SECTOR III

WATERSHED MANAGEMENT

SUPPORTING REPORT

SECTOR III

WATERSHED MANAGEMENT

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CHAPTER 1 INTRODUCTION

1.1 Study Area

The Perak River originates in the northern mountain range of more than EL. 4,000 feet (about 1,200 m). It runs southward and finally flows into the Strait of Malacca. The river has a catchment area of about 14,700 km^2 that covers about 70% of Perak State. The northern watershed boundary of the river borders on Thailand, while the eastern watershed boundary is on Kelantan State. The major tributaries are the Pelus River, the Kinta River and the Bidor River. These tributaries originate in the Titiwangsa mountain range that bounds on Kelantan State. Among the tributaries, the Kinta River flows down through Ipoh, the state capital. The topographic map is presented in Fig. III-1.

1.2 Issues for Enhancement of River Basin Management

Basin land conservation and/or development works are undertaken by various agencies such as the Forest Department (FD) for forest conservation, the Department of Agriculture (DOA) for agricultural development, and the Economic Planning Unit (EPU) for urban and industrial development. Information on basin land development is, however, hardly furnished to the agencies concerned in river basin management.

The major issues on the present river basin information system are summarized as follows:

(a) Most of the existing database systems related to river basin management are for the exclusive use of a particular government agency and the information stored in the system is seldom exchanged with the other agencies. Such situation causes difficulty in obtaining a comprehensive river monitoring information and basin land development conditions.

(b) The federal government has control over most of the river basin information while the state government is the principal body executing the actual river basin management. Such a dual management system could cause delay in the transmission of information from the federal government to the state government and the difficulty in the execution of appropriate river basin management work unless an effective data transmission system is established.

(c) Non-digitized river basin information tend to be scattered and lost, and are not being used effectively.

1.3 Study Approach

In order to establish an efficient River Basin Information System (RBIS), various kinds of information concerning river basin management should be integrated in the RBIS. These are categorized as follows.

- Natural Conditions
  - Topography
  - Geology
  - Soil
  - Land Use and Vegetation
- Human Response
  - Regional Development
  - Mining
  - Logging and Forest Conservation
  - Soil Conservation
  - River Reserve

For the proposed RBID, a precise screening of information sources was made through data collection and interview survey of the related agencies, paying attention to the following:

(a) Data availability in the related agency;

(b) Necessity of river basin management;

(c) Progress of computerization in the related agencies; and

(d) Enhancement and facilitation of routine work not only in the Department of Irrigation and Drainage (DID) but also in the related agency.

In due consideration of the above, the appropriate information to be integrated into the RBIS is as proposed in Chapters 2 and 3.

Completion of a fully functioning RBIS needs a lot of time, manpower and budget. The Operational System was developed within the study period, as a model for the futuristic RBIS. The information concerning watershed management mainly consists of geographic data such as polygons, lines and points, and their attributes. Digitizing of information needs much time and budget. Thus, a step-wise program linking both the operational and future systems has to be proposed if the database system is not yet been established in the agencies and data volume is too large to digitize for a short period.

From the results of screening work, the outline of the Operational System is proposed in Chapter 4. The conceptual design has materialized as the Operational System through the detailed system design.

CHAPTER 2 NATURAL CONDITIONS

2.1 Topography

2.1.1 Basin Topography

(1) General Features

The topography of Perak State is largely governed by the geology of the area. The main mountain ranges consist of extensive masses of granite whose original sedimentary cover has been moved by weathering and erosion. The Titiwangsa mountain range forms the state boundary between Perak and Kelantan. As a result of the northerly topography in the State of Perak, the drainage of the area can be divided into two systems, the coastal system and the Perak river system. The Bintang range forms the watershed separating the two systems. Further inland, the Keledang range forms the divide between both valleys of the Perak and Kinta rivers.

The Perak River which is the largest river on the west coast of Peninsular Malaysia flows along a broadly meandering course. The major tributaries of the Perak River such as the Kinta River and the Bidor River also flow along broadly meandering courses. There is a marked development of flood plains on both sides of the rivers. Meander scars, swamps and marshes abound in the flood plain.

(2) Perak Valley

In tracing the lower course of the Perak River, during early Quarternary times the river mouth was at the position occupied by the present estuary of the Dinding River in Manjung District. Since then, its mouth shifted to the south over a distance of about 32 km to the present position. Further, at a point near Kg. Sungai Buluh, some 28 km inland from the present shoreline, a progressive northwesterly displacement occurred during the more recent history of the river's development.

The floodplain of the Perak River is over 20 km wide. Former river channels, some straight and some meandering, can be observed on both sides of the lower reaches. Geomorphologically every channel is bordered by natural levees about 1.5-2.0 m higher than the adjoining flood basins. Houses, therefore, are built on the levees while the paddy fields are located in the flood basins. The marshy area west of the Perak River is presently being developed after the forest was cleared. The remainder of the coastal plain is very flat and featureless. Cut-off meanders can be seen along the lower reaches of the Perak River.

(3) Kinta Valley

The Keledang Range forms the watershed between the Perak River and the Kinta River, and constitutes the boundary between the districts of Kinta and Kuala Kangsar. The Kinta River, which flows through the ex-mining areas, has had its course frequently altered due to mining activities.

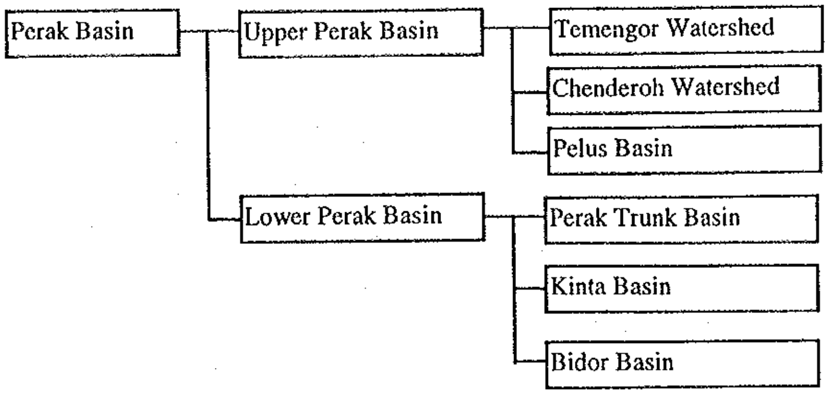
The bedrock floor of the Kinta Valley has a gradual slope to the south, and is covered with alluvium to depths varying from less than 1 m to more than 30 m. The general thickness of the alluvium increases southwards. Most of the bedrock beneath the alluvium is limestone.

2.1.2 Basin Divide

The Perak river basin can be divided into three parts, upper Perak, lower Perak and major tributaries, from the viewpoint of topographic feature. Further, from the water usage and water storage, the upper Perak can be divided into three parts, Temengor watershed, Chenderoh watershed and remains. The following table summarizes the sub-basin in the entire Perak river basin. The basin divide is also presented in Fig. III-2.

Major Basin	Sub-Basin	Reference Point	Drainage Area
Upper Perak	Temengor Watershed	Temengor Dam	3,420 km^2
	Chenderoh Watershed	Chenderoh Dam	3,133 km^2
(Major Tributaries)	Pelus River	Confluence with Perak	1,428 km^2
	Remains	-	207 km^2
Sub-Total		Iskandar Bridge	8,188 km^2
Lower Perak	-	Rivermouth	2,345 km^2
Major Tributaries	Kinta River	Confluence with Perak	2,540 km^2
	Bidor River	Confluence with Perak	1,670 km^2
Total Drainage Area			14,743 km^2

The information on the basin divide will be stored in the Operational System. As a result, basin information such as logging volume, land use and so on, will be easily summed up through the GIS overlay function, based on the following basin structure.



2.1.3 Selection of Base Map

Topographic mapping systems which can cover the whole Malaysia are in two map scales: 1:50,000 and 1:500,000. These mapping systems have the same mapping projection of Rectified Skewed Orthomorphic method as adopted in Malaysia and Brunei.

The basin topography is the most basic information for the RBIS. For the selection of appropriate map scale of the system, the following considerations have been taken into account:

(a) Topographic information is most essential for the establishment of river-related plans and the management of riparian structures and water usage;

(b) For this purpose, accuracy of the 1:50,000 scale is at least necessary for the map information;and

(c) As accuracy increases, the volume of data to be digitized and stored into the computer also increases, resulting in difficulty to input and renew the data.

The following table gives sheet number of each scale map that can fully cover the Perak river basin. Based on the interview with private companies in Malaysia, digitizing work costs approx. RM 3,000 per sheet on the average.

Map Scale	Year Surveyed	Number of Sheets
1:50,000	1981-1988	28
1:500,000	Early 1980's	2

Further, digitizing work of topographic map with a scale of 1:50,000 are now being carried out by the Department of Survey and Mapping, Malaysia (DSMM), and will be completed by the year 2002. Fig. III-3 illustrates the progress of this work in the basin as of October 1997.

Considering the accuracy and work volume of map information, the following stepwise program is recommendable:

(a) The limited major elements of the 1:50,000 map, such as contour lines, locations of cities and towns and so on, will be digitized for the Operational System because of easy input and cost saving.

