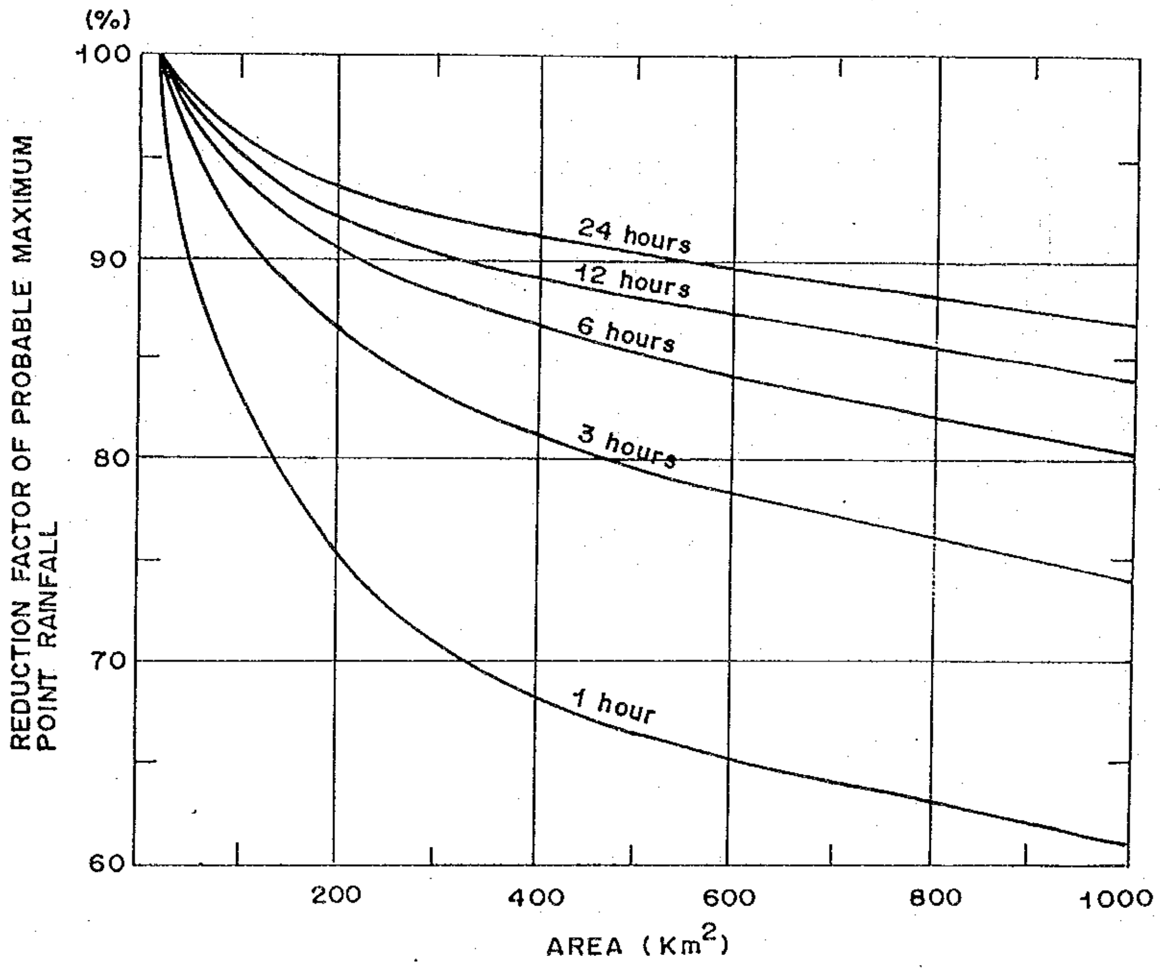
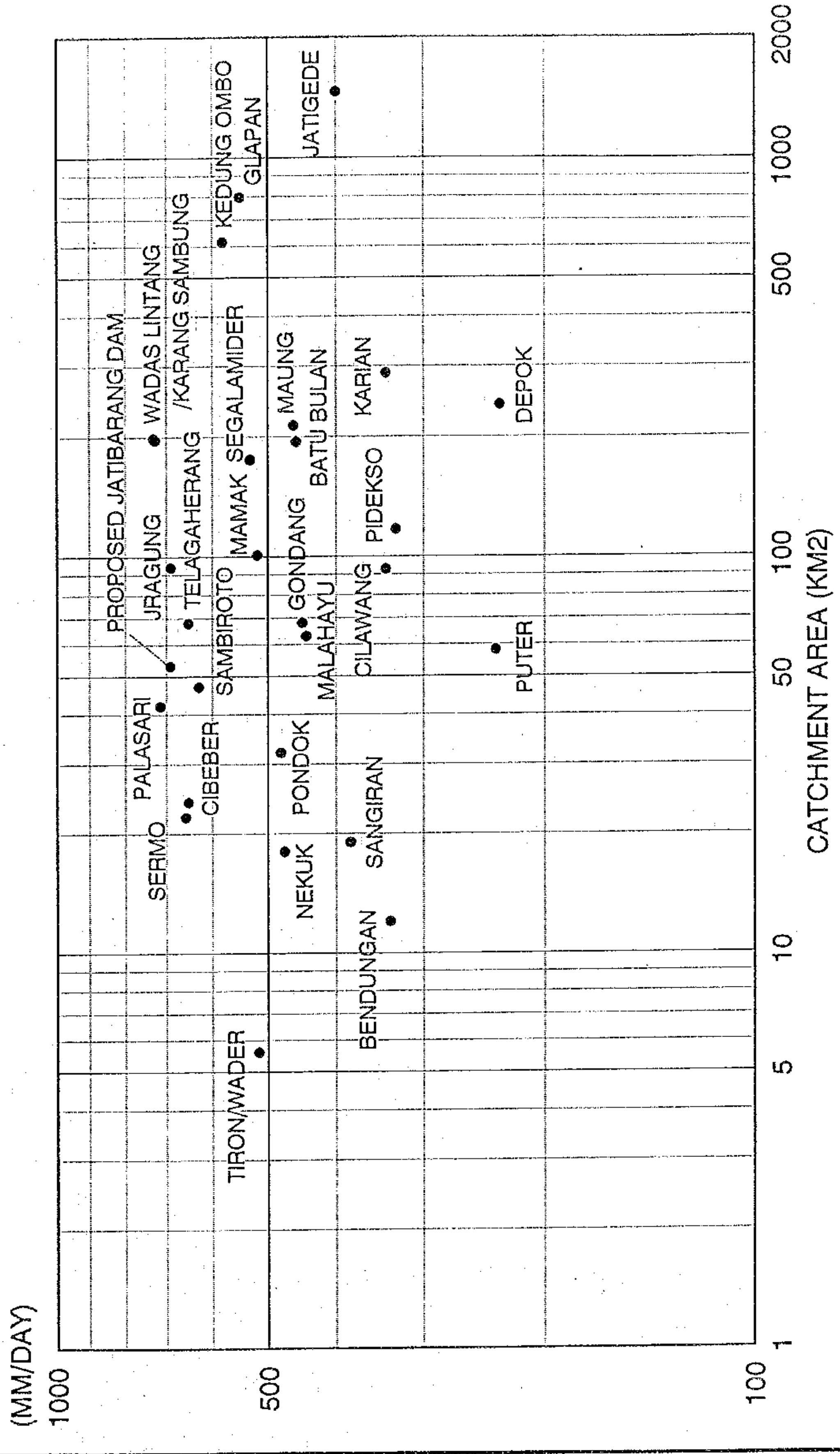
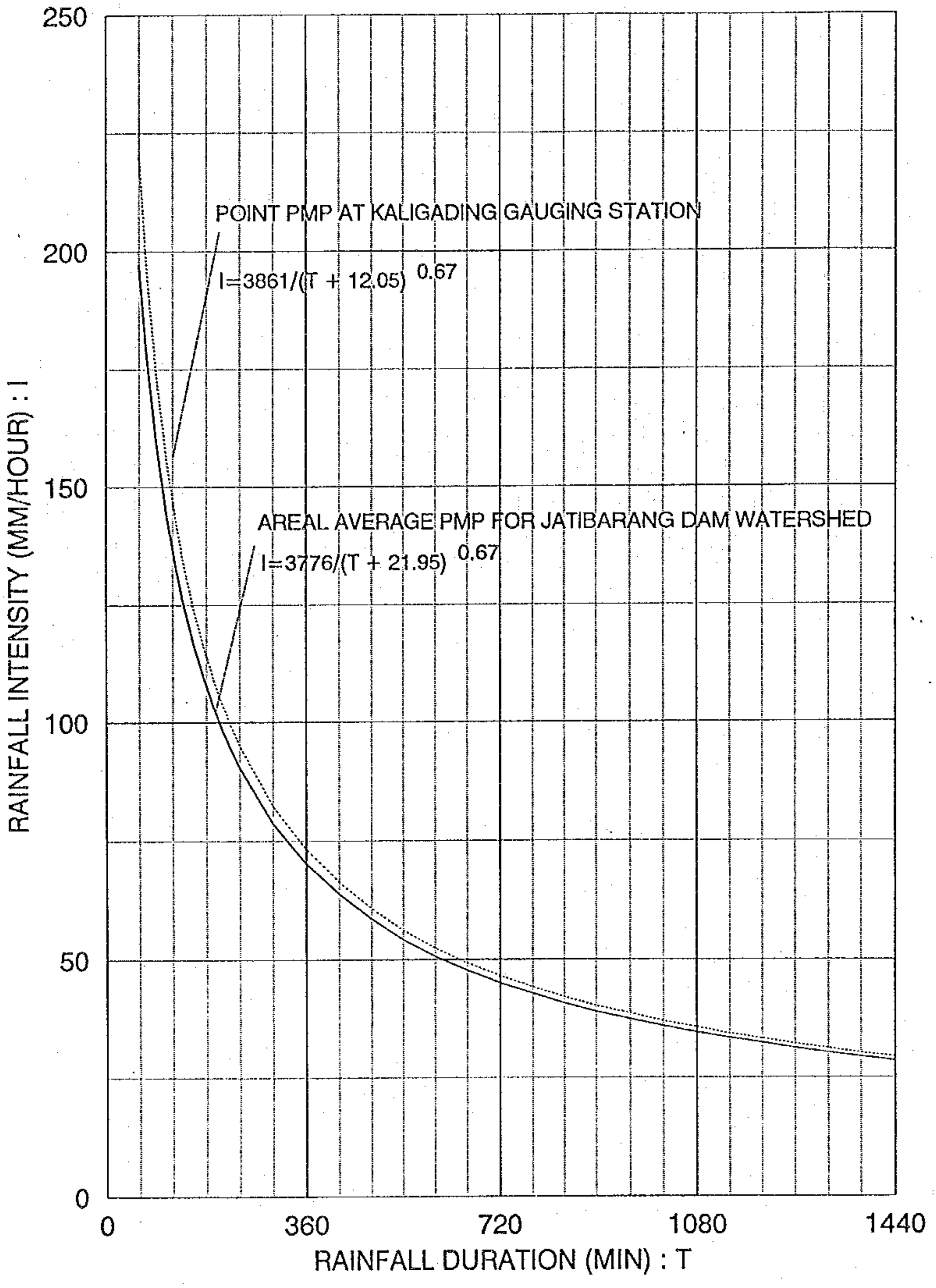


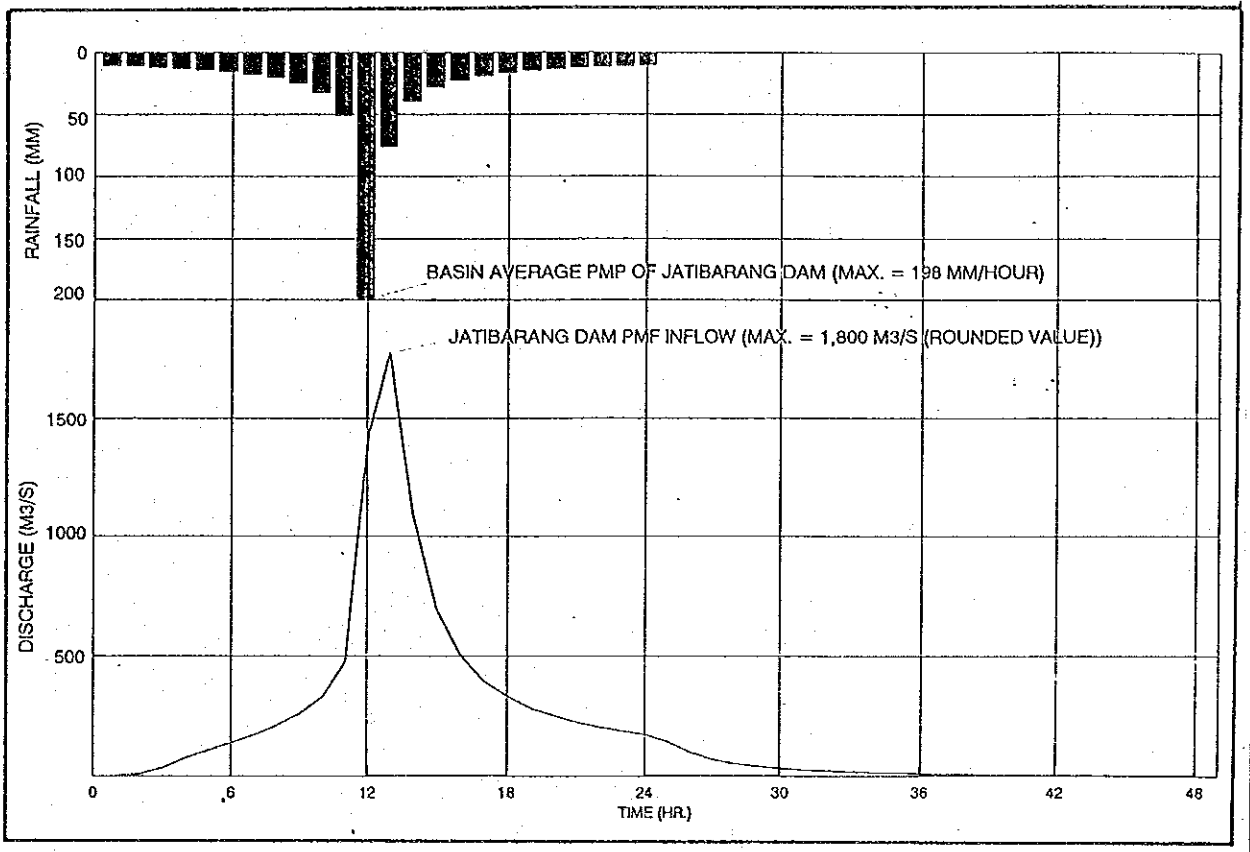
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.4.10 AREA REDUCTION CURVE FOR POINT PMP
JAPAN INTERNATIONAL COOPERATION AGENCY	



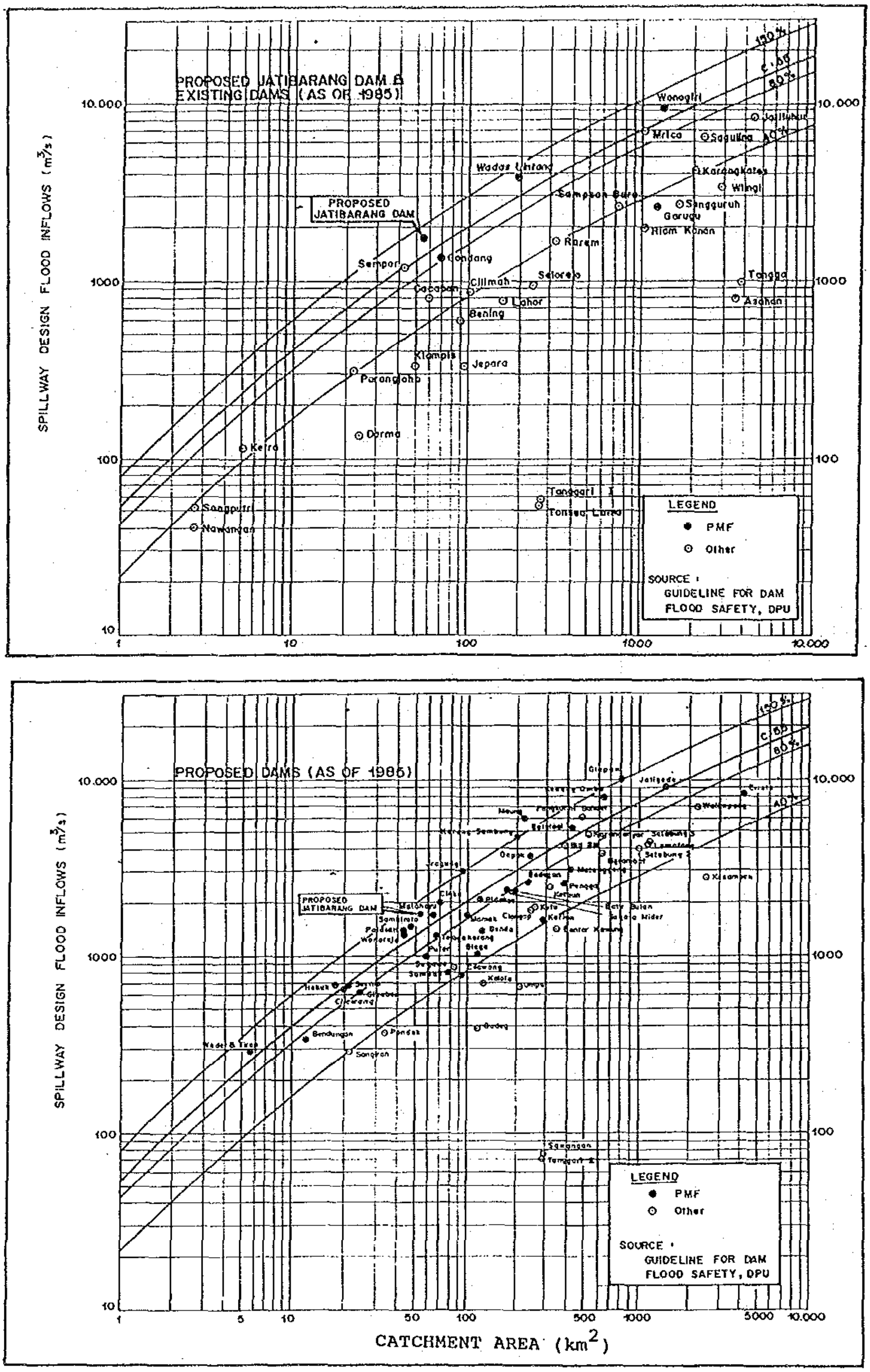
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.4.11 ONE-DAY PMP ESTIMATED FOR DAMS IN INDONESIA
JAPAN INTERNATIONAL COOPERATION AGENCY	



MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.4.12 RAINFALL INTENSITY-DURATION CURVE OF PMP FOR JATIBARANG DAM
JAPAN INTERNATIONAL COOPERATION AGENCY	

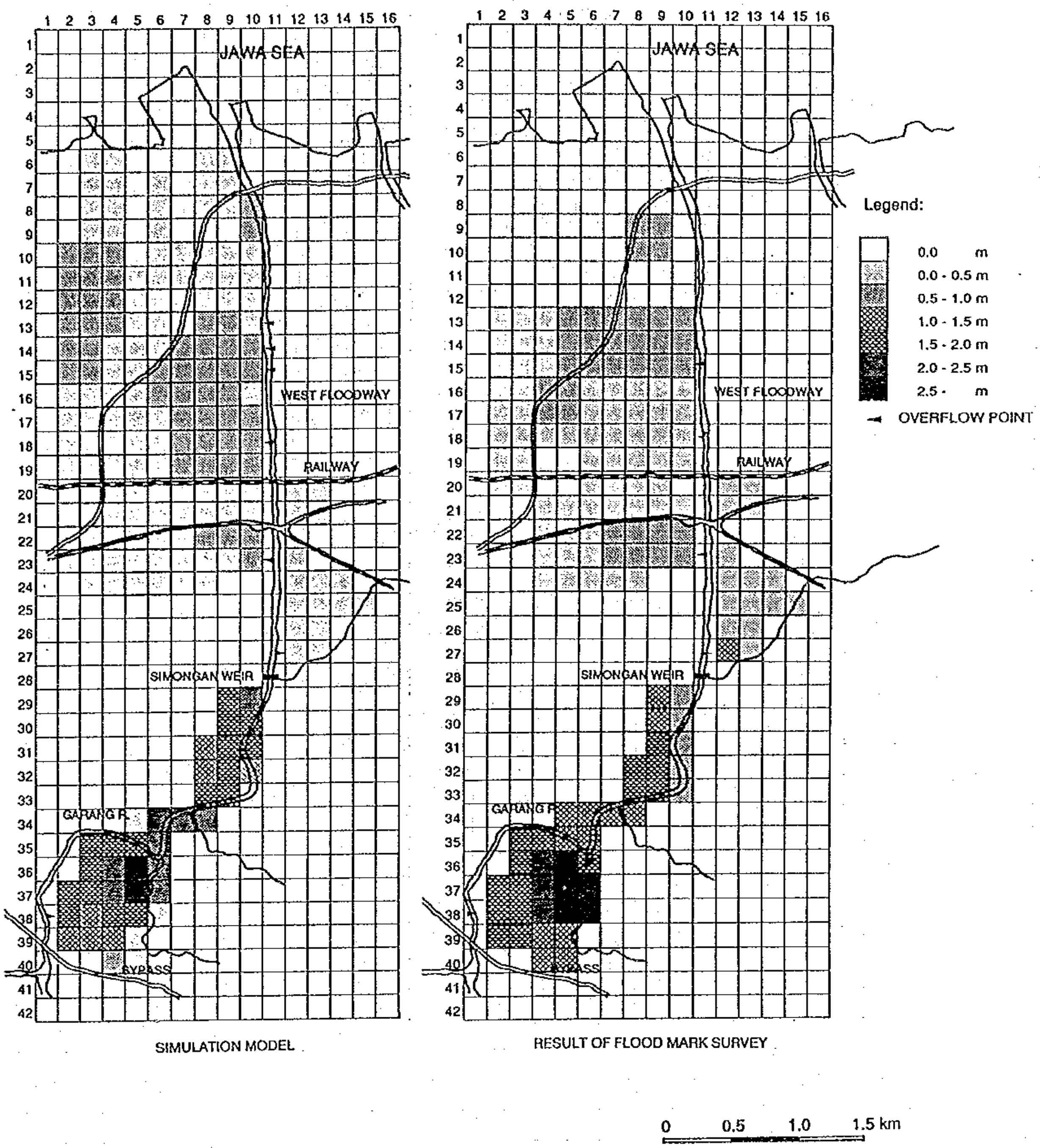


MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.4.13
JAPAN INTERNATIONAL COOPERATION AGENCY	MODEL HYETOGRAPH AND HYDROGRAPH OF PMP FOR JATIBARANG DAM

