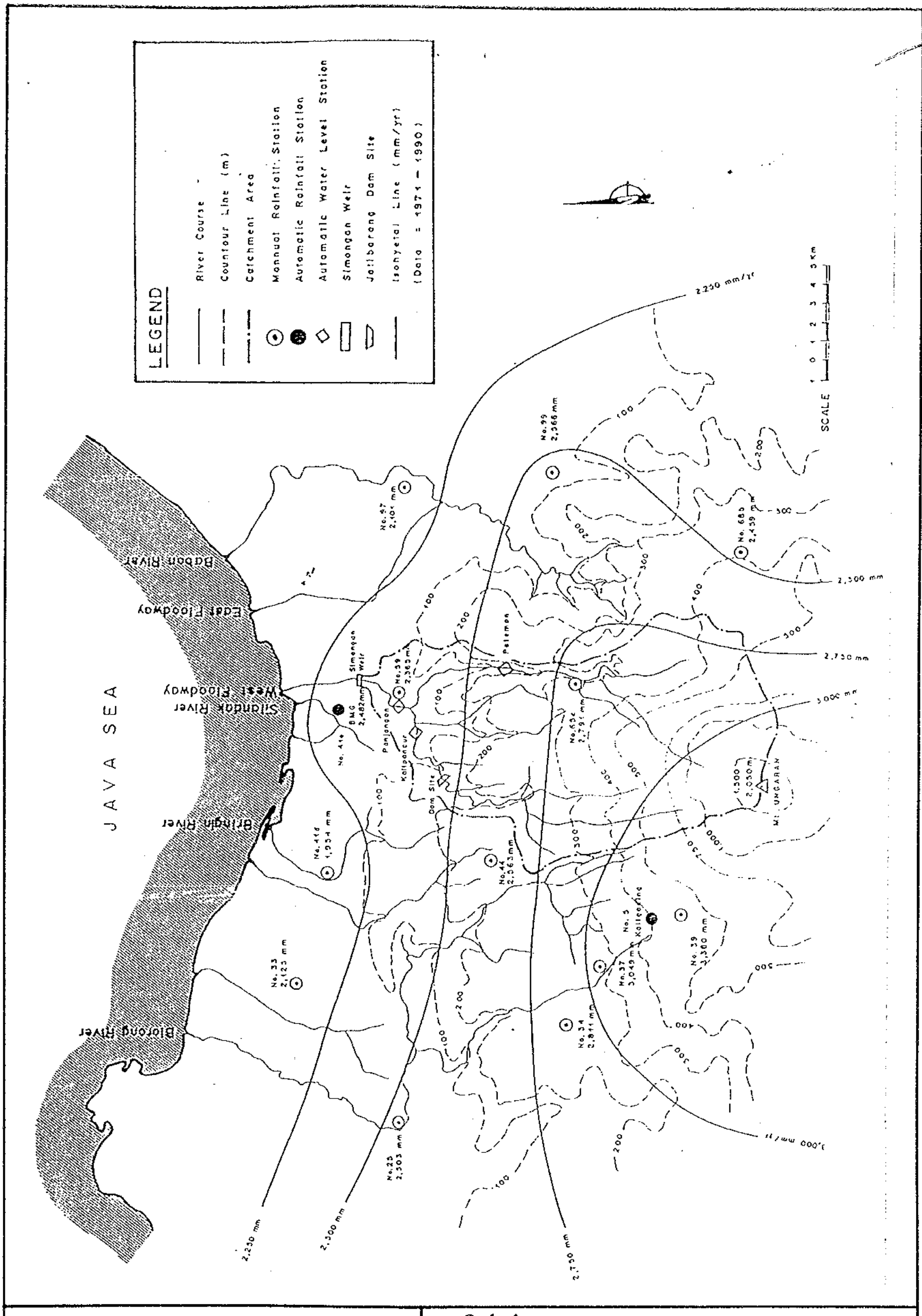
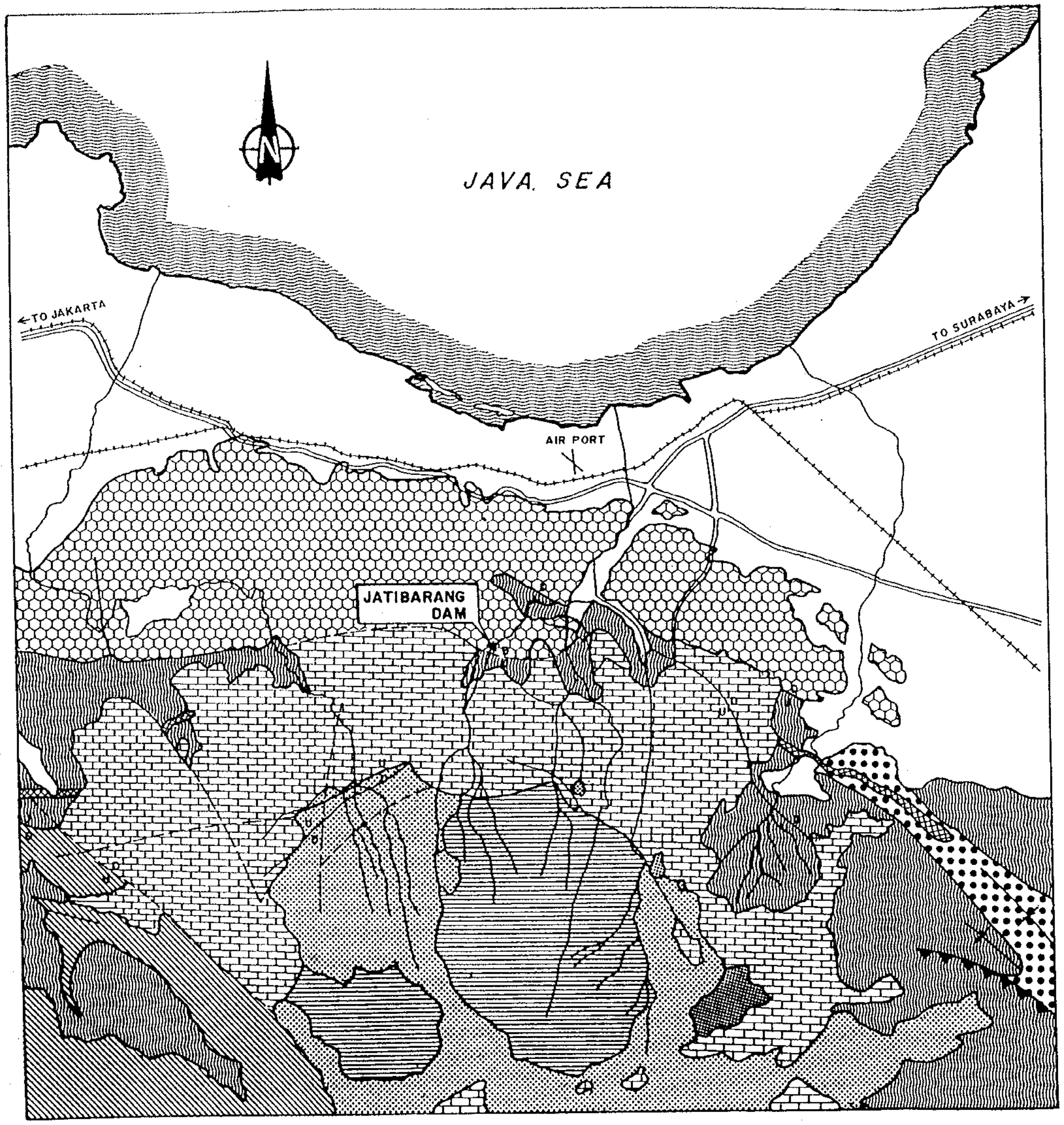
# FIGURES

## CHAPTER 2
## PRESENT CONDITION OF THE TARGET AREA




| THE DETAILED DESIGN OF FLOOD CONTROL, URBAN DRAINAGE AND WATER RESOURCES DEVELOPMENT IN SEMARANG IN THE REPUBLIC OF INDONESIA | Fig. 2.1.1 LOCATION OF OBSERVATORIES AND ISOHYETAL LINE |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | |




0 2 4 6 8 10 17.5 20 Km

SCALE 1: 200,000

## LEGEND :

- ALLUVIUM : COASTAL PLAIN; CLAY AND SAND, STREAM DEPOSITS; SAND, SILT, GRAVEL AND BOULDER
- MIDDLE G. UNGARAN LAHAR AND VOLCANIC ROCK : AUGITE - OLIVINE BASALT FLOWS
- LAVA FLOW OF G. UNGARAN : AUGITE - HORNBLENDE ANDESITE
- NOTOPURO FORMATION : VOLCANIC BRECCIA, LAVA FLOWS, TUFF, TUFFACEOUS SANDSTONE AND CLAYSTONE
- DAMAR FORMATION : TUFFACEOUS SANDSTONE, CONGLOMERATE, VOLCANIC BRECCIA AND TUFF
- KALIBIUK FORMATION : CLAYSTONE, MARL, SANDSTONE, CONGLOMERATE, VOLCANIC BRECCIA AND TUFF
- BANYAK MEMBER : ALTERNATION OF TUFFACEOUS, SANDSTONE, CALCAREOUS SILTSTONE, SANDSTONE AND PEBBLY SANDSTONE
- PENYATAN FORMATION : SANDSTONE, BRECCIA, TUFF, CLAYSTONE AND LAVA FLOW
- LIMESTONE
- INTRUSIVE ROCKS : AUGITE - HORNBLENDE ANDESITE AND AUGITE - OLIVINE ANDESITE
- NORMAL FAULT : U = UP, D = DOWN
- REVERSE FAULT
- FOLD AXIS
- INFERRED FAULT

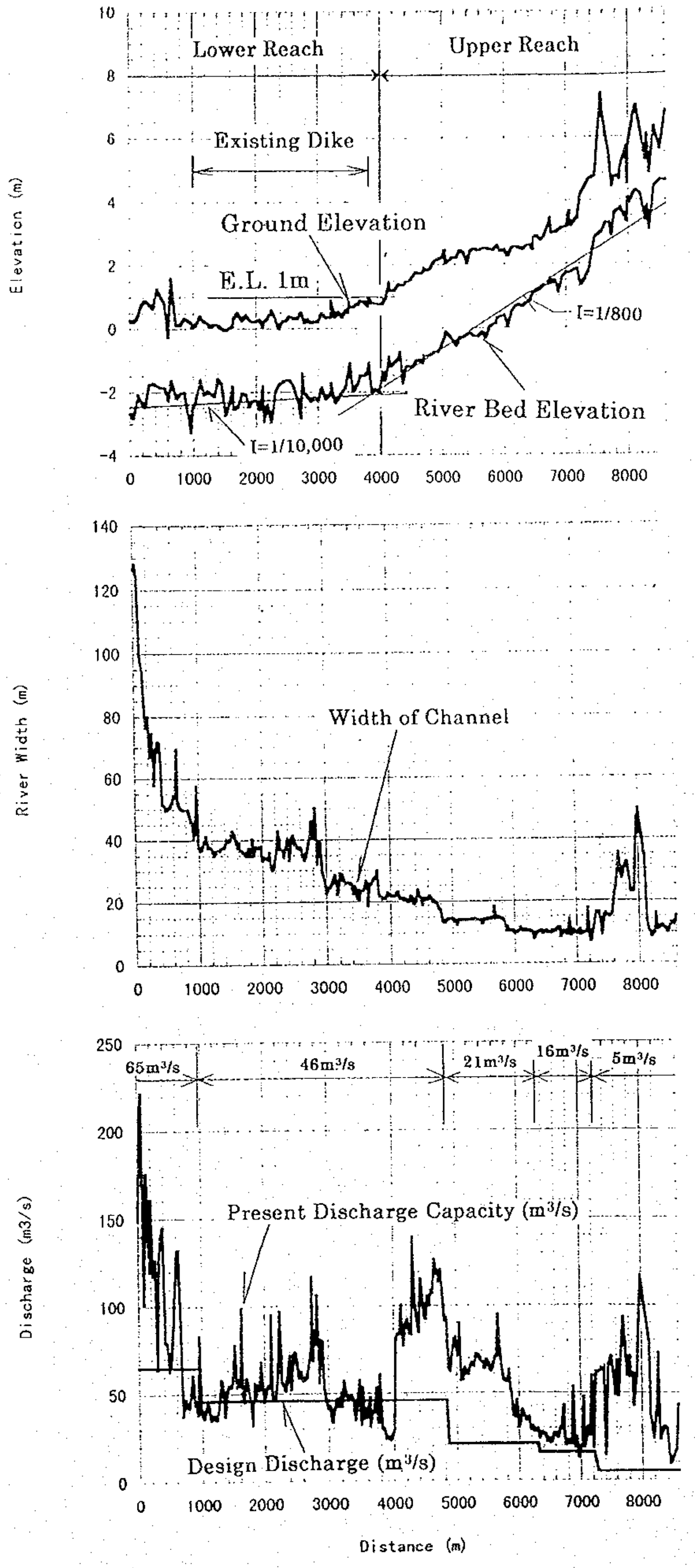
| SURFICIAL DEPOSITS | VOLCANIC ROCKS | SEDIMENTARY ROCKS | GEOLOGICAL AGE | |
|---|---|---|---|---|
| | | | HOLOCENE | QUATERNARY |
| | | | PLEISTOCENE | |
| | | | PLIOCENE | TERTIARY |
| | | | MIOCENE | |

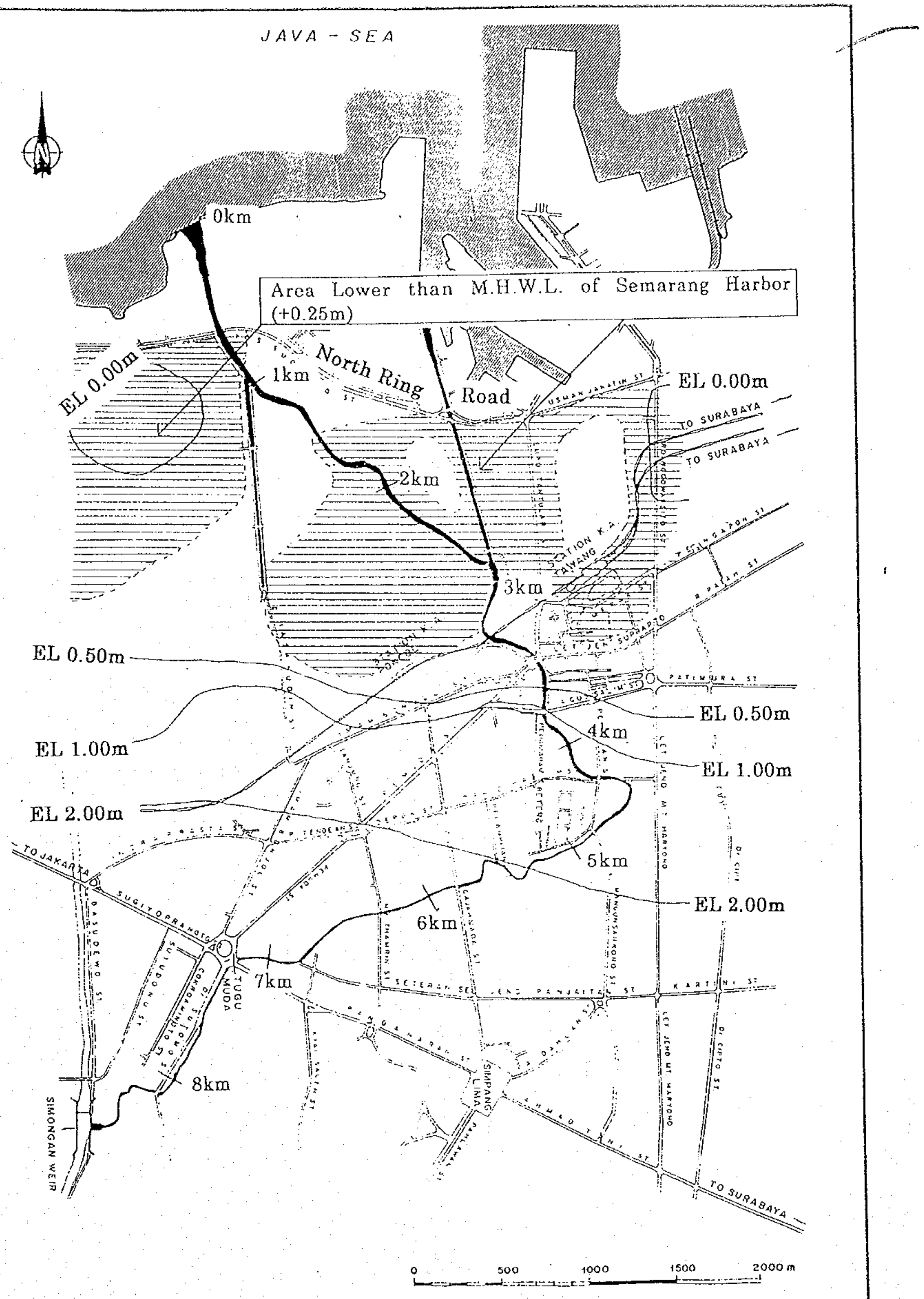
| THE DETAILED DESIGN OF FLOOD CONTROL, URBAN DRAINAGE AND WATER RESOURCES DEVELOPMENT IN SEMARANG IN THE REPUBLIC OF INDONESIA | Fig. 2.1.2 |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | REGIONAL GEOLOGICAL MAP ARROUND THE STUDY AREA |

