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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE GOVERNMENT OF MALAYSIA
PRIME MINISTER'S DEPARTMENT
ECONOMIC PLANNING UNIT
MALAYSIA

THE STUDY ON THE ESTABLISHMENT OF THE RIVER BASIN INFORMATION SYSTEM IN MALAYSIA

VOLUME 3

SUPPORTING REPORT

(FINAL REPORT)

JANUARY 1999

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LIST OF REPORTS

VOLUME 1	**SUMMARY**	
VOLUME 2	**MAIN REPORT**	
VOLUME 3	**SUPPORTING REPORT**	
	SECTOR I	Hydrology
	SECTOR II	River Management
	SECTOR III	Watershed Management
	SECTOR IV	River Basin Information System
	SECTOR V	Project Cost Estimation and Project Evaluation
	SECTOR VI	Institutional Setup Plan
VOLUME 4	**DATA BOOK**	

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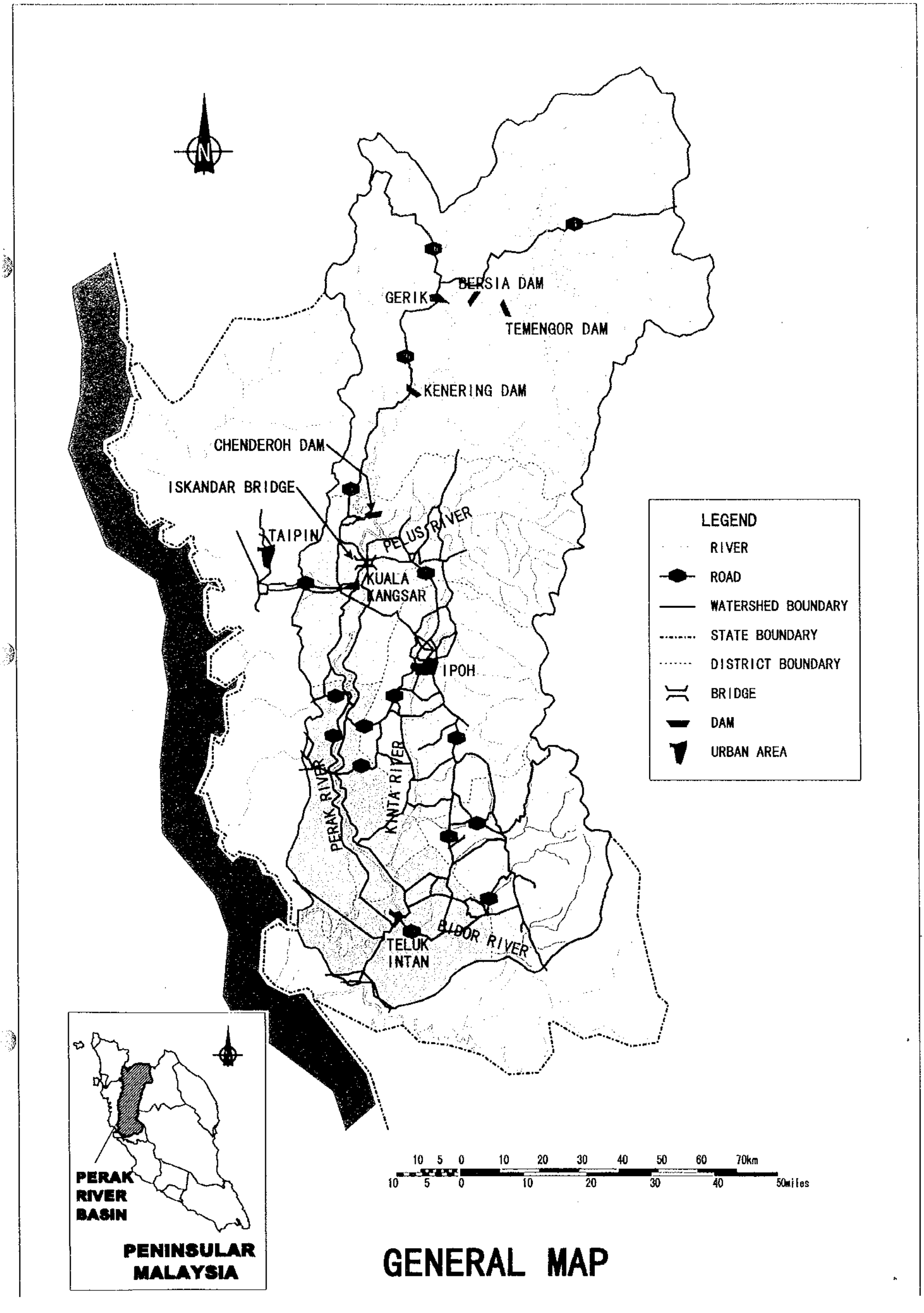