(b) After the digitizing work being done by DSMM is completed, the base map will be changed to the 1:50,000 map by obtaining the digital map from DSMM.

2.2 Geology

2.2.1 Regional Geology

The Perak river basin is located in the Western Tin Belt of Peninsular Malaysia. Acid intrusives (granitoids) extend widely over the basin. Tin deposits in Peninsular Malaysia are spatially and genetically related to granitoids. Silurian-Ordovician sedimentary rocks distribute, filling up the gaps of granitoids.

Two wide valleys, the Perak Valley and the Kinta Valley, are southerly formed in parallel in the south half of the basin. The bedrock is composed of Carboniferous sedimentary rocks in the Perak Valley, while it is composed of Devonian sedimentary rocks of limestone in the Kinta Valley.

2.2.2 Selection of Geological Information

Geological Survey is being responsibly conducted by the Department of Geological Survey of Malaysia (DGSM). DGSM prepares two kinds of geological map; one is a nationwide geological map with a 1:500,000 scale and the other one is a specific area's geological map with a 1:63,360 scale. The latter one, however, does not fully cover the Perak river basin. Therefore, the former map is selected as a geological information source for the system.

According to the head office of DGSM, they have no plan to digitize the data and to open their digitized data to the public.

The data to be integrated into the RBIS consists of polygon, line and their attributes. The details of the information are summarized in Table III-1. The geological map of the Perak river basin is presented in Fig. III-4. The geological information is mainly based on the work done by DGSM up to the end of 1983.

2.3 Soil Cover

2.3.1 Basin Soil Cover

In the Perak river basin, upland soils are generally medium to fine textured. Flood plain soils range from well-drained levee soils to poorly drained heavy clays and peat soils in very poorly drained areas. Most soils are suitable for a wide range of crops.

The only published soil cover information available is the reconnaissance soil map surveyed by the Department of Agriculture in the late 1960's. On this map, the soil cover was mapped mainly as Rengam-Jerangau Association, Serdang-Munchong Association, and areas with slopes greater than 20° (38%) were designated as steep land (tanah churam).

2.3.2 Selection of Soil Cover Information

The Department of Agriculture (DOA) is carrying out soil survey and storing its result into their database system. So far there are two kinds of soil information in the system. One is based on the work up to 1968 as described above, and the other is now being surveyed. The comparison of them is tabulated in the following table.

Item	Reconnaissance Soil Map	Semi-detailed Soil Map
Completion Date of Field Survey	1968	Still Continuing
Sampling Density	4 km Interval	1 km Interval
Scale of Base Map	1:500,000	1:25,000
Soil Classification	51	More than 300

For the river information system, the reconnaissance soil map was selected as a soil cover information source from the following reasons:

(a) Soil classification on semi-detailed map is over-specialized for the purpose of the river basin management; and

(b) A long time is still necessary for completion of the semi-detailed soil database system.

DOA has already digitized the selected reconnaissance soil map. Further, urban area, mining area and water surface (the newly created lake) are being updated on the basis of current land use in 1990.

Regarding the data structure of soil cover, data consist of polygons classified into 52 categories (including water surface) and their attributes. Soil cover in the Perak river basin is shown in Fig. III-5, and the soil classification is summarized in Table III-2.

2.4 Land Use and Vegetation Cover

2.4.1 Land Use

The present land use conditions of the Perak river basin are as shown in Fig. III-6 and Table III-3, based on the land use map edited by the Department of Agriculture (DOA). The forest spreads out in the upper reaches covering 60% of the river basin, while agricultural lands are developed in the Perak Valley and the coastal plain covering 30%. The first major crop area in the basin is the rubber plantation (taking about 13% of the basin), and the second is the palm oil plantation area (about 7% of the basin). Further, there are many ex-mining ponds, particularly in the lower reaches, which cover about 3% of the basin, and some of them are now being used for aqua-culture.

2.4.2 Vegetation Cover

The characteristics of vegetation cover are described in accordance with the topographic classifications, mountains and hills, the Perak Valley, the Kinta Valley and the coastal plain.

(1) Mountains and Hills[4]

Primary inland vegetation consists typically of tropical rain forest, which is also the climax vegetation of the Malay Peninsula. The rain forest consists of a great assortment of plants characterized by the predominance of the family Dipterocarpaceae in the lowlands and hills and Lauraceae and Fagaceae, ferns and mosses in the more elevated areas. Some members of the Dipterocarpaceae like *Dipterocarpus*, *Shorea* and *Balanops aromatica* provide valuable timber material. Limited cultivation of tapioca and vegetable crops is found along hill slopes.

(2) Perak Valley[4]

In the Perak Valley some lowland forests can be found. The Dipterocarpaceae forms the tree canopy of the lowland forest with a great number of epiphytes, climbers (lianes), shrubs and herbs. Tree cultivation consists essentially of rubber *Hevea braziliensis*. The rubber land is confined inland, generally over hill slopes and undulating ground. Paddy is cultivated in flat ground where irrigation does not present any problem.

(3) Kinta Valley[3]

There is no doubt that before the advent of miners practically all of the area examined was covered by primary jungle of the tropical rain forest. In both lowlands and hills up to 900 or 1,100 m the dominant tree family encountered is that of the *Dipterocarpus* and *Balanocarpus heimii*, frequently making up as much as 30% of the total of large trees present. After the commencement of mining in Kinta the primary jungle began to be cleared rapidly, both to make space for mining operation and to obtain charcoal for the local smelting of tin-ore.

(4) Coastal Plain[1][2][4]

The coastal plain, which until as recently as 30 years ago was covered with virgin jungle, has been developed for agriculture. Crops grown are rubber (Sitiawan), oil palm (Teluk Intan) and cocoa under coconut palms (Bagan Datoh). The newly developed area has partly been converted into paddy fields. A narrow fringe along the coast still supports a stand of mangrove.

The mangrove vegetation along the coast consists of evergreen trees and shrubs belonging mainly to the families Rhizophoraceae, Verbenaceae and Lythraceae. Species of *Rhizophora* and *Bruguiera* are used for piling and making charcoal; together they earn more revenue than any other Malayan forest type. Most of the plants in the mangrove swamp are characterized by the presence of aerophores and stilt-roots which are morphological adaptations for survival in soils of high salinity and extremely poor aeration.

2.4.3 Information on Land Use

DOA basically carries out land use survey at 5-year intervals. At present the survey is performed through remote sensing using satellite images. Changes of land use are recognized if land use in an area of more than 20 ha is changed in comparison with the previous one. Mapping scale is 1:50,000 and the latest map is based on the sources in 1990 (refer to Fig. III-6).

According to the interview with DOA, the land use in 1997 is now being digitized for renewal. On the other hand, the previous one is the 1985 land use map. This map, however, has not been digitized yet. As of now, historical change of land use cannot be clarified through the GIS system.

Regarding the data structure of land use, the data consist of polygons classified into forty-five (45) categories and their attributes, as shown in Table III-4.

CHAPTER 3 HUMAN RESPONSE TO NATURE

3.1 Regional Development

3.1.1 Development Framework

The State Government of Perak has formulated the state strategic development plan with four development corridors to develop urban and industrial centers in the state; namely, (1) the East-west corridor; (2) the North corridor; (3) the Central corridor; and (4) the South corridor (refer to Fig. III-7). This plan keeps step with Vision 2020 (Wawasan 2020).

Among the above development corridors, the East-west corridor is projected in the upper reaches of the Perak river basin, and its land development has a strong influence on the basin runoff discharge and water quality in the lower reaches. The Central and South corridors are also projected along the river course in the lower reaches, and could overlap with the possible flood inundation area. The excessive land development in the Central and South corridors may also increase the flood damage potential in the basin and further reduce the existing natural retarding effect on floods. Thus, the urban and industrial developments in the basin are closely related to the river management works, and the information on the basin development conditions could be one of the important data sources for the river basin management.

3.1.2 Development Details

Among the development components, the following detailed information is essential to the river basin management:

(1) Population Projection

Population projection by District is shown in Table III-5[1].

(2) Future Land Use

The Town and Country Planning Department, Perak State prepared the future land use plan based on the structural plan. The future land use plan is shown in Fig. III-8.

(3) Major Development Schemes

Major development projects[2] are shown in Table III-6 and Fig. III-9. They are composed of industrial, multi-sector, trade, tourism, infrastructure and special projects.

As described above, the target of the structural plan is the year 2020. If the economic situation drastically changes, the plan will be adjusted to the new situation. In this case, data renewal work will be necessary.

3.2 Mining

3.2.1 Mining History

The Kinta Valley was the world's largest alluvial tin field. Its tin field, discovered in 1880, subsequently became the most important tin-mining area in the world. The deposits consist of rich concentrations of alluvial cassiterite that have accumulated in the wide plain occupied by the Kinta River and its tributaries. In the annual report on the Perak State of 1886 it is stated that mining concessions in Kinta covered about 2,900 ha, of which 1,200 ha had been surveyed. By 1890 this figure had increased to 4,600 ha, by 1895 to 13,500 ha.