Ground Elevation and River Bed Elevation

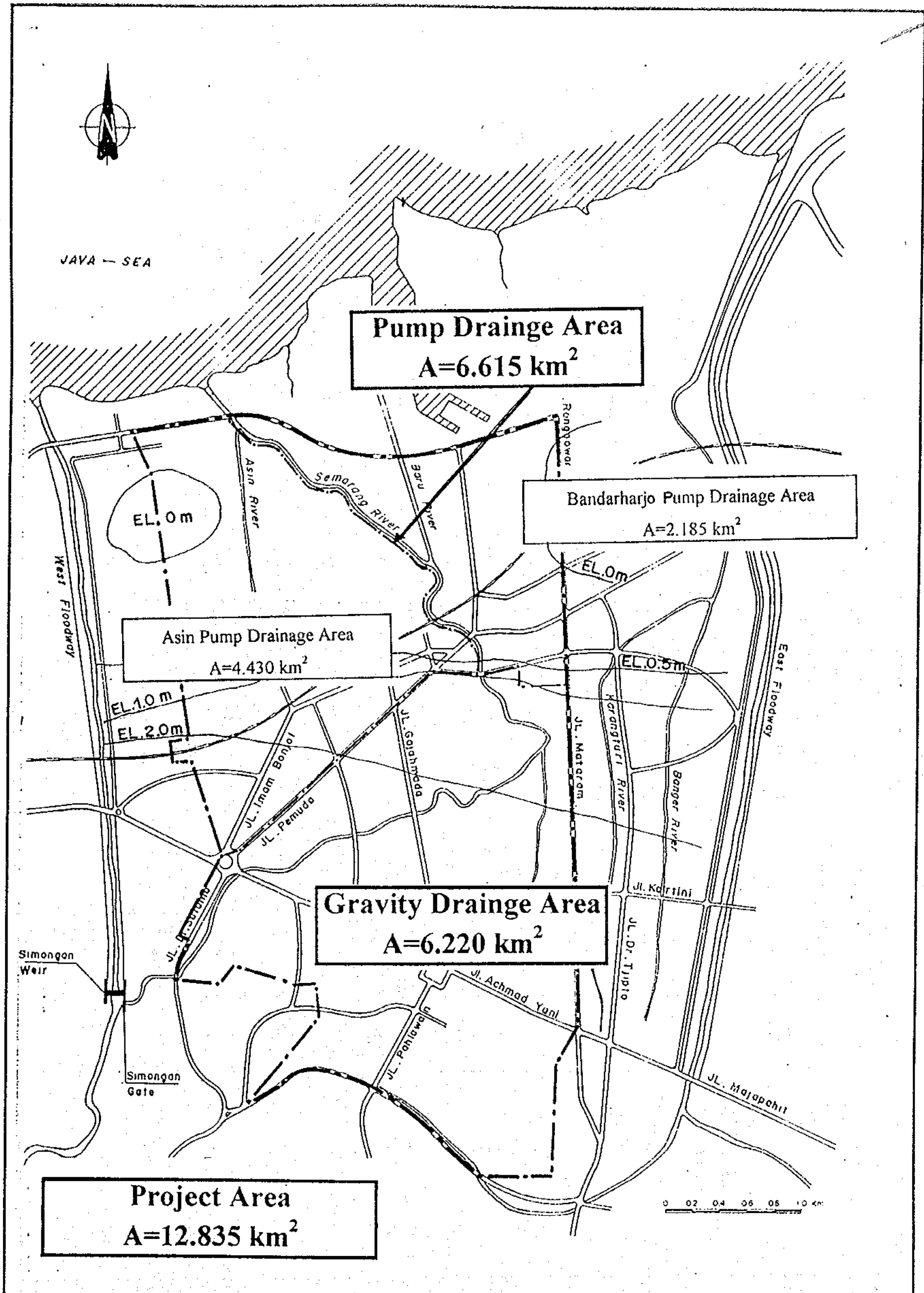
Width

Discharge Capacity




| THE DETAILED DESIGN OF FLOOD CONTROL, URBAN DRAINAGE AND WATER RESOURCES DEVELOPMENT IN SEMARANG IN THE REPUBLIC OF INDONESIA | Fig. 2.1.3 |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | FEATURES OF SEMARANG RIVER AND TOPOGRAPHY OF THE AREA |




THE DETAILED DESIGN OF FLOOD CONTROL, URBAN DRAINAGE AND WATER RESOURCES DEVELOPMENT IN SEMARANG IN THE REPUBLIC OF INDONESIA

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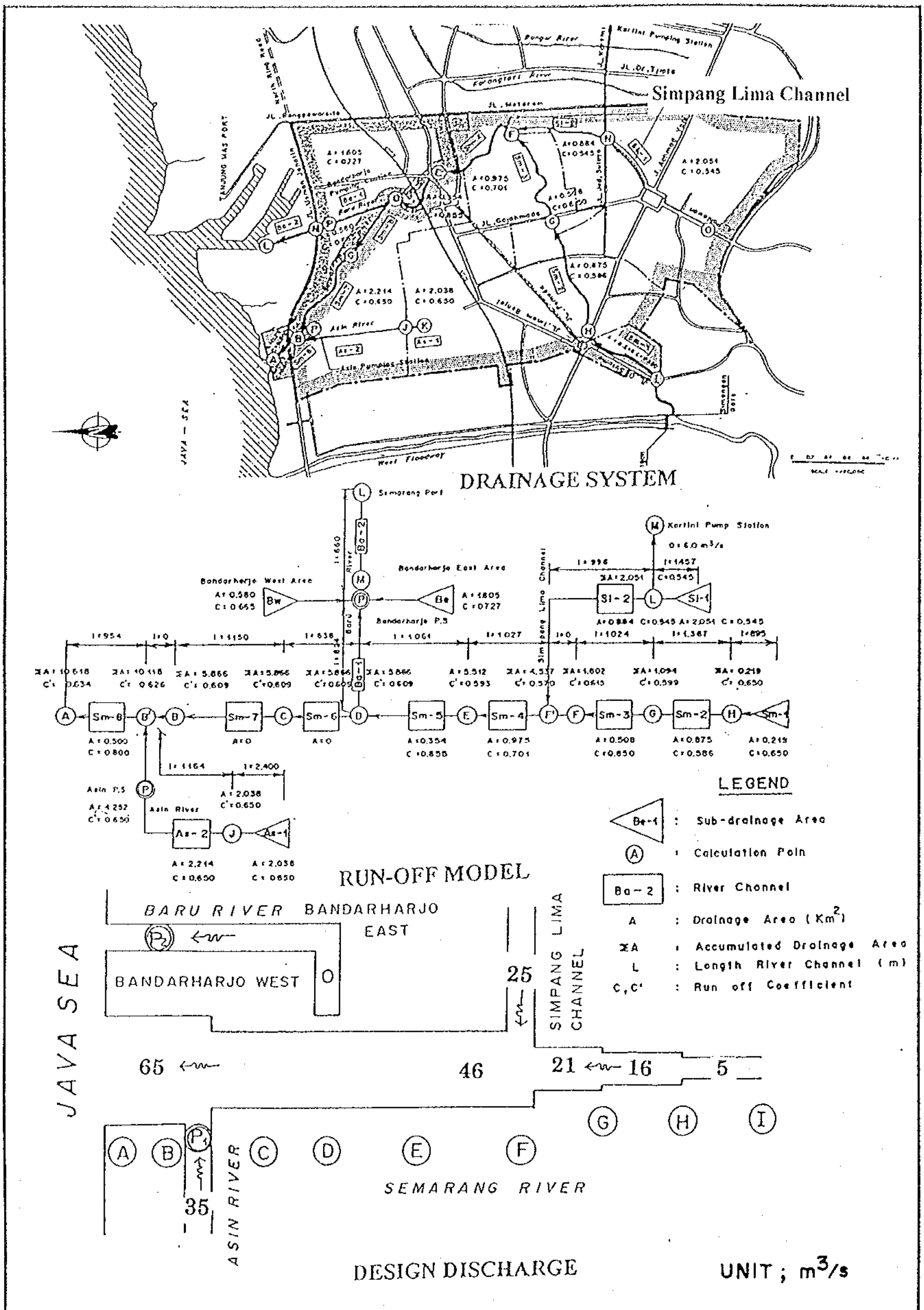
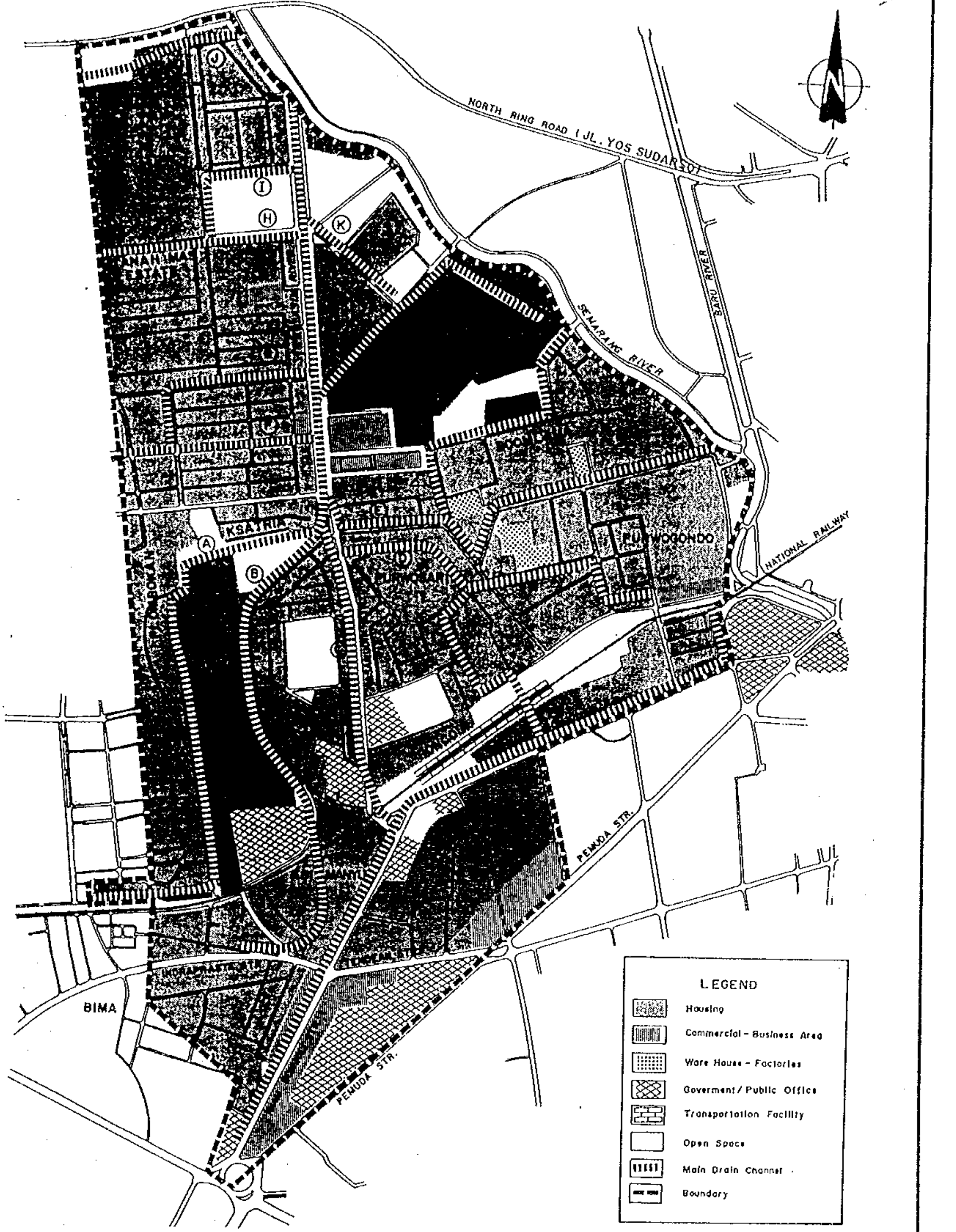
Fig. 2.1.4

STUDY AREA OF URBAN DRAINAGE SYSTEM IMPROVEMENT

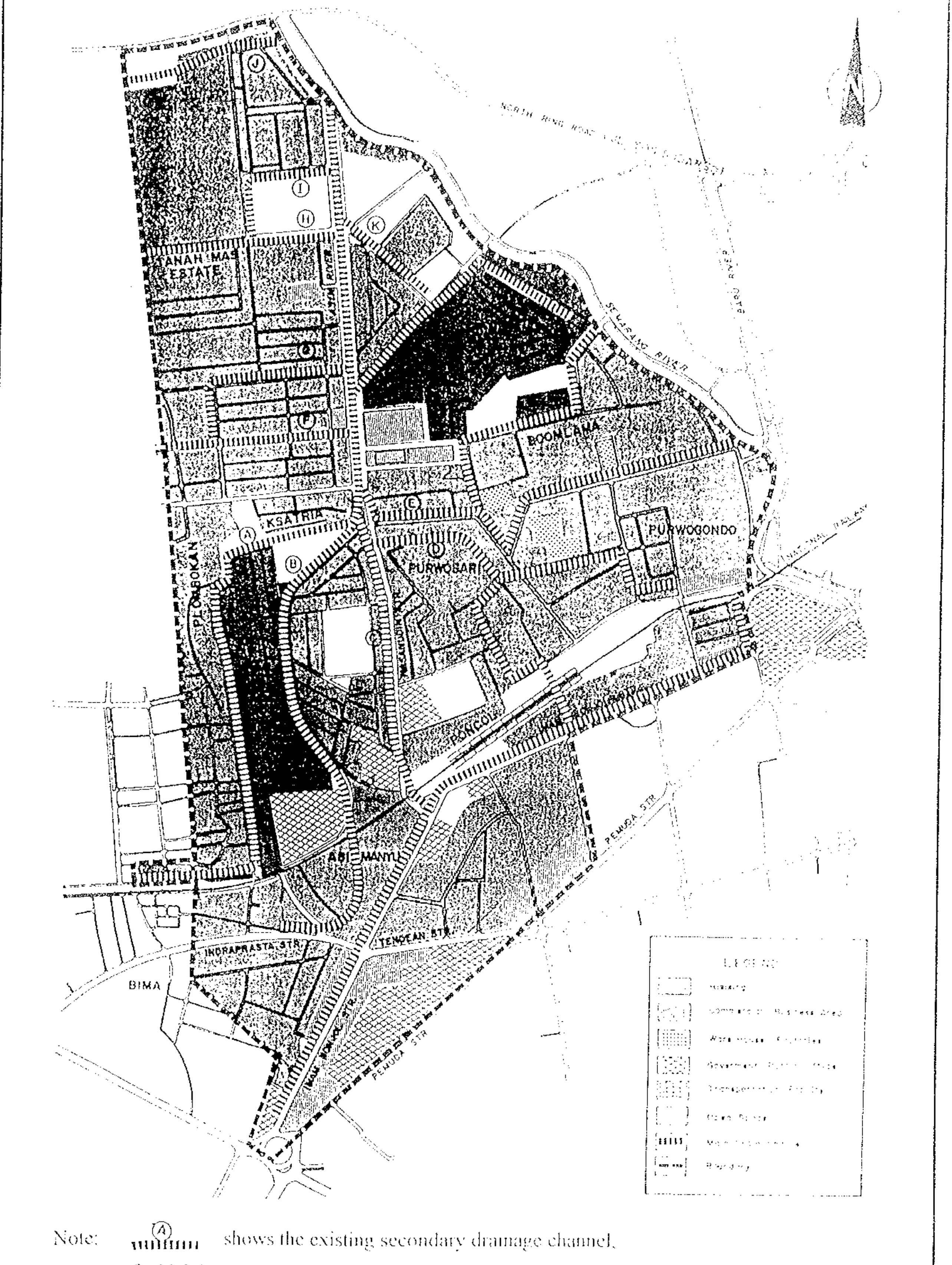



| THE DETAILED DESIGN OF FLOOD CONTROL, URBAN DRAINAGE AND WATER RESOURCES DEVELOPMENT IN SEMARANG IN THE REPUBLIC OF INDONESIA | Fig. 2.1.5 |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | DESIGN DISCHARGE OF THE MAIN CHANNELS |