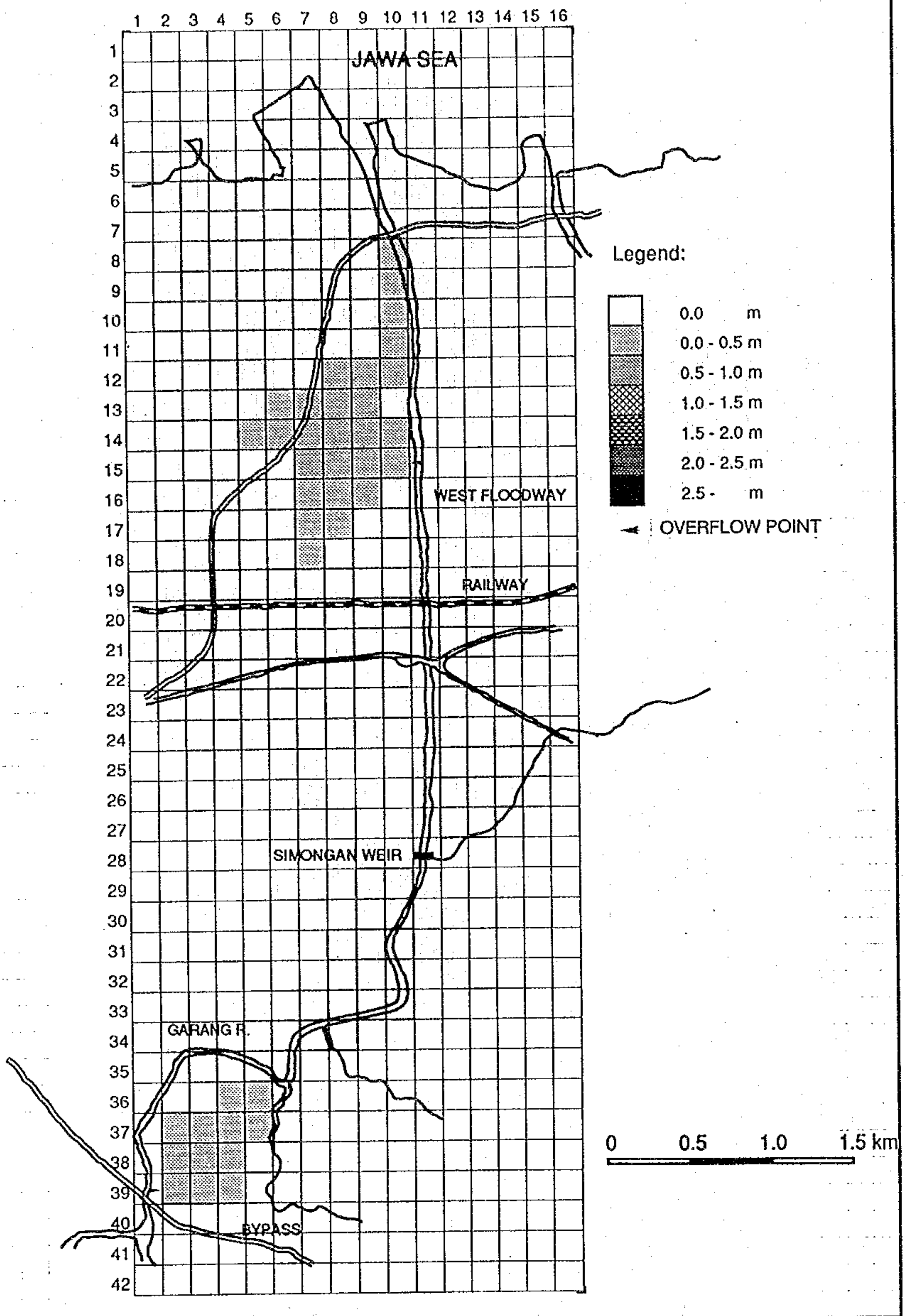


MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.4.14
JAPAN INTERNATIONAL COOPERATION AGENCY	DESIGN PEAK INFLOW DISCHARGE OF EMERGENCY SPILLWAY FOR DAMS IN INDONESIA

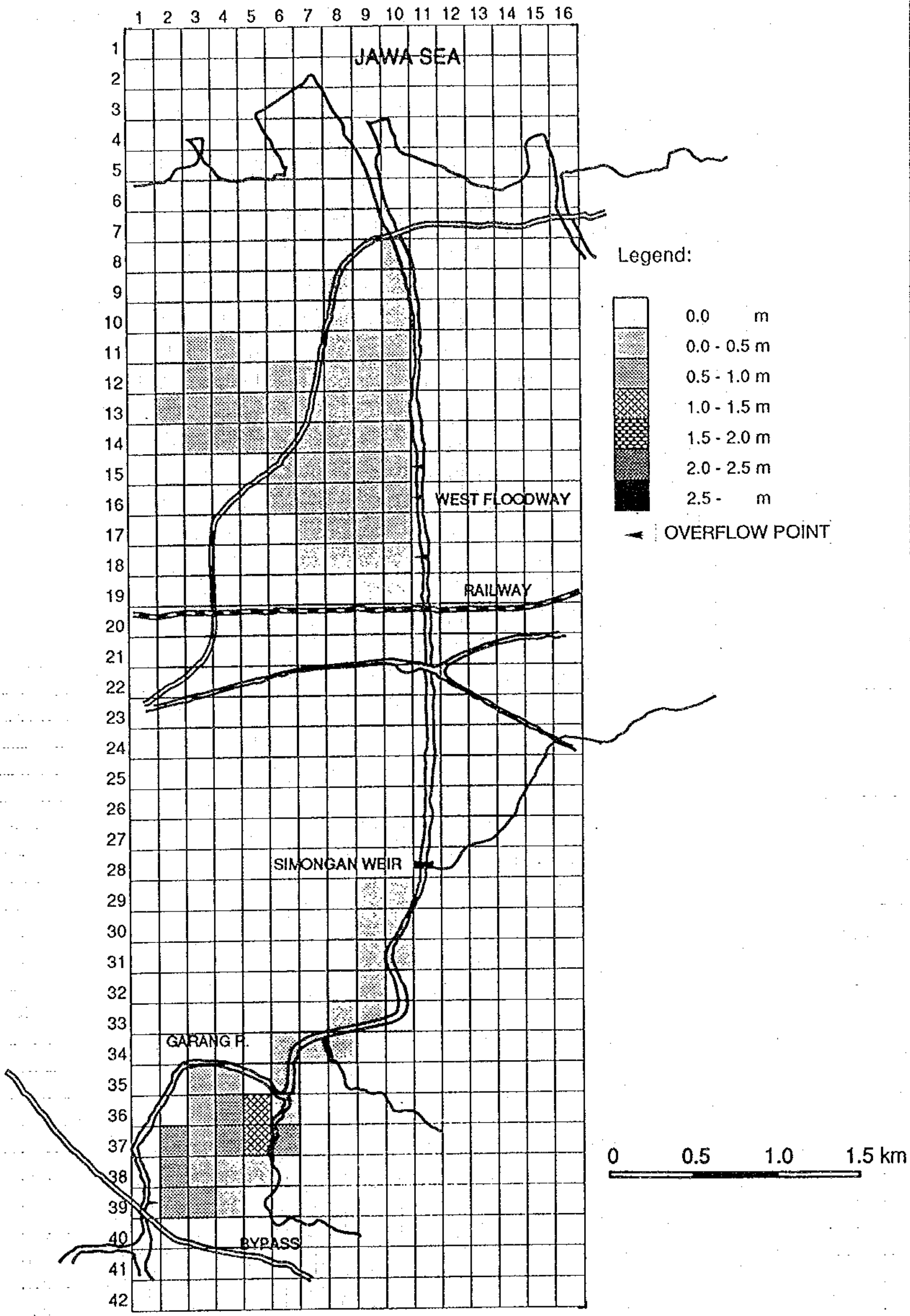
INUNDATION OF THE FLOOD IN 1990



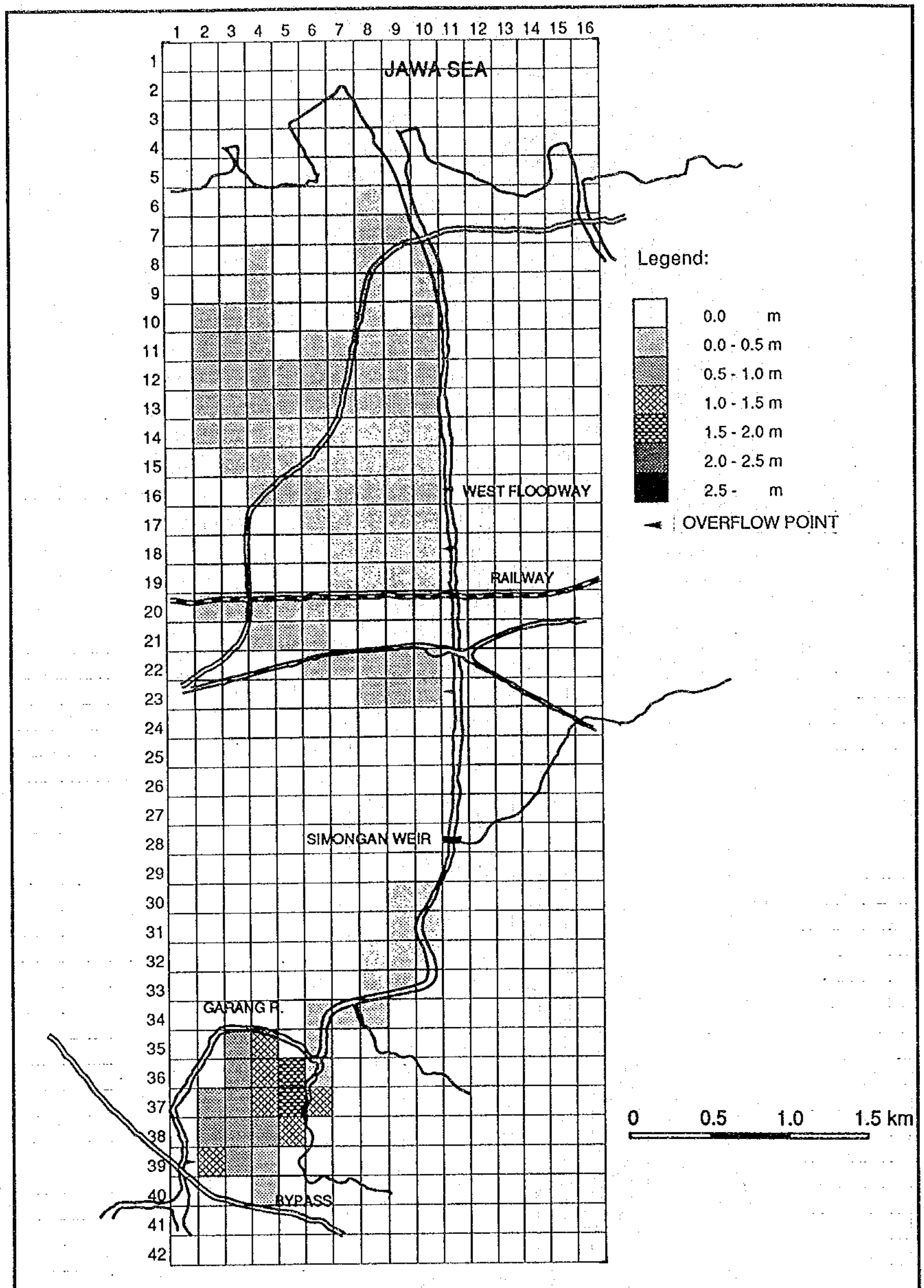
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.5.1 COMPARISON OF INUNDATION AREA IN 1990 BETWEEN FIELD SURVEY AND SIMULATION MODEL OF GARANG RIVER
JAPAN INTERNATIONAL COOPERATION AGENCY	



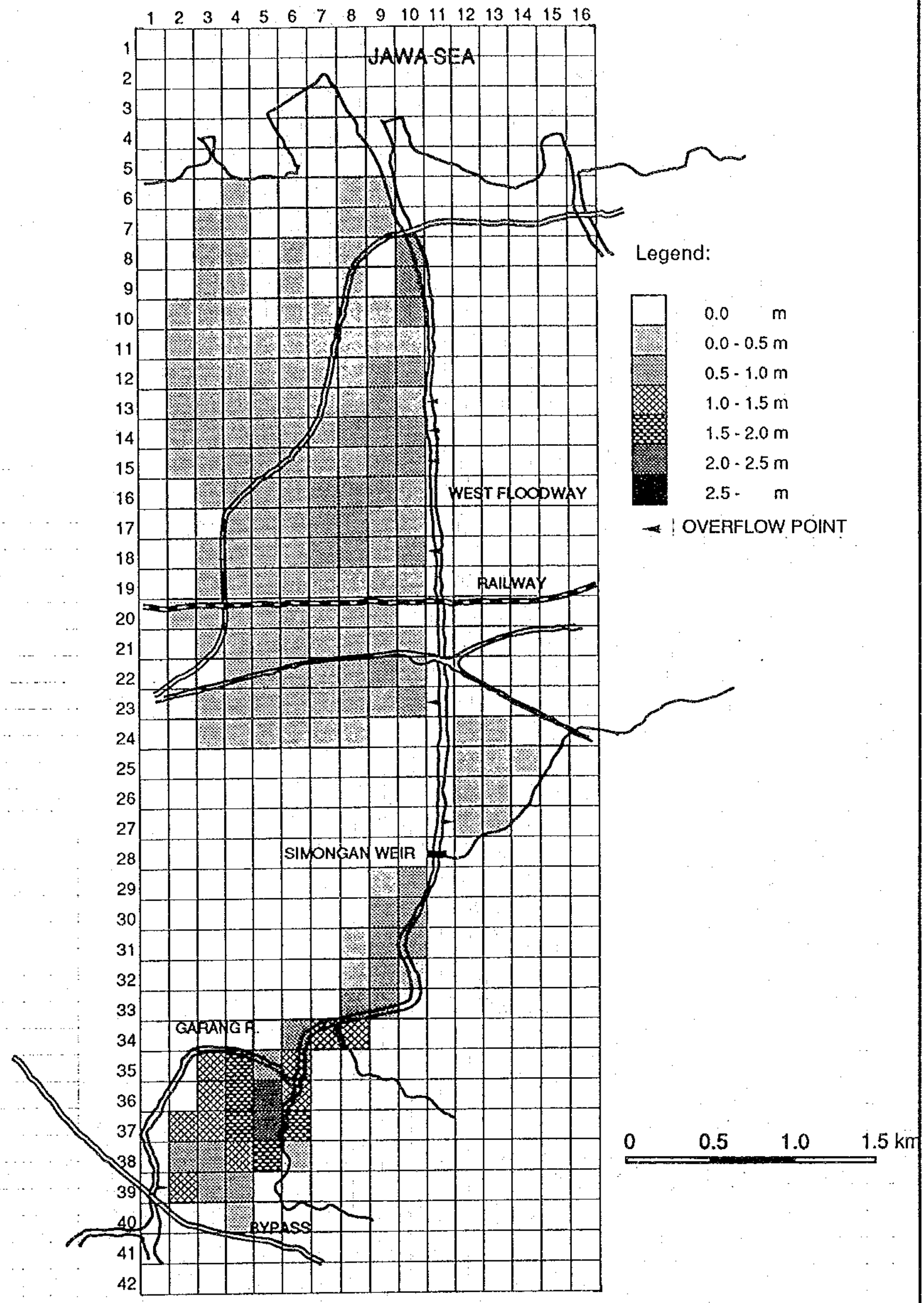
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.5.2 (1/4) PROBABLE INUNDATION AREA OF GARANG RIVER WITHOUT PROJECT (10-YEAR RETURN PERIOD)
JAPAN INTERNATIONAL COOPERATION AGENCY	



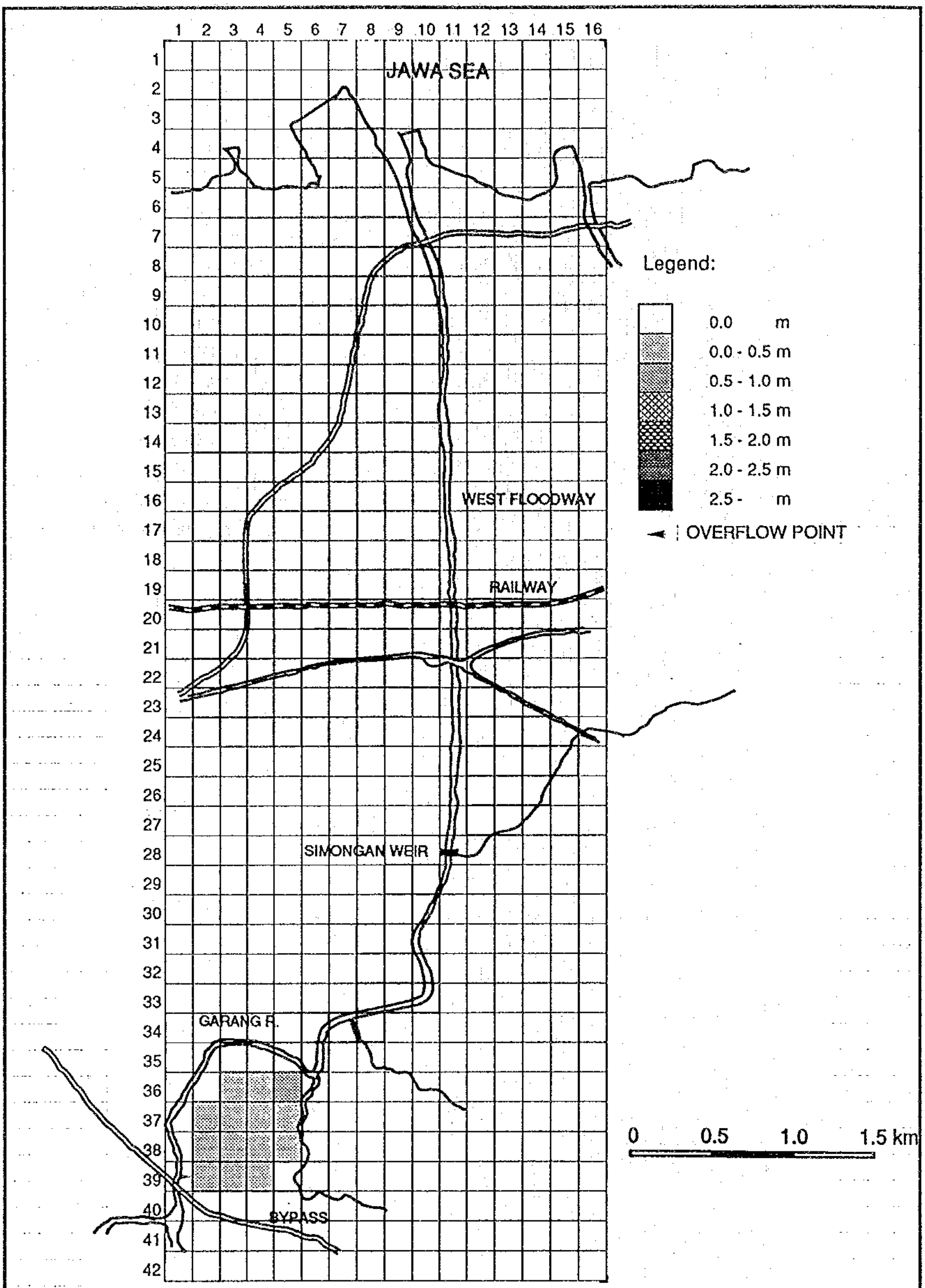
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.5.2 (2/4) PROBABLE INUNDATION AREA OF GARANG RIVER WITHOUT PROJECT (25-YEAR RETURN PERIOD)
JAPAN INTERNATIONAL COOPERATION AGENCY	



