JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE GOVERNMENT OF THE REPUBLIC OF INDONESIA
MINISTRY OF PUBLIC WORKS
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT

THE DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT

FINAL REPORT

VOL. II

MAIN REPORT

OCTOBER 1996

CTI ENGINEERING CO., LTD.

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VOLUME IV	WORK QUANTITIES
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COST ESTIMATE
IS BASED ON THE PRICE LEVEL OF NOVEMBER 1995
AND EXPRESSED IN INDONESIAN RUPIAH (RP.)
ACCORDING TO THE FOLLOWING EXCHANGE RATES:

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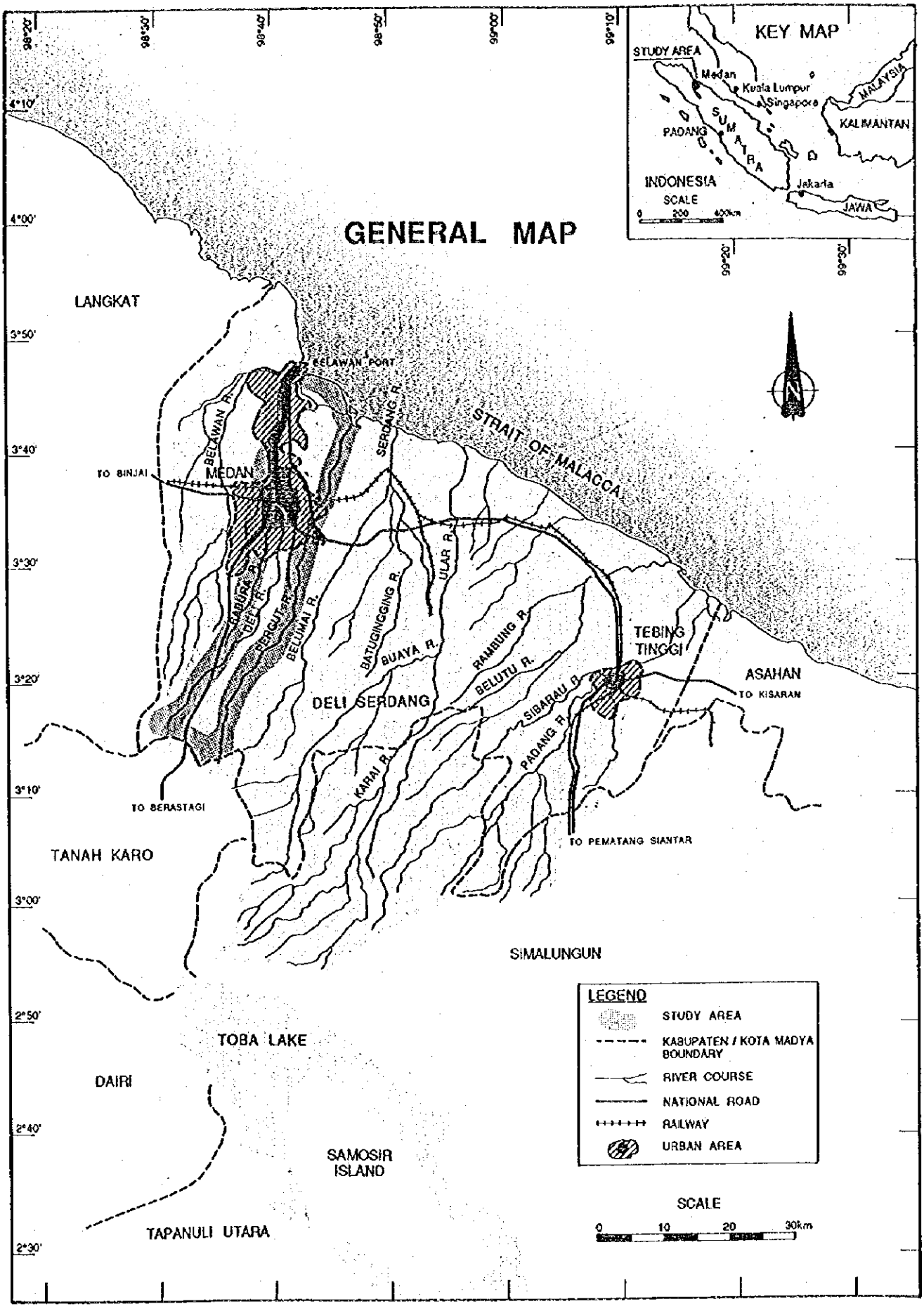
(AS OF NOVEMBER 1995)


GENERAL MAP
KEY MAP
STUDY AREA
Medan
Kuala Lumpur
Singapore
MALAYSIA
KALIMANTAN
PADANG
SUMATRA
INDONESIA
Jakarta
JAWA
SCALE
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LANGKAT
BELAWAN PORT
BELAWAN R.
SERDANG R.
STRAIT OF MALACCA
TO BINJAI
MEDAN
DELI SERDANG
BABURA R.
DELI R.
PERCUT R.
BELUMAI R.
BATUGINGGING R.
BUAYA R.
ULAR R.
RAMBUNG R.
BELUTU R.
SIBARAU R.
PADANG R.
KARAI R.
TEBING TINGGI
ASAHAN
TO KISARAN
TO BERASTAGI
TO PEMATANG SIANTAR
TANAH KARO
SIMALUNGUN
TOBA LAKE
DAIRI
SAMOSIR ISLAND
TAPANULI UTARA
N
LEGEND
STUDY AREA
KABUPATEN / KOTA MADYA BOUNDARY
RIVER COURSE
NATIONAL ROAD
RAILWAY
URBAN AREA
SCALE
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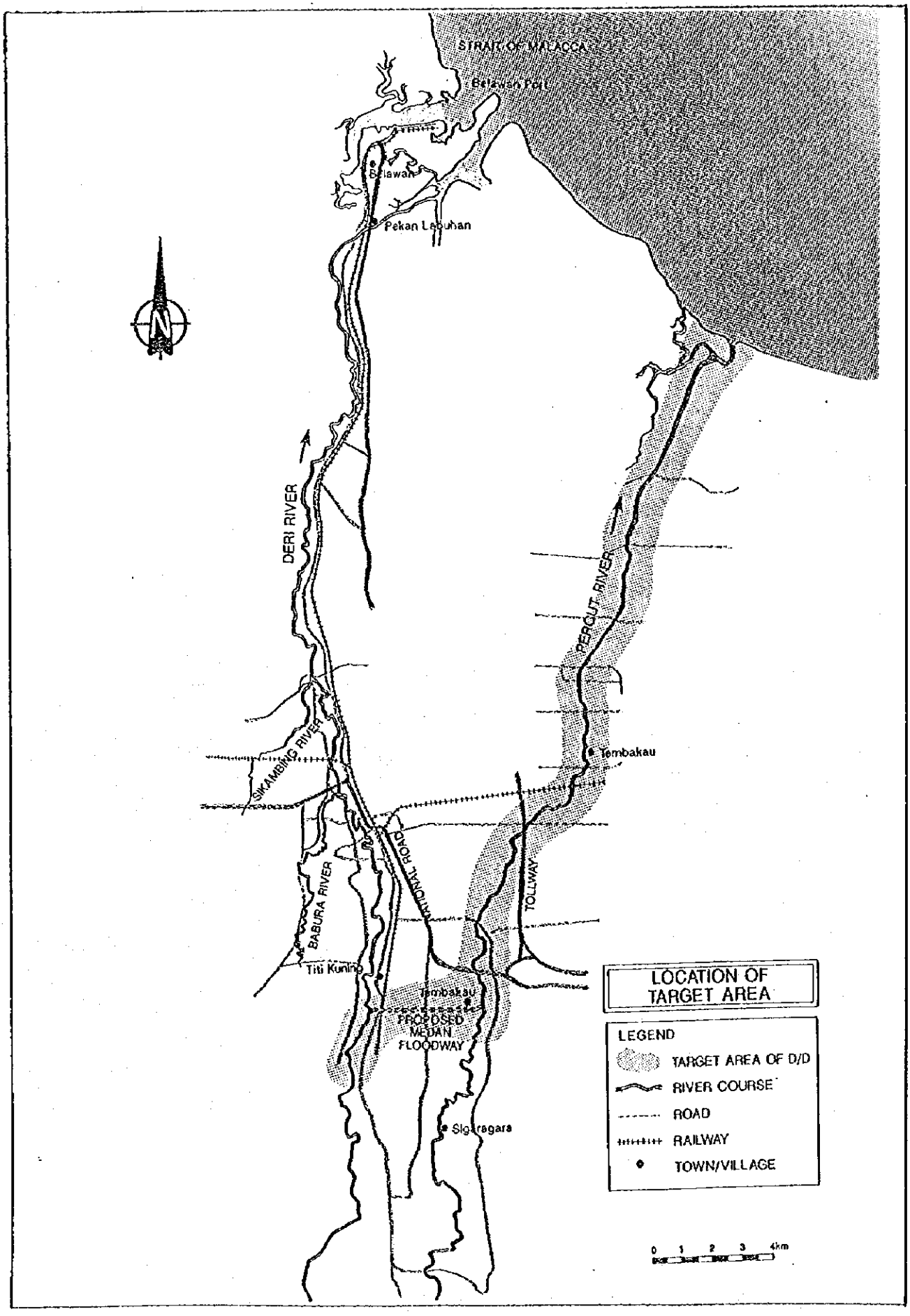
STRAIT OF MALACCA
Belawan Port
Belawan
Pekan Labuhan
DERI RIVER
PERCUT RIVER
SIKAMBING RIVER
BABURA RIVER
RADIAL ROAD
TOLLWAY
Tembakau
Titi Kuning
Tembakau
PROPOSED MEDAN FLOODWAY
Sigaragara
LOCATION OF TARGET AREA
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RIVER COURSE
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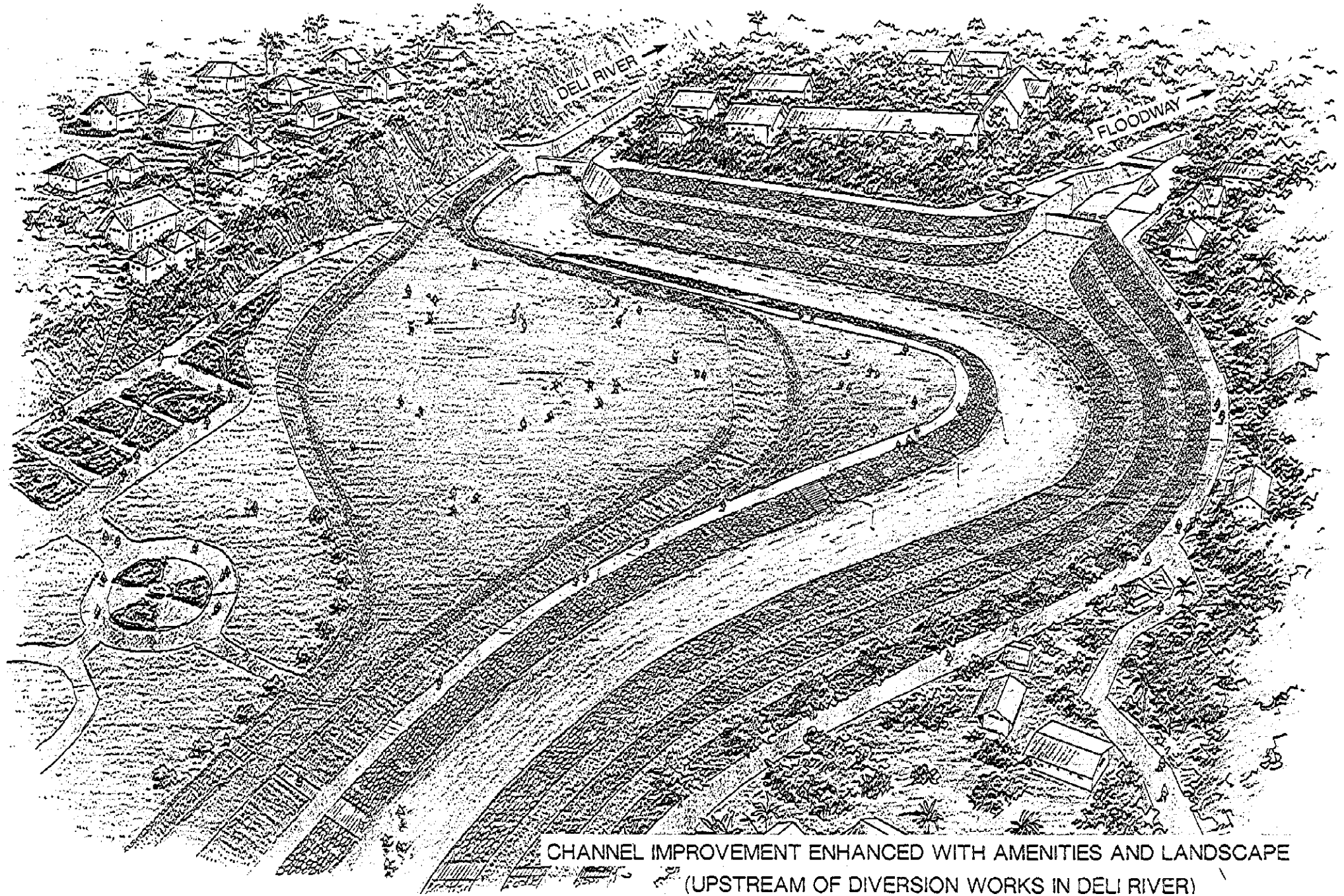

