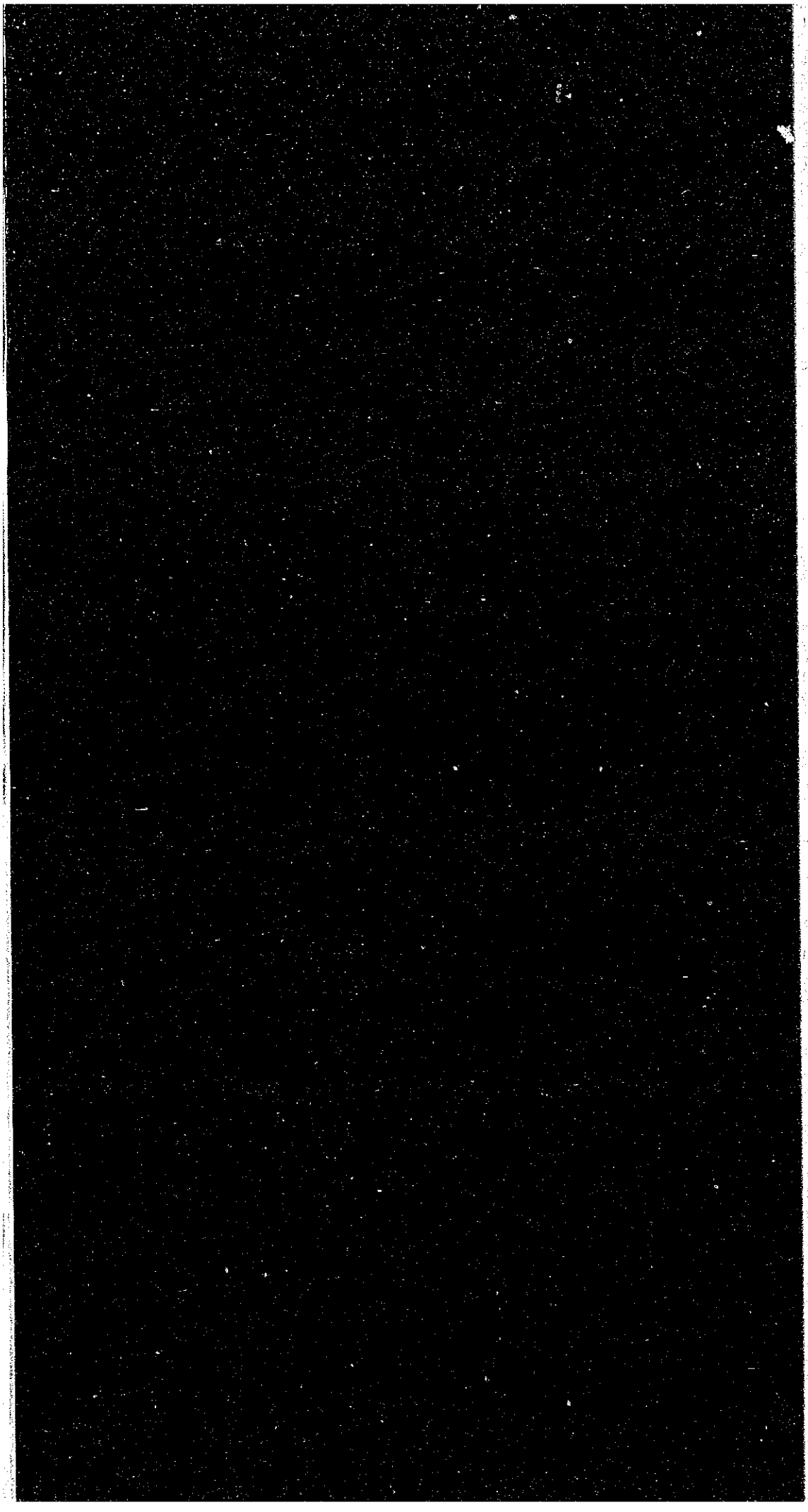
GOVERNMENT OF MALAYSIA

NATIONAL WATER RESOURCES STUDY (MALAYSIA)

FINAL REPORT

VOLUME 5 WATER QUALITY MANAGEMENT



GOVERNMENT OF MALAYSIA

NATIONAL WATER RESOURCES STUDY, MALAYSIA

SECTORAL REPORT

VOL. 18

WATER RESOURCES MANAGEMENT

OCTOBER 1982

JAPAN INTERNATIONAL COOPERATION AGENCY

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COMPOSITION OF THIS VOLUME

This Volume consists of two parts: Part 1 deals with the subject matters of Peninsular Malaysia and Part 2 is devoted to the States of Sabah and Sarawak.

ABBREVIATIONS

(1) Plan

FMP	:	First Malaysia Plan
SMP	:	Second Malaysia Plan
TMP	:	Third Malaysia Plan
4MP	:	Fourth Malaysia Plan
5MP	:	Fifth Malaysia Plan
6MP	:	Sixth Malaysia Plan
7MP	:	Seventh Malaysia Plan
NEP	:	New Economic Policy
OPP	:	Outline Perspective Plan
RESP	:	Rural Environmental Sanitation Program

(2) Domestic Organization

DID (JPT)	:	Drainage and Irrigation Department
DOA	:	Department of Agriculture
DOE	:	Division of Environment
DOF	:	Department of Forestry
DOFS	:	Department of Fishery
DOM	:	Department of Mines
DOS	:	Department of Statistics
EPU	:	Economic Planning Unit
FAMA	:	Federal Agricultural Marketing Authority
FELCRA	:	Federal Land Consolidation and Rehabilitation Authority
FELDA	:	Federal Land Development Authority
ICU	:	Implementation and Coordination Unit
MARDI	:	Malaysian Agricultural Research and Development Institute
MIDA	:	Malaysian Industrial Development Authority
MLRD	:	Ministry of Land and Regional Development
MMS	:	Malaysian Meteorological Service
MOA	:	Ministry of Agriculture
MOF	:	Ministry of Finance

MOH	:	Ministry of Health
MOPI	:	Ministry of Primary Industries
MRRDB	:	Malaysia Rubber Research and Development Board
NDPC	:	National Development Planning Committee
NEB (LLN)	:	National Electricity Board
PORIM	:	Palm Oil Research Institute of Malaysia
PWD (JKR)	:	Public Works Department
RDA	:	Regional Development Authority
RISDA	:	Rubber Industry Small-holders Development Authority
RRIM	:	Rubber Research Institute of Malaysia
SEB	:	Sabah Electricity Board
SEBC	:	State Economic Development Corporation
S(E)PU	:	State (Economic) Planning Unit
SESCO	:	Sarawak Electricity Supply Corporation
UDA	:	Urban Development Authority

(3) International or Foreign Organization

ADAA	:	Australian Development Assistance Agency
ADB	:	Asian Development Bank
ASCE	:	American Society of Civil Engineers
FAO	:	Food and Agriculture Organization of the United Nations
IBRD	:	International Bank for Reconstruction and Development
ILO	:	International Labour Organization
IMF	:	International Monetary Fund
IRRI	:	International Rice Research Institute
JICA	:	Japan International Cooperation Agency
JSCE	:	Japan Society of Civil Engineers
MOC	:	Ministry of Construction, Japan
OECD	:	Organization for Economic Cooperation and Development
OECF	:	Overseas Economic Cooperation Fund, Japan
UK	:	United Kingdom
UNDP	:	United Nations Development Program

UNSF	:	United Nations Special Fund
US or USA	:	United States of America
US/AID	:	United States Agency for International Development
USBR	:	United States Bureau of Reclamation
WHO	:	World Health Organization
WMO	:	World Meteorological Organization

(4) Others

B	:	Benefit
BOD	:	Biochemical Oxygen Demand
C	:	Cost
CIF	:	Cost, Insurance and Freight
COD	:	Chemical Oxygen Demand
D&I	:	Domestic and Industrial
dia	:	Diameter
EIRR	:	Economic Internal Rate of Return
El.	:	Elevation above mean sea level
Eq.	:	Equation
Fig.	:	Figure
FOB	:	Free on Board
FSL	:	Full Supply Level
GDP	:	Gross Domestic Product
GNP	:	Gross National Product
H	:	Height, or Water Head
HWL	:	Reservoir High Water Level
LWL	:	Reservoir Low Water Level
O&M	:	Operation and Maintenance
Q	:	Discharge
Ref.	:	Reference
SITC	:	Standard International Trade Classification
SS	:	Suspended Solid
V	:	Volume
W	:	Width

ABBREVIATIONS OF MEASUREMENT

Length

mm = millimeter
cm = centimeter
m = meter
km = kilometer
ft = foot
yd = yard

Area

cm^2 = square centimeter
m^2 = square meter
ha = hectare
km^2 = square kilometer

Volume

cm^3 = cubic centimeter
l = lit = liter
kl = kiloliter
m^3 = cubic meter
gal. = gallon

Weight

mg = milligram
g = gram
kg = kilogram
ton = metric ton
lb = pound

Time

s = second
min = minute
h = hour
d = day
y = year

Electrical Measures

V = Volt
A = Ampere
Hz = Hertz (cycle)
W = Watt
kW = Kilowatt
MW = Megawatt
GW = Gigawatt

Other Measures

% = percent
PS = horsepower
° = degree
' = minute
" = second
°C = degree in centigrade
10^3 = thousand
10^6 = million
10^9 = billion (milliard)

Derived Measures

m^3/s = cubic meter per second
cusec = cubic feet per second
mgd = million gallon per day
kWh = kilowatt hour
MWh = Megawatt hour
GWh = Gigawatt hour
kWh/y = kilowatt hour per year
kVA = kilovolt ampere
BTU = British thermal unit
psi = pound per square inch

Money

M$ = Malaysian ringgit
US$ = US dollar
¥ = Japanese Yen

CONVERSION FACTORS

	From Metric System	To Metric System
Length	1 cm = 0.394 inch 1 m = 3.28 ft = 1.094 yd 1 km = 0.621 mile	1 inch = 2.54 cm 1 ft = 30.48 cm 1 yd = 91.44 cm 1 mile = 1.609 km
Area	1 cm^2 = 0.155 sq.in 1 m^2 = 10.76 sq.ft 1 ha = 2.471 acres 1 km^2 = 0.386 sq.mile	1 sq.ft = 0.0929 m^2 1sq.yd = 0.835 m^2 1 acre = 0.4047 ha 1 sq.mile = 2.59 km^2
Volume	1 cm^3 = 0.0610 cu.in 1 lit = 0.220 gal.(imp.) 1 kl = 6.29 barrels 1 m^3 = 35.3 cu.ft 10^6 m^3 = 811 acre-ft	1 cu.ft = 28.32 lit 1 cu.yd = 0.765 m^3 1 gal.(imp.) = 4.55 lit 1 gal.(US) = 3.79 lit 1 acre-ft = 1,233.5 m^2
Weight	1 g = 0.0353 ounce 1 kg = 2.20 lb 1 ton = 0.984 long ton = 1.102 short ton	1 ounce = 28.35 g 1 lb = 0.4536 kg 1 long ton = 1.016 ton 1 short ton = 0.907 ton
Energy	1 kWh = 3,413 BTU	1 BTU = 0.293 Wh
Temperature	°C = (°F - 32)·5/9	°F = 1.8°C + 32
Derived Measures	1 m^3/s = 35.3 cusec 1 kg/cm^2 = 14.2 psi 1 ton/ha = 891 lb/acre 10^6 m^3 = 810.7 acre-ft 1 m^3/s = 19.0 mgd	1 cusec = 0.0283 m^3/s 1 psi = 0.703 kg/cm^2 1 lb/acre = 1.12 kg/ha 1 acre-ft = 1,233.5 m^3 1 mgd = 0.0526 m^3/s
Local Measures	1 lit = 0.220 gantang 1 kg = 1.65 kati 1 ton = 16.5 pikul	1 gantang = 4.55 lit 1 kati = 0.606 kg 1 pikul = 60.6 kg

Exchange Rate
(as average between July and December 1980)

$1 = M$2.22
¥100 = M$1.03

PART 1

PENINSULAR MALAYSIA

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SPECIAL ABBREVIATIONS

NSC : National Security Council
O&M : Operation and Maintenance
PUB : Public Utilities Board
SDIE: State Drainage and Irrigation Engineer
VHF : Very High Frequency

1. INTRODUCTION

Water resources management has an object to preserve the integrity of the surrounding conditions of water resources such as river, river facilities and basin area to maintain the quality and quantity of water resources, and to place them at the service of the various beneficial uses.

The main subjects of this field are as follows:

(1) Management of river and river facilities;

(2) Flood management;

(3) Low flow management;

(4) Ground water management;

(5) Structural standard on river facilities; and

(6) Arrangement of information related to water resrouces.

This Sectoral Report presents the results of a study on the present conditions of the water resources management which were investigated from July 1980 to January 1981, with respect to the 6 issues mentioned above.

2. MANAGEMENT OF RIVER AND RIVER FACILITIES

2.1 River Use and Conservancy

2.1.1 River area

Various actions are regulated in or beside the rivers in order to reduce bank erosion and maintain flood discharge capacity of the rivers in Peninsular Malaysia.

These regulations and restrictions are executed according to the laws.

The extent of the river is defined by the Waters Enactments of each state (see Ref. 1). National Land Code also defines it (see Ref. 2). According to these regulations, the river stretches longitudinally from the river mouth to the upper end as far as natural water course exists. Waters Enactment restricts the erection of any building or structure within 15.2 m (50 feet) of bank of any river.

If it is likely that this width of any river is insufficient to contain the waters in time of such floods as may be reasonably expected, any land abutting on such river and extending to such a distance from either bank or both banks may be designated as flood channel by notification in the gazette.

Meanwhile, there is an area called "reserved land" provided by National Land Code. Any state authorities may reserve any state land for any public purposes. As one of these public purposes the Code may provide the protection of bank erosion. Thus designated area is usually called river reserved land. Private venture is principally prohibited in this area. In Peninsular Malaysia it is acknowledged that maximum safety of river bank can most economically be maintained by preservation of natural vegetation.

River reserved land has its legal base on the National Land Code, however, most of them had been designated under the Land Enactments, which had been enforced by each State Government except the State of Pulau Pinang and Melaka, and were later succeeded by the National Land Code, which has no provisions directly related to the river reserved land. This land was defined and declared initially by the declaration of river section along which reserved land was established and the alienation may be prohibited requiring the reserved land within a fixed strip. The width of the above strip was wider than 45.7 m (50 yards) according to the Enactments. However, DID recommends smaller width as a standard for District Officer as follows (see Ref. 3):

Width of river between banks	Width of reserved land on each bank
More than 40.2 m (2 chains)	45.7 m (50 years)
Between 20.1 m (1 chain) and 40.2 m	40.2 m (2 chains)
Between 10.1 m (1/2 chain) and 20.1 m	20.1 m (1 chain)
Between 5.0 m (1/4 chain) and 10.1 m	10.1 m (1/2 chain)
Less than 5.0 m	5.0 m (1/4 chain)

DID also mentions in the manual the following related to the reserved land for meandering rivers flowing in coastal alluvial plains: "Where a river has a well developed meander pattern, it is desirable to retain as a reserve the full width of the meander belt." It also mentions that this full wide reserve could constitute the flood channels for rivers at Sungai Manik Irrigation Area and Tanjong Karang Irrigation Area.

2.1.2 Present conditions of river use

The functions of river can be classified into 2 major categories, that is, the function of flowing water and that of land and space. In addition to these, river produces natural gravel, sand and soil, and fishes.

The present conditions of the use of the functions of land and space of river as well as extraction of river products will be dealt with in this chapter, while the use of the function of flowing water will be dealt with in 4.1.

The patterns of these uses can generally be classified as follows:

(1) (flood prevention) as flood drainage channel and sites for facilities for this purpose;

(2) (water use) as service water channels, drainage channels of waste water, and as sites for water use and drainage facilities;

(3) (transport) as traffic channels and their related facilties and sites for bridges;

(4) (recreation) as land and space for recreation; and

(5) (taking of river products) taking sand and stone, and fishery.

