APPENDIX H

REVIEW
ON
PREVIOUS FLOOD CONTROL ACTIVITIES

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REVIEW ON PREVIOUS FLOOD CONTROL ACTIVITIES

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1. Existing and Ongoing Flood Control Works

The Padang area has been suffering from flooding since the Dutch ages. Floodings before the construction of flood relief channel (Banjir Kanal) were caused by the flood water both from the Arau and Kuranji rivers. Channel capacity of the Arau river was insufficient, in addition, flood water from the Kuranji river flowed into the Padang area through the Jati river and other irrigation canals. Flood relief channel was proposed intending to divert a part of flood runoff of the Arau river, to prevent the flood runoff of the Kuranji from attacking Padang city and to drain both the runoffs directly to the sea. The construction works of the flood relief channel and diversion structure at its head were started in 1911 and finished in 1918. The background and construction of the existing flood relief channel were recorded in the B.O.W. The brief of the annual reports is shown in ANNEX H-1 of this report.

The flood relief channel and flood diversion structure in Lubuk Begalung are the most important existing flood control facilities.

Incessant efforts for protection of Padang Area from floods have been made by the DPU, West Sumatra and its related authorities. Table H-1 shows the past budgets for the flood control of the Arau, Kuranji and Air Dingin rivers and Padang coast protection since 1969/70 fiscal year.

The works executed so far are mainly local protection, rehabilitation and maintenance of the flood relief channel, and jetty construction for Padang coast protection from erosion. These works seem to have been properly executed and performing their expected functions. These works, however, are not carried out under a comprehensive basinwide flood control plan, since the works are executed with the limited fund and are those of remedial measures.

1.1 Bank Protection and Channel Improvement Works

The river courses are meandering and braided in the plain reaches, and public roads and village houses along the river have suffered from severe bank erosion in places. Bank protection and river training works are executed in such critical portions of the Arau, Kuranji and Air Dingin rivers so as to protect these public roads and village houses. Stone basket (bronjong) is the most commonly used works in these rivers.

The stone basket and cylindrical gabion could be said appropriate works for bank protection and river training in these rivers because of its flexible structure and easiness of material procurement. The river bed is steep covered with cobble stones and boulders and the bed is changeable.

In the lower reaches of the Kuranji river, dredging works are on-going to increase the channel capacity. As a whole, flood levees are not provided for the Arau, Kuranji and Air Dingin rivers except for the flood relief channel and around its diversion structure.

1.2 Flood Relief Channel

In recent years maintenance activities of the flood relief channel have been executed more or less every year. Especially after 1980/81 rehabilitation works of relatively large scale have been implemented as follows :

a. 1980/81 : slope revetment works with surefooting and embankment works on the left bank from sta. 4.0 km to sta. 6.9 km.

b. 1981/82 : widening of channel by about 6 m, embankment works and slope revetment works with surefooting on the right bank from sta. 6.0 km to sta. 6.9 km.

c. 1982/83 : rehabilitation of right bank levees and slope revetment works with surefooting for the stretches from sta. 0.6 km to sta. 1.2 km and from sta. 3.7 km to sta. 5.1 km.

1.3 Padang Coast Protection

According to Uraian Ringkas; Masalah Pantai Padang (Brief Explanation; Problem of Padang Coast) prepared by DPU, West Sumatra in August 1978, the erosion of coastline occurred after the completion of the flood relief channel. The annual erosion rate was 2.2 m/yr on average extending on the coastline of 3,650 m between the river mouths of the Arau river and flood relief channel. The erosion gets active, in general, twice a year in July/August and November/December.

In the year 1942, about 400 m of sea wall was constructed from river mouth of the Arau. Substantial erosion control works were commenced in 1968 and are still ongoing (refer to Fig. H-1).

The erosion control works mainly consist of construction of jetties (krib) and supplying sand as well as repair and strengthening of sea walls constructed in earlier stages. By the end of 1982/83 fiscal year, 39 jetties totalling 1,655 m in length were constructed and sand amounting to about 16,000 m^3 was supplied for curing the coast.

2. Previous Flood Control Studies and Related Projects

2.1 Flood Protection and Control of Padang and Environments

The study was made by P.T. Indah Karya for DGWRD in 1973 through 1975, and the study results are involved in a series of reports. This study initiated the current studies on flood control of the Padang area. Brief description of these study reports is given in ANNEX H-2 and H-3.

Among these reports, the first report; Reconnaissance Report for the Flood Protection and Control of Padang and Environments presents the basic concept of flood protection and control as follows :

a. To retard flood runoff in upper reaches by means of re-afforestation, and river terracing/check dams

b. To accelerate drainage in the lower reaches by means of channel improvement and cut-off channels

c. To prevent flood water from overflowing by means of levees on both river banks, and decreasing flood runoff by floodway and watershed separation

d. To drain local rain by means of construction and rehabilitation of drainage canals

e. To regulate land use so as to reduce damages.

The report further presents the implementation of flood control works as follows dividing into short and long term works:

a. Long term works

- Reafforestation and forest maintenance
- Regulation on land use
- Separation of the Balimbing river watershed from the Kuranji river by a new canal (2.4 km long) taking a route through Kp. Tunggul Hitam and Air Tawar river
- Check dam construction and river terracing.

b. Short term works

- River training and levee construction
- Rehabilitation of the Arau flood relief channel and its flood control structure
- Rehabilitation and construction of drainage canals and gates.

2.2 West Sumatra Design Unit Reports

The reports were prepared by the Design Unit of Pengairan, DPU, West Sumatra in 1977 through 1981, under a technical cooperation by Sir William Halcrow & Partners under assignment by Overseas Development Administration, London. Most of these reports are so-called technical notes.

In a report with a title of Review of Flood Control and Irrigation Rehabilitation in the Arau, Kuranji and Air Dingin River Basins, June 1977, some short comments are given on the said Indah Karya Report which are briefly introduced as follows :

a. The significance of reafforestation and forest maintenance around Padang is small with reference to the existing flood problem.

b. A distinct reserve should be maintained on all waterways including the rivers, for maintenance access and to reduce the influence of flooding.

c. The separation of the Balimbing from the Kuranji catchment is not considered an effective measure considering the cost.

d. The proposal to build check dams in middle and upper reaches of the Arau and Kuranji rivers appears an unsuitable measure.

e. The so-called short term works appear better suited to the condition in the study area. River training works on the three major rivers are noticeable.

f. The construction of levee can be an expensive measure in terms of construction costs. However, levee should be considered for use in the study area.

g. Rehabilitation works of weir at Lubuk Begalung with provision of control gates and the raising of the flood channel banks would greatly increase the effectiveness of the flood relief channel. The channel mouth could be better protected from sandbars by the construction of sea groynes.

h. At present the storm water drains in Padang are in a very poor state and the provision of outfall structures with tidal gates is a sensible ideas and should be pursued.

2.3 Padang Kampung Improvement Program

The captured program was prepared by FENCO Consultants for DGCK in 1980, as a part of the Urban Development in 7 Medium Size Cities.

The basic objective of the Kampung Improvement Program is to provide the basic infrastructure services in low-income and unserviced kampung areas and to upgrade to minimum standards. These include (1) footpaths and pathways, (2) drainage, (3) water supply, (4) sanitation and (5) solid waste collection.

The Padang KIP project covers an area of 258 ha and is implemented in 4 phases as follows (refer to Fig. H-2):

Phase	Fiscal year	Kampung	Net area (ha)	Population
I	1980/81	Purus I	44	8,751
II	1981/82	Ujung Gurun, Purus II	55	14,430
III	1982/83	Alang Lawas, Pasar Gadang, Pondok	77	16,093
IV	1983/84	Seberang Padang, Parak Gadang	82	15,205
	TOTAL		258	54,479

The Phase I and II works were completed and Phase III works and detailed engineering for Phase IV are ongoing. Drainage improvement included in the KIP program is, in general, for tertiary drains of small size.

2.4 Padang Drainage Improvement Project

P.T. Indah Karya with advisor from DHV Consulting Engineers is conducting detailed engineering of Padang Drainage Improvement Project for DGCK aiming to propose drainage improvement works in order to reduce the floodings and to improve the sanitary condition of drains, in the old city area bounded by the flood relief channel, the Arau river and the Indonesian Ocean (approximately 1,000 ha : refer to Fig. H-3).

According to the Inception Report of the engineering services for the project, main components of the study are as follows :

a. Review of available reports and data regarding the urban drainage of Padang with special attention to the report prepared by P.T. Mesa Jaya in 1980.

b. Carry out topographical survey work in the town to determine ground elevation, distance, etc. as required for an adequate design of the drainage system.

c. Assess and review the extent of past floodings of the city and the related damage.

d. Prepare a general engineering study aiming at over-coming the flood problems in conjunction with an improved flushing of dirty water in the drainage systems.

e. Recommend on priorities for the implementation of the proposed schemes and prepare cost estimates for the work.

f. Prepare detailed designs and tender documents for the recommended scheme after approval of the Ministry.

g. Advise on a program of garbage collection and disposal within the project area.

h. Advise on a program of maintenance and any particular operational requirements for the rehabilitated drainage system.

i. Review and report on non-structural options available including administrative and organizational arrangements.

The services were commenced in August 1982 and the study is still ongoing. Series of supporting report and background papers have been prepared so far. Interim Report I was published in May 1983 and Interim Report II will be submitted in the beginning of November 1983.

According to the Interim Report I, the project area is covered with the following existing drainage systems:

a. Bandar Purus (120 ha)/Bandar Purus Kebun & Bandar Olo I (120 ha) system

b. Kalimati (55 ha) system

c. Bandar Olo II (90 ha)/Anak Jati (50 ha) system

d. Palinggam Hakim (50 ha) system

e. Jati (300 ha) system

f. Ganting Parak Gadang (60 ha) system

g. Aur Duri (150 ha) system

The report proposes the following improved drainage systems which are shown in the sequence of higher priority.

a. Olo-Nipah system (140 ha)

b. Ujung Gurun system (162 ha)

c. Damar system (115 ha)

d. Palinggam system (57 ha)

e. Jati 1 system (96 ha)

f. Kalimati and Anak Jati system (83 ha)

g. Jati 2 system (118 ha)

h. Air Camar system (96 ha)

i. Aur Duri system (187 ha)

The layouts of the existing and proposed drainage systems are shown in Figs. H-3 and H-4. The Damar system and Jati 1 & 2 system have the following alternative drainage routes which are not selected yet:

a. Damar system

- Drainage with a new outlet to the sea as shown in Fig. H-4
- Drainage by the route of the existing Purus I drain

b. Jati 1 & 2 system

- Drainage with a new outlet to the Arau river as shown in Fig. H-4
- Drainage by the route of the existing Jati drain.

Out of the proposed drainage systems, the Olo-Nipah system was subject to the preliminary design selected as the first priority area.

2.5 Other Studies

Study on Water Resources Development Plan in the Padang Metropolitan Area (Study Perencanaan Pengembangan Sumber-sumber Air Wilayah Metropolitan Padang) was made for DGWRD by P.T. Virama Karya in 1981.

Feasibility Study and Detailed Engineering for the Padang Water Supply Project were made for DGCK by Lahmeyer International in November 1982.

Padang City Master Plan (Rencana Induk Kota Padang 1983 - 2003) was set up lately in January 1983 by pemerintah Kotamadya Daerah Tingkat II Padang (refer to Fig. H-5).

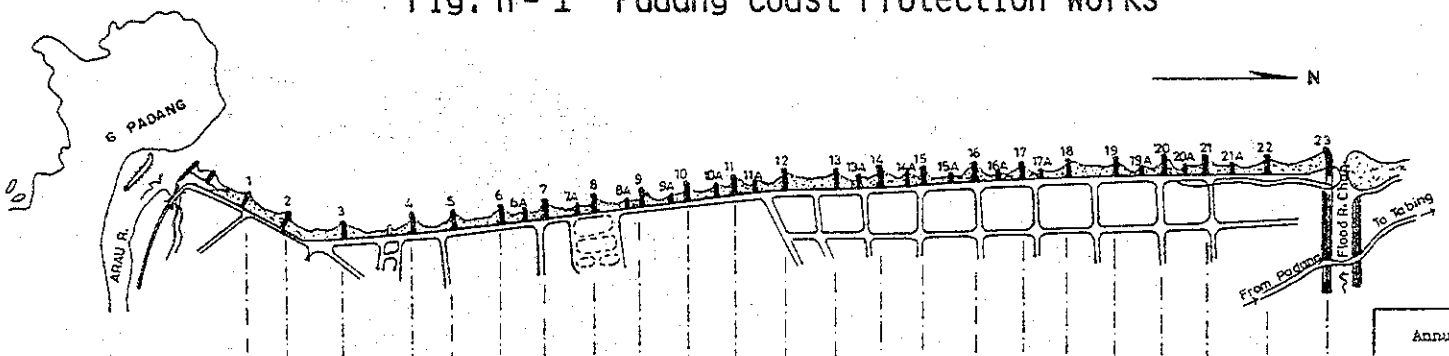
Regarding the studies on Padang coast, Prestudy on Padang Coast Problems (Prestudy Masalah Pantai Padang) and its several up-to-date versions on the Padang Coast problems were prepared by DPUTL or DPU, West Sumatra so far. Lately, Final Report on Inspection and Investigation Works of Deposition Effects of Jetties in Padang Coast (Final Report Pekerjaan Pengamatan dan Penelitian Krib Terhadap (Pengaruh) Endapan Pantai Padang) was prepared for DPU, West Sumatra by CV. Tri Udaya Sakri in 1983.

The studies mentioned above are also referred to in planning the Padang Area Flood Control Project.

Table H-1 Past Budgets for Flood Control and Coast Protection Works

Year	Budget ($Rp.10^3$)					
	Arau R.	Flood relief channel	Kuranji R.	Air Dingin R.	Padang coast	Total
1969 - 70	-	8,000	6,000	-	6,320	20,320
1970 - 71	4,500	13,500	2,500	-	-	20,500
1971 - 72	866	3,900	3,184	-	30,000	37,950
1972 - 73	1,583	11,531	-	5,902	35,000	54,016
1973 - 74	4,173	16,817	-	-	40,000	60,990
1974 - 75	-	6,025	3,510	-	40,000	49,535
1975 - 76	-	22,315	5,930	-	46,000	74,245
1976 - 77	-	14,898	9,601	4,000	45,000	73,499
1977 - 78	17,850	-	14,490	-	40,000	72,340
1978 - 79	19,108	-	20,000	-	50,000	89,308
1979 - 80	52,675	-	30,565	-	59,000	142,240
1980 - 81	12,338	107,678	29,889	-	69,992	219,897
1981 - 82	8,350	223,368	13,125	-	65,035	309,878
Total	121,443	428,032	138,994	9,902	526,347	1,224,718
1982 - 83	22,242	293,527	81,800	12,872	85,000	495,441