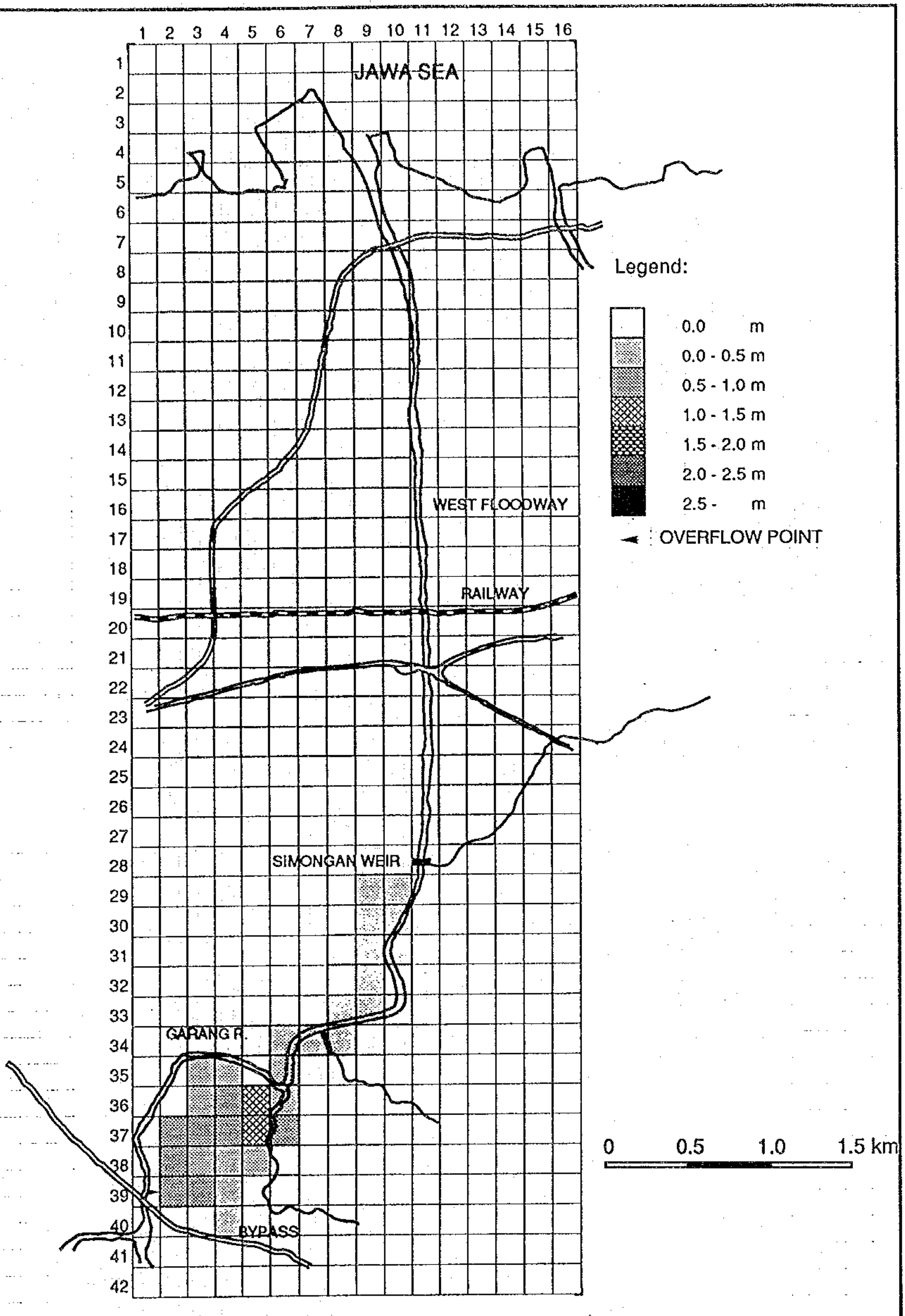
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.5.2 (3/4) PROBABLE INUNDATION AREA OF GARANG RIVER WITHOUT PROJECT (50-YEAR RETURN PERIOD)
JAPAN INTERNATIONAL COOPERATION AGENCY	



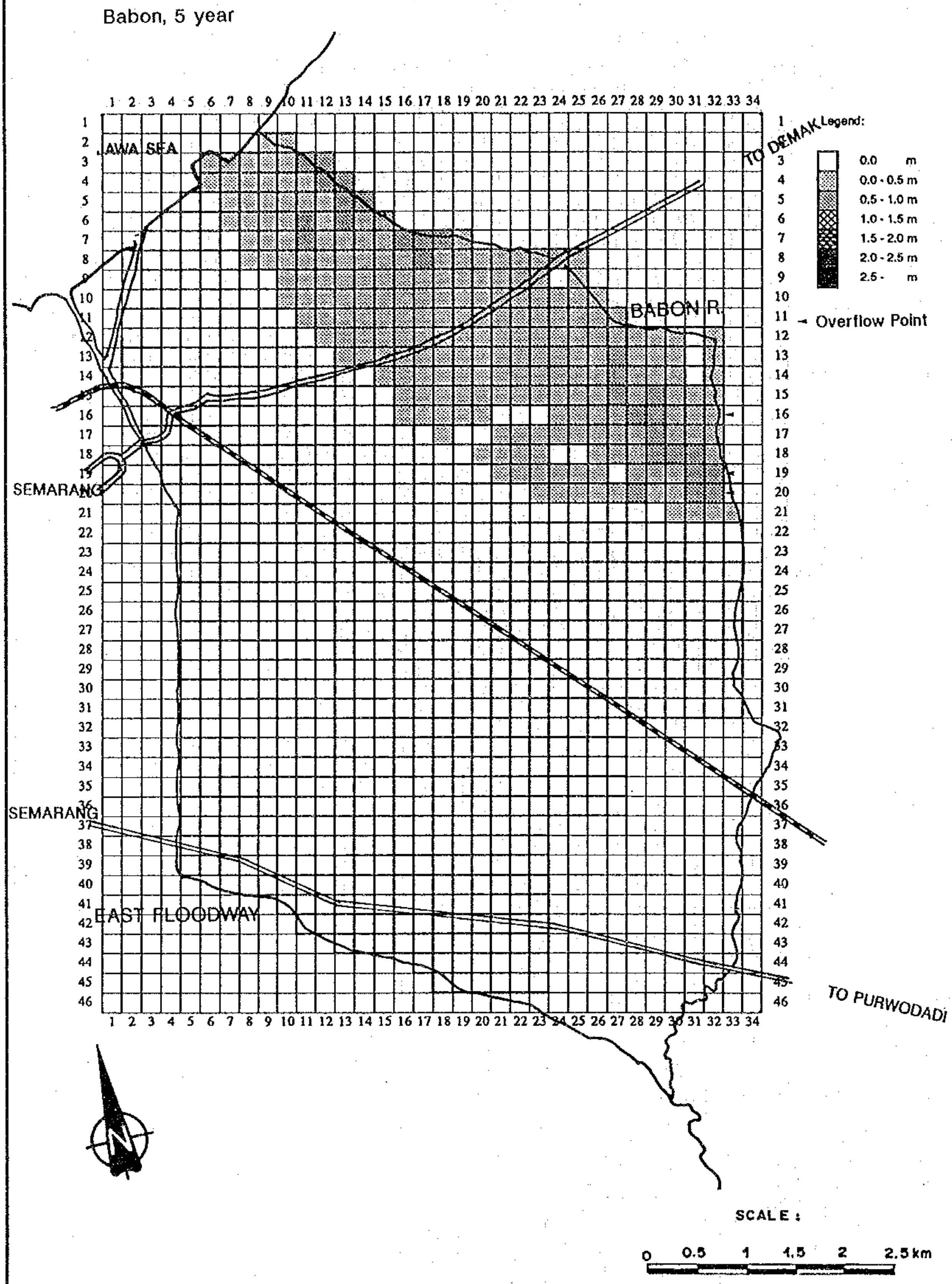
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.5.2 (4/4) PROBABLE INUNDATION AREA OF GARANG RIVER WITHOUT PROJECT (100-YEAR RETURN PERIOD)
JAPAN INTERNATIONAL COOPERATION AGENCY	



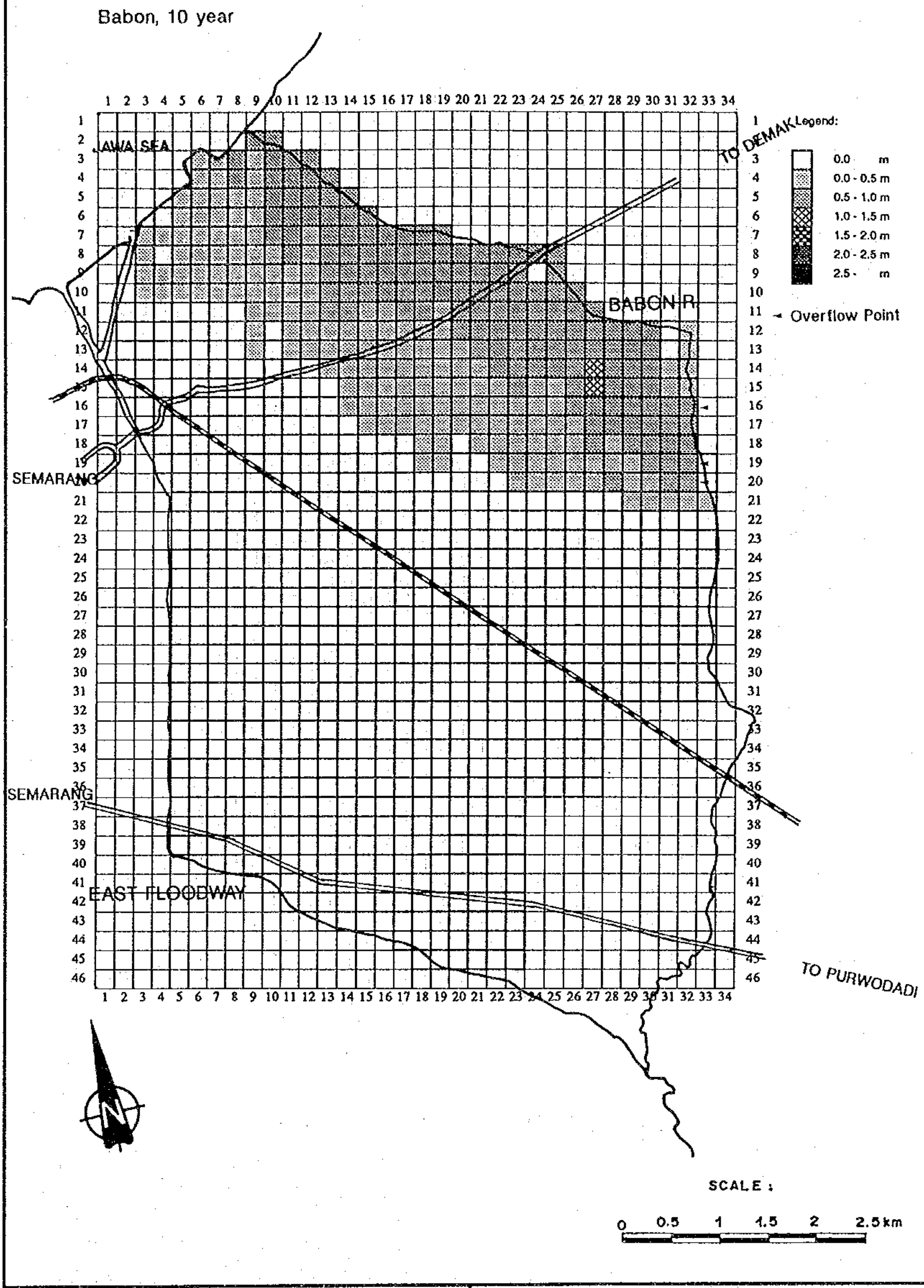
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. I.5.3 (1/2) PROBABLE INUNDATION AREA OF GARANG RIVER WITH PROJECT (50-YEAR RETURN PERIOD)



MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.5.3 (2/2) PROBABLE INUNDATION AREA OF GARANG RIVER WITH PROJECT (100-YEAR RETURN PERIOD)
JAPAN INTERNATIONAL COOPERATION AGENCY	



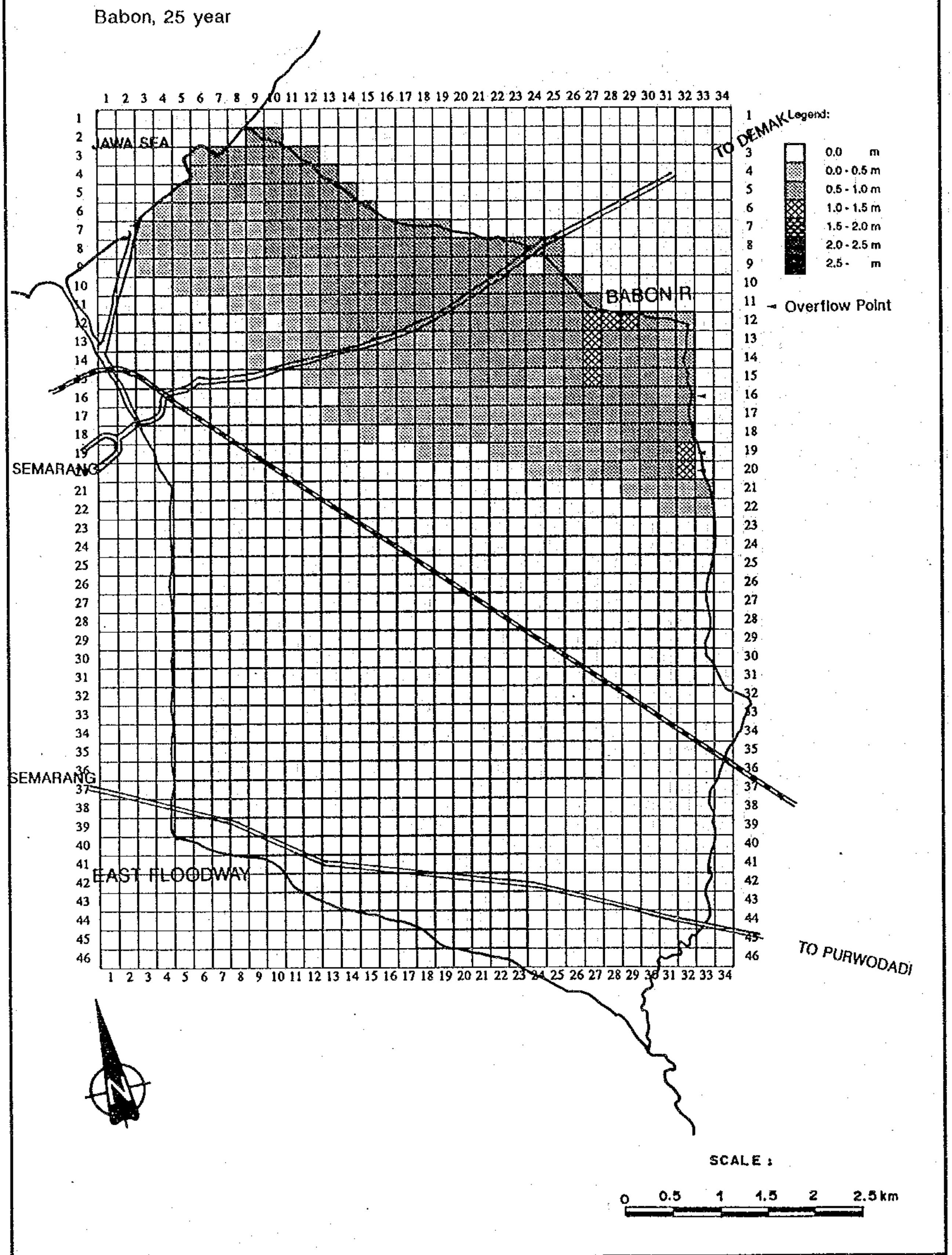
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.5.4 (1/5) PROBABLE INUNDATION AREA OF BABON RIVER (5-YEAR RETURN PERIOD)
JAPAN INTERNATIONAL COOPERATION AGENCY	



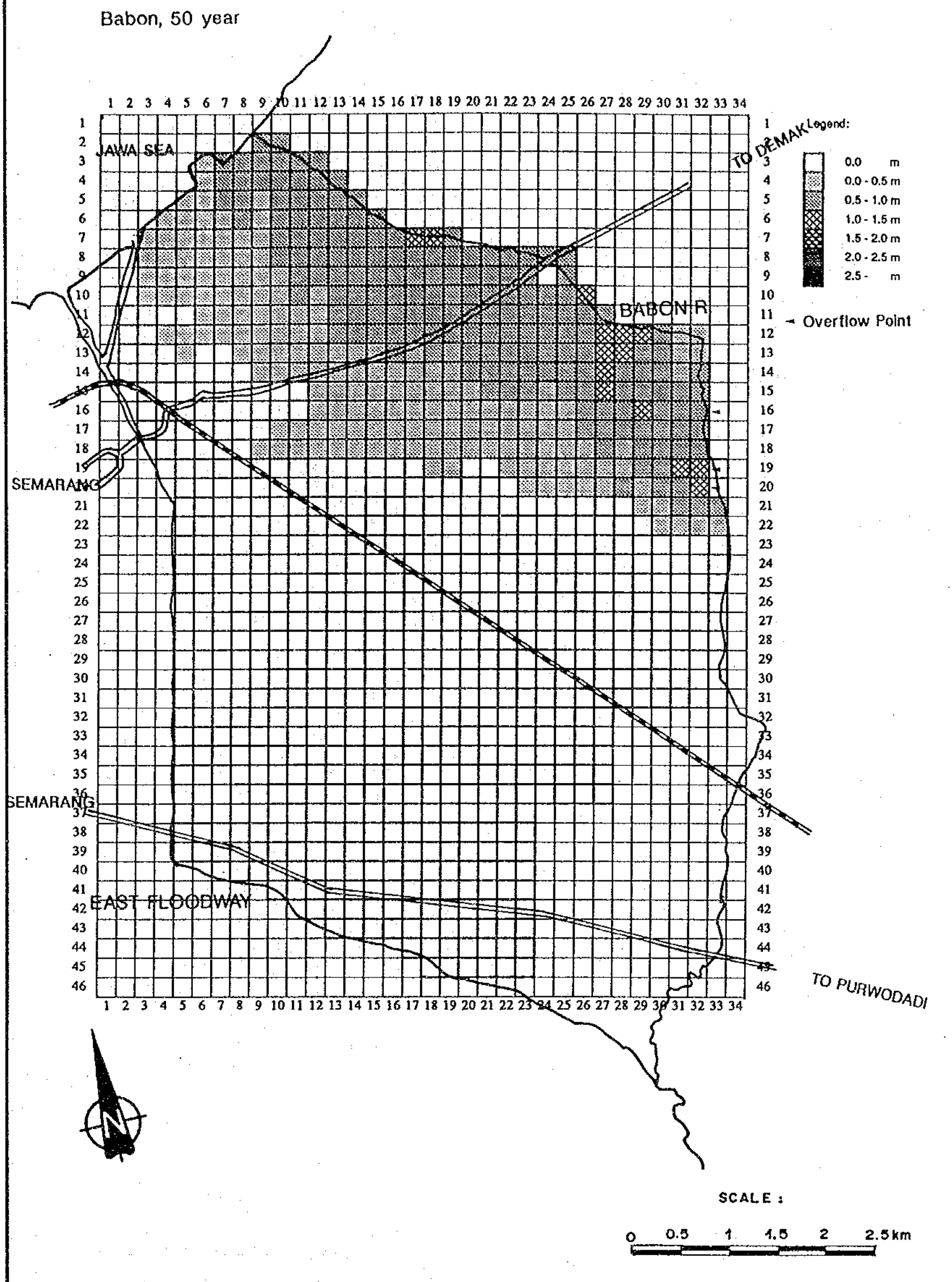
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS

JAPAN INTERNATIONAL COOPERATION AGENCY

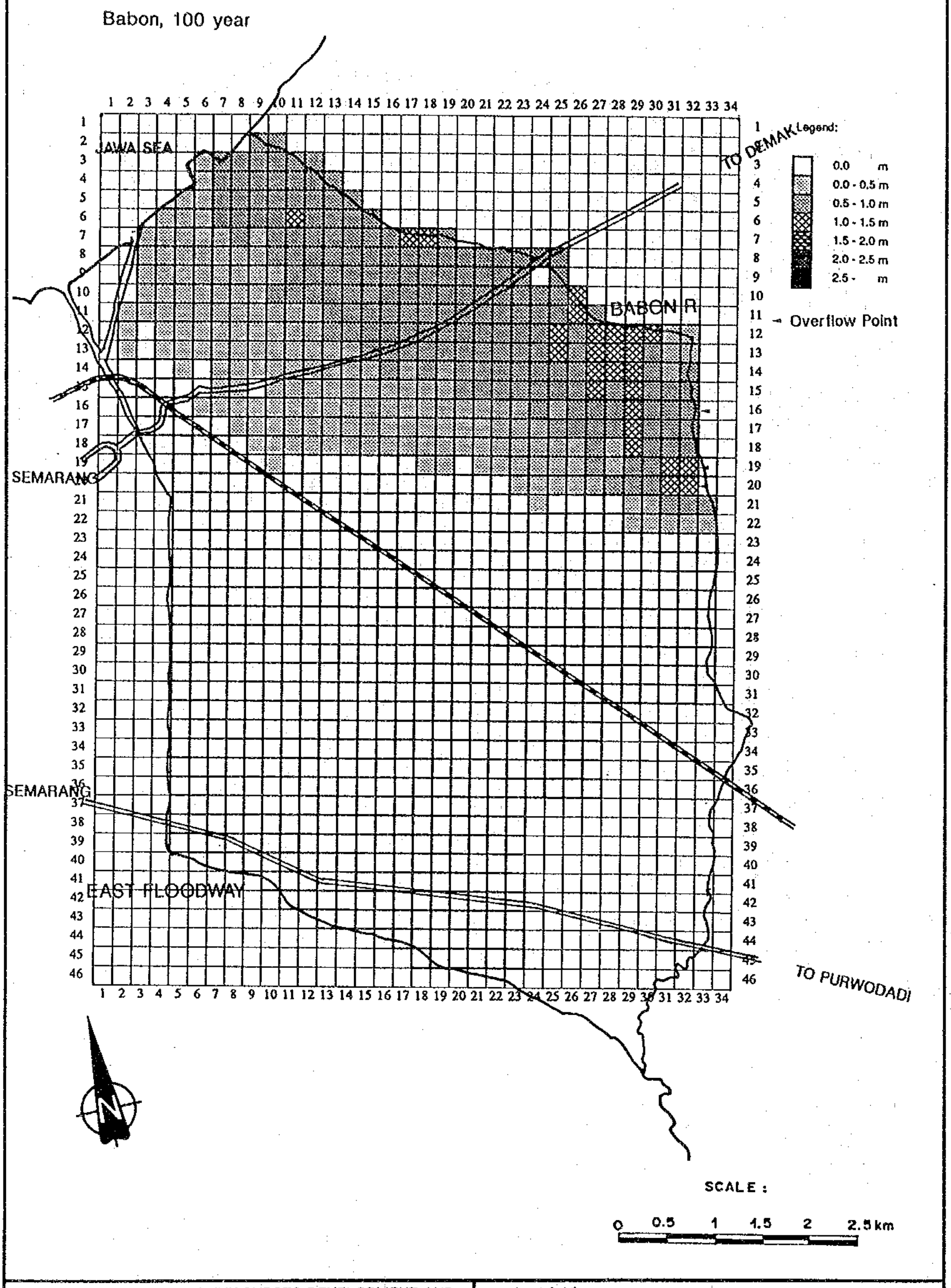
Fig. I.5.4 (2/5)
PROBABLE INUNDATION AREA OF BABON RIVER
(10-YEAR RETURN PERIOD)