The present situation of river use in Peninsular Malaysia is outlined as follows with respect to each pattern mentioned above.

(1) River use for flood prevention

Constructions of flood control dams and levees are the major engineering means to cope with flood disaster in Peninsular Malaysia. Two dams, both of which are multipurpose dams, such as Temengor, Kelang Gates, have been completed to cope with flood. And 5 dams such as Kenyr, Machap, Semberong, Bekok and Simpang Kiri are now under construction. It is said that the total length of levees so far constructed amounts to 406 km (see Ref. 4). These levees were mostly constructed as a part of drainage or irrigation project. There is no case of declaration of flood channel which may be conducted in accordance with Waters Enactment.

(2) River use for service water channel, drainage channel and construction of facilities for river water use

For the use of low water of the rivers, various kinds of facilities such as dams, weirs, salinity barrages and other intake facilities have been built and some of them have more than 50-year history. Total number of irrigation intake facilities on the rivers is supposed to amount to around 600 and water supply intake facilities are supposed to amount to more than 200. Total number of the dams for water supply and irrigation amounts to 32.

(3) River facilities for traffic, transportation and navigation

Total number of bridges is gradually increasing in proportion to recent construction of road network. Rivers are used also for navigation to some extent. Marine fishing boats occupy the most part of navigating ships in the rivers in Peninsular Malaysia. Meanwhile, some oil tankers go upstream as far as 57 km from the river mouth in the Perak river.

(4) Recreation

There are almost no recreation activities along the rivers in Peninsular Malaysia. There are almost no recreation activities around the existing reservoirs, which are mostly located in security areas or water supply catchment areas, a type of the reserved land for securing water quality in the catchment area for water supply.

(5) Taking sand, stone and others, and fishery

There are several cases almost in every big or medium-sized river. The purpose of taking sand and stone is mainly to obtain materials for construction. Fishery is carried out in almost every big or medium-sized rivers in Peninsular Malaysia. It is said that 25,000 tons of freshwater and brackishwater fishes were caught annually in rivers, swamps and other water bodies (Sectoral Report of Inland Fishery).

Among these patterns of river use, there have scarcely been big conflicts so far in Peninsular Malaysia.

2.1.3 Control of river use and river conservancy

In Peninsular Malaysia, land and water are principally a state property and the use of them is administered by the state government. The methods of the administration are similar for each state as follows.

If someone intends to start any action or venture which is restricted by laws with respect to river, he must get a relevant licence or permission and may be obliged to restore river bank, to perform his work, as follows:

(1) Restrictions by Waters Enactment (which do not apply to state government and its officials)(see Ref. 1)

(A) Restorations of broken river bank;

(B) Obtaining licence for the following actions;

(a) to fell any tree so that it falls into a river,

(b) to obstruct or interfere with river,

(c) to build bridge, jetty or landing stage (other than a bath-house) at a point where width of river exceeds 6.1 m (20 feet),

(d) to erect, cut or maintain pump, line of pipes, flume, race, drain, dam or reservoir,

(e) to divert river water by means of ditch, drain, channel, pipe from its natural course, and

(f) to discharge or cause to enter any river any poisonous, noxious or polluting matter (applies to Selangor State),

(C) Actions requiring authorization by other laws or permission by this law;

(a) to erect or build wall along the bank of river,

(b) to construct revetment along the bank of river, and

(c) to erect building or structure within 15.2 m (50 feet) of any bank or within any flood channel declared under this law,

(2) Restrictions by Mining Enactment with respect to mining operations (see Ref. 5)

(A) Obtaining permission for the following actions;

(a) to alter, interfere with or permit for other person to alter or interfere with the bank of river, stream or watercourse,

(B) Obtaining licence for the following actions;

(a) to erect, cut or construct any pump, line of pipes, flume, race, dam or reservoir, and

(b) to take, use and discharge water,

(C) Obtaining licence or permission by the land owner when the following action is done upon the alienated land, or requiring licence and the consent of the officer in charge of the reserve when the following action is done upon the reserved land or the reserved forest;

(a) to construct any works,

(D) Performance of the following actions;

(a) to make such provisions as will ensure that all water used in connection with mining operations, shall, before it leaves the mining area, be freed from all chemicals deleterious to animal or vegetable life,

(b) not to allow effluent water from any mining area under his control containing solid matter in excess of the amount prescribed by rule to discharge into any river or natural watercourse or otherwise to pass beyond his control, and

(c) to provide spillways, retaining walls, brush dams, settling pits and other mechanical appliances or devices and to use necessary chemical methods, in case of failure to comply with the above 2 requirements,

(3) Restrictions by Electricity Act (see Ref. 6)

(A) Serving of notice specifying the following work;

(a) to dam up or otherwise interfere with such prescribed source of water by this Act,

(4) Restrictions by Fisheries Act (see Ref. 7)

(A) Obtaining licence for the following actions;

(a) to use any poisonous or explosive substance with intent to stupefy, poison, or kill fish,

(5) Restrictions by Environmental Quality Act (see Ref. 8)

(A) Obtaining licence for the following actions;

(a) to emit, discharge or deposit any wastes into any inland waters in contravention of the acceptable conditions specified under this Act,

(6) Restrictions by National Land Code (see Ref. 2)

(A) Obtaining permission as far as the following action is done upon the state land, the alienated land, the mining land or upon the reserved land;

(a) to extract and remove rock material otherwise than for the purpose of obtaining metal or mineral therefrom.

These restrictions are managed mainly by the following organization on the basis of the laws:

(1) Restrictions by Waters Enactment; District Office

(2) Restrictions by Mining Enactment; Mines Department of Ministry of Primary Industry

(3) Restrictions by Electricity Act; NEB, State Government

(4) Restrictions by Fisheries Act; State Government

(5) Restrictions by Environmental Quality Act; DOE

(6) Restrictions by National Land Code; Collector of Land Revenue

The responsible agencies usually consult DID on river-related engineering aspects of (1), (2) and (6). However, there is no law which regulates and specifies the process and the contents of that consultation.

There are some documents exchanged between Mines Department and DID, and related manuals which regulate the process of the consultation on the river deviation method for mining operation. These documents and manuals indicate the process and the contents of this consultation as follows (see Ref. 3):

(1) Correspondence between the Director of DID and the Chief Inspector of Mines, exchanged in 1947, states

(A) All applications for the deviation of a river for mining operation should be submitted in duplicate to Mines Department for check as to general terms and conditions, and one copy with necessary comments should be forwarded to the relevant State DID. There is no need to preclude direct discussions between the miners and DID for the working out of the detailed scheme for the deviation.

(B) Permission to turn the river to the new channel for the deviation should be sought by the miner through Mines Department when DID should be asked to verify that the work has been executed in accordance with the plans and specifications.

(2) Inspectorate Manual of the Department of Mines states (see Ref. 3)

(A) The specification for a proposed deviation, including alignment, grade, cross section, weirs, etc., and the completed deviation, before use, must be approved by the State Drainage and Irrigation Engineer.

(B) Plans submitted to the Inspector for deviation of a river should show the following:

(a) Plan of existing course and proposed deviation course;

(b) Cross sections of the existing channel;

(c) Longitudinal sections of the bed of the existing channel;

(d) Plan, longitudinal and cross sections of any weir or erosion control proposed in the deviation; and

(e) Site plan showing the site of the deviation in relation to road or railway, and showing the catchment of the stream above the deviation.

(C) A deviation is authorized on condition that the deviator will maintain it for a declared period of 1, 2 or -- when there is a larger weir -- sometimes 3 years or for the period of the deviator's tenure of the land which it traverse, whichever is the longer. During that period, which beings on the date when the water is turned-in, officers of the Department of Drainage and Irrigation will inspect the deviation and will ask for repairs to be made; these being arranged through the Zone and Inspectorate offices. Inspectors and Mining Assistants also should inspect deviations and require miners to repair them as necessary.

(3) DID Manual

The DID Manual mentions that DID is interested in any form of mining which is potentially dangerous to rivers. The manual shows its interests especially in reference to the following types of tin mining.

(A) Dulang washing ..... The use by hand of a wooden dish (dulang) to wash and to recover a mineral concentrate from the beds of streams of rivers or elsewhere in convenient proximity to water

(B) Lampanning ..... The use of water under natural head by pipeline or tali ayer to cut ground, the tailings being deposited at a lower level

(C) Hydraulic mining ..... The use of water under natural or artificial head to cut ground and to raise it by means of a hydraulic elevator, the tailings being deposited at a higher or lower level as the case may be

(D) Dredging ..... The excavation plant is mounted on a floating vessel

DID shows its interests with respect to the river deviation as follows in its manual and gives the following explanation:

> "The river deviation occurs more often in connection with dredging than with other forms of mining. So far as DID is concerned, the planning of a deviation works out as follows in practice.
>
> The miner or his consultant puts up a proposal to the Mines Department, which refers it to DID. Generally the proposal is not satisfactory in some respects, and a meeting or a series of meetings is arranged during which the miners proposals are knocked, by the miner, into a shape which is acceptable to DID. It is often necessary and time saving to give the miner or his consultant a good deal of advice in preparing his final scheme.
>
> Advice from Headquarters should also be sought in the case of any major or tricky problem. The final proposal, however, must be the miner's and this proposal he puts up to the Mines Department, which refers it for formal approval to DID, which approves it if all is still well, subject to the condition that the miner shall sign some form of agreement for the proper execution and maintenance of the work. The technical clauses of the agreement will probably be drafted by DID at this stage.

DID will again appear in the deviation picture when a deviation has been completed and it is required to put it into use, for approval before use will be one of the requirements of the deviation agreement. Thereafter, DID will inspect the deviation from time to time, and will possibly note that it requires attention under the terms of the agreement. Approval for use must be signified to the Senior Inspector of Mines, and requests for any subsequent action must be made to the Senior Inspector of Mines, as DID has no executive authority whatsoever.

Occasionally a satisfactory deviation plan cannot be devised except for a major section of a river. In such a case several miners or companies may be affected. It would be impractical to require them to put forward a joint plan for deviation, and in such a case the only course is for Government to put up the plan. This was the case for the Kinta River Deviation, which has been under construction, in sections, for several years. A plan of the deviation is 24 miles long. The plans and the technical specification for the work were put up by DID, and it fell mainly to DID officers to obtain the consent and agreement of the companies which would be required to pay for it. Channel construction is done by the mining companies, but must be passed by the S.D.I.E. Perak before being put to use. Weirs are constructed on contract under DID supervision. The piecemeal construction of the deviation necessitates subsidiary agreements between the mining companies and the Government, and the S.D.I.E. Perak has the task of drafting the specifications. He is also responsible for maintenance of the deviation, when taken over."

The restrictions or regulations of river-related public undertakings are almost left to their executive agencies. Public undertakings carried out in the river area and their main responsible agencies are as follows:

(1) River conservancy and flood mitigation, DID;

(2) Drainage and irrigation, DID;

(3) Domestic and industrial water supply, PWD;

(4) Hydroelectric power generation, NEB; and

(5) Construction of bridge, PWD.

Some of these agencies have its own design manuals to regulate structural aspect of these undertakings instead of laws which regulate the private actions as afore-said. The present conditions are as in Table 1 with respect to the establishment of these manuals by each agency for their responsible river facilities.

There are 2 memoranda to regulate the process of the coordination of river-related facilities plans. These memoranda were exchanged between DID and PWD in 1949 to coordinate the process of their responsible subject, that is, bank erosion protection and road construction which were often so closely carried out that those agencies felt the necessity for a rule to coordinate their projects with each other. The agreed process was as follows (see Ref. 3):

(1) As to the protection of roads from bank erosion of rivers, which is due to natural causes and not to any work executed by DID, PWD is responsible for the construction of any retaining walls necessary to hold up the road. DID will assist in the attempts to train the course of a river so as to reduce future damage as much as possible and within the annually recurrent funds which they have for this purpose, but they must not be expected to bear the full cost of protecting roads, bridges, etc., from this damage. Where the construction (or proposed construction) of an irrigation canal or drainage channel, or the dredging (or proposed dredging) of a river channel by DID affects (or is likely to affect) the stability or safety of any PWD bridge, road, culvert, etc., DID Engineer responsible for the initiation of the work will at an early stage consult PWD Engineer concerned to ensure that both funds and measures to execute all necessary protection works are provided to the satisfaction of the State Engineer, PWD.

(2) In future cases where DID proposes to construct any irrigation waterway or other work which will affect PWD road or other structure, then the local DID Engineer will first put up his proposal in relationship to the PWD structure and obtain its agreement to the DID proposal before embarking on the work.

(3) Conversely, if a PWD proposal envisages the crossing of any irrigation canal, or any interference whatsoever with the DID controlled waterway, then PWD will similarly put its proposals before DID and obtain their agreement prior to any execution of the work.

(4) Where PWD roads suffer from annual flooding and where the flooding may be attributed partly or wholly to a choked river channel downstream of the flooded road section, then DID will endeavour to reduce the flooding by its usual methods of river training, river clearing, and desnagging. The PWD Engineer will report each case to DID Engineer in order that the latter officer can consider the inclusion of the river in question, in his program of river clearing for the following year. It is not possible to indicate a general policy where road flooding is due to silting up of river beds. There are so many factors involved outside the control of DID each case of this nature must be considered on its merits.

2.1.4 River conservancy and construction of levee

River conservancy was originally implemented to keep the waterways free for navigation in Peninsular Malaysia. Since around 1908, river conservancy has increased its importance for silting by the extensive development of land for rubber and tin mining. Therefore, river conservancy has been mainly carried out on the rivers flowing into the west coast of Peninsular Malaysia. The following projects have been done mainly at the places given below:

(1) Deviation and canalization of river;

Kinta river, Kelang river and South West Johor Area

(2) Dredging out objectionable sand deposits;

Kelang river, Langar river, Melaka river, Besut river

(3) River clearing and snagging;

Since 1920, considerable sums of money have been allocated annually.

(4) Interception of undersirable sediment loads at convenient places;

Teriang river of Pahang river system and other small rivers

(5) Construction of levee;

Total length of flood levees is said to be 406 km. These levees were mainly planned and constructed as a part of the irrigation and drainage works throughout the Peninsular Malaysia.

These constructions have been done usually to provide, maintain or regain a stable regime of river. Some of the works of (1) in the above were done by private mining companies in the Kinta river. Most of these were done by DID which is in charge of these subjects.

Rivers are periodically inspected by DID overseer in each state. Based on the result of the above survey, desilting, clearance, cutting of tree and weeding of channel are carried out as occasion arises. The interval of these operations varies on the average every 2 months in urban area to every 5 years in jungle area. In agricultural area, these operations are conducted once a year.

2.1.5 Inventory of present conditions of river

The following minimum information is necessary to understand the present river conditions, particularly their engineering aspects:

(1) Hydrologic data;

Rainfall in the catchment area, river discharge, river water use or withdrawal data and river water quality

(2) Data on structural conditions of the river;

Plane figure and longitudinal and cross section of the river channel; land use conditions of river side area and its neighboring area; engineering features of main river facilities such as dam, weir, levee, revetment and bridge

Present situations are surveyed by interviewing the State Government officials with respect to the preparation of any inventory concerning the above-mentioned information. As to the hydrologic data, the results will be mentioned in Chapter 7.

As far as the data of the structural conditions is concerned, the results are as follows:

Unified inventory regarding the above-mentioned data could not be found in any single section of the State Government agencies. Some kinds of the data were separately filed in one set of papers to certain extent by responsible or related sections of the Government as occasion arose. Meanwhile, inventory on the land use is prepared regarding the private land as revenue sheet which is produced by the Survey Department of MLRD. State DID often refers to this sheet when it intends to plan any river improvement project.

From the lack of uniform data, the Johor State DID felt some difficulties when they considered the existing water supply intakes during its planning of drainage scheme in the Batu Pahat river basin.

2.2 Operation and Maintenance of Man-made Facilities in River

2.2.1 Introduction

River facilities must be maintained and operated after their completion to fully realize their purposes.

