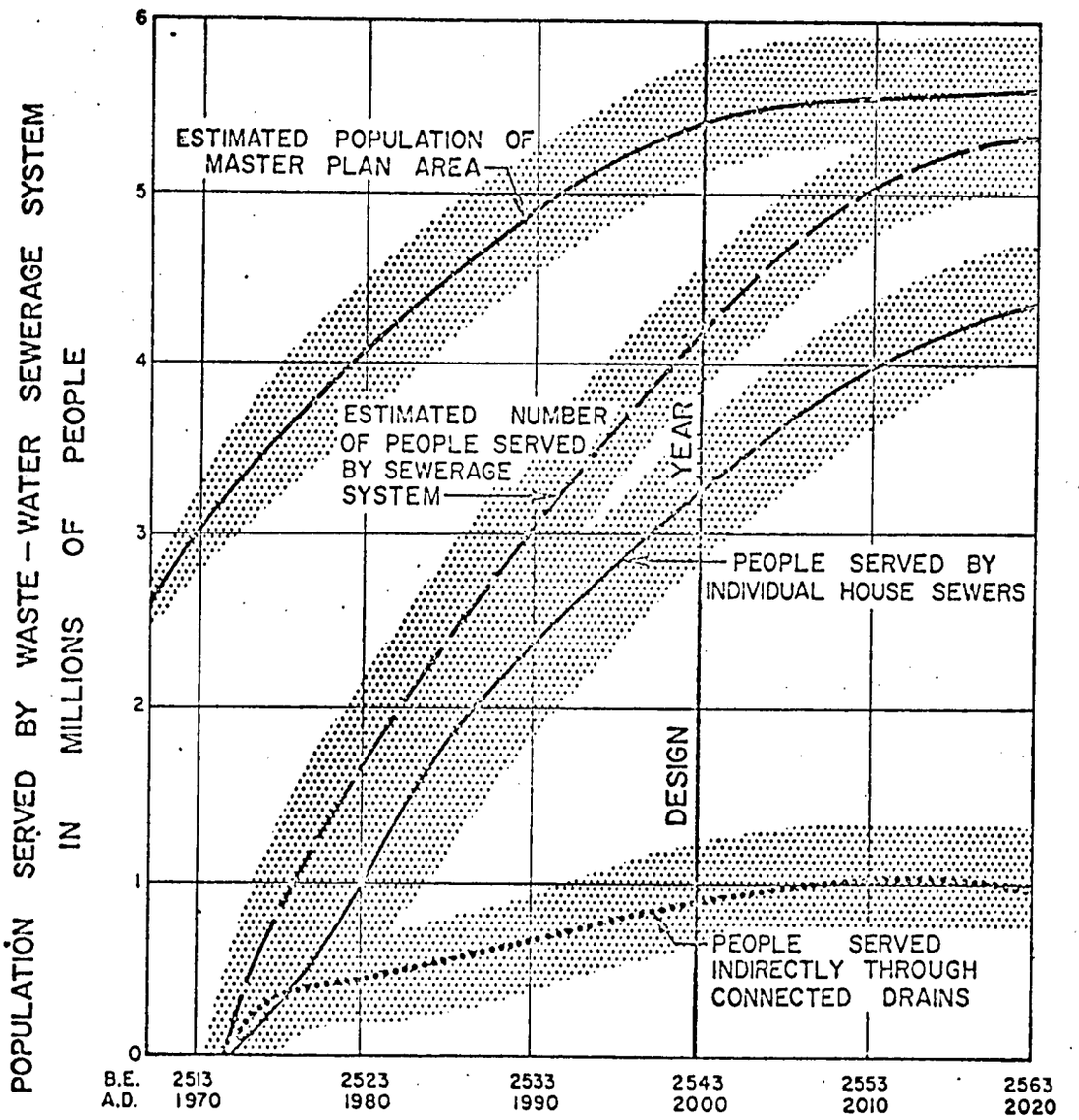

FIGURE 5

ESTIMATED POPULATION SERVED BY WASTE-WATER SEWERAGE SYSTEM

(From Master Plan Report of 1968)