Fig. H-1 Padang Coast Protection Works

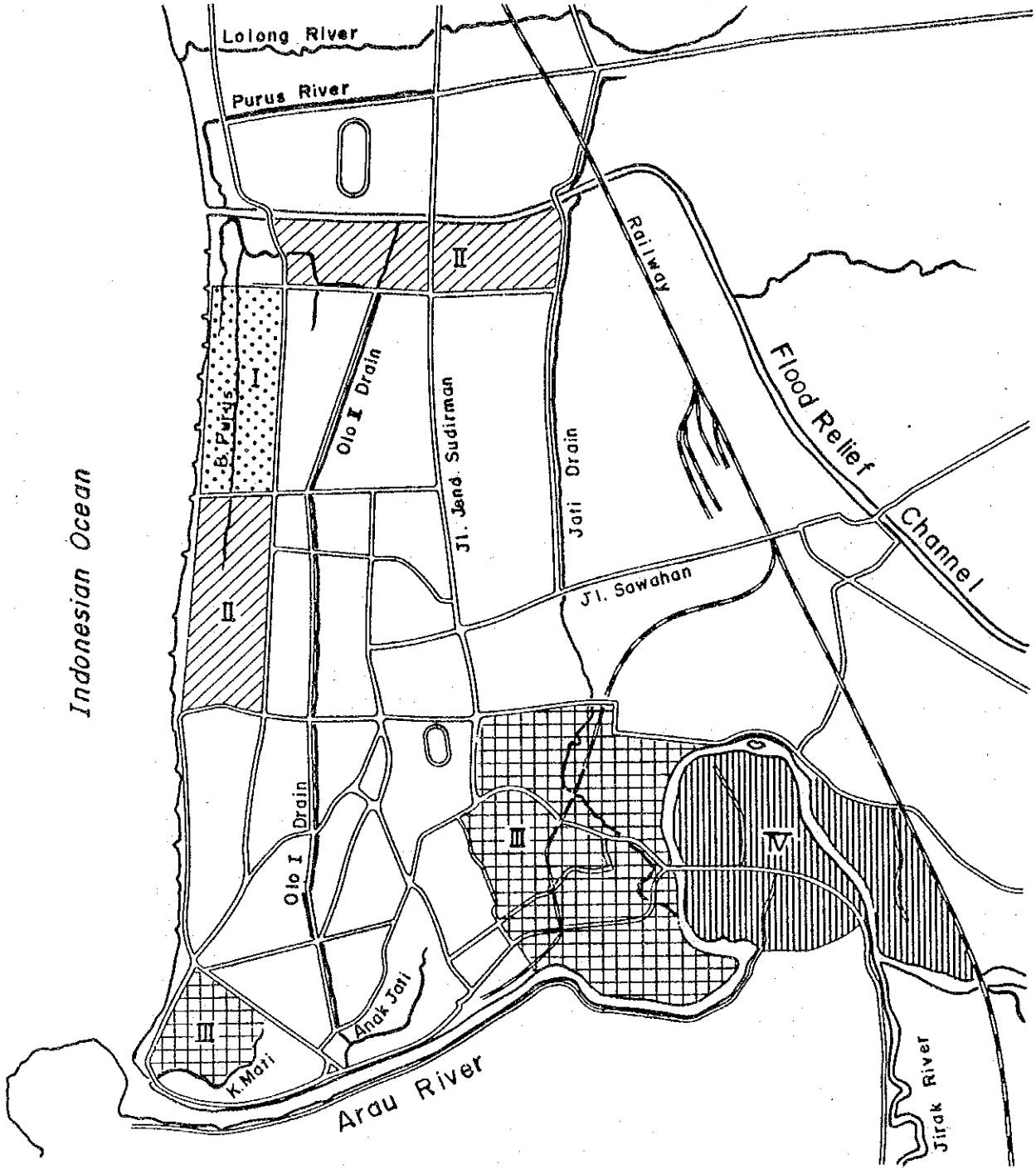


DISTANCE (M)	150	300	500	715	860	1000	1150	1300	1450	1600	1750	1960	2050	2170	2330	2500	2650	2800	2950	3100	3279	3475	3675	Annual work quantity		
Jetty No	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Seawall (m)	Jetty (m)	Supply sand (m^3)
1942	(Block : Dutch)																							400	-	-
1944	(Block : Japan)																							3,000	-	-
1964												(Temporary seawall)												485	-	-
1968/69	40		40		40		40	(Temporary seawall)																1,865	B. 160	-
1971/72				30		25	30	30	25	50	10													Re. 280	S. 200	-
1972/73	25										15	25	25	25	25	25		25		25		25	35		S. 275	-
1973/74															25	25			50				20	G. 480 Re. 150	S. 120	2,000
1974/75			25		25								25			25		25					25	Site:? Re. 120	S. 150	3,500
1975/76				25		25		25			25								5					Site:? G. 140	S. 105	3,000
1976/77									25			25			25		25								S. 100	3,000
1977/78						10		35		10			10			10			10						S. 95	2,000
1978/79									25		25			25	25										S. 100	Site:? 3,000
1979/80																25	25	25	25						S. 100	
1980/81						25													25	25	25				S. 100	
1981/82								25	25													25			S. 75	
1982/83						25	25	25																	S. 75	

LEGEND: Jetty works; Supplying sand; Seawall works

NOTES:
G.:gabion P.V.C. Re.:rehabilitation work B.:concrete block S:stone

Fig. H - 2 Padang Kampung Improvement Program



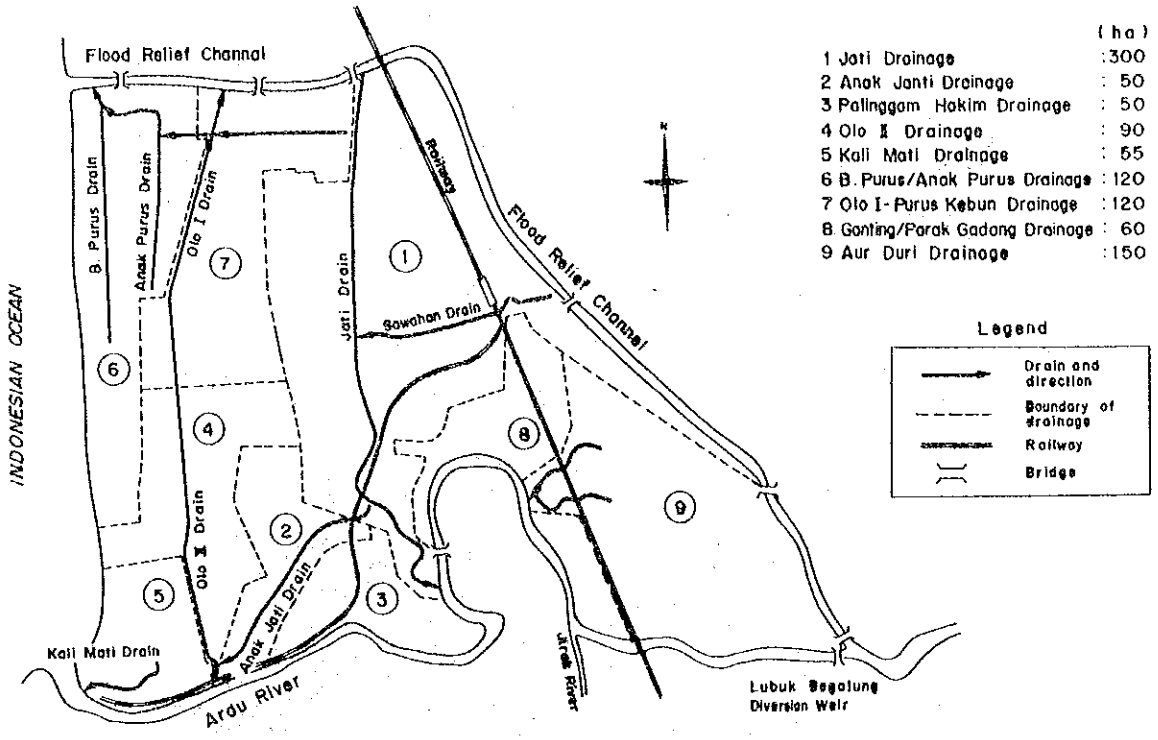
Legend

- KIP Area Phase I
- KIP Area Phase II
- KIP Area Phase III
- KIP Area Phase IV

Source:

Padang KIP Feasibility Study 1980

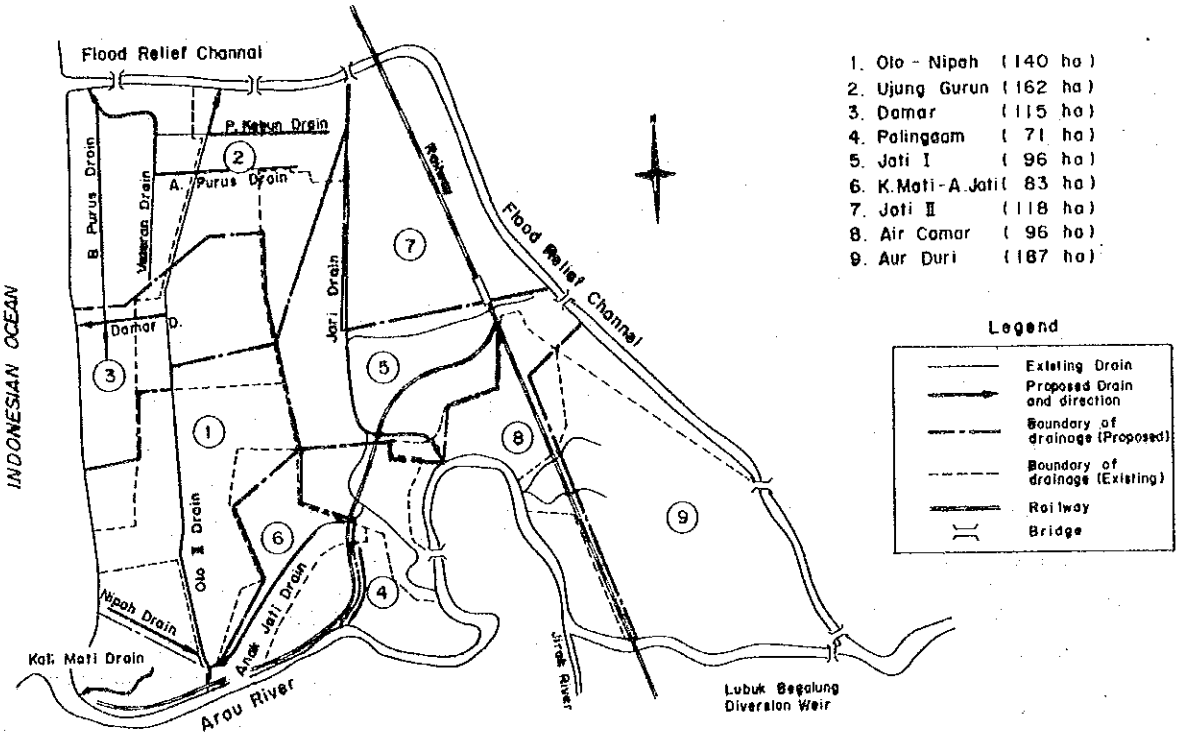
Fig. H-3 Existing Drainage System in Old Urban Area



	(ha)
1 Jati Drainage	:300
2 Anak Janti Drainage	: 50
3 Palinggam Hakim Drainage	: 50
4 Olo II Drainage	: 90
5 Kali Mati Drainage	: 55
6 B.Purus/Anak Purus Drainage	:120
7 Olo I-Purus Kebun Drainage	:120
8 Ganting/Parak Gadang Drainage	: 60
9 Aur Duri Drainage	:150

Source : Inception Report on Padang DRIP, Dec. 1982

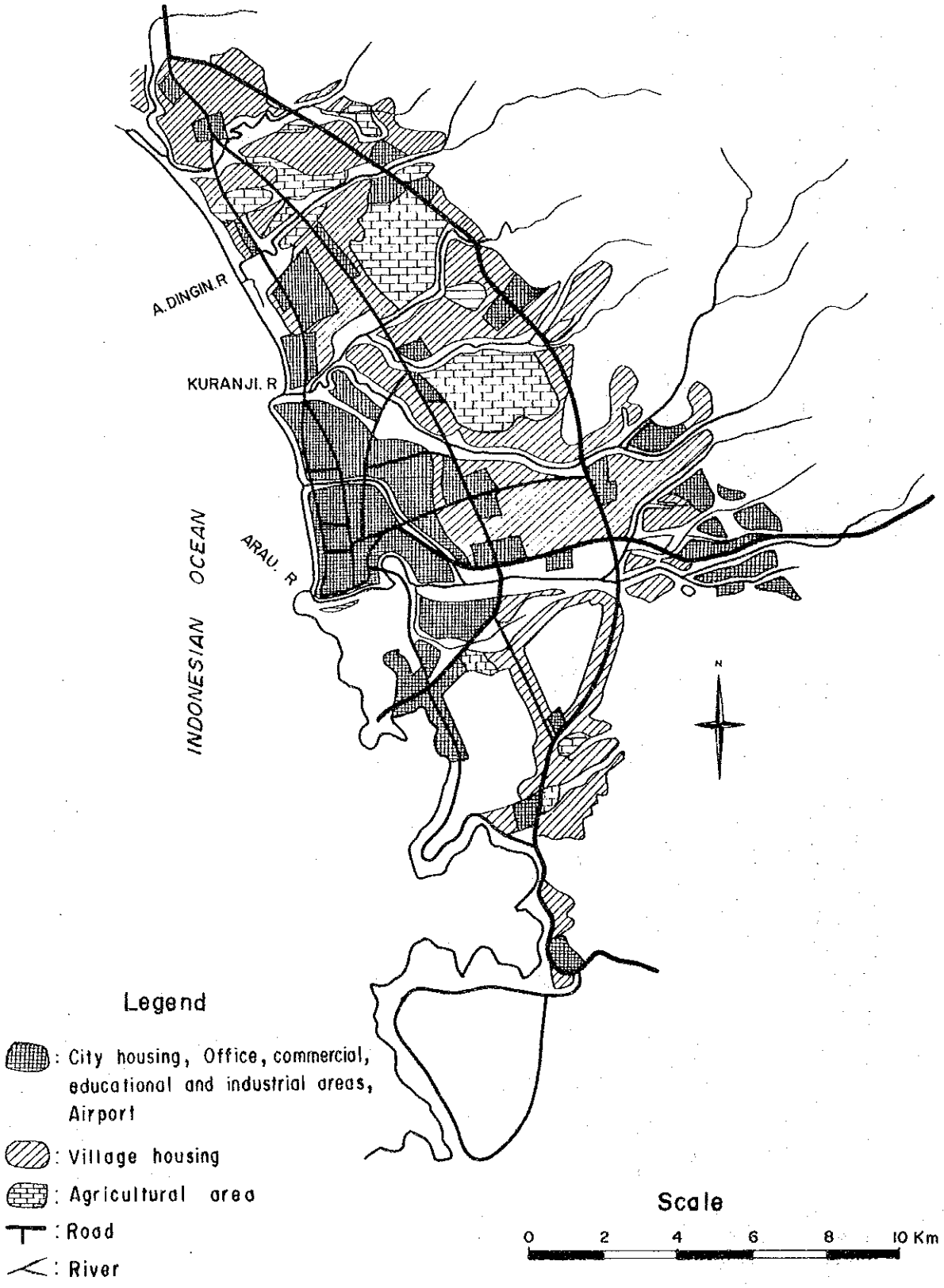
Fig. H-4 Proposed Drainage System in Old Urban Area



1. Olo - Nipah	(140 ha)
2. Ujung Gurun	(162 ha)
3. Damar	(115 ha)
4. Palinggam	(71 ha)
5. Jati I	(96 ha)
6. K.Mati-A.Jati	(83 ha)
7. Jati II	(118 ha)
8. Air Comar	(96 ha)
9. Aur Duri	(187 ha)

Source : Padang Drainage Improvement Project

Fig. H-5 City Development of Padang in 2003



Source : Rencana Induk Kota Padang 1983 - 2003

Briefing of;
BANJIRVRIJ MAKEN VAN DE STAD PADANG EN OMSTREKEN
B.O.W. VERSLAG 1894 - 1911 - 1918
(PROTECTION OF PADANG CITY AND SURROUNDINGS FROM FLOODS
B.O.W. REPORT 1894 - 1911 - 1918)

1. Data Source : Copy of B.O.W. (Burgelijke Openbare Werken) Annual Reports (Written in Dutch) from DHV Consulting Engineers, and its translation (into Indonesian) by DPU, West Sumatra.

2. 1894 - Annual Report : Major concerns of Padang area flood control are briefly presented hereunder;

   a. Bank protection works were executed in the lower Arau river (about 3 km upstream from the river mouth) to protect military housing area and buildings

      - Work quantity : 177 m long
      - Dike section : Dike crown at 3.0 m above the maximum flood water level with 1.50 m width, side slope with masonry at 1 on 2 for both river and land side slopes except river side slope lower than berm where slope was taken at 1 on 1.5.

   b. Groyne works in the upstream reaches of the above bank protection site.