CHANNEL IMPROVEMENT ENHANCED WITH AMENITIES AND LANDSCAPE
(UPSTREAM OF DIVERSION WORKS IN DELI RIVER)

PREFACE

In response to a request from the Government of the Republic of Indonesia, the Government of Japan decided to conduct a Detailed Design study on Medan Flood Control Project, and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Indonesia a study team headed by Mr. Hitoshi Kin, CTI Engineering Co., Ltd., three times between April 1995 and August 1996.

The team held discussions with the officials concerned of the Government of Indonesia, and conducted field surveys at the study area. After the team returned to Japan, further studies and detailed design were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Indonesia for their close cooperation extended to the team.

October 1996

Kimio Fujita
President
Japan International Cooperation Agency

October 1996

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Tokyo, Japan

S i r :

LETTER OF TRANSMITTAL

We are pleased to submit herewith, the Final Report of the Detailed Design Study on Medan Flood Control Project in North Sumatra, Indonesia.

The Study was completed through the discussions with the officials of the Government of Indonesia, field investigations and surveys during the two visits from April 1995 to March 1996, and the studies at the home office thereafter.

The Final Report consists of the following reports and documents:

Design Reports

Vol. I	Summary
Vol. II	Main Report
Vol. III	Design Notes
Vol. IV	Work Quantities
Vol. V	Cost Estimate
Vol. VI	Data Book

Prequalification Documents

Tender Documents

Vol. I	Invitation to Tender, Instruction to Tenderers, Particular Instructions to Tenderers, Form of Tender and Appendices, Form of Contract Agreement, Bond Specimens, and Bill of Quantities
Vol. II	General and Special Conditions of Contract
Vol. III	General and Technical Specifications
Vol. IV	Drawings

Taking this opportunity, we wish to express our sincere gratitude to your Agency, the Ministry of Foreign Affairs and the Ministry of Construction, and also to convey our appreciation to the officials of the Directorate General of Water Resources Development (DGWRD), Ministry of Public Works and the Embassy of Japan in Indonesia for their kind cooperation and assistance throughout our field study.

Very truly yours

Hitoshi Kin
Team Leader
The Detailed Design Study on Medan Flood Control Project

THE DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT

FINAL REPORT

VOL. II

MAIN REPORT

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TERMS AND ABBREVIATIONS

1. GOVERNMENT AGENCIES AND ORGANIZATIONS

ADB	:	Asian Development Bank
BAPEDAL	:	Badam Pengendalian Dampak Lingkungan
BAPPENAS	:	Badan Perencanaan Pembangunan National (National Development Planning Board)
BAPPEDA	:	Badan Perencanaan Pembangunan Daerah (Provincial Development Planning Board)
BPN	:	Badan Pertanahan Nasional (National Land Agency)
BPP	:	Balai Penyuluhan Pertanian (Agricultural Extension Centre)
CIDA	:	Canadian International Development Agency
DPU	:	Departmen Pekerjaan Umum (Ministry of Public Works)
DGWRD	:	Directorate General of Water Resources Development, Ministry of Public Works
DGCK	:	Directorate General of Cipta Karya (Housing, Building and Urban Development)
DPUP	:	Dinas Pekerjaan Umum Propinsi (Provincial Public Works Services)
GOI	:	Government of Indonesia
GOJ	:	Government of Japan
IBRD	:	International Bank for Reconstruction and Development (World Bank)
IHE	:	Institute of Hydraulic Engineering (Bandung)
IGGI	:	Inter-Governmental Group of Indonesia (Demolished)
JICA	:	Japan International Cooperation Agency
MOC	:	Ministry of Construction, Japan
OECF	:	Overseas Economic Cooperation Fund, Japan
P3SA	:	Proyek Pengembangan dan Penyelidikan
PDAM	:	Perusahaan Daerah Air Minum (Water Works Company)
PJKA	:	Perusahaan Jawatan Kereta Api (Railway Company)
PMG	:	Pusat Meteorologi dan Geofisika (Centre of Meteorology and Geophysics)
PLN	:	Perusahaan Listrik Negara (State Electricity Corporation)
RISPA	:	Research Institute of Sumatra Planter's Association
RIWRD	:	Research Institute of Water Resources Development
UNDP	:	United Nations Development Programme
WHO	:	World Health Organization

2. OTHERS

MUDP	:	Medan Urban Development Project
MMUDP	:	Metropolitan Mebidang Urban Development Project

3. UNITS OF MEASURE

Length			Weight		
mm	:	millimeter	g, gr	:	gram
cm	:	centimeter	kg	:	kilogram
m	:	meter	t, ton	:	metric ton
km	:	kilometer	dwt	:	dead weight
Area			**Time**		
mm^2	:	square millimeter	sec., s	:	second
cm^2	:	square centimeter	min	:	minute
m^2	:	square meter	h, hr	:	hour
km^2	:	square kilometer	d, dy	:	day
ha	:	hectare	y, yr	:	year
Volume			**Discharge**		
cm^3	:	cubic centimeter	ltr/sec, l/s	:	liter per second
m^3	:	cubic meter	m^3/sec,m^3/s	:	cubic meter per second
l, ltr	:	liter	m^3/yr, m^3/y	:	cubic meter per year