In 1892 European miners introduced hydraulic mining. In early 19th century, the steam engine and the bucket dredging were introduced successively. The introduction of new devices resulted in rapid increment of tin production.

The Kinta River, which flows through the mining area, had its course frequently altered due to mining activities. As a result, in particular the lower reaches of the Kinta River had been canalized in the 1950's based on the Kinta River Conservancy Scheme.

The tin-mining activities, however, has rapidly diminished in the recent years due to sharp drop of tin market price and exhaustion of economical mining sites. As of now tin dredges and gravel pumps can be rarely found in the State. The historical changes in number of mine workers employed are numerated in the following table.

Year	Number of Workers	Remarks
1900	50,728	in Kinta District[3]
1915	76,620	in Kinta District[3]
1950	22,043	in Kinta District[3]
1980	22,600	in Perak State[4]
1995	1,152	in Perak State[4]

As a result of tin mining, a large number of mining ponds (approx. 1,500) occur scattered throughout the previous mining areas. These range from small slime retention ponds to large deep ponds that were left behind after the mining especially when a dredge was used. Some ponds are deep and clear while others are cloudy due to suspended materials.

3.2.2 Information on Mining Activities

From the above-mentioned condition, the effects of tin-mining activities are considered minimal for the river management, although enormous rehabilitation works in the abandoned mining areas still remain. Furthermore, the tin-mining areas are delineated as a tin mining area in the GIS system of land use. Therefore, information on the mining activities is not independently dealt with in the RBIS.

3.3 Logging and Forest Conservation

3.3.1 Protection Forest

The present forest area of 9,960 km^2 spreads out in the Perak State, and the area is designated as the protection forest area managed by the Forestry Department (FD). The protection forest is further classified into seven (7) categories: (1) water catchment, (2) soil protection, (3) amenity, (4) education, (5) research, (6) forest sanctuary for wildlife, and (7) VJR [Virgin Jungle Reserve]. These protection forest areas in the State amount to 2,100 km^2, equivalent to 21% of the whole forest area. Among them, water catchment forest area accounts for 86% of the total protection forest. The water catchment forest is designated as a watershed upstream of an intake for public water supply. Among the protection forest areas, this area is considered essential for the river basin management. These areas in the State are summarized below.

Protection Forest	Number of Forests	Total Area (ha)
Water Catchment	44	181,981
Soil Protection	4	6,425
Amenity	10	7,798
Education	5	3,254
Research	4	3,059
Forest Sanctuary for Wildlife	8	1,558
VJR	13	5,929
Total	88	210,004

Data Source: Forest Department, Perak

3.3.2 Forest Reserve and Logging Activities

Forest management by FD is conducted following the three (3) hierarchic area classifications:

(a) Forest District: 4 districts in the Perak river basin

(b) Forest Reserve: 25 reserves in the Perak river basin

(c) Forest Compartment: 3,061 compartments in the Perak river basin

Forest management schemes such as logging, reforestation and forest protection are established on the unit of forest compartments. FD is recording the annual activities in each forest compartment.

On the other hand, forest in the forest reserves is classified into three (3) classes in accordance with the allowable activities:

(a) Protection Forest

(b) Virgin Forest: Logging activities are allowed but not yet started

(c) Production Forest: Logging activities are being carried out

These forest classes and forest reserve in the Perak river basin are presented in Fig. III-10.

Intensive logging activities may cause serious sedimentation of the river channel, high turbidity of river water, and hydrological changes of low flow regime and flood discharge. Thus, logging activities are closely related to the river management and the information on the forest reserve conditions is one of the important data sources for the river basin management. Furthermore, the logging activities can be quantified in any sub-basin if the geographic relationship between forest compartment and river sub-basin is established using the GIS system or database system.

3.3.3 Information on Forest Reserve and Logging

So far FD has not digitized the forest compartment boundary. According to the interview with FD, the present status of the GIS system in the Department is now under the experimental stage. A long time is still necessary for completion of the digitizing work over the country. Thus, the following stepwise program is proposed for the river information system.

(1) Operational System

The logging volume in the area will be calculated in the database system by summing up the forest management records with the relational table between forest compartment and river sub-basin. The digitizing work will be limited to the forest reserves.

(2) Future System

Upon receipt of the digitized data of forest compartment from FD, the river information system will calculate the logging volume for any area through the GIS overlay function and the summing-up of the forest management records.

Table III-7 summarizes the relationship between forest management areas and river sub-basins. The more detailed relational data in each forest compartment will be stored, together with the forest management records in the Operational System. The data items of forest management records based on the "Rancangan Tebangan (Forest Logging Plan)" are as follows. The forest management records compiled in 1997 are tabulated in the Data Book.

Item No.	Data Label
1	Forest District
2	Forest Reserve
3	Forest Compartment Code
4	Area in Ha
5	Logging Year
6	Logging Area by 30-Year Rotation Scheme
7	Logging Area by 55-Year Rotation Scheme
8	Logging Limitation for Dipterocarpaceae
9	Logging Limitation for Non-Dipterocarpaceae
10	Remarks (Protection Scheme, etc.)

Furthermore, if the above data file is owned jointly in the computer of the State Forestry Department as well as DID, the routine works, compilation of the forest management records by the Department and renewal work by DID, will be easier.

3.4 Soil Conservation

In parallel with forest management, soil conservation works, such as contour cultivation and selection of appropriate crops, are also effective against soil erosion. DOA is the responsible agency for this activity. They mainly lead the small-scale landholders of less than

100 acres (40 ha) to well-soil-conserving cultivation, while they advice the large-scale estate and plantation owners to perform the appropriate measures.

Regarding soil erosion potential, DOA is now calculating the slope factor in the whole of Malaysia, using topographic maps with a 1:25,000 scale. This work will be completed in 1999. The soil erosion potential will be quantified later on. Thus, the information on soil erosion potential has to be integrated into the future system of the RBIS.

3.5 River Reserve

3.5.1 Necessity of Geographic Information for River Reserve

The DID guideline on river reserve, "Issues Pertaining to and General Guidelines for the Gazetting of River Reserves, 1991", enumerates the following purposes of river reserves:

Item No.	Purpose
1	As space for future widening and straightening of the river
2	As space for river facilities such as revetment and embankment
3	As space for equipment and housing
4	To act as a flood plain
5	To preserve the stability of the bank
6	To act as a buffer zone against erosion
7	To allow for some erosion of the bank
8	To allow for the propagation of meanders
9	As access for operation and maintenance works
10	As working space for operation and maintenance works
11	As space for spoil dumps
12	As space for beautification works and recreation facilities

The necessary spaces for river reserve are classified in accordance with the river width. According to the guideline the width of reserve in the Perak River falls in the maximum range of 50 m on each bank. In addition to this, the reserves enveloping the well-meandered channel shall be considered in the lower reaches of the Perak River.

In order to enhance the effectiveness of river reserves, as the initial step, DID has to know the current situation of the reserves, such as boundary of a lot, area, landowner, land use and so on. For this purpose, the cadastral map should be integrated in the RBIS as one of the geographic information items.

3.5.2 Cadastral Mapping System

The Department of Lands and Mines (DOLM) handle land registration. Further, the Perak Water Board (PWB) digitize map information and store them in their computer system by Auto CAD. The Department of Survey and Mapping in Perak State prepared the original map with a scale of 66 feet to the inch (approx. 1:790). The map and attributes are renewed whenever the land registration is changed.

The cadastral map has an index in each sheet with approx. 4,000 by 5,600 m in the exact scale. In addition, the sheet is crosswise, divided into sixty-four (64) pixels (8 x 8). One pixel has dimensions of approx. 500 by 700 m in the exact scale. PWB provides the digitized data at a rate of RM 12 per pixel.

Furthermore, the NaLIS (National Land Information System) is now storing the digital data on cadastral maps and attributes. As of now, this system has not yet covered the Perak State.

Data compatibility between NaLIS and RBIS is essential for convenient data renewal in the future. NaLIS has two types of attributes from different sources. One is based on the land parcel information from DOLM, and the other is from the Local Government Department (LGD). The attributes based on DOLM are considered more useful for the RBIS, because of availability of the items stored in the database. Thus, the data structure of the system will follow the structure of DOLM. The proposed attributes of land parcels are tabulated in Fig. III-11, and an example of cadastral pixel is also shown in this figure.

3.5.3 Consideration on Usage of Cadastral Map

If the provided digitized data are intended to be utilized as polygon data in the GIS system, data conversion and manual polygon generation works will be necessary. In this case, the data renewal work will be very difficult because enormous manpower is necessary for the work. On the other hand, if the data are utilized as line data without any information, the renewal work will be limited to only conversion work from the Auto CAD system to GIS. The latter case of usage is the same as the present CAD system handled by PWB. Thus, the latter usage is recommendable from the viewpoint of easy maintenance.

Furthermore, the renewal work in the RBIS should be made as required, because of the following reasons:

(a) Land registration changes are unlikely to frequently occur in the narrow strips of river reserve areas; and

(b) RM 14,400 is needed only for purchasing the renewed data from PWB.