      - Work quantity : 15 units at 20 m intervals
      - Structure : Groyne made of gabion with crown width 1.0 m and height 0.5 m above low water level.

3. 1911 - Annual Report

   a. Flooding occurred from time to time in Padang city. The floods were caused by :

      - Overtopping of flood water from the Arau and Kuranji rivers
      - Poor drainage system in Padang city

   b. Irrigation water was taken from the Kuranji river by means of free flow and drained into the Arau river directly or through the Jati river.

c. Flood water overtopping the Kuranji river also took the same route as irrigation water. The floodings in Padang city were brought about not only by the Arau river but also by the Jati river.

d. Governor requested the study on flood control to the central government after Dec-5/6-1898 flood and the local government, Ir. Gijselaar, Ir. Van Marle, Ir. Straatman and Mr. Hartogh Heijs studied and proposed the flood control measures after 1900.

e. Finally, flood relief channel plan was derived. This plan was proposed in November 1903 and accepted by the Director of BOW in the letter dated on January 18, 1904.

f. Official order to study the flood was issued by the central government on April 28 in 1908, after experiencing the big floods on March 5 in 1904 and September 27 in 1907.

g. Flood control plan

- Alternative I : To construct flood relief channel from the Arau river to the sea and diversion weir for it.
- Alternative II : To protect right side bank along the Arau river and to construct a diversion channel through Gunung Padang.
- Alternative I (flood relief channel plan) was selected because of lower cost (Alt.I : f.550,000, Alt.II : f.700,000) and this plan had an advantage to stop the flood water from the Kuranji river outside Padang city.

h. The plan was determined by the Government on February 28, 1911

- Budget : f.320,764 for the 1st work division
- Excavation volume : 510,400 m^3
- Design discharge : 240 m^3/sec
- Dike crown : 2 m above the design high water level
- Opening of dike for local drainage : about 5 m wide at 50 m intervals along the right side dike

i. Work divisions for implementation of the flood relief channel project

- 1st work division : Land acquisition and excavation of channel
- 2nd work division : Construction of diversion weir at Lubuk Begalung
- 3rd work division : Appurtenant facilities related to the flood relief channel

j. Works in 1911 : only the 1st work division

- In June, land acquisition and compensation were started
- In July, the excavation works were started partly by the force account system and the others by the contract system
- Excavation : 65,725 m^3 (65,725 m^3 in total)
- Cost : f. 75,129 (f. 75,129 in total)

4. 1912 - Annual Report

a. 1st work division

- Excavation : 202,775 m^3 (268,500 m^3 in total)
- Cost : f. 92,490 (f. 167,619 in total)

b. 2nd work division

- Budget for the 2nd work division was determined at f. 140,000 by the Government on March 4, 1912
- Excavation works for foundation was started
- Cost : f. 46,825 (f. 46,825 in total)

c. 3rd work division

- Budget for the 3rd work division was determined at f. 83,000 by the Government on November 29, 1912
- Cost : f. 23,239 (f. 23,239 in total)

d. Others

- Mouth of flood relief channel was often closed with sand by waves
- Flood occurred on October 20, 1912

5. 1913 - Annual Report

a. 1st work division
   - Excavation works were not carried out smoothly because of difficulty of getting laborers and problems regarding interception of irrigation channels due to new flood relief channel
   - Excavation : 86,090 m^3 (354,590 m^3 in total)
   - Cost : f. 70,121 (f. 237,740 in total)

b. 2nd work division
   - Foundation was made of concrete up to 0.5 m high and of stone masonry for the upper part
   - Work volume (masonry) : 2,580 m^3

c. 3rd work division
   - Construction of Marapalam bridge was completed
   - Water supply pipe for drinking was installed 1 m under the flood relief channel
   - Cost : f. 59,748 (f. 82,987 in total).

6. 1914 - Annual Report

a. Because of announcement of war in Europe, only some unavoidable works were executed after August of this year.

b. 1st work division
   - Because of heavy rainfall, river bed of the flood relief channel was silted up from HM. 30 to 49
   - On May 10 in 1914, diversion weir in Lubuk Begalung was damaged, and heightenning of left dike of flood relief channel from HM 18 to 23 became urgently necessary
   - Excavation : 20,771 m^3 (375,361 m^3 in total)
   - Project budget was increased by f. 48,819, accordingly, the total budget amounted to f. 361,583 for the 1st work division.

c. 2nd work division
   - Construction of regulation gate to flood relief channel was completed in the preceding year and construction of bridge over the gate was completed and the bridge has been used from February, 1914

- During the first 3 months, concrete apron works could not be executed because of heavy rainfalls.

d. 3rd work division

- Project budget was increased by f. 49,500, accordingly, the total budget amounted to f. 132,500 for the 3rd work division.

7. 1915 - Annual Report

a. 1st work division

- There were no works because of economic recession in Europe
- On June 18 night, flood occurred and diversion weir at Lubuk Begalung was damaged. Therefore, the flood water from the Arau river was drained through the flood relief channel. In some places, the channel dikes were damaged
- On October 22 flood occurred again. By this flood, dikes of the flood relief channel were removed extending about 75 m long and paddy field behind them were damaged.
- Bed of the channel downstream of Jati bridge and Ujung Balantung bridge were eroded 1 m to 1.25 m deep. River bed consolidation works with gabion should be executed.

b. 2nd work division

- Masonry works were carried out during July through September. But after September the works were stopped because of heavy rainfall and continuous floods
- After the October 22 flood the regulation gate was shut
- The diversion weir was damaged by the flood that continued for 5 days from 24 to 28 of November
- Completed works : Left abutment and 4 piers of diversion weir, and metal works and handrails for the above
- Project budget was increased by f. 83,352,805, accordingly, the total budget amounted to f. 223,352.805 for the 2nd work division

c. 3rd work division

- At Purus, the mouth of flood relief channel was closed by sand. The DPU dredged it to open the mouth

- By the flood on December 5, 1915, the mouth of the flood relief channel shifted about 250 m to the southward
- Construction of siphon at Alai was completed and started functioning.

8. 1916 - Annual Report : **Records are not available.**

9. 1917 - Annual Report

a. 1st work division
   - Excavation : 46,000 m^3 for this year
   - Excavation of flood relief channel and its related works were nearly completed only some small works were remaining. The flood relief channel was already functioning.
   - The sediment which blocked the channel mouth was washed away by flood flows. But the flood flows also damaged the channel banks.
   - Erosion of channel bed between railway bridge and Ujung Belatung bridge were severe. Bed consolidation works near Jati and Ujung Belatung bridges were damaged.

b. 2nd work division : All of the works of this division were nearly completed. Heightenning of right side bank of the Arau river downstream of Lubuk Begalung diversion weir was remaining.

c. 3rd work division : Works of this division were also nearly completed. Installation of regulation gate of Purus gate was remaining.

10. 1918 - Annual Report

a. 1st work division
   - Heavy erosion of river bed occurred from river mouth (HM 68) to HM 27. Depth of erosion was more than 1.50 m
   - Masonry apron (90 cm thick) was constructed on the river bed downstream of the Jati bridge.

b. 2nd work division : Only some maintenance works were done.

c. 3rd work division : With installation of metal works of Purus gate, all the works were completed.

Briefing of ;
RECONNAISSANCE REPORT
FOR THE FLOOD-PROTECTION AND-CONTROL
OF PADANG AND ENVIRONMENTS

1. Prepared : by P.T. Indah Karya
for Directorate of Rivers and Swamps, DGWR, DPWEP
in March 1973.

2. Objective/scope of study : To conduct a reconnaissance study and formulate a concept for the goal of flood protection and control for Padang and environments covering two river systems of the Arau and Kuranji.

3. Study results

1. Contents : The report presents the following studies result :
   a. Socio-economic condition in survey area
   b. Natural and physical factors of river catchment area
   c. Existing conditions of river channels, coastline, and their facilities.
   d. Flood conditions including land use, flood records, cause of flood, and flood damages.
   e. Basic concept of flood protection and control with preliminary design of the proposed flood control facilities based on the reconnaissance study.

2. Basic concept of flood protection and control :
   a. To retard flood run-off in upper reaches by means of reafforestation, and river terracing/check dams.
   b. To accelerate drainage in the lower reaches by means of channel improvement and cut-off channel.
   c. To prevent flood water from overflowing by means of levees on both river banks, and decreasing flood run-off by floodway and watershed separation.

d. To drain local rain by means of construction and rehabilitation of drainage canals.

e. To regulate land use so as to reduce damages

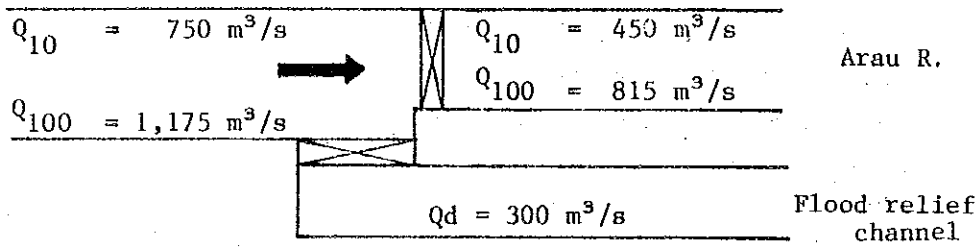
3. Design discharge

a. Design flood : 10 - year flood for levee construction and 100 year flood for weir construction.

b. Melchior, der Weduwen and Thiessen's method are applied for runoff analysis.

c. Design discharge :

- At Lubuk Begalung of the Arau river



- At river mouth of Kuranji river

Q_{10} = 785 m^3/s

Q_{100} = 1,165 m^3/s

4. Works to be implemented

a. Long term works

- Reaffoerestation and forest maintenance
- Regulation on land use
- Separation of the Balimbing river watershed from the Kuranji river by a new canal (2.4 km long) taking a route through Kp. Tunggul Hitam and Air Tawar river.
- Check dam construction and river terracing.

b. Short term works

- River training and levee construction
- Rehabilitation of the Arau flood diversion canal and flood control structure.
- Rehabilitation and construction of drainage canals and gates.

5. Outline of short term works

a. River training and levee construction.

Arau river

- River training : About 7 km from river mouth to Lubuk Begalung weir.
- Levee construction : Right bank levee for about 4 km from river mouth to Kp. Seberang Padang; left bank levee for about 3.5 km from Kp. Seberang Padang to Lubuk Begalung weir

Kuranji river

- River training : About 3.5 km from river mouth to the junction of the Balimbing river.
- Levee construction : Left bank levee for about 3.5 km from river mouth to the junction of the Balimbing river.

b. Rehabilitation of the Arau flood diversion canal and flood control structure.
   - Flood diversion canal : rehabilitation of both bank levees for about 7 km from river mouth to Lubuk Begalung gate.
   - Flood control structure at Lubuk Begalung needs to be up-graded.

c. Rehabilitation and construction of drainage canals and gates
   - Canal rehabilitation : for 3,950 ha
   - Canal construction : for 1,450 ha
   - Gated outlet structures : 15 units

d. Cost and benefit

Item	Alt-I	Alt-II
Construction cost ($Rp.10^6$)	650	825
Annual OMR cost ($Rp.10^3$)	7,490	9,690
Annual cost ($Rp.\ 10^3$)	39,600	54,700

Alt I : Excluding levee construction
Alt II : Including levee construction

4. Others

This report provides for the studies on Padang area flood control. This report also provides for data on 1972 - flood which was the historical flood as well as 1959 - flood in Padang area, since the report was prepared in the next year of the flood.

ANNEX H - 3

Briefing of ;

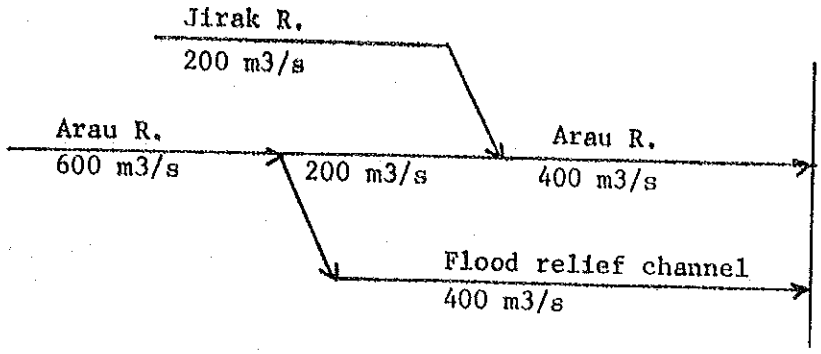
DESIGN PENGAMANAN DAN PENGENDALIAN BANJIR
BATANG - ARAU KOTA PADANG
(DESIGN OF FLOOD PROTECTION AND CONTROL OF
THE ARAU RIVER IN PADANG)

1. Prepared : by P.T. Indah Karya
   for Directorate of Rivers and swamps, DGWR, DPWEP consisting of report on;
   - Nota Penjelasan (Detailed Notes) in Feb, 1974
   - Tahap ke II, Nota Penjelasan (Phase II, Detailed Notes) in Feb, 1975
   - Tahap ke II, Hidrometri (Phase II Hydrometry) in Feb, 1975
   - Tahap ke II, Mekanika Tanah (Phase II Soil Mechanics) in Feb, 1975

2. Objective/scope of study : To prepare detailed design for flood protection and control of the Arau river including its flood relief channel and to conduct hydrometric study and soil mechanics investigation for the river.

3. Study result : In succession to the study in RECONNAISSANCE REPORT FOR THE FLOOD-PROTECTION AND-CONTROL OF PADANG AND ENVIRONMENTS, studies and detailed design were made focusing the Arau river and its flood relief channel.

(1) NOTA PENJELASAN : Study and detailed design for the flood protection and control of the Arau river.
   a. Runoff analysis : by Synthetic unit hydrograph
      - Design flood : 10 - year
      - The Arau R. at L. Begalung : Q_{10} = 601 m3/s
      - The Jirak R. at Arau jct : Q_{10} = 186 m3/s
   b. Study on discharge distribution to the lower Arau and the flood relief channel at Lubuk Begalung : Hydraulic model test for diversion is recommended.
   c. Proposed flood control works of the Arau river
      - Design discharge distribution



- Work volume :

  Embankment on left side : 21,462 m3
  on right side : 29,920 m3
  Land on left side : 102,900 m3
  on right side : 192,500 m3

- Construction cost : Rp. 104,000,000

(2) TAHAP KE II NOTA PENJELASAN : Detailed design of the flood relief channel

a. Design discharge : Q = 400 m3/sec

b. Proposed improvement works :

- Work quantity

Embankment	: 18,938 m3
Dredging/excavation	: 208,104 m3
Masonry	: 1,300 m3
Sodding	: 74,250 m2
Stop logs (wood + steel) for weir	: 336 m

- Construction cost : Rp. 149,000,000

(3) TAHAP KE II HIDROMETRI : Measurement of Mannings coefficient of roughness in the flood relief channel

a. At Muara Palam br.: n = 0.016

b. At Simpang Arau br.: n = 0.030

c. At Kp. Pinang Balik located between Alai railway br. and Jati br.: = 0.03

(4) TAHAP KE II MEKANIKA TANAH : Soil investigations along the flood relief channel and at Lubuk Begalung weir

a. Field works

Works	Along flood relief channel	At Lubuk Begalung
Sounding	10 places	3 places
Boring	3 "	3 "
Test pit	-	3 "
Sampling	8 "	3 "

b. Laboratory test : Physical and soil mechanics test of sampled materials

APPENDIX I

URBAN DRAINAGE

APPENDIX I

URBAN DRAINAGE

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1. General

The object of the study on urban drainage is to clarify the present condition of urban drainage and to make a drainage plan. The existing urban area of Padang is located on the coastal plain with an area of about 20 km^2 which may be divided into two, i.e., (1) the old urban area bounded by the Arau river, the flood relief channel and the Indonesian Ocean, and (2) the new urban area bounded by the flood relief channel, the road from Jati bridge on the flood relief channel to Nanggalo bridge on the Kuranji river, the Kuranji river in the stretch between Nanggalo bridge and the railway bridge, the railway from Kuranji bridge to Air Dingin bridge, the Air Dingin river and the Indonesian Ocean. The location of the existing urban area is shown in Fig. I-1.