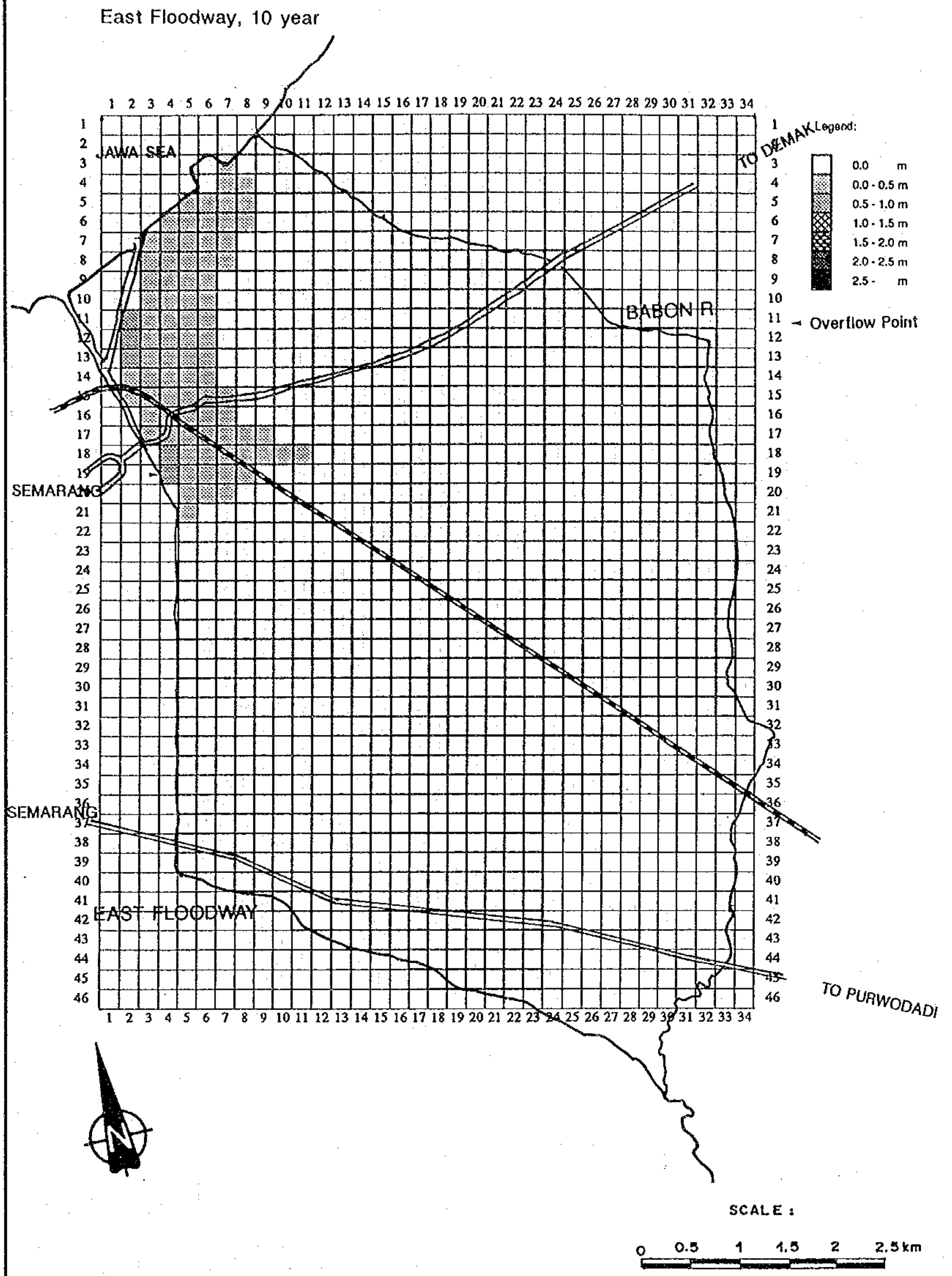
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.5.4 (3/5)
JAPAN INTERNATIONAL COOPERATION AGENCY	PROBABLE INUNDATION AREA OF BABON RIVER (25-YEAR RETURN PERIOD)



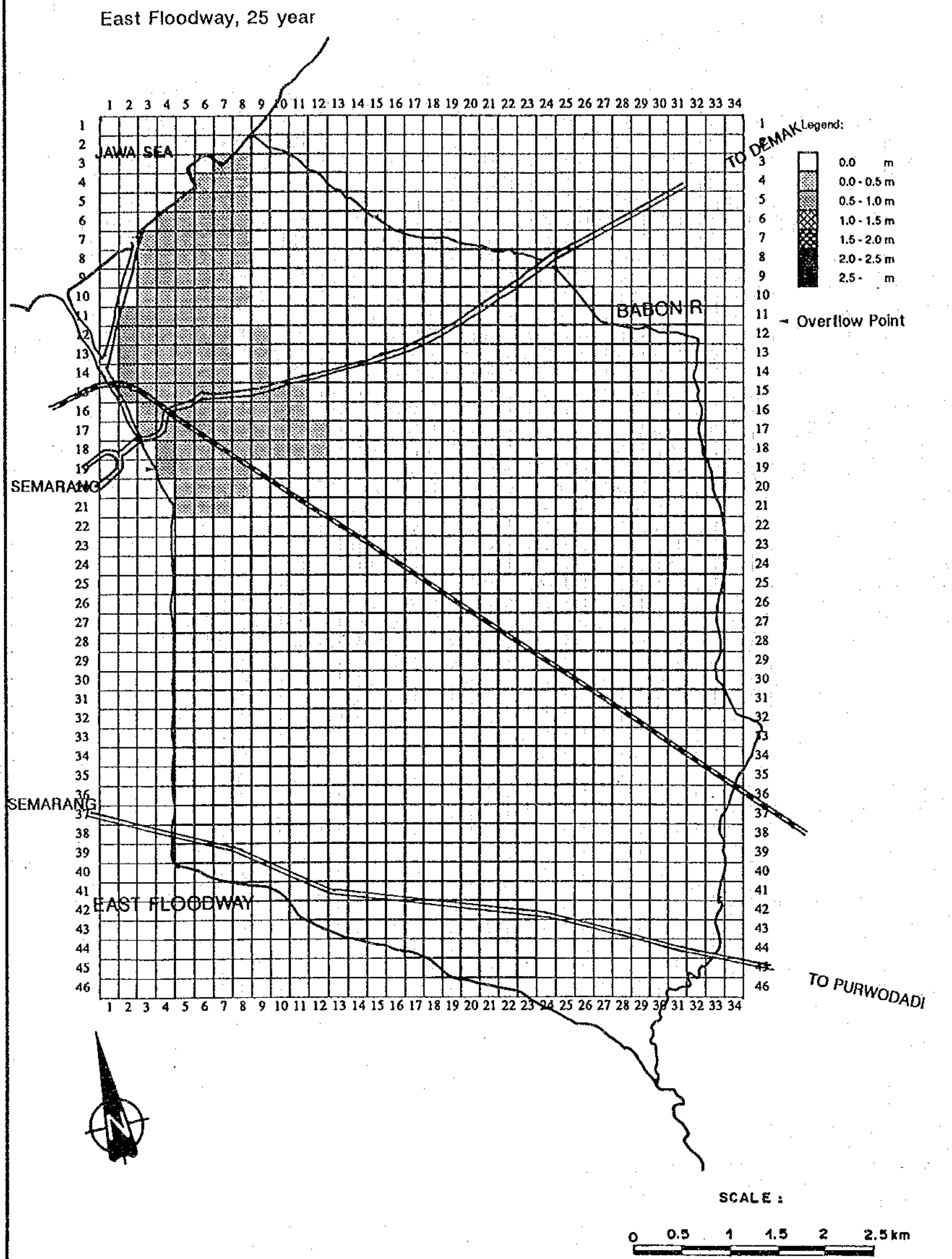
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.5.4 (4/5) PROBABLE INUNDATION AREA OF BABON RIVER (50-YEAR RETURN PERIOD)
JAPAN INTERNATIONAL COOPERATION AGENCY	



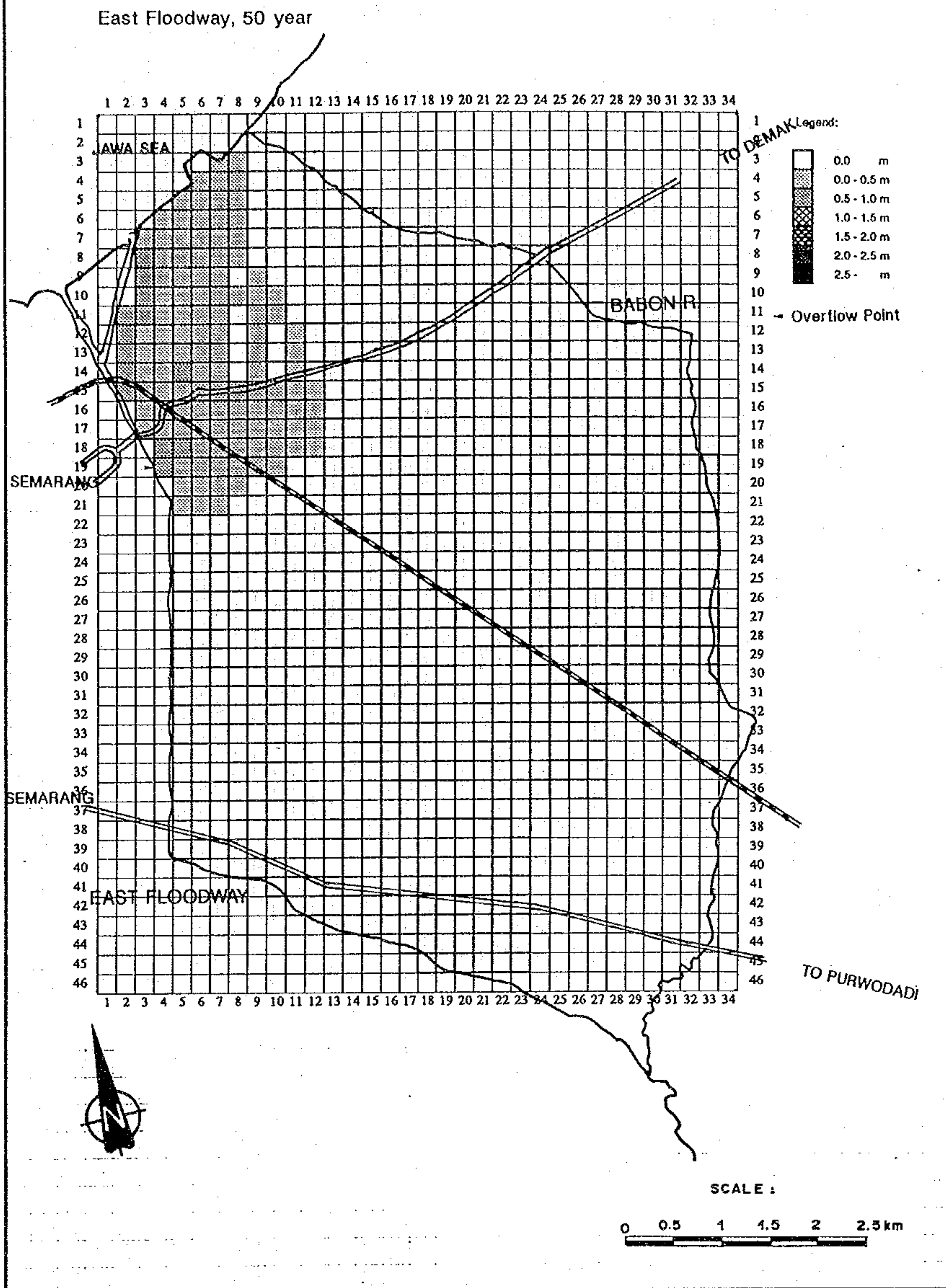
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.5.4 (5/5) PROBABLE INUNDATION AREA OF BABON RIVER (100-YEAR RETURN PERIOD)
JAPAN INTERNATIONAL COOPERATION AGENCY	



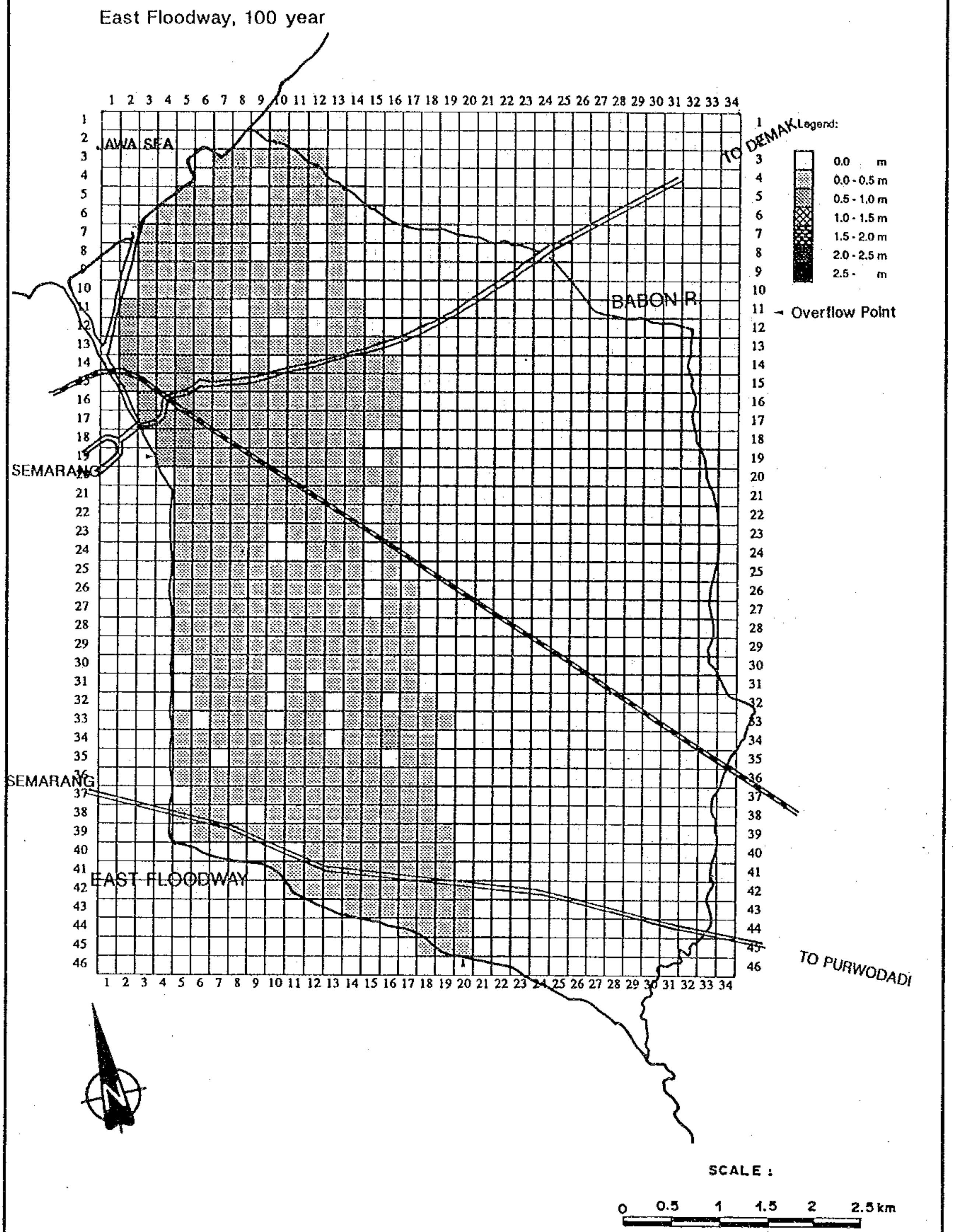
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.5.5 (1/4) PROBABLE INUNDATION AREA OF EAST FLOODWAY (10-YEAR RETURN PERIOD)
JAPAN INTERNATIONAL COOPERATION AGENCY	



MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.5.5 (2/4) PROBABLE INUNDATION AREA OF EAST FLOODWAY (25-YEAR RETURN PERIOD)
JAPAN INTERNATIONAL COOPERATION AGENCY	

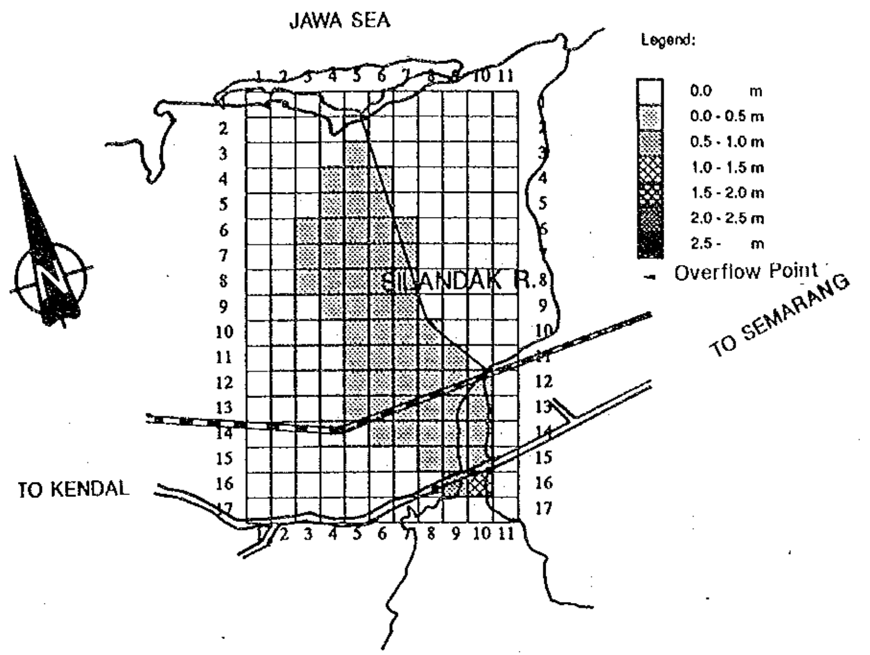


MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.5.5 (3/4) PROBABLE INUNDATION AREA OF EAST FLOODWAY (50-YEAR RETURN PERIOD)
JAPAN INTERNATIONAL COOPERATION AGENCY	

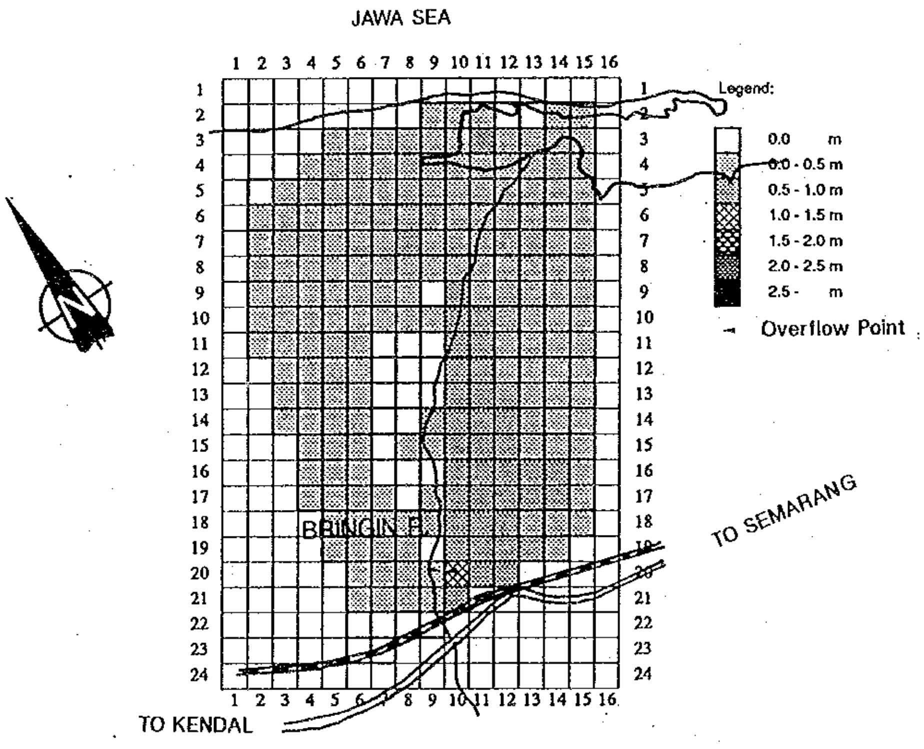


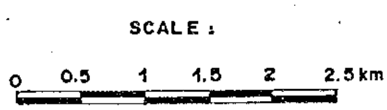
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. I.5.5 (4/4) PROBABLE INUNDATION AREA OF EAST FLOODWAY (100-YEAR RETURN PERIOD)