N
GERIK
BERSIA DAM
TEMENGOR DAM
KENERING DAM
CHENDEROH DAM
ISKANDAR BRIDGE
TAIPIN
PELUS RIVER
KUALA KANGSAR
IPOH
PERAK RIVER
KINTA RIVER
BIDOR RIVER
TELUK INTAN
LEGEND
RIVER
ROAD
WATERSHED BOUNDARY
STATE BOUNDARY
DISTRICT BOUNDARY
BRIDGE
DAM
URBAN AREA
10 5 0 10 20 30 40 50 60 70km
10 5 0 10 20 30 40 50miles
PERAK RIVER BASIN
PENINSULAR MALAYSIA

GENERAL MAP

SECTOR I
HYDROLOGY

SUPPORTING REPORT

SECTOR I

HYDROLOGY

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1 INTRODUCTION

This Supporting Report, Sector I, Hydrology, presents the results of the hydrological investigations to formulate the whole river basin information system for the Perak river basin and to develop the Operational System selected from the whole system.

Chapter 2 describes the hydrological features particular to the Perak river basin compared with the other major river basins in Malaysia. Chapter 3 presents the existing hydrological information system, namely, the hydrological observation network and the information system, while Chapter 4 gives an inventory of the presently available hydrological information and Chapter 5 presents the major issues on the existing hydrological information system.

On the other hand, Chapter 6 proposes the hydrological information to be covered by the Master Plan of the fully operational river basin information system, and Chapter 7 proposes the hydrological information to be covered by the Operational System to be established during the Study.

CHAPTER 2 PRESENT FEATURES OF PERAK RIVER BASIN

The hydrological features particular to the Perak river basin have been clarified through comparison with the other 14 major river basins in Malaysia, as presented below.

2.1 General

The present hydrological networks controlled by the Department of Irrigation and Drainage (DID) in Peninsular Malaysia are adequate, except in some remote areas that have the elevation of more than 500 m. The density of rainfall gauging stations fully satisfies the minimum density of 100-250 km^2/station under normal undulating to flat terrain recommended by the World Meteorological Organization (WMO), as shown in Table I-1. The stations in the basins along the west coast, including the Perak river basin, are densely distributed (158 km^2/station on average) compared to those along the east coast (225 km^2/station on average).

On the other hand, the density in the states of Sabah and Sarawak is 1,657 km^2/station and, accordingly, does not satisfy the minimum range of 250-1,000 km^2/station under "difficult condition" recommended by the WMO. WMO also recommends the density of 50,000 km^2/station for evaporation station and almost all of the major river basins satisfy the condition.

The density of river stage and discharge gauging stations in river basins along the west coast is 938 km^2/station on average. This average density fully satisfies the minimum range of 300-1,000 km^2/station under normal undulating to flat terrain recommended by the WMO. However, the Perak and Muda river basins have densities exceeding the recommended upper limit.

On the other hand, the density in river basins along the east coast is 1,510 km^2/station on average and it exceeds the minimum range of 300-1,000 km^2/station. The density in the states of Sabah and Sarawak is 7,946 km^2/station on average; hence, this average density also exceeds the minimum range of 1,000-5,000 km^2/station recommended by WMO under "difficult condition".