When NaLIS cover the Perak river basin, the maintenance work of the cadastral map will become easier and its cost will be lower because of joint ownership of the information.

3.5.4 Proposed System for River Reserve

The area of river reserve in the Perak river basin has not been actually defined yet. The following two stretches are considered most important from the flood mitigation viewpoint, since the alluvial and coastal plains extend widely in these areas:

(a) Perak River downstream of Iskandar Bridge up to the mouth; and

(b) Kinta River downstream of Anderson Bridge up to the confluence with the Perak River.

These stretches are presented in Fig. III-12, overlaying the index boundaries of the cadastral map. Based on preliminary estimate, 1,200 pixels are needed to cover the above-defined river reserves.

Considering the progress of digitizing work, the following steps are proposed to establish the system for river reserve management:

(1) Operational System

The digitized data of cadastral maps will be stored in the system by purchasing the digitized data from PWD. The necessary land registration data are collected in the related field office and are input into the Operational System.

(2) Future System

After completion of digitizing work of attributes by NaLIS, the renewal work will be made through jointly owning these attributes with NaLIS.

CHAPTER 4 CONCEPTUAL DESIGN OF THE OPERATIONAL SYSTEM

4.1 Proposed Geographic Information System

The necessary data and their availability to establish the Operational System for sound watershed management have been discussed in the preceding Chapters. The information to be stored in the system is composed of geographic data, their attributes and database of the records. Table III-8 summarizes the result of these discussions, including the future system.

4.2 Data Input and Renewal

So far the digitizing of maps enumerated in Table III-8 has not been completed yet in the related governmental agencies. Besides, the Wide Area Network (WAN) connecting the agencies has not been built yet. Under these circumstances, the data input and renewal work has to be carried out through the following manual procedure:

(a) If the map and its attributes were already digitized by the agencies, their data will be input into the hard disk by copying from the source disk to the data exchange media.

(b) If the data were not digitized, the geographic information will be digitized using digitizer and the attributes will be input manually by typing with the keyboard.

For establishment of the Operational System, the appropriate data input and renewal work is tabulated in Table III-9, considering the data source conditions. These are summarized below.

Data Input	Map/Table	Data Renewal	
		Item	Interval
Copy of Digitized Data	Soil Map	Urban Area	5 Years
	Land Use Map	Land Use	5 Years
	Cadastral Map	Land Parcel	As needed
Digitizer Input	Topographic Map	Roads, etc.	More than 10 Years
	Geological Map	-	-
	Future Land Use Map	Land Use	Occasion of New Planning
	Major Projects	Project Location	Occasion of New Planning
	Forest Reserve	-	-
Keyboard Input	Population Projection	Population	Occasion of New Projection
	Logging Record	Logging Record	1 Year
	Land Registration	Parcel Data	As needed

4.3 Data Dissemination

The original information related to watershed management, such as land use, structural plan, logging activities and land registration, should be limited to exclusive use within the governmental agencies from the following reasons:

(a) DOA sells land use map at a rate of RM 50 per sheet, so that attention should be paid not to disturb their services;

(b) Structural plan is an internal information within the governmental agencies because of avoidance of land speculation;

(c) FD controls logging activities, so that it should decide information dissemination to the public; and

(d) Land registration information is limited to the narrow strips of river reserve area, so that necessity of dissemination to the public is not considered high.

On the other hand, dissemination of the following image data is appropriate for enhancement of common knowledge on the Perak river basin to the public:

(a) Roughly delineated land use;

(b) Strategic development corridor; and

(c) Forest protection area.

Table III-10 summarizes the information to be disseminated to users. The details are described below.

(1) Land Use

Land use maps are used not only for river planning but also for water-related planning such as urban, irrigation, water supply and sewage planning. The information used for the planning includes distribution of land use and the area estimated in each land use pattern. Distribution will be made clear through the map itself. Quantitative areas can be computed using GIS applications. Thus, polygon data should be disseminated to the government agencies for this purpose.

On the other hand, the rough image data, as raster type data, should be disseminated to the public for the purpose of enhancement of common knowledge on the river basin.

(2) Regional Development

The following information can be disseminated concerning regional development.

Item No.	Name	Data Type	Attributes	Reference	Limitation of Usage
1	Development Corridors	Raster	-	Fig. III-7	Public
2	Future Land Use	Polygon	Land Use	Fig. III-8	Govt.
3	Major Projects	Point	Explanation Table	Fig. III-9, Table III-6	Govt.

Regarding the dissemination of information, the development corridor should be disseminated to the public, through the Internet, for enhancement of common knowledge on the river basin. On the other hand, future land use and major projects should be limited to only governmental use to avoid undesirable effects such as cornering land and land speculation.

(3) Logging and Forest Conservation

The following information concerning forest management and logging activities can be disseminated.

Item No.	Name	Data Type	Attributes	Reference	Limitation of Usage
1	Forest Reserve and	Raster	-	Fig. III-10	Public
	Protection Forest	Polygon & Point	Name, Area	Ditto	Govt.
2	Forest Management Record	Database	-	Data Book	Govt.
3	Logging Volume	Table & Graph	-	Fig. III-13	Govt.

Forest reserve, in particular, protection forest should be disseminated to the public as raster type data, through the Internet, for enhancement of common knowledge on the river basin. On the other hand, the polygon and point data of this information will be disseminated to the government agencies to establish a well-balanced management among DID, FD and related agencies.

The logging activities are controlled by FD, so that the decision on dissemination to the public should be decided by FD. The forest management records stored in the system should be owned jointly by both agencies, DID and FD to make the renewal work easier.

Using relational table between the river sub-basin and the forest compartment, the historical logging volume in the area can be calculated by sub-basin and forest reserve. Fig. III-13 presents an example of the historical logging volume by river sub-basin.

(4) River Reserve

Information on land registration stored in the RBIS is limited to the narrow strips of river reserve area, so that the necessity of dissemination to the public is not considered high. Thus, this information can be limited to government use only.

The following data are disseminated to the government agencies.

Name	Data Type	Attributes	Reference	Limitation of Usage
Cadastral Map	Line	-	Fig. III-11	Govt.
	Point	Land Registration		

CHAPTER 5 CASE STUDY ON SYSTEM USAGE FOR WATERSHED MANAGEMENT

5.1 Purpose of the Study

Watershed management aims to restore or enhance productivity through the prevention of permanent and irreversible deterioration of soil fertility. In order to attain a sound waterway management, continuous and effective efforts on watershed management is also essential to reduce sedimentation along the irrigation channels and river courses. In this context, DOA, the responsible agency for soil conservation, FD, the responsible agency for logging activities as the major cause of soil erosion, and DID have to cooperate with each other for the achievement of effective watershed management. The computer network such as the RBIS can strengthen the cooperation among the agencies concerned. This section will present how the RBIS can be utilized for the watershed management.

5.2 Procedure of Erosion Control

Focusing on river management, the major concern should be placed on erosion control in the watershed. The typical procedure of erosion control, in particular soil loss computation using the RBIS is explained in this Chapter. The Universal Soil Loss Equation (USLE), which was developed in the United States in the 1960's, is a worldwide applicable model for soil loss calculation. Thus the USLE is adopted in the study.

The procedure of estimation is presented in the following chart.

Data Collection and Basic Analysis
- division of watershed into sub-basins
- measurement of slope length and gradient in sub-basin
- hourly rainfall and simple calculation
- soil cover, soil mechanical data, land use

↓

Estimation of Annual Soil Loss by Using USLE
- preparation of iso-erodent map or classification of soil loss

↓

Evaluation of Incremental Soil Loss Caused by Logging Activities
- changing cropping management factor

↓

Recommendation of Appropriate Soil Conservation Measures
- changing erosion control practice factor

5.3 Methodology of Soil Loss Estimate

The following are brief explanations for the basic equation and component factors.

(1) Basic Equation

The basic equation of Universal Soil Loss Equation (USLE) is written as:

$$A = RKLSCP$$

Where, A is the computed soil loss per unit area; and R is the rainfall factor expressing the erosion potential of rainfall in the locality (also called index of erosivity or erosion index). On the other hand, K is the soil erodibility factor representing the average soil loss per unit of rainfall factor R from a particular soil in cultivated continuous fallow on a 9% slope and 22.1 m long. L and S are the topographic factors for adjusting the estimate of soil loss for a specific land length of slope (L) and gradient (S). C is the cropping management factor representing the ratio of soil quantity eroded from land that is cropped under identical slope and rainfall conditions. P is the erosion control practice factor representing the ratio of soil loss with contouring, strip-cropping or terracing to that with straight-row farming.

(2) Rainfall Factor (R)

The rainfall factor R is Wischmeier's erosion index (EI_{30}-index), i.e., the total kinetic energy of rainstorm (E) times its maximum intensity over 30 minutes (I_{30}), divided by 100. In order to arrive at the total kinetic energy, the precipitation is divided into periods with approximately the same rainfall intensity. For each period the kinetic energy is calculated according to:

$$E = 210.2 + 89 \log I,$$

Where,

E = kinetic energy in Joules/m^2 per cm of rain.