Silandak, 5 year

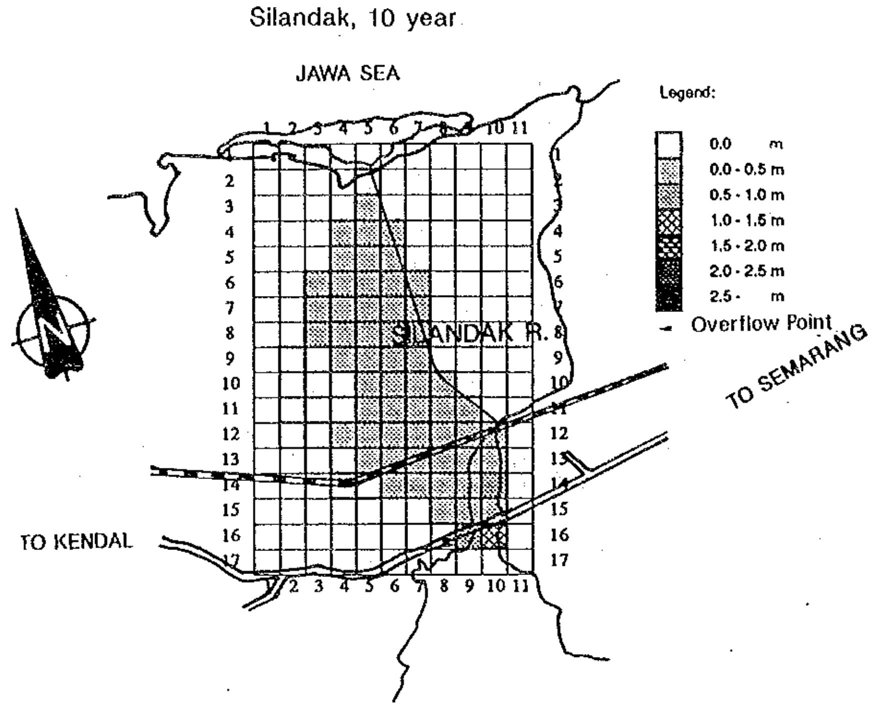


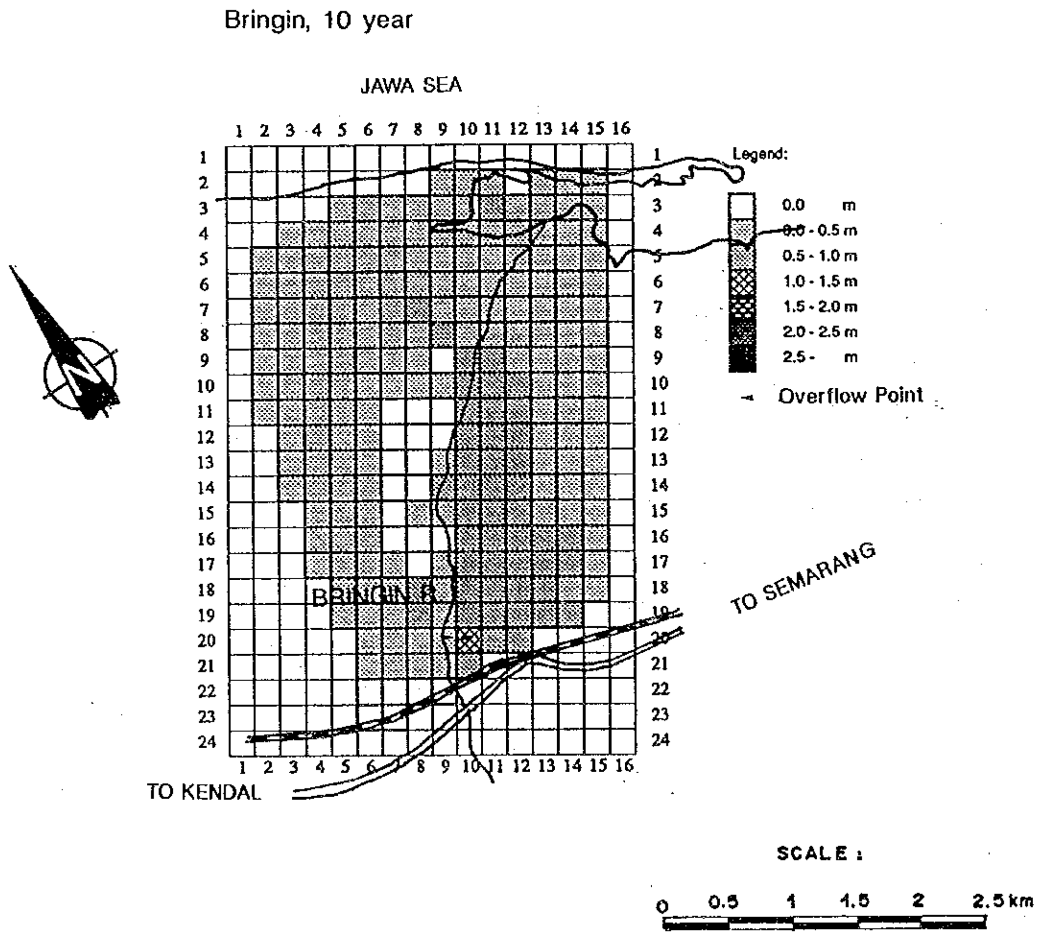
Bringin, 5 year





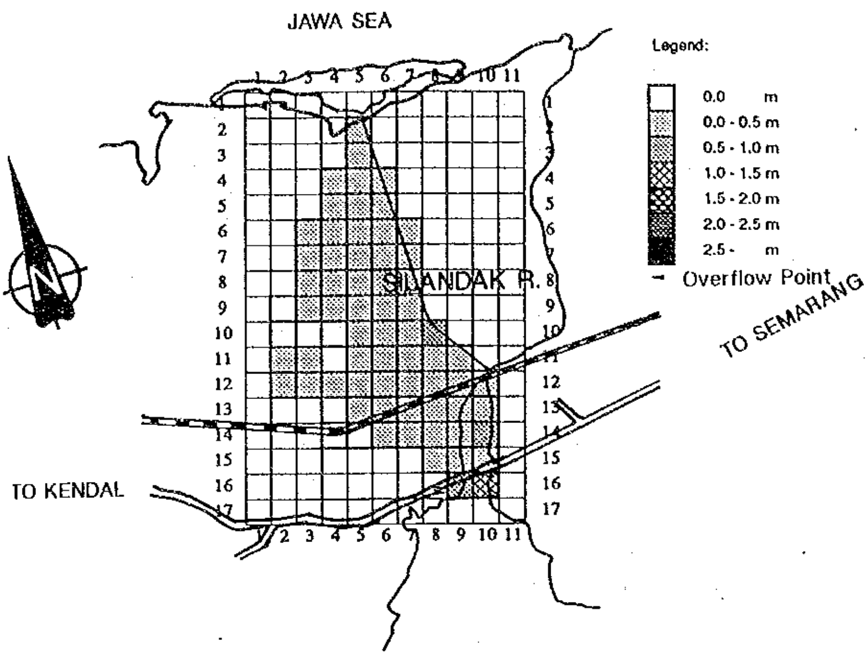
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.5.6 (1/5)
JAPAN INTERNATIONAL COOPERATION AGENCY	PROBABLE INUNDATION AREA OF SILANDAK AND BRINGIN RIVERS (5-YEAR RETURN PERIOD)



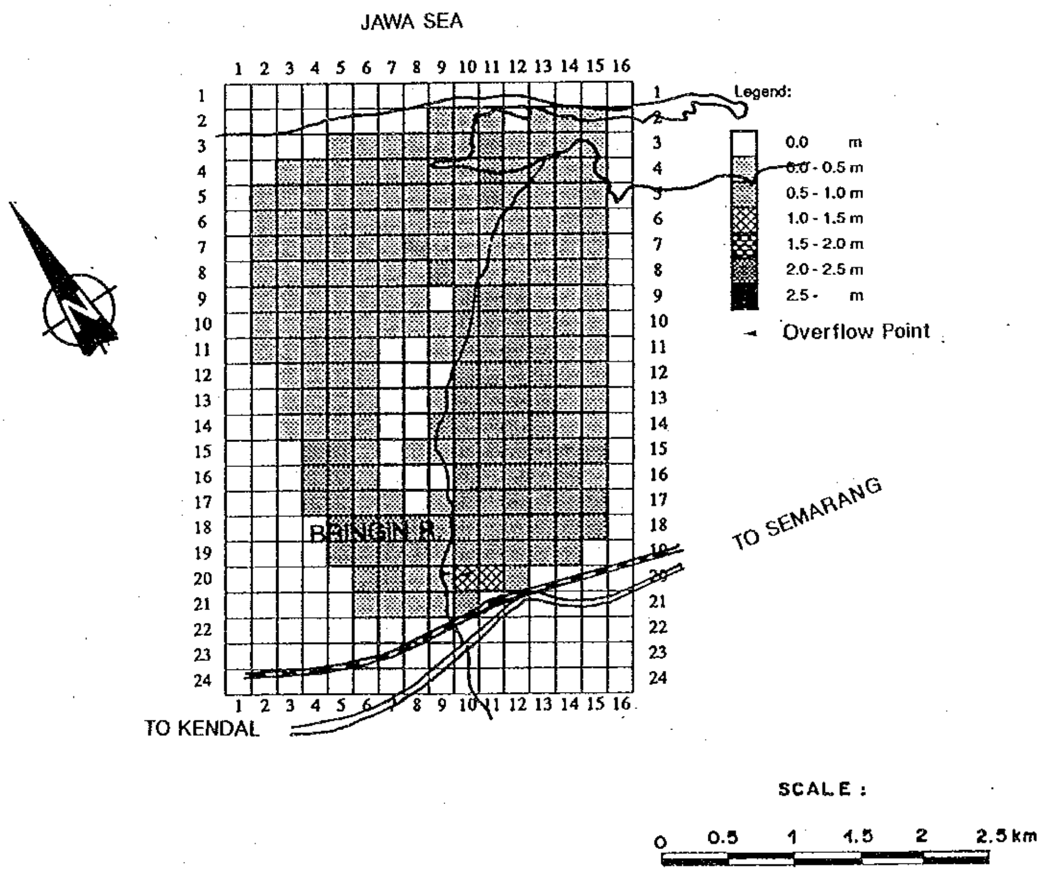


MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.5.6 (2/5) PROBABLE INUNDATION AREA OF SILANDAK AND BRINGIN RIVERS (10-YEAR RETURN PERIOD)
JAPAN INTERNATIONAL COOPERATION AGENCY	

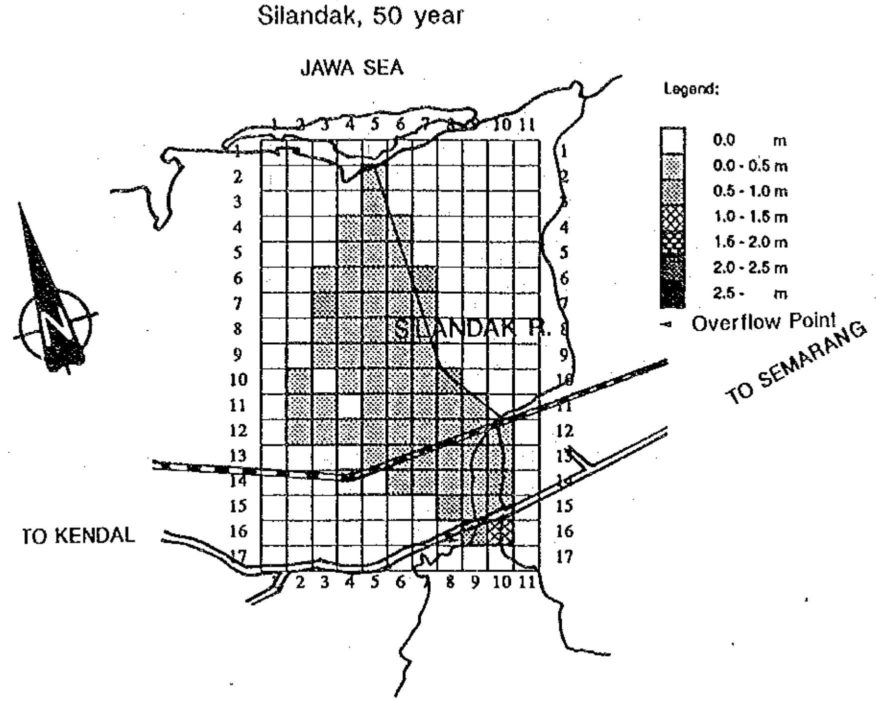
Silandak, 25 year

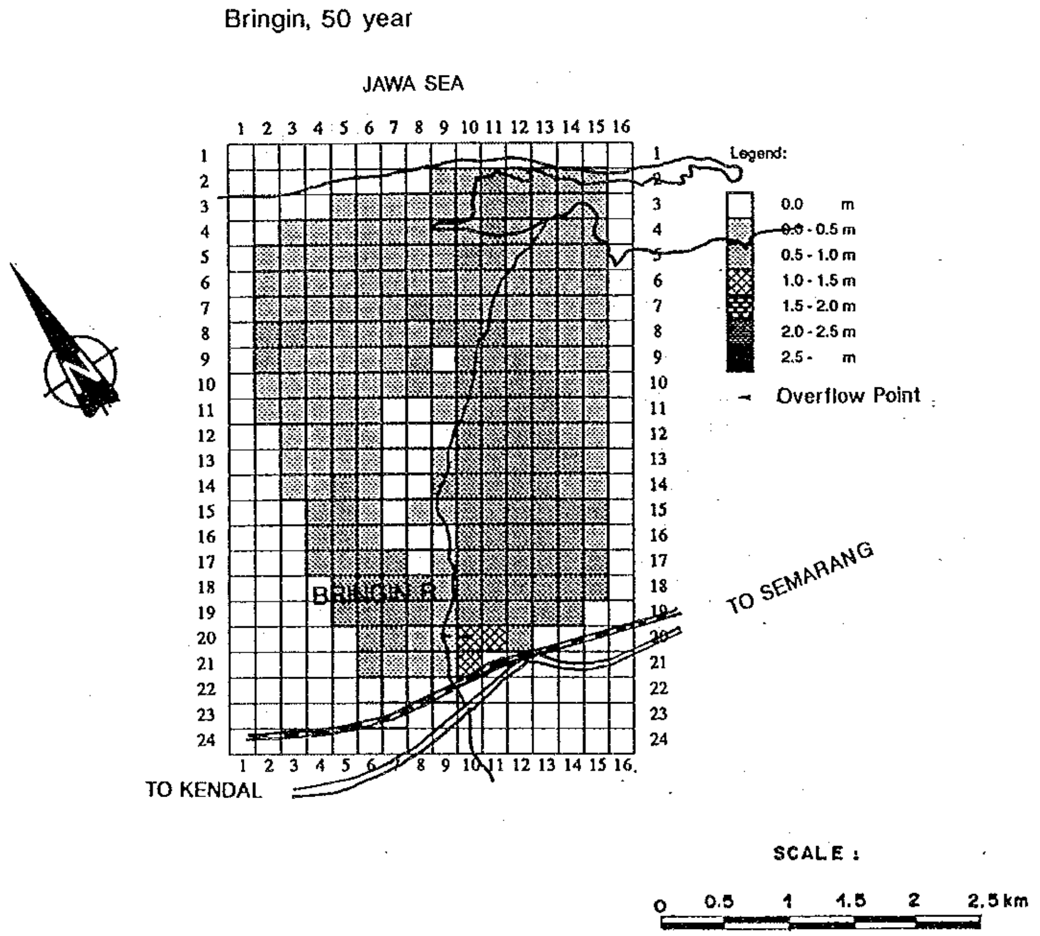


Bringin, 25 year



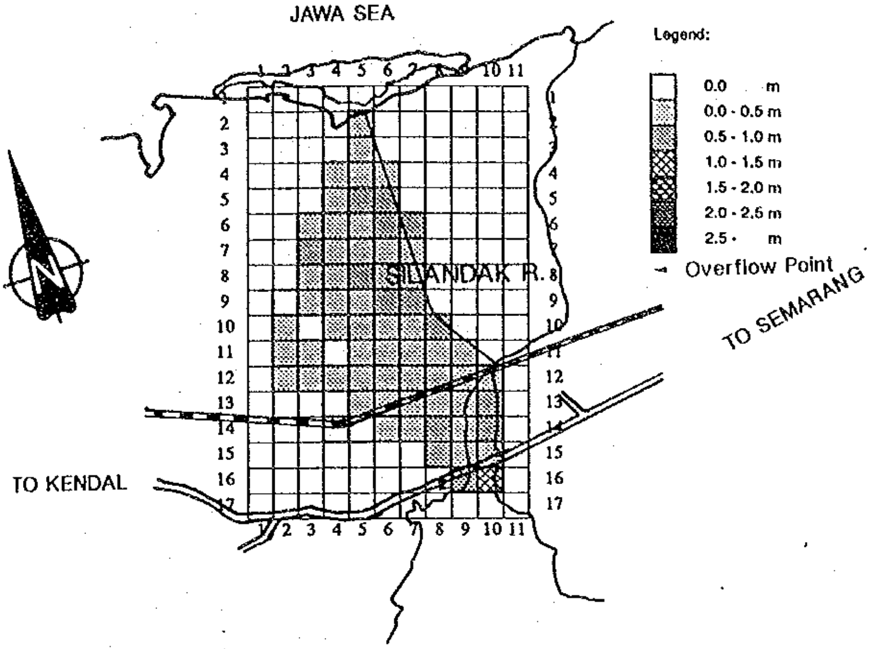
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.5.6 (3/5) PROBABLE INUNDATION AREA OF SILANDAK AND BRINGIN RIVERS (25-YEAR RETURN PERIOD)
JAPAN INTERNATIONAL COOPERATION AGENCY	



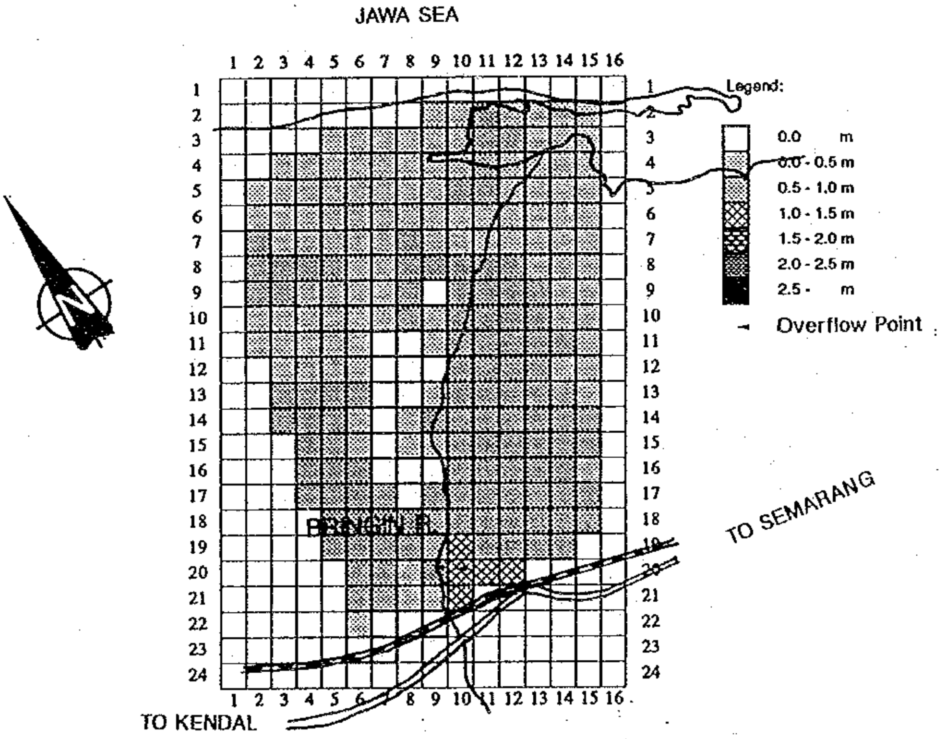


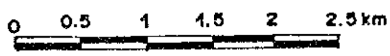
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.5.6 (4/5) PROBABLE INUNDATION AREA OF SILANDAK AND BRINGIN RIVERS (50-YEAR RETURN PERIOD)
JAPAN INTERNATIONAL COOPERATION AGENCY	