4. DERIVED MEASURES

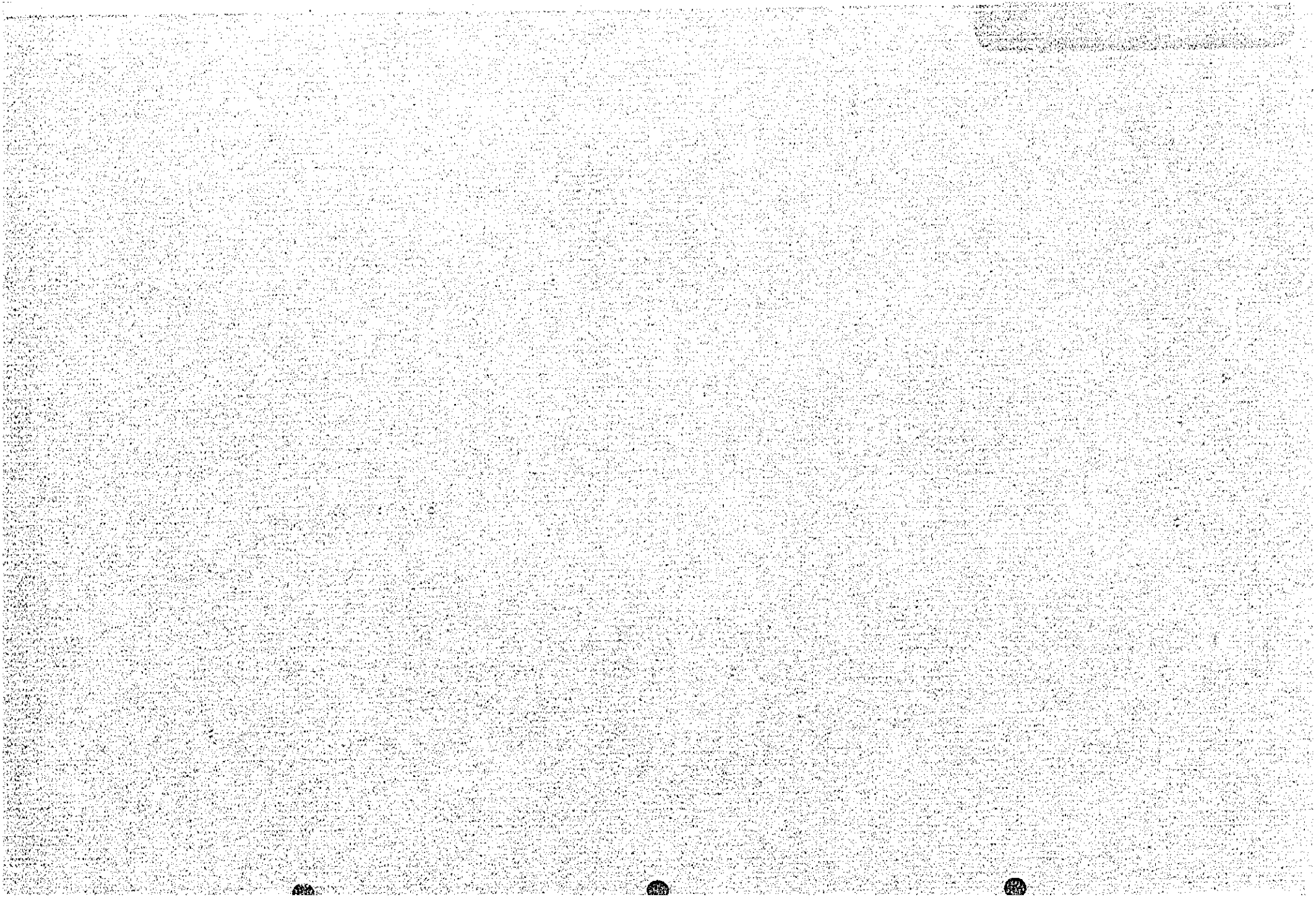
Speed/Velocity			Stress		
cm/sec, cm/s	:	centimeter per second	kg/cm^2	:	kilogram per square centimeter
m/sec, m/s	:	meter per second	ton/m^2	:	ton per square meter
km/hr	:	kilometer per hour			

5. INDONESIAN TERMS

Propinsi	:	province
Kabupaten, Kab.	:	district (regency)
Kotamadya, Kodya.	:	city (municipality)
Kecamatan, Kec.	:	subdistrict
Desa	:	village (rural)
Kampung, Kp.	:	village (rural)
Kelurahan	:	village (urban)
Sungai, Sei	:	river
Gunung	:	mountain
Sawah	:	paddy field
Rawa	:	swamp
Danau	:	lake
Laut	:	sea

CHAPTER 1

INTRODUCTION



CHAPTER 1. INTRODUCTION

1.1 Background

1.1.1 Project Preparation

The background of the Project is traced to the Study on Belawan-Padang Integrated River Basin Development (herein referred to as "the B-P Study") which was carried out with technical cooperation by the Japan International Cooperation Agency (JICA) from March 1990 to March 1992. The objectives of the B-P Study were: (1) to formulate a Master Plan of integrated river basin development from Belawan to Padang, focusing on flood control and water utilization; and (2) to conduct a Feasibility Study on urgent projects selected according to priority. The Master Plan was formulated in March 1991, and some high priority or urgent projects were selected for the Feasibility Study which was completed in March 1992.

1.1.2 Background of the B-P Study

The B-P study area is situated in the northern part of North Sumatra Province. It covers the basin of seven (7) major rivers, namely Belawan, Deli, Percut, Serdang, Ular, Belutu and Padang, as well as the basin of several small rivers. The study area also includes Medan City, the largest city in Sumatra and the third largest city in Indonesia.

Under the Fourth Five-Year Development Plan, the Government of Indonesia has embarked on promoting development policies for developed or developing areas like the reduction of regional discrepancies in labor force and economic potential, water resources development and flood control. The Government is particularly active in promoting the development of outlying areas like Sumatra in conjunction with the policy to promote transmigration. The rate of resettlement due to transmigration in North Sumatra Province is high, and the province is one of the areas where development is highly expected. The occurrence of floods causing serious damage is, however, a major factor impeding development.

The population of Medan City also makes up over a half of the total population of approximately 3.63 million in the study area. The growth of city population in recent years has made the shortage of municipal water more serious, resulting in unpleasant and unhygienic living conditions, as well as adverse environmental impacts.

The Government of the Republic of Indonesia had requested technical cooperation by the Government of Japan to resolve the problems of flood and water shortage. In response to the

request, the Japan International Cooperation Agency (JICA) had conducted the B-P Study as mentioned before.

1.1.3 Identification of the Project

Through prioritization and the implementation program developed in the Master Plan Study, areas or projects for the Feasibility Study were selected focusing on two (2) river basins, the Deli-Percut River Basin and the Padang River Basin. The project components in each basin are as listed below.

River Basin	Project Component
Deli-Percut River Basin	(1) Deli River Improvement (2) Percut River Improvement (3) Construction of Medan Floodway (4) Construction of Lausimeme Dam
Padang River Basin	(1) Padang River Improvement

1.1.4 Necessity of the Project

The Deli and Percut rivers pass through Medan City, the largest city and the center of social and economic development in Sumatra. Since the urban area of Medan City has been expanding every year due to rapid urbanization, damage inflicted by the frequent floods has also been more seriously hampering development giving adverse environmental impacts to the region.

A flood control project in the Deli-Percut River Basin is urgently required as figured out in the B-P Study. Inasmuch as flood control effects of river improvement works are more immediate than those of dam construction, the improvement of Percut River and the construction of Medan Floodway are given higher priority for implementation. On this concept, some improvement works of the Deli River are already being executed under the Second Medan Urban Development (MUDP II). For the purpose of this present undertaking by JICA, the project is called the **Medan Flood Control Project** (herein referred to as **"the Project"**), and the design work is named the **Detailed Design Study on Medan Flood Control Project** (herein called **"the D/D Study"**).

1.2 Objective of the D/D Study

The objective of the D/D Study is to carry out the detailed engineering design of the Medan Flood Control Project consisting of the improvement works of Percut River and the construction of Medan Floodway.

The Study Area of the D/D Study (3°10' to 3°45' N latitude and 98°35' to 98°50' E longitude) is administratively covered by Medan City and Deli Serdang District in North Sumatra Province and topographically included in the Deli and Percut river basins. The Medan Floodway with a length of 3.9 km is to be located from Titi Kuning at Deli River to Tembakau at Percut River, and the river improvement works of Percut River are to be undertaken for 28 km from the estuary.

1.3 Scope of the D/D Study

The D/D Study is to be carried out within 18 months from March 1995 to August 1996. Divided into two phases, the first phase work of the D/D Study is to be executed in the first eight (8) months to prepare the basic design, and the second phase work is to be executed consecutively for the next ten (10) months.

The D/D Study is to consist of field and home office works. The flow of work is as illustrated in Fig. 1.3.1, and the details of plan operation are as outlined below.