For the old urban area, detailed engineering study is being conducted by the Padang Drainage Improvement Project (Padang DRIP) under the responsibility of the Cipta Karya (DGCK). For the new urban area, the Study Team made the drainage plan on preliminary study level, since the integral plan is not made yet. A close relation has been made with the Padang DRIP Team exchanging the data and view on urban drainage.

This APPENDIX I presents the present condition of urban drainage, a comprehensive drainage plan and a drainage plan for the new urban area of Padang.

2. Present Condition of Urban Drainage

2.1 Existing Drainage System

2.1.1 Old Urban Area

The existing drainage system in the old urban area is shown in Table I-1 and Fig. I-2. The main drainage system of the area is :

a. Jati and Anak Jati,
b. Kali Mati,
c. Olo I and II, and
d. Bandar Purus and Purus Kebun.

These existing drainage systems are as a whole, not maintained well and poorly functioning. In the low-lying area, the drainage is sometimes affected due to high water stage of the rivers. The Jati, Anak Jati and Olo II drainages may be drained by gravity. Ground elevation of the Kali Mati drain area is low so that the drainage is affected by high tide. Drainage of the Bandar Purus, Purus Kebun and Olo I is discharged into the flood relief channel. During the periods of high water of the flood relief channel, inundation occurs due to insufficient terminal facilities.

2.1.2 New Urban Area

This area is rapidly being urbanized. New housing, industrial and commercial areas are taking the place of farm land. No integral plan for urban drainage system is made yet for the new urban area. The existing drainage area is presented in Table I-1 and Fig. I-3.

The main drainage systems of the area are as follows :

Area located between the flood relief channel and the Kuranji river

a. Purus river
b. Lolong river
c. Lapai river
d. Ulak Karang river

Area located between the Kuranji and Air Dingin rivers

a. Baung river
b. Penjalinan river
c. Tabing river

These existing drainage systems are as a whole not maintained well and poorly functioning. In the low-lying area, the drainage is sometimes affected due to high tide or high water stage of rivers. The Purus river is affected by the high water stage of the flood relief channel. As for the drainage of the Lolong river which discharges into the sea, the channel bed at the river mouth is elevated

by sand spit. The Lapai and Ulak Karang rivers are connected with the Kuranji river. The Lapai river may be drained by gravity, but the Ulak Karang is affected by high water stage of the Kuranji river. The Baung, Penjalinan and Tabing rivers are also affected by high water stage of the Kuranji and Air Dingin rivers. During the period of high water of those rivers, inundation occurs due to back water of the rivers.

2.2 Existing Drainage Facilities

Drainage outlet structures are constructed along the flood relief channel at the terminal of drain. On the Arau river, an outlet culvert is located only at Kp. Sudut area. Most of these structures are equipped with no gate at present. Any other drainage structures are not found in the urban area. Main features of the existing drainage facilities are listed in Table I-2 and the locations are shown in Fig. I-4.

2.3 Carrying Capacity of Drainage Channel

Carrying capacity of the existing drainage channels in urban area is estimated by use of the uniform flow formula. For the calculation, Manning's coefficient of roughness of 0.025 is adopted. The survey results of the channel cross-sections prepared by the Padang DRIP for the old urban area and by the Study Team for the new urban area are used. The contents of surveying by the Study Team are listed in APPENDIX E.

The estimated carrying capacity is small as a whole as shown in Table I-3.

2.4 Existing Condition of Drainage Channel

(1) Old Urban Area

In the old urban area, drainage channels are as a whole not maintained well. The flow capacity of the channels is affected by access bridges to houses and road bridges, and is also disturbed by the dumped solid waste.

(2) Purus River

The main drainage channel of this area is the Purus river which flows into the flood relief channel near the estuary. The channel capacity is not enough although the improvement in the lower stretch of the channel was executed in March and April 1983. The backwater effect by the flood relief channel and high tide causes the poor drainage in the lower reaches of the Purus river.

(3) Lolong River

The Lolong river originates from the irrigation canal of Gunung Nago weir and flows directly into the Indonesia Ocean. At the river-mouth, the channel bed is elevated by sand spit. To avoid the inundation in the lower reaches of the channel, the opening works have been done by the neighbour inhabitants several times every year. The channel is not improved yet.

(4) Ulak Karang River

The inundation in the Ulak Karang drainage area is occurred due to insufficient capacity of the drain and backwater effect of the Kuranji river. The new residential area is located in the eastern part of the drainage where the drainage conditions are not sufficient. The western part of the drainage is affected by the backwater of the Kuranji river.

(5) Lapai River

Runoffs in the Lapai river drainage area discharge into the Kuranji river. The channel improvement has not executed yet.

(6) Baung River

The Baung river is connected with the Kuranji river. The channel has an effect of storage basin for the drainage. The area with higher elevation along the railway was occupied with residential houses and commercial buildings in recent years.

(7) Tabing River

The Tabing river basin has a catchment area of 12 km^2. The hilly area in the upstream basin is covered with scattered forest. The lower area of the Tabing river consists of swampy area and paddy field and this area is not developed yet. The downstream reaches of the railway bridge are affected by the backwater effect of the Air Dingin river.

(8) Penjalinan River

The river channel of the Penjalinan area joins with the Air Dingin river. The whole stretch of this channel is affected by high tide of sea. This drainage area is rapidly being urbanized but channel has an effect of storage of water, because swampy area or open space still remains along the channel.

3. Comprehensive Plan for Urban Drainage

The objective area for the comprehensive plan of urban drainage is the urban area to be developed in future according to the master plan of Padang city on the coastal plain between the Arau river and the Air Dingin river. Major drainage channels in the urban area are planned to be improved. At the terminal point of the drainage channel, the outlet structure is planned to be constructed. The pumping stations are also planned to be constructed at the outlet in the low-lying area.

The design flood of 10-year return period is adopted for the formulation of the plan. Considering the channel capacity of the drain and the drainage conditions of terminal point, 14 major drainage channels are planned to be improved and 6 pumping stations are also planned to be constructed. The proposed plan is as follow :

Construction of pumping station : 6 places

a. Kali Mati 1.0 m^3/s
b. Ujung Gurun 5.0 m^3/s
c. Purus 3.5 m^3/s

d. Ulak Karang 5.5 m^3/s

e. Baung 5.5 m^3/s

f. Penjalinan 3.0 m^3/s

Drainage channel improvement : 43 km

a. Old urban area 24 km

b. New urban area 19 km

The proposed pumps mentioned above have a capacity to discharge 10 years flood without damage. The pump capacities are about 3 $m^3/s/km^2$ in terms of specific discharge. The length of drainage channel to be improved and the proposed capacity of pump are listed in Table I-4, and the general layout of the comprehensive plan is shown in Fig. I-5. The work quantity is listed in Table I-5.

4. General Plan for Urban Drainage

4.1 Drainage Plan in Old Urban Area

4.1.1 General

With regard to drainage plan in the old urban area, detailed engineering study is being executed by the Padang Drainage Improvement Project (Padang DRIP) aiming to propose drainage improvement works in order to reduce the floodings and to improve the sanitary condition of drains.

The study was commenced in August 1982 and the study is still on going and will be completed by March in 1984. This chapter presents the outline and preliminary conclusion conducted by Padang DRIP up to the end of August in 1983.

4.1.2 Priority Order of Implementation

The objective area of the study is bounded by the Arau river, the flood relief channel and the Indonesian Ocean (approximately 1,000 ha). The area is divided into 9 proposed drainages considering the existing drainage systems, topographic condition and proposed general lay-out of the drainage. The proposed drainage system is shown in Fig. I-6. The objective drainages for detailed design are selected based on the socio-economic aspect such as population, flood damage, KIP area and low

income area. The drainages for detailed design are the following areas :

Priority Order	Drainage	Area (ha)
1	Olo-Nipah	140
2	Ujung Gurun	162
3	Damar	115
4	Palinggam	71
5	Jati I	96
6	Kali Mati - Anak Jati	83
7	Jati II	118

As the total amount of the budget is decided by the International Bank for Reconstruction and Development (IBRD) to limit to Rp. 7 to 8 billion (June 1983 price), 50 % of above 7 drainage area will be improved. The rest will be improved by the Cipta Karya.

4.1.3 Design Criteria of Padang DRIP

The return periods of 5-year and 2-year are adopted for the design of secondary and tertiary drains respectively. Modified rational method considering the channel storage is applied for the estimation of design floods.

Regarding the channel design, Manning's coefficients of roughness of 0.022 to 0.030 are adopted. Side slopes are limited to 1:1 except small drain. Free board is considered corresponding to the design discharge.

4.1.4 General Plan of Drainage in Old Urban Area

General lay-out of the proposed drainage system is shown in Fig. I-6. The outline of the plan is as follows :

(1) Jati

The existing Jati drain joins the Arau river at about 200 m downstream of Seberang Padang bridge. Downstream reaches of the Jati drain is affected by high-water stage of the Arau river, and this makes the excess water goes down to the Anak Jati and Palinggam areas. A new

outlet is proposed to be constructed at 600 m upstream of Seberang Padang bridge to avoid the backwater effect of the Arau river.

(2) Palinggam

This area is affected by the excess water of the existing Jati drain. After completion of the new Jati drain, frequent inundation will be decreased.

(3) Anak Jati

The Anak Jati drain is at present diverted from the Jati drain just downstream the railway bridge. While the existing drainage area of the Anak Jati is 55 ha, excess water from the Jati drain flows into this low-lying area through the stop log weir at diversion point. The new Jati drain will relieve this area also.

(4) Olo-Nipah

Kp. Nias area in the existing Anak Jati drainage and Nipah area will be included in the Olo-Nipah drainage to reduce the damage in the Kali Mati and Anak Jati area.

(5) Kali Mati

Nipah area will be excluded to avoid the inflow to the Kali Mati drainage.

(6) Damar

New Damar drain will be constructed to reduce the damage in the low-lying area of the Ujung Gurun drainage. Main problem of the new drain plan is the maintenance of the outlet against blocking.

(7) Ujung Gurun

Upstream part of the existing Bandar Purus drainage will be separated by the proposed new Damar drain. Purus Kebun outlet will not be available during the high water stage of the flood relief channel so that the spillway facilities to the existing Ujung Gurun drain is proposed. Between the coast and the Bandar Purus drain, a strip of swampy

area lies. About 3 ha of this area will be avilable for retension basin or collecting pond for pump drainage.

(8) Air Camar and Aur Duri

A major drainage channel along the railway is proposed for the Aur Duri drainage and small drains discharging directly to the Arau river are proposed for the Air Camar Drainage.

4.1.5 Implementation Plan of Padang DRIP

The implementation of the project is not decided yet. At present two alternative implementation schedules which will be started in April 1984 and April 1985 have been proposed for a five years' implementation period. The first priority is given to the Olo-Nipah area and the preparation of the detailed designs for the remaining area will be started parallel to the construction works of Olo-Nipah drainage.

4.2 Drainage Plan in New Urban Area

4.2.1 General

Based on the comprehensive plan, the general drainage improvement plan for the new urban area is prepared. The general plan aims to reduce the frequent floodings in the present condition while the comprehensive plan is prepared for mitigation of flood damages in the future development condition.

4.2.2 Design Criteria

(1) Design discharge

Design discharge is calculated using the modified rational method considering the channel storage. The return period of 5-year is adopted for the design as well as that in the old urban area. Unit-graph method is applied for the preparation of design hydrographs.

(2) Channel design

The following criteria is applied for the channel design.

a. A series of the topographic map of 1/5,000 scale and the aero-photos of 1/5,000 scale are used for design of alignments.

b. The channel cross-sections surveyed by the JICA Team are used for channel design.

c. Required cross-section is calculated by the uniform flow equation,

$$Q = I^{1/2} A R^{2/3} / n$$

where,

Q : discharge (m^3/s)
I : slope of water surface
A : cross-sectional area (m^2)
R : hydraulic radius (m)
n : Manning's coefficient of roughness

d. Manning's coefficient of roughness of n = 0.025 is adopted.

e. The following are adopted for design of cross-section as standard values :

Design Discharge (m^3/s)	Free boad (m)	Crest width (m)		Side slope
0 - 5	0.30	3.0	1.0	1 : 0.5
5 - 10	0.40	3.0	1.0	1 : 0.5
10 - 25	0.50	3.0	1.0	1 : 0.5
more than 25	0.60	3.0	3.0	1 : 1.0

4.2.3 Design Discharge

(1) Modified Rational Formula

The following formula is adopted for the estimation of the peak discharge.

$$Q = 0.2778 (1 - x) f r A$$

$$X = \sqrt{\frac{T + b}{T} \left(1 - \frac{b}{T} \ln \frac{T + b}{b} \right) - \frac{T}{2 (T + b)}}$$

where, Q : peak discharge (m^3/s)
f : runoff coefficient
r : rainfall intensity (mm/hr)
A : drainage area (km^2)
X : storage coefficient
T : time of concentration (min)
b : constant in intensity formula of Talbot type

(2) Rainfall intensity

The same equation prepared for the Padang DRIP is adopted. That is,

$$r = a/(T + b)$$

where, r : rainfall intensity (mm/hr)
T : time of concentration (min)
a,b : constant

The recorded annual maximum values, probable depth and intensity are shown in Tables I-6 thru I-8.

(3) Time of concentration

The time of concentration is obtained by the following equation

$$T = To + Tc$$

where, T : time of concentration (min)
To : time of overland flow (min)
Tc : time of flow in channel (min)

The time of overland flow of 15 to 30 minutes is adopted. Regarding the time of flow in channel, the following equations generally used in Japan are adopted.

$$Tc = 2.40 \times 10^{-4} (L/\sqrt{S})^{0.7} \quad : \text{for urban area}$$

$$Tc = 1.67 \times 10^{-3} (L/\sqrt{S})^{0.7} \quad : \text{for un-developed area}$$

where, Tc : time of flow in channel (hr)
L : length from the remotest point to the interest point (m)
S : average slope between the remotest point to the interest point

(4) Runoff coefficient

The following runoff coefficients are applied for the areal average coefficients. These values are examined in comparison with those of the Padang DRIP and other projects in Indonesia.

Land Use	Runoff Coefficient
Commercial and business area	0.80
High density residential area	0.70
Sub-urban area	0.40
Park and open space	0.20
Cultivated area and forest	0.10

(5) Design Discharge

Design discharges are determined by adjusting the calculated discharge values according to the following criteria.

Magnitude of discharge (m^3/s)	Adjustment interval (m^3/s)
0.0 to 5.0	0.1
5.0 to 10.0	0.5
10.0 to 50.0	1.0
more than 50.0	5.0

Determined design discharges are shown in Table I-9.

4.2.4 Proposed Drainage Plan

The new urban area may be divided into seven drainage systems as shown below.

Drainage	Area
a. Purus river	106 ha
b. Lolong river	265 ha
c. Ulak Karang river	187 ha
d. Lapai river	142 ha
e. Baung river	182 ha
f. Tabing river	1,410 ha
g. Penjalinan river	110 ha

The outline of the general plan for the above drainages is as follows :

(1) Purus river

Considering the present condition, the effective measures are the channel improvement and construction of pumping station. The channel stretch 1500 m long between the confluence to the flood relief channel and the Jl. Khatib Sulaiman bridge is planned to be improved. The pumping station is planned to be constructed at the terminal point of the drain.

(2) Lolong river

The channel bed at the mouth of the Lolong river is elevated due to sand spit so that the flow capacity is small in the lower reaches of the channel. To solve this problem, conceivable countermeasures are to connect the Lolong river to the Purus river by constructing a 350 m new channel and to construct outlet culvert into the sea. The former measure would be expensive considering cost for land acquisition, house compensation, widening of the Purus river and additional pump plant of the proposed Purus pumping station. On the other hand, the latter measure would be cheaper than the former measure, although this measure will be involve the problem on maintenance of the mouth. Therefore, the existing channel improvement with construction of outlet culvert into the sea is proposed in this study. The objective channel length of the proposed channel improvement plan is 1,200 m in the stretch between the river mouth and the Jl. Khatib Sulaiman bridge.