Silandak, 100 year

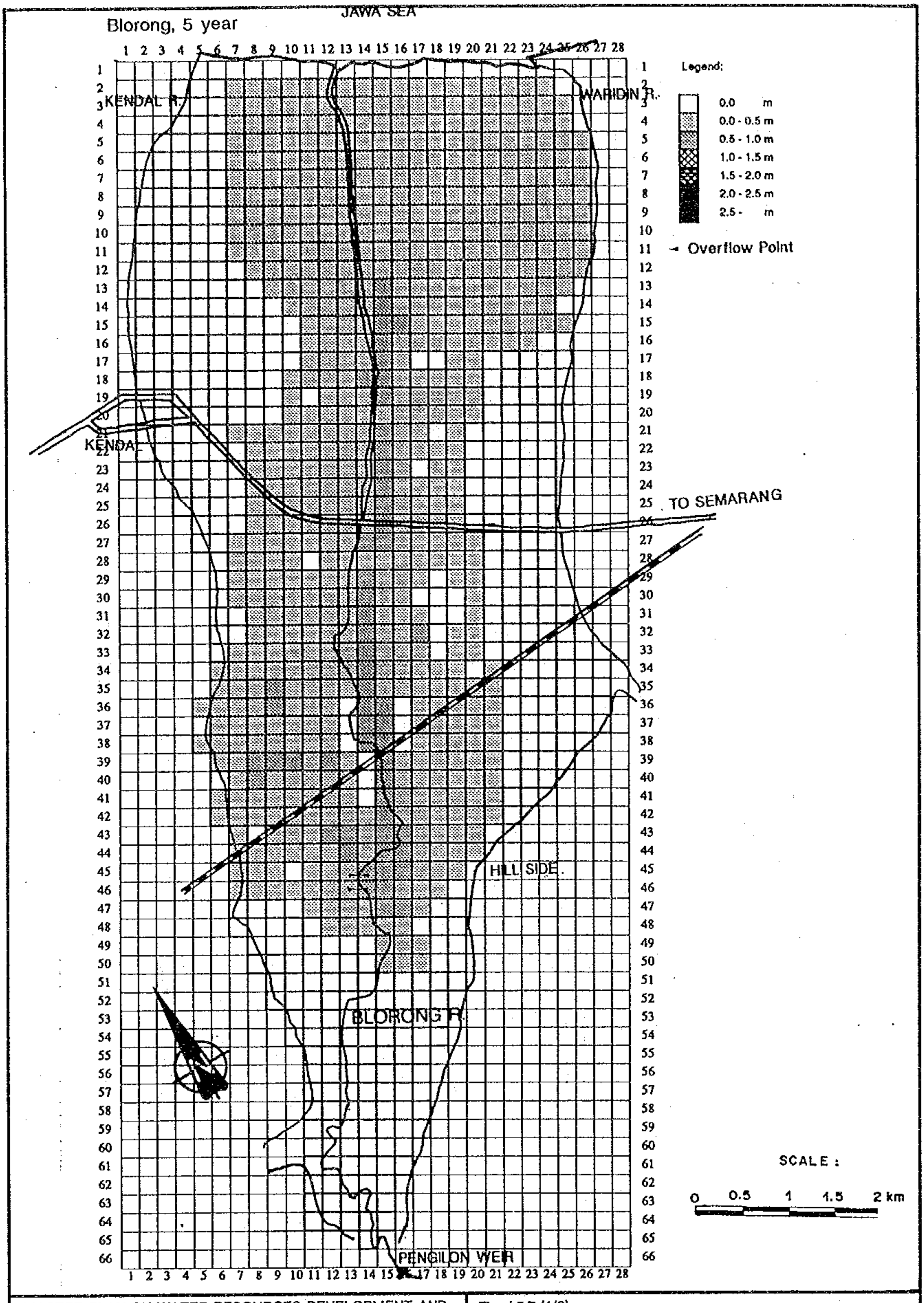


Bringin, 100 year

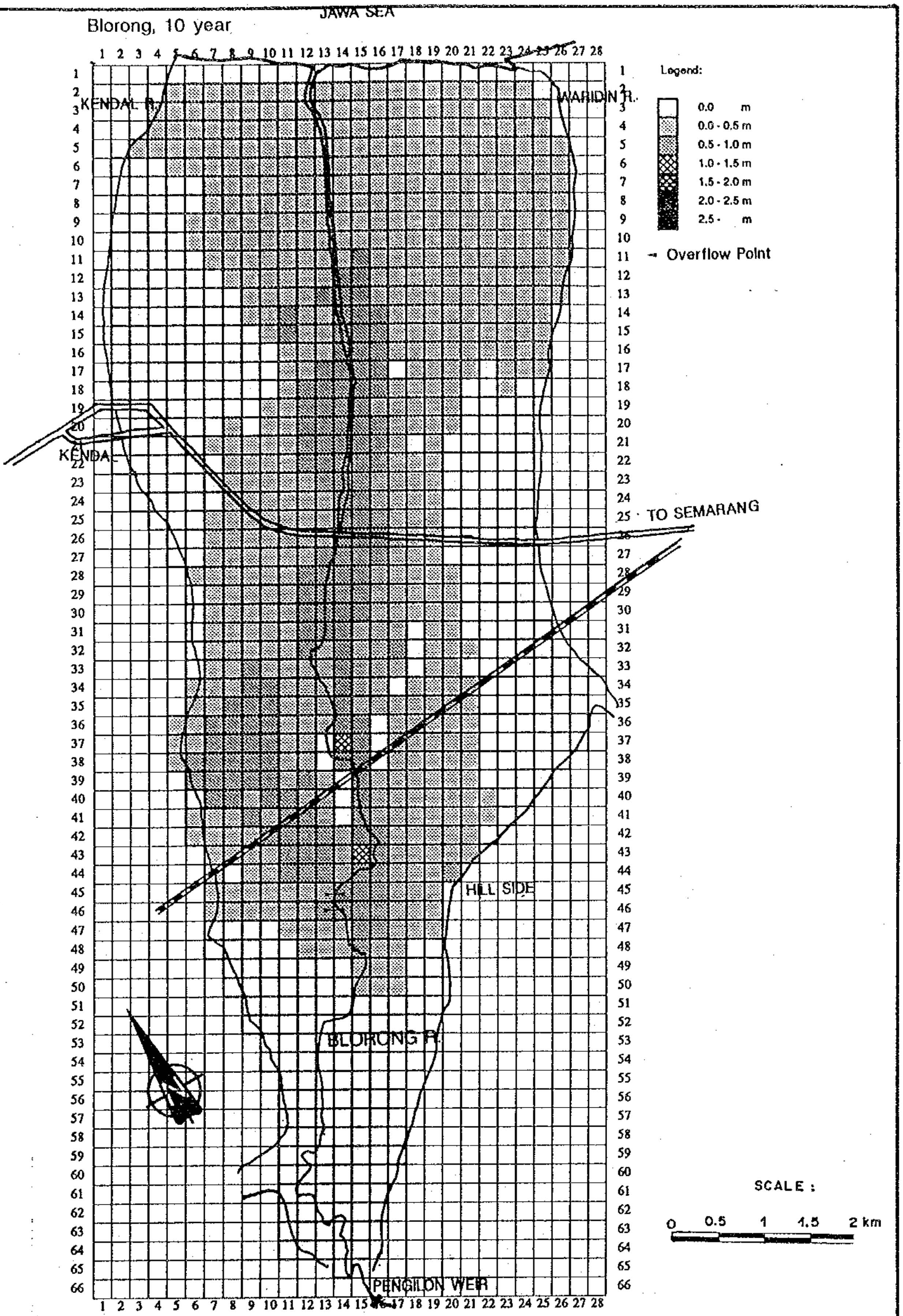




MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.5.6 (5/5) PROBABLE INUNDATION AREA OF SILANDAK AND BRINGIN RIVERS (100-YEAR RETURN PERIOD)
JAPAN INTERNATIONAL COOPERATION AGENCY	



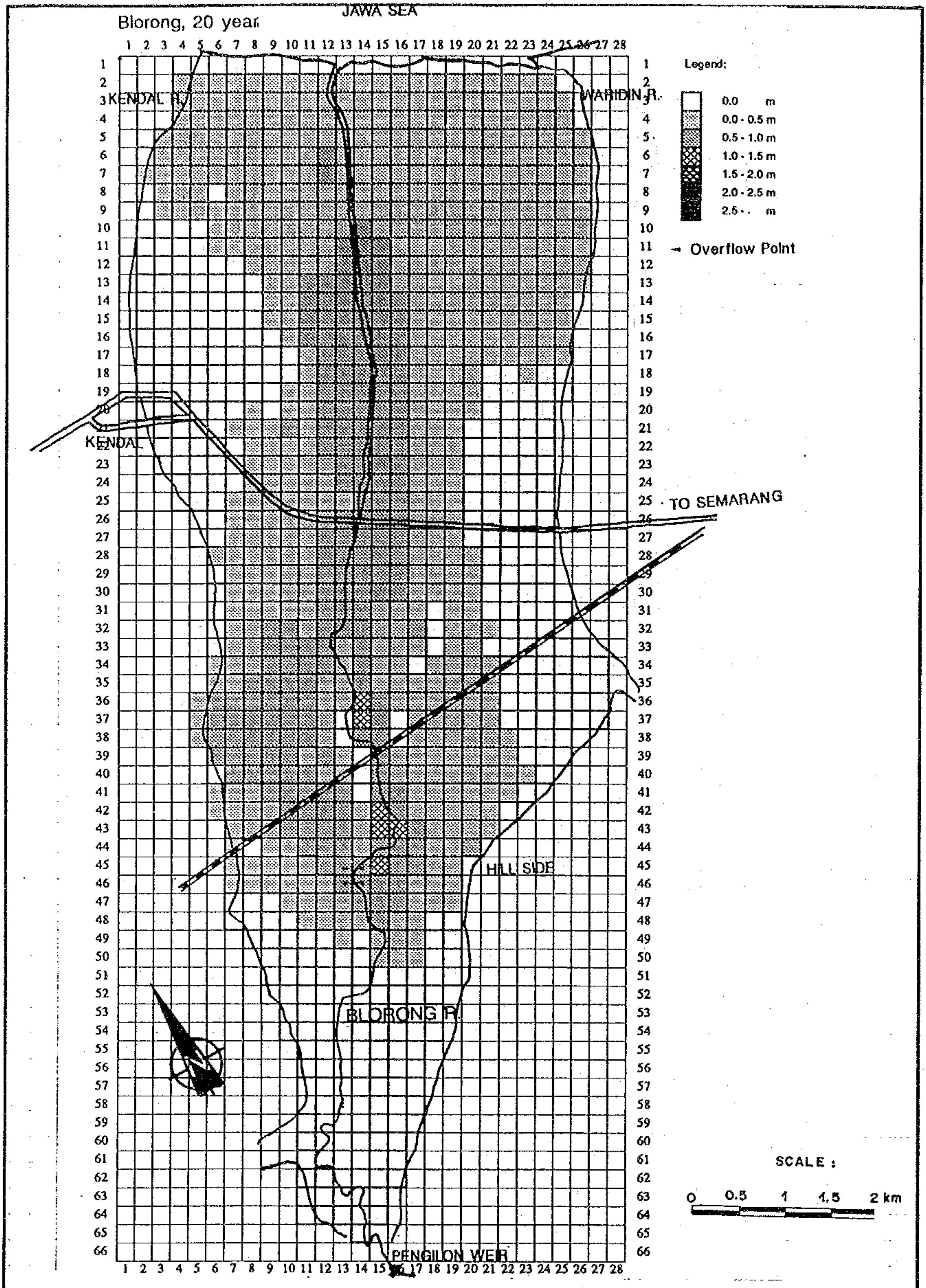
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. I.5.7 (1/6) PROBABLE INUNDATION AREA OF BLORONG RIVER (5-YEAR RETURN PERIOD)



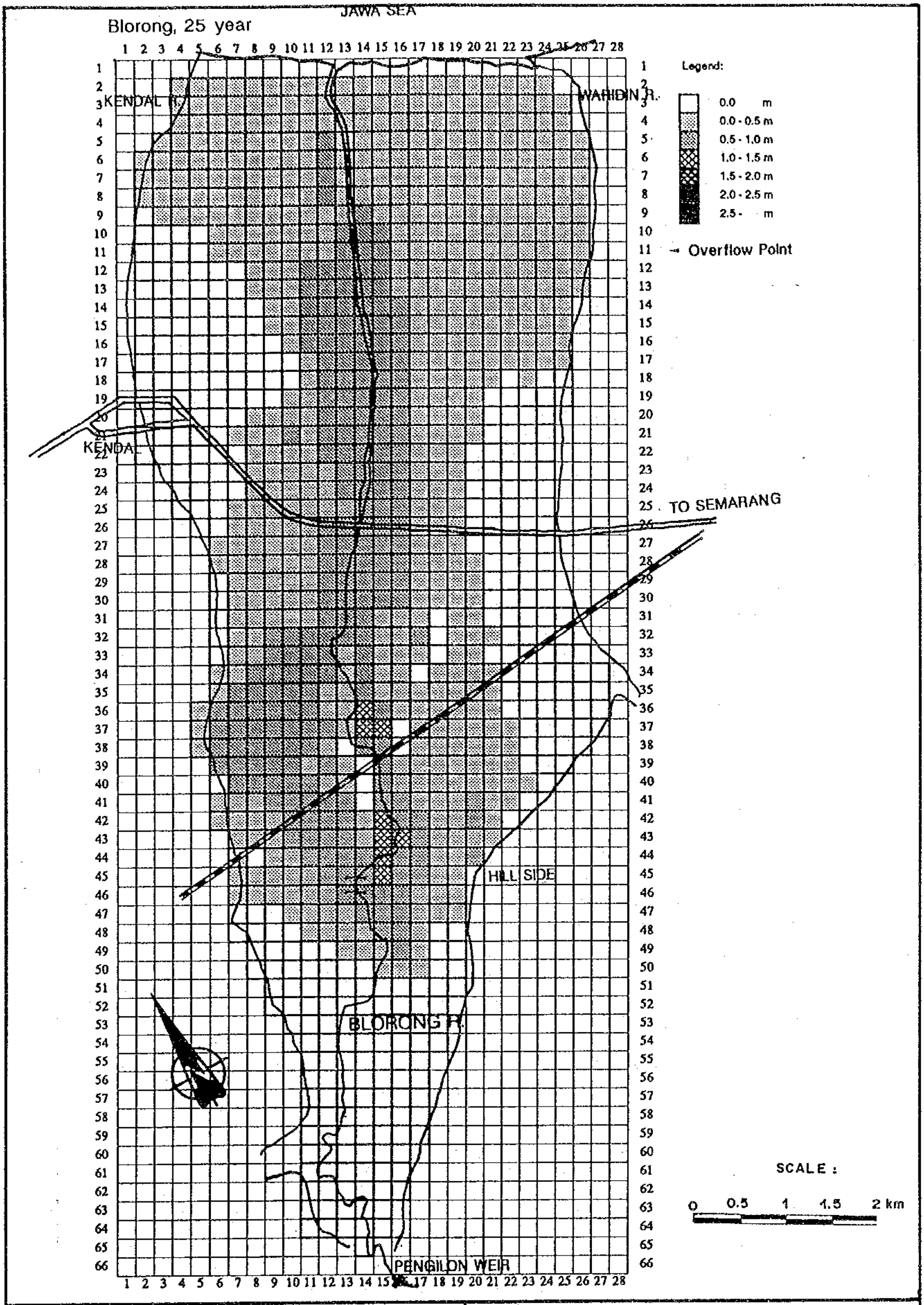
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS

JAPAN INTERNATIONAL COOPERATION AGENCY

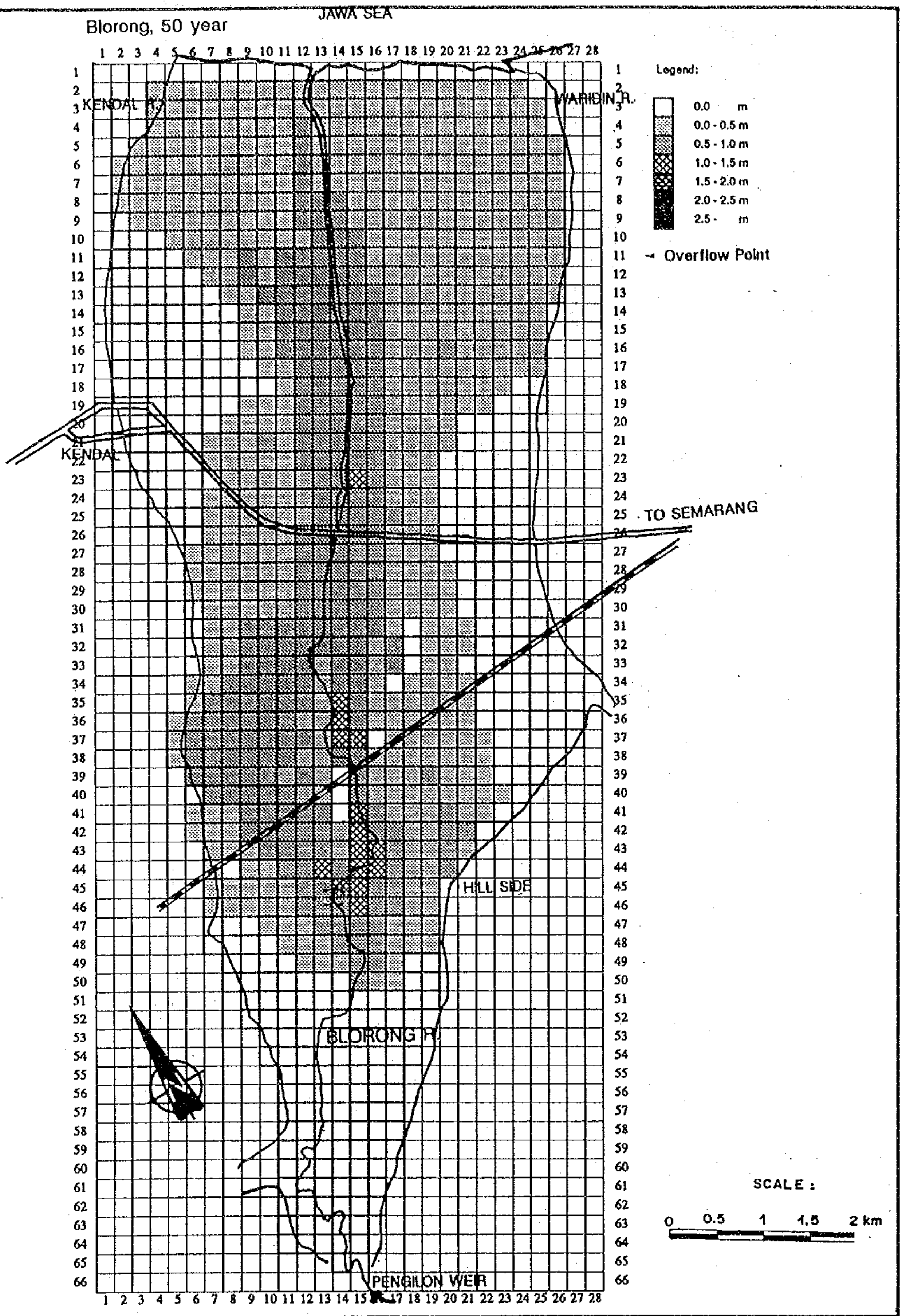
Fig. I.5.7 (2/6)
PROBABLE INUNDATION AREA OF BLORONG RIVER
(10-YEAR RETURN PERIOD)



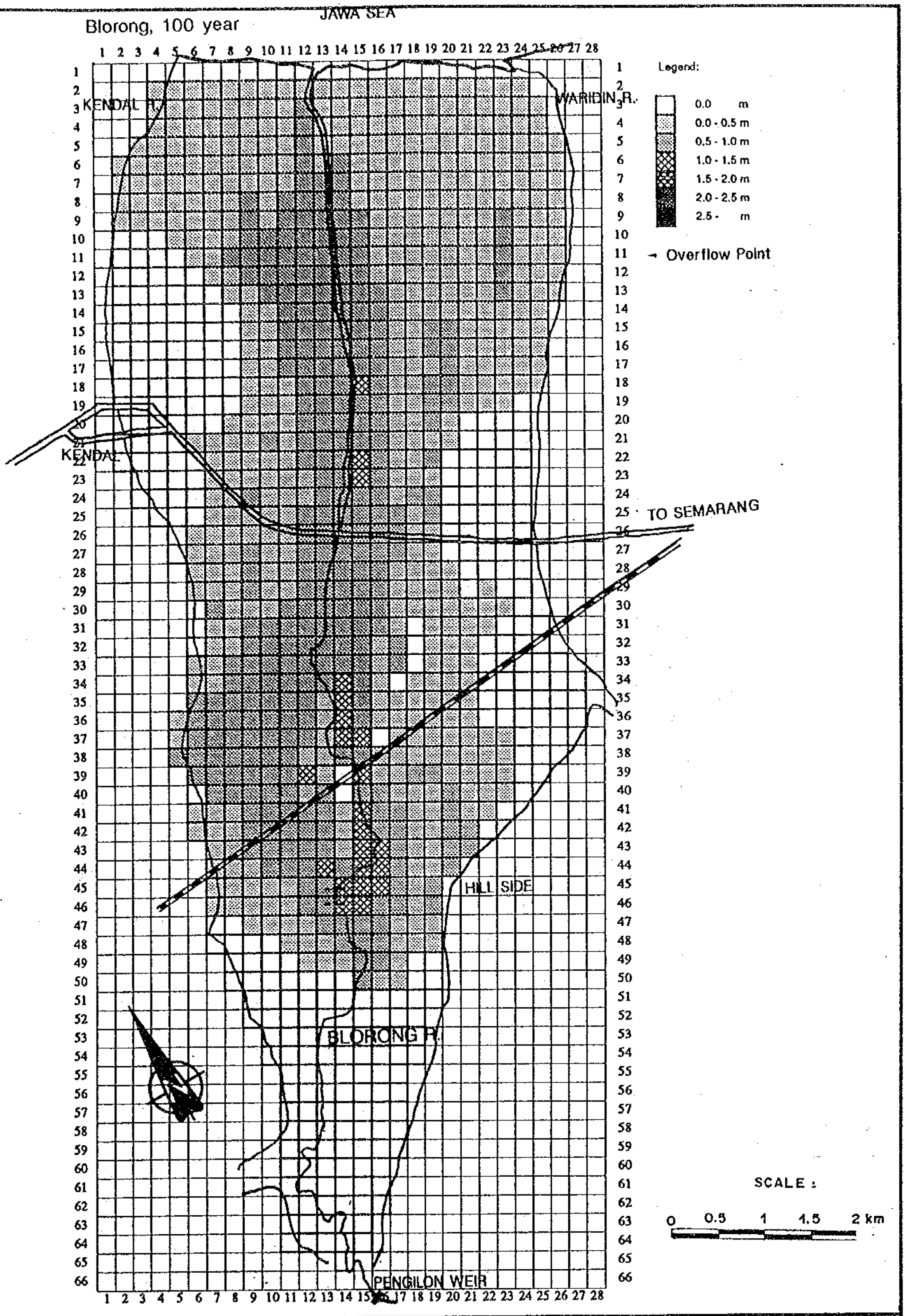
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.5.7 (3/6) PROBABLE INUNDATION AREA OF BLORONG RIVER (20-YEAR RETURN PERIOD)
JAPAN INTERNATIONAL COOPERATION AGENCY	