2.2 Hydrological Features Particular to the Perak River Basin

The Perak river basin has an annual rainfall of about 2,300 mm and this is higher than those of the river basins in the south-west coast (less than 2,000 mm) but lower than those in the north-east coast (more than 2,500 mm). The Perak river basin may have two (2) rainy periods during the inter-transitional monsoon seasons; i.e., from April to May during the south-west monsoon period and from October to January during the north-east monsoon period. The maximum monthly rainfall of the Perak river basin usually occurs during the north-east monsoon period.

Hence, the major concern on the river basin information system in this Study is the distribution of hydrological gauging stations. As shown in Table I-1, the hydrological gauging stations controlled by DID are densely distributed in the basins along the west coast of Peninsular Malaysia as compared to the other basins along the east coast and in Sabah/Sarawak. The density of gauging stations in the Perak river basin is, however, the lowest among those of the major river basins along the west coast. The rainfall gauging stations in the Perak river basin could barely satisfy the minimum limit (250 km^2/station) recommended by the WMO.

The density of river stage and discharge gauging stations in the Perak river basin is 1,265 km^2/station which is higher than the minimum limit (1,000 km^2/stations) recommended by the WMO. Nevertheless, the density of hydrological gauging stations in the basin is far higher than those along the east coast and in Sabah/Sarawak.

CHAPTER 3 PRESENT CONDITION OF HYDROLOGICAL INFORMATION

3.1 Hydrological Observation Network

3.1.1 General

Hydrological observation activities in Malaysia are being carried out by three government agencies; namely, (1) the Department of Irrigation and Drainage (DID); (2) the Public Works Department (JKR); and (3) the Tenaga Nasional Berhad (TNB). Both DID and JKR operate on the state and federal levels, while TNB operates only on the federal level.

DID maintains and operates a network of hydrological stations on a long-term basis. On the other hand, JKR and TNB restrict their hydrological observations to meet their specific requirements mainly on a short-term program. As for the general meteorological information, it is provided by the Malaysian Meteorological Service (MMS) headed by the Ministry of Science, Technology and Environment.

3.1.2 Hydrological Observation Activities of DID

DID, as a whole, is responsible for the collection, processing and publication of hydrological data such as rainfall, river stage and discharge, evaporation, river suspended sediment, river water quality and agro-hydrological data. After the major flood in 1971, the DID Hydrology Branch was established in 1972 and hydrological networks were simultaneously reorganized to meet international standards. In 1995, the Hydrology Branch was reorganized into the Hydrology Division in view of the expansion of personnel and activities.

The hydrological observations by DID are being carried out in accordance with the standards specified in the "Manual of Department of Irrigation and Drainage, Hydrology, 1991" (hereinafter referred to as the Manual). The Manual was published by DID in 1961 and revised in 1973 and 1988. In addition to the Manual, several detailed hydrological procedures published by DID are also adopted for detailed specific purposes. The criteria for hydrological data are defined clearly in the Manual to ensure that the quality of collected data is acceptable.

The hydrological network of DID consist of principal and secondary stations. Principal stations are permanent or fixed stations and are equipped with both manual and automatic gauges. Secondary stations are short-term or project stations that are subject to review after continuous operation for 5 to 10 years. They are equipped with either manual or automatic gauges but have the same priority as principal stations in data processing and analysis.

The operation and maintenance tasks of DID are:

(a) to develop, manufacture and test hydrological instruments or systems to suit local conditions; e.g., telemetric systems for flood forecasting and warning, flood siren systems and electronic rainfall and water level data loggers;

(b) to service, test and calibrate hydrological instruments such as rainfall and water level recorders and current meters, and suspended sediment samplers;

(c) to provide support services of hydrological instrumentation in the field; and

(d) to provide regular training on maintenance of hydrological instruments and telemetric equipment.

A questionnaire is attached to the Manual, to execute a thorough check during the regular inspections.