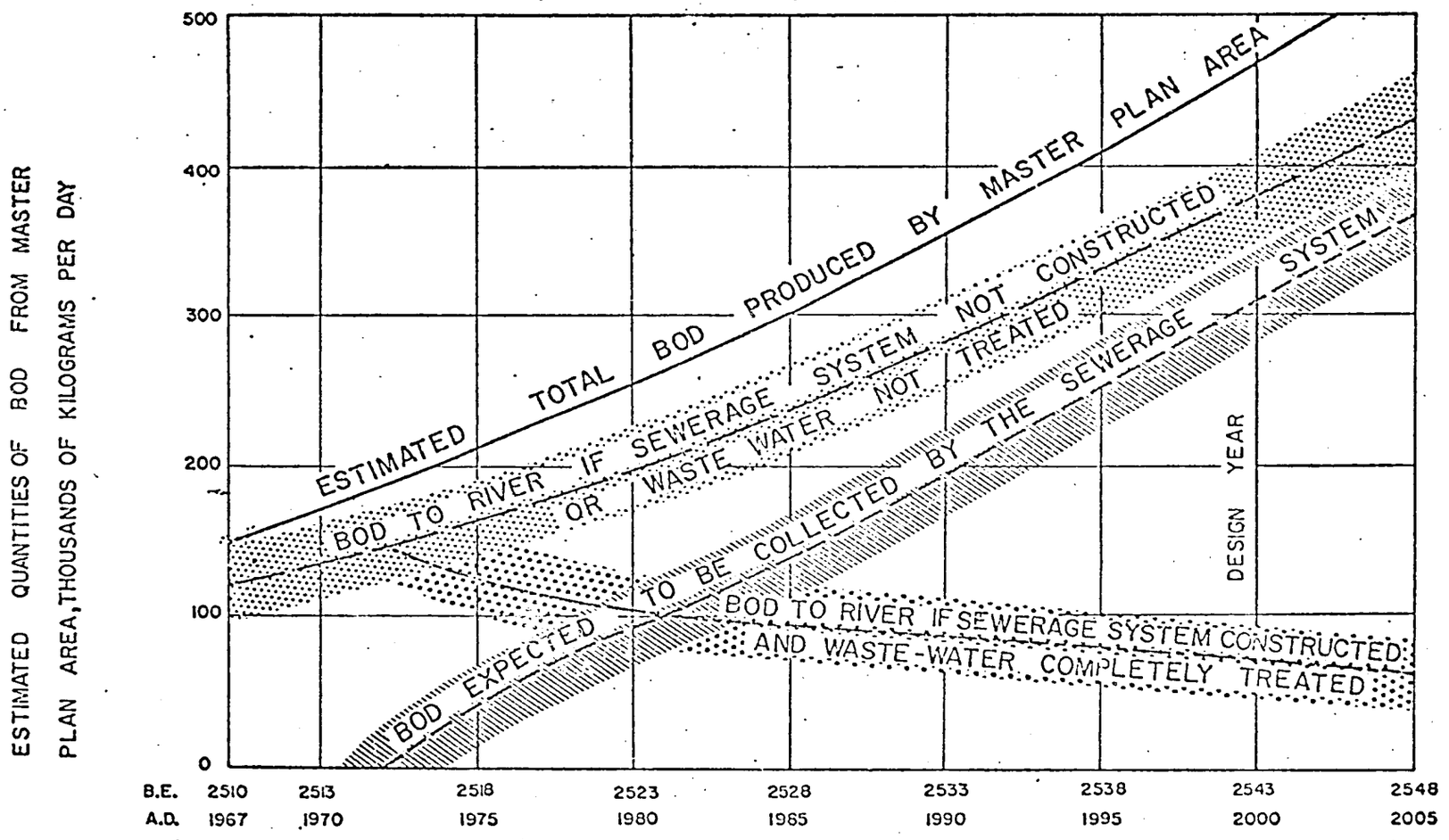

FIGURE 6

EFFECT OF WASTE—WATER COLLECTION AND TREATMENT ON RIVER POLLUTION

(From Master Plan Report of 1968)

VIII. APPENDICES

A. List of Persons Interviewed

B. List of References

C. Survey of Industries in Bangkok Region

D. Stream Standards According to Controlling Water Use

E. State Policy for Water Quality Control (California State Water Resources Control Board)

F. Committee on Environmental Quality Control

G. National Committee on Human Environment

H. Bangkok Sewerage and Drainage Committee

I. Food Quality Control Board

J. Advisory Committee on Family Health and Environment

K. Rules and Regulations of Ministry of Industry for Control of Industrial Wastes

APPENDIX A.

LIST OF PERSONS INTERVIEWED BY AGENCIES

National Research Council (NRC)

1. Dr. Pradisth Cheosakul, (Secretary-General) (also Chairman of National Committee on Environmental Quality Control) (16th October plus many)

2. Miss Praparsri Thanasukarn (Chief, Research Survey and Analysis Section) (Also Secretary of National Committee on Environmental Quality Control) (16th October plus many)

3. Dr. Choompol Swasdiyakorn (Deputy Secretary-General for Social Sciences) (16th October)

4. Mrs. Sakuntala Bhodhiprasart (Special Grade Scientific Officer (16th October)

Applied Science Research Corporation of Thailand (ASRCT)

1. Dr. Boon Indrambarya (Research Director, Environmental and Ecological Research Institute) (16th October) (31st October)

2. Dr. Sermpol Ratasuk (Research Officer, Environmental Engineering Unit, Environmental and Ecological Research Institute) (17th October) (30th October) (20th November) (12th December)

3. Dr. Malee Sundhagul (Chief, Micorbiology Section, Environmental and Ecological Research Institute) (30th October) (20th November)

4. Mr. R. Martin Bell (Consultant on Transfer Technology from University of Sussex) (2nd November)

5. Dr. C.L. Wrenshall (UNIDO Project Manager, Technological Research Institute) (1st November)

National Economic and Social Development Board

1. Mr. Renoo Suwansit (Secretary-General) (Also Chairman of Executive Committee of National Committee on Human Environment) (25th October)

2. Mrs. Valapa Chartprasert (Director, Social Projects Division) (Also Secretary of National Committee on Human Environment) (25th October)

3. Miss Oratip Tunskul (Chief, Health Sector, Social Projects Division) (Also Assistant Secretary of National Committee on Human Environment) (26th October) (13th November)

4. Mr. Jarar Buparat (Chief, Public Utility Sector, Social Projects Division) (Also Secretary of Bangkok Sewerage and Drainage Authority) (26th October)

5. Mr. Forrest Cookson (Senior Economist, Advisor to NESDB on Assignment from USOM) (29th November)

Ministry of Public Health

1. Dr. Komol Pengsritong (Under-Secretary) (18th October)

2. Dr. Chitt Hemachutha (Director General, Department of Health Promotion) (18th October)

3. Mr. Praphorn Charuchandr (Directory Division of Sanitary Engineering, Department of Health Promotion) (18th October) (13th November) (14th November)

4. Mr. Kasemsan Suwarnarat (Chief, Water Pollution Section, Division of Sanitary Engineering) (17th October)

5. Mr. Geraldo Rodriguez (WHO Engineer assigned to assist Sanitary Engineering Division) (14th November)

6. Mr. Pichak Tanhernhongs (Sanitary Engineer, Water Pollution Section) (14th November)

Ministry of Industry/Factory Control Operations

1. Mr. Damra Amatayakul (Chief Engineer, Office of Under-Secretary) (17th October) (25th October)

2. Mr. Udomsakdi Phasavanich (Director General, Department of Industrial Works) (17th October)

3. Mr. Vibul Viraphanich (Chief, Factory Control Division, Ministry of Industry) (25th October)

4. Dr. Charoen Vashrangsi (Chief of Physic and Engineering Division, Department of Science)

5. Mr. Jaral Intarangsi (Deputy Director, Sugar Institute) (8th Jan.73)

6. Mr. Somchai Chaitipa-at (Chief, Science and Technology Division, Sugar Institute) (8th Jan.73)

Asian Institute of Technology

1. Dr. Richard Frankel (Associate Professor of Environmental Engineering) (19th October)

2. Dr. M. G. McGarry (Associate Professor of Environmental Engineering) (7th November)

3. Dr. M.B. Pescod (Chairman and Professor of Environmental Engineering) (26th October) (12th December) (19th December)

4. Dr. Subin Pinkayan (Associate Professor of Water Science and Engineering)(19th October)

US/AID - USOM

1. Dr. Merrill M. Shutt (Chief, Office of Health and Population Planning) (9th October plus many)

2. Mr. Samuel Taylor (Chief, Rural Health, O/HPP) (9th October plus many)

3. Mr. Sa-ard Srinkapaibulaya (Chief, Water Resources Division, Field Operations) (20th October)

4. Mr. Rey M. Hill (Director) (6th November)

5. Mr. Frederick F. Simmons (Deputy Director) (6th November) (20th December)

6. Mr. A. Grayson (Chief Engineer, Field Operation) (10th November)

Mahidol University

1. Dr. Tongchai Papasarathorn (Dean, Faculty of Public Health) (20th October)

2. Mr. Piya Suvit (Acting Head of Sanitary Engineering, Faculty of Public Health) (20th October)

3. Dr. Vithya Pienvichitr (Professor of Physics/Public Health) (16th November)

Lower Mekong Basin (Committee for Coordination of Investigations)