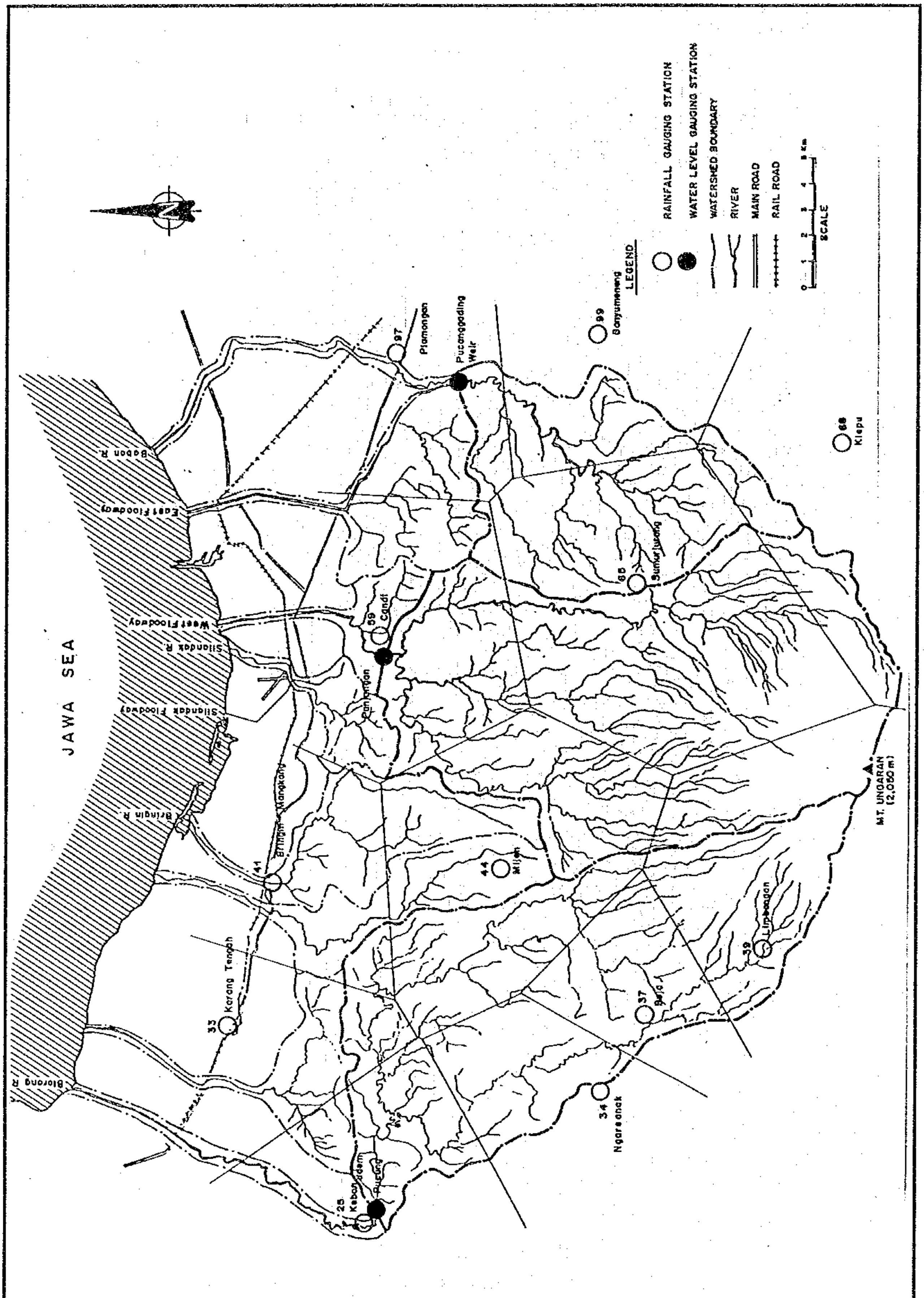
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.5.7 (4/6)
JAPAN INTERNATIONAL COOPERATION AGENCY	PROBABLE INUNDATION AREA OF BLORONG RIVER (25-YEAR RETURN PERIOD)



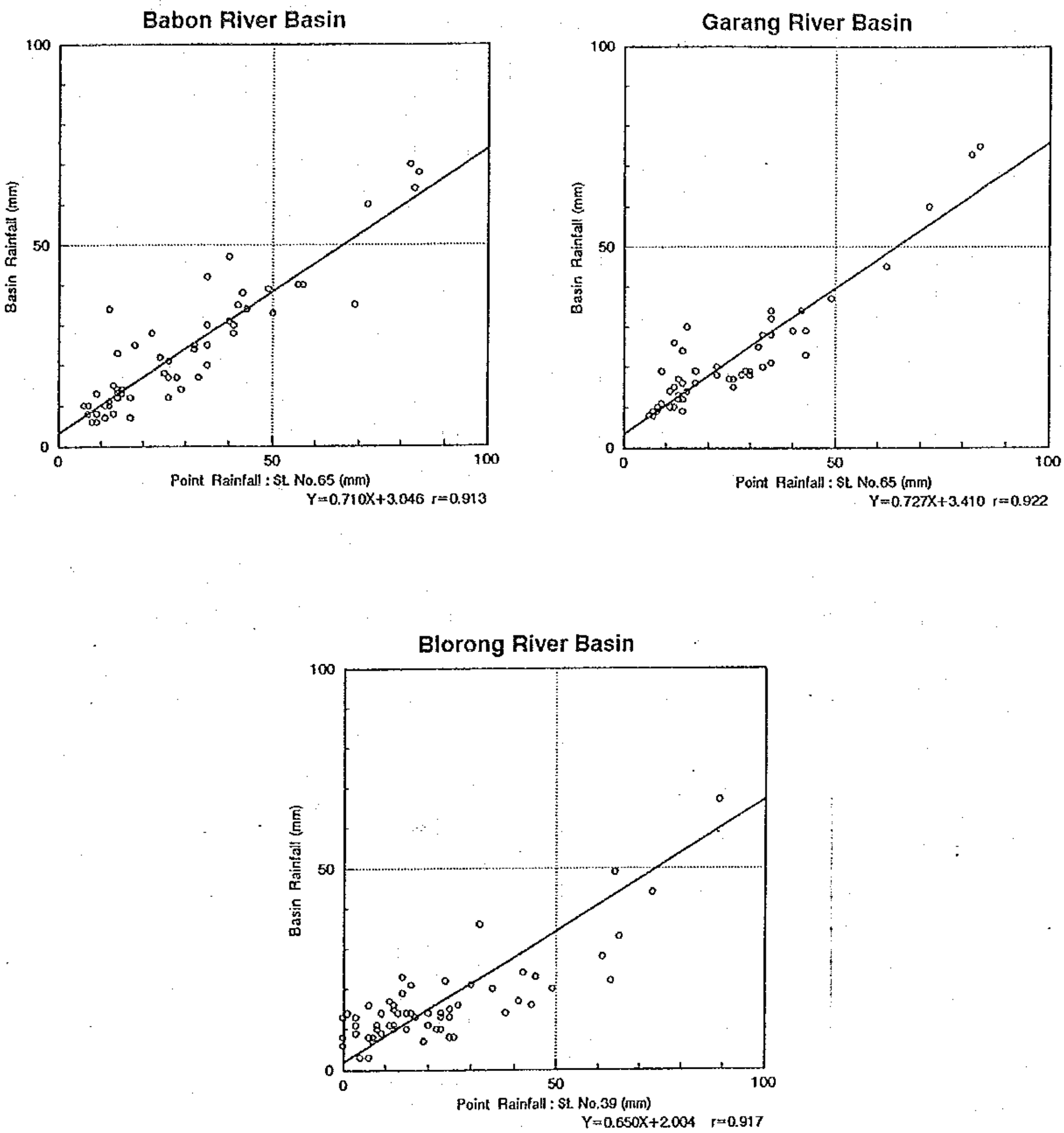
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.5.7 (5/6) PROBABLE INUNDATION AREA OF BLORONG RIVER (50-YEAR RETURN PERIOD)
JAPAN INTERNATIONAL COOPERATION AGENCY	



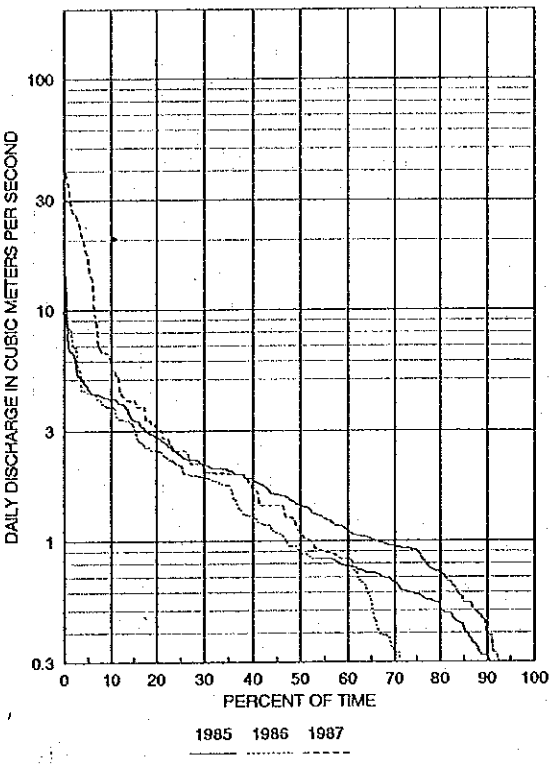
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.5.7 (6/6) PROBABLE INUNDATION AREA OF BLORONG RIVER (100-YEAR RETURN PERIOD)
JAPAN INTERNATIONAL COOPERATION AGENCY	



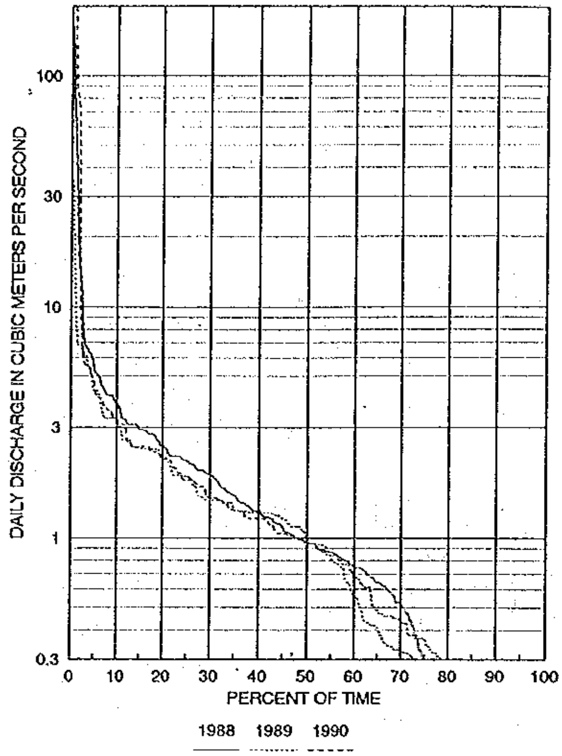
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. I.6.1 LOCATION OF HYDROLOGICAL STATIONS AND THIESSEN POLYGON



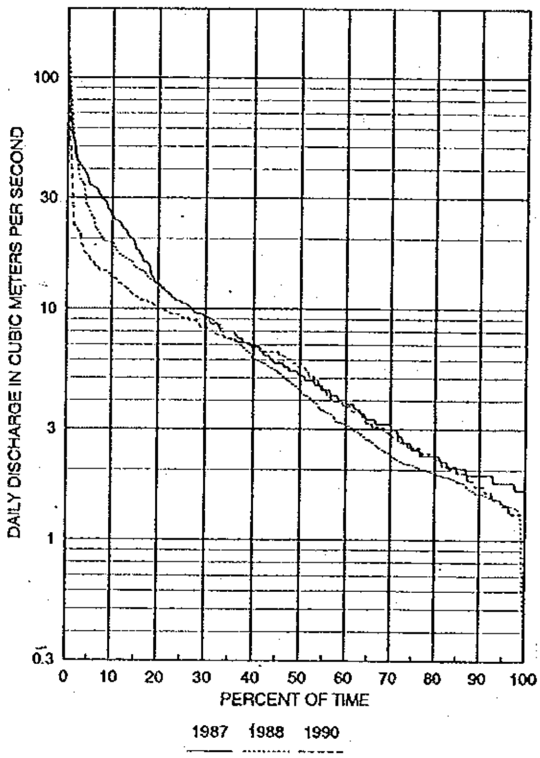
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.6.2
JAPAN INTERNATIONAL COOPERATION AGENCY	RELATION BETWEEN POINT AND BASIN RAINFALL



BABON R. (PUCANGGADING WEIR) -1

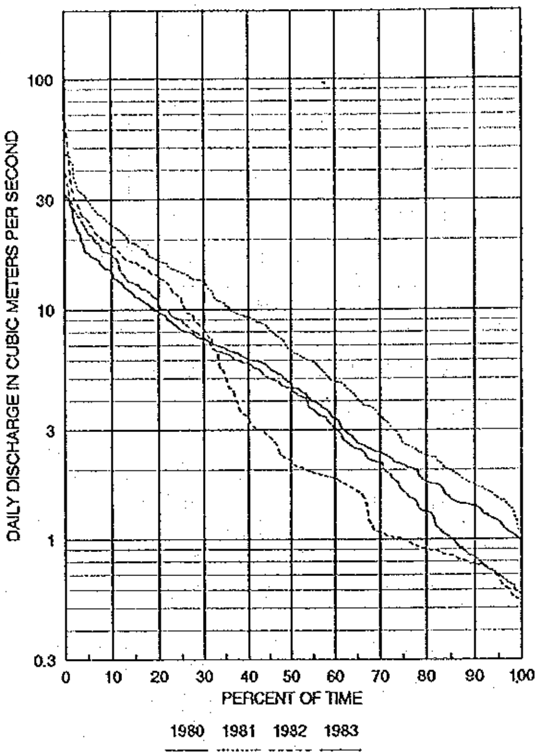


BABON R. (PUCANGGADING WEIR) -2

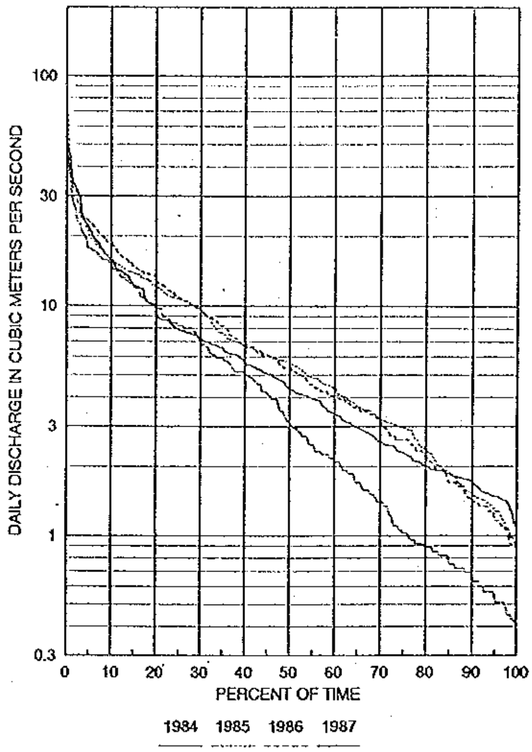


GARANG R. (PANJANGAN)

MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. I.6.3 (1/2) FLOW-DURATION CURVES OF OBSERVED DAILY DISCHARGE



BLORONG R.(PUCUNG)-1



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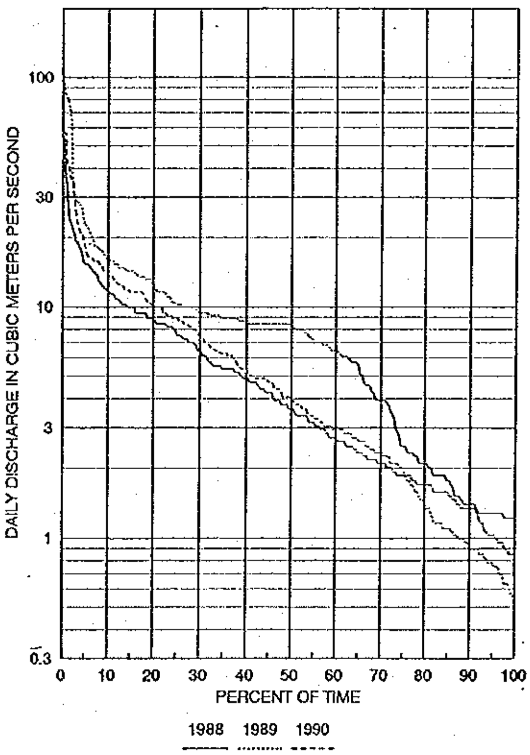
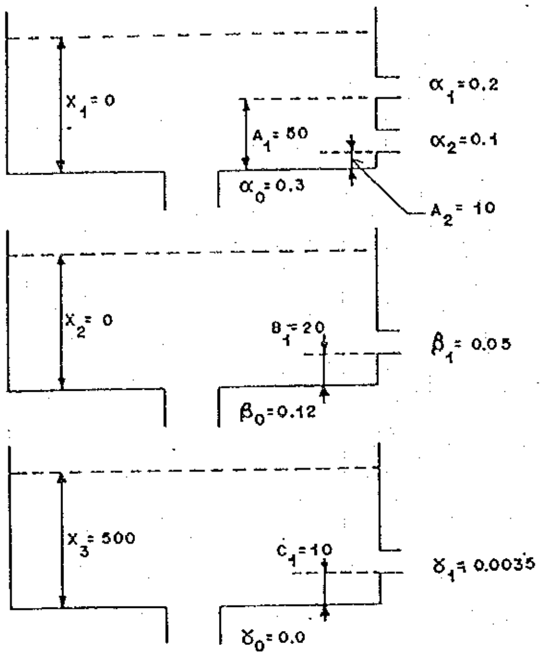
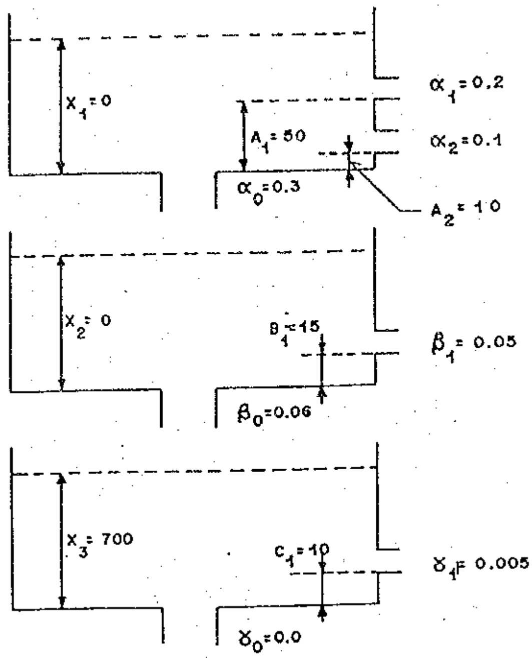


BLORONG R.(PUCUNG)-3

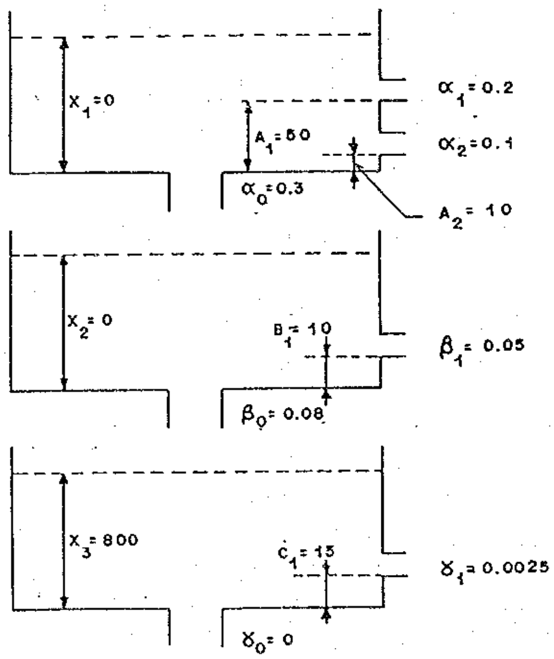
MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.6.3 (2/2) FLOW-DURATION CURVES OF OBSERVED DAILY DISCHARGE
JAPAN INTERNATIONAL COOPERATION AGENCY	



BABON R. (C. A = 77.0 Km^2)



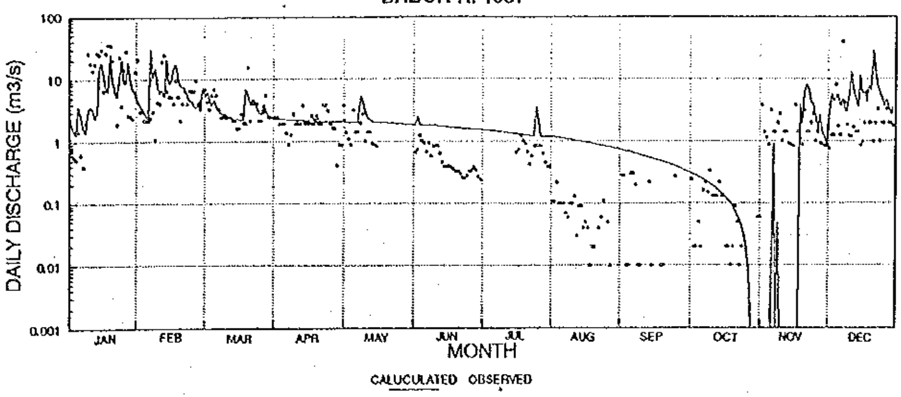
GARANG R. (C. A = 185.2 Km^2)