Of various kinds of river facilities, levees, revetments, bedsills, fixed weirs and bridges require only maintenance, while dam, salinity barrages, movable weirs and sluices both maintenance and operation for full realization of their purposes. The present conditions of the facilities requiring maintenance and operation (abbreviated hereinafter to O&M) were surveyed specifically by interviewing the officials concerned.

The following 16 river facilities which comprise 12 dams, 3 salinity barrages and 1 weir, have been picked up as samples of this survey.

(1) Dam

Name of Dam	Location
Pedu	Kedah
Muda	Kedah
Ayer Hitam	Pulau Pinang
Temenggor	Perak
Kelang Gates	Selangor
Sungai Langat	Selangor
Gunong Ledang	Johor
Pengkalan Bukit	Johor
Batu Pahat	Johor
Lebam	Johor
Tenglu Mersing	Johor
Sultan Abu Bakar	Pahang

(2) Salinity Barrage

Name of Facilities	Location
Sungai Kedah Tidal Barrage	Kedah
Rantau Panjang Barrage	Pulau Pinang
Sungai Melaka Tidal Barrage	Melaka

(3) Weir

Name of Facilities	Location
Pelubang Regulator	Kedah

Main features of the above dams are shown as in Tables 2 and 3.

The above dams and salinity barrages are the representative facilities of each group in Peninsular Malaysia. Although there are so many weirs in Peninsular Malaysia as aforementioned, only the above Pelubang Regulator, believed to be the largest of all, was specifically surveyed. The general level of O&M of other weirs and other types of facilities utilized for irrigation and drainage, was investigated by interviewing the State DID officials. Most of these facilities are intake gates, or tidal gates which are constructed along the river bank, not across the river.

The conditions of O&M of river facilities were surveyed with respect to the following points:

(1) Equipment and instrument for O&M;

(2) System of O&M;

(3) Practised items of O&M; and

(4) Method taken for O&M.

2.2.2 Equipment and instrument for O&M

The following items were examined to learn the present conditions of the equipment and instrument:

(1) Whether or not steel gate or another flow regulation equipment is furnished at the following structure.

(A) Spillway

(B) Low flow release structure

(2) What kind of power source is supplied for gate operation or for operation of flow regulation equipment, and whether spare source for emergency is provided or not.

(3) Whether or not the instruments for observation, measurement and watching of hydrologic phenomena and structural behavior for the following are equipped.

(A) Rainfall, river discharge and water level or rivers and reservoirs

(B) Following indices of dam behavior or its foundation's (in case of dam)

(a) Deformation of dam body including settlement of fill type dams

(b) Seepage volume

(c) Seepage line in case of uniform fill type dams

(d) Uplift

(C) Meteorological observation equipment

(4) Whether or not the following instruments are provided for the warning of the downstream area against the danger accompanied by the release of water from the river facilities

(A) Siren

(B) Warning car

The results are shown in Tables 4 and 5, and summarized as follows:

(1) There are some facilities whose gates are only manually operated;

(2) All the dams surveyed are furnished with spillway, however, more than a half of them are without gate or any other flow regulator;

(3) One-third of facilities whose gates are operated by electric power have no spare source other than manual;

(4) Most facilities have at least one rainfall gauge in their catchment areas;

(5) Most dams have no water level gauge in their catchment area;

(6) Some dams constructed less than 20 years ago are well equipped with measurement instrument for dam body behaviour; and

(7) Only the Sultan Abu Bakar Dam has been furnished with warning equipment (in this case, a siren). This equipment has been furnished after the flood in 1971, when a farmer was drowned in the river whose water level was rising partly due to the operation of the spillway gate.

The number of rainfall gauge stations was surveyed as for the catchment area of each dam, and the results are shown also in Table 4.

It was informed that other irrigation weirs, intake or drainage gates were operated according to water levels of river and canal, and to water demand of paddy-field.

2.2.3 System of O&M

The present condition of the system of O&M has been surveyed from the same river facilities. The points surveyed are as follows:

(1) Whether a field office has been provided near the site of the facilities;

(2) Total number of persons engaged in O&M at field office by each facility;

(3) Method of communication between field office and head office or its branch office responsible; and

(4) Whether or not each facility has been furnished with any manuals, instruction or rule on O&M.

The results are shown in Table 6, and summarized as follows:

(1) The dams for hydroelectric power generation have certainly the big field offices which also maintain and operate their hydroelectric power stations. These offices are manned with more than 100 staffs. Other dams except some quite old dams for water supply, are also provided with field office and manned with 11 - 23 staffs. The old dams for water supply are not provided with field office, however, are managed by 4 - 5 staffs of the branch offices of the State PWD as a part of its general service;

(2) The salinity barrages and weir except Sungai Melaka Tidal Barrage are observed through the day under the shift system;

(3) All the facilities except some quite old dams operated for water supply are equipped with a VHF or a subscribed telephone or both; and

(4) Most dams, salinity barrages and weir except the old dams are furnished with the manuals for O&M. Neither manual nor instruction nor rule for O&M of the old dams could be found. Those manuals seem in their style not to stipulate routine works but to explain the method of operation of various O&M equipment and to outline the river conditions which necessitate gate operation.

Other irrigation weirs, and intake and drainage gates are furnished with small cottage, manned with 2 gate keepers on an average but in shifts and provided with duty list which stipulates definitely necessary jobs of gate keeper. Gate keepers are under the control of irrigation inspector.

2.2.4 Practised items of O&M

The practised items of O&M work regarding the sampled dams have been surveyed.

Surveyed items are as follows. The survey was focussed on the frequency and occasion of the practised O&M work.

(1) Maintenance work;

(A) Measurement of dam deformation

(B) Measurement of seepage volume from underdrain

(C) Measurement of uplift

(D) Measurement of silting deposit in reservoir

(2) Operation-related work;

(A) Observation of water quality whether in reservoir, or upstream or downstream river

(B) Meteorological survey

(C) Reporting of the operational conditions especially of release amount from the dams during flood time

The practised frequency of the above issues is summarized as follows (equipping circumstances of the instrument for the above practices were already mentioned in Sub-section 2.2.2 and Tables 4 and 5).

(1) Maintenance work

(A) Measurement of dam deformation

This measurement is carried out on 6 of the 7 dams which are equipped with the required instrument at an interval from once a month to every 3 months. Muda dam is observed for its deformation especially during sudden change in the water level of the reservoir but actually once a month on an average.

(B) Measurement of seepage volume

This measurement is carried out at 4 of the 6 dams equipped with the required instruments. This measurement is made daily at Sultan Abu Bakar dam and monthly at Lebam dam.

(C) Measurement of uplift

This measurement is meant for concrete dam, particularly concrete gravity type dam and concrete buttress type dam. The measurement is carried out daily at Sultan Abu Bakar dam, one of the 3 concrete dams.

(D) Measurement of silting deposit in reservoir

This measurement is carried out only at Sultan Abu Bakar dam reservoir, where a lot of soil sediment from the wide-spread tea plantation or the market garden in its catchment area flowed in. The measurement is practised annually and the effective measure to curb the soil discharge is being studied by NEB, the owner of this dam. (It is informed that the intake of the Telom Tunnel which diverts the Telom river to the Bertam river on which this dam is located, is closed after heavy rain.)

(2) Operation-related work

(A) Measurement of water quality in the reservoirs or in the rivers upstream or downstream of the reservoirs

This measurement is carried out at 9 of the 12 dams for reservoirs and rivers. The measured parameters of water quality and frequency of the measurement vary with each dam. The object of the measurement in case of the dams for water supply or irrigation, is to get the informations for raw water treatment or to observe the suitability of the river water for irrigation. The measured parameters are chosen by considering the surrounding sources of effluent. At the Muda scheme area, the concentration of sucrose is measured in addition to the general parameters, namely, pH, SS, BOD, COD and others, because of the existence of starch factories. The measurement of water quality at Sultan Abu Bakar dam, purposed for hydroelectric power generation, is carried out when some phenomenal

change occurs to the water quality of the reservoir such as change of water color due to abrupt increase of certain plankton.

(B) Meteorological survey

This survey is carried out at 5 of the 12 dams. Atmospheric temperature, humidity and evaporation are commonly measured at these 5 dams.

(C) Reporting or communication of the operational conditions of dams especially on release amount of the dams during flood between agencies

The above work is carried out at 4 of the 12 dams. The other parties of the reporting or communication are District Office in case of Muda and Pedu dams, and DID in case of Kelang Gates and Tenglu Mersing dam. It is informed that this reporting is usually done twice an hour.

Survey on O&M practised on salinity barrages and weir listed in Table 5 was made. Check was made on whether the following works are being carried out or not, and the results obtained were as follows:

(1) Reporting of the operational conditions especially of release amount from the salinity barrages and weir during flood time

The above-mentioned work is being carried out only at Sungai Kedah Tidal Barrage and Pelubang Regulator, both of which are the intake facilities of Muda irrigation scheme. The above communications are carried out as a part of the reporting to DID on the operational conditions of the whole facilities of this scheme.

(2) Observation of water quality of impounded water

The above observation is not carried out at any facilities. The water quality of the 2 salinity barrages which are purposed to water supply, is checked at the treatment plant.

(3) Compensation releasing of water from the salinity barrages or the weir

This operation is not carried out at any facilities.

A survey was made on the kinds of O&M works carried out at other irrigation weirs, and intake and drainage gates.

Maintenance works compiled from the duty list of tidal control gate-keeper of Melaka DID and duty list for gate-keeper or irrigation worker of Negeri Sembilan DID are given below.

(1) Cleaning of concrete weir structures

(2) Applying of oil or lubricants to the lifting apparatus

(3) Throwing away all rubbish from the gate

(4) Clearing of weir area

(5) Painting of the gate

Operational works concerning irrigation weirs, intake and drainage or tidal gates are as follows according to the above-mentioned duty lists:

(1) Monitoring of river water level and operation of gates in proportion to it

According to the duty list of Melaka DID, the operation of tidal gate is carried out daily according to the tide time-table except during the rainy season.

(2) Reporting of the damages occurring in any part of the facilities

2.2.5 Method of O&M

Study was made on the 16 facilities to find out what authorities or documents were being followed to proceed with the work on O&M. General tendency of the same theme was also investigated on other irrigation weirs and intake or drainage gates. In addition, O&M based on the rule coordinated by 2 agencies, was investigated.

(1) O&M of the dams

O&M manuals are furnished for 7 of the 12 dams according to the information from the officials concerned. Comparatively old dams are without manuals. Most manuals are made by the respective consultant which had been engaged in the supervision of the construction work. These manuals are usually approved as a standard for O&M work by the headquarter concerned. However, no document specifying the above-mentioned approval of those manuals as a standard of O&M work by each headquarter, could be found. Also there is neither law nor ordinance which stipulates the approval mentioned above. In addition, there is neither law nor ordinance which fundamentally regulates the O&M works and their standard. These manuals explain mainly the operation and maintenance method of O&M-related equipment and instrument. They do not stipulate that the downstream area should be confirmed by dam operator to be free from any danger which may be brought about there by discharge from the dams, warned against this danger and informed of it, if necessary. These manuals do not stipulate the observation of rainfall and river water level or discharge in their catchment area.

On the other hand, the Kelang Gates dam is furnished with a detailed O&M standard titled "Kuala Lumpur Flood Mitigation Project, Klang Gates Dam Standing Operating Procedures, Nov., 1980." This procedure has been recently completed in connection with the recent extension of the Kelang Gates dam to furnish it with flood control function in addition to its original purpose of water supply. This procedure has been completed by close coordination between the Selangor State Water Supply Department and the Federal Territory DID. This procedure consists of the following issues (see Refs. 10 and 11).

PART I General

(A) Emergency preparedness plan

(B) Unusual occurrence reporting

(a) Failure or extensive damage to Kelang Gates Dam

(b) Earthquakes

(c) Flooding

(d) Cracking of the Dam or abutment

(e) Failure of appurtenant structures of operating equipment

(f) New springs or increased drainage

(g) Landslide

(h) Severe storms

(i) Fires

(j) Sabotage

(k) Oil, chemical, pesticide or pollution spills

(l) Drowning, major accident or criminal action

(C) Communications directories

(D) General matter

(a) Assignment of responsibility

- Basic responsibility
- Dam operator's responsibility

(b) Communication procedure

(c) Cooperation with other agencies

(d) Data and unusual occurrence reporting

- Data reporting
- Unusual occurrence reporting

(e) Restricted areas

(f) Safety and health

- Law enforcement
- Medical aid
- Fire prevention and protection

(g) Civil defense and sabotage security plans

- Plan for protection of facilities
- Bomb threats
- Demonstrations
- Office to be notified in event of bomb threat or disturbance
- Procedure to be followed during a nuclear attack

(h) Revisions to standing operating procedures

(i) Distribution of standing operating procedures

(E) Structural, electrical and mechanical

(a) General information

- History
- Operation consultant and advice

(b) Description

- Location
- Description of dam
- Spillway
- Municipal and industrial water supply outlets
- Water treatment equipment
- Evacuation outlet
- Access road

(F) Reservoir operations

(a) Reservoir allocations and capacities

(b) Design flood study and routing

PART II Designer's Operating Criteria

(A) General description

(a) Location

(b) Purpose

(c) General description

(B) Concrete dam

(a) Dam and abutments

(b) Drainage

(C) Spillway

(a) Description

(b) Discharge curves

(c) Top seal radical gates, hoists and controls

- Description
- Operation
- Emergency operation
- Maintenance

(D) Municipal and industrial water supply outlet

(a) Description

(b) Rate of discharge

(c) Lime feeding equipment

- Description
- Operation
- Maintenance

(E) Pumping units

(a) Vertical-shaft, turbine-type pump

- Description
- Lubrication
- Operation
- Maintenance

(b) Motor

(c) Ventilating system for water treatment equipment building

(F) Gantry crane

(a) 7,200-pound gantry crane

- Description
- Operation
- Maintenance

(G) Access road

(a) Retaining wall and weep holes

(b) Gutter and culvert

(H) Electrical equipment

(a) Power

- Normal power
- Standby power

(b) Radial gates controls

- Description
- Automatic operation
- Manual operation

(c) Lighting fixtures and wiring devices

- General
- Operation
- Maintenance

(I) Periodic preventive maintenance

(J) Protective coating inspection and maintenance

(a) General

(b) Inspection schedules and maintenance materials

(K) Reference material

(a) Specifications

(b) Bureau publications

(c) Contract drawings

As the above list of contents shows, wide field of O&M work is covered by this procedure. The high hazard potential to the downstream area as a result of failure or misoperation of Kelang Gates dam are well considered. Cross-agency reporting system is provided for every kind of emergency or usual occurrence. The informations of any emergencies at the Dam are to be reported at first to the Engineering Assistant Production at the Selangor Water Supply Department by the Dam operator. The record of the above reporting and its form are also stipulated.

The agencies to be reported by the Selangor Water Supply Department cover not only the Federal Territory DID but also the following agencies:

(A) Gombak District Officer;

(B) Contingent Control Center of the District and DOE;

(C) State Health Department and DOE (in environmental emergencies); and

(D) Setapak Police Station (for communication service assistance during emergencies).

It is notable that the procedure stipulates the necessity of the reporting of environmental emergencies as follows:

(A) Hazardous chemical spills, such as chlorine, ammonia, industrial acids, etc.;

(B) Unexplained fish kills;

(C) Accidents involving pesticides; and

(D) Floods or other natural disasters that affect water supplies and treatment.

It is also notable that the periodical review and updating are mentioned for specific information particular to the Dam to assist the Dam operator in determining "normal" situations from "emergency".

(2) O&M of the salinity barrages and the weir

O&M manuals are furnished for all the 4 facilities surveyed. All manuals were written by the respective local consultant. There is no document which certifies the approval of these manuals as a standard for O&M work by the headquarter or any other authority.