1. Mr. I.J. Silverstone (Sanitary Engineer Consultant) (21st October)

2. Mr. Louis A. Cohen (Acting Chief Engineer, Public Works Division) (17th November)

3. Mr. Plin-San (Sanitary Engineer with Social Projects Division). (17th November)

Consulting Engineers (Bangkok)

1. Mr. Joseph Lawler (Partner, Camp, Dresser and McKee, Consulting Engineers (while visiting Bangkok) (30th October)

2. Mr. Frank T. Smith, Jr. (Resident Manager for Camp, Dresser and McKee) (30th October)

3. Mr. A. L. Tholin (Consulting Engineer, Ploenchit Building, Bangkok) (16th November)

Royal Irrigation Department (Ministry of Agriculture)

1. Mr. Suthep Tingsabhet (Director, Planning Division) (31st October)

2. Mr. Swaeng Poonsuk (Director General) (24th November)

3. Mr. Suthorn Runglak (Assistant to Director General)(24th November)

Hydrographic Department (Royal Thai Navy)

1. Captain Tavorn Pongsapipatt (Chief, Oceanographic Division) (6th November plus several)

2. Miss Gullaya Sapsongwong (Laboratory Analyst) (6th November)

Municipality of Bangkok

1. Mr. Charoen Antarikarnanda (Senior Engineer, Division of Sanitation) (1st November)

2. Mr. Kamol Nuchantanon (Director, Division of Sanitation) (1st November)

3. Mr. Udom Srisaovajati (Deputy City Clerk for Engineering) (20th November)

4. Mr. Prasert Navaratana (Deputy Director, Bureau of Public Works) (28th November)

5. Mr. Chalitpakorn Virabalin (Chief, Division of Planning) (29th November)

Metropolitan Water Works Authority

1. Mr. Chamras Chayapong (Governor) (1st November)

Department of Public Works (Ministry of Interior)

1. Mr. Samreong Komolsiri (Chief, Sanitary Section, Division of Planning) (9th November)

2. Mr. Sawadi Orvichian (Chief Engineer, Provincial Water Supply Division) (9th November)

3. Mr. Humberto Sanchez (WHO Sanitary Engineer on Assignment to Provincial Water Supply Division) (9th November)

Department of Technical and Economic Cooperation (DTEC)

1. Mrs. Sansanee Yamasmit (Chief, United Nations Division) (9th November)

Chulalongkorn University

1. Prof. Aroon Sorathesn (Rector) (15th November)

2. Dr. Surin Setamanit (Assistant Professor) (Also Staff Assistant to Dr. Aroon) (5th December)

3. Dr. Suraphol Sudara (Department of Marine Science) (12th December)

4. Dr. Manuwadi Hungspreugs (Department of Marine Science) (12th December) (19th December)

5. Dr. Twesukdi Piyakarnchama (Department of Marine Science) (19th December)

Ministry of Agriculture

1. Mr. Sant Bandhukul (Director General of Department of Fisheries) (15th November)

2. Dr. Ritsh Syamanonda (Director, Project for Strengthening Plant Protection Service) (6th December)

3. Mrs. Chalanya Tharnbupha (19th December)

World Health Organization

1. Mr. W.H. Huehne (WHO Liaison Officer to ECAFE) (17th November)

Town and Country Planning/Ministry of Interior

1. Mr. Vichai Pakdidinden (Director) (22nd November)

Planning and Policy Bureau/Ministry of Interior

1. Dr. Mayura Viseskul (Deputy Director) (4th December)

2. Dr. Nart Tantaviro (Staff Assistant) (4th December)

3. Dr. Anuwat Wattanapongsiri (Staff Assistant) (4th December)

World Bank

1. Dr. Gene Reese (Deputy Chief, Bangkok Regional Office) (6th December)

Ministry of Industry/Department of Mineral Resources

1. Mr. Saman Buravas (Director General) (7th December)

2. Mr. Charoen Phiancharoen (Hydrologist, Division of Ground Water) (7th December)

Electric Generating Authority of Thailand (EGAT)

1. Mr. Pat Kessasamli (Chief Engineer) (7th December)

Southeast Asian Fisheries Development Center (Samutprakarn)

1. Dr. Arporna Sribhibhadh (Secretary General) (8th December)

APPENDIX B.

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APPENDIX C

SURVEY OF INDUSTRIES IN BANGKOK REGION

No.	Name of Company	Type of Industry	Number of Employees	Discharge CMD	Estimated BOD Kg/day	Finished Monthly	Product Output	Wastes Discharge Location
1	Bireley's	Soft Drinks	50	250	30	580,000	liters	Mun. drain
2	Fraser & Neave	Soft Drinks	50	300	30	570,000	liters	Mun. drain
3	Green Spot	Soft Drinks	70	800	30	630,000	liters	Mun. drain
4	Union Soda	Soft Drinks	65	150	30	750,000	liters	Mun. drain
5	Thai Amarit	Brewery	150	400	320	420,000	liters	Chao Ph. Riv.
6	Boon Rawd	Brewery	1,700	1,600	950	2,100,000	liters	Chao Ph. Riv.
7	Pop Products	Ice Cream	150	160	450	25,000	liters	Kl. Saen Saep
8	Bangkok Dairy	Milk, Soft Drinks	80	150	350	230,000	liters	Chao Ph. Riv.
9	Sermsuk	Soft Drinks	135	600	100	6,200,000	liters	Mun. drain
10	Thai Nam Thip	Soft Drinks	430	250	50	2,900,000	liters	Mun. drain
11	Foremost Dairies	Dairy	300	200	550	-----		Chao Ph. Riv.
12	Asia Factory	Paper Mill	10	15	50	15	tons	Klong
13	Lever Brothers	Soap, Margerine	450	50	20	1,200	tons	Klong
14	Bang Yee Khan	Distillery	2,500	600	400	720,000	liters	Chao Ph. Riv.
15	Thai Klong Toey	Dye House	40	30	100	-----		Mun. drain
16	Rubia Industries	Soap, Cosmetics	110	15	150	Soap:40	tons	Mun. drain
						Cosmetics:8	tons	Mun. drain
17	Thai Tobacco	Cigarettes	4,000	600	120	2,800	cartons	Klong
18	Siam Cement Co.	Cement	300	1,000	30	48,000	tons	Klong
19	Livestock Trading	Meat Packing	800	4,700	1,900	7,500	cows	Klong Toey &
						50,000	pigs	Phra Kanong
						125,000	chickens	
20	Thai Tanning	Tannery	100	520	250	4,500	hides	Klong Toey
21	Seri Industry	Soap, Cooking Oil		40	500	-----		Klong
22	Thonburi Textiles	Cloth	370	480	120	75,000	yards	Kl. Dao Kanong
23	Fish Marketing	Shrimp Processing	400	80	80	225	tons shrimp	Chao Ph. Riv.
		TOTAL	12,260	12,990	6,610			