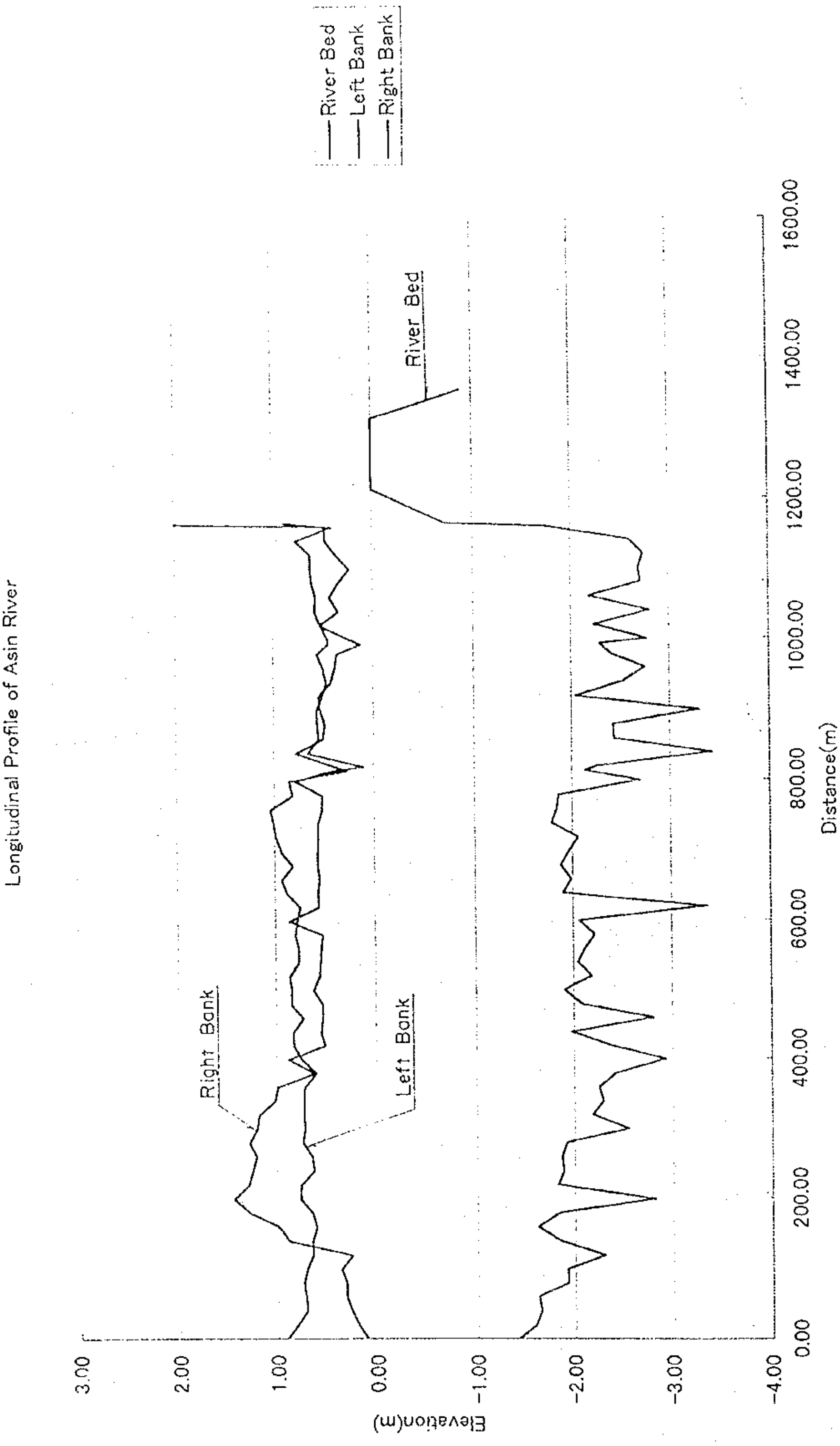

Note: (A) shows the existing secondary drainage channel, of which hydraulic features are presented in Table 2.1.4

| | |
|---|---|
| THE DETAILED DESIGN OF FLOOD CONTROL, URBAN DRAINAGE AND WATER RESOURCES DEVELOPMENT IN SEMARANG IN THE REPUBLIC OF INDONESIA | Fig. 2.1.6 |
| JAPAN INTERNATIONAL COOPERATION AGENCY | PRESENT LAND USE AND DRAINAGE SYSTEM IN ASIN RIVER BASIN |




Note: (A) shows the existing secondary drainage channel, of which hydraulic features are presented in Table 2.1.4

| | |
|---|---|
| THE DETAILED DESIGN OF FLOOD CONTROL, URBAN DRAINAGE AND WATER RESOURCES DEVELOPMENT IN SEMARANG IN THE REPUBLIC OF INDONESIA | Fig. 2.1.6 |
| JAPAN INTERNATIONAL COOPERATION AGENCY | PRESENT LAND USE AND DRAINAGE SYSTEM IN ASIN RIVER BASIN |




| THE DETAILED DESIGN OF FLOOD CONTROL, URBAN DRAINAGE AND WATER RESOURCES DEVELOPMENT IN SEMARANG IN THE REPUBLIC OF INDONESIA | Fig. 2.1.7 |
| --- | --- |
| JAPAN INTERNATIONAL COOPERATION AGENCY | LONGITUDINAL PROFILE OF ASIN RIVER |

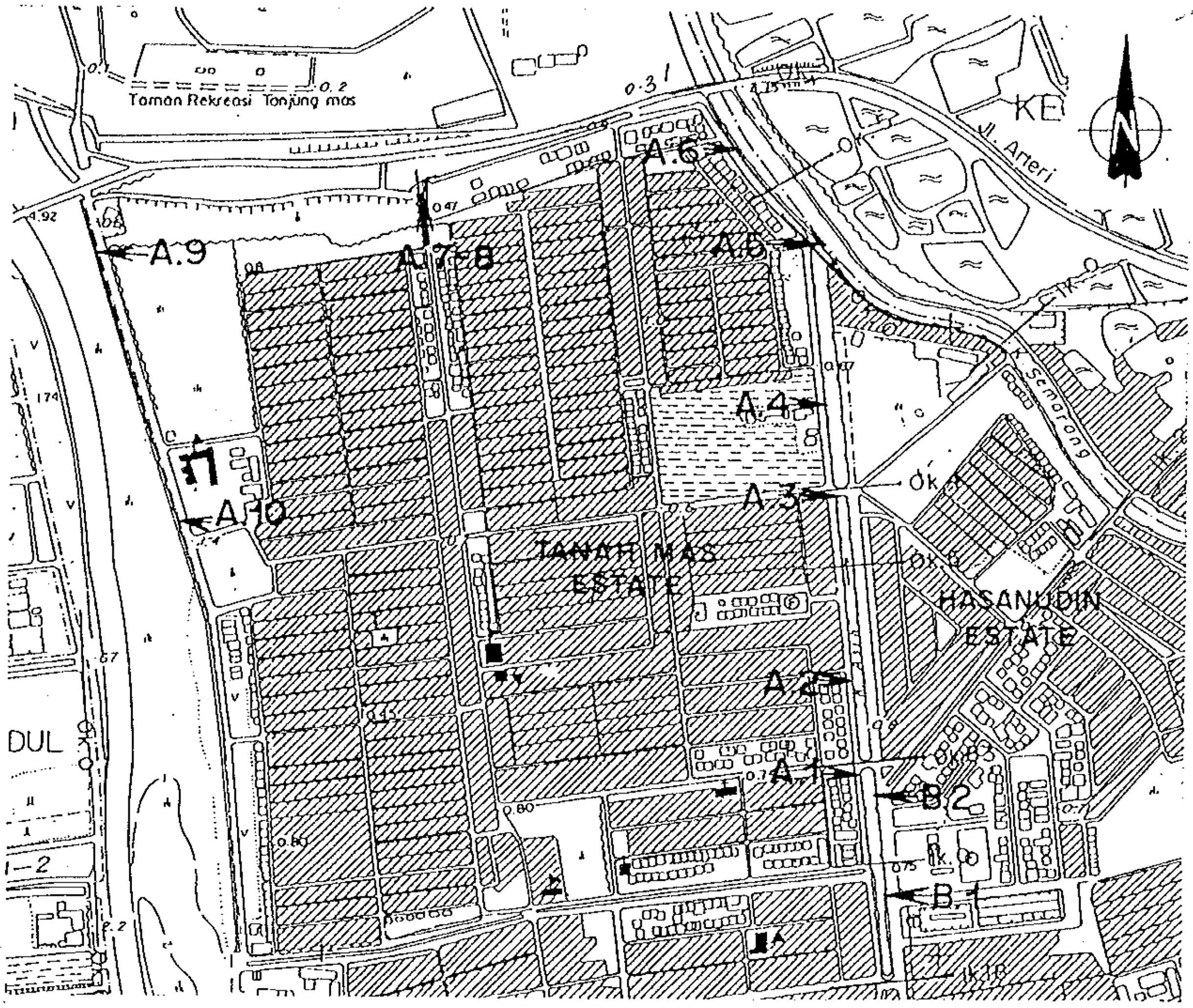



Table the local pump station at Tanah Mas Estate
and Hasanudin Estate

A. Tanah Mas Estate

| Pump Sta. | No. of Equipment (unit) | Pump Capacity (m³/min) | Pump Type |
|---|---|---|---|
| 1 | 1 | 5.0 | Submersible large volume sewage pump |
| 2 | 1 | 5.0 | |
| 3 | 2 | 10.0 | |
| 4 | 1 | 5.0 | |
| 5 | 1 | 5.0 | |
| 6 | 1 | 5.0 | |
| 7-8 | 2 | 10.0 | |
| 9 | 1 | 5.0 | |
| 10 | 1 | 5.0 | |
| Total | | 55.0 | |

B. Hasanudin Estate

| Pump Sta. | No. of Equipment (unit) | Pump Capacity (m³/min) | Pump Type |
|---|---|---|---|
| 1 | 8 | 40.0 | Centrifugal pump |
| 2 | 6 | 30.0 | |
| Total | | 70.0 | |

THE DETAILED DESIGN OF FLOOD CONTROL, URBAN DRAINAGE AND WATER RESOURCES DEVELOPMENT IN SEMARANG IN THE REPUBLIC OF INDONESIA

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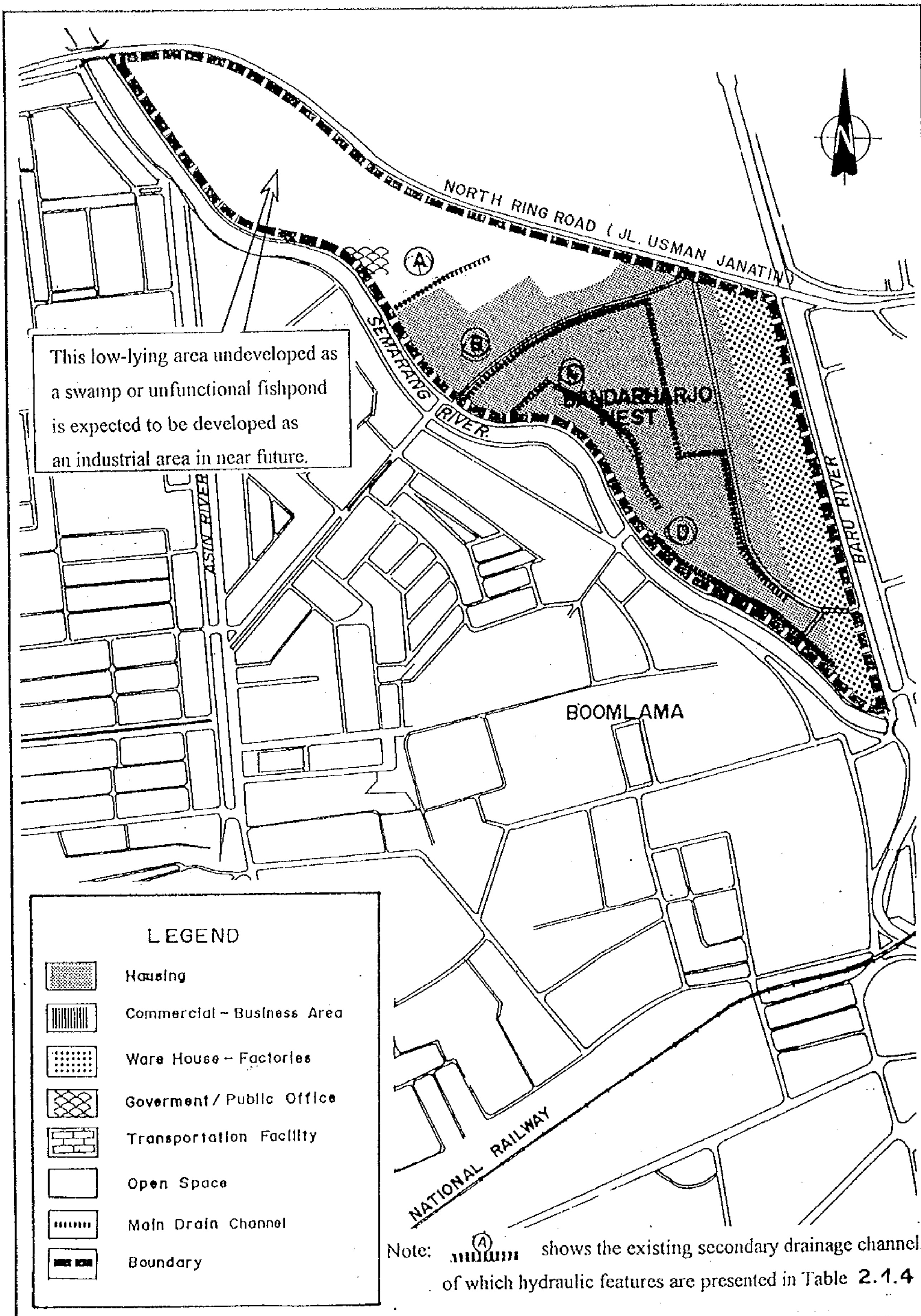
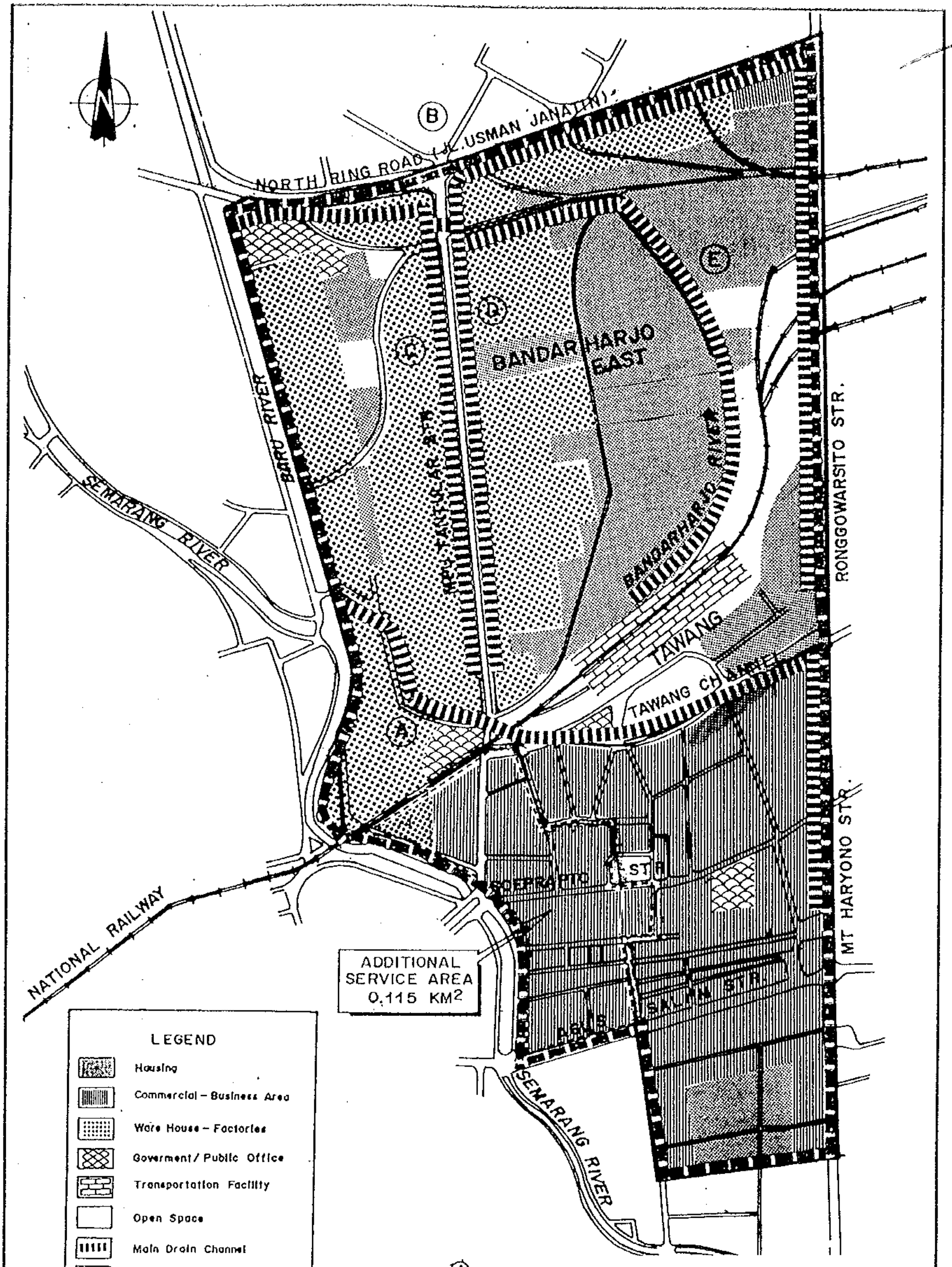
Fig.2.1.8