1.3.1 Basic Design

The main study items of the basic design work are as follows:

(1) Data Collection and Compilation
(2) Review of Design Discharge
(3) Topographic and River Survey
(4) Geological and Soil Mechanics Survey
(5) Hydraulic Model Test
(6) Formulation of Basic Plan
(7) Preliminary Construction Plan and Cost Estimate
(8) Socioeconomic Evaluation
(9) Preliminary Operation and Maintenance Plan
(10) Preparation of Design Criteria
(11) Basic Design
(12) Environmental Management and Monitoring Plan

1.3.2 Detailed Design

The detailed design is to be carried out as outlined below.

(1) Detailed Design Work
(2) Quantity Estimation
(3) Construction Plan
(4) Cost Estimate
(5) Implementation Program
(6) Operation and Maintenance Plan
(7) Tender Documents

Prequalification and tender documents will be prepared after the preparation of detail designs, and the tender documents shall include the following:

(1) Invitation to Tender
(2) Instructions to Tenderers
(3) Form of Tender
(4) Form of Contract
(5) Specimens of Various Bonds
(6) Bill of Quantities
(7) General Conditions of Contract
(8) Special Conditions of Contract
(9) General Specifications
(10) Technical Specifications
(11) Tender Drawings

1.3.3 Transfer of Knowledge

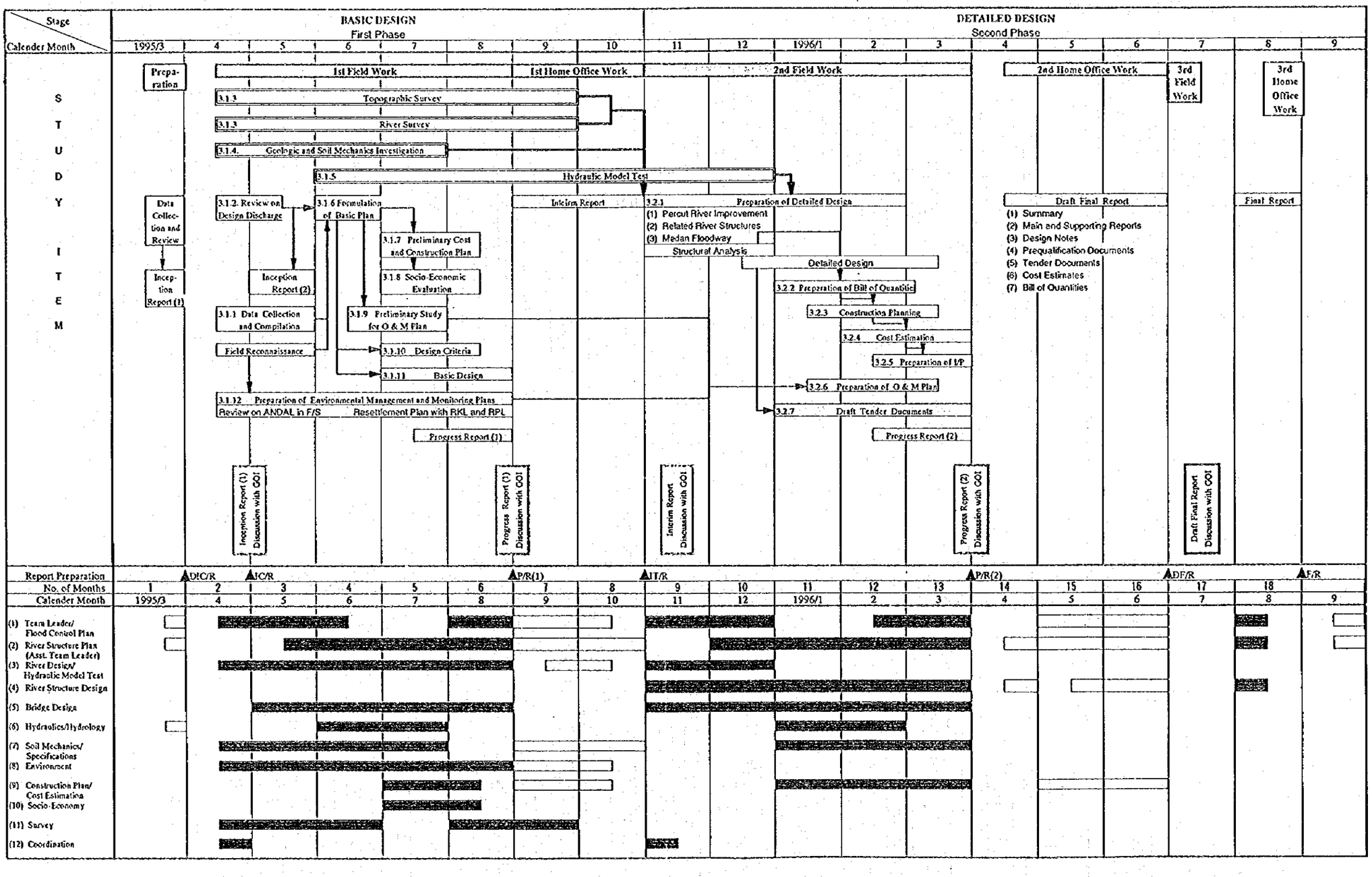
Technical knowledge related to the D/D Study will be imparted to the counterpart personnel of the Government of Indonesia, through their actual participation in the D/D Study at the site.

FIGURES

CHAPTER 1

INTRODUCTION

STUDY FLOW CHART



DETAILED DESIGN STUDY ON MEDAN FLOOD CONTROL PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. 1.3.1 STUDY FLOW CHART

CHAPTER 2

PRESENT CONDITION OF THE STUDY AREA

CHAPTER 2. PRESENT CONDITION OF THE STUDY AREA

2.1 Natural Condition

2.1.1 Hydrology

Existing Observatory

There exists a meteorological station at Sampali which is operated by the Center of Meteorology and Geophysics (PMG) for the observation of temperature, relative humidity, sunshine duration, wind velocity, evaporation and rainfall. The other stations in and around the Study Area are maintained by the Research Institute of Sumatra Planter's Association (RISPA) for the observation of daily rainfall.

Location and data availability of rainfall stations are as shown in Fig. 2.1.1 and in Tables 2.1.1 and 2.1.2. Although all of the stations under RISPA are manually operated, observation has continued for a long time (the oldest is in 1948) and covers a wide area.

There are the three stations (Helvetia and Simeme in Deli River, Tembung in Percut River) under the Hydrology Section of the North Sumatra Provincial Public Works (DPUP). Location and data availability of water level stations are as shown in Fig. 2.1.1 and in Tables 2.1.3 and 2.1.4.

Climatic Characteristics

The climate of the Study Area is characterized by a little difference between wet and dry seasons. Since Sumatra Island is located near the southern side of the continent across the Strait of Malacca, the Study Area is not greatly affected by northeasterly monsoons and trade winds. Climatic data at Sampali Station are summarized in Table 2.1.5.

Temperature ranges between 21°C and 33°C and the average annual temperature is 26°C. Relative humidity ranges between 83% and 87%, and the average is 85%. The temperature and relative humidity in the Study Area are rather high throughout the year with the annual pan evaporation as high as 1,566 mm. Northerly or northeasterly monsoons blow throughout the year, but the area is located outside of the region affected by tropical depressions or cyclones.

Rainfalls in the southern mountainous area and the northern coastal plain are estimated at 2,800 mm/yr and 1,700 mm/yr, respectively. Rainfall records throughout the year are low in February and high in September, as shown in Fig. 2.1.2. The higher elevation the area is

located, the more rainfall is observed. Mean annual rainfall is estimated at 2,337 mm/yr for the Deli river basin and 2,402 mm/yr for the Percut river basin, as shown in Table 2.1.6.

Flow Regime

The annual maximum flood discharges at three (3) sites are given in Table 2.1.7. The maximum water level data have been studied by the Institute of Hydraulic Engineering (IHE) in Bandung and the rating curves that were used in the calculation are as shown in Figs. 2.1.3 to 2.1.5. The low flow area of the rating curves were prepared using the observed discharge data, and the high flow area were estimated using Manning's Uniform Flow Formula with the cross section of the river.

Flow regimes of observed discharges at the three sites in the last ten years are presented in Tables 2.1.8 to 2.1.10. Comparing the specific discharges, similar flow regimes are estimated at the Simeme and Helvetia stations. On the other hand, discharge fluctuations are slightly bigger at Tembung Station (Percut River). However, flow regimes at all sites are stable on the whole; the annual minimum specific discharge is about 0.02 $m^3/s/km^2$ at all sites. Daily discharges at Simeme and Tembung are shown in Fig. 2.1.6 to 2.1.7. Basic data were provided by the IHE.

2.1.2 Geography and River

Geography

The Study Area covers the Percut and Deli river basins which have the catchment area of about 195 km^2 and 350 km^2, respectively (refer to Fig. 2.1.8). The upper stream of the Deli-Percut River runs on the northern slopes of a series of volcanoes, while the lower stream area consists of an outwash plain of volcanic material and alluvial deposits. The geography of the area is described as:

(1) Eastern lowland in the northern part of the area, consisting of volcanic outwash surface, sloping gently northward from about EL 100 m to the sea. Percut and Deli rivers run in parallel in the northern direction through this lowland and flow out into the sea; and

(2) Highland located south of the above eastern lowland, where land slopes steeply northward from about EL 1,000 m.