APPENDIX D.

STREAM STANDARDS ACCORDING TO CONTROLLING WATER USE (SUGGESTED BY PESCOD)

Controlling Water Use	Stream Standard	
	Quality Parameter	Suggested Level
Potable Water Supply	Most Probable Number of Coliforms (MPN)	90% of samples examined throughout any year 10/100 ml., no sample 20/100 ml.
	pH	6.5 - 8.5
	Dissolved Oxygen (DO)	2 mg/l
	Arsenic	0.2 mg/l
	Chromium (hexavalent)	0.05 mg/l
	Cyanide	0.01 mg/l
	Lead	0.1 mg/l
Irrigation	Total Dissolved Solids (TDS)	400 mg/l - poor drainage 1000 mg/l - good drainage
	Electrical Conductivity (EC)	750 micromhos per cm (poor drainage) 2250 micromhos per cm (good drainage 0 (low SAR)
	Sodium Adsorption Ratio (SAR)	10 - high mineral content (poor drainage) 18 - low mineral content (good drainage)
	Boron	1.25 mg/l - sensitive crops 3.75 mg/l - tolerant crops
Fishing	Dissolved Oxygen (DO)	2 mg/l
	Pesticides: DDT	0.0002 mg/l
	Endrin	0.0004 mg/l
	BHC	0.21 mg/l
	Methyl Parathion	0.10 mg/l
	Malathion	0.15 mg/l
	Carbon Dioxide (CO_2)	12 mg/l
	pH	6.5 - 8.2
	Ammoniacal Nitrogen (NH_3 - N)	1.2 mg/l
	Cyanide	0.01 mg/l
	Arsenic	1.0 mg/l
	Chromium	0.05 mg/l
Waste Disposal	Dissolved Oxygen (DO)	0

APPENDIX E.

CALIFORNIA STATE WATER RESOURCES CONTROL BOARD

STATE POLICY FOR WATER QUALITY CONTROL

I. FOREWORD

To assure a comprehensive statewide program of water quality control, the California Legislature by its adoption of the Porter-Cologne Water Quality Control Act in 1969 set forth the following statewide policy:-

> The people of the state have a primary interest in the conservation, control, and utilization of the water resources, and the quality of all the waters shall be protected for use and enjoyment.
>
> Activities and factors which may affect the quality of the waters shall be regulated to attain the highest water quality which is reasonable, considering all demands being made and to be made on those waters and the total values involved, beneficial and detrimental, economic and social, tangible and intangible.
>
> The health, safety, and welfare of the people requires that there be a statewide program for the control of the quality of all the waters of the state. The state must be prepared to exercise its full power and jurisdiction to protect the quality of waters from degradation.
>
> The waters of the state are increasingly influenced by interbasin water development projects and other statewide considerations. Factors of precipitation, topography, population, recreation, agriculture, industry, and economic development vary from region to region. The statewide program for water quality control can be most effectively administered regionally, within a framework of statewide coordination and policy.

To carry out this policy, the Legislature established the State Water Resources Control Board and nine California Regional Water quality control Boards as the principal state agencies with primary responsibilities for the coordination and control of water quality. The State Board is required pursuant to legislative directives set forth in the California Water Code (Division 7, Chapter 3, Article 3, Sections 13140 Ibid) to formulate and adopt state policy for water quality control consisting of all or any of the following:-

Adopted by the State Water Resources Control Board by motion of July 6, 1972.

Water quality principles and guidelines for long-range resource planning, including groundwater and surface water management programs and control and use of reclaimed water.

Water quality objectives at key locations for planning and operation of water resource development projects and for water quality control activities.

Other principles and guidelines deemed essential by the State Board for water quality control.

II. GENERAL PRINCIPLES

The State Water Resources Control Board hereby finds and declares that protection of the quality of the waters of the State for use and enjoyment by the people of the State requires implementation of water resources management programs which will conform to the following general principles:-

1. Water rights and water quality control decisions must assure protection of available fresh water and marine water resources for maximum beneficial use.
2. Municipal, agricultural, and industrial wastewaters must be considered as a potential integral part of the total available fresh water resource.
3. Coordinated management of water supplies and wastewaters on a regional basis must be promoted to achieve efficient utilization of water.
4. Efficient wastewater management is dependent upon a balanced program of source control of environmentally hazardous substances 1/, treatment of wastewaters, reuse of reclaimed water, and proper disposal of effluents and residuals.
5. Substances not amenable to removal by treatment systems presently available or planned for the immediate future must be prevented from entering sewer systems in quantities which would be harmful to the aquatic environment, adversely affect beneficial uses of water, or affect treatment plant operation. Persons responsible for the management of waste collection, treatment, and disposal systems must actively pursue the implementation of their objective of source control for environmentally hazardous

1/ Those substances which are harmful or potentially harmful even in extremely small concentration to man, animals, or plants because of biological concentration, acute or chronic toxicity, or other phenomenon.

substances. Such substances must be disposed of such that environmental damage does not result.

6. Wastewater treatment systems must provide sufficient removal of environmentally hazardous substances which cannot be controlled at the source to assure against adverse effects on beneficial uses and aquatic communities.