(3) Ulak Karang river

The Ulak Karang river may not be drained by gravity during the period of high water stage of the Kuranji river and ground elevation is low so that the pumping station is planned to be constructed at the confluence to the Kuranji river. The improvement of the existing channel is planned to increase the flow capacity. The proposed stretches of channels to be improved have a length of 1,030 m in the stretch between the confluence to the Kuranji river and the bridge at Pasir Ujung Karang and a length of 300 m of a tributary.

(4) Lapai river

The existing channel has poor drainage capacity due to insufficient network of the drainage system. The channel is planned to be improved. At the outlet point to the Kuranji river, gated culvert is planned to be constructed.

(5) Baung river

Drainage of the Baung river may not discharge by gravity during floods of the Kuranji river or high tide, so a gate would be effective to prevent the backwater effect.

Although a pumping station is to be required in the future, it is not necessary to construct a pumping station at present because density of houses in this area is not high. The gated structure is planned to be constructed at outlet of the channel. The channel length of 1,000 m from the confluence of the Kuranji river is also planned to be improved.

(6) Tabing river

The Tabing river has insufficient carrying capacity as the existing drainage channel and is affected by backwater effect due to high tide. The channel 1,600 m long in the reaches downstream from the railway bridge is planned to be improved by means of cutoff. The gated structure is also planned at the outlet of the drain.

(7) Penjalinan river

The construction of the gated culvert at the outlet is proposed to prevent the back-water effect of the Air Dingin river. Channel improvement by excavation work is also proposed for a length of 1,000 m in the lower reaches.

The proposed drainage plan in the new urban area is summarized below.

a. Purus drainage
   - channel improvement : 1,500 m
     from confluence to the flood relief channel to the Jl. Khatib Sulaiman bridge.
   - construction of pump station.

b. Lolong drainage
   - channel improvement : 1,200 m
     from the rivermouth to the Jl. Khatib Sulaiman bridge.
   - construction of outlet culvert.

c. Ulak Karang drainage
   - channel improvement : 1,300 m
     from the confluence to the Kuranji river to the bridge at Pasir Ujung Karang (1,000 m) and the tributary (300 m).
   - construction of pump station.

d. Lapai drainage
   - channel improvement : 550 m
     from the confluence to the Kuranji river to the road from Ulak Karang to Kandis.
   - construction of outlet culvert.

e. Baung drainage
   - channel improvement : 1,000 m
     from the confluence to the Kuranji river to the confluence of the left tributary.
   - construction of outlet culvert.

f. Tabing drainage
   - channel improvement : 1,600 m
     from the confluence to the Air Dingin river to the railway bridge.
   - construction of outlet culvert.

g. Penjalinan drainage

- channel improvement : 1,000 m
  from the confluence to the Air Dingin river.
- construction of outlet culvert.

4.2.5 Priority Order of Improvement

The preliminary study on the priority order for the implementation of drainage improvement works is made. The scale of drainage, carrying capacity of the existing channel and the present urbanization are considered. The following items are examined :

a. design discharge,
b. specific discharge,
c. ratio of carrying capacity to design discharge, and
d. density of houses.

All items are functions of urbanization so that the priority order might fluctuate in the future according to the conditions.

The results of the examined priority is shown in Table I-10. The decided priority order is summarized below :

Priority Order	Drainage
1	Purus
2	Ulak Karang
3	Lolong
4	Baung
5	Lapai
6	Tabing
7	Penjalinan

4.3 Proposed Drainage Improvement Plan for Urgent Flood Control Project

4.3.1 General

Among the drainage plans for the old and new urban areas described above, the terminal drainage facilities and major drainage channels

which are required to be included in the urgent flood control project are selected considering the following items :

a. drainage with high priority,
b. drainage of a serious inundation area to be improved urgently,
c. drainage connected directly to the mainstreams of the Arau, the flood relief channel, the Kuranji and Air Dingin rivers.

The construction and/or improvement plan of terminal drainage facilities and selected drainage channels are included in the urgent flood control project as the framework of the river channel improvement.

4.3.2 Improvement Plan of Major Drainage Channel

Regarding the old urban area, the Olo-Nipah and Ujung Gurun drainages are selected for the urgent flood control project based on the study result of the Padang DRIP. The stretches to be improved urgently is determined considering the effectiveness of the improvement.

As for the new urban area, the Purus and Ulak Karang drainages are proposed to be included in the urgent flood control project. Necessity of urgent improvement is not found in the other drainages at present.

The length subject to the improvement is summarized below and illustrated in Fig. I-7.

Drainage	Length to be improved (m)	Design Discharge (m^3/s)	Stretch to be improved
Olo-Nipah	590	25 - 14	confluence of the Arau river - confluence of Kp. Dobi drain
Ujung Gurun	810	18 - 10	confluence of flood relief channel - confluence of Ujung Gurun drain
Purus	580	13	confluence of flood relief channel - Jl. Veteran bridge
Ulak Karang	1,030	6.5 - 2.5	confluence of the Kuranji river - road bridge at Pasir Ujung Karang

4.3.3 Plan of Terminal Drainage Facilities

(1) Objective Drainages

According to the study results by Padang DRIP, about 70 to 75 % of the direct damage in the old urban area is expected to be avoided by the implementation of the Padang DRIP. But the interior drainage problems in the Kali Mati and Ujung Gurun area will remain. Regarding the Ujung Gurun drainage, necessity of pump drainage is recognized by the Padang DRIP but the construction of pumping station at the outlet is not proposed so far because of the much construction cost.

On the other hand, high priority is given to the Purus and Ulak Karang drainage in the new urban area as described in the section 4.2.5.

The pump capacity for the Ujung Gurun, Purus and Ulak Karang drainages is preliminarily determined by the Study Team considering no inundation damage against 5 years flood. The hydraulic analysis and economic consideration for determination of the optimum pump capacity are described below.

(2) Hydraulic Analysis

The relation between probable storm, inundation depth-duration-area and pump capacity is studied by use of the storage equation shown below :

$$I \cdot dt - dS = O \cdot dt$$

where, I and O are the average values of inflow and outflow for the time interval dt and dS is the change in volume of water in the inundation area during time dt. Inflow hydrographs for respective return periods were prepared by the unitgraph method. Water stage hydrographs of the flood relief channel and the Kuranji river are estimated based on the discharge hydrographs of the mainstream and stage discharge curves at the outlet points of the drainage. When the water level of the mainstream is higher than that of drainage area, interior water is discharged by pump and when the water level of the mainstream is lower, gravity flow passes through the culvert.

The water volume can be converted into the water stage or inund-

ation area by the contour map. The study results of the hydraulic Analysis are tabulated in Table I-11.

(3) Economic Consideration

Based on the hydraulic analysis, the damages due to inundation is estimated. Methodology of the study is described in APPENDIX G "Flood Damage".

Benefit of the drainage improvement including construction of pump station and channel improvement is expressed by the reduction of flood damages. Economic cost for the pumping station and channel improvement is estimated by the same procedure described in APPENDIX M.

Comparative study is carried out for 3 cases of pump capacity. The results of comparative study are summarized below.

Drainage	Pump Capacity (m^3/s)	Specific Discharge ($m^3/s/km^2$)	Benefit ($Rp.10^6$)	Economic Cost ($Rp.10^6$)	B/C with Discount Rate of 12 %
Ujung Gurun	2.0	1.23	423.7	3,238	1.02
	3.5	2.16	577.1	3,727	1.21
	5.0	3.09	601.3	4,237	1.10
Purus	1.0	0.98	265.0	2,093	0.99
	2.0	1.96	376.5	2,644	1.11
	3.5	3.43	386.6	3,395	0.89
Ulak Karang	2.0	1.07	324.9	2,563	0.99
	3.5	1.87	432.3	3,014	1.12
	5.0	2.67	450.1	3,562	0.98

(4) Proposed Terminal Facilities

Based on the economic aspect, the capacities of pump plants at three stations are determined below.

Pumping station	Ujung Gurun	Purus	Ulak Karang
Pump capacity (m^3/s)	3.5	2.5	3.5

Furthermore, the necessity of the terminal facilities in the old urban area are examined for the major drainage channel. Outlet culverts for the drains are not proposed except the Kali Mati drainage on the Arau river in comparison of the design high water levels. The terminal of the Purus Kebun drainage needs the outlet culvert. The dimension of the proposed culvert is determined according to the proposed profiles prepared by the Padang DRIP. Proposed terminal facilities are pse-sented in Table I-12.

4.3.4 Required Works

Required work quantity and construction cost are tabulated in Tables I-13 through I-16. The construction cost of all culverts is counted in the river channel improvement cost described in APPENDIX L.

Table I-1 Existing Major Drainage System

River/drain	Outlet		Channel length (km)	Drainage area (km^2)	Channel width at outlet point (m)	Remarks
	Confluence	Location				
Old urban area						
Jati	Arau	A 70 (R)	3.6	3.00	9.4	
Anak Jati	Olo II	O 12^{K}(L)	1.5	0.50	3.0	
Olo II	Arau	A 120(R)	1.9	0.90	13.2	Excluding Anak Jati drainage area
Kali Mati	Arau	A 131(R)	0.7	0.55	21.0	
Olo I, Purus Kebun	Flood relief channel	B 1 (L)	1.9	1.20	4.2	
Bandar Purus	- do -	B 1 (L)	2.4	1.20	11.4	Including Anak Purus drainage area
Anak Purus	B. Purus	O 18^{K}(R)	1.3	-	6.5	
Ujung Gurun	Anak Purus	0.58^{K}(R)	1.2	-	2.0	
New urban area						
Purus	Flood relief channel	B 1 (R)	1.6	1.06	12.4	
Lolong	Indonesian Ocean	-	3.1	2.65	13.8	
Ulak Karang	Kuranji	K 9 (L)	1.2	1.87	14.2	
Lapai	- do -	K 28(L)	1.5	1.42	7.0	
Baung	- do -	K 5 (R)	2.1	1.82	10.0	
Tabing	Air Dingin	C O (L)	4.6	12.08	17.2	
Penjalinan	- do -	C O (L)	1.5	1.10	80.0	

Table I-2 Existing Drainage Facilities

River	Kind of facilities	Location		Dimension (m)	Remarks
Arau River					
	culvert	A 94	Left	Ø 1.0	
Flood Relief Channel					
	culvert	B 0	Left	Ø 1.0 x 2	Bandar Purus drain
	- do -	B 3	Right	Ø 0.06	consist of precast R.C. pipe
	- do -	B 9	Right	1.40 x 1.20	under construction
	- do -	B 11	Left	Ø 1.0 x 2	Purus Kebun drain with flap gate
	- do -	B 57	Right	Ø 1.0 x 2	with gate
	- do -	B 59	Right	Ø 1.0 x 2	
	syphon	B 27	-	Ø 1.0	just upstream of Jati bridge, with gate
	- do -	B 57	-	Ø 1.0	with gate

Note : All gates are to be operated by man power.

Table I-3 Bankful Discharge of Major Drainage Channel

River/drain	Width (m)	Depth (m)	Cross-section area (m^2)	Slope of water surface	Bankfull discharge (m^3/s)
Old urban area					
Jati drain	7 - 10	1.0 - 2.5	6 - 15	1/800	10 - 25
Olo II drain	3 - 6	1.0 - 1.5	2 - 5	1/900	2 - 6
Kali Mati drain	5 - 20	1.0	3 - 15	1/1,000	2 - 12
B. Purus drain	6 - 7	1.0 - 1.5	7 - 9	1/1,650	6 - 9
Anak Purus drain	3 - 7	0.5 - 1.5	1 - 7	1/2,150	1 - 6
Purus Kebun, Olo I drain	3 - 5	1.0 - 1.5	2 - 4	1/850	2 - 4
New urban area					
Purus river	4 - 5	1.0 - 1.5	5 - 6	1/500	8 - 9
Lolong river	6 - 8	1.5	5 - 8	1/630	2 - 12
Ulak Karang river	7 - 14	1.0 - 2.0	5 - 12	1/700	5 - 15
Lapai river	3 - 7	0.5	4 - 7	1/275	1 - 8
Baung river	12 - 15	1.0 - 2.0	4 - 12	1/5,600	2 - 6
Tabing river	6 - 15	1.0 - 2.0	6 - 20	1/1,450	7 - 15

Table I-4 Length of Drainage Channel to be Improved and Proposed Capacity of Pump Station

Drainage system	Drainage area (km^2)	Channel length to be improved (km)	Drainage	Capacity of pump (m^3/s)	Terminal	Remarks
Old urban area						
Jati	2.14	4.40	Gravity	-	Arau river	Including 574 m of diversion drain.
Palinggam	0.71	1.35	- do -	-	- do -	
Anak Jati	0.62	2.45	- do -	-	- do -	Including Kelenteng drain.
Olo-Nipah	1.40	5.75	- do -	-	- do -	
Kali Mati	0.21	0.95	Pump	1.0	- do -	Excluding Nipah area.
Damar	1.15	4.00	Gravity	-	Indonesia Ocean	
Ujung Gurun	1.62	5.05	Pump	5.0	Flood relief channel	
Sub-total	7.85	23.95	-	6.0		
New urban area						
Purus	1.06	2.0	Pump	3.5	Flood relief channel	
Lolong	2.65	2.05	Gravity	-	Indonesia Ocean	
Ulak Karang	1.87	3.85	Pump	5.5	Kuranji river	
Lapai	1.42	3.70	Gravity	-	- do -	
Baung	1.82	2.50	Pump	5.5	- do -	
Penjalinan	1.10	1.45	Pump	3.0	Air Dingin river	
Tabing	12.08	3.50	Gravity	-	- do -	
Sub-total	21.46	19.05	-	17.5		
Total	29.41	43.00	-	23.5		

Table I-5 Work Quantity of Drainage Improvement for Comprehensive Plan

Work Item	Unit	River				Total
		Arau	Flood Relief Channel	Kuranji	Air Dingin	
1. Civil Work						
1.1 Pump Plant						
Qp = 1.0 m^3/s	L.S	1	-	-	-	1
Qp = 3.0 m^3/s	L.S	-	-	-	1	1
Qp = 3.5 m^3/s	L.S	-	1	-	-	1
Qp = 5.0 m^3/s	L.S	-	1	-	-	1
Qp = 5.5 m^3/s	L.S	-	-	2	-	2
1.2 Earth Work						
Excavation	10^3m^3	160	140	48	14	362
Embankment	10^3m^3	15	13	14	4	46
Transportation	10^3m^3	141	125	32	10	308
Disposal of soil	10^3m^3	141	125	32	10	308
1.3 Revetment						
Wet masonry	10^3m^2	54	48	31	15	148
Dry masonry	10^3m^2	12	11	13	4	40
1.4 Inspection Road	m	19,900	17,500	13,500	6,200	57,100
2. Land Acquisition & House Compensation						
2.1 Land Acquisition						
I (residential)	ha	5.1	4.6	0.8	-	10.5
II (agricultural)	ha	-	-	-	-	-
III (others)	ha	3.5	3.2	5.0	2.2	13.9
2.2 House Compensation						
I (permanent)	nos.	---	3	2	-	5
II (semi-permanent)	nos.	-	6	-	-	6
III (small)	nos.	4	7	-	-	11
IV (others)	nos.	-	36	-	-	36

Table I-6 Annual Maximum Values of Short Duration Rainfall Depth at Tabing

(Unit: mm)

Year	Duration (min)						
	5	15	30	60	120	360	720
1973	10.5	29.0	50.5	87.5	119.2	166.2	172.3
1974	23.4	35.2	48.9	75.6	79.3	87.2	129.0
1975	12.6	34.9	42.9	73.2	106.1	116.7	127.5
1976	19.3	35.8	57.4	83.3	98.2	115.3	119.0
1977	21.2	36.1	65.9	86.5	103.5	115.0	140.0
1978	13.1	34.3	46.6	63.9	84.9	109.0	109.0
1979	10.0	21.9	49.2	64.7	82.5	118.4	160.2
1980	11.6	24.4	39.2	59.8	72.5	122.5	139.3
1981	16.1	35.5	51.4	101.7	132.4	168.1	179.9
1982	7.2	26.5	47.1	67.3	96.1	200.2	225.9