LOCATION OF EXISTING PUMPING STATIONS AND THEIR FEATURES AROUND TANAH MAS ESTATE

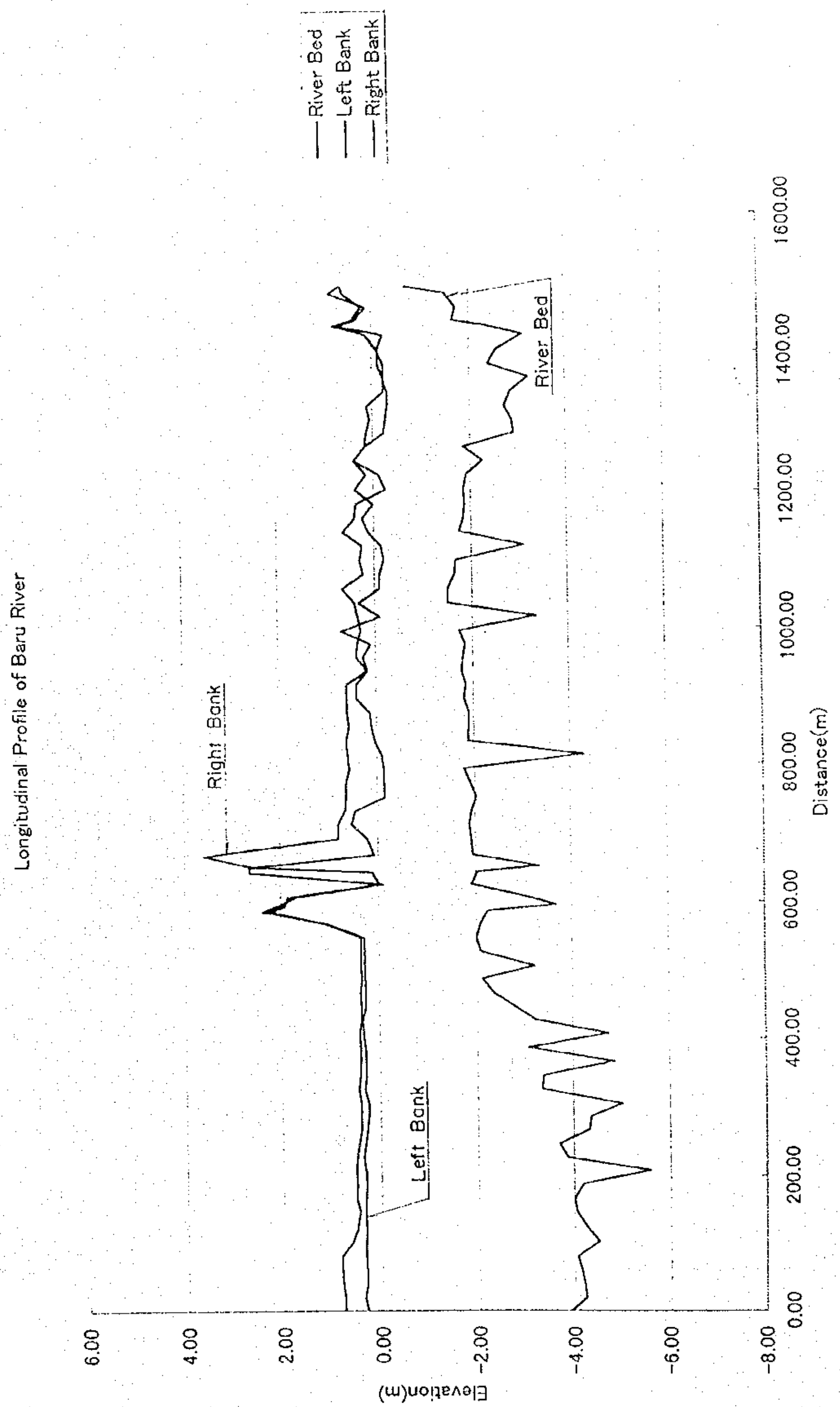



| THE DETAILED DESIGN OF FLOOD CONTROL, URBAN DRAINAGE AND WATER RESOURCES DEVELOPMENT IN SEMARANG IN THE REPUBLIC OF INDONESIA | Fig.2.1.9 |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | PRESENT LAND USE AND DRAINAGE SYSTEM IN BANDARHARJO WEST AREA |



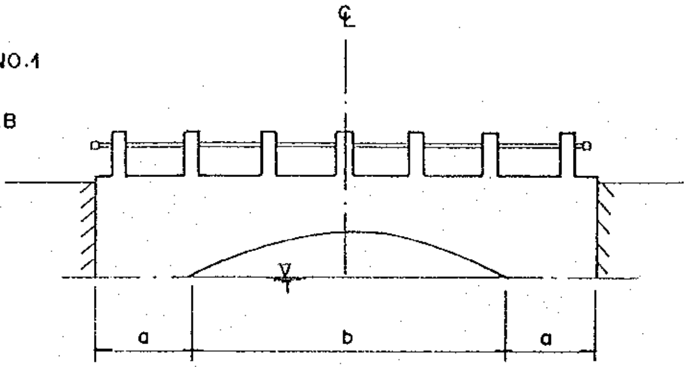

Note: (A) shows the existing secondary drainage channel, of which hydraulic features are presented in Table 2.1.4

| THE DETAILED DESIGN OF FLOOD CONTROL, URBAN DRAINAGE AND WATER RESOURCES DEVELOPMENT IN SEMARANG IN THE REPUBLIC OF INDONESIA | Fig.2.1.10 |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | PRESENT LAND USE AND DRAINAGE SYSTEM IN BANDARHARJO EAST AREA |



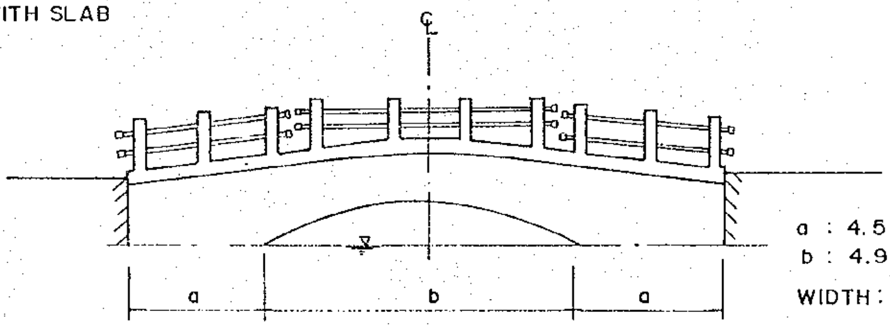

| | |
|---|---|
| THE DETAILED DESIGN OF FLOOD CONTROL, URBAN DRAINAGE AND WATER RESOURCES DEVELOPMENT IN SEMARANG IN THE REPUBLIC OF INDONESIA | Fig. 2.1.11 |
| JAPAN INTERNATIONAL COOPERATION AGENCY | LONGITUDINAL PROFILE OF BARU RIVER |

SEE SIDE BRIDGE NO.1
CONCRETE CURVE
DEVELOP WITH SLAB




a : 1.80 m
b : 4.80 m
WIDTH : 8.25 m

SEE SIDE OF BRIDGE NO.2
CONCRETE CURVE
DEVELOP WITH SLAB




a : 4.55 m
b : 4.90 m
WIDTH : 9.60 m

THE DETAILED DESIGN OF FLOOD CONTROL, URBAN DRAINAGE AND WATER RESOURCES DEVELOPMENT IN SEMARANG IN THE REPUBLIC OF INDONESIA

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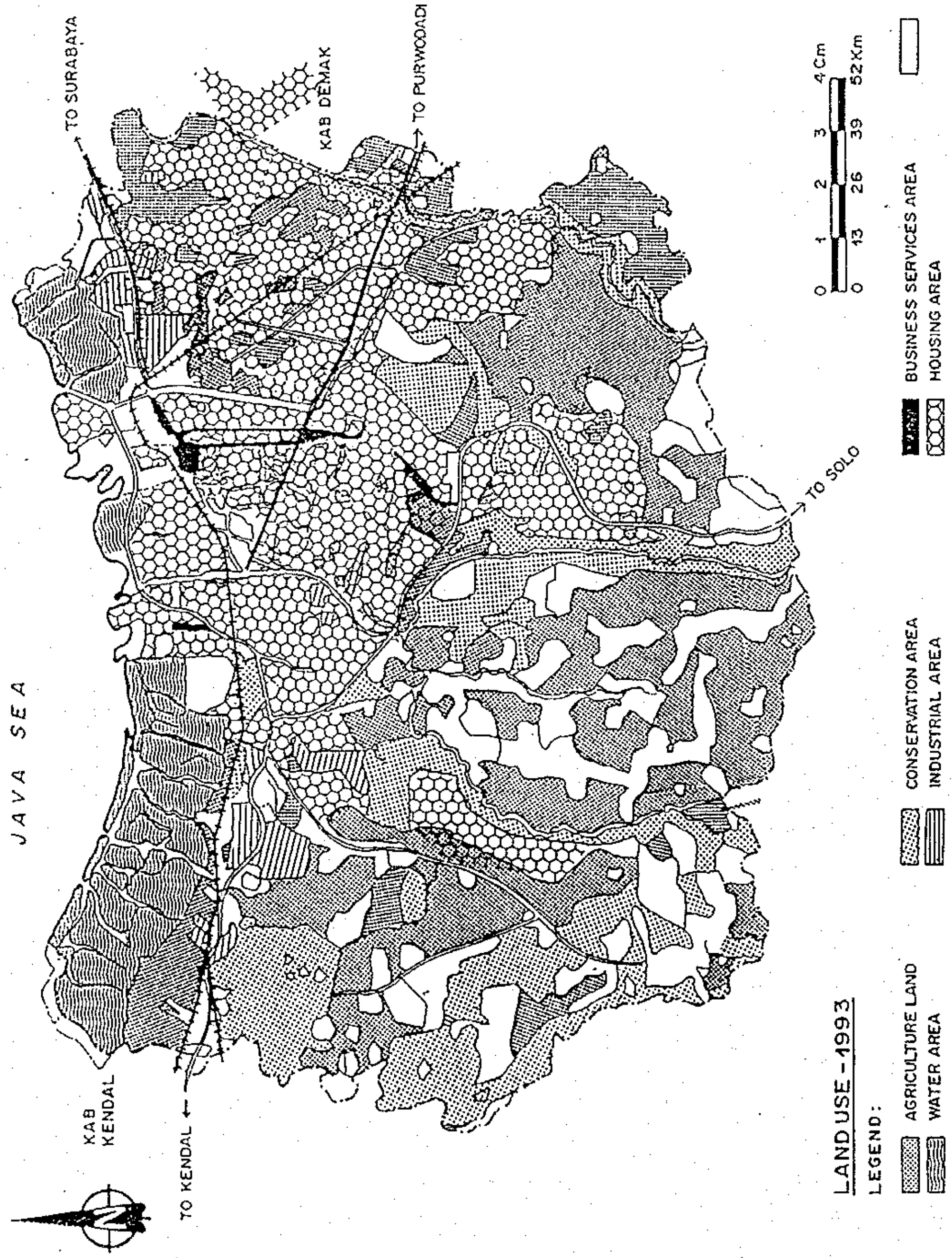
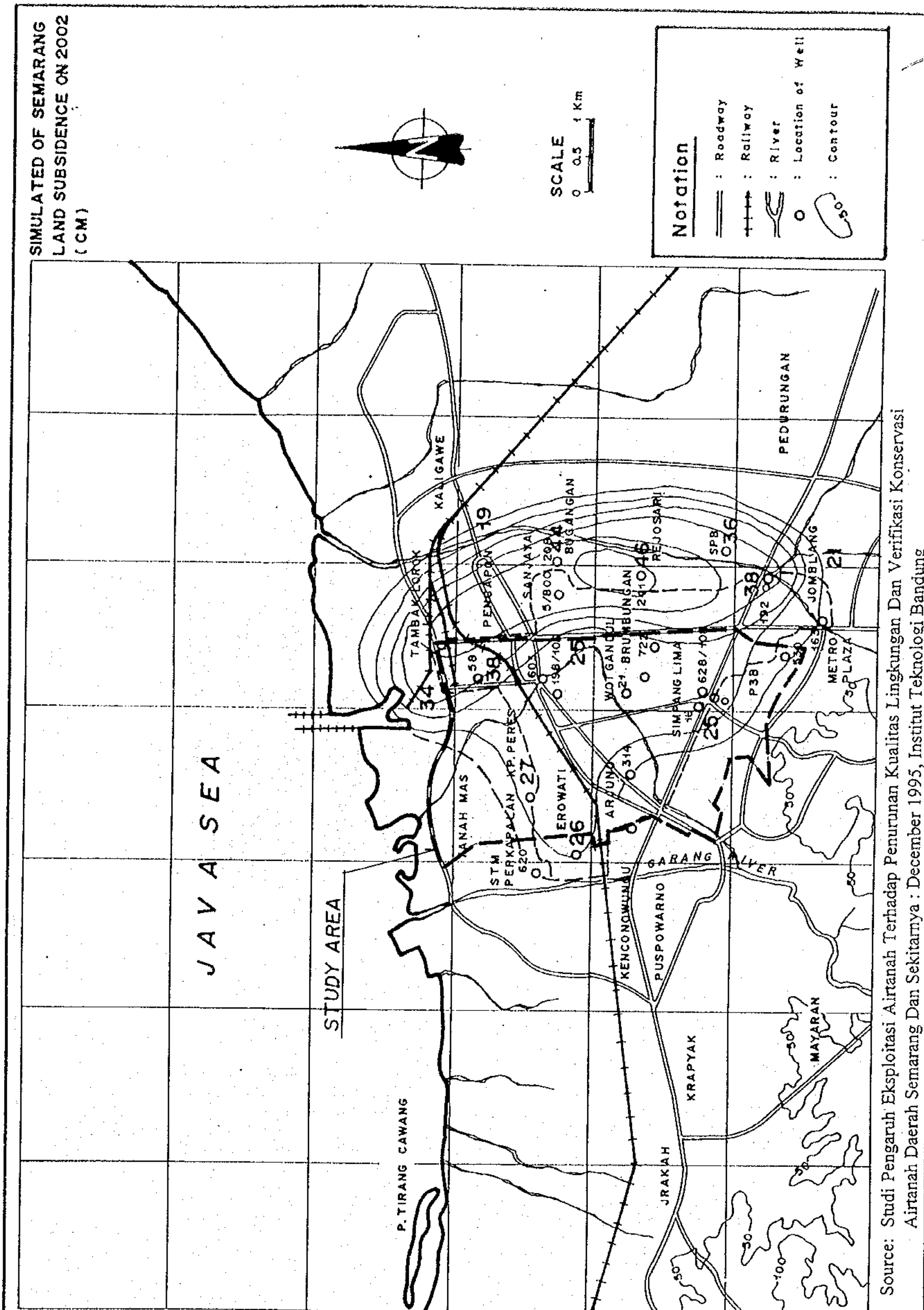
Fig. 2.1.12