I = average rainfall intensity of the considered period in cm/hr.

The kinetic energy calculated for each period is multiplied by the cm of rain (r) that fell during that period. Finally the total kinetic energy is calculated through summation of these products. To obtain the R value, the total kinetic energy is multiplied by twice the maximum average 30-minute intensity (I_{30}) and divided by 100.

$$R = \sum(E \times r) \times 2\, I_{30} / 100$$

(3) Soil Erodibility Factor (K)

The soil erodibility factor K had been evaluated on experimental plots by solving the equation K = A/(RLSCP). A nomograph was subsequently devised that enabled evaluation of the K-value from five simple soil parameters:

(a) percent silt + very fine sand (0.002 mm - 0.10 mm particle size);

(b) percent sand (0.10 mm - 2.0 mm particle size);

(c) percent organic matter;

(d) structure; and

(e) permeability.

Structure is coded as: 1 = very fine granular and very fine crumb (< 1 mm); 2 = fine granular and fine crumb (1 mm - 2 mm); 3 = medium granular, medium crumb (2 mm - 5 mm) and coarse granular (5 mm - 10 mm); and 4 = platy, prismatic, columnar, blocky and very coarse granular.

Permeability is also coded as: 1 = rapid to very rapid; 2 = moderately rapid; 3 = moderate; 4 = moderately slow; 5 = slow; and 6 = very slow.

The soil-erodibility nomograph is presented in Fig. III-14. The procedure for evaluating the Kfactor with this graph is as follows:

(a) Enter the nomograph on the vertical scale at the left with the appropriate percentage silt + very fine sand.

(b) Proceed horizontally to intersect the correct percent-sand curve, interpolating to the nearest percent.

(c) Proceed vertically to the correct organic matter content.

(d) Proceed horizontally to the right.

(e) For soils with a fine granular or fine crumb structure and moderate permeability; the value of K can be read directly from the first approximation of K scale on the right hand edge of the first section of the nomograph.

(f) For all other soils, continue horizontally to intersect the correct structure curve.

(g) Proceed vertically to the correct permeability curve.

(h) Proceed horizontally to the soil-erodibility scale on the left-hand edge of the second section of the nomograph to read the value of K.

(4) Slope Length Factor: L and Slope Gradient Factor: S

Slope length is defined as the distance from the point of origin of overland flow to either of the following: (a) the point where the slope decreases to the extent that deposition begins, or (b) the point where runoff enters a well defined channel that may be part of a drainage network or a constructed channel such as a terrace of diversion. For practical estimate, the combined effect for slope length and slope gradient can be calculated according to the following equations:

(a) For slopes up to 20% and 350 m long:

$$LS = \lambda 0.5\ (0.0138 + 0.00965s + 0.00138s2)$$

(b) For slopes from 10% up to 50% and up to 800 m long:

$$LS = (\lambda / 22.1)^{0.6} \times (s / 9)^{1.4}$$

Where, λ = field slope length (m), s = slope gradient (%)

(5) Cropping Management Factor (C)

Cropping management factor C describes the total effect of vegetation, residue, soil surface and management on soil. The value of C needs to be established experimentally in many cases.

For permanent pasture, range lands, idle lands and woodlands, tables have been published from which the average annual C value can be read. These tables are reproduced as Table III-11 and Table III-12.

(6) Erosion Control Practice Factor: P

The effect of erosion control measures is thought to be an independent variable, therefore, it is not included in the cropping management factor. The soil loss ratios for erosion control practices vary according to slope gradient. Soil loss ratios for contouring, contour stripcropping and terracing are given in Table III-13.

(7) Sediment Delivery

Not all of the eroded material is effectively sluiced through the river system and delivered to the sea. The rate at which sediment is discharged to the oceans is usually less and often much less than one-fourth of the rate at which it is eroded from the land surface.

The ratio of soil loss from hillsides to the sediment yield of a catchment is called the sediment delivery ratio of the catchment. The ratio varies with drainage basin size, and with the overall steepness of the catchment. If local data are available, the variation of sediment yield with these factors can be quantified, but if such data are lacking, Fig. III-15 may be used to estimate the sediment delivery ratio.

5.4 Utilization of the RBIS for Soil Loss Calculation

(1) Information Stored and to be Stored in the RBIS

Concerning watershed management, so far, the Operational System of the RBIS contains the following information:

(a) Topographic information based on the topo-map with a scale of 1:50,000;

(b) Recorded real-time rainfall received from fourteen (14) gauges;

(c) Soil cover based on the reconnaissance soil map;

(d) Current land use based on the sources in 1990;

(e) Forest conservation information based on the map with a scale of 1:63,360; and

(f) Logging data file compiled in 1997 by FD.

Further the RBIS will obtain the following detailed information related to watershed management in the future:

(a) Digital Topo-map with a Scale of 1:50,000

The limited data were digitized from the 1:50,000 topo-map and were stored in the Operational System because of the limited time and budget. In particular, the contour lines were digitized at 100 m interval in the areas located above 100 m in elevation.

On the other hand, the digitizing works on topographic maps with a scale of 1:50,000 are now being carried out by DSMM, and will be completed by the year 2002. After compilation of the digital map in the area covering the Perak river basin, the RBIS can store or link to the full-scale digital map.

(b) Semi-detailed Soil Map

The semi-detailed soil map is being surveyed at present. This survey is based on the topo-map with a scale of 1:25,000 and sampling density is a 1 km interval. The semi-detailed soil map is considered as the appropriate data from the required accuracy for soil loss calculation, although a long time is still necessary for completion of this database system.

(c) Forest Reserve Map

The Operational System stores the digitized data of forest compartment of which the boundaries are drawn on a blank map with a scale of 1:63,360. Therefore, the accuracy of boundary data is considered to be low. However, FD is planning to digitize the forest compartment map drawn on the topo-map with a scale of 1:50,000. After completion of the digitized work, the RBIS can store or link to the more accurate digital map.

(2) Present Status for estimation of Erosion Factors

As described in the Item (1), most of the digitized data cannot be completely prepared in the Operational System for the purpose of soil loss calculation. These conditions are summarized in the following table, and calculation procedure of each factor is explained thereafter.

Erosion Factor	Present Status	Future Prospect
Rainfall (R)	completed	-
Soil Erodibility (K)	not available	integrating the information on semi-detailed soil map
Slope Length (L) & Slope Gradient (S)	not available	integrating the survey results being executed by DOA
Cropping Management (C)	additional survey - clarification through field survey	data renewal for the current land use
Erosion Control Practice (P)	additional survey - collection of field information	data renewal for the current practice

Rainfall Factor R

The RBIS stores hourly rainfall data received from the fourteen (14) automatic rainfall gauges. Using these data, the calculation process of rainfall factor R for annual value is described below.

(a) Selection of Hydrological Average Year

Among the stations observing daily rainfall, three (3) rainfall stations are selected considering their locations in the entire basin, recording periods and data availability. These are Bikam (No. 4012143), Telok Sena (No. 4209093) and Bekalan Talang (No. 4708084).

Their annual rainfall series are tabulated and delineated in Fig. III-16. Comparing average annual rainfall and annual values at each station, the year 1979 is selected as a hydrological average year of which annual values approximate the average values at all of the three stations.

(b) Selection of Rainfall Stations from Data Availability

Among the fourteen (14) stations observing hourly rainfall, the rainfall data of only four (4) stations are available for further calculation of R factor. The data of the other ten (10) stations are composed of missing data in some parts. The stations selected are Telok Intan (No. 4010001), Telok Sena (No. 4209093), Pejabat Daerah Kampar (No. 4311001) and Kubang Haji (No. 4409091).

(c) Selection of Storms

For calculation of R factor, the representative storms are selected at each station, judging from the following criteria:

(i) having an intensity of more than 25 mm/hr in a continuous rain (If the rain stops for more than three hours, the rains in both sides of the non-rainfall period are regarded as different rain groups.); or

(ii) having a total amount of more than 25 mm in a continuous rain.

(d) Estimation of R factor

The annual rainfall factor R is calculated at each rainfall station following the equations as explained in the section of 5.3 (2). The estimate results are presented in Fig. III-17.

As shown in Fig. III-17, the rainfall stations being able to provide the available data for R estimation are only limited in the areas with relatively low altitudes. On the other hand, major problems concerning soil erosion are occurring on the hill and mountain slopes. Thus the following continuous efforts are necessary to increase the accuracy of R estimation and, further, to strengthen the watershed management:

(i) denser rainfall observatory network covering the hills and mountains, and

(ii) more proper rainfall observation for lessen the data missing periods.

Soil Erodibility Factor K

As described in Section 5.3(3), five parameters are necessary to estimate the soil erodibility factor K, namely, percent silt + very fine sand, percent sand, percent organic matter, structure and permeability. After completion of the soil sampling survey being carried out in parallel with the semi-detailed soil map preparation, these data will be available.

Slope Length Factor L and Slope Gradient Factor S

At present DOA is estimating these factors in the whole Malaysia, using topographic map with a scale of 1:25,000. This work will be completed in 1999. The information on the work results can be utilized in the RBIS.