Source ; Background Paper No. 1 on Padang Drainage Improvement Project, Jan. 1983

Table I-7 Probable Rainfall Depth and Intensity

Rainfall Depth

(Unit: mm)

Duration (min)	Return Period (year)			
	2	5	10	20
5	13	18	23	26
15	31	36	40	42
30	49	56	60	63
60	75	87	95	100
120	96	112	125	132
360	127	158	181	195
720	148	177	199	212

Rainfall Intensity

(Unit: mm/hr)

Duration (min)	Return Period (year)			
	2	5	10	20
5	156	216	276	312
15	124	144	160	168
30	98	112	120	126
60	75	87	95	100
120	48.0	56.0	62.5	66.0
360	21.17	26.33	30.17	32.50
720	12.33	14.75	16.58	17.67

Source : Backgroumd Paper No. 1 on Padang Drainage Improvement Project, Jan. 1983

Table I-8 Average Rainfall Intensity for Different Return Periods

(Unit: mm/hr)

Duration (min)	Return Period		
	2 - yr	5 - yr	10 - yr
5	149	212	268
10	136	185	204
15	125	141	154
30	100	116	127
60	72.0	85.3	94.0
120	46.4	56.2	61.6
240	27.0	33.2	36.7
300	22.3	27.6	32.8
360	19.1	23.8	28.8
720	-	-	16.6

Note ; Rainfall intensity $i = a/(t + b)$

where, t ; duration (min)
a.b ; constant shown below

Return Period (year)	Duration (min)	a	b
2	5 - 360	7,740	47
5	5 - 10	7,200	29
	15 - 360	9,756	54
10	5 - 10	4,284	11
	15 - 240	10,800	55
	300 - 720	14,040	130

Tabke I-9 Runoff Discharge for 5-yr Storm in New Urban Area

Drainage	Point	Drainage Area (km^2)	Time of Concentration (min)	Rainfall Intensity (mm/hr)	Runoff Coefficient	Storage Coefficient	Discharge (m^3/s) Estimated	Design
Purus	confluence of flood relief channel	1.06	47	96.6	0.64	0.321	12.4	13
Lolong	rivermouth	2.65	241	33.1	0.20	0.508	2.4	2.4
Ulak Karang	confluence of Kuranji river	1.87	136	51.4	0.43	0.446	6.4	6.5
Lapai	confluence of Kuranji river	1.42	149	48.1	0.27	0.457	2.8	2.8
Baung	confluence of Kuranji river	1.82	176	42.5	0.47	0.475	5.3	5.5
Tabing	confluence of Air Dingin river	14.10	283	29.0	0.13	0.524	7.0	7.5
Pen-jalinan	confluence of Air Dingin river	1.10	130	53.1	0.23	0.441	2.1	2.1

Table I-10 Priority Order of Drainage Improvement in New Urban Area

Drainage	Area (km^2)	Design discharge (Q)		Specific discharge (q)		Capacity/Q		Density of houses		Scoring								Total Rank
		(m^3/s)	Rank	($m^3/s/km^2$)	Rank	-	Rank	nos/ha	Rank	1	2	3	4	5	6	7	Total	
Purus	1.06	13	1	12.3	1	0.7	1	21.3	1	4							4	1
Lolong	2.65	2.4	6	0.9	6	0.8	2	10.7	3		1	1			2		14	3
Ulak Karang	1.87	6.5	3	3.5	2	0.8	2	11.5	2		3	1					9	2
Lapai	1.42	2.8	5	2.0	4	0.9	4	2.3	4				3	1			17	5
Baung	1.82	5.5	4	3.0	3	0.9	4	1.8	5			1	2	1			16	4
Tabing	14.10	7.5	2	0.5	7	1.0	6	0.8	7		1				1	2	22	6
Penjalinan	1.10	2.1	7	1.9	5	1.1	7	1.0	6					1	1	2	25	7

Table I-11 Maximum Water Level of Inundation

(Unit : m, MSL)

Drainage	Terminal Condition	Return Period						
		1 - yr	2 - yr	5 - yr	10 - yr	25 - yr	50 - yr	100 - yr
Ujung Gurun	with gate	1.03	1.06	1.11	1.16	1.24	1.33	1.36
	Qp = 2.0 m^3/s	1.03	1.06	1.09	1.14	1.19	1.23	1.25
	Qp = 3.5 m^3/s	1.02	1.05	1.08	1.12	1.16	1.18	1.20
	Qp = 5.0 m^3/s	1.02	1.04	1.07	1.10	1.13	1.14	1.16
Purus	with gate	1.03	1.06	1.12	1.17	1.27	1.40	1.45
	Qp = 1.0 m^3/s	1.03	1.06	1.11	1.16	1.23	1.32	1.34
	Qp = 2.0 m^3/s	1.03	1.05	1.10	1.14	1.20	1.24	1.26
	Qp = 3.5 m^3/s	1.03	1.05	1.09	1.12	1.15	1.17	1.19
Ulak Karang	with gate	1.02	1.16	1.31	1.45	1.58	1.61	1.64
	Qp = 2.0 m^3/s	1.02	1.16	1.29	1.37	1.47	1.51	1.53
	Qp = 3.5 m^3/s	1.02	1.14	1.24	1.28	1.34	1.39	1.43
	Qp = 5.0 m^3/s	-0.42	-0.03	0.74	1.07	1.26	1.30	1.33

Table I-12 Proposed Outlet Facilities in the Old Urban Area
(Urgent Flood Control Porject)

Drainage	Area (km^2)	Location of Outlet	H.W.L (m, MSL)		Channel Bed		Side Slope	Design Discharge (m^3/s)	Proposed Outlet Structure
			Main-stream	Drainage Channel	Elevation (m, MSL)	Width (m)			
Arau River									
Jati (proposed)	2.14	A 60 + 140	2.60	2.90	-0.26	9.50	1 : 0.5	31.95	-
(existing)	-	A 75 + 90	2.00	-	-	-	-	-	Bridge
Palinggam	0.71	A105 + 70	1.30	1.35	-0.70	3.60	1 : 0.0	6.70	-
Kelenteng	0.18	A112 + 40	1.15	1.25	0.27	2.00	1 : 0.5	2.77	-
Olo-Nipah	1.40	A122 + 80	1.05	1.05	-1.23	5.50	1 : 1.5	24.78	-
Kali Mati	0.21	A132 + 30	0.80	0.15	-1.43	1.75	1 : 1.0	4.96	Culvert h 2.0xb 2.5
Flood Relief Channel									
Purus Kebun	0.46	B 17 + 20	2.70	1.55	0.02	1.60	1 : 1.5	6.55	Culvert h 2.0xb 2.5
Ujung Gurun	1.62	B 0 + 50	1.55	0.27	-1.45	4.00	1 : 1.5	17.38	Pump

Table I-13 Work Quantity of Drainage Improvement for Urgent Flood Control Project

Item	Unit	Drainage				Total
		Olo-Nipah	Ujung Gurun	Purus	Ulak Karang	
1. Civil Work						
1.1 Pump Plant						
Qp = 2.0 m^3/s	L.S	-	-	1	-	1
Qp = 3.5 m^3/s	L.S	-	1	-	1	-
1.2 Earth Work						
Excavation	10^3m^3	12.0	39.8	8.5	7.4	67.7
Embankment	10^3m^3	-	2.3	0.5	1.8	4.6
Transportation	10^3m^3	12.0	37.1	7.9	5.3	62.3
Disposal of soil	10^3m^3	12.0	37.1	7.9	5.3	62.3
1.3 Revetment						
Wetmasonry	10^3m^2	8.8	3.7	2.3	0.3	15.1
Drymasonry	10^3m^2	-	0.4	0.6	2.2	3.2
1.4 Inspection Road	m	-	2,230	640	1,450	4,320
2. Land Acquisition & House Compensation						
2.1 Land Acquisition						
I (residential)	ha	0.4	3.7	0.9	0.2	5.2
II (agricultural)	ha	-	-	-		
III (others)	ha	-	3.2	-	0.6	3.8
2.2 House Compensation						
I (permanent)	nos.	-	2	1	2	5
II (semi-permanent)	nos.	-	4	2	-	6
III (small)	nos.	4	6	1	-	11
IV (others)	nos.	-	6	30	-	36

Table I-14 Work Quantity and Construction Cost of Ujung Gurun Drainage for Urgent Flood Control Project

Item	Unit	Quantity	Local Currency (Rp.)		Foreign Currency (US$)	
			Unit Cost	Amount (10^6)	Unit Cost	Amount (10^3)
Civil Work						
Preparatory	l.s			49.43		142.84
Pumping Plant (3.5 m^3/s)	l.s			435.32		1,611.57
Earth Work						
- Excavation	10^3m^3	39.8	2,391	95.17	-	-
- Embankment	10^3m^3	2.3	425	0.98	1.51	3.48
- Transportation	10^3m^3	37.1	788	29.24	2.13	79.03
- Disposal of soil	10^3m^3	37.1	176	6.53	0.81	30.05
Revetment						
- Wet masonry	10^3m^2	3.7	11,410	42.22	13.74	50.84
- Dry masonry	10^3m^2	0.4	7,453	2.98	9.32	3.73
Inspection Road	m	2,230	2,422	5.41	3.03	6.76
Sub-total				617.85		1,785.46
Miscellaneous				66.73		192.83
Total				734.01		2,121.13
Land Acquisition & Compensation						
Land	10^3m^2	69		286.00		-
House	nos.	18		18.30		-
Engineering and Administration	l.s			103.83		212.11
Contingency	l.s			114.21		233.32
Grand Total				1,256.35		2,566.56

Table I-15 Work Quantity and Construction Cost of Purus Drainage for Urgent Flood Control Project

Item	Unit	Quantity	Local Currency (Rp.)		Foreign Currency (US$)	
			Unit Cost	Amount (10^6)	Unit Cost	Amount (10^3)
Civil Work						
Preparatory	l.s			33.55		117.13
Pumping Plant (2.0 m^3/s)	l.s			358.94		1,400.88
Earth Work						
- Excavation	10^3m^3	8.5	2,391	20.33	-	-
- Embankment	10^3m^3	0.5	425	0.22	1.51	0.76
- Transportation	10^3m^3	7.9	788	6.23	2.13	16.83
- Disposal of soil	10^3m^3	7.9	176	1.40	0.81	6.40
Revetment						
- Wet masonry	10^3m^2	2.3	11,410	26.25	13.74	31.61
- Dry masonry	10^3m^2	0.6	7,453	4.48	9.32	5.60
Inspection Road	m	640	2,422	1.51	3.03	1.94
Sub-total				419.36		1,464.02
Miscellaneous				45.30		158.12
Total				498.21		1,739.27
Land Acquisition & Compensation						
Land	10^3m^2	9		54.00		-
House	nos.	34		12.20		-
Engineering & Administration	l.s			56.44		173.93
Contingency	l.s			62.09		191.32
Grand Total				682.94		2,104.52

Table I-16 Work Quantity and Construction Cost of Ulak Karang Drainage for Urgent Flood Control Project

Item	Unit	Quantity	Local Currency (Rp.)		Foreign Currency (US$)	
			Unit Cost	Amount (10^6)	Unit Cost	Amount (10^3)
Civil Work						
Preparatory	l.s			38.59		132.72
Pumping Plant (3.5 m^3/s)	l.s			435.32		1,611.57
Earth Work						
- Excavation	10^3m^3	7.4	2,391	17.70	-	-
- Embankment	10^3m^3	1.8	425	0.77	1.51	2.72
- Transportation	10^3m^3	5.3	788	4.18	2.13	11.29
- Disposal of soil	10^3m^3	5.3	176	0.94	0.81	4.30
Revetment						
- Wet masonry	10^3m^2	0.3	11,410	3.43	13.74	4.13
- Dry masonry	10^3m^2	2.2	7,453	16.40	9.32	20.51
Inspection Road	m	1,450	2,422	3.52	3.03	4.40
Sub-total				482.26		1,658.92
Miscellaneous				52.09		179.17
Total				572.94		1,970.81
Land Acquisition & Compensation						
Land	10^3m^2	8		24.00		-
House	nos.	2		7.20		-
Engineering & Administration	l.s			60.41		197.08
Contingency	l.s			66.46		216.79
Grand Total				731.01		2,384.68