ASIN BRIDGES ( NO.1 AND NO.2 )




| THE DETAILED DESIGN OF FLOOD CONTROL, URBAN DRAINAGE AND WATER RESOURCES DEVELOPMENT IN SEMARANG IN THE REPUBLIC OF INDONESIA<br>JAPAN INTERNATIONAL COOPERATION AGENCY | Fig. 2.1.13<br>THE LAND USE OF SEMARANG MUNICIPALITY IN 1993 |
|---|---|




THE DETAILED DESIGN OF FLOOD CONTROL, URBAN DRAINAGE AND WATER RESOURCES DEVELOPMENT IN SEMARANG IN THE REPUBLIC OF INDONESIA

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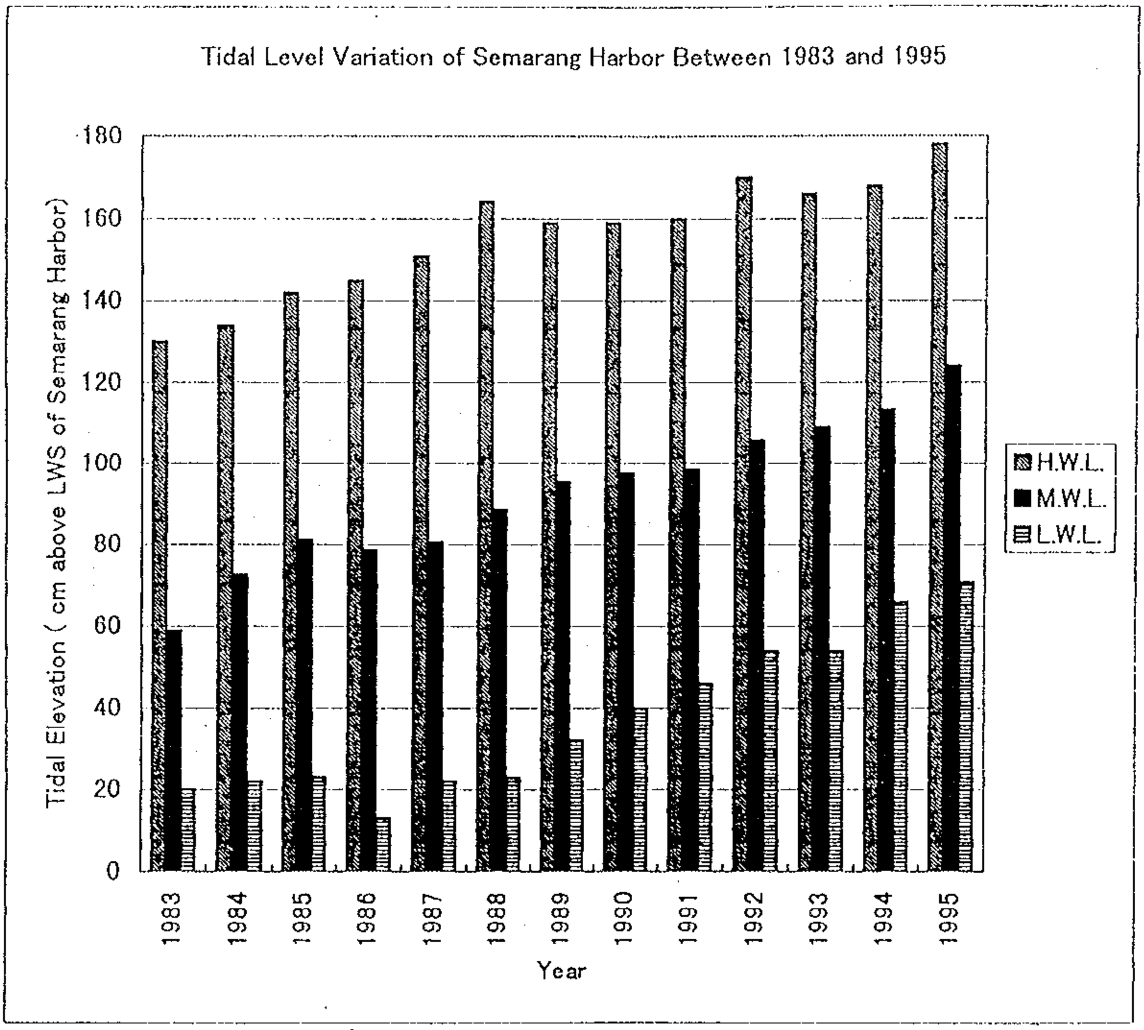
Fig. 2.1.14

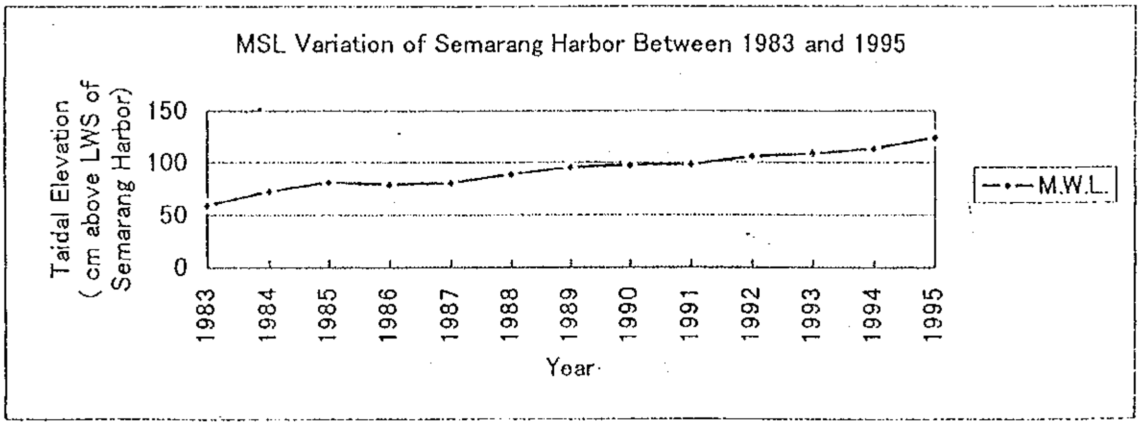
SIMULATED LAND SUBSIDENCE OF SEMARANG AREA IN 2002

## Tidal Level of Semarang Harbor

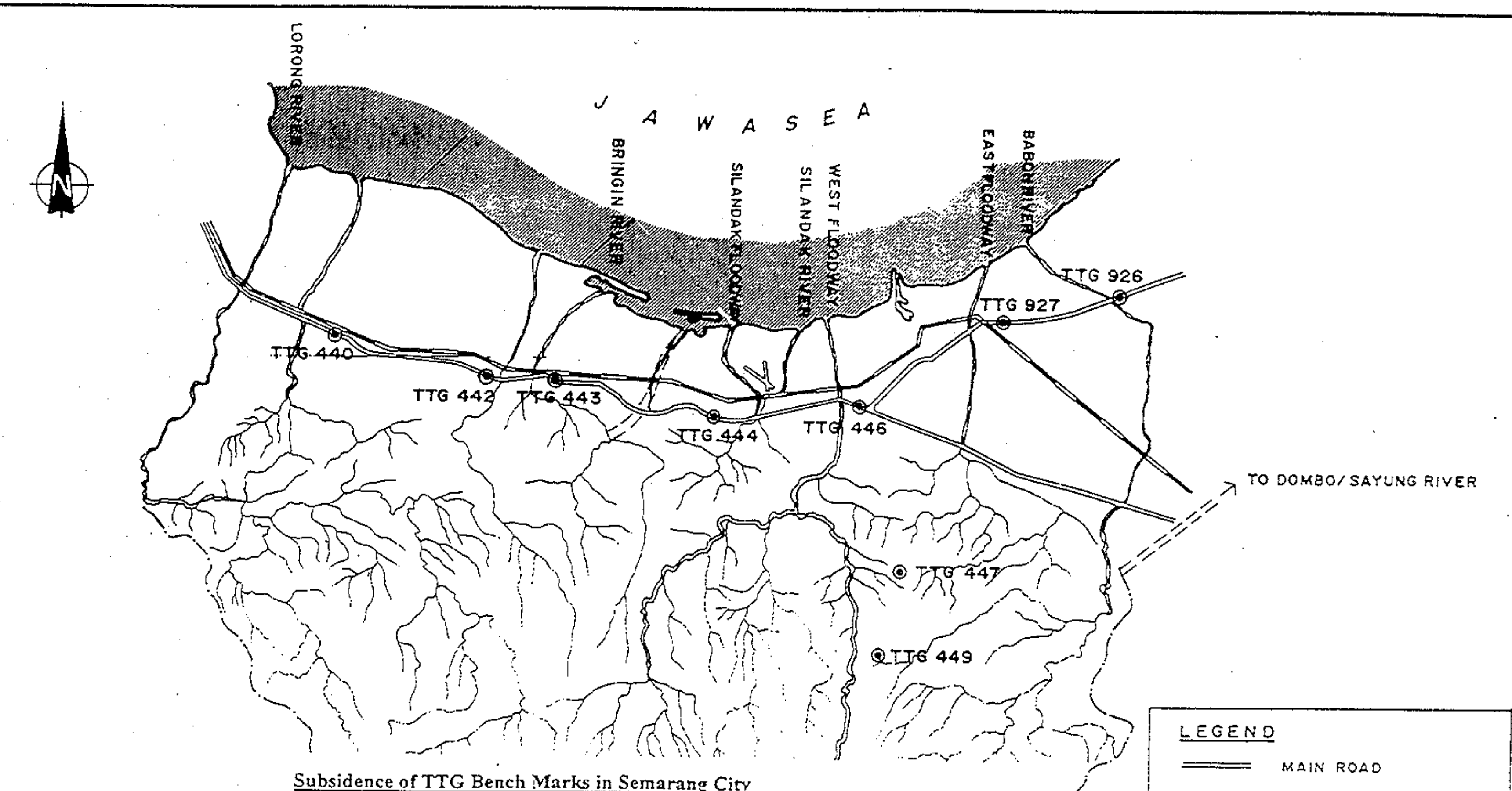
| | 1983 | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| H.W.L. | 130 | 134 | 142 | 145 | 151 | 164 | 159 | 159 | 160 | 170 | 166 | 168 | 178 |
| M.W.L. | 58.9 | 72.7 | 81.2 | 78.7 | 80.6 | 88.6 | 95.4 | 97.5 | 98.3 | 106 | 109 | 113 | 124 |
| L.W.L. | 20 | 22 | 23 | 13 | 22 | 23 | 32 | 40 | 46 | 54 | 54 | 66 | 71 |

Note: unit: cm above Low Water Spring (LWS) of Semarang Harbor




| THE DETAILED DESIGN OF FLOOD CONTROL, URBAN DRAINAGE AND WATER RESOURCES DEVELOPMENT IN SEMARANG IN THE REPUBLIC OF INDONESIA | Fig.2.1.15 |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | TIDAL LEVEL VARIATION OF SEMARANG HARBOR BETWEEN 1983 AND 1995 |




**Subsidence of TTG Bench Marks in Semarang City**

| Station | Name | Established Date | Elevation (m) (Survey Date) | | Differece (cm) | |
|---|---|---|---|---|---|---|
| | | | BAKOSURTANAL | JICA Study Team | Total | Annual |
| TTG449 | Dekat Pertigaan Tol Srondo) | 19 Mar. 1983 | 220.627 ( - ) | 220.613 (1 Oct. 1997) | 0.014 | 0 |
| TTG447 | Pertigaan Kali Wiru | 20 Mar. 1983 | 104.987 ( - ) | 104.987 (1 Oct. 1997) | 0 | 0 |
| TTG446 | Taman Tugu Muda | 24 Feb. 1983 | 4.563 (15 Sep. 1983) | 4.362 (1 Oct. 1997) | -0.201 | -0.014 |
| TTG444 | IAIN Walisongo | 23 Feb. 1983 | 23.316 (15 Sep. 1983) | 23.321 (1 Oct. 1997) | 0.005 | 0.000 |
| TTG443 | Kantor P dan K | 23 Feb. 1983 | 3.839 (15 Sep. 1983) | 4.137 (1 Oct. 1997) | 0.298 | 0.021 |
| TTG442 | Sebrang Pos | 24 Feb. 1983 | 6.339 (15 Sep. 1983) | 6.338 (1 Oct. 1997) | -0.001 | 0.000 |
| TTG440 | Stasiun Kali Wungu | 22 Feb. 1983 | 4.045 (15 Sep. 1983) | 3.990 (1 Oct. 1997) | -0.045 | -0.003 |
| TTG927 | Karang Kimpul | 05 Feb. 1984 | 4.132 (01 Sep. 1984) | 3.234 (1 Oct. 1997) | -0.895 | -0.069 |
| TTG926 | Trimulyo | 01Apr. 1984 | 1.612 (01 Sep. 1984) | 0.640 (1 Oct. 1997) | -0.972 | -0.075 |

THE DETAILED DESIGN OF FLOOD CONTROL, URBAN DRAINAGE AND WATER RESOURCES DEVELOPMENT IN SEMARANG IN THE REPUBLIC OF INDONESIA