Cropping Management Factor C

Based on the current land use map, each land use category except for residential use and urban areas has to be converted to the value of C. The additional survey is necessary in order to establish the relationship between land use type and cropping conditions of canopy and vegetation cover. For this purpose, sampling survey using remote sensing or aerial-photo interpretation combined with field survey may be a suitable method.

Erosion Control Practice Factor P

Soil conservation works such as contouring and selection of appropriate crops are being executed to the small-scale landholders or advised to the large-scale estate and plantation owners by DOA. However, these data has not been compiled for the database system.

(3) Concept of Future RBIS Utilization for Erosion Control

In order to attain the effective watershed management, the Operational System, in particular, the stored data, has to be upgraded as described before. In parallel with necessary improvement of the RBIS, the database system of the related agencies such as DOA and FD will also be upgraded, including the spatial data for the GIS system.

In this context it is considered to be advantageous that the RBIS has a linkage to the related database of DOA and FD instead of storing the necessary data by copying from the database. The concept is illustrated in Fig. III-18. In this figure the soil loss tolerance is mentioned. This value should be established in the further study judging from the following factors:

(a) Sedimentation in the water control structures such as open ditches, ponds, irrigation canals;

(b) Occurrence of excessive sheet erosion, accompanied by gully formation; and

(c) Loss of plant nutrients.

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(6) Perangkaan Utama Negeri Perak (Principal Statistics of Perak State), 1996, Economic Planning Unit, Perak State

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(8) Perak Menjanjikan Emas, 1996, Mustaffa Ismail

TABLE

Table III-1 GEOLOGICAL INFORMATION STRUCTURE

Geographic Features	Attributes	
	Category	Geological Classification
Polygon	Geological Age	Quaternary
		Tertiary
		Cretaceous-Jurassic
		Triassic
		Permian
		Carboniferous
		Devonian
		Silurian-Ordovician
		Cambrian
	Lithology (Unconsolidated Deposits)	Sand (mainly marine)
		Clay and Silt (marine)
		Peat, Humic Clay and Silt
		Clay, Silt, Sand and Gravel (undifferentiated, continental)
	(Sedimentary and Metamorphic Rocks)	Shale, Mudstone, Siltstone, Phyllite, Slate and Hornfels
		Sandstone/Metasandstone
		Conglomerate
		Limestone/Marble
		Schist
	(Extrusive Rocks)	Ignimbrite
		Acid to Intermediate Volcanics (mainly pyroclastics, rhyolitic to dacitic composition)
		Intermediate to Basic Volcanics (mainly pyroclastics)
	(Intrusive Rocks)	Vein Quartz
		Acid Intrusives (undifferentiated)
		Intermediate Intrusives (undifferentiated)
		Basic Intrusives (mainly gabbro)
		Ultrabasic Intrusives (commonly altered to serpentinite)
Line		Fault

Source : Geological Map of Peninsular Malaysia, Department of Geological Survey of Malaysia

Table III-2 SOIL COVER CLASSIFICATION

Topography		Soil Label
Alluvial Soil	on Coastal Plains	1. Rudua-Rusila, 2. Keranji, 3. Linau-Sedu, 4. Tuluk-Guar, 5. Selangor-Kangkung, 6. Cengai
	on Coastal Plains and/or Riverine	7. Kangar, 8. Beriah-Organic Clay & Muck, 9. Organic Clay & Muck, 10. Peat
	on Riverine Flood Plains and/or Low Riverine Terraces	11. Telemung-Akob-Lanar Tempatan, 12. Tok Young-Cempaka-Lundang, 13. Lubuk Itik-Lubuk Sendung, 14. Batu Hitam-Tepus-Sungai Amin, 15. Hutan-Sungai Amin
	on Intermidiate and Higher Terraces	16. Sogomana-Sitiawan-Manik, 17. Cerang Hangus-Lubuk Kiat, 18. Holyrood-Lunas, 19. Kelau-Kawang, 20. Harimau-Tampoi
Sedentary Soil	on Undulating Plains to Rolling Land	21. Batu Enam-Durian, 22. Batu Enam-Melaka-Tavy, 23. Marang-Apek, 24. Marang-Batu Enam-Bungor, 25. Melaka-Tavy-Gajar Mati, 26. Melaka-Durian-Muncung, 27. Durian-Melaka-Tavy, 28. Muncung-Seremban, 29. Muncung-Serdang, 30. Bungor-Muncung, 31. Serdang-Bungor-Muncung, 32. Rengam-Jerangau, 33. Rengam-Tampin, 34. Segamat-Katung, 35. Kuantan, 36. Perang, 37. Batang Merbau-Muncung, 38. Langkawi
	on Rolling and Low Hilly Land	39. Durian-Muncung-Bungor, 40. Bungor-Durian, 41. Cenian, 42. Jenpol, 43. Kulai-Yong Peng, 44. Kuala Berang-Kedah-Serdang, 45 Pohoi-Durian-Tavy, 46. Serdang-Kedah, 47. Rengam-Kala, 48. Rengam-Bukit Temiang
	on Hills and Mountains	49. Tanah Curam
Urban and Mined Land		50. Urban Area, 51. Mined Area, 52. Water Surface

Source : Reconnaissance Soil Map, Department of Agriculture

Table III-3 LAND USE CONDITIONS IN PERAK RIVER BASIN IN 1980 AND 1990

Classification of Land Use	Area in 1980		Area in 1990	
	(ha)	(%)	(ha)	(%)
1 Settlement and Associated Non-Agriculture Lands	**889**	**5.86**	**821**	**5.41**
1 - 1 Urban and Associated Area			187	1.23
1 - 2 Estate Building and Associated Areas			4	0.03
1 - 3 Tin Mining Areas			601	3.96
1 - 4 Power Line Right of Ways			29	0.19
2 Agricultural Area (Non-Paddy Area)	**2,916**	**19.21**	**3,642**	**23.99**
2 - 1 Horticulture			319	2.10
2 - 2 Rubber			1,944	12.81
2 - 3 Palm			1,100	7.24
2 - 4 Others			279	1.84
3 Paddy Area	**145**	**0.96**	**271**	**1.79**
4 Forest Lands	**10,320**	**67.98**	**9,490**	**62.52**
4 - 1 Forest			8,953	58.98
4 - 2 Scrub Forest			344	2.27
4 - 3 Recently Cleared Land			32	0.21
4 - 4 Grass Land			159	1.05
4 - 5 Pasture			1	0.01
5 Swamps, Marshlands and Wetland Forests	**910**	**5.99**	**661**	**4.36**
5 - 1 Wetland and Associated Forest			486	3.20
5 - 2 Unused Land			175	1.15
6 Non-classified			**295**	**2.99**
TOTAL	**15,180**	**100**	**15,180**	**100**

Source : Land use map prepared by DOA in 1990 and National Water Resources Study in 1982 by JICA

Table III-4 CATEGORY FOR LAND USE MAPPING

Land Use Category		Code No.	Label Name
Settlement and Associated Non-Agricultural Area	Urban and Associated Area	10	1U
	Estate Buildings and Associated Area	11	1E
	Tin Mining Area	12	1T
	Other Mining Area	13	1X
	Power Line	14	1P
	Cemetry	101	1U(C)
	Recreational Land	102	1U(R)
	Poultry Farm	103	1U(P)
	Road or Highway	104	1U(J)
	Railway	105	1U(K)
	Saw Mill	106	1U(T)
Horticultural Land	Agriculture Experimental Station	20	2E
	Mixed Horticulture	21	2H
	Market Gardening	22	2M
Tree, Palm and Other Permanent Crops	Rubber	30	3G
	Oil Palm	33	3O
	Coconut	36	3C
	Pineapple	39	3N
	Cocoa	40	3A
	Banana	41	3B
	Fiber Crops	42	3F
	Fish and Hyacinth Pond	43	3H
	Coffee	44	3K
	Pepper	45	3P
	Arecanut	46	3R
	Sago	47	3S
	Tea	48	3T
	Orchards	49	3X
	Sugar Cane	50	3Y
Cropland	Diversified Crops	51	4C
	Paddy	52	4P
	Shifting Cultivation	53	4X
	Tobacco	54	4T
Permanent Pasture/Improved Grassland		59	5
Grassland	Scrub Grassland	60	6
	Grass Covered Erosion Scar	61	6E
Forest Land	Newly Cleared Land	70	7C
	Forest	71	7F
	Scrub Forest	72	7S
	Reclaimed Land	73	7T
	Treated Forest	711	7F(T)
Swamp (Mangrove, Gelam, Nipah, etc.)		80	8
Unused Land	Unused Land	90	9
	Water (Lake and Pond)	98	Water
	Unclassified	99	UN

