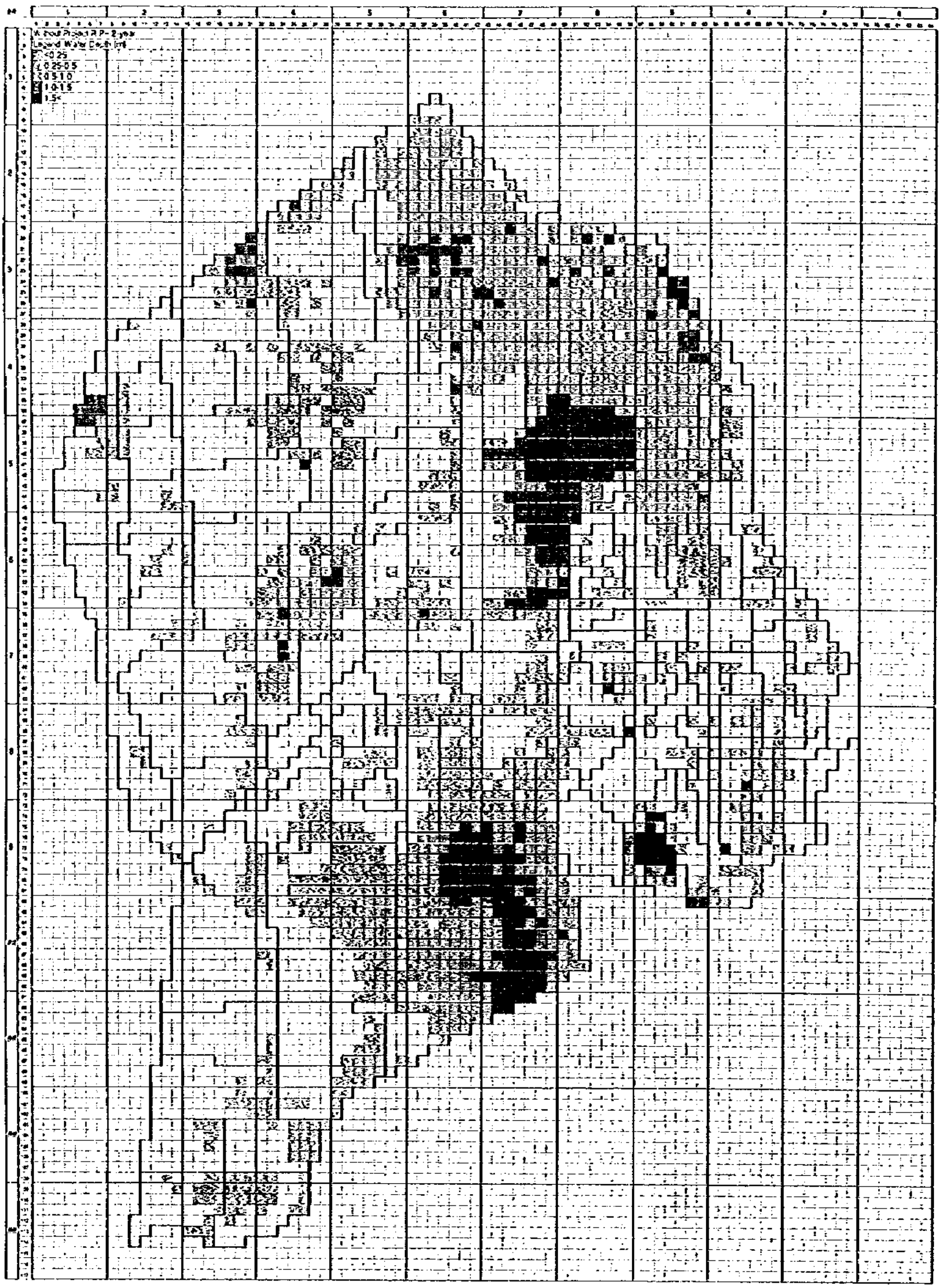
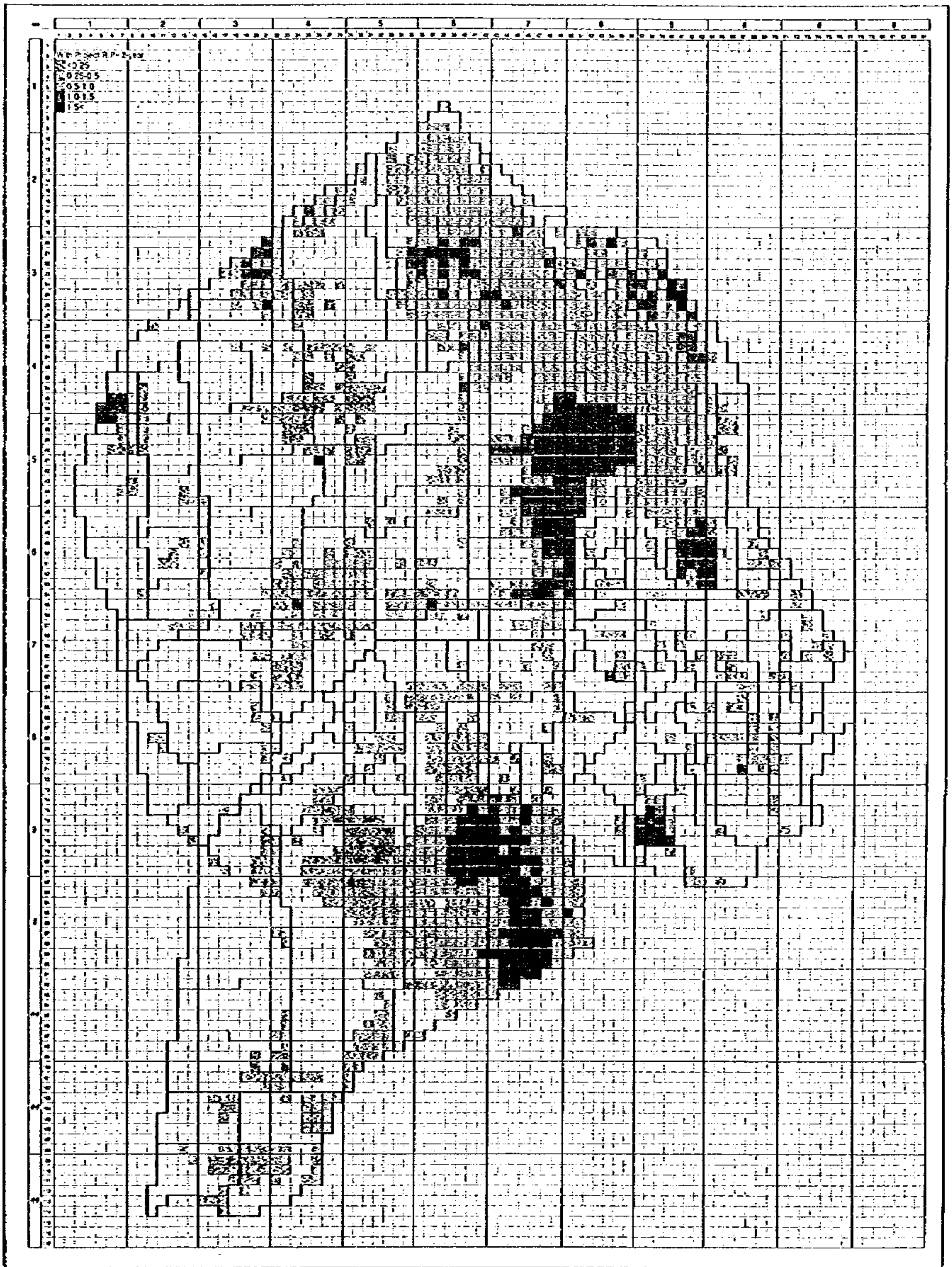
The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh JICA-CTIE International Co., Ltd. -Nippon Koei Co., Ltd.	Figure B4-7 Simulated Inundation Map of Case 1 (Year 1996)