3.1.3 Basic Policy of DID on Hydrological Network

The basic policy of DID on the hydrological network aims:

(a) to improve the data quality of existing hydrological stations, especially, to decrease the data-missing period at river stage and discharge stations;

(b) to introduce work-saving equipment such as computerized solid state data loggers and non-stilling well type water level recorders; and

(c) to transfer periodical discharge measurement activities to the private sector.

Presently, DID does not intend to drastically increase the number of hydrological stations, mainly because of the shortage of personnel for installation and maintenance of new stations. As to river stage and discharge stations, many of those in the Perak river basin were closed in the 1970's and 1980's, as mentioned in Subsection 4.1.3.

3.2 Hydrological Information System of DID

3.2.1 Hydrological Data Bank System

The Hydrological Data Bank System (the Data Bank) in the DID Hydrology Division was established in 1974. Introduced in the Data Bank was the Time Dependent Data Processing System (TIDEDA) originally developed by the Ministry of Works, New Zealand. The present computer system consists of Aviion AV8500 using UNIX-based operating system and local area network (LAN) by TCP/IP protocol.

The objectives of the Data Bank are to process, update and archive hydrological data, as well as to provide data to end users. The hydrological data from the Data Bank are analyzed, published and provided to end users. Due to the large amount of hydrological data, they are summarized for publication. On special request through a designated application form, the hydrological data for any period can be retrieved in any desired format and time interval directly from the Data Bank. End users can analyze the data in the Data Bank by using the PC version of TIDEDA (Micro TIDEDA).

The data of each state can be abstracted from the Data Bank. At present, however, the data of each river basin cannot be abstracted. It is desirable that the Data Bank and/or the ongoing Hydrological Information System (HIS) is equipped with the data abstraction function by river basin (major river basin level, at least) for convenient use in various river planning activities.

3.2.2 Hydrological Information System (HIS)

The DID Hydrology Division started to establish the Hydrological Information System (HIS) in early 1996. As the Phase I pilot project, HIS will first cover three (3) states, namely Johor, Malacca and Negeri Sembilan. HIS is scheduled to cover the whole of Malaysia at the stage of Phase IV in Sabah and Sarawak, however, the schedule for the state of Perak has not yet been decided.

HIS will be equipped with a data fill-in function. Since the discharge data in the Data Bank contain "gaps" or periods of missing data, the objective of this function is to fill in the gaps in this Data Bank with daily discharge values generated by using HYRROM, a rainfall-runoff modeling software developed by the Institute of Hydrology, Wallingford, U.K.

The existing Data Bank is planned to be included in HIS in the future; however, the Data Bank itself will remain as an "engine". So far, the end user has to submit the designated application form to the DID Hydrology Division to access and use the hydrological data in the Data Bank. After the completion of HIS, however, the end user will be able to directly access the Data Bank through the interface of HIS.

3.2.3 Flood Forecasting and Warning System

The flood forecasting and warning (FFW) system for the Perak river basin was set up by DID in 1976, and upgraded in 1997 after the big flood in June 1993. The inventory and the location of the present FFW system such as telemetry gauging stations and related facilities are shown in Table I-2 and Fig. I-1.

The current system monitors flood condition through five (5) telemetry rainfall gauges, eight (8) telemetry river stage gauges and two (2) non-telemetry river stage (flood monitoring) stations. The flood information monitored at these gauging stations are collected on real-time base through either telemetry line or telephone line to the State DID Terminal Station located in Ipoh. The real-time information can be monitored and displayed at the Terminal Station through the existing software TeleWin32 developed by Powermatic Sdn Bhd.

The State DID issues the warning through sirens and telephone lines to residents and/or the government agencies related to flood evacuation and flood fighting whenever the water level is predicted to reach the alert, warning and danger levels. These water levels are described in "Inventori Sistem Amaran Banjir" (DID, 1997). The stage-correlation method is used to predict flood levels of the flood-threatened areas along the Perak River. The stage-correlation graph was prepared by the State DID based on the relationship among the previous big flood stages and the lag-times between the Chenderoh Dam and the river stage stations downstream.