The southern part of the Study Area, formed by the Kabanjahe Plateau, is relatively flat and sloping westward. The geology of the area is primarily determined by Tertiary and Quaternary volcanic activity, and the morphology is a direct result of this volcanic activity. The geologic

structure is a result of the succession of several phases of volcanism, phases of erosion, and changes of the sea water level, possibly in combination with vertical differential movements of the land. (refer to Fig. 2.1.9)

Pre-Cenozoic rocks, as well as Tertiary deposits are encountered only in small isolated pockets in the upstream part of the area. Almost all Pre-Quaternary rocks are covered by products of recent Pleistocene and even more recent volcanism and their erosion products.

In chronological order, the following volcanic units are discerned in the area:

(1) Mentar unit is related to the activity of Takur-Takur Volcano during the Pliocene and consists of andesitic to dacitic pumiceous pyroclastics. The unit is exposed along the western border of the area, south of Pancurbatu and around Sibolangit.

(2) Toba Tuff is related to the activity of Toba Volcano during the early Pleistocene and consists of rhyodacitic tuff. The entire southeastern quarter of the Study Area is underlain by these deposits.

(3) Sinkut unit is related to the activity of Sibayak Volcano in the Pleistocene. It consists of andesites, dacites, microdiorites and tuffs.

The Medan Formation, consisting of eroded products of volcanic deposits, spreads over the entire width of the northern side of the area, and Medan City is located in the middle of this zone. This formation is overlain and intercalated with young fluviatile and paralic deposits known as alluvium, which consists of gravel, sand and clay.

Detailed characteristics based on the geological and soil investigation are described in Section 3.2 of CHAPTER 3.

River

The major river system and its catchment area is as shown in Fig. 2.1.8. Among the rivers, directly related to the subject Project are the Percut River and the Deli River. The Kera River which is located between the Deli and Percut rivers, and the Tuan River which is located between the Percut and Serdang rivers are only for drainage of the lowland area with their own independent, small catchment basins.

Both of the Percut and Deli rivers originate in the Barisan mountain range, flow down northeastward and out into the Strait of Malacca after passing through Medan City. Except for the urban areas, almost all areas are covered with verdant vegetation with no remarkable gully erosion. The upstream river basin is covered with dense forest without any trace of local landslide. The basic characteristics of the Deli and Percut rivers are summarized as follows:

River	Elevation at Origin (EL m)	Length of Mainstream (km)	Mean Slope (m/km)
Percut River	1,700	81	5.71
Deli River	1,725	86	6.11

Source: 1/50,000 scaled map

The improvement of Deli River, from the estuary to the confluence with Babura River, is being undertaken under the Second Medan Urban Development Project (MUDP II) with financial assistance from the Asian Development Bank (ADB).

2.2 Socio-Economic Condition

2.2.1 Population and Land Use

Population

Since the 1960's, the population census of Indonesia was made four times; the years 1961, 1971, 1980 and 1990. The national population of Indonesia in 1990 reached 179.4 million at the average annual growth rate of 2.13% from the population of 97.1 million in 1961. The population of North Sumatra Province indicated 10.3 million in 1990 and the average annual growth rate was 2.54% during the period 1961-1990 (refer to the B-P Study).

The Study Area of 906 km^2 covers the whole of Medan City and seven (7) sub-districts (kecamatans); Pancur Batu, Namo Rambe, Patumbak, Deli Tua, Labuhan Deli, Percut Sei Tuan and Pantai Labu in Deli Serdang District (Kabupaten). In 1990, the Study Area indicated a population of 2.13 million, consisting of 1.73 million in Medan City and 0.40 million in the seven kecamatans of Deli Serdang District. During the intercensal period from 1980 to 1990, the population growth rate of the Study Area was 2.78% per annum on average, composed of 2.33% for Medan City and 5.02% for the seven kecamatans. These population growth rates are fairly high compared with that of the country as a whole due to the rapid urbanization of Medan and its surrounding areas.

Area, census population, growth rate, population density, and the number of households and household sizes of Indonesia, North Sumatra Province and the Study Area are given in Table 2.2.1.

(1) Population Density

Population density in the Study Area reached 2,350 persons/km^2 in 1990, increasing by 32% from 1,786 persons/km^2 in 1980. In the Study Area, Medan City and the seven kecamatans of Deli Serdang District showed the population density of

6,526 persons/km^2 and 622 persons/km^2, respectively, in 1990. These figures indicate an increase of 26% and 63% compared with the respective population densities in 1980. These increase rates of population density in the Study Area for the period 1980-1990 are fairly high compared with the increase rates of 21% in the whole country and 22% in North Sumatra Province for the same period.

(2) Number of Households

In 1990, the Study Area had 401,288 households, consisting of 324,084 households in Medan City and 77,204 households in the seven kecamatans. During the period 1980-1990, the average annual growth rates were 3.73%, 3.36% and 5.48%, respectively. These rates show a more rapid growth than the foregoing population growth. This is mainly due to the change from compound family to single family.

According to the 1990 Census, the average household size in the Study Area is estimated to be 5.31 persons/household (p/hh), composed of 5.34 p/hh in Medan City and 5.17 p/hh in the seven sub-districts. These figures decreased by 0.51 p/hh, 0.56 p/hh and 0.23 p/hh, respectively, compared to the average size in 1980. Such a reduction in household size is a general trend throughout North Sumatra Province and the whole country.

(3) Review of Demographic Projection

In 1991, the B-P Study projected the future populations of Deli Serdang District, Medan City, a part of Simalungun District and Tebing Tinggi City by using a mathematical method. Among the projections, the 2000 population was estimated to be 2.06 million for Deli Serdang District and 2.16 million for Medan City, at the average annual growth rate of 2.53% and 2.24%, respectively, for the period from 1990 to 2000. Furthermore, the 2010 population was projected to be 2.63 million and 2.68 million, at the average annual rate of 2.46% and 2.17%, respectively, for the period 2000-2010. Details are provided in the B-P Study Report.

On the other hand, at the beginning of 1995, the Metropolitan Mebidang Urban Development Project (MMUDP) carried out a population projection by demographic analysis for the Mebidang area (Medan, Binjai, and Deli-Serdang), which contains Medan City, Binjai City and 14 sub-districts in Deli Serdang District. This Mebidang area, except Binjai City, approximately coincides with the present Study Area.

In this demographic analysis, the population of Mebidang region was projected to be 3.434 million in 2000, consisting of 0.759 million in the Medan inner core and

2.675 million in the other area. The average annual growth rate of Mebidang region for the period 1990-2000 was estimated to be 2.06%, composed of 0.22% in the Medan inner core and 2.65% in the other area. For the period 2000-2010, the growth rate indicated 1.58%, 0.05% and 1.98%, respectively.

The Medan inner core is composed of nine (9) sub-districts; namely, Medan Kota, Medan Area, Medan Baru, Medan Polonia, Medan Maimun, Medan Petisah, Medan Barat, Medan Timur and Medan Perjunangan. This inner core is characterized as a negative or a very low growth area of population due to the high land prices and few available land. On the other hand, rapid growth in population due to urbanization is expected to continue in the other area (Medan outer core and its surrounding areas).

The growth rate of population density approximately coincides with the rate of population growth. On the other hand, the growth in number of households is expected to be more rapid than population growth, in accordance with the progress of change from compound family to unit family.

According to the MMUDP Report, the number of households in the Mebidang region is projected to be 0.771 million in 2000, consisting of 0.170 million in the Medan inner core and 0.601 million in the other area, and the average annual growth rate for the period 1990-2000 shows 3.80%, 1.83% and 4.40%, respectively. Furthermore, the number of households in 2010 is expected to reach 1.079 million in the Mebidang region as a whole, 0.204 million in the Medan inner core and 0.875 million in the other area, at the average annual growth rate of 3.42%, 1.85% and 3.82%, respectively, for the period 2000-2010. These growth rates are fairly high compared with the population growth rates.

Land Use

The Study Area consists summarily of urban areas, wet paddy fields, plantations, swampy lands and open spaces. The urban areas contain residential, commercial/official and industrial areas, and concentrate in the Medan inner core and along two trunk roads which run north to south and east to west from the Medan inner core. Besides, new settlements are being constructed in some places outside of the core, as shown in Fig. 2.2.1.

A majority of the wet paddy fields together with swampy areas spread over the lower reaches of the Deli and Percut rivers, and other wet paddy fields exist in the southwestern part of Medan City. Major plantations spread in the lower and middle reaches from the river mouth to 28 km upstream of Percut River. The plantation crops are represented by rubber, oil palm,

tobacco, sugarcane, coconut and coffee. Open spaces are scattered all over the Study Area, except the Medan inner core.