The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh JICA-CTIE International Co., Ltd. -Nippon Koei Co., Ltd.	Figure B4-8 Simulated Inundation Map of Case 2 (2-year Return Period, Without-project)



The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh JICA-CTIE International Co., Ltd. -Nippon Koei Co., Ltd.	Figure B4-9 Simulated Inundation Map of Case 3 (2-year Return Period, With-project)

The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh JICA-CTIE International Co., Ltd. -Nippon Koei Co., Ltd.	Figure B4-10 Simulated Inundation Map of Case 4 (5-year Return Period, Without-Project)

The Study on Drainage Improvement and Flood Control
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Figure B4-11
Simulated Inundation Map of Case 5
(5-year Return Period, With-Project)

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in the Municipality of Phnom Penh
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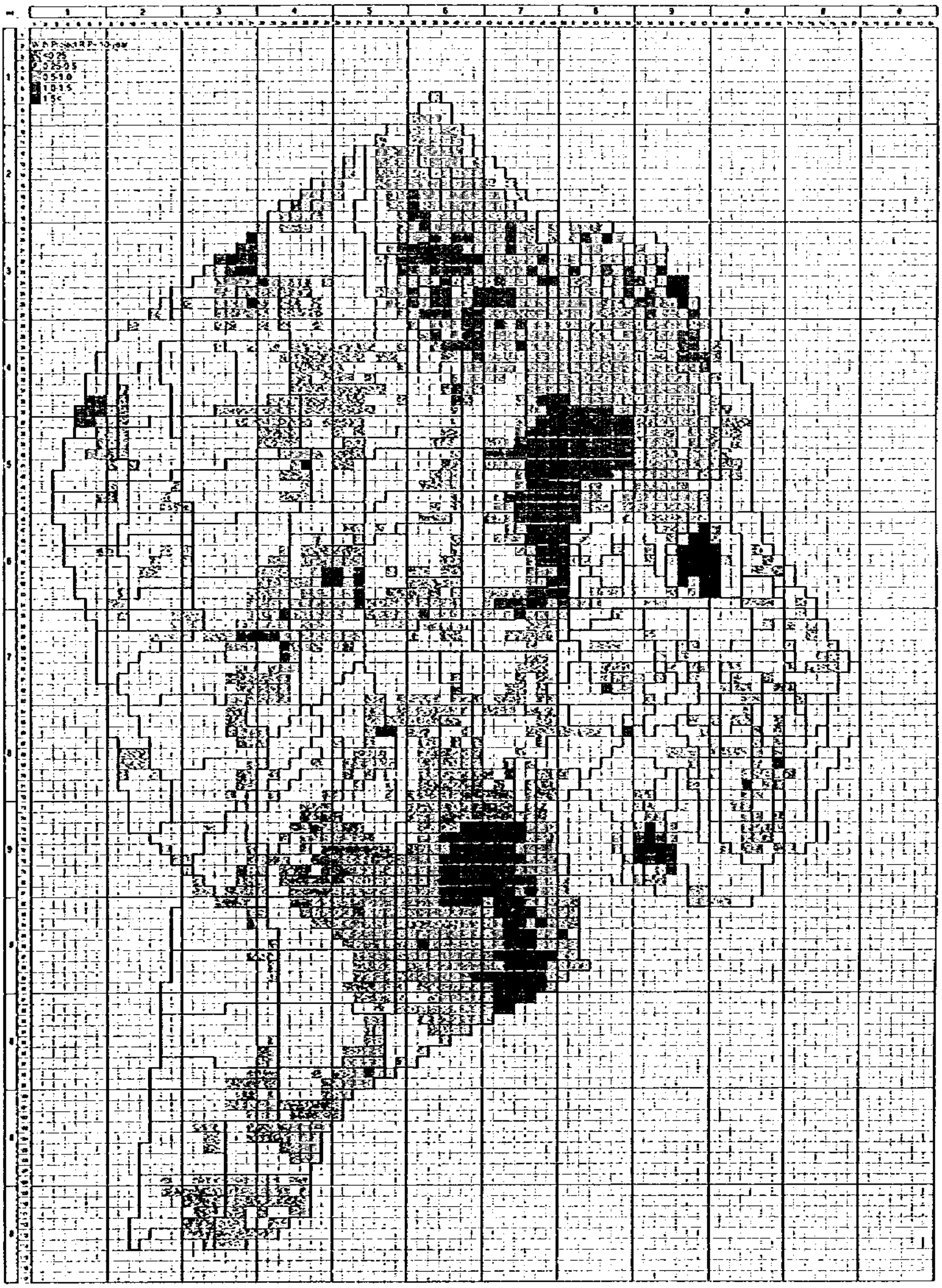
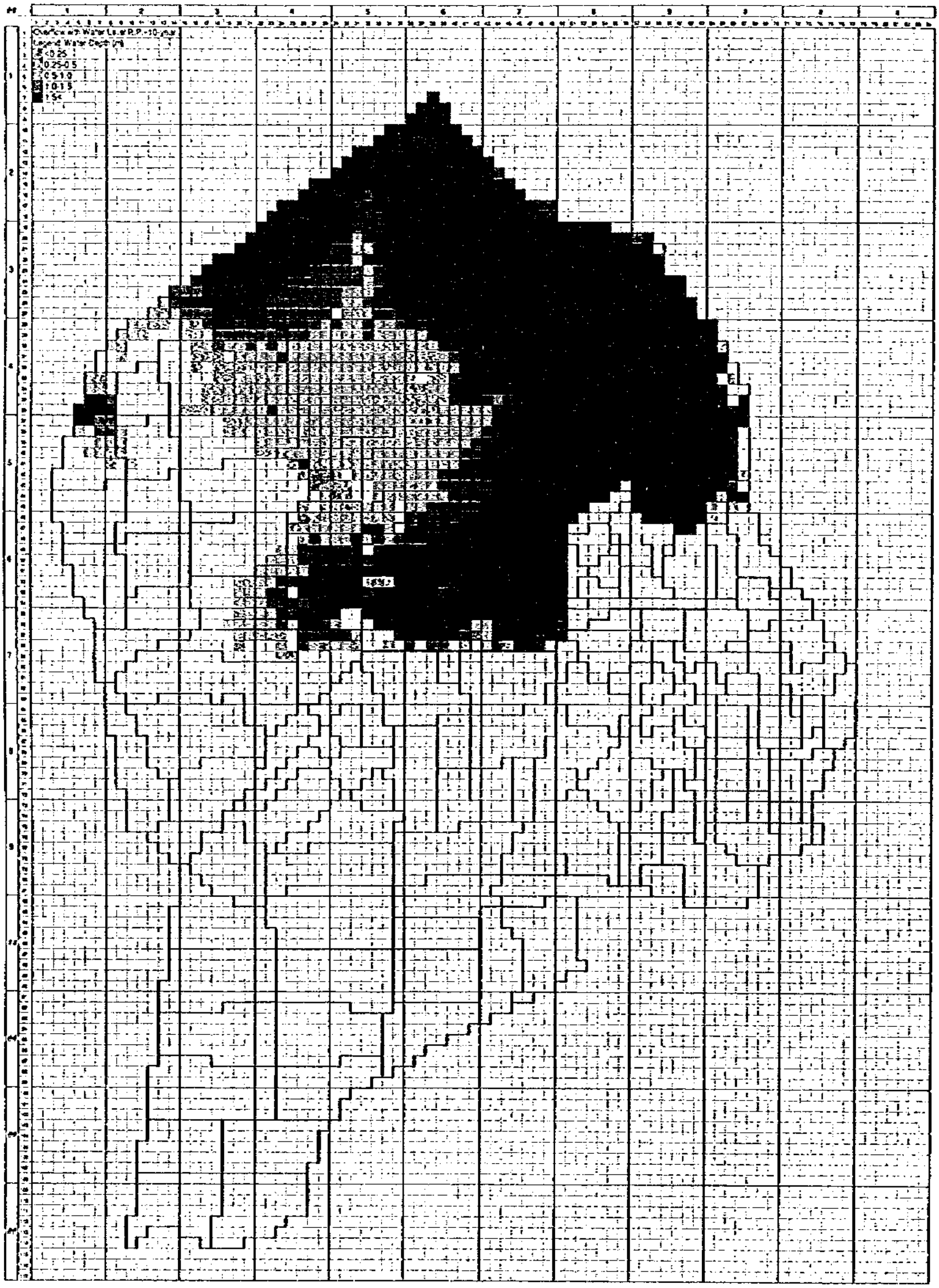
Figure B4-12
Simulated Inundation Map of Case 6
(10-year Return Period, Without-Project)