According to the previous studies, major floods of the Perak River are caused by the breakthrough of the north-east monsoon air into the northeastern extremity of the catchment across the relatively low saddle between the two peaks G. Hulu Merah (1,450 m) and G. Noring (1,889 m). When this breakthrough occurs, heavy rainfall persists in the northeast corner of the catchment for three (3) days. Typically, the rainfall decreases rapidly in a southerly and to a lesser extent westerly direction away from the areas of heaviest rainfall. The two most recent extreme floods occurred in 1967 and 1973. The extreme floods mainly occurred in both December and January.

CHAPTER 4 INVENTORY OF PRESENTLY AVAILABLE INFORMATION

In the Perak river basin, hydrological gauging is being carried out by DID, TNB and MMS. Inventories of these gauging stations are given in Tables I-3 to I-7, and summarized below.

Gauging Item	DID Station	TNB Station	MMS Station	Total
Rainfall	62	3	26	91
River Stage and Discharge	12	6	-	14
River Suspended Sediment	10	-	-	14

4.1 Hydrological Information of DID

4.1.1 General Inventory

DID is the main agency for gauging rainfall and river stage/discharge. According to the "Inventory of Hydrological Stations in Malaysia, 25th. Edition (DID, 1997)", the following gauging stations are currently in operation.

Gauging Item	Principal Station (Automatic)	Secondary Station		Total
		(Automatic)	(Manual)	
Rainfall	12	2	48	62
River Stage and Discharge	3	9	0	12
River Suspended Sediment	3	7		10

The inventories of stations are given in Tables I-3 to I-5 and the locations are shown in Figs. I-2 and I-3. All principal rainfall stations are under the direct management of DID. Other agencies such as JKR, police departments and hospitals assist in the operation of some DID secondary rainfall station. All river stage and discharge stations, as well as suspended sediment stations, are also managed directly by DID. There are no evaporation, agro-hydrological and groundwater stations existing in the Perak river basin.

In the States, hydrological data on forms such as monthly rainfall cards and recorder charts are collected by the field parties or local observers under the supervision of the State Hydrological Officer. The data are forwarded to the DID Hydrology Division at monthly intervals for centralized processing. On receipt of the data, they are checked, recorded in the registers and then processed, updated and archived using the Electronic Data Processing (EDP) System. After the data are processed by the EDP system, they are merged into the Hydrological Data Bank System set up in the DID Hydrology Division.

4.1.2 Rainfall Stations

All of the principal stations and two of the secondary stations are equipped with both manual and automatic gauges. Both manual and automatic measurements are taken at all the recording stations. Automatic Hattori type weekly or long-term graphical rainfall recorders are used mainly for the principal stations in the Perak river basin. Automatic Kent type weekly recorders and Ota type weekly recorders are also used for some stations.

Many stations in the basin are now equipped with solid-state data loggers. This device is designed for computerized data collection with self-recording at 15-minute intervals. The data in the data logger are forwarded to the DID Hydrology Division at monthly intervals for centralized processing. The data logger will replace the current mechanical recording paper in the near future. However, DID plans to use the recording paper simultaneously with the data logger for the time being in order to calibrate and examine the performance of this new device.

Some stations are equipped with telemetry gauge for flood forecasting and warning. The telemetric real-time gauge records rainfall at any interval by teleprinter (in addition to self-recording by the Hattori type long-term recorder). The telemetry gauge actually observes rainfall throughout the year at one-hour intervals. The observed data are not registered in the Hydrological Data Bank System at present. However, DID plans to register the data into the Data Bank in the near future.

Forty-eight (48) secondary stations in the basin are non-recording stations. Manual measurements are taken at the fixed time of 8:00 a.m. daily, using daily rain gauges with diameters of 203 mm (8 inches) or 127 mm (5 inches).

The water year of the Perak area commences in the first day of July. The water year instead of the calendar year is used for the analysis of annual rainfall.