The contents of the manuals are also similar. Most part deals with the explanation of the operation and maintenance method of O&M-related equipment. The following is the contents of the manual of the Rantau Panjang barrage in Pulau Pinang:

(A) Operation control and panel switches

(B) Manual operation

(C) Automatic operation

(D) Control equipment at gates

(E) Description of electrical circuit

(F) Circuit diagram

(G) Interval timer

(H) Setting limit switches and level control electrodes

(3) O&M of other irrigation weirs, and intake and drainage gates

The O&M of middle to under-sized river facilities for irrigation and drainage are mostly carried out by 2 gate keepers or irrigation workers under the management of irrigation overseer in accordance with a duty list which is made by the District DID Engineer or the Director of the State DID. The specified duties are as follows regarding the Negeri Sembilan and Melaka DID:

(A) Operating of the gate in accordance with the water level in the river and irrigation or drainage channel and by the method specified;

(B) Clearing of rubbish around the facilities;

(C) Oiling of the gate;

(D) Painting of the gate once a year;

(E) Reading and recording by the method specified, of the water level at the gate and presenting the record to an overseer by specified date every month;

(F) Quick reporting of the damage of gate and related structures;

(G) Not leaving the place of work without obtaining permission from overseer;

(H) Daily cutting of the grass on embankment near gate or neighboring areas;

(I) Being responsible to and receive directions from Junior Technician-in-charge; and

(J) Quick reporting to State DID of requests and problems of farmers.

The above form of duty list are quite similar throughout Peninsular Malaysia. The standard of these duties is given as a guideline by the DID Manual in 1973 (see Ref. 3). It is mentioned in the Manual that routine maintenance and operation of gates should be laid down for each gate in the form of standing orders to the gate-keeper, and that these orders should include the following issues:

(A) Duties of the gate-keeper;

(B) Instructions when the gate is to be opened and shut;

(C) From whom the gate-keeper may receive orders;

(D) To whom he will report;

(E) Records to be kept; and

(F) Daily, weekly, monthly or, as necessary, maintenance to be done.

This manual also provides detailed instruction for paint scheme of the tidal gate.

(4) O&M based on document coordinated by 2 agencies

This kind of O&M is not common in Peninsular Malaysia. Two cases could be found. The first case is O&M of the Kelang Gates dam and the second case is O&M of the 2 salinity barrages of the Public Utilities Board of Singapore (PUB) on the Teberau and Sekudai rivers, purposed to supply domestic water to Singapore Island. The former case has already been mentioned in (1) of this paragraph. Then, the latter case will be mentioned hereinafter. The guidelines have been coordinated for the operations of the gates of these salinity barrages by the Johor State DID and PUB according to the agreement contracted by the Johor

State Government and the City Council of the State of Singapore in 1961 as later touched. These guidelines provide the standards to regulate the positions of the gates in accordance with the river water levels. In addition to the standards the "Remarks" in both of these guidelines state that "these are only guidelines for gate operations for cases where continuous and persistent rains have fallen for a number of hours. Officer-in-Charge should note that there will be time lag of several hours before concentration of catchment flow reaching the intake. Operation are to be carried out in anticipation of peak flow".

The "Note" states also in both of these guidelines that "in the event of high flood flows, 1/2-hourly readings of the river levels are to be taken to keep records of the rate of rise of the river levels. The operations given above serve as a guideline. Officers-in-Charge are advised to use their discretion in determining the necessity of any further operations at every stage taking into consideration the rate of rise of river levels, intensity and duration of rainfall. All gates may be shut with flaps fully raised when the river level has receded to below 15.5 ft. for Sekudai river and 8.0 ft. for Teberau river."

These guidelines originated in an agreement as already mentioned. An agreement is provided related to the water withdrawal on the Sekudai and Teberau rivers, titled "Tebrau and Scudai Rivers Water Agreement".

In Section 8 of this agreement, it is stipulated that "water shall be drawn off the Tebrau and Scudai Rivers only at agreed points and in a manner to be agreed between the City Water Engineer (PUB) and the State Drainage and Irrigation Engineer" (see Ref. 12).

This agreement is originally contracted to witness the rights, liberties and obligations of the partners with respect to rent, land, water and premises as well as actions done by their staffs with respect to the following 3 water works of PUB:

(A) Gunong Pulai Works with 2 reservoirs on the Pulai river and the Pontian Kechil river;

(B) Sekudai River Works with a salinity barrage and a pump station on the Sekudai river; and

(C) Teberau River Works with a salinity barrage and a pump station on the Teberau river.

The necessary lands and premises located in the Johor State, could be demised, reserved or set aside exclusively for the sake of PUB by Johor Stage Government for a period of 50 years.

There exists another similar agreement between the same partners regarding the water withdrawal on the Johor river.

A pumping station is provided on the Johor river by PUB for water supply (see Ref. 13).

3. FLOOD MANAGEMENT

3.1 Land Use Restriction in Flood-Prone Area

The total flood-prone area of Peninsular Malaysia was estimated in the Sectoral Report PJ at 15.24 x 10^3 km^2, which comprises the following land use patterns:

Land Use Pattern	Area (km^2)	Share (%)
Rubber and oil palm tree	2,650	17
Padi	1,489	10
Horticulture and other crops	1,514	10
Grassland	262	2
Forest land	2,966	19
Mining	76	1
Urban area	113	1
Swamp	6,169	40

It is officially understood that the wide-spread flood disaster as mentioned above could not be abated economically by only engineering method. Non-engineering measures like flood forecasting, evacuation and land use restriction in flood-prone area, also are considered in Peninsular Malaysia, and TMP mentioned especially the importance of land use restriction in flood-prone area as follows:

> "A large proportion of the population live in valleys and river basins which are flood-prone. Recognizing the need to alleviate the hardship and to improve the living conditions for these people, the Government has embarked on a wide ranged of engineering, non-engineering and legislative measures, both on a short- and long-term basis, to overcome the flood problem systematically. It is pertinent to note that while effective flood control can be achieved, the toll of flood losses may well continue to increase if the areas subject to flooding and flood hazards are developed and utilized indiscriminately. In these circumstances, the effects of flood control measures are nullified by unwise land use, which in turn aggravates the flooding situation. An integrated approach and awareness of the flood element as a natural phenomena in land use development projects and planning is necessary. To the extent that floods are caused by natural phenomena and therefore cannot be prevented, it is imperative that planning for settlements and land use take this factor into account to minimize the extent of the damage and adverse effects likely to be caused in the event of a flood occurring. This is particularly necessary in the case of the larger river basins with flood-prone areas."

The land use regulations are conducted throughout Peninsular Malaysia on ad hoc basis regarding the development for housing and industrial estate or agricultural farm, based on the National Land Code. The land use restriction in specific flood-prone area is conducted only as a part of the above general cases. The raising of ground level and its height are obligatorily instructed to the applicant who intends to develop his land for housing or industrial estate, by the Land Officer. This instruction will be issued after considering the flood conditions which may be advised for each case by the SDID. However, any demarcation of flood-prone areas could not be found whether on legal or administrative basis.

Though legal basis for the land use planning has already been established with regard to the town areas and their environs, its enforcement is quite limited. Flood mitigation aspect is taken into account in this procedure in the form of urban drainage. Town and Country Planning Act is enacted for this purpose.

On the other hand, a basin-wide land use plan has been provided for the Teberau and Sekudai river basins. In recent years, the urbanization is progressing in these basins, and land use plans were required according to the State DID officials. These plans do not provide zoning of flood-prone area, but enable the State Government to regulate the land use by taking into account the flood disaster in these river basins. The Government can also restrict the land use in watershed area. These restrictions are implemented through the granting of the title for alienated land or limiting the conversion of the type of land use. According to these plans, housing development is permitted principally in several Town Council areas and industrial development only in the areas designated for this purpose. Alienation for agricultural land use is also done according to these plans and the kind of cropping plant is regulated.

The feasibility of these plans and each land use regulation are examined by the State DID with respect to flood mitigation. Final decision is done solely by the Land and Mines Department of the State.

Resettlement scheme to relatively flood-free areas has been carried out for the people residing in flood-prone areas since the January 1971 flood (see Ref. 15) in the Pahang State. It was said that there were approximately 60,000 people living in rural areas in the Pahang River basin which were inundated by a flood of 20 year return period. About 30,000 of these were affected by a 5 year flood. The rural people have traditionally lived on the river banks because the rivers have provided means of communication and trade, plentiful water supplies and fishing and because of the availability of land suitable for padi growing. However, with the advent of modern facilities, such as roads, motor vehicles and pumped water supplies, it is now possible for the people to move away from these flood-prone areas. The first stage of the resettlement was done under 35 schemes which catered for almost 6,000 families, or about 30,000 people, roughly equal to the number of people in the Basin affected by a flood of 5 year period.

3.2 Land Use Restriction in Watershed Area

In Peninsular Malaysia, the development of the watershed area has been planned for the following purposes:

(1) Oil palm and rubber tree planting;

(2) Logging;

(3) Housing and industrialization;

(4) Road construction; and

(5) Tin mining.

These developments in watershed area are regulated according to the Land Conservation Act by the Land Office or Land and Mines Department of the State. It is usual that the above land authorities refer to the State DID's view concerning flood mitigation and the prevention of soil erosion when they judge the land applicable for the above land use development. The main issues advised by DID are usually as follows (informed by the Pahang State DID officials):

(1) Oil palm and rubber tree planting

(A) Method of jungle cutting and logging

(B) Preparation of drainage system in steep slope area

(C) Exclusion of planting in steep slope area

(D) Reservation of the land along river for the prevention of the disturbance

(E) Prohibition of drifting trees

(2) Logging

(A) Restriction of logging area of one period

(3) Housing and industrial estate development

(A) Providing of drainage facilities such as concrete drains, sewers, outfall structures, bridges and other related facilities

(B) Covering of exposed earth slopes and vacant land

(C) Providing of silt traps

(D) Maintaining of channel system for drainage in good condition

(4) Road construction

None

(5) Tin mining

(A) Consideration on the river reserved area

(B) Consideration on the river flowing in mining land

(C) Providing of returning system of water

(D) Retaining the restriction on solid concentration of mining effluent

(E) Providing of bunds in the tailing area and their maintenance of them

Johor State DID states that any private person who intends to develop the upper reach of river basins in Johor State for housing or industrial estate, should be charged M$4,940 per ha (M$2,000/acre) of developing area by the Collector of Land Revenue under the name of river improvement of downstream area.

3.3 Flood Forecasting and Warning

3.3.1 Introduction

The effect of flood forecasting and warning draws much attention in Peninsular Malaysia and they are actually playing an important role.

The flood forecasting and warning system as well as evacuation system, are under the responsibility of the National Security Council (NSC) in the Prime Minister's Department. This council and its state and district level organization, namely, the State Security Executive Committee and the District Security Executive Committee, organize the Disaster Relief Committee respectively. These Relief Committees consist of the following members:

(1) Malaysian National Disaster Relief Committee

(A) The Minister of Information - Chairman

(B) Deputy Minister of Communication

(C) Deputy Minister of Finance

(D) Chief Secretary to the Government

(E) Chief of Armed Forces Staff

(F) Inspector - General of Police

(G) Secretary of the National Security Council

(2) State Disaster Relief Committee

(A) The State Secretary - Chairman

(B) The Chief Police Officer

(C) The Bridge Commander

(D) The Director of Drainage and Irrigation

(E) The Director of Welfare Services

(F) The Director of Medical and Health Services

(G) Secretary to the State Security Executive Committee

(H) Other coopted members such as representatives from the Malaysian Red Crescent Society, Youth Organization, St. Johns Ambulance and Civil Defence

(3) District Disaster Relief Committee

(A) The District Officer - Chairman

(B) The Officer-in-Charge of Police District

(C) The local military representative

(D) The District Engineer

(E) The District Medical and Health Officer

(F) The District Welfare Officer

(G) Other coopted member such as the representatives from the Malaysian Red Crescent Society, St. Johns Ambulance, Youth Organization, and local Civil Defence Corps

Each Disaster Relief Committee organizes the following centers for its activity respectively:

(1) National Flood Control Center

(2) State Flood Control Center

(3) District Flood Control Center

at the following place respectively:

(1) National Security Council Secretariat

(2) Police Contingent Headquarters

(3) District Police Headquarters

The representatives of the above organizations attend their corresponding committee or control center and fulfill their duties. DID is in charge of flood forecasting among them.

There is neither law nor ordinance which regulates flood forecasting, warning and evacuating activities in Peninsular Malaysia.

3.3.2 Observation of hydrologic data

The following data are used in Peninsular Malaysia to forecast and cope with flood:

(1) Rainfall;

(2) River water level or river discharge; and

(3) Other meteorological data.

Of the above 3 kinds of data, the meteorological data will show the earliest signs of heavy rain. These data are provided by MMS. Basic meteorological data from all parts of Malaysia and the ASEAN countries are collected via the national and regional exclusive meteorological point to point circuits at the Malaysian National Meteorological Centre in Kuala Lumpur. These data, together with those from outside areas, and other national meteorological input, such as radar echos and satellite pictures, are analysed to deduce weather forecasts. Storm warnings are issued to NSC Secretariat and DID if necessary. On receipt of this warning, the State DID Engineer will alert all the staffs in the state or the districts concerned.

Most of the rivers that tend to overflow their banks in flood time and do damage to riverine people are equipped with stick gauges along them including their tributaries for forecasting flood. But it is very difficult to warn with enough time in some rivers such as the Pinang, Kelang, Sekudai, Mersing and the Kuantan rivers which have less than 3 hs to warn (see Sectoral Report; River Conditions).

After the warning by MMS, the relevant stick gauge and rainfall gauge will be observed by the District DID staffs. Each gauge is marked with 3 grades of water level to distinguish the scale of impending flood. The frequency of the reading will change in proportion to the actual flood water level as follows:

(1) Alert water level to Warning water level; from once a day to every 6 hours;

(2) Warning water level to Danger water level; from every 4 hours to every hour; and

(3) Higher than Danger water level; every hour.

3.3.3 Transmission of the result

The results of the water level observation are reported each time from the nearest police station to the District Flood Control Centre through the police communication system. Then, the District Flood Control Centre will report the same results to the State Flood Control Centre. The State Flood Control Centre will inform these results to the Secretary of the State Flood Relief Committee, when deemed necessary by the Director of the State DID. The necessity of the warning is judged by this Relief Committee.

The result of the judgement will be communicated to the District Flood Control Centre concerned as a warning, to the National Flood Control Centre as a report and to the people through radio and television.

Meanwhile the telemetric systems for river water level and rainfall are established in Kelantan river basin, Trengganu river basin, Pahang river basin and Perak river basin. These systems provide automatic transmission of rainfall and water level data from the fields to the State DID Offices respectively. As for the first 3 basins, these data are further transmitted to the Headquarter of DID in Kuala Lumpur by telex to be processed and deduced for flood forecast through computer. The results of this processing are sent back by telex to each State DID and reported to the State Flood Disaster Relief Committee. As for the Perak river basin, transmitted data are analysed at the State DID Office in Ipoh. In Johor State, the state-wide VHF telemetric system will be constructed soon.

3.3.4 Data analysis

The river water level measured manually and informed through the police communication system is checked by the stage correlation technique at the State DID Office.

The data of the Pahang, Trengganu and Kelantan river basins are analysed at the Headquarter of DID by computer based on the following models for each basin:

(1) Pahang river basin; Unit hydrograph

(2) Trengganu river basin; Sacramento model

(3) Kelantan river basin; Sacramento model

The data of the Perak river basin are analysed at the State DID Office by the stage correlation technique.

3.4 Evacuation System

Evacuation system is managed by Federal, State and District Disaster Relief Committees and activated by the Flood Control Centre of each Committee. Malaysian National Disaster Relief Committee is specifically served by 2 Working Groups as follows (see Ref. 16):

(1) Working Group on Supply which is responsible for the coordination of food, welfare and medical supplies; and

(2) Working Group on Transport and Communication which is responsible for the coordination of all required transport facilities and the maintenance and repair of vital communication system.