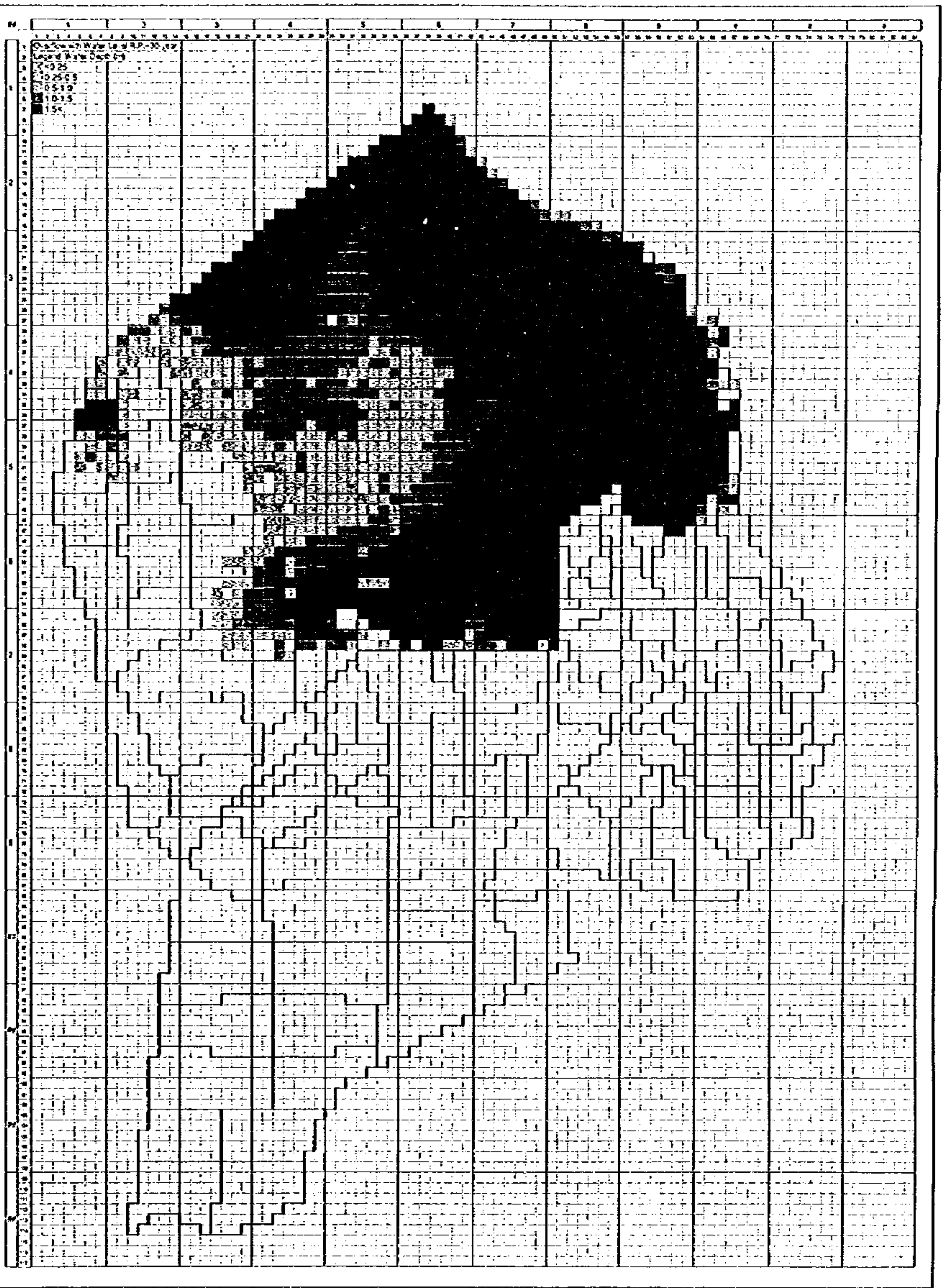
The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh JICA - CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	Figure B4-13 Simulated Inundation Map of Case 7 (10-year Return Period, With-Project)