4.1.3 River Stage and Discharge Stations

Twelve (12) river stage and discharge stations are currently in operation in the basin. All stations are equipped with both manual and automatic gauges. Three (3) stations are principal stations and nine (9) are secondary. The principal stations are located on the Perak mainstream and major tributaries, while the secondary stations are located on the small tributaries.

Automatic Ott or the SEBA float-type weekly or long-term graphical water level recorders are mainly used for principal and secondary stations in the basin. Manual gauges installed along with the recorders are only for checking purposes; manual gauges are read only when the recording paper of automatic gauges is replaced.

Many automatic gauges in the basin are now equipped with the solid-state data loggers. The data loggers will replace the current mechanical recording paper in the near future. However, DID plans to use the recording paper simultaneously with the data logger for the time being in order to calibrate and examine the performance of this new device.

Some stations are equipped with telemetric gauge for flood forecasting and warning. The telemetric real-time gauge records river stage at any interval (in addition to self-recording by SEBA float-type long-term recorder). The telemetric gauge actually observes river stage throughout the year at one-hour intervals. The observed data are not registered in the Hydrological Data Bank System at present. However, DID plans to register the data into the Data Bank in the near future.

River flow discharge is derived by applying the river stage to the discharge rating curve. Regular measurements by Ott type current meter are carried out in order to establish the discharge rating curves at least once or preferably twice a month.

The regular cross-sectional surveys at river stage and discharge stations are carried out once a year in principle. The actual measurement intervals at the principal stations in recent years are as follows and the overlay of these cross sections is shown in Fig. I-4.

Station Number	Station Name	Surveyed Year
4310401	Sg. Kinta at Weir G. Tg. Tualang	1982, 1992, 1993, 1994
4809443	Sg. Perak at Jam. Iskandar	1988, 1992, 1993, 1994, 1995
4911445	Sg. Pelus at Kg. Lintang	1978, 1992, 1994, 1995

There used to be 27 river stage and discharge stations in the Perak river basin; however, more than half of them were closed in the 1970's and 1980's. The main cause of the closure is shortage of manpower for maintenance work such as ordinary observation, periodical discharge measurement, cross-sectional survey and routine inspection.

4.1.4 River Suspended Sediment Stations

Regular suspended sediment measurements are carried out at ten (10) river stage and discharge stations in conjunction with discharge measurement of at least once a month using

US DH48, DH59 or D49 suspended sediment samplers. Samples are analyzed at the DID Laboratory. River suspended sediment data are derived by applying river discharge data to suspended sediment-discharge rating curves.

4.1.5 Data Availability in Data Bank System

Data availability at the principal stations was investigated by using the data in the Hydrological Data Bank System. As shown in Table I-8, the commencement year of the observation at some stations does not coincide with that of the digitized data in the Data Bank. As to rainfall data, the digitized data in the Data Bank is available only after around 1970 in most of the principal stations.

The data availability is considerably good. However, the availability in the 1990's is lower than the previous one. As for the river stage and discharge data, the data availability is also good. The observation at the Iskandar Bridge on the Perak River has been carried out since 1915, whereas the digitized data in the Data Bank became available only after 1960.

4.2 Hydrological Information of TNB

From the viewpoint of hydrology, the distinctive features of the Perak river basin is a series of hydroelectric dams controlled by the Tenaga Nasional Berhad (TNB) mainly for hydropower generation in the upper reaches. The principal features of these dams are as follows.

Name of Dam	Catchment Area (km^2)	Purpose	Capacity at FSL ($m^3 \times 10^6$)	Completion Year
Temengor	3,420	Hydropower generation & flood control	6,050	1978
Bersia	140	Hydropower generation	58	1983
Kenering	1,930	Hydropower generation	352	1984
Chenderoh	1,000	Hydropower generation	95	1932

Note: The catchment area of each dam does not include the area of upstream dams.

The total catchment area of the Chenderoh Dam (6,490 km^2) accounts for more than 40% of the whole Perak river basin (14,700 km^2). Except the Chenderoh Dam, the real-time inflow and outflow discharge information, and the water level of reservoirs, are continuously monitored and displayed on the screen in the "Bersia Group Control Center". The dam inflows are not derived from direct measurement but are estimated indirectly by the change of reservoir water levels.