The activation criteria of evacuation system are as follows:

(1) Flood occurring in 1 or 2 areas in a district. Flood relief efforts are coordinated at the District Flood Control Centre. The State Flood Control Centre is on standby to provide assistance if necessary;

(2) Flood occurring in 2 or more districts in a state. Flood relief efforts are coordinated by the State Flood Control Centre. The National Flood Control Centre will be activated and manned, by skeletal staff to follow and assess the situation. The National Flood Control Centre will provide assistance if the state has exhausted all its initial relief resources; and

(3) Flood occurring in several states. Flood relief efforts are coordinated by the National Flood Control Centre. Flood relief machinery will be activated at all levels, round the clock. If the flood situation worsens, the Chairman of the National Flood Relief Committee consults the Prime Minister to declare a state of emergency.

The evacuation and rescue plan is designed to make use of the existing resources available with government machinery and voluntary organizations, like the Malaysian Red Crescent Society and St. John's Ambulance.

This evacuation and rescue plan is determined according to the roles and duties of ministries and departments as follows (see Ref. 16):

(1) Ministry of Welfare Services

This Ministry is responsible for the coordination and administration of evacuation centers, the preparation for distribution of food, clothing and other supplies and rehabilitation of flood victims with

the support of the Malaysian Red Crescent Society, St. John's Ambulance and youth organization.

(2) Ministry of Commerce and Industry

This Ministry, with the cooperation of the National Rice and Padi Board, is responsible for the distributing and storing of essential food supplies in various flood-prone areas.

(3) Ministry of Defence

This Ministry, the Police and the Civil Defence Corps are responsible for the evacuation of flood victims, water, land and air transportation and the maintenance of communication networks.

(4) Ministry of Health

This Ministry provides the supplies and distribution of emergency stock of drugs, vaccines and medicine and performs preventive and curative medical and health services.

For those operations, each ministry establishes operation room by itself in flood time. Each ministry draws up previously its own contingency plan for each flood season. In this contingency plan, the following items are laid down, for example, in case of the Ministry of Welfare Services:

(1) On the role and duty of the Ministry of Welfare Services in the operations on flood disaster;

(2) The duty roster for the Social Welfare Officers at the National Security Council and the Ministry of Welfare Services' operation room;

(3) The list of house addresses and telephone numbers of the Ministry of Welfare Services, the Secretary, the Director General of Social Welfare Services, Malaysia and other officers;

(4) The state of necessary materials (mainly rice) stock or the method of storage;

(5) The list of evacuation centers and forward supply bases in Peninsular Malaysia with its address and telephone numbers of the National Social Welfare Directors, the Deputy Directors and the District Social Welfare Officers.

The state and district level agencies also draw up its own contingency plan.

4. LOW FLOW MANAGEMENT

4.1 Kinds of River Water Use

River water uses can be classified for convenience into 2 types of use: withdrawal use and non-withdrawal use. The existing uses of river water in Peninsular Malaysia are classified as shown below.

Withdrawal Water Use

(1) Domestic and industrial water supply

(2) Agriculture

(3) Fish pond

(4) Mining

(5) Hydropower

Non-withdrawal Water Use

(1) Navigation

(2) Maintenance of water level for withdrawal water use

(3) River fishing

(4) Prevention of salinity intrusion

(5) Prevention of estuary clogging

(6) Recreation

Different from the withdrawal water uses, the quantities and users of the non-withdrawal water uses cannot generally be specified individually and a river flow is for their common uses. The river discharge for the non-withdrawal water uses is often called "river maintenance discharge".

4.2 Compensation Discharge and River Maintenance Discharge

When river water is stored in a reservoir or withdrawn from a weir, the release of some quantity of water is often needed for the existing water uses in the downstream. This release water is usually called as "compensation water" in Malaysia. In Peninsular Malaysia, there are only few rivers, where compensation water is stipulated clearly as far as informed. The following statements are the existing stipulations on compensation water which were informed from the state governments.

Temengor dam of the Perak river, which is a multipurpose dam for hydropower and flood control, is stipulated to operate to maintain 113 m^3/s (4,000 cusec) of river discharge at the Iskandar bridge for the existing irrigation use in the downstream.

Durian Tunggal dam of the Melaka river, which is a dam for Melaka water supply, is compelled to release 0.53 m^3/s (10 mgd) of river discharge for the existing irrigation use in the downstream.

Sungai Langat dam of the Langat river, which is a dam for Kuala Lumpur water supply, must be operated so that the overflow depth at the crest of the diversion weir of water supply located about 20 km downstream may be maintained over 20 cm (8 inches) for the existing water uses in the downstream.

Maintaining of the compensation water in the Teberau and Sekudai rivers is stipulated as follows in the water agreement between the Government of Johor State and the Government of Singapore (see 2.2.5). "The City Council (Singapore Government) agrees that the flow of the Teberau and Sekudai rivers below the point of pumping shall not be reduced to such an extent as to cause the present users to suffer unreasonably by reason of an increase in the salinity thereof." Maintaining of the compensation water in the Johor river is also stipulated in the same way by the water agreement on the Johor river between the Government of Johor State and the Government of Singapore (see Refs. 12 and 13).

In the Muda river, there exists no rule on compensation water. Although the downstream areas suffered from water shortage in the drought of 1978 and 1979, no water was released from the Muda dam for the existing water uses in the downstream.

There exists no river in Peninsular Malaysia, where river maintenance discharge is assured. However, considerations of river maintenance discharge are required for several rivers of Peninsular Malaysia. Table 7 shows the necessities of considering river maintenance discharge in the main rivers of Peninsular Malaysia. Consideration of river maintenance discharge may be mainly required for dillution of water pollution in the west coast rivers, while the same consideration may be mainly required for prevention of salinity intrusion in the east coast rivers.

4.3 Standard for River Water Use

River water use is usually permitted within the limit of low flow discharge with a certain probability of drought. The river water will be wasted if the probability is assumed too small, while the water users will often be unable to use the river water if it is assumed too large. In Peninsular Malaysia, design low discharge has been conventionally assessed at a level of 5-year probability for planning irrigation projects. And it has generally been assessed at the level of 25 to 30-year probability for planning normal-scale municipal water supply and 50-year probability for planning large scale municipal water supply

(see Table 8). However, any standards of design on low discharge for permission of private water uses are not given.

4.4 Water Licence

In Peninsular Malaysia, any private person or organization who wishes to withdraw river water, is obliged to get a licence from the state government. Licences are usually granted with some conditions. The typical example of the conditions obtained from the State of Melaka is shown below.

(1) To furnish a water meter at the entrance of the water;

(2) To record water usage from time to time;

(3) To permit the State government officer concerned, to inspect the said records;

(4) To maintain a part of the river and to repair as directed by the government officer without claim; and

(5) To abide by the conditions and limits of the quality of waste waters as determined by DOE.

District Officer is responsible for granting the water licence other than that for the generation of electricity, which may be granted by the Ruler in Council or the Commissioner of each State (see Ref. 1).

4.5 Management of Extreme Drought

In Peninsular Malaysia, it is usually recognized that the priority order of river water use at extreme drought is given as follows:

1st priority ; water supply,
2nd priority ; irrigation,
3rd priority ; private company.

This information was obtained from states DID and PWD. It seems that this priority order is reflecting the difference of the probability of design low discharge for planning and the degree of the damages caused by the reduction in water use. However, in actual case, almost no effective coordination has been maintained for the reduction of river water use, leaving the conflicts among the users as they are. The conflicts among the existing water users have occurred at extreme drought in the Muda, Melaka and the Muar rivers. Effective coordinations of such conflicts is expected.

4.6 Restriction of Waste Water Discharge and Monitoring System of Inland Water Quality

The water quality of the rivers in Peninsular Malaysia has deteriorated gradually with the economic growth of the country. As a result, the number of the complaints of water pollution from the public has been increasing since 1974, the starting year of the investigation of complaints with the exception in 1977 when it decreased. It has reached 50 in 1978 and 1979. In 1979, 44% of the total number of complaints was originated in the state of Selangor and Johor. And the Kelang, Linggi and Sekudai-Pontaian-Tebrau were the worst rivers. The number of complaints by river in 1979 is shown in Table 9. Palm oil mill was the biggest cause of complaints in 1979, followed by rubber factory, mining and siltation, pig waste and domestic sewage in that order. The number of cause for complaints in 1979 is shown in Table 10 (see Ref. 17).

The major pollution sources in Malaysia: palm oil mill, rubber factory, sewage and industry, are controlled by the Environmental Quality Act, 1974, the Environmental Quality (Prescribed Premises) (Crude Palm Oil) Regulations, 1977, the Environmental Quality (Prescribed Premises) (Raw Natural Rubber) Regulation, 1978 and the Environmental Quality (Sewage and Industrial Effluents) Regulations, 1979.

The effluent from palm oil mill and rubber factory is controlled as follows:

(1) No person can occupy or use crude palm oil processing premises and raw natural rubber premises which are 2 major pollutant sources, unless he is a holder of licence;

(2) The effluent from these premises must not contain more pollutant than the prescribed value and every occupier of these premises must submit a quarterly return for every quarter in some respects of his premises which include the pollutant level of the effluent;

(3) Effluent discharge from palm oil mills for watercourse shall be reduced below 500 ppm in terms of BOD concentration before July 1981. Effluent discharge from rubber factory for watercourse shall be reduced below 200 ppm in terms of BOD concentration before April 1981; and

(4) The Director General of Environment may impose the conditions to the licence which include requirements pertaining to pollution control measures, installation of pollution control and monitoring devices and general conditions for permissible waste discharge.

Up to the end of 1979, 84 out of the 132 palm oil mills currently in operation have installed their treatment systems. Sixteen mills are under construction for their treatment systems. The remaining 32 mills have submitted their plans of the treatment systems (see Ref. 5).

Sewage and industrial effluents are controlled as follows:

(1) From January, 1979, all new factories have been required to obtain approval from the Director General of Environment prior to construction to ensure that the necessary pollution control units have been incorporated. The existing factories shall install their treatment plants before January 1981; and

(2) Effluent discharge from sewage and industry shall be reduced below 20 ppm in terms of BOD concentration for the areas upstream of water supply intakes for human consumption and below 50 ppm in terms of BOD concentration for the other areas.

Regular river water quality monitoring programme has started in 1978. DOE executed the monitoring at 443 points on the rivers of Peninsular Malaysia in 1979. The monitored items totalled 38, including BOD, pH, COD, NH_3-N, NO_3-N, Cl, SO_4^{--}, SS and others. In addition, DID has been monitoring river water quality in a similar way, and monitored 25 items at 170 points on the rivers of Peninsular Malaysia (Sections 4.1 and 4.2 of the Sectoral Report of Water Quality).

The criteria of river water quality for such beneficial uses as domestic water, industrial water, irrigation and fishery has not been established so far, although DOE recognizes the necessity of its establishment (see Refs. 17 and 25).

5. GROUND WATER MANAGEMENT

The aims of ground water management are to regulate ground water extractions so as to prevent salinity intrusion into ground water, drying up of ground water and ground subsidence arising from excessive extraction of ground water.

Ground water management will require at least the following data:

(1) Location of a well, its kind and depth;

(2) Running extraction volume by each well; and

(3) Ground water level at each well.

There exists no law which impose the periodical reporting of these data to any responsible agency. But there exists related law called Geological Survey Act. This law was enacted to regulate and control geological surveys and to establish geological archives. In this law, the notification of the following issues to the Director General of Geological Survey was required to be done by any person who bores, drills, digs or otherwise developes a well for the purpose of searching for or extracting water therefrom:

(1) Location of the wells;

(2) Depth of the wells;

(3) Geological log of the wells;

(4) Pumping tests of the wells; and

(5) Results of water sample chemical analysis.

However, a well which is less than 9.1 m (30 feet) in depth without reaching bedrock or yield less than 2,250 lit (500 gal.) of water per day and used only for the domestic purposes of the household of the person responsible for its development, are exempted from this notification.

The officials of GSD informed that this notification are not sufficiently abided.

Therefore, the present conditions of the ground water use in Peninsular Malaysia is not exactly known. Ground water is used mainly for domestic and industrial water supply, and irrigation. And the data related to the management are recorded mainly by operating agencies of ground water extraction. But there is no standard which regulates or controls the recording of those data by these agencies. In addition, although it is said that private extraction of ground water cannot be ignored in Peninsular Malaysia, this kind of extraction is beyond the

control of any agencies. In these circumstances, however, the present conditions of the extraction of ground water for water supply in the Kota Bharu area are well grasped by operating agency, namely, Kelantan State PWD. Also the data of the extraction in the Kedah-Perlis area are gradually being arranged by GSD.

6. STRUCTURAL STANDARD ON RIVER FACILITIES

Dam and other big river facilities such as weir and salinity barrage were basically designed, constructed and maintained in Peninsular Malaysia on the manuals made by international engineering consultant. The manual to be applied was left to the designers. Medium or undersized river facilities were almost designed, constructed and maintained based on the manuals of each agency concerned as already mentioned in Sub-section 2.1.3 and in Table 1.

There is no unified manual to be followed by each river facility.

7. ARRANGEMENT OF INFORMATION RELATED TO WATER RESOURCES MANAGEMENT

Present conditions were surveyed along the following data with respect to the arrangement of the data concerning water resources management:

(1) Water resources potential

rainfall, river discharge, ground water, dam operation record

(2) Water use

water extraction and supply of surface and ground water

(3) Flood record

(4) Environment

river water quality

The results are as follows:

(1) Water resources potential

(A) Rainfall and river discharge

Rainfall and river discharge data are arranged in a data bank of DID. This data bank consists of the data of the stations of various agencies scattered nation-wide with their daily values. This data bank includes the data from 1960 to 1979. The data were provided for this bank by 17 agencies including DID, PWD, NEB, police, school, FELDA and others. Registered stations totalled 793 for rainfall and 142 for river discharge. This bank includes also the data concerning evaporation, sediment and water quality. Other agencies also contributed similar data as shown in Table 11. DID has also published the summarized results of the above data in the 5-yearly reports.

(B) Ground water potential

The evaluation of ground water potential is conducted mainly by GSD in the Kedah-Perlis area. The inventory of the existing tube wells was arranged by GSD and further 45 test wells were bored additionally to evaluate the ground water potential in this area. Kelantan State PWD arranged the inventory of their operating tube wells in the Kota Bharu area with respect to their location, extraction volume and depth.

On the other hand, although it is said that the tube wells operated by private companies and persons cannot be ignored, actual state of these wells is not clearly understood.

(C) Dam operation record

The form of dam operation record were investigated for the Pedu, Muda and the Sultan Abu Bakar dams. The data of impounding, discharging, intake and inflow volumes of the dams are arranged for daily values and compiled monthly at each head office.

(2) Water use

(A) Domestic and industrial water supply

Supplied volume are measured at the treatment plant. These data are compiled monthly for the daily amount.

(B) Irrigation water

No water intake has been measured at any irrigation farm.

(3) Flood record

Flood reports are submitted to the Federal DID by the State DID whenever the damage occurs. Reported subjects are as follows:

(A) Meteorological conditions

(B) Rainfall

(C) River water level and peak discharge estimated thereof

(D) Inundated area, depth and duration

(E) Length of flooded road and railway, its period and the extent of the damaged cultivated land

(F) Number of killed and wounded person

(G) Number of evacuees, families and of evacuation centers set up

However, the extent of the damage of private property were not estimated.