The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh JICA - CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	Figure B4-14 Simulated Inundation Map of Case 8 (30-year Return Period, Without-Project)

The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh JICA - CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	Figure B4-15 Simulated Inundation Map of Case 9 (30-year Return Period, With-Project)



The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh JICA - CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	Figure B4-16 Simulated Inundation Map of Case 10 (Overflow with 10-year Return Period Water Level)



The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh JICA - CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	Figure B4-17 Simulated Inundation Map of Case 11 (Overflow with 30-year Return Period Water Level)

Sector C

Topography and Geology

6-T-8/

THE STUDY ON
DRAINAGE IMPROVEMENT AND FLOOD CONTROL
IN THE MUNICIPALITY OF PHNOM PENH

SECTOR C: TOPOGRAPHY AND GEOLOGY

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C1. Introduction

This Supporting Report, Sector C "Topography and Geology" presents the results of the topographic survey and soil mechanical investigation for the Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh. Field work and data processing for both survey and investigation were carried out on subcontracting basis: the former was sublet to a joint survey company formed by FINNMAP in Phnom Penh and THAI MAPPING SERVICE in Bangkok, while the latter to a local investigation company entitled CONIPEX Corporation Ltd. Detailed field data and information are therefore filed in separate volumes prepared and submitted by either firm.

This Sector comprises the following chapters:

(a) C1. Introduction: this chapter;

(b) C2. General Topography and Geology: mentioning overall features of the topography and geology in and surrounding the Study Area in use of the survey and investigation results obtained as well as existing publications available;

(c) C3. Mapping in the Master Plan Stage: stating the baselines and methodology for the survey works in order to produce 1:2,000 and 1:10,000 topographic maps, complete with 0.5 m-interval contour lines, covering the whole Master Plan study area;

(d) C4. Surveys in the Feasibility Study Stage: briefing the survey results of cross-sectioning, profiling, sounding and topographic mapping in and along the expected construction sites identified for two feasibility studies: Reinforcement of Kop Srov and Tompun Dikes, and Tompun Watershed Drainage Improvement; and

(e) C5. Soil Mechanical Investigation in the Feasibility Study Stage: compiling the soil mechanics investigation results and technically important findings through boring, test pitting and laboratory tests, which will serve as basic data for the preliminary design of major structures to be proposed in the feasibility studies.

C2. General Topography and Geology

2.1 Topography

The land of Cambodia is composed practically solely of a vast lowland, although it is dotted with small hills and plateaus, and fringed by mountainous areas on its border. The lowland, usually called the central plain, extends with the Tonle Mekong and Sap rivers and their tributaries, and shares extremely important position in terms of population, economy and politics of the country.

The City of Phnom Penh is located at the southern part of the central plain, where the Tonle Mekong and Sap rivers merge on it's western side. The old city area, together with nearby villages and settlements, develops on natural levees which are relatively high land with elevations of 9 to 11 m formed by the two rivers. The rest of the city area is literally low and flat, where there are cultivated lands, grazing lands, lakes/swamps and small to medium streams flowing towards the major rivers.

The Study Area, as a whole, slopes down moderately from west to east and from north to south. The difference between the lowest and highest elevations is approximately 10 m (4 to 14 m). There is a high terrain zone measuring a maximum elevation of 14 m between Prey Key Village and the western part of Pochentong Airport, however no terrain is higher than EL. 14 m within the Study Area. The Boeng Puongpeay area has low elevations of 5 to 6 m, and the Tompun area of 4 m at the lowest point. The remaining area representing most of the Study Area, in general terms, ranges between 7 m and 10 m in elevation.

2.2 Geology

The geological structure of the Mekong Delta region, where the Study Area is situated, was formed from Precambrian to Holocene ages. The oldest massif of the region includes granite, gneiss, quartzite and other crystalline rocks considered being of Precambrian to early Paleozoic ages. During Paleozoic Age, areas north and south of this massif were downwarped and a thick series of limestone, sandstone and shale of Ordovician to Carboniferous ages accumulated in the depressed areas.