7. Wastewater collection and treatment facilities must be consolidated in all cases where feasible and desirable to implement sound water quality management programs based upon long-range economic and water quality benefits to an entire basin.

8. Institutional and financial programs for implementation of consolidated wastewater management systems must be tailored to serve each particular area in an equitable manner.

9. Wastewater reclamation and reuse systems which assure maximum benefit from available fresh water resources shall be encouraged. Reclamation systems must be an appropriate integral part of the long-range solution to the water resources needs of an area and incorporate provisions for salinity control and disposal of non-reclaimable residues.

10. Wastewater management systems must be designed and operated to achieve maximum long-term benefit from the funds expended.

11. Water quality control must be based upon latest scientific findings. Criteria must be continually refined as additional knowledge becomes available.

12. Monitoring programs must be provided to determine the effects of discharges on all beneficial water uses including effects on aquatic life and its diversity and seasonal fluctuation.

III. PROGRAM OF IMPLEMENTATION

Water quality control plans and waste discharge requirements hereafter adopted by the State and Regional Boards under Division 7 of the California Water Code shall conform to this policy.

This policy and subsequent State plans will guide the regulatory, planning, and financial assistance programs of the State and Regional Boards. Specifically, they will (1) supersede any regional water quality control plans for the same waters to the extent of any conflict, (2) provide a basis for establishing or revising waste discharge requirements when such action is indicated, and (3) provide general guidance for the development of basin plans.

Water quality control plans adopted by the State Board will include minimum requirements for effluent quality and may specifically define the maximum constituent levels acceptable for discharge to various waters of the State. The minimum effluent requirements will allow discretion in the application of the latest available technology in the design and operation of wastewater treatment systems. Any treatment system which provides secondary treatment, as defined by the specific minimum requirements for effluent quality, will be considered as providing the minimum acceptable level of treatment. Advanced treatment systems will be required where necessary to meet water quality objectives.

Departures from this policy and water quality control plans adopted by the State Board may be desirable for certain individual cases. Exceptions to the specific provisions may be permitted within the broad framework of well established goals and water quality objectives.

APPENDIX F.

COMMITTEE ON ENVIRONMENTAL QUALITY CONTROL
(NRC/December 1972)

Rapid increases in industry and population have made the environment in many countries deteriorate to a critical level. Air and water pollution, once ignored in Thailand, is now threatening the economic progress of the country and the health of people.

The problems of environmental pollution have recently received attention from various concerned authorities. A committee was officially appointed in 1962 to investigate the effect of air pollution due to vehicle exhaust fumes and industrial activities on public health, and to give recommendations on solutions to the problem. Various aspects of water pollution and wastewater treatment and disposal have also been investigated by some concerned government organizations including the Applied Scientific Research Corporation of Thailand in conjunction with the Asian Institute of Technology. However, there is virtually no other cooperation nor-coordination among the organizations imvolved in research on environmental pollution and no organization is directly responsible for planning or making policy on pollution abatement. The necessity for having such an organization is thus apparent.

The National Research Council has recognised that air and water pollution are most urgent problems which must now be tackled. This can be achieved only through full coordination and cooperation among the concerned authorities and through cooperation and assistance from some international organizations such as the American Council on Environmental Quality. The National Research Council therefore set up on February 9, 1971 with approval from the Government a special committee under the name of "The Committee on Environmental Quality Control". The term of office of each committee member is two years. This committee has authority to appoint appropriate sub-committees.

The Committee under the chairmanship of the Secretary-General of the National Research Council, consists of 13 members representing the following organizations:

Office of the Prime Minister
Ministry of Agriculture
Ministry of National Development
Ministry of Public Health
Ministry of Interior
Ministry of Education
Ministry of Industry
Chulalongkorn University
Meteorological Department
Hydrographic Department

Bangkok Municipality
Dhonburi Municipality
Applied Scientific Research Corporation of Thailand

The Committee is responsible for the following functions:

To set up national programmes, plans and policies on environmental pollution control.

To provide suggestions and recommendations to the government on the prevention and solution of environmental problems.

To encourage and promote coordination and cooperation among various concerned government or foreign organizations in research on and study of environmental pollution problems.

The Committee on Environmental Quality Control

1.	Dr. Pradisth Cheosakul Secretary-General, National Research Council Office of the Prime Minister	Chairman
2.	Mr. Boonchoo Chenpanas Inspecting Commissioner Office of the Prime Minister	Member
3.	Mr. Thalerng Thamrong Nawasawat Deputy Under-Secretary Office of the Under-Secretary of State Ministry of Agriculture	Member
4.	Mr. Niyom Vachnonda Chief, Project Analysis-Engineering Division Technical and Planning Office Ministry of National Development	Member
5.	Mr. Siri Santabutra Inspecting Commissioner Office of the Inspecting Commissioners Ministry of Interior	Member
6.	Khunying Ambhorn Meesook Under-Secretary of State Office of the Under-Secretary of State Ministry of Education	Member
7.	Dr. Kusug Kamolrit Sanitary Engineer, Division of Sanitary Engineering Department of Health Ministry of Public Health	Member
8.	Mr. Damra Amatyakul Chief Engineer of the Ministry of Industry Office of the Under-Secretary of State	Member
9.	Professor Aroon Sorathesn Rector, Chulalongkorn University Office of the Prime Minister	Member
10.	Lt. Commander Dhawee Montrivade, R.T.N. Special Grade Meteorologist Meteorological Department Office of the Prime Minister	Member

11. Captain Tavorn Pongsapipatt, R.T.N. — Member
Chief, Oceanographic Division
Hydrographic Department, The Royal Navy
Ministry of Defence

12. Dr. Chek Dhanasiri — Member
Director, Bureau of Public Health
Metropolitan City

13. Mr. Chalitpakorn Virabalin — Member
Acting First Grade Engineer
Public Works Division
Metropolitan City

14. Dr. Boon Indrambarya — Member
Research Director of EERI
Acting Research Director of TRI
Applied Scientific Research Corporation of Thailand

15. Miss Sachee Sirison — Member
First Grade Economist
Under-Secretary of State
Ministry of Communication

16. Mrs. Vallapha Chartprasert — Member
Acting Director, Social Project Division
Office of the National Economic and Social Development Board

17. Dr. Upadis Pachariyangkul — Member
Representative from Ministry of Foreign Affairs

18. Mrs. Boonthom Dhamcharee — Member and Secretary
Chief
Research Compilation and Coordination Division
National Research Council

19. Miss Praparsri Thanasukarn — Member and Assistant Secretary
Chief
Research Survey and Analysis Section
National Research Council

APPENDIX G.