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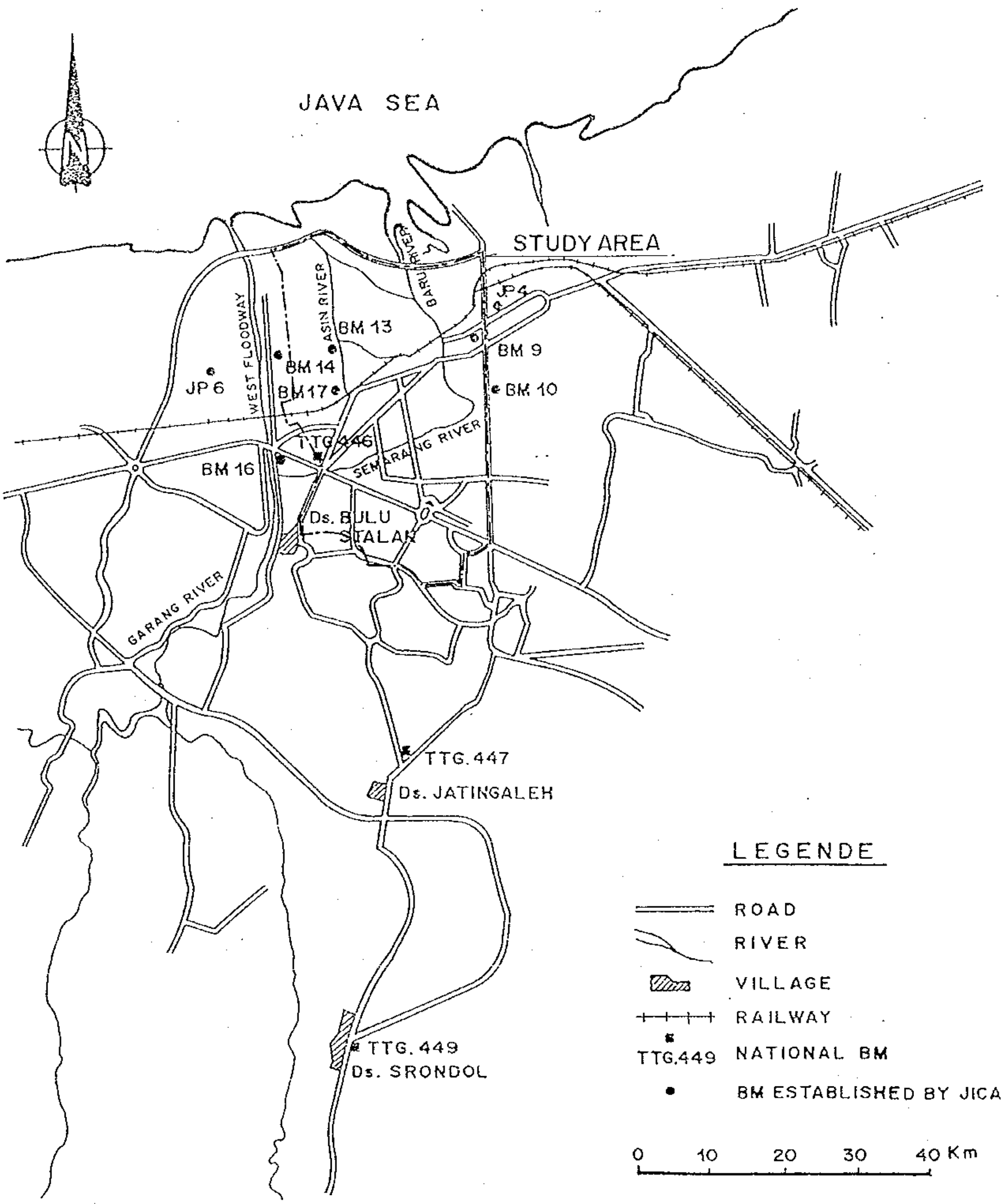
Fig. 2.1.16

TOP ELEVATION OF TTG BENCH MARK IN SEMARANG CITY




| Station | Elevation (m) | | Difference | Station | Elevation (m) | | Difference |
|---|---|---|---|---|---|---|---|
| | Aug.1997 | Aug.1998 | | | Aug.1997 | Aug.1998 | |
| TTG447 | 104.987 | 104.987 | 0.000 | BM14 | 0.892 | 0.849 | -0.043 |
| TTG446 | 4.362 | 4.353 | -0.009 | BM16 | 5.023 | 5.012 | -0.012 |
| BM9 | 0.287 | 0.197 | -0.090 | BM17 | 1.604 | 1.564 | -0.040 |
| BM10 | 0.968 | 0.897 | -0.071 | JP4 | 0.744 | 0.644 | -0.100 |
| BM13 | 0.349 | 0.285 | -0.064 | JP6 | 0.986 | 0.938 | -0.048 |

THE DETAILED DESIGN OF FLOOD CONTROL, URBAN DRAINAGE AND WATER RESOURCES DEVELOPMENT IN SEMARANG IN THE REPUBLIC OF INDONESIA

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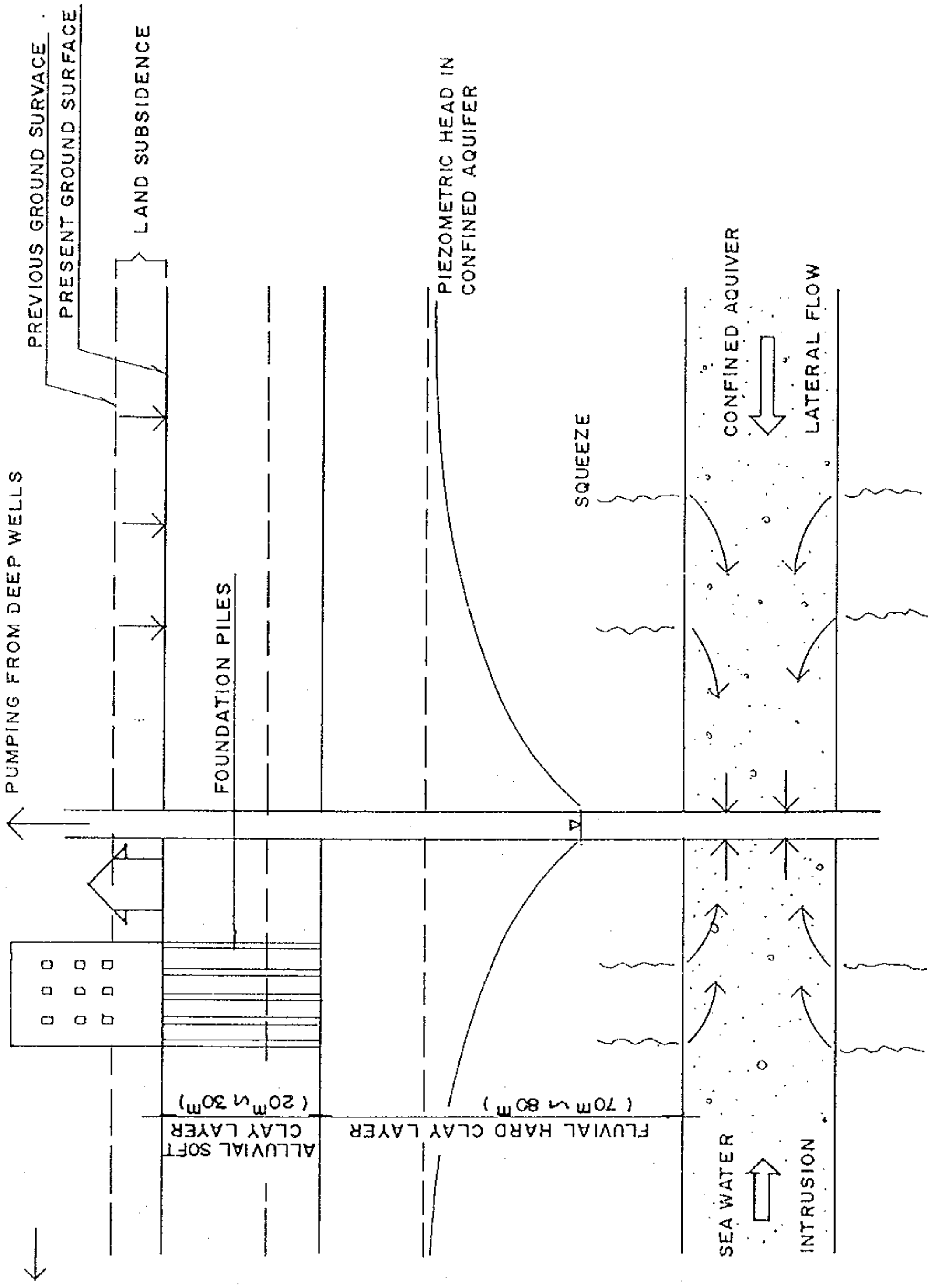
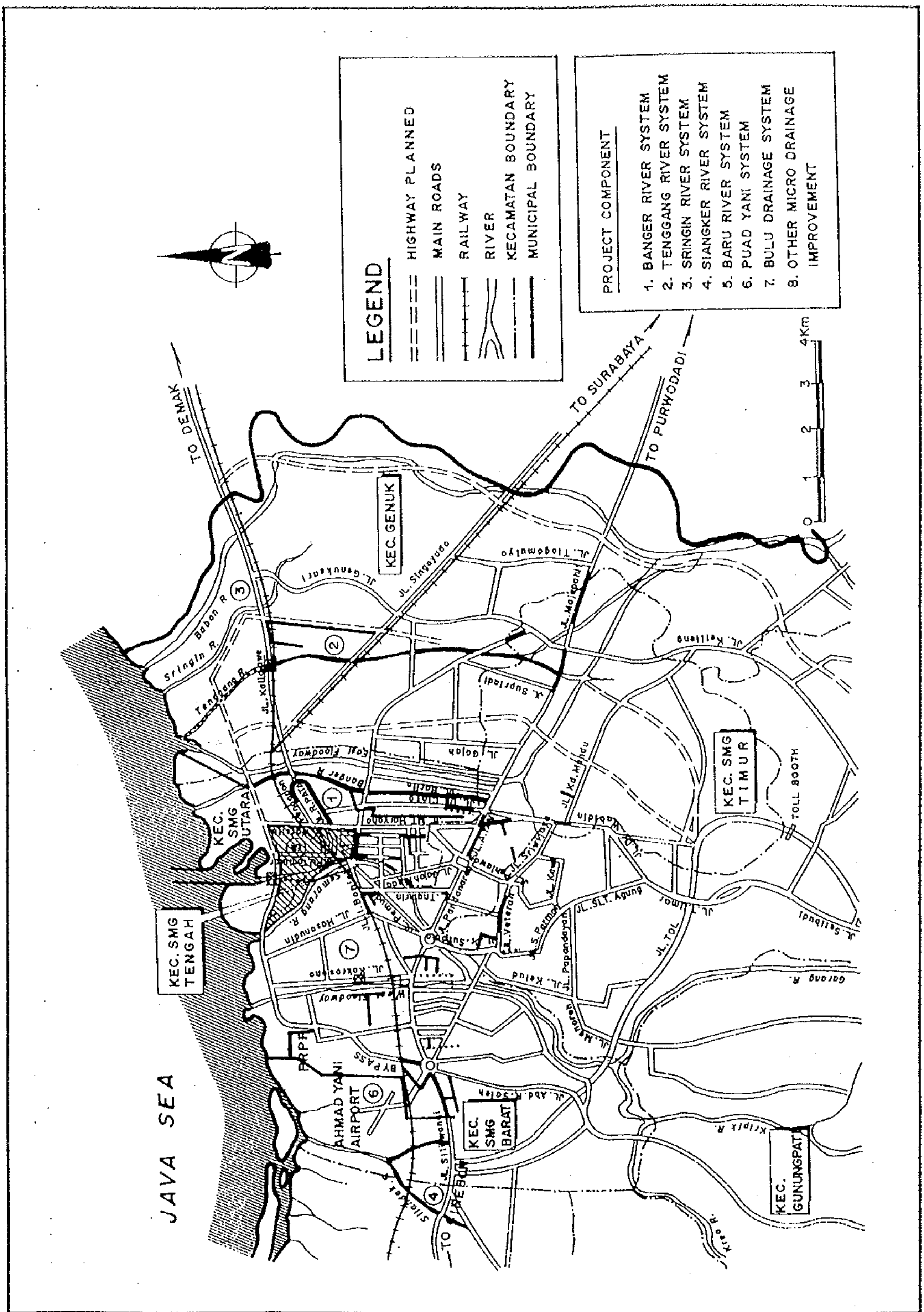
Fig. 2.1.17

MEASUREMENT OF LAND SUBSIDENCE




| THE DETAILED DESIGN OF FLOOD CONTROL, URBAN DRAINAGE AND WATER RESOURCES DEVELOPMENT IN SEMARANG IN THE REPUBLIC OF INDONESIA | Fig. 2.1.18<br>THE MECHANISM OF LAND SUBSIDENCE CAUSED BY GROUND WATER EXTRACTION |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | |




| THE DETAILED DESIGN OF FLOOD CONTROL, URBAN DRAINAGE AND WATER RESOURCES DEVELOPMENT IN SEMARANG IN THE REPUBLIC OF INDONESIA | Fig. 2.2.1 LOCATION OF PROJECT COMPONENT IN SSUDP |
|---|---|
| JAPAN INTERNATIONAL COOPERATION AGENCY | |

# CHAPTER 3

# INVESTIGATION AND ANALYSIS

# CHAPTER 3 INVESTIGATION AND ANALYSIS

## 3.1 Photogrammetric Mapping and Topographic Survey

### 3.1.1 Aerial Photography and Mapping

(1) Aerial Photography

Aerial photography at a scale of 1:8,000 and covering approximately 64 line kilometer in total was started after obtaining permission from the Central Survey and Mapping ABRI (PUSSURTA ABRI).

The results of the aerial photography are as follows:

| | |
|---|---|
| Total No. of Films | 1 Roll |
| Total Flight Runs | 12 Runs |
| Total Exposures | 156 Photos |
| Overlap and Side Lap | 55% and 35% |

The aerial photographs were taken by using Semarang Airport as a base, and processing of film and printing of aerial photos were done in Jakarta. The aerial photos were developed for mapping after checking navigation routes. The extent of the aerial photograph and navigation routes are shown in Fig. 3.1.1.

(2) Uncontrolled Mosaic

Using aerial photographs that are newly taken at a scale 1:8,000 in 1997, uncontrolled mosaic photo at a scale of 1:10,000 was established for the area of 35 $km^2$ in total. The uncontrolled mosaic are shown in Fig. 3.1.2.

(3) Photo Control Point Survey

Photo control point survey was conducted by Global Positioning System (GPS), and spirit leveling started from the photo control points and bench marks (BMs) for the above-mentioned photogrammetry and the existing national control points and Tanda Tinggi Geodesi (TTGs). (refer to Fig. 3.1.1)

(a) Control Point Survey

The control point survey by GPS was executed to determine the X and Y coordinates of a minimum two (2) existing control points to be used for the photogrammetric mapping, cross section survey, longitudinal profile and topographic survey. Final results of all photo control points by GPS are shown in Table 3.1.1.

(b) Datum Coordinates

The Indonesian Government changed the surveying datum in 1997 from the Indonesian Datum 1974 (ID74) ellipsoid to the World Geodetic System in 1984 (WGS 84).

Two (2) existing GPS stations having the new Indonesian Datum, namely N1.0259 and N.0004, which were established by Badan Koodinasi Survey Dan Pemetaan National (Bakosurtanal) in 1994, were chosen and applied as the X and Y geographical coordinates datum for this study by the JICA Study Team.

(c) GPS Observation

At least four (4) satellites were simultaneously observed for one hour for all the control points. In general, the base line lengths were planned between two (2) to five (5) km.

(d) Post-processing

The post-processing was done using GPS survey software to obtain the best independent baseline solutions for all the GPS sessions. With the existing two stations (N1.0259, N.0004) fixed as the planimetric control on the modified WGS ellipsoid and the same stations serving as the vertical control for mean sea level height, the whole GPS network was constrained and adjusted by the GPS surveying software.

(e) Accuracy of GPS Survey

Accuracy of trigonometric closures for coordinates and height were checked to be less than 10 PPM (10/1,000,000) between the control points (refer to Figs. 3.1.3 and 3.1.4).

(4) Leveling

Minor order leveling was executed to obtain the heights of control points necessary for the topographic survey, cross section survey and longitudinal profile survey.

Leveling survey was conducted by means of closed loops and double runs, and temporary bench marks were established at every 2 km interval on the leveling routes. Also temporary bench marks were established at 49 points in Semarang City. And a total distance of the leveling survey was approximately 105 km.

The leveling works are described below:

(a) Datum Height

Government bench marks obtained from the Mean Sea Level of Indonesia as established by Bakosurtanal are applied for the leveling survey.

(b) Checking of Government Bench Marks

Before starting leveling survey, heights of three government bench marks namely TTG446, TTG447 and TTG449 were checked by the local contractor.

| Leveling Loops | Distance | Misclosure |
|---|---|---|
| TTG449 to TTG447 | 4.601 km | 14 mm |
| TTG447 to TTG446 | 5.095 km | -201 mm |

From the above, it was judged by the JICA Study Team that TTG446 shall be ignored because TTG446 had ground subsidence about 20 cm from 1983.