In the late Carboniferous age, the older Paleozoic sedimentary rocks were metamorphosed, deformed and uplifted during the Hercynian orogeny. Also, during the Hercynian orogeny, large granite plutons with associated dacite dikes invaded the older Paleozoic sedimentary rocks. During and following the Hercynian orogeny, major volcanic activity was recorded in andesite flows and in rhyolite/dacite flows that rise above the deltaic alluvium in the north of the Study Area. The trend coincided with that of the tectonic trough in which the alluvial complex of the Mekong Delta was later deposited.

The northwest-trending tectonic trough, now filled with the Quaternary alluvial complex of the Mekong Delta, began to subside in late Tertiary age, probably along lines of crustal weakness that had developed in the Hercynian orogeny. During Plio-Pleistocene Age, the Old Alluvium was deposited by the Mekong River and its tributaries in a vast deltaic fill. The deltaic fill attained a thickness of 600 m or more along the axis of the trough, but thinned to a featheredge along the massif margins. Concurrent with the early stages of the alluviation, local basaltic eruptions in lava flows and small volcanoes occurred along the northeastern and southwestern (running west of the Study Area) margins of the trough.

Along both margins, the Old Alluvium is in places interbedded with and in part overlain by basalt flows. Basalt flows are also interbedded with sand and gravel beds of the Old Alluvium near the Study Area.

Gentle downwarping along the axis of the delta and some uplift of the Old Alluvium along the northeast and the southwest margins has occurred as the trough has subsided and succeedingly Holocene deltaic alluvium was deposited. The Holocene Alluvium, consisting largely of unconsolidated silt and clay with some lenses of sand, blankets virtually the entire delta. The Holocene Alluvium in and around the Study Area has generally a thickness of less than 25 m and thickens to more than 100 m along the seaward of the delta. The Holocene Alluvium differs from the Old Alluvium in having a generally finer texture, almost no laterite, and a relative abundance of shell and lignite layers. Both the Holocene and the bulk of the Old Alluvium are considered to be of Quaternary Age.

C3. Mapping in the Master Plan Stage

3.1 Existing Maps and Survey Datum

3.1.1 Existing Maps and Aerial Photographs

The following table shows a list of existing topographic maps and aerial photographs for the Study Area:

Item	Scale	Covering Area	Quantity on Project Area	Prepared by	Year	Issued by
Topo. Map	1:2,000	Phnom Penh Area	100	IGN France	1995	Cadastral Dep. Municipality of Phnom Penh
	1:5,000	Ditto	24	Ditto	Ditto	Ditto
	1:10,000	Ditto	9	Ditto	Ditto	Ditto
	1:50,000	Whole Country	2	AMS (US Army Map Service) Viet Nam Army Mapping Agency	1960-1980	AMS (US Army Map Service) Viet Nam Army Mapping Agency
	1:100,000	Ditto	7 (Catchment Area)	Viet Nam Army Mapping Agency	1960-1980	Viet Nam Army Mapping Agency
Aerial Photo	1:10,000	Phnom Penh Area	Approx. 170	IGN France	1993	Cadastral Dep. Municipality of Phnom Penh
	1:25,000	Mekong River Basin Area	34	FINNMAP	1992-1993	Cambodia National Mekong Committee

3.1.2 Geodetic Datum, Map Projection and Vertical Reference

The geodetic datum applied in this topographic mapping works are as follows:

- Datum : NAD 83 (North American Datum 1983)
- Ellipsoid : GRS80 (Geodetic Reference System 1980)
- Semi-major axisis : a = 6378137.00000 m
- Reciprocal Flattening : 1/f = 298.257222101

Map Projection System is the UTM (Universal Transverse Mercator) Zone-48 as follows:

- False Northing : 0.000 m
- False Easting : 500,000.000 m
- Longitude of the Central Meridian : 105° 00.00 ˝
- Latitude of Origin of Projection : 0° 00.00 ˝
- Scale Factor at Central Meridian : 0.9996

Vertical Reference is the Mean Sea Level at HA TIEN:

- Reference Point : F/P SPK 11.504m

Note: Horizontal UTM values based on the GRS 80 Ellipsoid applied in this project differ approximately 317 m south and 422 m east from the UTM grids of the Indian 1960 datum on the 1:50,000 and 1:100,000 scale national base map series.

3.2 Ground Control Survey

3.2.1 Ground Control and GPS Surveys

A total of 13 new ground control points were established by GPS for the two separate photogrammetric Digital Mapping areas, 8 points in the northern (Block 1) and 5 points on the southern (Block 2). The starting points for the ground control survey were IGN GPS-stations No 2, 5 and 9. The distribution and numbering of new GPS stations are shown in Figure C3-1.