Source : Department of Agriculture

Table III-5 POPULATION PROJECTION IN PERAK STATE

District	1991		2000		2010		2020		Growth Rate (1991/2020)
	Population	Percentage (%)	Population	Percentage (%)	Population	Percentage (%)	Population	Percentage (%)	
Kinta	628,303	33.4	741,145	34.2	888,744	35.0	1,105,917	35.7	1.97
Kuala Kangsar	146,684	7.8	167,079	7.7	197,778	7.8	240,400	7.8	1.72
Hulu Perak	81,524	4.3	88,331	4.1	93,488	3.7	111,911	3.6	1.10
Hilir Perak	202,227	10.8	219,666	10.1	235,069	9.2	289,341	9.3	1.24
Perak Tengah	75,676	4.0	82,500	3.8	95,600	3.8	108,200	3.5	1.24
Manjun	168,457	9.0	199,400	9.2	249,800	9.8	307,800	9.9	2.10
Kerian	148,575	7.9	162,950	7.5	185,650	7.3	208,800	6.7	1.18
Larut Matang & Selama	272,006	14.5	328,779	15.2	391,735	15.4	474,900	15.3	1.94
Batang Padang	156,514	8.3	178,877	8.2	203,940	8.0	252,732	8.2	1.67
Total	1,879,966	100.0	2,168,727	100.0	2,541,804	100.0	3,100,001	100.0	1.74

Source : Rancangan Struktur Sebahagian Daerah Kinta (Kinta District Structure Plan), 1996

Table III-6 MAJOR DEVELOPMENT SCHEMES IN PERAK RIVER BASIN (1/3)

No.	Sector	Name	Owner	Location	Area (ha)	Cost (million RM)
1	Industry	Alor Bakong Integrated Development Project, Mk. Changkat Jong	MAJUPERAK Co., Ltd.	Langkap, Teluk Intan, Daerah Hilir Perak	77.3	50
2		Chemor Ceramic Park	PKNP	Jl. Jelapang, Chemor, Daerah Kinta	90.7	20.6
3		Fondari Park	PKNP	Estet Perindustrian Pengkalan II, Daerah Kinta	32.8	6.3
4		Tambun Industrial Estate	PYP Sdn., Ltd.	Tambun, Daerah Kinta	128.5	500
5		Bercham Industrial Estate	Sumitomi Sdn., Ltd.	Bercham, Daerah Kinta	4.1	6.4
6		Gopeng Industrial Park	Gopeng Land & Properties Sdn., Ltd.	Mk. Teja & Mk. Sg. Raya, Daerah Kinta	60.7	21.6
7		Tungxen Industrial Estate, Simpang Pulai, Ipoh	Tungxen Development Sdn., Ltd.	Batu 8, Mk. Sg. Raya, Daerah Kinta	40.5	7
8		IKS Industrial Estate, Kuala Kangsar	MIEL Sdn., Ltd.	Mk. Lubok Merbau/Kota Lama Kiri, Daerah kuala Kangsar	40.9	111.9
9		Seri Iskandar Technology Park	Palmshine Development Sdn., Ltd. & Majlis Daerah Perak Tengah	Bandar Baru Seri Iskandar, Daerah Perak Tengah	61.1	200
10		Seri Iskandar Pharmaceutical Park	PKNP	Bandar Baru Seri Iskandar, Daerah Perak Tengah	114.3	29.5
11	Multi-Sector	Tapah New Town Development	Permodalan Perak, Ltd.	Tapah, Daerah Batang Padang	728.57	1,400
12		PKNP Complex, Meru Raya	PKNP	Taman Meru, Ipoh, Dareah Kinta	11.7	75.74
13		Greentown New Town Development	IZIN Develpoment Sdn., Ltd.	Greentown, Bandaraya Ipoh	35.6	100
14		Tronoh Water Sports Complex	Lembayung Sukma Sdn., Ltd.	Tronoh, Daerah Kinta	477.6	1,000

Source : Perangkaan Utama Negeri Perak 1996 (Principal Statistics of Perak State 1996)

Table III-6 MAJOR DEVELOPMENT SCHEMES IN PERAK RIVER BASIN (2/3)

No.	Sector	Name	Owner	Location	Area (ha)	Cost (million RM)
15	Multi-Sector	Kinta Highland Development Project	Rimba Raya Sdn., Ltd.	Dataran Tinggi Kinta	1,355.7	2,500
16		Tasek Perdana Town Center, Batu Gajah	Syarikat Maju Perak, Ltd.	Batu Gajah, Daerah Kinta	512.3	400
17		Lapangan Hill City Condominium	MORUBINA Sdn., Ltd.	Jl. Gopeng, Daerah Kinta	1.6	18
18		Seri Iskandar Town Development	SIDEC Sdn., Ltd.	Bandar Baru Seri Iskandar, Daerah Perak Tengah	4,047	20,000
19		Bagan Datoh Beach Development	Innovest Sdn., Ltd.	Bagan Datoh Daerah Hilir Perak	566.3	3,700
20	Trade	Medan Gopeng Business Complex, Ipoh (Megoplex Medan Gopeng)	PKNP	Jl. Gopeng, Ipoh, Daerah Kinta	0.6	15.2
21		Galaria Expo-Site, Ipoh (Silveritage Galleria)	PKNP	Jl. Gopeng, Ipoh, Daerah Kinta	4.5	12
22		Meru Raya Town	PKNP	Persimpangan Bertingkat Jelapang-Chemor, Daerah Kinta	461	1,478
23		Ipoh Metro Town	Intan Payung Sdn., Ltd.	Jl. Sultan Azlan Shah, Dareah Kinta	23.5	80
24		Ipoh Pulai Town	Desa Chandan Sdn., Ltd.	Simpang Pulai, Daerah Kinta	40.5	40
25		Ipoh Raya Town	KRIS Properties	Jl. Raja Muda Aziz, Ipoh, Daerah Kinta	8.1	10.4
26		Teluk Intan New Town	Bukit Mewah Development Sdn., Ltd.	Teluk Intan, Daerah Hilir Perak	11.5	180
27	Tourism	Sunway City	Kinta Valley Resort & Sunway Town	Tambun, Perak, Daerah Kinta	544.7	830.6
28		Gua Tempurung Development	Heritage Acres Sdn., Ltd.	Kg. Gunung Mesah, Daerah Kinta	2,428	500
29		Chenderoh Lake Golf Course Development, Lenggong, Perak	Land & General, Ltd.	Lengong, Daerah Hulu Perak	428.1	141

Source : Perangkaan Utama Negeri Perak 1996 (Principal Statistics of Perak State 1996)

Table III-6 MAJOR DEVELOPMENT SCHEMES IN PERAK RIVER BASIN (3/3)

No.	Sector	Name	Owner	Location	Area (ha)	Cost (million RM)
30	Special Project	Asean Medical College, Ipoh (Kolej Perubatan Antarabangsa)	Suci Teguh Holdings Sdn., Ltd.	Ipoh (Belakang Hospital Ipoh), Daerah Kinta	2.4	40
31		Hospital Pantai Puteri	Paloh Medical Centre Sdn., Ltd.	Jl. Tambun, Ipoh, Daerah Kinta	1.1	24.8
32		University Commonwealth of Malaysia	Renong, Ltd	Bandar Baru Tapah, Daerah Batang Padang	1,249.7	1,000
33		Petronas Technology Institute	Petronas Property Management Service Sdn., Ltd.	Seri Iskandar, Daerah Perak Tengah	404.7	18
34		Office & Staff Housing Project of Perak Govt. Service	UDA Holdings Sdn., Ltd.	Mk. Sg. Terap, Daerah Kinta	242.3	160
35		Education Valley and Tourism Town	Gopeng, Ltd.	Bandar Gopeng, Daerah Kinta	3,657.3	2,652.5
36		New Privatised Complex of Perak	Konsortium Suvla Lines Sdn., Ltd.	Ipoh, Daerah Kinta	607.05	500
37		Perak Science Park of Education University		Kuala Kangsar	404.7	1,000

Source : Perangkaan Utama Negeri Perak 1996 (Principal Statistics of Perak State 1996)

Table III-7 RELATIONSHIP BETWEEN RIVER BASIN DIVIDE AND FOREST MANAGEMENT AREA

River Sub-Basin	Forest Management			
	Forest District	Forest Reserve	Number of Forest Compartment	Forest Area (km^2)
Temengor	Hulu Peark	Belum	382	1,336.15
		Temengor	258	1,488.70
		Gerik	23	95.57
		Total	663	2,920.42
Chenderoh	Hulu Peark	Gerik	60	276.63
		Papulut	72	123.40
		Lepang Menering	18	38.04
		Padang Chong	10	12.04
		Bintang Hijau	232	585.07
		Air Cepam	51	230.92
		Gunung Lang	8	14.19
		Belukar Semang	40	90.74
		Sungai Kuak	15	14.99
		Kenderong	45	66.19
	Kuala Kangsar	Piah	237	546.58
		Bintang Hijau	23	55.06
		Total	811	2,053.85
Pelus River	Kuala Kangsar	Piah	123	211.39
		Korbu	311	890.97
		Kledang Saiong	24	31.46
		Total	458	1,133.82
Upper Perak (Remaining Basin)	Kuala Kangsar	Piah	9	16.67
		Bintang Hijau	23	37.93
		Total	32	54.60
Kinta River	Kinta/Manjung	Bukit Kinta	360	691.84
		Kledang Saiong	72	100.43
		Parit	37	21.68
	Perak Selatan	Bujang Melaka	16	30.44
		Bukit Tapah	14	40.56
		Total	499	884.95
Bidor River	Perak Selatan	Bikam	4	4.01
		Bukit Slim	31	99.94
		Bukit Tapah	213	597.52
		Chikus	34	20.53
		Gunung Besout	9	15.91
		Total	291	737.91
Lower Perak	Kuala Kangsar	Kledang Saiong	140	165.17
		Bubu	121	180.29
		Bintang Hijau	6	19.25
	Kinta/Manjung	Kledang Saiong	22	22.28
		Parit	18	20.20
		Total	307	407.19
Grand Total			3,061	8,192.74

Source : Estimation was made using Forest Compartment Map and "Rancangan Tebangan" provided by Forestry Department, Perak State.