The JICA Study Team decided to use TTG447 as the bench mark for topographic survey, river cross section survey and longitudinal profile survey in this project.

(c) Accuracy of Leveling

As show in Figs. 3.1.5 and 3.1.6, any misclosure of leveling does not exceed $20\sqrt{S}$ between bench marks and/or control points (S: a single distance between bench marks in kilometer). And Standard division was 3.80 mm/km.

(5) Field Verification

Using two (2) times enlarged aerial photographs, the keys for interpretation required for plotting and cartography was done by verifying them in the field. The work quantity was 35 $km^2$ for mapping with the scale of 1:2,000 and 1 $km^2$ for mapping with the scale of 1:1,000. The area of field verification are shown in Fig. 3.1.7.

(6) Aerial Triangulation

The implication and purpose of Aerial Triangulation work are to obtain the coordinates (X, Y, Z) of the aerial photo points necessary for the orientation process of each stereo model on the plotting instrument for the purpose of topographic map on the scale of 1:2,000 and 1:1,000 applying coordinates (X, Y, Z) of ground control points resulting from field measurement (GPS and leveling) (refer to Figs. 3.1.8 and 3.1.9).

(a) Aerial Triangulation and Block Adjustment

The sequence of works to be carried out is as follows:

(i) Quantity

119 models of aerial triangulation work was carried out, and the quantity of models for each flight run was as follows:

| Run Number | Number of Photo | Number of Model |
|---|---|---|
| Run 1(Semarang Area) | 10 PCs | 9 Models |
| Run 2(Semarang Area) | 14 PCs | 13 Models |
| Run 3(Semarang Area) | 13 PCs | 12 Models |
| Run 4(Semarang Area) | 13 PCs | 12 Models |
| Run 5(Semarang Area) | 13 PCs | 12 Models |
| Run 6(Semarang Area) | 11 PCs | 10 Models |
| Run 7(Semarang Area) | 18 PCs | 17 Models |
| Run 8(Semarang Area) | 19 PCs | 16 Models |
| Run 9(Semarang Area) | 17 PCs | 6 Models |
| Run 11(Ungaran Area) | 9 PCs | 6 Models |
| Run 12(Ungaran Area) | 9 PCs | 6 Models |
| Total | 146 PCs | 119 Models |

(ii) Data Collection

All necessary data such as flight index, control point coordinate and calibration of the aerial photographic camera were collected.

(iii) Planning

Preparation of aerial triangulation was carried out as follows:

Selection of the Aerial Photos

Total sheets of aerial photos for Ungaran Area : 12 models

Total sheets of the aerial photos for Semarang Area : 107 models.

Control Point Selection

Total control points were 22, consisting of 5 horizontal and 17 vertical control points for aerial triangulation processing at Ungaran area.

Total control points of 74, consisting of 21 horizontal and 53 vertical control points for aerial triangulation processing at Semarang area.

(iv) Preparation

The preparation stages were carried out as follows:

Point selection and numbering

Pass points and tie points were selected within the triple overlap area with the circle notation on the index model.

Numbering system for aerial triangulation

Ex. Model number : 8011*1*

Where:

8011 : First two digits show the number of flight run as shown and last two digits show the number of aero photographs.

*1* : Tie point number

The horizontal and vertical control points were annotated on the index models as a square, and vertical control points were annotated as triangle. The point selection and numbering were carried out on the 1:2,000 and 1: 1,000 scale of aerial photographs by using mirror stereoscope.

(v) Point Transfer

The selected and control points on the diapositive film were marked and then transferred to adjacent diapositive film by using Wild PUG-4 instrument. This process was carried out until the last photo.

(vi) Index Model

The index model on 1:50,000 scale, where all point numbers were plotted showing the relationship between each point, was produced.

(vii) Measurement of Coordinates

Photo coordinates were observed and measured by using an analytical stereoplotter Leica SD-2000. All points including fiducial marks were measured.

(viii) Adjustment

The final step of the aerial triangulation is the block adjustment using PATM-GPS software.

(ix) Result

Block adjustment of Ungaran Area

Sigma Naught in the model system is as below.

Sigma naught for horizontal block = 21.064 micron
Sigma naught for vertical block = 14.773 micron

Weight root mean square values and check value of residual of Photogrammetric observations.

| Model Points | RMS. (meter) Terrain system | RMS. (micron) Model system | CHV VXY/Z Model system |
|---|---|---|---|
| OBS X/Y | 0.090 | 11.216 | 47.586 |
| OBS z | 0.063 | 7.888 | 23.664 |
| Projection center | RMS. (meter) Terrain system | RMS. (micron) Model system | CHV VXY/Z Model system |
| OBS X/Y | 0.120 | 14.975 | 65.532 |
| OBS z | 0.094 | 11.750 | 73.658 |

Block adjustment of Semarang Area

Sigma Naught in the model system, is as below.

Sigma naught for horizontal block = 18.890 micron
Sigma naught for vertical block = 20.353 micron

Weight root mean square values and check value of residual of Photogrammetric observations.

| Model Points | RMS. (meter) Terrain system | RMS. (micron) Model system | CHV VXY/Z Model system |
|---|---|---|---|
| OBS X/Y | 0.094 | 12.118 | 51.411 |
| OBS z | 0.080 | 10.273 | 30.820 |
| Projection center | RMS. (meter) Terrain system | RMS. (micron) Model system | CHV VXY/Z Model system |
| OBS X/Y | 0.254 | 32.718 | 138.809 |
| OBS z | 0.130 | 13.292 | 39.875 |

(x) Equipment

The equipment used in Aerial Triangulation is as follows:

| | |
|---|---|
| Stereoscope | 2 units |
| Point transfer Wild PUG-4 | 1unit |
| Analytical Stereoplotter Leica SD-2000 | 1 unit |
| Computer | 1 unit |
| PATM-GPS Software | 1 unit |

(6) Plotting and Editing

The implication and purpose of stereo plotting and editing work are drawing details and contour lines using aerial photo diapositives, which are placed on the plate holders of the stereo plotter instrument (refer to Figs. 3.1.10 to 3.1.13).

The sequences of the plotting and editing works are as follows:

(a) Data collection

All the following necessary data were collected and prepared for stereo plotting.

- Model index of aerial triangulation
- Print out of aerial triangulation adjustment
- Vertical control points and description on two (2) times enlarged aerial photographs
- Field identification on two(2) times enlarged aerial photographs

(b) Planning

Preparation of stereo plotting was carried out as follows:

(i) Control sheets

Total control sheets of the stereo plotting topographic map are:

- 48 sheets for 1:2,000 scale of Semarang topographic map (including 4 sheets of sounding survey result);
- 4 sheets for 1:2,000 scale of Ungaran topographic map; and
- 26 sheets for 1:1,000 scale of channel topographic map

(ii) Models

Total models of stereo plotting are:

- 52 models for 1:2,000 scale of Semarang topographic map

- 4 models for 1:2,000 scale of Ungaran topographic map
- 12 models for 1:1,000 scale of channel topographic map

(c) Preparation of Control Sheets

Control sheets were produced by block adjustment result of aerial triangulation on polyester base material.

(d) Plotting

Plotting manuscript at the scale of 1:2,000 and 1:1,000 were produced from aerial photos at the scale of 1:8,000 by using second order precision plotter.

The sequences of the stereo plotting works are as follows:

- Inner Orientation;
- Relative Orientation;
- Absolute Orientation; and
- Plotting of details, spot height, vegetation boundary and contour lines.

Contour intervals for intermediate contour line are 1 m both maps with the scale of 1:2,000, and 1:1,000.

Editing works was carried out on the plotting manuscript by compiling result of field identification, such as symbol annotation etc.

(e) Result

The final manuscript was used for the fair drawing work and the number of sheets plotting manuscript are as below.

- 48 sheets plotting manuscript at scale of 1:2,000 for Semarang area (including 4 sheets of sounding survey result)
- 4 sheets plotting manuscript at scale of 1:2,000 for Ungaran area
- 26 sheets plotting manuscript at scale of 1:1,000 for channel area

(f) Equipment

The equipment used for plotting and editing are:

| | |
|---|---|
| Computer | 2 units |
| Roland Plotter | 1 unit |
| Stereo Plotter, Wild A-8 | 2 units |
| Plotter Wild AG-1 | 1 unit |
| Stereo Plotter, Leica SD-2000 | 1 unit |
| Drafting Table | 3 units |

(7) Fair Drawing

The implication and purpose of fair drawing work are drawing details using symbols and contour lines with tracing method from the plotting manuscript and other additional data and information.

The sequence of the fair drawing were carried out as follows:

(a) Data Collection

All necessary data were collected and prepared for fair drawing such as:

- Plotting manuscript
- Vertical control points and description on two (2) times enlarged aerial photographs
- Field identification results on two (2) times enlarged aerial photographs

(b) Planning

Preparation for fair drawing were carried out as follows:

(i) Drawing sheets

Total sheets of fair drawing are 78 sheets, consisting of 48 sheets of Semarang map (including 4 sheets of sounding survey result) and 4 sheets of Ungaran map at the scale of 1:2,000; 26 sheets of map at scale of 1:1,000.

(ii) Legend and Symbol

Legend, symbols and annotation used for the map are shown in Table 3.1.2.

(c) Preparation

The preparations were carried out as follows:

(i) Drawing sheets

Drawing sheets were made using computer PC on polyester base. The sheet's size is A1 (60 cm ~ 85 cm). Numbering system is as follows:

Sheet number 45-*12*

Where:

45 = Total sheets

*12* = Sheet number

(d) Fair drawing

Fair drawing was carried out with tracing method using drafting pen and black ink from plotting manuscript at scale of 1:2,000 and 1:1,000.

Fair drawing works are as follows:

- Drawing details
- Spot heights and contour lines
- Symbols and annotations, on the map symbols must be matched to legend
- Vegetation boundary

Contour interval for intermediate contour lies are 1 m for map at scale of 1:2,000 and 1 m for map at scale of 1:1,000.

(e) Results

The final results of the fair drawing are:

- 48 sheets of topographic map at scale of 1:2,000 for Semarang area,
- 4 sheets of topographic map at scale of 1:2,000 for Ungaran area,
- 26 sheets of topographic map at scale of 1:1,000 for Channel area,
- 48 sheets duplicate at scale of 1:2,000 for Semarang area,
- 4 sheets duplicate at scale of 1:2,000 for Ungaran area, and
- 26 sheets duplicate at scale of 1:1,000 for channel area.

The equipment used for the fair drawing works are:

- Computer : 2 units

- Roland plotter : 1 unit
- Drafting table : 9 units
- Drafting tools : 9 units

### 3.1.2 Ground Survey

(1) River Longitudinal Profile and Cross-Section Survey

(a) Installation of Kilometer Post

Prior to the commencement of the river longitudinal profile survey, kilometer posts of wooden pegs were installed on the right and left banks of West Floodway, Garang, Semarang, Asin and Baru rivers. When the location of a kilometer post is very close to such structures as bridges, water intake and water pipes, kilometer posts were shifted to the center line of these structures. The position of a kilometer post was decided by traverse method in the field.

(b) Longitudinal Profile Survey

The river longitudinal profile survey (the profile survey) by direct leveling was executed to obtain heights of kilometer posts for the river cross section survey and to prepare longitudinal profile sections. Leveling routes were formed by closed loops and double-runs. A total distance of the leveling survey covering West Floodway, Garang, Semarang, Asin and Baru rivers was 41 km.

The datum height was applied for the longitudinal profile survey including river cross section survey and auxiliary leveling. The heights of TTGs bench marks are applied to the kilometer posts by direct leveling.

All results of heights of kilometer posts by the profile survey, the deepest height of the river cross section survey, names of bridge and others were edited by Auto CAD system. The longitudinal profile sections at a horizontal scale of 1:2,000, 1:1,000 and vertical scale of 1:100 were prepared on the draft plotting paper sheets using the longitudinal profile data.

(c) River Cross Section Survey

Heights and distance of slope changing points, roads, channels, etc. along the cross section lines were measured by using a Total Station System, levels and Electric Distance Meter (EDM).

Water levels and depths of the rivers were measured using a survey rod, and the distance of these measured simultaneously. The bridges, irrigation intakes and water pipes of all rivers were also measured. A total number of cross sections surveyed are approximately 814.

(d) Checking of Longitudinal Profile

(i) The check results of differences in height closure between the kilometer posts did not exceed $20\sqrt{S}$ (S: length of single run in kilometer) as specified in the Technical Specifications.

(ii) Checking of River Cross Sections

At the same kilometer posts checked above, river cross section lines were measured. The check results of height of these cross section line points did not exceed ±50 mm and distance errors between the cross section line points are less than 1/300 as specified in the Technical Specifications.

Longitudinal profile and cross-section were surveyed along Semarang, Asin, and Baru rivers.

Semarang River

| Work Item | Volume | Drawing | | Remarks |
|---|---|---|---|---|
| | | No. of | Scale | |
| Longitudinal Profile | 8.650 km | Sheets | H=1/1,000 V=1/100 | Sheet Size: A1 |
| Cross-Section Survey | 303 sections | 88 | H=1/200 V=1/100 | Sheet Size: A1 |

Asin River

| Work Item | Volume | Drawing | | Remarks |
|---|---|---|---|---|
| | | No. of Sheets | Scale | |
| Longitudinal Profile | 1.318 km | 2 | H=1/1,000 V=1/100 | Sheet Size: A1 |
| Cross-Section Survey | 70 sections | 19 | H=1/200 V=1/100 | Sheet Size: A1 |

Baru River

| Work Item | Volume | Drawing | | Remarks |
|---|---|---|---|---|
| | | No. of Sheets | Scale | |
| Longitudinal Profile | 1.498 km | 2 | H=1/1,000 V=1/100 | Sheet Size: A1 |
| Cross-Section Survey | 78 sections | 20 | H=1/200 V=1/100 | Sheet Size: A1 |

East Bandarharjo

| Work Item | Volume | Drawing | | Remarks |
|---|---|---|---|---|
| | | No. of Sheets | Scale | |
| Longitudinal Profile | 0.792 km | 1 | H=1/1,000<br>V=1/100 | Sheet Size: A1 |
| Cross-Section Survey | 17 sections | 2 | H=1/200<br>V=1/200 | Sheet Size: A1 |

West Bandarharjo

| Work Item | Volume | Drawing | | Remarks |
|---|---|---|---|---|
| | | No. of Sheets | Scale | |
| Longitudinal Profile | 1.423 km | 1 | H=1/500<br>V=1/100 | Sheet Size: A1 |
| Cross-Section Survey | 73 sections | 8 | H=1/200<br>V=1/200 | Sheet Size: A1 |

### 3.1.3 Topographic Survey

Topographic survey was carried out for Asin Pumping Station, West and East Bandarharjo Pumping Station, West and East Bandarharjo Drainage area, a bridge across Semarang River and a water gate at Baru River.

The work quantities carried out are as follows:

(a) Scale 1:200

| | |
|---|---|
| Asin Pumping Station | 9.0 ha |
| West Bandarharjo Pumping Station | 6.0 ha |
| East Bandarharjo Pumping Station | 3.0 ha |
| Bridge (Semarang River) | 0.5 ha |
| Water gate (Baru River) | 1.0 ha |

(b) Scale 1:500

| | |
|---|---|
| West Bandarharjo Drainage Area | 2.8 ha |
| East Bandarharjo Drainage Area | 3.2 ha |

### 3.1.4 Sounding Survey

(1) Location and Quantity

The location is shown in Fig. 3.1.14. The work quantities are 3 $km^2$, consisting of 16 survey lines and 1 km per line.

(2) Setting of Base Survey Line

Base survey line was established along the coastline for 3 km eastward from the mouth of West Floodway by GPS, traversing and spirit leveling. All control monuments were set at 200 m interval along the base survey line.

Misclosure of leveling does not exceed $20\sqrt{S}$ between bench mark and control points (S: a single distance in kilometer between control points).

(3) Measuring Interval of Survey Line

From the control point, water depth of each line 1 km offshore were measured at 30 m interval. Water surface was also measured.

(4) Equipment

Echo sounder and survey rod for water depth measurement, GPS and Total Station Surveying System for positioning were used.

(5) Chart Drawing

Charts were interpolated in the 1:2,000 scale topographic map.