Fig I -1 Location Map of Existing Urban Area

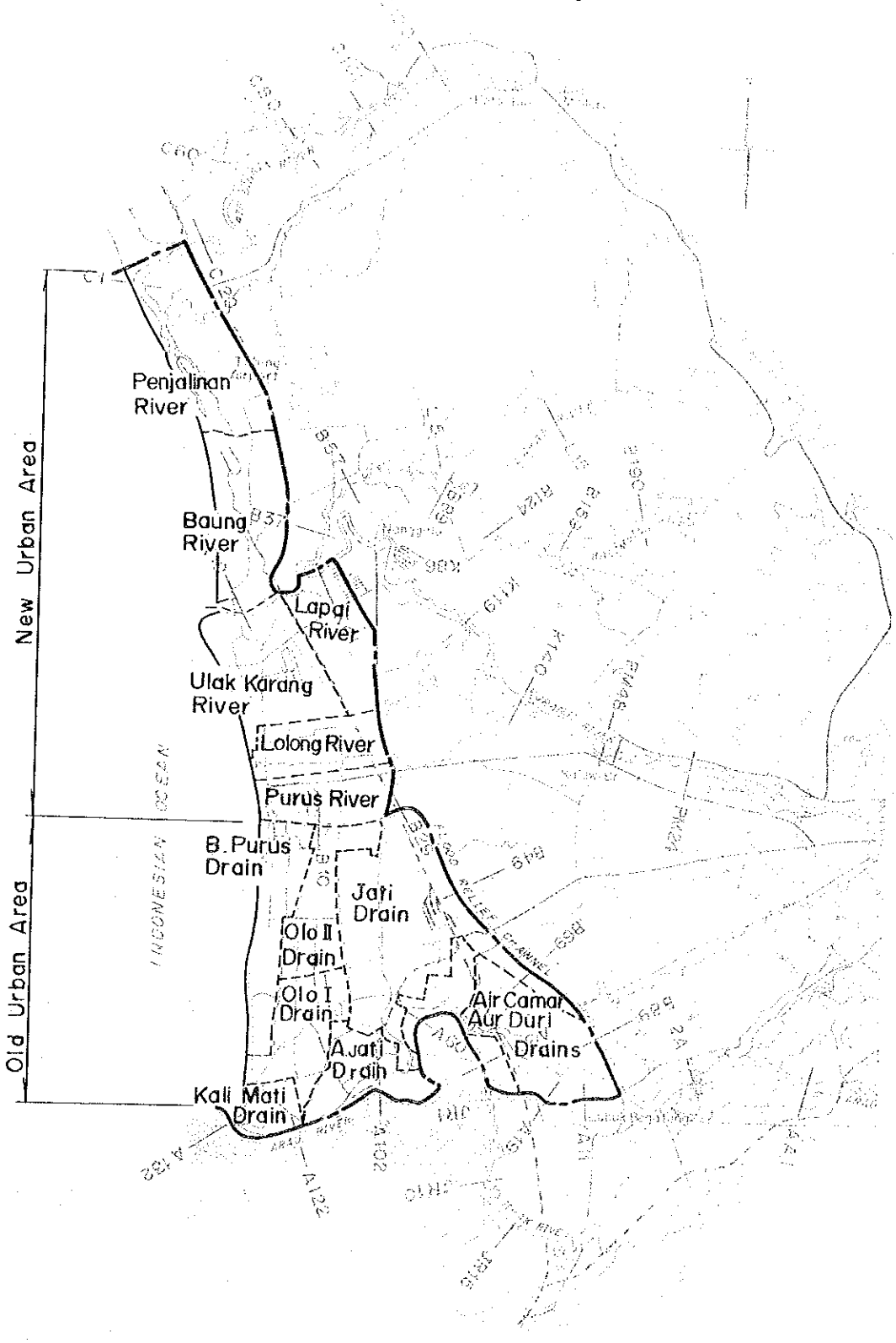
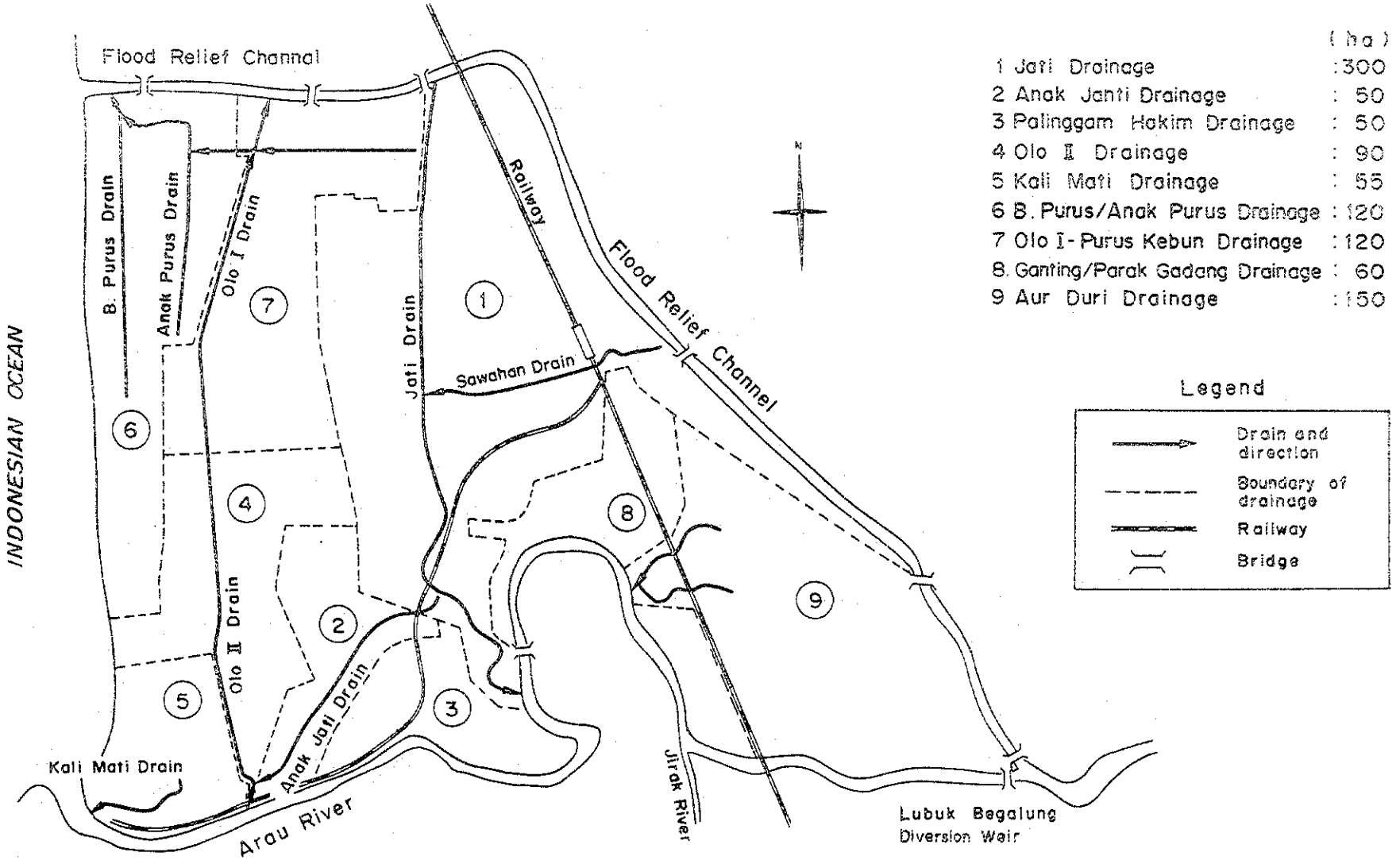


Fig. I - 2 Existing Drainage System in Old Urban Area



	(ha)
1 Jati Drainage	:300
2 Anak Janti Drainage	: 50
3 Palinggam Hakim Drainage	: 50
4 Olo II Drainage	: 90
5 Kali Mati Drainage	: 55
6 B. Purus/Anak Purus Drainage	: 120
7 Olo I - Purus Kebun Drainage	: 120
8 Ganting/Parak Gadang Drainage	: 60
9 Aur Duri Drainage	: 150