(4) Environment

Since 1978, DOE has carried out the National Water Quality Monitoring Program and monitored surface water quality for maximum of 38 parameters at 443 points on the rivers in 1979. DID has also carried out its own surface water quality monitoring system since 1974 and monitored

for maximum of 25 parameters in 1979 at 170 points. But the latter system lays emphasis on monitoring the rivers close to irrigated area. On the other hand, the quality of the effluent from crude palm oil mills and raw natural rubber factories has been reported to DOE every 4 months by the occupiers of the above premises, since July 1978 and April 1979 respectively. The reported parameters of pollutant are established as follows by Environmental Quality Act:

(A) Crude palm oil mill

pH, BOD, COD, TS, SS Oil and Grease, AN and TN

(B) Raw natural rubber factories

pH, BOD, COD, TS, SS, AN and TN

REFERENCES

1. WATERS ENACTMENT

2. NATIONAL LAND CODE

3. MANUAL, DRAINAGE AND IRRIGATION DEPARTMENT, MOA, 1973

4. REPORT OF THE TYPHOON COMMITTEE REVIEW MISSION, Typhoon Committee, 1978

5. MINING ENACTMENT

6. ELECTRICITY ACT

7. FISHERIES ACT

8. ENVIRONMENTAL QUALITY ACT

9. PLANNING AND DESIGN PROCEDURE, NO. 1, URBAN DRAINAGE DESIGN STANDARDS AND PROCEDURES FOR PENINSULAR MALAYSIA, 1975, DID

10. KUALA LUMPUR FLOOD MITIGATION PROJECT, KLANG GATES DAM, STANDING OPERATING PROCEDURES (Unpublished), Prepared by Bahagian Parit dan Tali Air, Kementerian Pertanian, Malaysia, 1980

11. KUALA LUMPUR FLOOD MITIGATION PROJECT, KLANG GATES DAM, STANDING OPERATING PROCEDURE VOL. TWO, DESIGNER'S OPERATING CRITERIA, Prepared by Bahagian Parit dan Tali Air, Kementerian Pertanian, Malaysia, 1980

12. TEBRAU AND SCUDAI RIVERS WATER AGREEMENT, 1961

13. JOHORE RIVER WATER AGREEMENT, 1962

14. THIRD MALAYSIAN PLAN 1976 - 1980, 1976

15. GOVERNMENT OF MALAYSIA, PAHANG RIVER BASIN STUDY, Australian Consortium of Consultants, 1974, Vol. 5, FLOOD MITIGATION MEASURES, PLANNING AND DESIGN STRATEGIES IN FLOOD-PRONE AREAS

16. ASEAN DISASTER PREPAREDNESS SEMINAR, JAN 28 - FEB 3, 1980 MANILA, MALAYSIAN'S NATIONAL DISASTER RELIEF PLAN AND PREPAREDNESS

17. WATER POLLUTION CONTROL, ANALYSIS OF WATER POLLUTION COMPLAINTS IN PENINSULAR MALAYSIA, DOE, 1979

18. FEASIBILITY STUDY FOR STORAGE SCHEME, EPU, 1979

19. INVESTIGATIONS FOR SUITABLE SOURCES OF WATER SUPPLY FOR THE KELANG VALLEY, EPU, 1979

20. WATER RESOURCES DEVELOPMENT IN THE KUANTAN REGION, EPU, 1977

21. STUDY OF WATER RESOURCES-DEVELOPMENT IN THE TRENGGANU TENGAH REGION, GOVERNMENT OF MALAYSIA, 1977

22. WATER RESOURCES MANAGEMENT IN THE PAHANG TENGGARA REGION, GOVERNMENT OF MALAYSIA, 1979

23. DEVELOPMENT PLAN OF SEREMBAN AND PORT DICKSON WATER SUPPLY, GOVERNMENT OF NEGERI SEMBILAN, 1979

24. FEASIBILITY STUDY OF PROPOSED EXTENSIONS TO TAIPING GUNONG SEMANGGOL WATER SUPPLIES, GOVERNMENT OF PERAK, 1978

25. REGULATORY MEASURES AND PROGRAMMES FOR WATER POLLUTION CONTROL IN MALAYSIA; A. Maheswaran, 1979

26. INVENTORY OF HYDROLOGICAL STATIONS IN PENINSULAR MALAYSIA, 7th edition, DID, 1978

TABLES

Table 1 PRESENT CONDITIONS ON THE AVAILABILITY OF DESIGN MANUAL

River Facilities	DID	PWD	NEB
Dam	x	x	x
Weir/Barrage	o/1	x	x
Bridge	o/2	o/3	-
Pumping Station	o/1	x	-
Levee	o/1	-	-

Remarks; o: Available
x: Not available
-: Not applicable

Source; /1: Ref. 3
/2: Ref. 9
/3: By interviewing the officials of PWD

Other marks indicate the informations provided with by interview with the officials of the above organization.

Table 2 MAIN FEATURES OF THE SURVEYED DAMS (1/2)

Dam Mark	A	B	C	D
Name	Pedu	Muda	Ayer Hitam	Temengor
Involved River	Pdg. Terap	Muda	Ayer Hitam	Perak
Involved Basin No.	3	5	7	10
Catchment Area (km^2)	168	984	4 (Div) 4 (Dir)	3,420
Storage Capacity (m^3)				
Gross Active	N.A	N.A	N.A	2.2×10^9 m^3
Dam Dize; H (m)	60	37	61	127
L (m)	N.A	N.A	N.A	537
Volume (m^3)	Fill 580×10^3 Conc. 8×10^3	30×10^3	N.A	7.28×10^6 m^3
Dam Type	Rock Fill	Conc. Buttress	Rock Fill	Rock Fill
Year of Completion	1968	1969	1962	1979
Operating Agency	MADA	MADA	Pinang Water Works	NEB

Dam Mark	E	F	G	H
Name	Kelang Gates	Sungai Langat	Gunong Ledang	Pengkalan Bukit
Involved River	Kelang	Langat	Muar	Muar
Involved Basin No.	15	16	21	21
Catchment Area (km^2)	75.5	41.4	N.A	N.A
Storage Capacity (m^3)				
Gross Active	31.6×10^6 m^3	N.A	N.A	N.A
Dam Size; H (m)	N.A	60	N.A	N.A
L (m)	N.A	360	N.A	N.A
Volume (m^3)	N.A	N.A	N.A	N.A
Dam Type	Conc. Gravity Arch	Earth Fill	Earth Fill	Earth Fill
Year of Completion	1979	1981	Before World War II	N.A
Operating Agency	Selangor Water Works	Selangor Water Works	Johor PWD	Johor PWD

Table 3 MAIN FEATURES OF THE SURVEYED DAMS (2/2)

Dam Mark	I	J	K	L
Name	Batu Pahat	Lebam	Tenglu Mersing	Sultan Abu Bakar
Involved River	Batu Pahat	Lebam	Mersing	Bertam
Involved Basin No.	22	24	26	30
Catchment Area (km^2)	350	18.9	N.A	183
Storage Capacity (m^3)				
Gross Active	N.A	2.96×10^6	N.A	4.55×10^6
Dam Size; H (m)	N.A	11.6	4.6	39.6
L (m)	N.A	N.A	N.A	N.A
Volume (m^3)	N.A	229×10^3	N.A	52×10^3
Dam Type	Earth Fill	Earth Fill	Earth Fill	Conc. Buttress
Year of Completion	Before 1930	1979	1960	1963
Operating Agency	Johor PWD	Johor PWD	Johor PWD	NEB

Source; Sectoral Report of Water Resources Engineering

Table 4 PRESENT CONDITIONS OF THE EQUIPMENT AND INSTRUMENT FOR O&M OF DAMS AND BARRAGES (1/2)

	A	B	C	D	E	F	G	H	I	J	K	L	A'	B'	C'	D'
(1)	x	x	x	x	o	x	x	x	x	x	o	o	o	o	o	o
(2)	o	o	-	o	-	o	-	-	-	-	-	o	-	-	-	-
(3)	El	El	-	El'	El	Ot	-	-	-	-	Mn	Ot	El	El	Mn	El'
(4)	o	o	o	o	o	o	N.A	N.A	N.A	N.A	N.A	o	o	x	o	o
(5)	x	x	x	x	x	o	x	x	x	x	x	x	o	o	o	o
(6)	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
(7)	o	o	o	o	x	o	x	x	x	o	x	o	-	-	-	-
(8)	o	x	o	x	o	o	x	x	x	o	x	o	-	-	-	-
(9)	-	-	-	-	-	o	x	x	x	o	x	-	-	-	-	-
(10)	-	o	-	-	o	-	-	-	-	-	-	o	-	-	-	-
(11)	x	x	x	x	x	x	x	x	x	x	x	o	N.A	x	x	x
(12)	5	2	20	4	1	1	1~0	1~0	1~0	1~0	1~0	N.A				

Remarks;

- o : Equipped
- x : Not equipped
- - : Not applicable, not furnished with the structure concerned or not required
- N.A : Not available
- El : Electric power source with spare
- El': Electric power source without spare or power plant of its own
- Mn : Manual
- Ot : Other system than the above source
- (1)~(11) : Questioned issue
- (1),(2) : Whether or not steel gate or other flow regulation equipment is furnished at spillway (1) or low flow release structure (2), respectively

Table 5 PRESENT CONDITIONS OF THE EQUIPMENT AND INSTRUMENT FOR O&M OF DAMS AND BARRAGES (2/2)

(continued)

(3) : Kind of power source supplied for gate operation or for operation of flow regulation equipment, and whether or not, spare source for emergency provided

(4) : Rainfall gauge in the catchment areas

(5) : Water level gauge on the rivers in catchment area

(6) : Water level gauge at spillway or near low flow release structure

(7) : Instrument for measurement of the deformation of dam doby

(8) : Instrument for measurement of seepage volume (in case of dam)

(9) : Instrument for measurement of seepage line (in case of earthfill dam)

(10) : Instrument for the measurement of uplift (in case of concrete dam)

(11) : Warning equipment

(12) : Number of rainfall gauge stations in catchment area (in case of dam)

A~L : Dam marks as defined in Table 2 and 3

A'~D' : Salinity barrages' and weir's marks as follows

A' : Sungai Kedah Tidal Barrage

B' : Rantau Panjang Barrage

C' : Sungai Melaka Tidal Barrage

D' : Pelubang Regulator

Source; By interviewing officials of the state DID, PWD or Water Supply Dept. and NEB

Table 6 PRESENT CONDITIONS OF THE SYSTEM FOR O&M OF DAMS AND BARRAGES

	A	B	C	D	E	F	G	H	I	J	K	L	A'	B'	C'	D'
(1)	o	o	o	o	o	o	x	x	x	x	x	o	o	o	N.A	o
(2)	19	22~23	20	>100	11	16	4~5	4~5	4~5	4~5	4~5	>100	9~10	2	2	2
(3)	V	V	V,S	Ex,S	V,S	V,S	-	-	-	-	-	S,Ex	V	V	N.A	V
(4)	o	o	x	o	o	o	x	x	x	o	x	o	o	o	o	N.A

Remarks;
- o: Provided or furnished
- x: Not provided or not furnished
- V: VHF
- S: Subscribed telephone
- Ex: Exclusive circuit
- -: Not applicable
- N.A: Not available
- (1): Whether or not, a field office is established at the site of facilities
- (2): Total number of engaged persons at field office
- (3): Method of communication between field office and head office or its branch office concerned
- (4): Whether or not each facility has been furnished with any of manual, instruction of rule for O&M
- A to L : Dam marks as defined in Tables 2 and 3
- A' to L': Marks of salinity barrages and weir defined in Table 5

Source; By interviewing officials of the state DID, PWD or Water Supply Dept. and NEB

Table 7 PRESENT DEMAND FOR THE RIVER MAINTENANCE DISCHARGE

Name of river	Not-withdrawal use of river water (1)	(2)	(3)	(4)
Kedah	x	x	o	x
Muda	x	x	o	x
Perak	o	o	o	x
Kelang	x	x	o	x
Linggi	x	x	o	x
Melaka	x	x	o	x
Muar	x	o	x	x
Johor	x	x	x	o
Pahang	x	o	x	x
Kuantan	x	x	x	o
Trengganu	x	o	x	o
Kelantan	o	o	x	o

Remarks; o : Consideration may be required
x : Negligible
(1): Inland navigation
(2): Fishing recreation
(3): Dillution of polluted water
(4): Prevention of salinity intrusion

Source; - Sectoral Reports of Inland Navigation, Inland Fishery, Ecology, Water-related Recreation, Water Quality and River Conditions for (1), (2) and (3)
- Ref. 17 for (2) and (3)
- By interviewing officials of the State DID for (4)

Table 8 PROBABILITY OF DESIGN LOW DISCHARGE FOR WATER SUPPLY

Name of Project	Probability	Supplied Population or Supplied Water	Data Source
Penang Water Supply	1/30	$1,900 \times 10^3$	Ref. 18
Kelang Valley Water Supply	1/50	$4,580 \times 10^3$	Ref. 19
Kuantan Region Water Supply	1/30-1/50	200×10^3	Ref. 20
Dungun & Kemaman Water Supply	1/25	110×10^3	Ref. 21
Pahang Tenggara Region Water Supply	1/25	400×10^3	Ref. 22
Seremban & Port Dickson Water Supply	1/30	660×10^3	Ref. 23
Taiping & Gunong Semmangol Water Supply	1/25	23 mdg	Ref. 24

Table 9 WATER POLLUTION COMPLAINTS (JAN - DEC 1979)

River	No. of Complaints	River	No. of Complaints
Kedah	1	Linggi	5
Merbok	1	Melaka	2
Muda	1	Kesang	1
Perai	2	Muar	3
Juru		Batu Pahat	2
Jajawi	2	Sekudai	
Tengah		Pontian	4
Kerian	2	Teberau	
Sapetang	1	Endau	2
Perak	2	Pahang	3
Selangor	1	Kemaman	1
Buloh	1	Trengganu	1
Kelang	7	Kelantan	2
Langat	3		

Source; Ref. 17

Table 10 CAUSES OF WATER POLLUTION COMPLAINTS (JAN. - DEC., 1979)

Cause	No.	Cause	No.
Palm oil mill	15	Paper mill	2
Rubber factory	12	Sawmill	1
Mining & siltation	5	Sugar mill	1
Other industrial effluents	4	Feedmeal	1
Pig waste	4	Herbicide	1
Domestic sewage	3	Ship wreck	1

Source; Ref. 17

Table 11 NUMBER OF STATIONS FOR HYDROLOGIC OBSERVATION

		DID Data Bank (As of 12,1978)	MMS (As of 9,1980)	NEB (1974)	DOE (1979)
(1)	Rainfall (Manual)	647	174	29	-
(2)	Rainfall (Automatic)	146	56	9	-
(3)	River water level and discharge (Manual)	22	-	3	-
(4)	River water level and discharge (Automatic)	120	-	22	-
(5)	Evaporation (Manual)	55	36	9	-
(6)	Sediment	36	-	-	-
(7)	Water Quality (Manual)	69	-	-	443

Remarks; -: Not applicable

Sources; MMS, NEB: By interviewing officials of the agencies concernted

DOE: Sectoral Report of Water Quality

DID: Ref. 26

PART 2
SABAH AND SARAWAK

TABLE OF CONTENTS

1. INTRODUCTION

In this sector, present condition of water resources management in Sabah and Sarawak was studied in line with the criteria employed by the Phase II Study.

Water resources management has an objective to preserve the integrity of circumstances of water resources, to maintain the quality and quantity of water resources, and to make the best possible use of water resources for various beneficiaries.

The main subjects of this sector are as follows:

(1) River management;

(2) River facilities management;

(3) Flood management;

(4) Low flow management; and

(5) Groundwater management.

2. MANAGEMENT OF RIVER AND RIVER FACILITIES

2.1 River Use and Conservancy

As rivers in Sabah and Sarawak are used for various purposes but to limited extent, adverse effects which might originate from these river uses have, so far, not been remarkable. The development of procedure for the control of river use has, therefore, recently been commenced. The fundamental framework to control river use, however, has already been established in each state as described hereinunder.

This chapter will deal with measures which are taken by public agencies to maintain the structural stability of rivers. Chapter 4 will be devoted to the measures to maintain the order of river water use.

2.1.1 River area

Waters Enactments which provide general and fundamental procedures to regulate activities conducted in the river, in the States of Peninsular Malaysia, are not enacted in the States of Sabah and Sarawak. The longitudinal extent of a river is not mentioned in any law of both the States. However, the word "river" is used in several laws which provide the responsibilities or rights of the State Governments and their agencies and the restrictions to be followed by the people with regard to the administrations of actions conducted in or along the rivers.