The survey was carried out by using four geodetic accuracy GPS receivers of type ASHTECH P-12, with one hour observation time on each station. The observed vectors were post-processed by ASHTECH's FILLNET GPPS post processing software and the whole network was adjusted by a three dimensional adjustment software. Adjusted WGS-84 coordinates were transformed to GRS-80 referenced ellipsoid. The elevations of all newly established stations were determined by leveling.

The GPS control points were marked by concrete monuments according to the national survey standard of Cambodia. A point description sheet was prepared for each of the new ground control points. Each point was pricked on aerial photo enlargements (in scale 1:7,500 scale) and on contact prints. The final adjusted coordinates are listed in Table C3-1.

3.2.2 Vertical Control and Third Order Leveling

A total of 60.5 km leveling lines along main roads, the outer and inner ring dikes was measured and tied to the existing network for vertical control. The elevations of all newly established GPS-monuments were also leveled. The work was carried out with closed loop leveling by one leveling team with one auto leveling instrument and two rod-men and by double running observations.

Temporary bench-marks were established in 2-3 km interval. Reference height of Bench-Marks to be used for the third order leveling were as flows:

BM No.	Elevation (m)	BM No.	Elevation (m)
IGN 3	12.02	IGN 13	10.27
IGN 10	10.55	IGN 19	10.24
IGN 11	10.32	IGN 32	9.08
IGN 12	9.18	IGN 39	9.73

3.2.3 Spot Height Leveling

Spot height leveling was carried out by four leveling teams with four auto-leveling instruments in two different phases. The first phase covered the core areas of Phnom Penh City and the second phase covered the surrounding sub-urban and rural areas.

The interval of spot heights were approximately 100m. The level points were pricked on the aerial photo enlargements. The temporary bench marks were established at every 2-3 km. Those temporary bench marks were also pricked on the aerial photo enlargements.

All the location of spot height leveling points were first marked on both existing and new paper plots of 1:2,000 maps. The X and Y coordinate of each point were obtained by manually digitizing on a table digitizer, and the height values are added to the digitized data set. Those digital data are then processed in the same way as the radiation leveling data addressed below.

3.2.4 Radiation Leveling

Radiation leveling was done from traverse points, which are measured and established around the areas outside Phnom Penh, covering the 210 km^2. The traverse points were tied to the existing GPS-network.

The measurements were carried out by five survey teams using total stations. All X, Y and H coordinates of each point were surveyed and stored. The necessary supplementary points, needed as the starting points for the spot height measurements, were established at the same time with this traversing. The distribution of all leveling routes and spot height points are shown in Figure C3-2.

3.2.5 Field Verification

Field verification was done in two phases. In the first phase, the keys for photo interpretation, together with all other data needed in stereo plotting were collected simultaneously by GPS-survey. All such data, which are not visible on the aerial photography, but should have to be shown on the maps, were verified in the field and marked on the 1:7,500 scaled aerial photo enlargements. In the second phase, the preliminary plots of the maps were used to verify some matters raised during plotting, and to classify public buildings etc.

3.3 Photogrammetric Digital Mapping

3.3.1 Aerial Triangulation

Aerial triangulation of fourteen (14) stereo models were carried out by analytical stereo-plotter Kern DSR1/Qasco using existing 1:25,000 scale aerial photographs which were taken in November 1992, and owned by Cambodia National Mekong Committee. The northern area (block 1) had eight models and the southern area (block 2) had six models. The observations of photo coordinates were made using QASCO aerial triangulation software in stereo comparator mode. Photo details were selected as pass and tie points. Measurement of fiducial marks (interior orientation) was performed prior to the corrections of control- pass- and tie point measurements due to the lens distortion, atmospheric refraction and earth curvature.

Computation of aerial triangulation was done by using MMH85O BUNDLE BLOCK ADJUSTMENT program. All thirteen new GPS points and total of twenty eight (28) leveling points were used as control points in the block adjustment. The standard error of unit weight in block 1 was 5.3 microns in image (0.13 m on the ground), and that in block 2 was 4.2 microns in image (0.16 m on the ground). The X, Y and H residuals of control points and discrepancies at the pass points between the adjacent models after adjustment have been specified to be less than 0.08 % of the flight altitude of the photography in the technical specifications.

The distribution and numbering of the aerial triangulation are shown in Figure C3-3 and the final adjusted coordinates are listed in Table C3-2.

3.3.2 Photogrammetric Digital Mapping

The digital data capture was done by using KERN DSR1/Qasco analytical stereo-plotter and KORK Digital Mapping software. The separation of data layers and general map layout were designed referring to the Phnom Penh Map Series 1:2,000, produced by IGN International, France. In total, thirty six (36) layers of lines, 5 layers of symbols and some text layers were collected by stereo digitizing and those data were converted into DXF-format for editing. A list of layers is shown in Table C3-3.

Plotting the photogrammetric spot heights was done after completion of the radiation leveling over both of the new mapping areas. The radiation leveling points were used as additional control points in absolute orientation of the models.