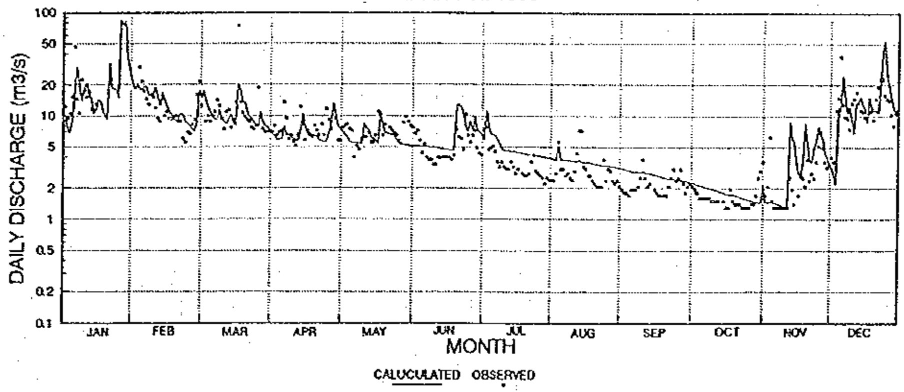
BLORONG R. (C.A = 157.0 Km^2)

MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.6.4 TANK MODEL PARAMETERS
JAPAN INTERNATIONAL COOPERATION AGENCY	

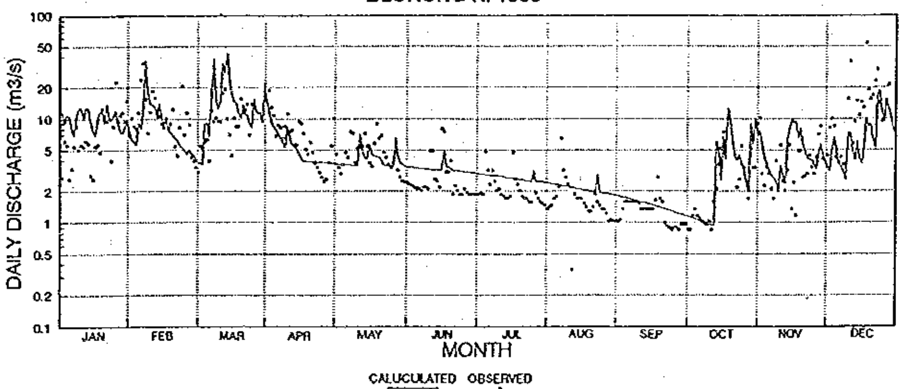
BABON R. 1987



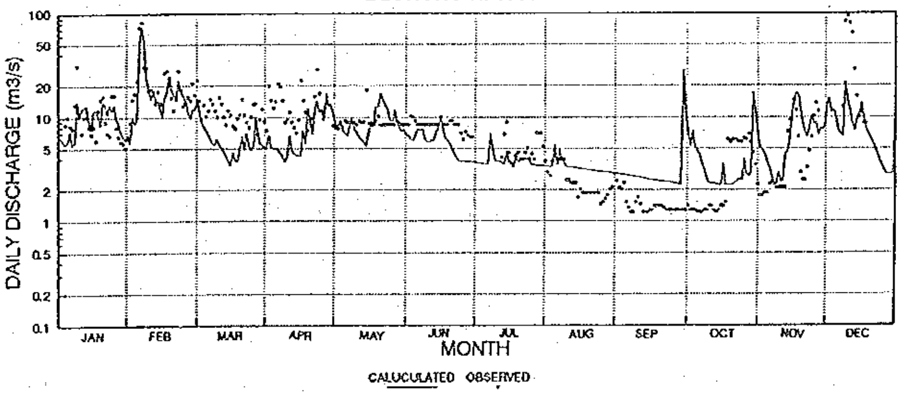
GARANG R. 1990



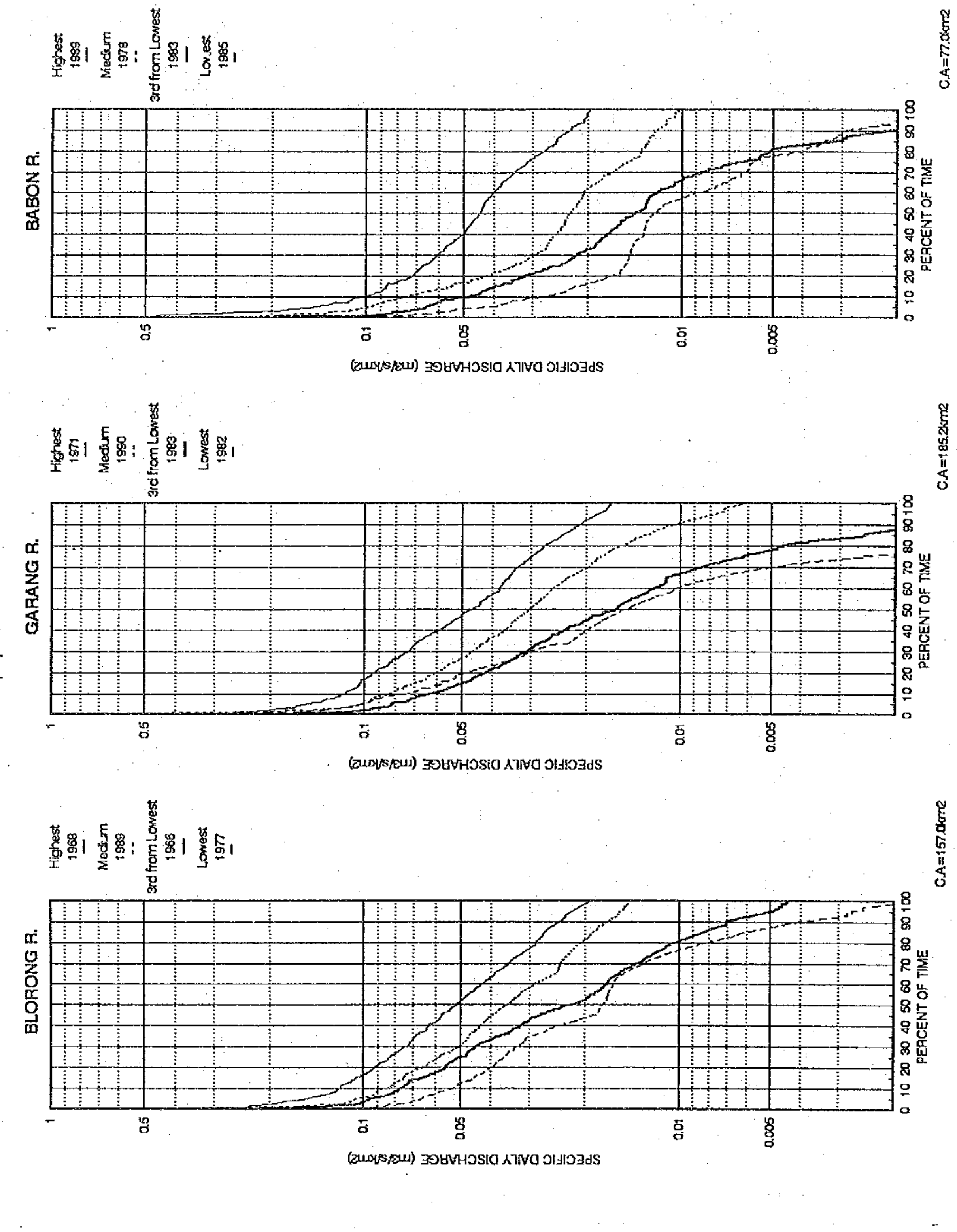
BLORONG R. 1988



BLORONG R. 1989



MASTER-PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. I.6.5 COMPARISON BETWEEN CALCULATED AND OBSERVED HYDROGRAPH



MASTER PLAN ON WATER RESOURCES DEVELOPMENT AND FEASIBILITY STUDY FOR URGENT FLOOD CONTROL AND URBAN DRAINAGE IN SEMARANG CITY AND SUBURBS	Fig. I.6.6 CALCULATED FLOW-DURATION CURVES
JAPAN INTERNATIONAL COOPERATION AGENCY	

II GEOLOGY AND SOIL MECHANICS

II GEOLOGY AND SOIL MECHANICS

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CHAPTER 1 GENERAL

Geological and soil investigations have been carried out in three stages; namely, the master plan, the feasibility study and the soil investigation for the West Floodway/Garang River.

CHAPTER 3 deals with the master plan study and describes the outlines of all possible dam sites and their geological conditions. CHAPTER 4 deals with the feasibility study and described the priority dam site selected in the master plan stage, Jatibarang Dam, and its geological condition. CHAPTER 5 describes the soil investigation for the West Floodway/Garang River with a feasibility study on the urgent river improvement works.

1.1 Outline of the Investigation

Geological investigation in the master plan study has been carried out for five major rivers, namely, Blorong River, Kreo River, Kripik River, Garang River and Babon River (named Penggarong River upstream). Kreo River and Kripik River are tributaries of West Floodway/Garang River. The study area and possible dam sites are shown in Fig. II.1.1

Field reconnaissance and drilling have been carried out at the Jatibarang dam site in the feasibility study. The soil investigation described in CHAPTER 5 consists of drilling works and laboratory tests.

1.2 Study Area

The study area is within the watershed boundaries of Blorong River, West Floodway/Garang River, East

Floodway and Babon River, covering approximately 1,000 km^2, located in Semarang City and part of two regencies, Kabupaten Kendul and Kabupaten Semarang of Central Jawa Province (refer to Fig. II.1.1).

CHAPTER 2 GENERAL DESCRIPTION OF STUDY AREA

2.1 Geomorphology

The study area is located in the northern slope of Mt. Ungaran which has an altitude of 2,050 m. The area can be divided into three topographical types: mountainous region, hilly region and alluvial plain.

(1) Mountainous Region

Mountainous regions ranging widely in elevation from about 300 to 2,050 m bound the catchment area of the study area of the southern, western and eastern parts. Small plateaus characterized by the volcanic region are distributed here and there. Rivers in this mountainous region are characterized with steep slope and long and slender catchment area. Volcanic rocks are commonly distributed in this region.

(2) Hilly Region

Hilly regions widely extend in the study area with elevations of about 50 to 300 m which have the distinctive feature of an undulated plateau and a steep-walled valley. This geographical feature is in the young stage of development. The catchment areas of rivers in this region are long and slender, same as in the mountainous regions. Volcanic rocks and sedimentary rocks of marine origin are distributed. All proposed dam sites are located in this hilly region.

(3) Alluvial Plain

Alluvial plains with elevation of about 0 to 50 m extend along shorelines and rivers in the study area. Rivers in this region are characterized with meandering and wide and gentle valley. Flood plain deposit, coastal plain deposit and shallow marine deposit are distributed in this region.

The five major rivers in the study area are Blorong River, Kreo River, Kripik River, Garang River and Babon River from the west. The rivers originate from Mt. Ungaran and flow approximately from south to north in the study area. In the mountainous and hilly regions these rivers are characterized with steep slope because of the short stream length and large difference in ground elevation. In addition, the catchment area is long and slender. The geographical feature of this area is still in the young stage of development, with the vertical erosion being stronger than horizontal erosion.

2.2 Geology

The regional geology and stratigraphy in and around the study area are shown in Fig. II.2.1 and Table II.2.1. Geology of this area is roughly divided into three categories; volcanic rock, sedimentary rock which is marine in origin, and alluvial deposits which cover these basement rocks. Volcanic rocks consist of lahar, lava flow of Mt. Ungaran, Notopuro Formation and intrusive rock. Sedimentary rocks consist of Damar Formation, Kalibiuk Formation, Banyak Member and Penyatan Formation.

2.2.1 Stratigraphy

(1) Volcanic Rocks

(a) Lahar

Lahar is distributed along the west and north slope of Mt. Ungaran and covers the old lava flow. Lahar is interlayered with andesitic lava flows which are abundant but with limited distribution near Mt. Ungaran. Lahar deposit (mudflow) is composed of poorly sorted volcanic rock debris with angular to poorly rounded boulders as much as 2.0 m in diameter.

(b) Lava Flow of Mt. Ungaran

This lava flow which is generally well jointed is augite-hornblende andesite, uncomformably overlying Notopuro Formation, and distributed around Mt. Ungaran.

(c) Notopuro Formation

Notopuro Formation consists of volcanic breccia, lava flow, tuff, tuffaceous sandstone and claystone. The distribution of Notopuro Formation is mostly flow breccia and lahar intercalated with small lava flow and fine to coarse-grained tuff. This unit locally include tuffaceous sandstone and claystone, sedimented horizontally and widely distributed in the foot of Mt. Ungaran and uncomformably covered with new lahars and new lava flows.

Volcanic Lahar in the study area, composed of augite-olivine andesite, was supplied from Mt. Ungaran. Fresh volcanic breccia is well consolidated with a few joints having sufficient soundness to support a dam of less than 70 m in height. The ground surface of volcanic rocks is deeply weathered to form reddish-brown soil. Larger boulders may be fresh and hard, or of a weathered rind. This unit is deposited generally 50 meters thick in the northeast to more than 200 m in the west, reflecting in part the irregular topography it was deposited on. New lahars, new lava flows and Notopuro Formation form the geographical feature of the mountainous region.

(d) Intrusive Rock

Intrusive rocks are distributed in the north and east area of Mt. Ungaran, intruded with Notopuro Formation, and form small hills which are very steep exemplified by the peaks of Mt. Mergi (the highest), Mt. Kalong, Mt. Siwakul and Mt. Turun. Augite-hornblende andesite is found at Mt. Turun and augite-olivine andesitic basalt, at Mt. Mergi (Van Bemmelen, 1941). However, rocks at Mt. Mergi turned out to be andesite according to a recent investigation (Ir. Kardiyono, 1991).

The youngest strata intruded are marine beds of Middle Miocene to Pliocene age, but intrusive rocks may be considerably younger (Robert E. Thaden and others, 1975). These intrusive rocks may be utilized as construction materials like aggregate and rock/riprap material.

(2) Sedimentary Rocks

(a) Damar Formation

Damar Formation can be divided into four zones, the transition zone, the lower zone, the middle zone and the upper zone. The transition zone was deposited in the Upper Pliocene and consists of black clay with calcareous concretion and tuffaceous sandstone with marine mollasse. The lower zone was deposited in the Lower Pliocene and consists of conglomerate with calcareous concretion and tuffaceous sandstone. The middle zone is composed of laharic deposits characterized with gravels of lahar augite-olivine andesite, cross-bedded tuffaceous sandstone, conglomerate and lapilli tuff. The upper zone is composed of tuffaceous claystone, sandstone and andesitic conglomerate characterized with laharic deposits.

Damar Formation forms a hilly geographical feature and is distributed along the coastal plain and near the flood plain. This formation mainly consists of tuffaceous sandstone with conglomerate, volcanic breccia and tuff that is weakly consolidated and not suited for the basement rock of a dam. Rockfalls and small landslides are observed here and there.

(b) Kalibiuk Formation and Banyak Member

These two formations are marine in origin and related contemporaneous heterotopic facies. Kalibiuk Formation is mainly composed of bluish to greenish grey claystone with marl, sandstone including mollasse, conglomerate and limestone. On the other hand, Banyak Member consists of alternation of various sandstones. Kalibiuk Formation is distributed in the downstream of Kreo River, Kripik River and Garang River and in the eastern and western parts of the study area. Banyak Member is merely distributed in the eastern part of the study area.

These formations are uncomformably overlain by Notopuro Formation and Damar Formation and locally interfingered with Damar Formation. These formations are weakly consolidated and are not suitable for the basement rock of a dam. Claystone of this marine bed is most troublesome, because it has little strength and tends to slide or creep when wet.

(c) Penyatan Formation

This formation is distributed west of the study area and consists of sandstone, breccia, tuff and claystone.

(3) Alluvial Deposits

Alluvial deposits consist of recent river deposits, flood plain deposits and shallow marine deposits. River deposits mainly consist of unconsolidated sand and gravel intercalated with silt and clay and are generally 1 to 3 m thick. On the other hand, flood plain deposits, generally 2 to 10 m thick, are mainly composed of unconsolidated clay, sand and gravel, but contain a greater amount of silt and clay than river deposits. The shallow marine deposit is explained in 5.2. Attention should be paid on the gravel content of each deposit in the selection of construction materials.

2.2.2 Geological History of Study Area

The geological history of the study area has started from the Tertiary Period. The study area is in the shallow marine from the Miocene Epoch of the Tertiary Period to the Pleistocene Epoch of the Quaternary Period. Penyatan Formation, Banyak Member, Kalibiuk Formation, Lower Damar Formation and Lower Notopuro Formation have sedimented in this sedimentary environment. At the same time, volcanic activity had occurred in and around the study area and supplied the Upper Damar and Upper Notopuro Formation with volcanic products. In addition, folding and faulting activity was caused by this volcanic activity.

In the Pliocene Epoch of the Quaternary Period, volcanic activity of Mt. Ungaran occurred along the North Serayn Mountains south of the study area.

2.3 Geological Structure

Folds and faults caused by volcanic activity are distributed in the study area. A comparatively large fault is found in the Mundingan Reservoir and many minor faults are formed in the basement rock (Damar Formation) of the Kripik dam site. Small-scale folds are developed in the proposed dam sites and reservoir area.

CHAPTER 3 SELECTION OF POSSIBLE DAM SITE

3.1 Selection of Possible Dam Site

Sites proposed for dam were firstly examined at a few sites in each river based on the topographical map of scale 1:50,000. Also field reconnaissance was conducted at each site from the topographical and geological point of view. Site selection was conducted in consideration of various factors, as follows:

(1) Narrower valley should be better.

(2) Basement rock should have the necessary soundness in proportion to the dam scale.

(3) Large-scale faults should not exist.

(4) Weathering of basement rock should be weak.

(5) Abutment should have a sufficient width of more than 100 m to prevent water leakage.

(6) Leakage should not be permitted.

(7) A larger reservoir area and catchment area is preferable.

(8) Landslide should not develop in the reservoir area.

(9) Compensation cost for realty and natural assets should be at minimum and/or none.

(10) Quarry site should be located near the dam site.

Possible dam sites which were preliminarily selected from the topographical point of view and the outline of each dam site are described below (refer to Table II.3.1).

3.1.1 Blorong River

B-1 site has a large catchment area and reservoir capacity, but it is not possible to plan a large-scale dam because of heavy weathering. Moreover, a weir for irrigation exists in the site.

B-2 site, located near Kudung Suren Village, has a large catchment area and reservoir capacity where Damar Formation composed of tuffaceous sandstone and conglomerate is exposed. These rocks are heavily weathered, and attention should be paid to the existence of many residences, paddy fields and electric transmission lines.

B-3 site has good topographical and geological conditions. Basement rock composed of volcanic breccia is sufficient to support a dam of over 50 m in height.

B-4 site has a large reservoir capacity and the topographic feature (narrow valley) is good. However, the basement rock mainly consists of limestone characterized by potential leakage.

Based on the above circumstances, B-2 and B-3 are selected as possible dam sites from the topographical and geological points of view.

3.1.2 Kreo River

K-1 and K-2 sites have good topographical and geological conditions, but the reservoir areas are very small compared to those of K-3 and K-4 sites.

K-3 site has the same topographical and geological conditions as the K-1 and K-2 sites, except the reservoir area which is large. It is necessary to pay attention to the existence of electric transmission lines, the national park "Goa Kreo" and paddy fields in the proposed reservoir area.

K-4 site has a widely shaped valley, and geologically good with large reservoir area. Attention should be paid to the existence of electric transmission line and paddy fields in the reservoir area.

Based on the above circumstances, K-3 and K-4 are selected as possible dam sites from the topographical and geological points of view.

3.1.3 Kripik River

KR-1 site has a wide valley and a large reservoir area, but the geological condition is not good because of the development of faults and rockfalls. In addition, the catchment area is small and there are paddy fields in the reservoir area.

KR-2 site has a narrow valley and good geological condition, but the catchment area and reservoir area are small.

Based on the above circumstances, KR-1 is selected as a possible dam site from the topographical and geological points of view.

3.1.4 Garang River

G-1, G-2 and G-3 sites have narrow valleys and good geological conditions and their catchment areas are not so different from each other. The reservoir capacity of G-3 site is larger than those of G-1 and G-2.

Based on the above circumstances, G-3 is selected as a possible dam site from the topographical and geological points of view.

3.1.5 Babon River (Penggarong River)

Ba-1 site is located on the alluvial plain and has a wide valley and large reservoir capacity. A high dam is not practicable because of topographical and geological limitations.

Ba-2 site is located 3 km upstream of Ba-1. The Ba-2 site is very wide and leakage is anticipated due to the existence of limestone. Both sites require attention to the existence of villages and paddy fields.

Based on the above circumstances, Ba-2 is selected as a possible dam site with protection works against possible leakage from the topographical and geological points of view.

3.2 Topography and Geology of Proposed Dam Site and Reservoir Area

This section describes the topography and geology of possible dam sites and reservoir areas. The outline of possible dam sites is given in Table II.3.2.

3.2.1 Blorong Dam (B-3) on Blorong River

(1) Topography and Geology of Dam Site

(a) Topography

Blorong Dam is located downstream on Blorong River, near the confluence with the tributary, Manggis River and near Sebubut Village. (Refer to Fig. II.1.1)

Blorong River in the vicinity of the proposed dam axis has a roughly straight channel in the SSE-NNW direction for approximately 500 m, while the upstream and downstream in the reservoir area are meandered. Around the dam axis, the river forms a gorge where volcanic breccia is distributed. The riverbed elevation at the proposed dam axis is EL. 140 m and the width is 15 to 20 m. The slope gradient is 55 degrees along the left bank and 35 degrees along the right bank. The gorge width is 118 m at the elevation of the proposed dam crest, EL. 190 m, and the ratio between height and valley width at EL. 190 m is approximately 1:2.4.

(b) Geology

Basement rocks in the vicinity of the proposed dam axis consist mostly of volcanic breccia (VB) and partly of tuffaceous sandstone (VBs) that belong to Notopuro Formation. Tuffaceous sandstone, conformably overlying volcanic breccia, is limited to above EL. 190 m. These basement rocks are covered with topsoil above EL. 200 m and slope wash along the river. Besides, claystone of