Source : Inception Report on Padang DRIP, Dec. 1982

Fig. I - 3 Existing Drainage System in New Urban Area

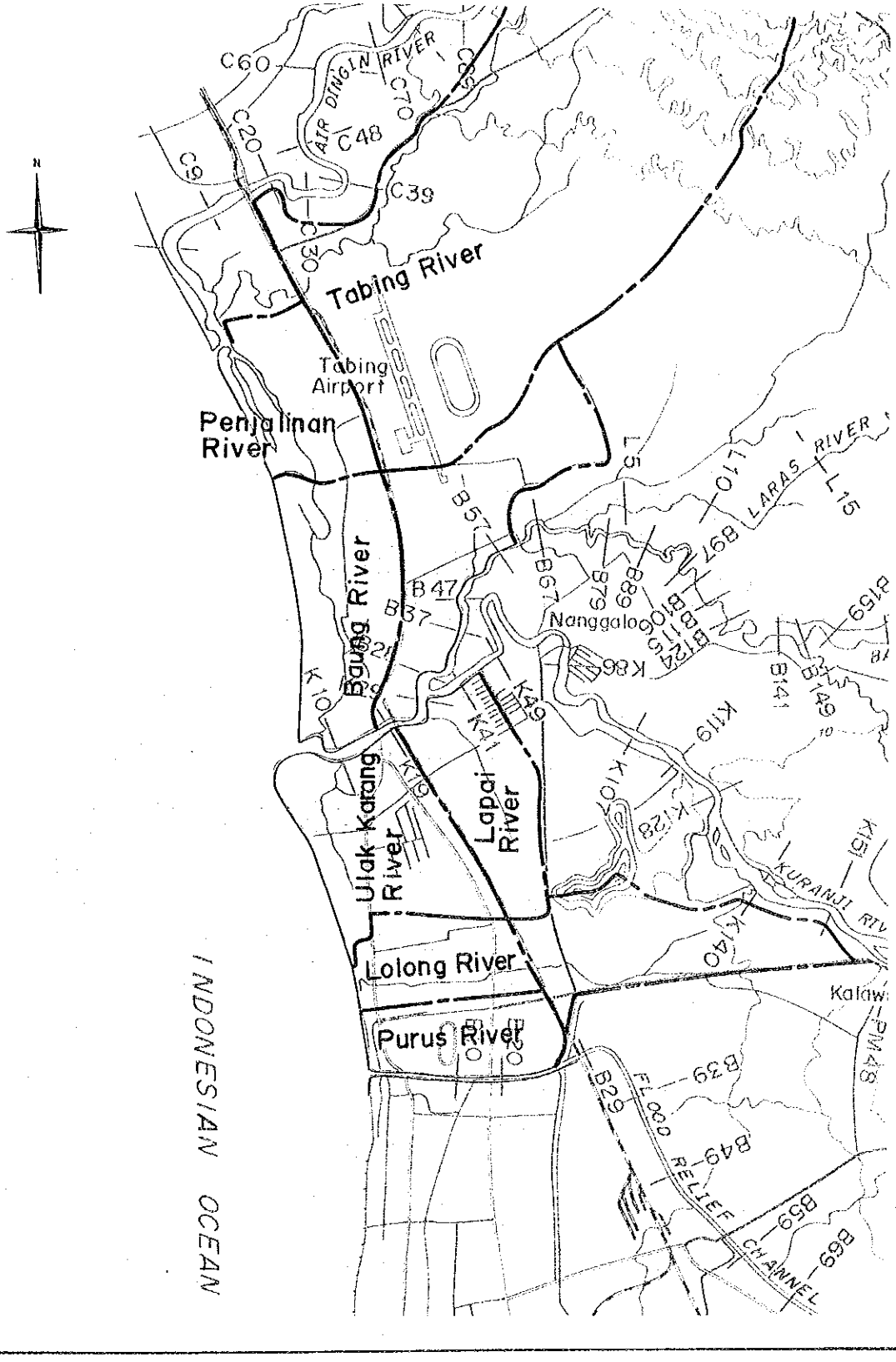


Fig. I - 4 Location of Existing Drainage Facilities

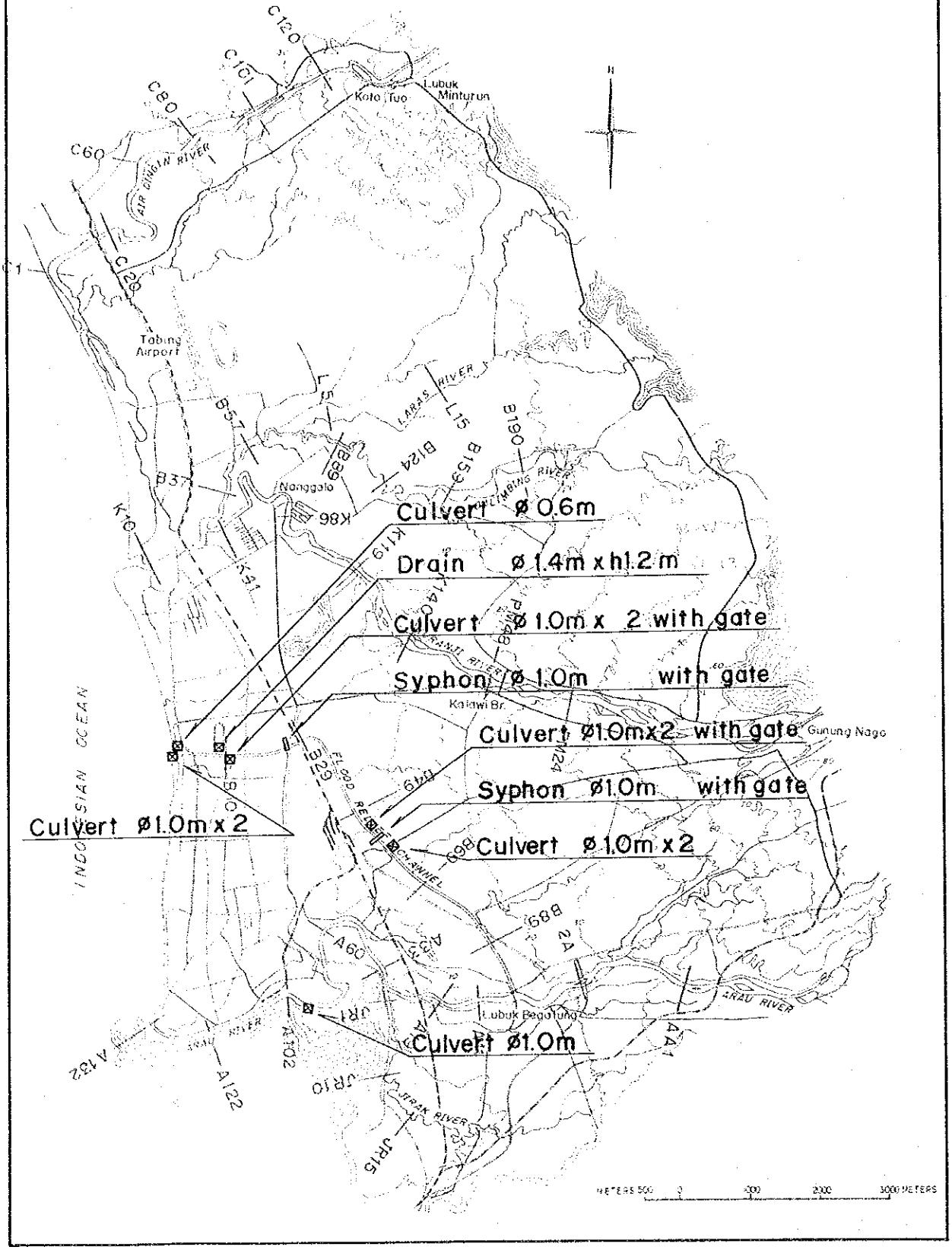


Fig I-5 General Layout of Comprehensive Plan for Urban Drainage

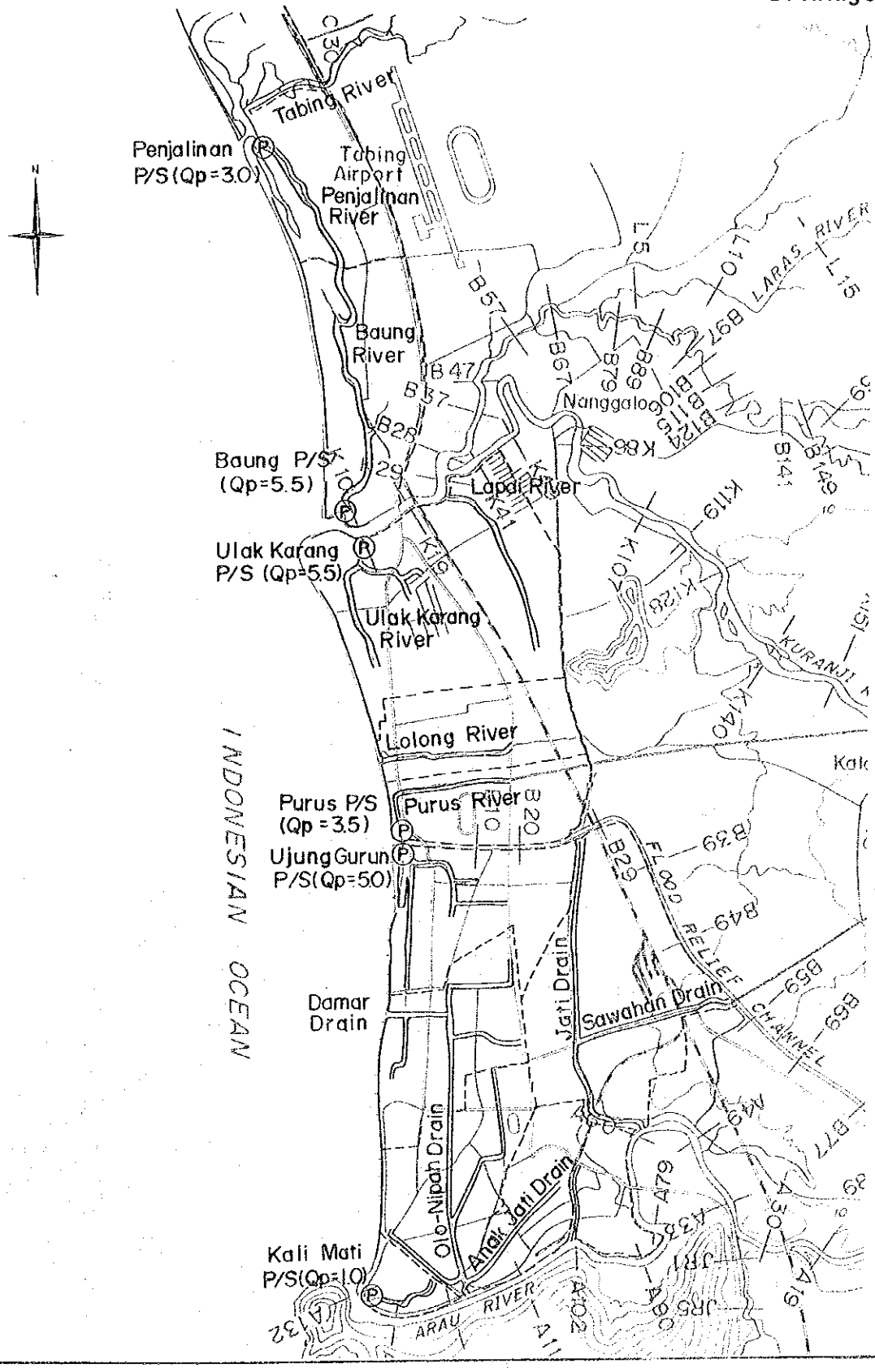
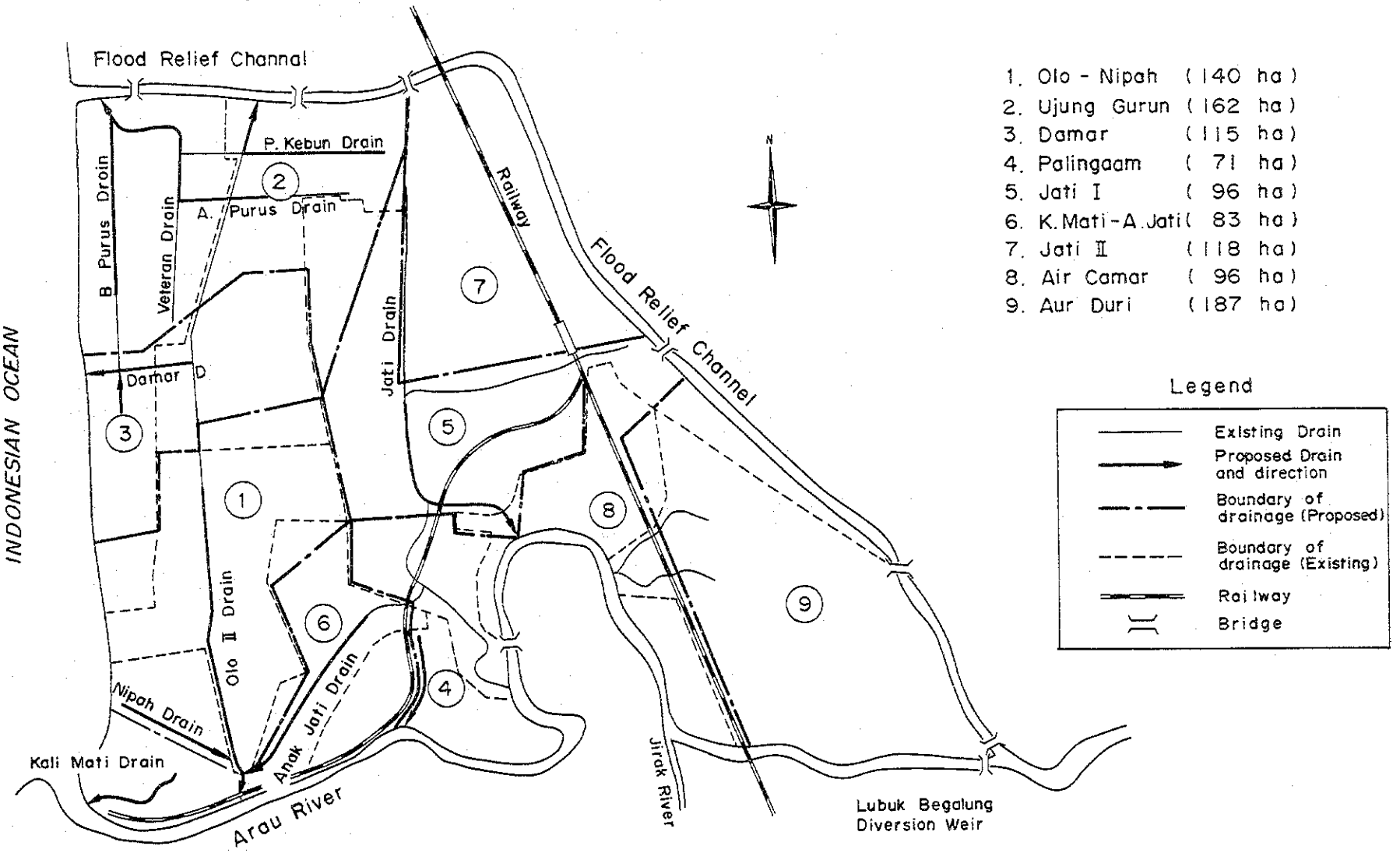
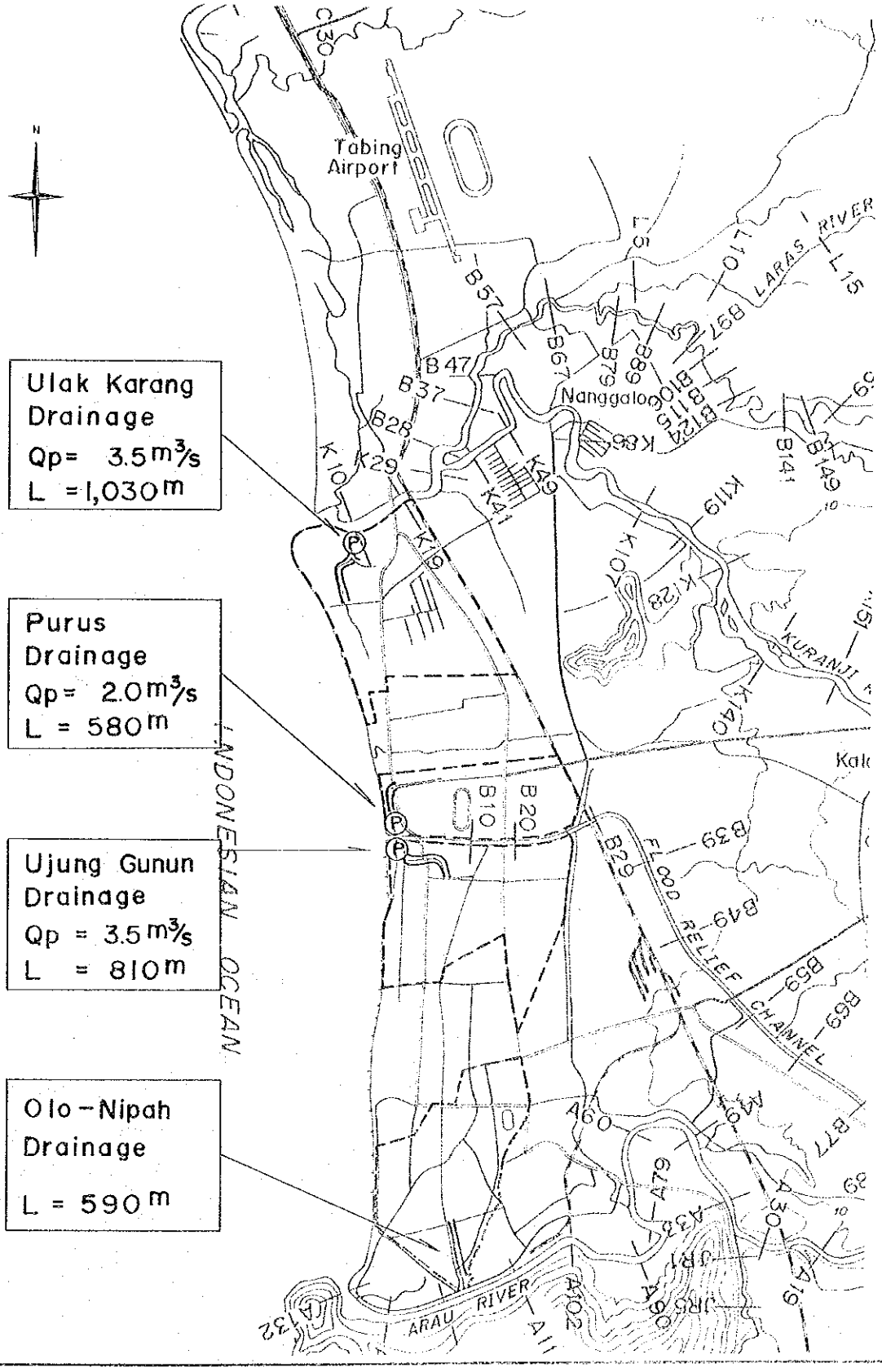


Fig I-6 Proposed Drainage System in Old Urban Area by Padang DRIP



Source : Padang Drainage Improvement Project

Fig. I - 7 Proposed Layout of Urban Drainage



APPENDIX J

COMPREHENSIVE FLOOD CONTROL AND DRAINAGE PLAN

APPENDIX J

COMPREHENSIVE FLOOD CONTROL AND DRAINAGE PLAN

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1. General

On the basis of the results of field investigation and study on the present conditions of the study area and in consideration of the results of review on the previous studies, conceivable alternative schemes for comprehensive flood control and drainage plan are developed, and the plan is formulated based on the comparative study of the alternative schemes. The results of the comparative study and the proposed comprehensive flood control and drainage plan are presented in this APPENDIX J.

2. Objective Area for Comprehensive Plan

The urban area of Padang has been developed on the coastal plain between the Arau and Air Dingin rivers. But recent general trend of urbanization is to the eastward surrounding the existing urban area.

According to the master plan of Padang city, which envisions the future city development at the target year of 2003, the new urban zone is planned mainly to the area located between the existing urban area and the foot of mountains on the east. The new urban area proposed by the master plan is introduced in APPENDIX C.

Within the three river basins, the future city area of Padang is to be about 130 km^2 bounded by (1) the foot of the mountains on the left side of the Arau river on the south, (2) the existing road connected Kp. Lubuk Minturun, Kec. Tangah and Kp. Bandar Buaya, Kec. Lubuk Kilangan running on the foot of the mountains on the east, (3) the Air Dingin river on the north, and (4) the Indonesian Ocean on the west.

In the present study, the comprehensive flood control and drainage plan is prepared in order to relieve the existing and future urban area of 130 km^2 from flooding.

3. Alternative Schemes

3.1 Flood Control Method

The flood control method should adopt an optimum measure

taking account of regional characteristics of river basin such as topography, scale of catchment area, type of flood runoff, flooding conditions, etc. In general, the following measures are considered as flood control method.

Upper basin : flood regulation by reservoir.

Middle basin : flood retardation by retarding basin and flood prevention by existing channel improvement.

Lower basin : flood diversion by diversion channel and flood prevention by existing channel improvement.

3.1.1 Flood Control Method in Upper Basin

The river slopes in the upper basin of the Arau, Kuranji and Air Dingin are very steep more than 1/40 as described in APPENDIX E. The flood runoff is therefore of the flashy type with time of concentration of about 6 hours. One of the effective measures of flood control for such rivers is to store a flood runoff by reservoir in the upper basin. In the upper basin of the rivers, the river has very steep slopes of deep and narrow valleys. The appropriate dam site with reservoir is found only at Danau Kering in the upstream reaches of the Limau Manis river of the Kuranji river basin. The location of this Limau Manis dam is shown in Fig. J-1. The catchment area of this dam is 17.5 km^2. The reduction of peak discharge by regulation of the dam is calculated using the flood runoff simulation model described in APPENDIX F, and the result is shown in ANNEX J-1 of this APPENDIX. The result of calculation shows that about 10 % of peak discharge in the case of 50 yr probable flood is to be reduced by dam construction. This dam scheme is shown in Fig. J-2, and the construction cost is estimated as shown in Table J-1. The result of the comparative study with the existing channel improvement shows that the dam measure would be expensive in comparison with the existing channel improvement measure. This measure is therefore not recommendable for the purpose of flood control only. On the other hand, from the viewpoint of development of natural energy under the difficulty in acquisition of oil, this dam scheme might be taken up as multipurpose project including hydropower in future.

With regard to the proposal in the previous study by P.T. Indah Karya to build a series of stepped dams (check dams) in the upper reaches of the Arau and Kuranji rivers, the Study Team checked the reduction of peak discharge by means of the stepped dams construction by calculation using the flood runoff simulation model described in APPENDIX F. The method of calculation and the result are shown in ANNEX J-2 of this APPENDIX. The result of the calculation shows that the reduced peak discharge by stepped dams is very small for the following reasons.

a. The rivers are too steep for any effective storage to be provided to attenuate flood discharges.

b. Flattening of the river bed slope would be local and the delay of time of concentration is small.

Therefore the stepped dam measure is not recommendable for the flood control method in the upper basin.

As mentioned in APPENDIX D, there are several knick points near the new railway bridge of the Arau river. The deposition of the upper reaches of the knick point is big, but considerable part of the sand and gravel is stopped by the knick point, and smaller gravel is allowed to flow down via the knick point. The deposition of the lower reaches of the Arau river is small. In case of the Kuranji river, the lowering of the river bed is accelerated by Gunung Nago weir. The facts mentioned above show that construction of check dam is not necessary to reduce sediment runoff in the upper basin.

The re-afforestation and forest maintenance are necessary and commendable practices to reduce runoff in the upper basin. But the effect by such activities of watershed management will be expected after the effort extended over a long time. Therefore the re-afforestation and forest maintenance are usually not included into the flood control plan.

On the other hand, the model forest scheme in the upper basin of the Arau river is proposed by Andalas University. The outline of this

scheme is introduced in APPENDIX C. This proposal should be encouraged from the viewpoint of conservation of the forest in the upper basin.

3.1.2 Flood Control Method in Middle Basin

In the middle basin of the three rivers, most of the plain area has been developed as agricultural lands or residential quarter. The possible area for retarding basin is found only in the small area on the right side of the Laras river where the land has not been developed yet because of swampy area during the wet season. This area may be considered as for retarding basin.

Since the existing river channel in the middle reaches has sufficient carrying capacity in the most stretches except the Balimbing and Laras rivers. The continuous dike is not always necessary in the all stretches. Therefore the channel improvement method by means of construction of dike and excavation of channel is to be effective and recommended for the method in the middle reaches.

3.1.3 Flood Control Method in Lower Basin

In the lower reaches of the rivers, the existing channel has not enough carrying capacity in the all stretches. Improvement of the existing channel or construction of diversion channel should be considered.

With regard to diversion channel, the following four measures are studied in order to reduce flood discharge of the existing channel.

a. Construction of a new diversion channel of the Arau river.
b. Construction of a cutoff channel of the Arau river.
c. Separation of the Balimbing river from the Kuranji catchment.
d. Construction of a diversion channel of the Kuranji river.

(1) New Diversion Channel of the Arau River

The new diversion channel of the Arau river aims to divert the excess flood water of the Arau river by constructing a 4.7 km channel from the point upstream of Lubuk Begalung weir to Teluk Bayur harbor.

This diversion scheme is shown in Fig. J-3 and the construction Cost is estimated as shown in Table J-2.

The result of the comparative study with the existing channel improvement shows that the diversion measure would be expensive in comparison with the existing channel improvement measure. Moreover, the sedimentation problems will be brought to the Teluk Bayur harbor due to construction of diversion channel. This measure is therefore not recommendable.

(2) Cutoff Channel of the Arau River

The cutoff channel aims to shorten extreme meandering stretch of the mainstream of the Arau river by constructing a 460 m cutoff channel in the stretch between the confluence of the Jirak river and 400 m downstream from Seberang bridge. The channel is planned by tunnel in consideration of topography on the planned route. This cutoff channel scheme is shown in Fig. J-4 and the construction cost is estimated as shown in Table J-3. The result of cost estimate shows that the cutoff measure would be expensive in comparison with the existing channel improvement. This measure is also not recommendable.

(3) Separation of the Balimbing River from the Kuranji catchment

The separation of the Balimbing river from the Kuranji catchment by constructing a 2.4 km channel to the sea is studied in order to reduce flood discharge of the Kuranji river. The separation scheme is shown in Fig. J-5 and the construction cost is estimated as shown in Table J-4. The result of cost estimate shows that the construction cost of separation measure would be expensive in comparison with the existing channel improvement. This separation measure is also not recommendable.

(4) Diversion Channel of the Kuranji River

The diversion channel of the Kuranji river aims to divert the excess flood water of the mainstream of the Kuranji river by constructing a 2 km channel from the point downstream of Kalawi bridge to the point upstream of the railway bridge of the flood relief channel. The flood relief channel shall be widened to carry its flood water in addition to