These land use areas could be estimated by using the land use maps of the B-P Study Report and the RUDS-MMA, as well as the aerial photograph (1991). The land use areas are summarized as follows:

Classification of Land Use	Area (km^2)
Wet Paddy Field	200
Plantation	182
Residential	173
Commercial/Office	19
Factory	10
Swamp	42
Open Space	280
Total	906

2.2.2 Regional Economy

Gross Regional Domestic Product

Gross Regional Domestic Product (GRDP) of North Sumatra Province amounted to Rp. 13,834 billion in 1992 at current prices, an average annual growth rate of 17.4% (nominal rate) during the period from 1987 to 1992, and the real annual growth for the same period also indicated a fairly high rate of 9.0%. Nominal and real growth rates of North Sumatra Province are fairly high compared to those of the country as a whole.

The GRDP in the Study Area amounted to Rp. 1,792 billion for Deli Serdang District and Rp. 3,447 billion for Medan City. During the same period, the nominal annual growth rates were 18.3% and 17.6% on average, respectively. On the other hand, the respective real growth rates indicated 9.1% and 9.9%, which were more rapid than those of the whole country and North Sumatra Province (refer to Table 2.2.2).

Table 2.2.3 lists the GRDP per capita in the regions above for the period from 1987 to 1993. In 1992, the GRDP per capita of North Sumatra Province and. Deli Serdang District grew to Rp. 1,283.000 and Rp. 1,077,000, respectively, at the nominal average annual rates of 14.7% and 15.6% (or real rate of 6.4% and 6.5%) during the said period. Despite such a rapid growth, these growth rates were somewhat lower than the GDP per capita of the whole country. On the other hand, the GRDP per capita of Medan City achieved higher than the per capita GDP, i.e., Rp. 1,926,000 in 1992, at the real average growth rate of 7.6% per annum.

Agricultural Crops

(1) Major Food Crops

Tables 2.2.4, 2.2.5 and 2.2.6 provide the harvested area, production and yield rate on major food crops produced in North Sumatra Province, Deli Serdang District and Medan City. Of the major crop fields, the area of paddy field accounts for 70% of the major cropland areas throughout North Sumatra Province, Deli Serdang District and Medan City. In Medan City, the wet paddy field had an area of 5,871 ha in 1993, achieving growth at the average annual rate of 1.73% during the period 1988 to 1993. However, the harvested area of paddy fields in the future is expected to gradually decrease due to the increase in settlement areas in Medan and its environs under the developed urbanization of Medan City.

The production of wetland paddy in North Sumatra Province, Deli Serdang District and Medan City has been increasing at the annual rate of 2.5% to 4.0% during the period 1988-1993, due to not only the increase in harvested area but also the improvement of yield rate. In 1993, the average yield rate of wet paddy showed 4.04 tons/ha in North Sumatra Province, 4.32 tons/ha in Deli Serdang District and 4.36 tons/ha in Medan City. For the same period, the average annual rise in wet paddy yield rate in Medan City indicated 2.67%, which was more rapid than the rates in North Sumatra Province and Deli Serdang District.

Following the paddy fields, the maize fields had an area of 122,039 ha in 1993 in North Sumatra Province, 15,473 ha in Deli Serdang District and 443 ha in Medan City. Shares of these areas to the total harvested areas of the major food crops in the respective regions were 12%, 7% and 5%. During the period 1988-1993, despite the remarkable increase rates of 8%, 14% and 29% in the harvested area of maize in the respective regions, the actual harvested area in 1993 was still small.

In the Medan City area, the cassava field with the harvested area of 568 ha in 1993 follows the maize field on harvested area. The development of cassava field, however, was very slow during the same period.

(2) Plantation Crops

(a) Small-holder Estate in North Sumatra Province

North Sumatra Province is among the most developed provinces in the country as to estate plantation. The Deli and Percut river basins, however, have a relatively

little share, although there exist some plantations of tobacco, sugarcane and cocoa. Tables 2.2.7 and 2.2.8 show the production situations of major plants in small-holder estates and large scale enterprise estates in North Sumatra Province.

With regard to the small-holder estates in North Sumatra Province, the rubber plantation in 1993 had an area of 331,237 ha with a share of more than 50% of the total area of the major crop plantations, and the annual increase rate of plantation area was 1.33% on average from 1988 to 1993. Despite a little increase in the plantation area, rubber production indicated a high growth at the annual rate of 8.83% during the same period, owing to the improvement of yield rate.

Following the rubber plantation, the coconut and oil palm plantations had an area of 140,633 ha and 86,535 ha in 1993, with the share of 22% and 14% of the total area, respectively. Although the coconut plantation ranks second in the planted area of small-holders, the increase in planted area and the production of coconut indicated a relatively low rate. On the other hand, the oil palm plantation area during the same period showed a fairly high annual increase rate of 8.36% on average, but the growth in production was inevitably low, due to the decline in yield rate.

In contrast with rubber, coconut and oil palm plantations, the planted area of cocoa plantation has been increasing remarkably. In 1993, the cocoa plantation was a comparatively small area of 19,421 ha (3% share), but the area indicated a considerable increase rate of 20% during the period 1988-1993. The yield rate also showed a high growth rate of 19% due to the improvement of yield technique. Accordingly, the production achieved the average annual growth rate of 40% during the same period, and amounted to 8,194 tons in 1993.

(b) Enterprise Estate in North Sumatra Province

In the enterprise estate in North Sumatra Province, the oil palm had a dominant plantation area of 315,108 ha (a share of more than 70%) in 1993, an average increase rate of 4% per annum, during the period 1988-1993. For the same period, the productions of oil palm and palm kernel achieved a high average growth rate of 10% and 17% per annum, respectively, being supported by high yield rate, and in 1993, 1,324,962 million tons and 291,794 million tons were produced.

Following the oil palm plantation, the rubber plantation, which had 15% in area, produced 74,496 tons of rubber in 1993. However, in contrast to the small-holder rubber plantation, the plantation area and yield rate of rubber had diminished gradually at the annual rate of minus 4.3% and minus 1.2% on average, during the same period.

In 1993, the cocoa plantation area of the enterprise estate had 19,870 ha, which corresponded to only 4% of the total area of the enterprise estate. However, the area had increased at the high average rate of 14% per annum for the period from 1988 to 1993. Accordingly, the production also indicated a high growth rate of 16% per annum during the same period. Judging from the trend of growth in cocoa production, the rapid growth of production is expected to continue for the time being in either the enterprise and small-holder estates.

(c) Small-holder Estate in Deli Serdang District

Table 2.2.9 shows the production situation of the smallholder estate in Deli Serdang District in 1993. The major plantation crops in this district are rubber, oil palm, coconut, cocoa, sugarcane and coffee. Among them, rubber plantation has a dominant share in area; for example, in 1993, it had an area of 22,023 ha, which corresponded to 60% of the total area of the said major crop plantation.

Following the rubber plantation, the coconut plantation had a planted area of 9,901 ha (27% share) in the same year. Concerning tobacco and sugarcane plantations, they have been planted alternately in the same plantation land. Accordingly, for example, in 1993, the planted area was 295 ha for sugarcane, and zero ha for tobacco.

The seven sub-districts in Deli Serdang District had the production area of 3,470 ha in 1993, consisting of 735 ha for rubber, 2,570 ha for coconut and 165 ha for coffee. However, the production area of oil palm, cocoa, tobacco and sugarcane plantations was zero ha in the same year.

Prices

Table 2.2.10 shows the consumer price indices and inflation rate in Medan and Jakarta for the period from 1990 to 1993. In Medan, the 1993 consumer price of the average general goods rose by 27.2% compared with the 1990 price of the goods. This price escalation corresponds to the average inflation rate of 8.35% per annum. Besides, the average annual inflation rate by sector for the same period indicated 6.19% for food price, 10.41% for the housing price, 8.57%

for the clothing price and 9.42% for the miscellaneous price. These inflation rates in Medan were somewhat low compared with those in Jakarta.

Producer prices of cereals, secondary food crops and vegetables in North Sumatra Province are provided in Table 2.2.11. Among them, the producer prices of staple food such as paddy and maize were relatively stable during the period 1990-1993. The price of dried paddy rose from Rp. 30,567/100 kg in 1990 to Rp. 33,610/100 kg in 1993. However, it was a low rise rate of 3.81% per annum on average during the said period. The price of yellow maize also indicated an average low rise rate of 2.04% per annum for the same period. While, the prices of eggplant and onion rose the most rapidly among the producer prices of vegetables, i.e., the average annual rise rate was 10.67% and 12.74%, respectively, for the same period.

2.2.3 Relevant Development Plans

Medan Urban Development Project

The study on the master plan for Medan Urban Development Project (MUDP) was conducted in 1978 with financial assistance by ADB as a part of the Integrated Urban Development Program of the Directorate General of Human Settlement (DGCK), Ministry of Public Works, and completed in October 1980. Based on the study, the project was implemented in 1982 with ADB funds. It covered a relatively small area focusing on only Medan City consisting of 21 sub-districts. The study included various sectors of development schemes and had the following objectives:

(1) To establish a long-term strategy of urban development for the year 2000;

(2) To formulate a mid-term plan for the improvement of social infrastructure and urban environment; and

(3) To conduct a feasibility study for housing development, water supply, drainage, and solid waste management.

Since flooding has been occurring frequently in the city due to the insufficient flow capacity of the river channel and the inadequate drainage system, a further study needed to be carried out for flood control and drainage improvement. Hence, the study has been conducted in the second stage of the project, namely MUDP II, and Deli River and its tributaries, Sikambing and Putih, have been improved together with urban drainage works.