The structural stability of river, especially related to its bank, is protected against extravagant land use based on the Land Ordinance of Sabah and Land Code Ordinance of Sarawak. These Ordinances provide the State Governments with the power to reserve strips along the banks of rivers to themselves (Refs. 1 and 2).

According to the Land Ordinance of Sabah, "the Government has the power to reserve portion of land as may be deemed advisable along the banks or rivers, streams or creeks". Strips within 20 m of each bank of most rivers are customarily reserved to the State Government. In the meandering section of rivers, the width of the strips range from 20 to 60 m from the river banks.

In Sarawak, the Land Code Ordinance states that "the Government shall reserve all unalienated land within 66 feet on each side along the banks of all navigable rivers, streams, canals, or creeks; if the width is less than 33 feet, the reserve on each bank shall be twice its width".

2.1.2 River use

River water is withdrawn mainly for irrigation or water supply in the States of Sabah and Sarawak. Of water intake facilities, pumping station prevails, reflecting the significance of navigation which is a dominant purpose of river use and one of the most important means of transportation in each state.

Both State DIDs have already developed more than 20 irrigation schemes for paddy, all of which are dependent for their water sources upon rivers. These schemes are equipped with pumping stations or weirs.

For the domestic and industrial supply of water, each state PWD and two Water Boards of Kuching and Sibu in Sarawak, take river water of 188×10^3 m^3/d by 65 projects, which covers about 90% of the total water supply. Furthermore, the Federal Ministry of Health (MOH) has been constructing many small water works under the Rural Environmental Sanitation Program in each state. In addition to these water intake facilities, there exist six impounding dams with the purpose of water supply; one in Sabah and five in Sarawak.

For hydroelectric power generation, two large-scale schemes have been started throughout the States of Sabah and Sarawak. One is the Tenom Pangi Hydroelectric Project with generating facilities of 66 MW under which a concrete weir across the Padas river is being constructed in the Interior Residency of Sabah. The other is the Batang Ai Hydroelectric Project with the installed capacity of 92 MW under which a rock fill main dam with the height of 85 m with the total storage capacity of 2.87×10^9 m^3 and three saddle dams are being constructed on the Ai river, a tributary of the Lupar river, in the Second Division in Sarawak.

Rivers in the eastern part of Sabah and in Sarawak provide important and efficient means for the transportation of goods and people, as road network has not been developed yet. River also provides indispensable means of transportation for timber which provides the biggest revenue for Sabah and the second biggest revenue after petroleum for Sarawak. There exist, therefore, several jetties and/or timber ponds along the big rivers. Districts Engineers of the State DID in Sabah hold a consultation around 10 cases a year with District Forest Officers about the permission of river area occupation for timber ponds.

The construction of embankments has been being carried out mainly as a part of drainage schemes by both the State DIDs to protect paddy or rural residential areas against river water flooding. In the States of Sabah and Sarawak, no other facilities such as dam have, so far, been constructed for the purpose of flood control.

Mining activities in Sarawak have their origin in the 19th century but the activities closely related to river like tin mining in Peninsular Malaysia are quite few. Mining in Sabah has been developed mainly as copper mining at Mamut since 1975. The effluent from the tailing dam

had caused some harm to paddy in the downstream areas by its high contents of silt, until a drainage system of the tailing dam was improved in 1977.

Permission of quarrying activities in rivers are newly asked by around 10 persons a year to both the State Governments respectively. Quarried sand and stones are used mainly as road and other construction materials. The increase in land development schemes converting swamp areas to housing and industrial areas has recently created a new demand for these construction materials in some places in Sarawak.

2.1.3 Control of river uses

Although, in the States of Sabah and Sarawak, the property in and control of all rivers is vested solely in the respective State Governments, the use of river for the purposes mentioned in Sub-section 2.1.2 is administrated by the State Government to a slight extent in accordance with the laws concerned.

In both the States, the protection of the structural stability of rivers against extravagant river use can principally be expected to attain through the legitimate distribution of the relevant responsibilities among the Government agencies engaging in the implementation of river use schemes or through the adoption of the licensing or permission system in accordance with the laws concerned. The present features of river use control in Sabah and Sarawak are described hereinunder.

(1) Control of the construction, operation and maintenance of water intake facilities and other related facilities in river for irrigation or water supply

DIDs of both the States are in charge of the construction, maintenance and operation of irrigation and drainage facilities which include weirs and/or pumping stations in rivers. In Sabah, the State DID performs its responsibilities based on the Drainage and Irrigation Ordinance (Ref. 3), while, in Sarawak, the State DID has no legal provisions for undertaking its responsibilities.

PWDs of both the States and the two Water Boards, Kuching and Sibu in Sarawak, are in charge of the construction, maintenance and operation of waterworks including river water intake facilities.

Small waterworks, which were constructed by the Federal MOH under the Rural Environmental Sanitation Program in Sabah and Sarawak, are maintained by those beneficial residents themselves.

(2) Control of the construction, operation and maintenance of hydroelectric power generation station in river

Legal provisions for this aspect are given by the Electricity Ordinance of each state under which the Electricity Board Ordinance, Sabah, and the Sarawak Electricity Supply Cooperation Ordinance have the provision for the establishment of a statutory body with duties including the control of hydroelectric power generation activities (Refs. 4 to 6).

(3) Control of quarrying sand and stones in river

Legal provisions for quarrying are given by the Land Ordinance of Sabah and Land Code Ordinance of Sarawak. The control of quarrying activities in rivers is usually executed as a part of general control of land use.

When either the Lands and Surveys Department (LSD) of Sabah or the Land and Survey Department (LSD) of Sarawak deals with the above control, each department consults the State DID on the conditions to be attached to a licence of quarrying activities from the viewpoint of the prevention of bank erosion and consequential flood disaster. Both the State DIDs usually recommend the Departments to give approval to the applications for quarrying, provided certain conditions shall be attached. In the State of Sabah, DID upon consultation by the District Officers advises on the river sand/gravel extraction based on the following guidelines:

(a) The length of river approved for gravel/sand extraction shall be limited to three (3) km, which shall be well demarcated on the ground to enable the DID to monitor and inspect periodically the extraction work;

(b) No extraction is permitted within 1,000 m upstream and downstream of any permanent structure unless otherwise stated;

(c) Where a pumping station exists in the river, the advice of the Hydrology Section of DID must first be sought before recommendation is given to the District Officer pertaining to the application for the T.O.L.;

(d) Extraction shall be carried out only on the annex side of river beds and/or where sand/gravel bars have been formed along the river;

(e) Where river banks are unstable, extraction shall be prohibited;

(f) Extraction shall be carried out by scrapping uniform layers or by using sand pumps without forming isolated holes and pits on the riverbeds and/or side slopes;

(g) Extraction shall, in general, not be permitted beyond the original river bed level which may be taken as the same as that immediately downstream or upstream of the extraction point, where formation of sand/gravel bars does not occur. The maximum depth of extraction shall be specified by the DID who will be monitoring the extraction work by surveying the river sections periodically;

(h) Stock piling of sand/gravel extracted from the river in the river banks shall not be permitted to avoid undue surcharging of the banks which may result in slipping;

(i) No debris, fuel and oil etc. shall be discharged into the river; and

(j) Notwithstanding the approval and supervision by DID to extract sand/gravel, the contractor shall bear full responsibility in making good any damages including bank erosion caused by such extraction works, as directed by the DID.

(4) Control of inland navigation and construction of jetty or wharf

The Federal Marine Department has also set up its state branches in the States of Sabah and Sarawak to control navigation in the rivers and sea of Sabah and Sarawak. The maximum velocity of express boats which operate between Sibu and Kapit on the Rajang river is limited to restrain bank erosion due to flow turbulence by the boats.

This Department also controls and examines the principal features of jetty and wharf in a planning stage of each scheme from the navigational viewpoint. Detail design and construction of Government's jetties and wharves are entrusted to the State PWDs by the Marine Department. Private jetties and wharves are designed and constructed by private sectors under the control of the Marine Departments.

(5) Control of timber transportation and storing in river

The Forest Department of each state regulates river traffic in the field of the transport of timber or forest produce in conformity to the Forest Enactment of Sabah and Forest Ordinance of Sarawak (Refs. 7 and 8).

In the State of Sabah, floating of timber on river and storing of it on river banks are regulated in view of the protection of river banks, bridges, dams or other public works. These activities are also regulated in view of keeping any waterway or navigation channel free from obstruction or danger. The size and shape of log rafts and the types of vessels to tug such rafts may also be regulated by the provisions based on the Enactment.

In the State of Sarawak, specific rules are not provided for timber transportation, however, the Marine Department regulates this as a part of navigation.

2.1.4 River conservancy

In Sabah and Sarawak, the State DIDs conduct river dredging, clearing and river training.

Dredging is done very little in each State. The only one case is carried out in Sarawak, which is the opening of river mouth of the Miri river where drifting sand from the South China Sea often clogges its river mouth during the north-east monsoon season.

River clearing in each State is a daily work which is conducted in response to the request of residents. Residency or Division DID offices are in charge of this matter which is carried out by employing the inhabitants concerned. The State DID in Sarawak prepares guideline instructing procedure of river clearing for the conveniences of its local staffs.

At present, the number of schemes for river training, river widening and bank protection construction is very few in both States. River bank erosion is controlled by the Federal Marine Department in Sarawak. No Government department/agency has yet been entrusted with the responsibility of controlling river bank erosion in Sabah even though such incidents are quite commonly referred to DID for advice. The Ministry of Agriculture and Fisheries Development has instructed the DID to include river bank protection as one of its functions under the river conservancy programs in 1983. PWD in Sabah does not control river bank erosion, it normally only undertakes to protect its own infrastructure such as roads and bridges against river bank erosion. The implication of antierosion works is far reaching in terms of the heavy commitment on the part of the Government, a careful approach has to be adopted to evaluate any request for river bank protection works.

2.2 Operation and Maintenance of Man-made Facilities in River

2.2.1 General

In the States of Sabah and Sarawak, river-situated man-made facilities are concentrated in urban areas or adjacent rural areas. These facilities such as fixed weirs, pumping stations and bridges, or culverts do not vary in their category and capacity so widely in each State. These can be classified into two groups from the viewpoint of necessity of maintenance and operation. The one requires maintenance only and the other needs both maintenance and operation.

The first group comprises bridge, culvert, fixed weir and others. The second one consists of pumping station and other gravitational intake facilities with gate along river bank. The Study was made to examine the general standard of the operation and maintenance (O&M) of facilities grouped into the second, based on the result of interview to the State officials concerned.

In the State of Sarawak, the existing river-situated facilities mostly belong to the State PWD, DID or Kuching and Sibu Water Boards. Those capacity is generally small compared to the scale of river where the facilities are located. It can be considered, therefore, that the skill on O&M of the existing river-situated facilities does not affect the structural stability of river at the downstream of each river-situated facility.

2.2.2 Practice of O&M

Existing water intake facilities for water supply are maintained and operated in common with other portion of water supply facilities such as water treatment plant, conveyance and storage facilities, even if these facilities are located separately. The main effort is directed towards maintaining the cleanliness of treated water and constant operation of the plant. Three-shift system is laid down in the field office.

Standing orders and instructions are made by the Chief Hydraulics Engineer in the case of the State PWD of Sarawak as guidelines. These orders and instructions enable pump or plant engineers to operate and maintain water treatment plants in a proper manner whenever these are followed or modified to suit local conditions. The State DID in Sabah and the two Water Boards in Sarawak have also provided site staffs with similar standing orders and instructions. As for the O&M of water intake facilities for water supply, the regular removal of all debris and floating vegetation from the intake grill and the weekly inspection of intake site are mentioned in the above standing orders and instructions.

The existing river facilities for drainage and irrigation of paddy are operated and maintained according to the duty list made by the State DIDs.

2.3 Compilation of Data on River Structure

Lot map of river fringe area is referred to by the State DID in Sabah, when the DID designs river channel improvement plan. The data related to both the cross and longitudinal sections of the rivers are firstly arranged in the phase of river improvement planning.

There exists no activity to organize several river-related agencies for the collection and arrangement of data with regard to the structural features of river including existing man-made river facilities.

3. FLOOD MANAGEMENT

3.1 Land Use Control in Flood-prone Area

3.1.1 Characteristics of flood disaster

Most floods in Sabah and Sarawak occur during the rainy season caused by the north-eastern monsoon through December to February. Most disasters occur in urban areas and its surroundings. However, the submergence of paddy and trunk road happens quite frequently in flood time. Combination of flood with high tide causes detrimental effect to urban areas located along the tidal reach of river, like Sibu in Sarawak.

Most flood damages of urban areas are considered to be caused by its insufficient drainage system, especially in Sabah.

The velocity of flooding water is usually not so big as to bring away houses and other properties. The State PWD of Sabah has conducted studies for future drainage system including sewerage for Kota Kinabalu, Sandakan, Tawau and Labuan. On the other hand, the Sarawak LSD is going to conduct a similar study for Kuching and Sibu, and the Bintulu Development Authority also will undertake the studies for its related urban area.

3.1.2 Consideration of flood disaster in land use planning

An act called Town and Country Planning Ordinance is furnished in each state with provisions for the orderly and progressive development of towns and country and for the preservation and improvement of the amenities thereof (Ref. 9). According to this Act, a related Local Authority must prepare a draft land use scheme for the area under the jurisdiction of this Act and regulate land use in accordance with the Act after obtaining approval on the scheme from the Central Board. In the State of Sabah, the town and its surrounding areas of Kota Kinabalu, Sandakan, Tawau, Kudat, Beaufort, Labuan and Keningau have been provided with the above schemes.

The areas involved under these schemes are demarcated and set into several zones in an attached map with the scale 1/3,168 (4 chains to 1 inch) according to the existing land use conditions and the following six patterns of future land use with one to six sub-categories for each. This setting of zones is common throughout the State of Sabah, regulating the land use. These six patterns and each land use purpose are as follows:

(1) Residential

Residential 'S': for special houses

Residential 'A': for first class detached houses

Residential 'B': for semi-detached houses

Residential 'C': for flat

Residential 'D': for government houses

Residential 'K': for other small houses

(2) Commercial

Central business : for retail shops, showrooms, commercial offices and others in urban area

District business : for retail shops, supermarkets, offices for the residents in district

Local shopping : for small retail shops and personal service uses

(3) Industrial

General industrial: to accommodate industries which do not create any appreciable noise, smoke, smell, dust or other nuisance

Special industrial: to accommodate industries which have noxious or dangerous characteristics and which require special siting consideration

Petroleum/oil storage

Warehouse

(4) Open spaces

(5) Drainage basin

(6) Rural: for agricultural purposes

On the other hand, land use categories taken up in the applications by private sectors to the Local Authorities, are more specific than the above-mentioned categories. The number of these land use categories attains to around 60. These categories are evaluated in view of suitability for the future land use patterns mentioned in the above and the result of this evaluation is expressed in a matrix form with three levels; "Predominant use", "Discretionary use" and "Prohibited use". According to this matrix, land use for residential, commercial, industrial and public purposes are prohibited in the "Drainage Basin" with some exception such as sewerage plant, water works, defence depot, slaughter house, log pond, jetty and wharf.

In the State of Sarawak, though similar legal framework is provided for town and country planning, land development is substantially controlled under the provisions of the Land (Control of Subdivision) Ordinance (Ref. 10) and the Land Code (Ref. 2).

This Ordinance applies to an area called the "development area" which is specified in the Schedule of this Ordinance. Whenever any person who owns any land in the development area proposes to subdivide his land, he is obliged to prepare a draft plan showing general features of the proposed subdivision of land and its purpose including the proposed plan of sewers and drains. The Director of LSD may, subject to the rules based on this Ordinance, approve or refuse the plan or require a new plan to be made if he considers that it is expedient to formulate the proper planning for the development area. However, the specific criteria for the approval or refusal of the proposed subdivision plan is not provided.