Table III-8 NECESSARY WATERSHED INFORMATION FOR ESTABLISHMENT OF RIVER INFORMATION SYSTEM

Theme	Map (Scale)	Agency as Data Source	Renewal Interval	Components of Map Information			System Construction Program	Existence of Digital Data
				Component	Type	Attributes		
Topography	Topographic Map (1:50,000)	DSMM	More Than 10 Years	Contour	Polygon	Altitude	Operational	Under Preparation
				Geographic Features	Polygon/Line /Point	Name		
Geology	Geological Map (1:500,000)	DGSM	Unnecessary	Classification	Polygon	Class	Operational	Non
				Fault	Line	-		
Soil Cover	Soil Map (1:500,000)	DOA	Unnecessary	Classification	Polygon	Class	Operational	Existing
Land Use	Land Use Map (1:50,000)	DOA	5 Year	Classification	Polygon	Class	Operational	Existing
Regional Development	Future Land Use Plan (1:250,000)	TCPD	Target Year : 2020	Classification	Polygon	Class	Operational	Non
				Development	Point	Explanation		
				Population	-	Table		
Logging/ Forest Conservation	Forest Reserve Map (1:50,000)	FD	1 Year (Only Data Base)	Forest Reserve	Polygon	Name	Operational	Non
				Logging Record	-	Table		
				Compartment	Polygon	Name	Future	Planning in Future
Soil Conservation	Soil Erosion Map (1:25,000)	DOA (Under Studying)	Unnecessary	Classification	Polygon	Erosion Rate	Future	Planning in Future
River Reserve	Cadastral Map (1:790)	DOLM	Occasion at Need	Land Parcel	Line	Lot No	Operational	Existing (Only Map)
		PWB		Land Parcel	Polygon	Parcel Data	Future	Planning in Future

Table III-9 DATA INPUT AND RENEWAL SYSTEM OF WATERSHED INFORMATION

Theme	Map (Scale)	Data Source	Data Form	Existence of Digital Data	Data Input Measures	Necessary Interval of Data Renewal	Data Volume (Approx. Sheet Size)
Topography	Topographic Map (1:50,000)	DSMM	Map & Attributes	Non	Digitizer Input	More Than 10 Years	28 Sheet (A2)
Geology	Geological Map (1:500,000)	DGSM	Map & Attributes	Non	Digitizer Input	Unnecessary	1 Sheet (A2)
Soil Cover	Soil Map (1:500,000)	DOA	Map & Attributes	Existing	Copy	Unnecessary	1 Sheet (A2)
Land Use	Land Use Map (1:50,000)	DOA	Map & Attributes	Existing	Copy	5 Years	28 Sheets (A2)
Regional Development	Future Land Use Plan (1:250,000)	TCPD	Map & Attributes, Table (Population Projection)	Non	Digitizer & Keyboard Input	Target Year : 2020	2 Sheets (A2)
Logging/ Forest Conservation	Forest Reserve Map (1:50,000)	FD	Map & Attributes, Table (Logging Records)	Non	Digitizer & Keyboard Input	Unnecessary Table : 1 Year	1 Sheet (A1) 4,000 Compartments in Perak State
River Reserve	Cadastral Map (1:790)	PWB	Map & Attributes,	Existing	Copy	Occasion at Need	1,200 Sheets (A1)
		DOLM	Table (Land Registration)	Non	Keyboard Input		55,000 Parcels

Table III-10 SUMMARY OF WATERSHED INFORMATION TO BE DISSEMINATED BY RBIS

Information Item	Map/Data	Data Type	Attributes/ Data Item	Dissemination Level*	Remarks
Land Use	Land Use Map	Raster	-	Level 2	Image Data
		Polygon	Land Use	Level 1	
Regional Development	Development Corridor	Raster	-	Level 2	Image Data
	Future Land Use	Polygon	Land Use	Level 1	
	Major Project	Point	Project Explanation	Level 1	
Logging and Forest Conservation	Forest Reserve and Protection Forest	Raster	-	Level 2	Image Data
		Polygon	Forest Reserve Name	Level 1	
		Point	Forest Name and Area	Level 1	
	Forest Management Record	Database File	Compartment Data	Level 1	
	Logging Volume	Table/Graph	Historical Logging Volume	Level 1	
River Reserve	Cadastral Map	Line	-	Level 1	
		Point	Land Registration	Level 1	

Note : Level 1 means dissemination to the governmental agencies only, while Level 2 means dissemination to the public.

Table III-11 C VALUES FOR PERMANENT PASTURE, RANGELAND, AND IDLE LAND

Vegetal Canopy			Cover That Contacts the Surface					
Type and Height of Raised Canopy [1]	Canopy Cover (%) [2]	Type [3]	Percent Ground Cover					
			0	20	40	60	80	95-100
No appreciable canopy		G	.45	.20	.10	.042	.013	.003
		W	.45	.24	.15	.090	.043	.011
Canopy of tall weeds or short brush (0.5 m fall ht.)	25	G	.36	.17	.090	.038	.012	.003
		W	.36	.20	.13	.082	.041	.011
	50	G	.26	.13	.070	.035	.012	.003
		W	.26	.16	.11	.075	.039	.011
	75	G	.17	.10	.060	.031	.011	.003
		W	.17	.12	.090	.067	.038	.011
Appreciable brush or bushes (2 m fall ht.)	25	G	.40	.18	.090	.040	.013	.003
		W	.40	.22	.14	.085	.042	.011
	50	G	.34	.16	.085	.038	.012	.003
		W	.34	.19	.13	.081	.041	.011
	75	G	.28	.14	.080	.036	.012	.003
		W	.28	.17	.12	.077	.040	.011
Trees but no appreciable low brush (4 m fall ht.)	25	G	.42	.19	.10	.041	.013	.003
		W	.42	.23	.14	.087	.042	.011
	50	G	.39	.18	.09	.040	.013	.003
		W	.39	.21	.14	.085	.042	.011
	75	G	.36	.17	.09	.039	.012	.003
		W	.36	.20	.13	.083	.041	.011

Note 1) Average fall height of waterdrops from canopy to soil surface.
2) Portion of total-area surface that would be hidden from view by canopy in a vertical projection.
3) G: Cover at surface is grass, grasslike plants, decaying compacted duff, or litter at least 5 cm deep.
W: Cover at surface is mostly broadleaf herbaceous plants (as weeds) with little lateral-root network near the surface, and/or undecayed residue.

Source: Technical release No. 51, Geology: Procedure for computing sheet and rill erosion on project areas, Soil Conservation Service, U. S. Department Agriculture, 1972

Table III-12 C FACTOR FOR WOODLAND

Stand Condition	Tree Canopy % of Area [1]	Forest Litter % of Area [2]	Undergrowth [3]	C Factor
Well stocked	100-75	100-90	Managed [4]	.001
			Unmanaged [4]	.003-.011
Medium stocked	70-40	85-75	Managed	.002-.004
			Unmanaged	.01-.04
Poorly stocked	35-20	70-40	Managed	.003-.009
			Unmanaged	.02-.09

Note 1) When tree canopy is less than 20%, the area will be considered as grassland, or cropland for estimating soil loss.
2) Forest litter is assumed to be at least two inches deep over the percent ground surface area covered.
3) Undergrowth is defined as shrubs, weeds, grasses, vines, etc. on the surface area not protected by forest litter. Usually found under canopy openings.
4) Managed: grazing and fires are controlled.
Unmanaged: stands that are overgrazed or subjected to repeated burning.

Source: Technical release No. 51, Geology: Procedure for computing sheet and rill erosion on project areas, Soil Conservation Service, U. S. Department Agriculture, 1972

Table III-13 P FACTOR FOR CONTOURING, CONTOUR STRIPCROPPING AND TERRACING

Land Slope (%)	P Value			
	Contouring	Contour Stripcropping	Terracing	
			a)	b)
2 - 7	0.50	0.25	0.50	0.10
8 - 12	0.60	0.30	0.60	0.12
13 - 18	0.80	0.40	0.80	0.16
19 - 24	0.90	0.45	0.90	0.18

Note Value of a) represents soil loss from the field, while value of b) represents effect on sediment yield. The difference is the sediment lost from the field, but it is trapped in the terrace channel.

Source: Technical release No. 51, Geology: Procedure for computing sheet and rill erosion on project areas, Soil Conservation Service, U. S. Department Agriculture, 1972