MUDP II covers a total of 31 sub-districts, including Medan, Binjai and part of Deli Serdang. Although the project was scheduled for completion in June 1995, the related work is still under the responsible agency which requested the ADB for postponement of completion period until

the end of the current year. The number of project-affected families by the improvement of Deli River is estimated at 2,100, and the total area of expropriated lands is approximately 161 ha consisting of 3,584 parcels. The compensation work started in fiscal year 1991/92 and the total amount will reach nearly Rp. 22 billion by the end of 1995/96, accounting for 57% of the total local budget of the project.

The Metropolitan Mebidang Urban Development Programme, called MMUDP for short, is planned to be undertaken as MUDP III from fiscal year 1997/98. The main objectives are to establish a long-term development strategy up to the year 2015 for the Mebidang area (Medan, Binjai and Deli Serdang), and also to provide a mid-term plan for the next five to seven years aiming at preparing the detailed work approach for each development scheme such as flood control and drainage, water supply, transportation, sanitation, housing and solid waste management. The number of sub-districts involved in MMUDP will amount to 40, which include two cities (Medan, Binjai) and 14 sub-districts of Deli Serdang. According to the 1990 Census, the total coverage area is estimated at 1,700 km^2, out of which 600 km^2 is in urban area accounting for 36% of the total. This figure shows a drastic urbanization as compared to 15% in 1980.

The river improvement on the Deli River for a length of about 6 km from the confluence with the Babura to Titi Kuning is to be planned under MMUDP. It is expected that flooding in Medan City will be substantially controlled under such an integrated system combined with the Medan Flood Control Project.

Medan Urban Planning

Based on the master plan established in 1974, an industrial area called Kawasan Industri Medan (KIM) has been steadily developed in about 1,500 ha of land. The total number of factories was reported to be 85 in 1995, but those who own a treatment plant for wastewater is limited to only 12 due to the anticipated environmental impacts around the river and the estuary. In addition, the increase of population and cars has greatly affected the urban environment in a negative way. According to the national census of 1990, the population of Medan City was 1.73 million showing 2.31% of annual growth rate for the last 10 years (1980-1990). Population projections for the years 1995, 2000 and 2005 also show 1.96, 2.19 and 2.41 million, respectively. As commonly said, the more the city grows the more people must fight against pollution.

Under these circumstances, the study on a new urban plan was conducted in fiscal year 1992/93, under the guidance of PEMDA (Pemerintah Daerah: Regional Government), to

improve and/or to cope with the present situation. The study was completed in 1994 and now, the Government wishes to carry out a feasibility study and detailed design work as early as possible. The financial source has not been decided, but the following items are considered to be the main points in the new urban plan (refer to Fig. 2.2.2):

(1) To upgrade business and other activities by improving the road network;

(2) To establish a new industrial area (Kawasan Industri Baru, KIB) in the outskirts of the city;

(3) To develop a housing area in harmony with population growth and distribution;

(4) To establish a fishermen's village in promoting the fish industry; and

(5) To improve urban environment for upgrading people's living standard.

Improvement of the road network is urgently required to cope with the rapid urbanization. To approach this scheme, new roads are planned to be constructed encircling the city as outer and inner rings which are designed to link with the existing roads. The proposed road network may serve to establish a new traffic system, of which people can take advantage to upgrade both business activities and urban life. The terminal which is located near the junction of two main roads can be effectively used to facilitate public transportation, as well as distribution of commercial goods.

PEMDA emphasizes the need to tackle the housing problem as a bottleneck of the urban development scheme. The total required number of housing units was estimated at 397,000 in 1995, and this number will increase to 409,000 in the year 2000 and 483,000 in the year 2005 as the city grows year by year. These numbers are figured out on the assumption that each family would have a house of its own. According to REPELITA VI (Five-Year Plan, 1995-2000), the construction of 46,000 units in Medan City is proposed to meet the increasing demand of housing and, further, 45,800 units are planned under REPELITA VII (2000-2005).

A fishermen's village is now under construction in about 80 ha of reclaimed land at the river mouth of the Deli. The PEMDA plans to build 2,040 houses in this area, but the total number of units so far constructed is 930, out of which 220 are occupied. Some of those who moved to this new village were project-affected people by the MUDP. However, the number of those people is not clear. They used to live along Deli River and agreed to evacuate the land due to project implementation.

The houses in this new village are all pilot type and costs vary depending on the floor space such as 21 m^2, 27 m^2 and 36 m^2. Housing loan is available from the Bank Tabungun Negara (BTN), payable in 15 years with 1.8% of annual interest. Giving an example, to

purchase one unit of 21 m^2, Rp. 100,000 is required as down payment, and then Rp. 32,000 should be paid every month for a period of 15 years. So far, people wishing to resettle in this village are limited to those from the four (4) districts (Medan Deli, Belawan, Labuhan and Marelan), and in principle, no one is allowed to move in from Deli Serdang District.

Based on Hak Guna Bangunan (HGB, Land Permission) and Hak Guna Usaha (HGU, Operational Permission), the maximum operation period is determined to be 20 years for all companies located in the KIM mentioned above, so that none of them is allowed to continue its operation over that period if the field of business remains unchanged. It means that almost all of the existing factories are obliged to move out from the KIM in the near future. In view of these facts the swampy area of about 3,000 ha of land at the lower reaches of Deli River is planned to be developed as a new industrial area (KIB), mainly for the relocation of factories, and it can also be an incentive to new investors. It is expected that a number of factories move in KIB step by step in 5 or 10 years, and wastewater will be discharged into Kera River after being treated under the responsibility of the individual companies. Consequently, it may lead to a positive way in improving the quality of river water of the Deli.

Solid waste management is also a great concern in establishing a proper urban planning. It has to be planned in a systematic way combined with the housing scheme and proposed road network. Presently, there are two dumping sites, Kampung Terjun in the north of the city and Namo Bintang in the south. However, both sites will be filled to capacity before the target year of 2005, so that a study is now ongoing to look for a new dumping site.

Water Supply Project

The water supply system in Medan City and its surrounding areas is under the control of Perusahaan Daerah Air Minum (PDAM). The capacity of the present system is estimated at 3.5 m^3/s, which is the total amount of water served from the following three sources: (1) Belawan River, 1.5 m^3/s; (2) Deli River, 1.4 m^3/s; and (3) Spring, 0.6 m^3/s.

However, this amount is not sufficient to meet the water requirement of about 3 million inhabitants. It would cover only 60% of the total demand if the daily consumption per capita is set to be 170 liters.

Under the above circumstances, PDAM has formulated a project to improve the situation by developing the water resources of Belumai River, and the detailed design work is now being undertaken by an American consultant with financial assistance from the ADB. The study was scheduled to be completed by the end of 1995, expecting that the project be implemented in 1996 as FBOT (finance-build-operate-transfer) in which a Canadian company will take share

in 75%, PDAM in 10%, the local government in 10%, and a local private company in the remaining 5%.

The project includes the construction of intake facilities on Belumai River, and treatment plant and the installation of conduction pipe for a total length of about 13 km to connect with the reservoir which was constructed in Amplas last year. The reservoir has a capacity of 5,000 m^3.

The project is expected to be accomplished in 1997, by which the capacity of water supply will be increased by 3 m^3/s to a total of 6.5 m^3/s, and it will cover about 80% of the whole demand by the year 2005. The water can be served to the residents following the program which is composed of three stages, that is to say, the capacity will augment at the rate of 1 m^3/s on each stage, as the distribution system may be developed or improved at a foot's pace. Thus, the whole water supply system will function fully by the target year.

2.3 Floods and Flood Control Works

2.3.1 Major Floods and Flood Damage

The flood of November 26, 1990 caused a vast inundation along the Deli River, and a big flood resulted in overflow and heavy inundation in Percut River in December 1992. Since flood runoff is dictated by a few hours of heavy rainfall, the magnitude of flood discharge is not evaluated by daily rainfall. Therefore, the annual maximum daily rainfall was recorded on May 18, 1990, while the big floods took place on November 26, 1990 and December 23, 1992.

With reference to the annual maximum flood discharge at Simeme Station in Deli River, although the records are only for 13 years from 1980 to 1993, floods of more than a 10-year return period were experienced three times: October 1985, December 1986 and November 1990. On the other hand, Percut River had experienced floods of more than a 5-year return period three times in the same period. Fortunately, no destructive flood has taken place in the Deli-Percut River, but there will likely be serious floods hitting the area as shown from the statistical analysis.

The flood damage in November 1990 is summarized as follows:

(1) Peak flood discharge was recorded at 240 m^3/s at Simeme Station;

(2) Inundation was caused by overbank flow at the confluence with Sikambing River;

(3) Flooding area was estimated at approx. 45 km^2 with the maximum depth of 1.5 m;

(4) Households totaling 8,309 were evacuated due to the flooding and 2 people died; and

(5) Direct and indirect flood damages were estimated at Rp. 38 billion and Rp. 16 billion, respectively.

Fig. 2.3.1 shows the flood inundation areas in the Lower Deli-Percut River Basin, estimated under various probable floods.