In the State of Sabah, the regulation of subdivision of land is taken care in the enforcement of the Town and Country Planning Ordinance by the Local Authorities. According to the "Draft Scheme Sandakan Town and Environments" (Ref. 11), the Local Authority may refuse the approval of the proposed plan of subdivision, if, with respect to urban drainage, the followings are foreseeable or evident:

(1) The land shown thereon, or any part thereof, is liable to tidal, drainage or flood waters; or

(2) There is no provision, or insufficient provision, for the safe and efficient drainage and disposal of storm water from the land or any part thereof.

3.1.3 Promotion of the resettlement from flood-prone area

Several public agencies of each state are conducting housing schemes including new town schemes both in urban and rural areas to promote national unity and to eradicate poverty.

In Sabah, construction of 10,438 units of housing, comprising 7,213 of urban housing and 3,225 of rural housing, have been achieved under TMP (Ref. 12). These housing units were constructed by the State Housing and Town Development Authority (LPPB), SEDCO, SCC and SLDB. LPPB contributed to the most part of housing units in urban areas. The vulnerability of their existing residence to flood is among the conditions which the applicants for the resettlement may suffer or meet.

3.2 Land Use Control in Watershed Area

In Sabah and Sarawak, the development of watershed area has been planned and carried out by public agencies or private sectors mainly for the following purposes:

(a) oil palm, rubber and other tree croppings,

(b) logging,

(c) housing,

(d) road construction, and

(e) shifting cultivation.

Land use for the purpose of (a) to (d) is regulated under the self-control of the implementing agencies. Shifting cultivations are quite out of control.

The Forestry Department of each state controls logging activities done by private enterprise throughout the State by providing permission or licence.

SLDB of each state converts forest area into permanent cropping areas such as oil palm, rubber, coconut, cocoa and pepper. This agency also implements housing schemes for settlers who engage in permanent crop cultivation under SLDB's land development schemes.

There is no rule to secure coordination among these agencies including the State DIDs which are in charge of river conservancy and flood mitigation, in order to evaluate a land use plan in watershed area from the viewpoint of its technical feasibility related to the flood mitigation or soil erosion. According to the information from the State DID of Sarawak, the Sarawak LSD once consulted the State DID regarding the technical requirements for soil erosion abatement for a housing scheme proposed in the Maong river basin of the Sarawak river, 5 km from the city center of Kuching. In this case, river training had just been carried out by the State DID upon the request by the LSD.

A Land Utilisation Committee (L.U.C) does exist in each district of Sabah to control land use/applications. Maybe this Committees have put little or no emphasis at all on the effect of land use in respect of water management catchment areas. It may be useful if the L.U.C take the effect of land use in catchment water management as one important factor in screening through land use.

3.3 Flood Forecasting, Warning and Evacuation System

Flood forecasting activities in both the States are carried out quite involved in and as a part of warning and rescue activities under the supervision of the Flood Relief Committee of each state. The State DIDs are not involved in these committees at the present.

At the Residency, Division and District levels, a local committee is also established and chaired by the Resident, Division Chief and District Officer, respectively. These committees are composed of the representatives of various agencies excluding SDID, at the respective levels. In near future, a system, similar to Peninsular Malaysia, will be established for flood forecast, including the SDID, in the State of Sabah.

The police are in charge of specific rescue actions. Refuges are established at schools or community halls. The means for transport of victims to the refuges are long boat operated and maintained by the police. The measures for communication to the police on the flood conditions, degree of disaster and rescue actions, are VHF telephone.

Flood forecasting systems will be established as a model study in the Kinabatangan river basin by the Sabah State DID, and in the Sadong and Sarawak river basins by the Sarawak State DID during 4MP.

A siren station for flood warning was established by the State DID as a trial in 1976 and has been put to practical use at Siniawan near Bau on the Sarawak river since then. This station is operated by the police at the site provided with electric power from SESCO. The first warning level was determined 2 m below the road surface along the river. This level was agreed between the inhabitants living both sides of the river and the State DID. This level was estimated to give sufficient time for evacuation to the people. As for the second level, the decision of police officer-in-charge is final as circumstances required (Ref. 13).

3.4 Compilation of Flood Record and Flood Disaster Statistics

In Sabah, officers in charge of hydrology in each branch office at residency level report flood conditions, damages and losses by document to the Engineer of Hydrology Section of the State DID as soon as possible after flood occurs. The items to be reported are as follows:

(a) peak level of flood and its reached time,

(b) number of submerged and damaged houses,

(c) number of evacuees and life lost,

(d) damaged area of cropped land estimated by crops and estimated damaged cost,

(e) flood mark painting, and

(f) rescue action.

The State DID of Sarawak had collected and compiled flood and flood damage information which had appeared in a commercial newspaper from 1946 to 1976 into a book in June, 1979 (Ref. 14). This book does not deal with any technical analysis of these informations. Although the contents of the reports deal with mainly qualitative aspects of flood and its damages, some informations on urban floods in this book touched on a few quantitative aspects of floods such as inundation depth, flooding duration or the latest tendency of flooding water level at that moment. The conditions of evacuation or rescue activities and the State officers' activities are also mentioned.

Meanwhile, many parts of Sarawak experienced the most disastrous flood between January and February, 1963. This flood is the most disastrous in recorded history. Various hydrological aspects of these floods were collected, analyzed and compiled in the Hydrological Year Book for the Water Year 1962-3 (Ref. 15).

4. LOW FLOW MANAGEMENT

4.1 River Water Use

The main purposes of river water use in Sabah and Sarawak are quite similar with each other and can be enumerated and classified as follows:

(1) Non-withdrawal water use;

  (a) Navigation including transportation of logs,

  (b) River fishing,

(2) Withdrawal water use;

  (a) Water supply,

  (b) Irrigation, and

  (c) Fish culture.

River water uses for navigation including transportation of logs have an important significance in each state because road transportation network is insufficient.

4.2 Control of River Water Withdrawal

River water withdrawal is predominantly carried out by state agencies or public statutory bodies which is good for the maintenance of order. These water withdrawal is independently initiated by the agencies responsible for respective water-related services based on related laws or custom.

On the other hand, there is no rule which directly regulates the authorization of these kinds of activities by private person or company. There is no licence system for river water withdrawal. The Royal Dutch Shell Company takes water from the Miri river by itself to supply domestic water for its employees of several thousands. Meanwhile, the Miri PWD of which supply area is next to the Shell Company's residential area for its employees, has neither information on nor responsibilities for the water supply to this area.

Water supply for domestic, commercial and industrial uses is conducted by PWD of each state and the two Water Boards in Sarawak, based on the Water Supply Ordinance of each state (Refs. 16 and 17). Water withdrawal for irrigation is conducted by the State DID based on the Drainage and Irrigation Ordinance, Sabah. In the State of Sarawak, though this kind of Ordinance is not provided, the State DID is conducting the above services.

Thus, river water withdrawal for water supply and irrigation are individually conducted by each responsible agency, principally based on each realted legal provision. There exists no law which regulates overall water withdrawal in each state.

There is no case of the voluntary or obliged restriction of river water withdrawal to compensate release for water use in downstream during drought time. There is no established criteria concerning the priority order of river water withdrawal among their purposes during drought time.

The State PWD of Sabah insists on the priority of water withdrawal for water supply over that for irrigation. The State DID and PWD of Sabah had once individually constructed their intake facilities close to each other on the Membakut river in the District of Beaufort without any compromisation in planning stage. In this case, the irrigation intake was situated upstream of the water supply intake. After a while, the State PWD changed its intake to the upstream of the irrigation intake to secure the adequate water withdrawal planned after consultation with DID.

The return period of design drought is estimated at 5 years in the case of irrigation and 20 years in the case of water supply in each state.

4.3 Preservation of River Water Quality and Quantity

River water in Sabah and Sarawak, except in some localized area, is not polluted by human activities, however, turbidity is similar to the rivers in Peninsular Malaysia. Some officials engaged in water supply in Sabah and Sarawak complain of muddy river water due to excessive logging or unproper method of timber transportation.

Local pollutant sources which downstream water users such as the State PWDs or Water Boards, State DIDs or farmers fear, are factories including rubber factories and palm oil mills, urban sewage, rural latrine or animal husbandry. A copper mine in the State of Sabah had damaged paddy in its downstream areas by excessive muddy effluent until it was ordered by the State Government of Sabah in 1977 to improve its drainage system.

Most water supply agencies examine raw water quality periodically for their use. Every water supply agencies examine treated water quality and compare the results with the maximum allowable concentration of WHO.

Public sewerage services are partly provided in Kota Kinabalu, Sandakan, Tawau, Kundasang, Tuaran, Keningau and Labuan areas in Sabah, while there are no such services in Sarawak.

It is usual that the new beneficiaries of water supply extension are obliged to set up septic tank in urban area or latrine in rural area. Every house or building in the area of Kuching Municipality Council is obliged to equip themselves with septic tank.

The branch office of Federal MOH in Sarawak has established a standard for septic tank.

Housing schemes by private developer are permitted, provided that they are furnished with a sewerage system plan, consisting of a septic tank or oxidation pond, which will be examined by the PWD of each state. This sewerage system is also required to be furnished with trunk pipe connecting with future public sewerage system by developer in the case of the Labuan Town Board area.

The branch office of Federal DOE was established in April, 1981 in Sabah and in January, 1981 in Sarawak. A monitoring system of DOE for river water quality has been being established in each state by respective Federal branch. The operation of this system has just been started since 1981 in Sabah and Sarawak. Two rubber factories and 15 palm oil mills in Sabah and three rubber factories and four palm oil mills in Sarawak have been identified by the Federal DOE branch offices as prescribed premises in accordance with the Environmental Quality Act (Ref. 18).

The Mamut copper mine has mining concession of 16 km^2 for 30 years in the upper reaches of the Nasapang river, a tributary of the Labuk river and of the Lohan and Mamut rivers, tributaries of the Sugut river. The Mamut copper mine damaged the downstream paddy by its excessive muddy flow in 1977. This damage was compensated with money by the mining company. The State Government ordered the company to construct settling ponds to prevent silt from entering paddy field. The State Government has been monitoring the river water quality at 16 points just downstream of the mine since 1978.

Legal measures to maintain the quantity and quality of river flow for water supply during low flow period, have been provided by the Land Ordinance of Sabah and the Water Supply Ordinance of Sarawak. "Water Reserve" area is declared with respect to the catchment area of water supply intake for Tawau and Semporna areas, and "Water Catchment Areas" are declared for water supply in Miri, Bintulu, Sarikei and Kuching areas in Sarawak. By these declarations, private activities are restricted. Effectiveness of these declarations is equal to that of the reserved land provided by the Land Ordinance of Sabah or the Land Code Ordinance of Sarawak. All activities other than the ones for water supply purpose are prohibited.

4.4 Compilation of Low Flow-related Information

Present conditions were surveyed with respect to the arrangement of the following data which relate to low water management:

(a) (Water resources potential data) rainfall, daily river discharge;

(b) River water withdrawal volume; and

(c) River water quality.

(1) Water resources potential data

Systematic rainfall measurement in Sabah was started as early as 1879 when the first gauge was installed at Sandakan. The first stream flow measurement in Sabah was carried out in 1959. Periodical publications of these data have been made since 1968 by the State DID. In Sarawak, this kind of publication was started in 1963. These publications contain daily observation records on the above aspects.

According to the latest hydrological publication in Sabah, the observation records at 106 rainfall stations and 47 stream flow stations and the evaporation record at 10 stations are compiled. Out of these stations, all the stream flow stations belong to the State DID, while rainfall stations belong to not only the State DID but also the State DOA, Meteorological Department, Forestry Department, SLDB and private plantations, and so on (Ref. 19). In Sarawak, the observation records at 151 rainfall stations and 33 stream flow stations and the evaporation record at eight stations are compiled in the latest hydrological publication (Ref. 20).

(2) River water withdrawal volume

"Water Works Operating Log" is maintained at every water supply treatment plants. Raw water withdrawal volume is not directly measured but distributed amount of treated water is recorded in this log.

As for measurement of irrigation water withdrawal, pump operation records are kept at each pumping station. Withdrawal volume at gravity intake site is not measured.

(3) River water quality

The Federal DOE has established monitoring system for river water quality in both the States. In 1980 and 1981, the Federal DOE branch offices conducted monitoring works at 20 points in Sabah and at 19 points in Sarawak. The Federal DOE is going to increase the number of monitoring points to around 60 within a few years.

Monitored items are 14 in case of DOE monitoring system, including such indices as suspended solid, dissolved oxygen, ammoniacal nitrogen, chloride, biochemical oxygen demand, chemical oxygen demand and so on.

The State DID of Sabah also monitors river water quality from the viewpoint of irrigation water use. The number of monitored places amount to 19, and monitored items are selected from 22 items depending on site conditions. The State DID of Sarawak has not monitored river water quality.

The State PWDs and two Water Boards of Sarawak measures quality of raw water at intake of treatment plant and that at outlet. Monitored items by the State PWD of Sabah, amount to 20 including both chemical and biological indices, while 15 items are monitored by the State PWD and two Water Boards in Sarawak.

5. GROUNDWATER MANAGEMENT

Groundwater is used for domestic water supply. Especially in Labuan, groundwater covers 100% of water supply of 5×10^3 m^3/d by 32 boreholes. In Sandakan, 16.5×10^3 m^3/d or 82% of the total water supply are extracted from 21 boreholes. On the other hand in Sarawak, groundwater is going to be developed for water supply in two villages of the coastal area: Belawai in the District of Sarikei in the Sixth Division and Kabong in the District of Kalaka in the Second Division. In the former village, six shallow boreholes have been excavated.

The water supply agencies of these projects pay attention to the effect of land use pattern on recharged amount of groundwater. According to the "Draft Scheme Sandakan Town and Environment", "Escarpment" is enumerated in the list of land use category in order to restrict land use in this area. Land use in this area is permitted only for the discretionary purposes such as detached house, shop, primary school, health center, library and other similar kind of works as well as recreation area, golf course, agriculture, plant nursery, and agistment and stockholding.

For rural water supply to Belawai village, 50 acres of land has been bought up by the State PWD to stop any other land use to promote groundwater recharge. In Kabong village, 100 acres of land are going to be bought up for the same purpose. The Labuan Town Board prohibits a private person to dig bored well throughout its area. To excavate a dug well is out of control.

REFERENCES

1. LAND ORDINANCE (Sabah)
2. LAND CODE (Sarawak)
3. DRAINAGE AND IRRIGATION ORDINANCE (Sabah)
4. ELECTRICITY ORDINANCES (Sabah & Sarawak)
5. ELECTRICITY BOARD ORDINANCE (Sabah)
6. SARAWAK ELECTRICITY SUPPLY CORPORATION ORDINANCE (Sarawak)
7. FOREST ENACTMENT (Sabah)
8. FOREST ORDINANCE (Sarawak)
9. TOWN AND COUNTRY PLANNING ORDINANCES (Sabah & Sarawak)
10. LAND (CONTROL OF SUB-DIVISION) ORDINANCE (Sarawak)
11. SANDAKAN TOWN AND ENVIRONS SCHEME,
    Prepared by the Town and Regional Planning Department,
    State of Sabah
12. FOURTH MALAYSIA PLAN SABAH, Phase 1 Report Vol. 2, State of Sabah
13. SINIAWAN FLOOD WARNING STATION, DID Sarawak, March, 1976
14. FLOOD RECORDS OF SARAWAK, ABSTRACTED FROM SARAWAK TRIBUNE
    (FROM 1946 TO 1976), DID Sarawak, June 1979
15. SARAWAK HYDROLOGICAL YEAR BOOK FOR THE YEAR 1962-3
    Compiled by Drainage and Irrigation Branch of PWD, Kuching,
    Sarawak
16. WATER SUPPLY ORDINANCE (Sabah)
17. WATER SUPPLY ORDINANCE (Sarawak)
18. ENVIRONMENTAL QUALITY ACT, Government of Malaysia
19. HYDROLOGICAL RECORDS FOR SABAH 1969-1975, DID Sabah, 1980
20. SARAWAK HYDROLOGICAL YEAR BOOK 1977 & 1978, DID Sarawak