TNB currently operates several rainfall, river stage and/or discharge stations for dam operation. The inventory of these stations is shown in Table I-6 and the locations are shown in Fig. I-5.

Manual measurement is taken once a day at the rainfall stations. Automatic gauges observe river stage at hourly intervals. The hydrological data on forms such as rainfall cards and recorder charts are usually collected at 2-months interval.

The data are forwarded to the TNB Hydrology Section for centralized processing. On receipt of the data, they are stored in TIDEDA format (same as in DID) in the Hydrology Section, Engineering and Project Development, Generation Division.

4.3 Meteorological Information of MMS

In the Perak river basin, two (2) principal meteorological stations exist at Ipoh Airport and Lubok Merbau. These stations undertake overall meteorological observation and are equipped with standard non-autographic instruments from which hourly eye-readings are made and autographic instruments from which hourly values are tabulated, when no eye-readings are available.

There are also twenty-four (24) manual rainfall gauges in the basin, composed of thirteen (13) climatological stations and eleven (11) rainfall stations managed by MMS. Manual measurements are taken at the fixed time of 8:00 a.m. daily. Most of the rainfall gauges are actually operated by other authorities such as hospitals and the local inhabitants.

MMS currently has no computerized data bank system similar to the existing DID Hydrological Data Bank System. The inventory of MMS meteorological stations is shown in Table I-7.

CHAPTER 5 MAJOR ISSUES ON HYDROLOGICAL INFORMATION

5.1 Dam Reservoir Information

The Temengor Dam, which is located at the uppermost stretch of the Perak River, has the largest capacity, i.e., 6,050 million m^3. The annual peak flood discharges as well as the inundation areas have remarkably decreased since the dam was constructed in 1978 (refer to Fig. I-6).

The Temengor Dam has a virtually large flood storage effect; flood flow was discharged through the spillway only once in 1993 since 1978. The flood control volume of the Temengor Dam is 850 million m^3.

Excluding the Chenderoh Dam, the real-time hydrological reservoir information is now monitored at the "Bersia Group Control Center". During flood time, TNB informs the outflow discharge from the Chenderoh Dam to the DID, police and other related agencies through the public telephone line.

However, the dam outflow discharge is determined by the National Load Dispatch Center (NLDC) at the TNB headquarters in Kuala Lumpur without adequate coordination with DID and the other agencies related to flood management work. Thus, the dam outflow discharge is, in principle, determined according to the necessary power generation load, but not flood control for the downstream of the Perak River.

TNB informs the State DID the daily average reservoir levels at the Temengor, Bersia and Kenering dams and the daily rainfall at the Temengor dam site at 2 weeks interval. However, some of the hydrological information such as dam inflow/outflow data are still not open to the State DID and other agencies.

In this connection, proper coordination between DID and TNB is required. This cooperation will be especially effective for the periods of both flood and drought.

5.2 Flood Forecasting and Warning System

The outflow discharge from the existing hydropower dams controlled by TNB seriously influences the flood forecasting and warning in the Perak river basin. As described above, however, TNB releases only the information on the outflow discharge from the Chenderoh Dam through the public telephone line to the State DID during flood time.

Information on outflow discharge from the other three (3) dams, as well as dam reservoir level, are not released to the State DID. On the other hand, the flood forecasting information as well as flood condition in the lower reaches is seldom released to TNB. Thus, both DID and TNB do not effectively exchange real-time information during flood time. Moreover, the dam outflow discharge is determined by NLDC in TNB Kuala Lumpur, without consideration of the flood conditions in the lower reaches.

Under the above situations, it is essentially necessary that both TNB and DID maintain proper coordination through the exchange of information. Since the dam outflow discharge is determined by NLDC in Kuala Lumpur, inconvenience between NLDC and the State DID is foreseen in exchanging flood information and coordinating control of dam outflow. From this viewpoint, therefore, it is also necessary for the Federal DID to monitor the flood forecasting information so as to initiate immediate and appropriate coordination with NLDC in Kuala Lumpur.