NATIONAL COMMITTEE ON HUMAN ENVIRONMENT

(NRC/December 1972)

The Committee, appointed by the National Executive Council, consists of not more than 15 heads of the concerned government organizations (including the Chairman and Vice Chairman), and has the following functions:

1. To set up the following policies related to the environmental quality control;
   a. To propose the Master Plan to the cabinet for the approval.
   b. To supervise and control the coordination among the concerned organizations.
   c. To enhance and make the proposals on operative methods in accordance with the Master Plan.
   d. To study the reports on this matter submitted by the Executive Committee and plan to improve the operative scheme when confronting the problems.
2. To appoint the sub-committee to solve the problem of environmental control both in administrative and technology.

The Executive Committee

The Committee consists of not more than 20 representatives from the concerned organizations. At the beginning the office of the National Economic Development will be used as the action unit. The Committee has the following responsibilities:

1. To propose the Master Plan to the Committee on Environmental Quality Control for further consideration before submitted to the cabinet.
2. To perform as liaison group in the matter of the environmental quality control.
3. To provide technological advices for local and regional areas where solutions are urgently needed.
4. To follow up and assess the result of action and present to the Committee on Environmental Quality Control.

5. To study the problems arising in this task and provide recommendations on the improvements and corrections.

6. To appoint working groups to do this work when needed.

7. To do any other works assigned by the government or the Committee on Environmental Quality Control.

National Human Environment Committee

1.	Pol. Gen. Prasert Ruchirawongse	Chairman
2.	Mr. Renoo Suwansit Secretary-General of National Economic Development Board	Vice Chairman
3.	Dr. Komol Pengsritong Under-Secretary of State Ministry of Public Health	Member
4.	Mr. Puang Suwanarat Under-Secretary of State Ministry of Interior	Member
5.	Professor Yos Bunnag Under-Secretary of State Ministry of Industry	Member
6.	Mr. Bhunthin Attagara Under-Secretary of State Ministry of Education	Member
7.	Mr. Prida Karnasut Under-Secretary of State Ministry of Agriculture	Member
8.	Dr. Vija Sethaput	Member
9.	Dr. Pradisth Cheosakul Secretary-General, National Research Committee	Member
10.	General Chan Ansuchote Director, the Budget Bureau	Member
11.	Professor Chamras Chayabongse Governor, Water Supply Authority	Member
12.	Professor Aroon Sorathesn Rector, Chulalongkorn University	Member
13.	Mrs. Vallapha Chatprasert Director, Social Project Division	Secretary
14.	Mr. Praphorn Charuchandr Director, Sanitary Engineering Division	Asst.Secretary

15.	Miss Orathip Tansakul Chief, Public Health Section	Asst. Secretary

Executive Committee of the National Human Environment

1.	Mr. Renoo Suwansit Secretary-General of National Economic Development Board	Chairman
2.	Dr. Komol Pengsritong Under-Secretary of State Ministry of Public Health	Vice Chairman
3.	Professor Yos Bunnag Under Secretary of State Ministry of Interior	Vice Chairman
4.	Dr. Chitt Hemachutha Director-General Department of Health Promotion	Member
5.	Mr. Udomsakdi Dhasavanich Director-General Department of Industrial Works	Member
6.	Mr. Sunt Bandhukul Director-General Department of Fisheries	Member
7.	Dr. Bhakdi Lusanandana Director-General Department of Agriculture	Member
8.	Mr. Saman Buravas Director-General Department of Mineral Resources	Member
9.	Mr. Amphorn Uttangkorn Director-General Department of Land Transport	Member
10.	Professor Aroon Sorathesn Rector, Chulalongkorn University	Member
11.	Professor Chamras Chayabongse Governor, Water Supply Authority	Member
12.	Dr. Vinyu Angkhanarak Governor, Greater Bangkok Municipality	Member
13.	Deputy Director, Police Department	Member
14.	Representative, Budget Bureau	Member

15.	Representative Office of the Juridical Council	Member
16.	Mrs. Vallapha Chatprasert Director, Social Project Division	Asst. Secretary
17.	Mr. Praphorn Charuchandr Director Sanitary Engineering Division	Asst. Secretary
18.	Miss Orathip Tansakul Chief, Public Health Section	Asst. Secretary

APPENDIX H.

BANGKOK SEWERAGE AND DRAINAGE COMMITTEE

The Executive Committee of the NESDB submitted to the Cabinet a recommendation to set up a Sewerage and Drainage Committee, which was approved in 1962. The Committee is composed of:-

1.	Dr. Puey Ungphakorn	Chairman
2.	Prof. Chamras Chayabonse	Member
3.	Prof. Aroon Sorathesn	"
4.	Director-General, Department of Public Work	"
5.	Representative, Royal Irrigation Department	"
6.	Representative, NESDB	"
7.	Representative, Budget Bureau	"
8.	Representative, Ministry of Finance	"
9.	Representative, Municipality	"
10.	Representative, Department of Local Administration	"
11.	Representative, Department of Town & Country Planning	"
12.	Dr. Vinyoo Vichitvathakarn (now Dean, Faculty of Economic, Thammasart University)	Secretary

(The Committee is currently being reformed)

The Committee considered the reports of three experts (Litchfield, Husband, and Tholin) and found that these reports were not sufficient for the Committee's purpose. Therefore the Committee decided to prepare a Master Plan on a Sewerage and Drainage System for Bangkok and Thonburi by requesting the WHO and the world Bank to make a survey for feasibility. The consulting firm of Camp, Dresser and McKee agency was subsequently chosen to do the Master Plan.

APPENDIX I

FOOD QUALITY CONTROL BOARD

I. 1. The Food Quality Control Board of Directors was established pursuant to the Food Quality Control Act B.E. 2507 (1964).

2. The Board shall be comprised of the Under-Secretary of State for Public Health as Chairman; representatives of the Departments of Health, Medical Science, Science, Domestic Trade and Customs, with not more than ten qualified persons appointed by the Minister as members of the Board.

The office term of the Board Members appointed by the Minister is two years each. A retired Board Member may be re-appointed.

When a Board Member vacated office before due retirement, a replacement may be appointed by the Minister.

The Board Members appointed hereof shall hold office for the term of the Members they replace.