### 3.1.5 Land Subsidence

During this study period, leveling measurements were conducted between TTGs and 49 permanent bench marks established in the Study.

The survey results are shown in Fig. 2.1.17.

No subsidence was found in the western part of the study area. However in the eastern part of the city and the study area, considerable subsidence was found with a maximum measure of – 0.0972 m observed.

The amount of annual subsidence in future can easily be checked by re-examining these points at regular intervals.

## 3.2 Geological and Soil Mechanical Investigation

### 3.2.1 Boring and Soil Mechanical Test

(1) Core Drilling

(a) Purpose

The purpose of core drilling is to obtain the subsurface geology of the drilling area, i.e. soil type, thickness, sequence, physical condition, etc.

During the drilling, Standar Penetration Tests (SPT) are executed in order to gain the soil property.

(b) Method

Core drilling is performed according to "Hydraulic feed rotary drilling" method, mounted appropriately on a platform. Single tube core barrels and tungsten bit are used in order to gain good quality of core samples.

The core samples are sequentially arranged in core boxes from top to bottom, representing soil types and layer distribution.

SPT are performed by dropping a 63.5 kg hammer from a height of 75 cm. The numbers of drop to penetrate 45 cm deep are noted, and the drops for the last 30 cm is taken as N value.

(c) Scope of Work

27 bore holes, with total length of 535 m were drilled. SPT were performed at every 1.0 metre depth with total test number is 501.

The detailed specification of each boreholes is available in the table below and the locations of borings are shown in Fig. 3.2.1.

| No | Hole | Depth (m) | SPT | Undisturbed Samples |
|---|---|---|---|---|
| 1 | DB – 1 | 30 | 27 | 3 |
| 2 | DB – 2 | 30 | 27 | 3 |
| 3 | DB – 3 | 30 | 27 | 3 |
| 4 | DB – 4 | 30 | 27 | 3 |
| 5 | DB – 5 | 30 | 27 | 3 |
| 6 | DB – 6 | 30 | 27 | 3 |
| 7 | DB – 7 | 30 | 27 | 3 |
| 8 | DB – 8 | 30 | 27 | 3 |

| | | | | |
|---|---|---|---|---|
| 9 | DB – 9 | 30 | 27 | 3 |
| 10 | DB – 10 | 20 | 20 | - |
| 11 | DB – 11 | 10 | 10 | - |
| 12 | DB – 12 | 10 | 10 | - |
| 13 | DB – 13 | 20 | 20 | - |
| 14 | DB – 14 | 10 | 10 | - |
| 15 | DB – 15 | 10 | 10 | - |
| 16 | DB – 16 | 30 | 30 | - |
| 17 | DB – 17 | 10 | 10 | - |
| 18 | DB – 18 | 10 | 10 | - |
| 19 | DB – 19 | 10 | 10 | - |
| 20 | DB – 20 | 10 | 10 | - |
| 21 | DB – 21 | 10 | 10 | - |
| 22 | DB – 22 | 10 | 10 | - |
| 23 | DB – 23 | 10 | 10 | - |
| 24 | DB – 24 | 10 | 10 | - |
| 25 | DB – 25 | 10 | 10 | - |
| 26 | DB – 26 | 35 | 31 | 3 |
| 27 | DB – 27 | 30 | 27 | 3 |
| | TOTAL | 535 | 501 | 33 |

(d) Result

The core drilling results at each bore hole, including information about the soil type, thickness of layers, physical condition, N values, etc. are tabulated in Drilling Logs which is attached in the Volume VII Data Book.

(2) Laboratory Test

(a) Purpose

The laboratory test is subjected to determine the physical and mechanical properties of soil sample.

(b) Method

The laboratory test for soil sample followed the standard method of ASTM tabulated below:

| Item | Standard Method |
|---|---|
| Soil Samples | |
| Gradation Analysis | ASTM D422 |
| Moisture Content | ASTM D4959 |
| Specific Gravity | ASTM D854 |
| Liquid and Plastic Limits | ASTM D431 |
| Density | USBR 5370 |
| One dimensional consolidation | ASTM D2435 |
| Triaxial compression UU | ASTM D2850 |

(c) Result

The results of laboratory tests are presented in detail in the Volume VII Data Book.

### 3.2.2 Geological Condition and Soil Properties

(1) Semarang River

The soil profile along Semarang River was figured out from the result of the core drilling at the boreholes DB-4 to DB-6, DB-10 to DB-21, and DB-27.

In general, the upper parts of the boreholes were dominated by Riverbed Deposit (**Rd**), embankment (**B**) and or very soft Clay (**Ac**), while the lower parts are Hard Clay layer (**Dc**).

- Riverbed Deposit (**Rd**) consists of clay and is very soft. It was found at all boreholes, from the surface up to 3.0 m deep.
- Embankment (**B**) consists of clay, silt, sand, gravel, and sometimes masonry was found in the lower part. The average N value of this layer is nearly 1. The thickness of embankment is about 1 m.
- Very soft Clay (**Ac**) was found beneath the Embankment (B) in general and or Riverbed Deposit (**Rd**), consisting of clay and sandy clay, very soft to soft with N values ranging 0 to 20 with average less than 10. The thickness of this layer is estimated at more than 24 m. This layer locally contains a lense of 1.7 m of coarse grain Sand (**As**) and Original Clay (**Ao**).
- Hard Clay layer (**Dc**) is dark brown and the surface part is characterized by oxidation containing coral limestone. This layer lies beneath the very soft Clay layer (**Ac**). It ranges 20 m from the ground surface to the bottom of the holes.
- The N value of this layer is more than 50 in general.

(2) Asin River

The soil profile along Asin River is reflected from the result of core drilling at the boreholes DB-1, DB-2, DB-22, and DB-23.

In general, the upper part of the boreholes was dominated by Embankment (B) and very soft Clay (**Ac**), while the lower part is hard Clay layer (**Dc**), containing 3 m thick of Coarse grain Sand (**Ds**) lense at the bore hole DB-1.

- Embankment (B) consists of clay, silt, sand and gravel. The thickness of embankment is about 1 m.
- Very soft Clay (Ac) was found beneath the Embankment (B) in general, consisting of clay and sandy clay, very soft to soft with N value ranging 0 to 8. The thickness of this layer is estimated as 20 m.
- Hard Clay layer (Dc) is dark brown. The surface part is characterized by oxidation, containing coral limestone. The N value of this layer is in general more than 50.

(3) Baru River

The soil profile along Baru River was figured out from the results of core drillings DB-7, DB-8, DB-9, DB-24, DB-25 and DB-26.

In general, the upper part of the boreholes was dominated by Embankment (B) or Riverbed Deposit (Rd) and very soft Clay (Ac), while the lower part is Hard Clay layer (Dc), containing 1.5 m lense of coarse grain Sand (Ds) at the borehole DB-9.

- Riverbed deposit (Rd) consists of sand and clay and it is very soft. It was found at the borehole DB-24 at 1.8 m deep from the ground surface.
- Embankment (B) consists of clay, silt, sand, gravel in the upper part and masonry in the lower part. The average N value of this layer is 5 and more than 50 for the upper and lower part, respectively. The thickness of embankment is about 2 m to 7 m.
- Very soft Clay (Ac) in general was found beneath the Embankment (B) and or Riverbed Deposit (Rd), consisting of clay and sandy clay, very soft to soft with N value of 0 to 10 and average value of 6. The thickness of this layer is estimated as 17 m. This layer contains a lense of 1.7 m thick of coarse grain Sand.
- Hard Clay (Dc) is dark brown and the surface part is characterized by oxidation, containing coral limestone and 1.4 m lense of coarse grained Sand (Ds). This layer lies beneath the very soft Clay layer (Ac), from 22 m deep to the bottom of the holes. The N value of this layer is in general more than 50.

(4) Conclusion

- The project area geologically belongs to Damar Formation and alluvium deposit.
- Alluvium deposit is sedimented as river, lake, swamp, or coastal deposits. Each

type of deposit is physically and mechanically varied.

## 3.3 Hydrological Analysis

### 3.3.1 Data Collection and Compilation

The location of the Garang river basin and hydrological observatories are shown in Fig. 2.1.2 and the conditions of data recording are tabulated in Table 3.3.1. These observatories are being operated by Provincial Public Works Services (DPUP), Center of Meteorology and Geophysics (BMG), or Institute of Hydraulic Engineering (IHE).

Hourly rainfall data are available at two (2) automatic rainfall stations, namely BMG-Semarang station in lowland and Kaligading station in highland. Manual rainfall stations have only daily rainfall data. The stations shown in the table and figure were selected in the Feasibility Study in 1993.

The kinds and periods of the hydrological data added in this study stage are shown in the right part of Table 3.3.1 as "Additional Data" ranging from 1991 to 1996. The hydrological analyses, which are necessary for the flood control plan and water use plan, are supposed to be updated using the additional data.

### 3.3.2 Probable Rainfall

(1) Annual Maximum Rainfall

Hourly rainfall data are available at BMG-Semarang station and Kaligading station. Of the two, the latter has shorter record period of 17 years and contains many missing data. And it was found in the Feasibility Study that probable rainfall by the latter is smaller than that by the former. Therefore, the former, which has longer record period and contains less missing data, is adequate to be adopted.

Annual maximum rainfall for each duration (5, 10, 15, 30, 45, 60, 120 minutes, 3, 6, 12 hours and 1 day) at BMG-Semarang station in 28 years until 1996 are extracted and tabulated in Table 3.3.2.

(2) Probable Rainfall

Gumbel Method was employed to calculate probable rainfalls. The results are shown in Table 3.3.3 and Figs.3.3.1 and 3.3.2. One (1) hour probable rainfall of 100-year return period was calculated at 144.6 mm, and one (1) day rainfall of 100-year at

319.4 mm. These values are bigger than that of Feasibility Study by some 10 percent (refer to the lower part of Table 3.3.3).

(3) Rainfall Intensity Formula

As to Rainfall Intensity Formula, the Horner Type equation is used as well as the Feasibility Study (F/S) conducted in 1993 by the other JICA Study Team. The results of calculation are shown in Tables 3.3.4 and 3.3.5 and Fig.3.3.3. Two types of rainfall intensity curves are presented in Fig. 3.3.3 for short duration less than two (2) hours which is used for planning urban drainage and long duration more than one (1) hour which is used for planning dams.

(4) Design Storm

The length of One (1) day is appropriate to the duration of design storm to be used in the flood control plan, considering actual rainfall patterns, the size of river basin and the kind of flood control facilities.

Hourly distribution pattern of the design storm should be made from hourly rainfall data of actual storms. Hourly rainfall data of annual maximum rainfalls in the past 10 years at BMG-Semarang station are tabulated in Table 3.3.6. The ratio of each hourly rainfall to total are calculated, and shifted so that the peak ratio can locate in center time. Shown in Table 3.3.7 are the results. The average ratio of 10 storms are adopted to express the hourly distribution ratio of the design storm.

The design storm of each return period is calculated from probable one (1) day rainfall multiplied by the hourly distribution ratio (refer to the lower part of Table 3.3.7).

### 3.3.3 Design rainfall

(1) For Channel Improvement Plan

The rainfall intensity-duration with 2-year and 5-year return period are employed for the hydraulic design of channel improvement.

<u>2-year Return Period</u>

$$I = 1,567/(T + 11.79)^{0.74} : T \leqslant 2 \text{ hr}$$

$$I = 2,417/(T + 10.80)^{0.81} : 2 \text{ hr} < T \leqslant 12 \text{ hr}$$

5-year Return Period

$$I = 1{,}271/(T + 6.95)^{0.61} : T \leqq 2 \text{ hr}$$

$$I = 3{,}245/(T + 14.75)^{0.83} : 2 \text{ hr} < T \leqq 12 \text{ hr}$$

where, I : average rainfall intensity during time of concentration (mm/hr)

T : time of concentration (min)

(2) For Pump Drainage Plan

Consecutive 12 hours rainfall with a 5-year return period proposed in the previous F/S is applied as the design rainfall for the pump drainage plan. The rainfall depth and its hourly distribution are shown in Fig. 3.3.4.

### 3.3.4 Flood Discharge Plan

(1) Run-off Formula

The Modified Rational Formula, which developed in Urban V and proposed in the previous F/S, is also applied for the calculation of design discharge for channel improvement considering the topographic and land use conditions of the catchment area.

$$Q = 0.2778 \times C_s \times C \times I \times A$$

where,
- Q : peak discharge ($m^3$/sec)
- I : average intensity of rainfall (mm/hr)
- A : catchment area ($km^2$)
- C : run-off coefficient
- $C_s$ : storage coefficient (0.8 justified in Urban V)

The applied run-off coefficient ( C ) by land use is shown in the following table, which is the same one as the previous F/S.

| Land Use | Run-off Coefficient : C |
|---|---|
| Business & Surrounding Area | 0.8 |
| Residential Area | |
| - High density | 0.7 |
| - Medium density | 0.6 |
| - Low density | 0.5 |
| Industrial and Harbor Area | 0.8 |
| Green Zone and Others | 0.3 |

(2) Design Discharge

The design discharges of the Semarang river system have been revised based on the following revision:

(a) to use the design rainfall of 5-year return period revised for channel improvement plan,

(b) to use the actual flow velocity after completion of channel improvement for estimation of time of concentration,

(c) to change the sub-drainage area of Old City from the Semarang to Baru river basins, and

(d) to add the drainage areas reclaimed from the river mouth of Semarang River to North Ring Road.

Design discharges of Semarang, Baru and Asin rivers are estimated by Modified Rational Formula mentioned for the following options:

Option A: Original Semarang River System, with three pumping stations

- Tributary : Asin River, Simpang Lima Channel
- Diversion : Baru River
- Pumping Station : Asin, Bandarharjo East and West

Option B: No Diversion System, with three pumping stations

- Tributary : Same as Alternative 1
- Diversion : None
- Pumping Station : Same as Alternative 1

Option C: No Diversion System, with two pumping stations

- Tributary : Same as Alternative 1
- Diversion : None
- Pumping Station : Asin and Bandarharjo

Table 3.3.8 shows the design discharge of the above options. Fig. 3.3.5 shows the drainage system, run-off model and design discharge of the options.

Finally the Option C was selected following the discussion with Semarang Municipality and Semarang Harbor Authority.

### 3.3.5 Design Tidal Level at River Mouth

The design tidal level at the mouth of Semarang River is reviewed based on the current tidal records at Semarang Harbor. The automatic tidal recorder was installed at the harbor in 1980 by Japan Port Consultants Ltd. and has always been adjusted to the bench mark of BPP M2 (+ 2.014 m from Low Water Spring of Semarang Harbor), which was installed on the pier supported by 27 m piles since 1976. According to the leveling survey conducted by the Study Team in October 1997, the elevation of BPP M2 is observed to be + 0.506 m for TTG (Titik Tinggi Geodesi), which is the national bench mark system based on MSL of Jakarta Harbor. So, the chart datum of the automatic water level recorder is 1.598 m below MSL of Jakarta Harbor and the conversion from BPP M2 to TTG can be made by the formula : TTG = BPP M2 - 1.598 m.

The revised design tidal levels at the mouth of Semarang River is proposed as follows:

| Water Level | BPP M2 System | TTG System |
|---|---|---|
| Highest High Water Level (HHWL) | + 2.048 | + 0.45 |
| Mean High Water Level (MHWL) | + 1.848 | + 0.25 |
| Mean Sea Level (MSL) | + 1.368 | - 0.23 |
| Mean Low Water Level (MLWL) | + 0.898 | - 0.70 |
| Lowest Low Water Level (LLWL) | + 0.698 | - 0.90 |

The revised HWL of + 0.25 m above MSL of Jakarta Harbor is analyzed to be 0.35 m lower than the previous one due to the land subsidence of the bench marks, TTG and BPP M2. Fig. 3.3.4 shows the tide levels of Semarang Harbor. MHWL of + 0.25 m above MSL of Jakarta Harbor is to be applied as the starting water level for the calculation of the design high water levels of Semarang and Baru rivers. However, considering the future land reclamation at the river mouth by further 800 m toward offshore as mentioned in Chapter 2, the starting water level for hydraulic calculation was assumed as +0.35 m.