The existing stage-correlation chart prepared by the State DID is based on the previous big floods on record such as January 1947, November 1967, November 1969, December 1970 and December 1975 which occurred before the Temengor dam construction. Accordingly, it is recommended that the review of stage-correlation shall be conducted by using the data of the recent big flood in June 1993, because the runoff mechanism may have changed due to the remarkable flood control effect of the Temengor Dam.

5.3 Coverage of Rainfall Gauging Station

As described in the preceding chapters, there are 91 rainfall gauge stations in the Perak river basin and most of them are operated by DID. The average density of the existing DID rainfall stations in the Perak river basin is 237 km^2/station (14,700 km^2/62 stations) and this could satisfy the minimum density requirement of 100-250 km^2/station recommended by the WMO.

However, the rainfall stations are biased to the lower and middle parts of the Perak river basin, and scarcely distributed in the upstream basin of the Chenderoh Dam (refer to Fig. I-2). The density of rainfall stations both of DID and TNB in the upper reaches is only 788 km^2/station. Such scarce rainfall stations in the upper reaches may be attributed to the difficult accessibility, and deemed extremely difficult to increase. Moreover, DID is reluctant to increase the number of hydrological stations due to the shortage of personnel for installation and maintenance work.

5.4 Location of River Stage and Discharge Gauging Station

Along the mainstream of the Perak River, there exists only one (1) key river discharge gauging station at Iskandar Bridge (refer to Fig. I-3). Most of the existing major water intake points are located downstream of the gauging station and, therefore, this discharge gauging station is quite useful to monitor the flow discharge to the intake facilities.

No river gauging station is installed downstream from the existing water intake facilities resulting in difficulties in the estimation of water intake volume. Under these conditions, it is necessary to newly install several river discharge gauging stations on the downstream of the Iskandar Bridge.

As for the upper reaches of the Chenderoh Dam, the existing TNB hydropower dams regulate the river flow discharge. The real-time inflow and outflow discharge information, and reservoir water levels at four (4) dams are continuously monitored by TNB. TNB also monitors the river flow stage and/or discharge through six (6) gauging stations along the Perak River (refer to Fig. I-5). Thus, the existing monitoring system of TNB is deemed to be adequate to monitor the river discharge in the upper reaches of the Perak river basin.

5.5 Discharge Measurement

DID develops discharge rating curves through regular discharge measurements using the current meter and cross-sectional survey results at the stations. In principle, the measurements are carried out twice a month, while the cross-sectional surveys are once a year.

Suspended sediment measurements are also made at least once a month. These measurements are, however, made as a routine work according to a fixed timetable, and not in response to the change of river water level.

Consequently, the measured river stage tends to concentrate within a low and narrow range, and the flood flow discharge is estimated by extraordinary extrapolation leading to little reliability. The typical example of such unfavorable conditions is given by the existing gauging station at Iskandar Bridge, where the maximum observed flood level is EL. 41.94 m while the measured river stages only range from EL. 32.65 m to EL. 33.64 m (refer to Fig. I-7).

The main cause of this condition is derived from the shortage of manpower for direct management. DID is now planning to transfer periodical discharge measurement work from direct management to private sector management so that the measurement could be carried out flexibly and immediately in accordance with the change of river stage.

5.6 Tidal Level

No tidal level gauging station is currently available for the Perak River. Instead, the Directorate of Hydrology, Royal Malaysian Navy published the tidal table at Bagan Datoh located near the estuary. According to the previous study by DID (1992), the reliability of the table may be relatively low, because the table was estimated based on the short-term tidal observation from 29 September to 10 October in 1986 and the observations did not fully cover the tidal cycles.

Accurate tidal level data as a hydrological boundary condition is essential not only to estimate the river channel flow capacity by non-uniform flow calculation but also to study riverbank erosion control at Teluk Intan by unsteady flow calculation. Accordingly, it is necessary to install a new tidal gauging station at Bagan Datoh.