2.3.2 River Flow Capacity

The flow capacity of the existing channel has been estimated for the Percut and Deli rivers, as follows:

Percut River	About 30 km from the river mouth to the confluence with the proposed Medan Floodway.
Deli River	About 25 km from the tollway bridge (Toll Belmera) to the confluence with Babura River, and about 15 km upstream of the confluence with Babura River.

Percut River

The bankfull flow capacity has been estimated, as shown in Fig. 2.3.2. The following stretches were found to have a relatively low flow capacity:

(1) In the lowest stretch, about 5 km long from the river mouth, the flow capacity is quite low at about 40 m^3/s due to the low elevation of both banks of about EL 1.0 m and affected by tide.

(2) In the upstream from Section P5K, the flow capacity is about 130 m^3/s except Sections P8K+800, P9K+600 and P27K+800.

(3) At Sections P8K+800 and P9K+600, the flow capacities are determined at less than 100 m^3/s due to the low bank of both sides where a dilapidated small earth dike is found.

(4) As for Section P27K+800 with the flow capacity of 112 m^3/s, the elevation of the left side bank is lower compared to the adjacent sections. However, the elevation of the ground surface at about 30 m behind the left bank is almost the same as the other sections.

Deli River

The lower stretch from Toll Belmera to the confluence with Babura River has been improved under MUDP II with the design discharge of 464 m^3/s to 427 m^3/s, as presented in Fig. 2.3.3. The flow capacity of the stretch was estimated based on the standard cross sections in the tender drawing. When the freeboard of 0.8 m, as indicated in the "Flood Control Manual," was

applied to this stretch, the flow capacity of the stretch was generally evaluated to be lower than the design flow capacity, as shown in Fig. 2.3.4.

The revised flow capacity is summarized as follows:

(1) For Section BD0 to BD221 where the design discharge is 464 m^3/s, the flow capacity is estimated at only 400 m^3/s. Therefore, the flow capacity is smaller than the design discharge by 64 m^3/s.

(2) For Section BD221 to BD394 (confluence with Sikambing River) where the design discharge is 455 m^3/s, the flow capacity is also estimated at only 400 m^3/s. Therefore, the flow capacity is smaller than the design discharge by 55 m^3/s.

(3) For Section BD394 to BD508 (confluence with Babura River) where the design discharge is 427 m^3/s, the flow capacity is estimated at 370 m^3/s. Therefore, the flow capacity is smaller than the design discharge by 57 m^3/s.

In the upper stretch from the confluence with Babura River, the flow capacity has been estimated for the existing channel, as shown in Fig. 2.3.5. The flow capacity of the stretch is generally evaluated as follows:

(1) In the stretch from the confluence of Babura River (D25+700) to the proposed Deli River Weir (UD12), the flow capacity of about 30 m^3/s is quite low because of the low bank elevation from D28+410 to D31+740. According to the site inspection for this stretch, the ground elevation on the left and right banks is almost the same. When reference is made to the survey drawing in the B-P Study, however, the bank elevation is quite low, forming the squatter area.

(2) In the stretch from D35+070 (Titi Kuning) to UD26, since the river passes through the valley portion of the hilly land area, the flow capacity is relatively big at about 300 m^3/s. At some sections such as UD7, UD8 and UD12, the flow capacity is small.

(3) In the upper stretch from UD27, the figure indicates a small capacity of about 200 m^3/s or more. This is also caused by the low elevation of the bank. Judging from the actual capacity by ground elevation, it may be more than 300 m^3/s.

2.3.3 Previous and Ongoing Flood Control Works

Since the 1980's the Deli River Improvement Works which include Sikambing River (tributary of Deli River) and Kera River has been undertaken by DPUP-SU, while those under MUDP II commenced in 1990. The main works of these river improvements are new dike construction,

deepening and widening of existing river channel, reconstruction of bridges and installation of drainage facilities. The previous and ongoing projects are as presented below.

River Improvement by DPUP

River improvement works in and around the Study Area were undertaken by DPUP from 1980 to 1990, as presented in Table 2.3.1. Most of the works were the rehabilitation of existing dikes to protect paddy fields. Recently, on account of the serious flood damage in Medan City, flood control works are mainly focused on the improvement works for Deli River. Some of the flood control works were drawn up by the DPUP, as shown in Table 2.3.2. Among them, only the Deli River Improvement Project has been carried out with financial assistance from OECF and IBRD.

The scale of improvement was determined mainly according to the relative importance of individual river basins. Since the work volume was limited by financial conditions, the priority of implementation was placed firstly on the low-lying areas where flood damage was serious. The investigation and design of the Deli River improvement have been executed for a length of 40 km from the river mouth, as a part of the North Sumatra Flood Control Project (PPS.SU) under DPUP from fiscal year 1987 to 1990. The following river improvement works for protection against a 10-year return period flood have been accomplished.

Work Item	Improvement Stretch	Improvement Volume (m^3)
Excavation	River mouth to 7.5 km upstream	498,400
Left Embankment	River mouth to 12.0 km upstream	209,200
Right Embankment	Tollway to 7 km upstream	93,400
Total		801,000

The design and construction works were financed by foreign loans such as OECF and IBRD, and also by local funds (APBN). From fiscal year 1987 to 1990, land acquisition along the river from the estuary to the confluence with Sikambing River, an area of 97.11 ha corresponding to 23 km long, was accomplished by PPS.SU.

River Improvement by MUDP II

All flood control works on rivers flowing through Medan City were turned over from PPS.SU to MUDP II at the end of 1990. MUDP II is the second phase of a continuing program for Medan urban development to improve the urban environment and essential urban services with ADB loan. The proposed project has the following components:

(1) Water Supply;

(2) Sewerage and Drainage;

(3) Solid Waste Management;

(4) Flood Control;

(5) Urban Roads and Traffic Management;

(6) Small Towns Infrastructure Improvement;

(7) Kampung Improvement Program(KIP) and Market Infrastructure Improvement Program (MIIP); and

(8) Institutional Development and Consulting Services.

The implementation of this multi-component project involves the agencies at central, provincial and municipal government level. The execution agencies for MUDP II are DGCK, Medan City, PDAM Tirtanadi and the National Housing Authority (PERUMNAS). For flood control, however, only the DGWRD was appointed as executing agency. The project area under the flood control sector is situated in Medan City, and the scope of work includes, among others, channel improvement and river dike construction along the Deli, Sikambing, Putih and Kera rivers.

The Project Management Office of the Medan Flood Control Project under the Second Medan Urban Development Project (MUDP II) was established in January 1991 with financial assistance from ADB. The office projected the river improvement of Deli River and its tributaries, Sikambing and Putih in 1991 through 1992, and the construction was commenced in 1993 with funds from ADB and APBN. The related works were scheduled to be completed by the end of 1995.

Aiming at increasing the flood carrying capacity, channel excavation, construction of river dikes and cut-off channels, bridge reconstruction, etc., have been carried out. The project is as illustrated in Fig. 2.3.3.

Longitudinal profiles of channel bed, high water level and dike crown are shown below (refer to Fig. 2.3.6). Cross section is a trapezoidal type with a bottom width of 30.0 m to 19.2 m and side slope of 1 : 1.5.

Section No.	Channel Bed (EL m)	High Water Level (EL m)	Crown of Dike (EL m)
BD000	- 4.00	2.10	2.60
BD102	- 1.86	4.24	4.74
BD234	2.46	8.73	9.23
BD400	8.58	14.85	15.35
BD508	13.88	19.61	30.11

Deli River Improvement Works, from the estuary (cross point of Toll Belmera) to the confluence point of Babura River for a total stretch of about 24 km, is being implemented under MUDP II. The improvement stretch is divided into the following four (4) packages:

Package No.	Improvement Stretch
FCD 1 (Package 1)	BD000 to BD221 (L = 10,456 m)
FCD 2 (Package 2)	BD221 to BD311 (L = 4,695 m)
FCD 3 (Package 3)	BD311 to BD394 (L = 3,888 m)
FCD 4 (Package 4)	BD394 to BD508 (L = 5,321 m)

The Deli River Improvement Works was scheduled to be completed in June 1995. Two packages (FCD 1 and FCD 3) have been completed, and the others (FCD 2 and FCD 4) were expected to be completed within the year 1995.

Improvement of Upper Deli River

A preliminary improvement plan of Upper Deli River (from confluence with Babura River to Titi Kuning) was prepared by DPUP-SU in 1988. The longitudinal profiles of Upper Deli River are as given below (refer to Fig. 2.3.7).

Section No.	Channel Bed (m)	High Water Level (m)	Crown of Dike (m)
D.221	14.36	20.51	21.11
D.170	16.50	22.34	22.96
D.155	16.59	22.46	23.06
D.56	18.90	24.98	25.58
D.34	22.55	26.16	26.76

The cross section is a single trapezoidal type with bottom width of 15.0 m and side slope of 1.0 : 1.5. Design discharge was set at 267 m^3/s, which corresponds to a 10-year return period. For the proposed improvement plan, the bankfull flow capacity was examined by non-uniform calculation, which shows that the improvement channel has enough flow capacity for its design discharge. However, the freeboard was assumed at 0.5 m which is smaller than the 0.8 m in the "Flood Control Manual."

In addition, the project office proposed river improvement for the stretch of about 6 km from the confluence with Babura River to Titi Kuning. The project is expected to be carried out under MUDP III.