3. The Board shall have the duty to impart advice to the Minister on the following subjects:-

I. 1. Naming the foods to be controlled.
2. Specifying the quality.
3. Prescribing the ratio of ingredients.
4. Prescribing the food barred from importation.
5. Prescribing the methods of using preservatives.
6. Laying down the procedures of food inspections.
7. Prescribing the categories and kinds of food as produced and sold.

II. Other matters pertaining to food quality control consulted by the Minister. Besides the above duties, the Board shall have to give their approval to:-
1. Food production licences.
2. Order that impure or adulterated food be destroyed or appropriate actions taken in the event no court proceeding is taken.
3. Empower to order suspension of the licences for those who violate this Act.

4. Up to now these have been promulgated as follows:-

I. Eight categories of controlled food as follows:
1. Canned food in metalic containers.
2. Seasoning powder containing monosodium glutamate.
3. Vinegar.

4. Milk and milk products.
5. Food colors.
6. Non-alcolic beverages.
7. Edible fats and oils.
8. Irradiated food.

II. The prohibition of importing and using as food ingredients:
1. Dulcin.
2. Cydamic acid and its salts.

III. Controlled food submitted for registration:

5140 categories of importing
2705 categories of production
licences of registration number of those controlled food
5094 categories of importing
1574 categories of production

II. 1. A Drug Commission has been set up by virtue of the Sale of Drug Act B.E. 2493 (1950).

2. The Commission has consist of the Under-Secretary of State for Public Health, Director-General of the Medical Sciences Department, Director-General of the Medical Services Department, Director-General of the Health Department, Chief of the Medical Registration Division, and Chief of the Food and Drugs Control Division, and not more than fifteen qualified members appointed by the Minister, of which at least two must be modern practitioners and at least two traditional practitioners.

The Under-Secretary of State for Public Health shall be Chairman and the Chief of the Food and Drugs Control Division, secretary.

The offices and terms of the commission shall be the same as the Food Quality Control Board of Directors.

3. The commission shall have the duty to give advice and opinions in:-

1. Granting the production, sale or bringing or import of drugs.
2. Suspending, revocation of licences or formular registration.
3. Establishment of the rules, measures and conditions concerning the production, sale, bringing or import of drugs.

4. Exercise the powers to give notice in the government gazette specifying:

1. Pharmacopoeias.
2. Substances which are drugs.
3. Poisonous drugs.
4. Specially - controlled drugs.
5. Household remedies.
6. Traditional drugs.
7. Drug whose expiry date may be given on the label.

8. Drugs for the use of which a warning must be given in the insert, leaflets and the test of such warnings.

5. Specify diseases or symptoms prohibited to be advertised as capable of cure, mitigation, treatment or prevention of the diseases or symtoms.

Up to the present there have been promulgated:

68 categories of poisonous drugs.
27 specially-controlled drugs.
49 household remedies.
16 traditional drugs.
9 pharmacopoeias.
113 narcotics.

APPENDIX J

ADVISORY COMMITTEE ON FAMILY HEALTH AND ENVIRONMENT

The Advisory Committee was set up in March 1972 and is composed of:

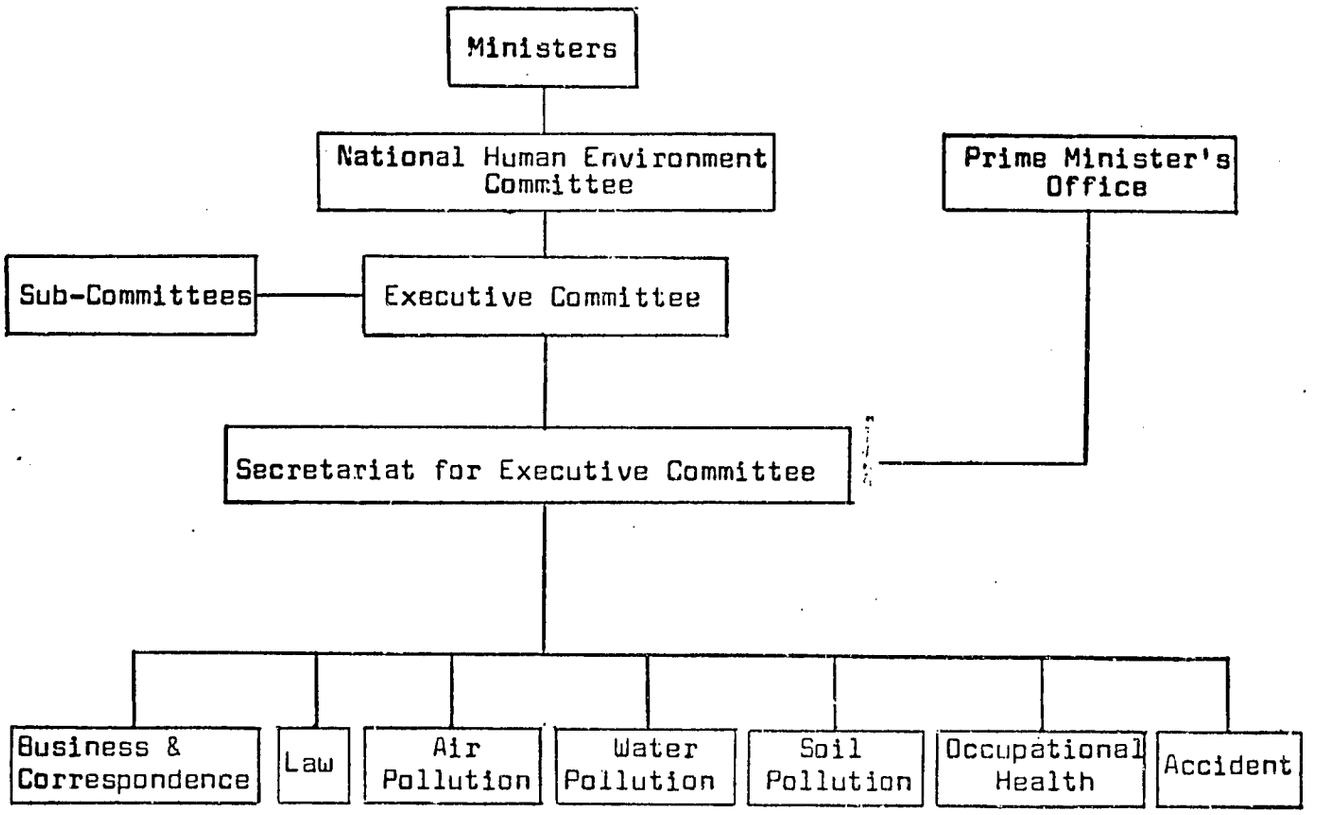
1.	Professor Chamnas Chayabong	Chairman
2.	Dr. Chitt Hemachutha Director-General, Dept. of Health Promotion	Advisor
3.	Mr. Amphorn Utthangkorn Director-General, Dept. of Land Transport	"
4.	Dr. Niphon Suwatthana	"
5.	Dr. Pradisth Cheosakul	"
6.	Pol. Maj. Gen Charoen Suwanmusiko	"
7.	Dr. Winich Assawasena	"
8.	Mr. Udomsakdi Passawanich	"
9.	Mr. Praphorn Charuchandr	"
10.	Dr. Udom Ektasaeng	Advisor & Secretary,

The Advisory Committee on Family Health and Environment, in its fourth 1972 meeting on September 1972, made a resolution about the National Human Environment Committee as follows:

1. Membership
   a) The number of the National Committee should be increased to add:
      1) The Under-Secretary of State, Ministry of Communication.
      2) Secretary-General, Office of the Juridical Council to advise in improving the law.
   b) Revise the membership of the Executive Committee
      1) Cancel the Under-Secretary of State, Ministry of Industry, second Vice-Chairman.
   c) The Chairman and the Secretary should be the persons in the same unit for proficeincy.

2. To set up the Secretariat for the Committee

An independent unit should be set up by the Act for environmental work and should be organized as following:-



These resolutions will be submited to Pol. Gen. Prasert Ruchirawongse, Director, Education and Public Health sector for the NEC.

APPENDIX K.

RULES AND REGULATIONS OF MINISTRY OF INDUSTRY FOR CONTROL OF INDUSTRIAL WASTES

Annex 12: Duties

For the purpose of the prevention of nuisance caused by water pollution discharged by industrial factories, the factories are obligated to perform the following duties:

1. Location and area of factory must be:-
   (1) In suitable places for discharge of wastewater or in the places allocated by the government.
   (2) Enough area for waste water treatment or reservation.

2. Treatment process:-
   (1) Suspended solids must be separated from waste.
   (2) Sludge separated from wastewater must be treated properly in order to avoid further nuisance.
   (3) pH value and alkalinity must not be too high or too low.
   (4) Any poisonous matter which may be dangerous to public health must not be discharged from the factory without proper treatment.
   (5) Wastewater treatment process must be shown by drawing together with the plant layout.
   (6) Wastewater must be treated properly, the method of treatment should be approved by government official.

Annex 7: Working Standards for Effluent Discharging to Inland Streams

BOD (5 days 20°C)	max	20	ppm
Suspended solids	max	30	ppm
Dissolved solids	max	2000	ppm
pH value	between 5 and 9		
Permanganate value	max	60	ppm
Sulphide (as H_2S)	max	1	ppm
Cyanide (as HCN)	max	0.2	ppm
Oils and grease	none		
Tar	none		
Formaldehyde	max	1	ppm
Phenols and creates	max	1	ppm
Free chlorine	max	1	ppm
Zinc			
Chromium			
Arsenic			
Silver — individually or in total	max	1	ppm
Selenium			
Lead			
Nickel			
Insecticides	none		
Radioactive materials	none		
Temperature	max	40°C	
No disagreeable taste and odor			

Standard for sewage effluents discharging to inland streams of high dilution ratic

Volumes of dilution	Max. permitted suspended solids
8 - 150	30
150 - 300	60
300 - 500	150

Annex 11: Factory Inspection Report on Waste Water Discharge for Factory Applying for Establishment, Expansion and Operation

1. Name of Factory.....
   Location: No.....Soi (Lane).....Street.....
   Precinct (Tambon).....District(Amphur).....
   Province(Changwat).....Phone number.....
   Kind of Factory and its Product.....

2. Name of Licensee for operating the factory.....
   Residence: No.....Soi (Lane).....Street.....
   Tambon.....Amphur.....
   Changwat.....Phone number.....

3. Indicate existance in the surroundings of the factory:
   O Residential Buildings O Factories O Commercial Buildings
   O River O Canal O Public Sewer
   O Others.....

4. Raw Materials used:
   1) .....
   2) .....
   3) .....

5. Description of Production Process (briefly) .....
   .....

6. Volumes of waste water discharged:
   O Process water.....m^3/d ..... m^3/hr
   O Wash Water.....m^3/d ..... m^3/hr
   O Waste Waters from worker's quarters.....m^3/d..... m^3/hr
   O Other Waste Waters m^3/d ..... m^3/hr

7. Nature of Waste Water:
   O Acidity O Alkalinity
   O Color O Odor

8. Draining of Waste Water:

8.1 Draining period

- O .....hr/d
- O 24 hours
- O .....times/d
- O .....days of retention per period

8.2 Discharges into:

- O Ditch
- O River
- O No Discharges
- O Canal
- O Public Sewer
- O Others

8.3 Distance from Factory site to

- O Ditch
- O River
- O Canal
- O Public Sewer (.....m)

8.4 Neighbouring Factories:

- O Discharging Waste Water
- O No discharge

9. Process of Waste Treatment.....
.....
.....

- O With sedimentation tanks capacity.....m^3
  number of tanks.....

10. Availability of Space in the Factory Compound

- O Available Area .....m^2
- O Not available

IX. SUPPLEMENTAL APPENDICES

A. Sewerage, Drainage, Flood Protection - Bangkok, Thailand (Journal Water Pollution Control, May 1972).

B. Suggested State Water Pollution Control Act, Revised (U.S. Federal Water Pollution Control Administration, November 1965).

C. Digest, FY 1972 State Programs (US/EPA/1972).

D. Water Quality Control Plan, Ocean Waters of California, and Guidelines for Preparation of Technical Reports on Waste Discharges to the Ocean and for Monitoring Effects of Waste Discharges to the Ocean (California Water Resources Control Board, 1972).

E. Industrial Waste Effluent Guidelines (US/EPA/1972).

F. Recommendations on Standards for Industrial Effluents and on Regulations for Control of Industrial Wastes in Thailand ("Industrial Effluents and Trade Waste Disposal", Bachman, Bucksteeg, and Kornatzki, UNIDO, 1970).