The photogrammetric spot heights were made as separate layer in DXF files. The DXF-formatted data collected by stereo digitizing were loaded to the Auto CAD workstation. The data collected in field identification such as names were added to the digital data sets. The line types and symbols were designed to be similar to those in IGN-map series of Phnom Penh, and the general map layout, the legend were referred to that map series, as well. A total of thirty-seven (37) new map sheets were produced, of which thirteen (13) sheets were combined with existing digital map data of the IGN 1:2000 scale map series.

Before the final out puts, a separate plotting of map data combined with radiation leveling and spot heights was produced. The final plotting of each sheet of scale 1:2,000 was performed in black and white on a polyester base, using HP Design-Jet 2500CP color ink jet plotter. The map data were stored in DXF format on CD-ROMs.

3.4 Contour Line Maps

The study area is covered by one-hundred-three (103) sheets in total of 1:2000 scale maps, of which sixty-six (66) sheets were existing and thirty-seven (37) sheets were newly produced. Contours of 0.5 m interval are generated for whole study area, by using the spot height leveling and radiation leveling data.

The existing map sheets were scanned as raster image in 200 dpi resolution and imported to ADOBE Photo-Shop software. The spot height and radiation leveling data were first sorted by corresponding map sheet and imported to the ADOBE Photo-Shop as well. Both data sets were combined sheet-by-sheet and plotted black and white in 1:2,000 scale on polyester base using HP Design-Jet 2500CP color ink jet plotter.

Difficulties encountered in automatic contour line creation and compilation by the computer software, which is unsuitable for correlation of map notation among raster topographic futures, and for production of connected 0.5m intervals contour line properly, especially on the very flat terrain area. For this reason, contour lines were generated and edited by manual drawing and inking method for all the map sheets, that is 37 new maps and 66 scanned existing map sheet. The sheet index of contour map compilation area is shown in Figures C3-4 and C3-5.

In addition, eight sheets of 1:10,000 scale topographic maps with 0.5 m interval contour lines were compiled and printed out using the data automated from both new and existing plotting data files. The contour line generation has been done by manual drawing and inking method likewise with 1:2,000 scale mapping. The size of the map sheets conforms to the existing map series of the same scale. The sheet index of 1:10,000 scale compiled map is shown in Figure C3-6.

3.5 Results of Survey Work

Following results were produced by topographic mapping work.

(1) 1:2,000 scale topographic maps with 0.5m-interval contour lines:

- (a) New Mapping Area : 37 sheets, 1 set
- (b) Existing Map Area : 66 sheets, 1 set

(2) 1:10,000 scale compiled topographic maps with 0.5m-interval contour lines : 8 sheets, 1 set

(3) Map Data in CD-ROM : 4 pieces, 1 set

(4) Computation Result and Field Book of Control Survey

- (a) Computation Result : 1 volume, 1 set
- (b) Field Book : 2 volumes, 1 set

C4. Survey in the Feasibility Study Stage

The following table shows topographic survey work items in the feasibility study stage. The location map is shown in Figure C4-1.

Work Item	Location		Work Volume
(1) Cross-Sectioning and Profiling	(1)-a	Kop Srov Dike	10.5 (km)
	(1)-b	Tompun Dike	5.3
	(1)-c-i	Meanchey Channel	5.0
	(1)-c-ii	Salang Channel	1.1
	(1)-c-iii	Tompun Inlet Channel	1.02
	(1)-c-iv	Tompun Outlet Channel	0.43
	(1)-d-i	Samdach Monireth Road	3.1
	(1)-d-ii	Jawaharlal Nehru Road	1.16
	(1)-e	Sap River Front	1.07
	Total		28.68
(2) Sounding	(2)-a	Boeng Kak	6 (lines), 5.7 (km)
	(2)-b-i	Upper Boeng Trabek (North)	2 , 0.51
	(2)-b-ii	Lower Boeng Trabek (South)	3 , 1.06
	(2)-c	Boeng Salang	3 , 0.95
	(2)-d	Boeng Tompun	6 , 3.52
	Total		20 , 11.74
(3) Topographic Mapping	(3)-a	Tompun Pumping Station	5.5 (ha)
	(3)-b-i	Tum Nup Toel Sluiceway	1.0
	(3)-b-ii	Samdach Monireth & Salang Sluiceways	6.5
	(3)-b-	Svay Pak Sluiceway	0.4
	Total		13.4

For all the survey works in the feasibility study stage, elevation and coordinates in the works were referred to same coordinates system as the master plan stage works.

4.1 Cross-sectioning and Profiling

Cross-sectional survey was carried out in the sections where exist dikes, channels/river and roads at every 100 meter pitch in direction perpendicular to the route using total station and level equipment.

(1) The elevation for the cross section survey was measured at:

(a) Every two (2) meters from the center line at least;

(b) Center point of the line;

(c) Slope changing point;

(d) Water level and channel bed; and

(e) Road, bridge, house and other artificial structures at their every corners and edges.

(2) Accuracy of the leveling based on the reading was less than 1 cm.

(3) Accuracy of distance measuring was less than 0.1 m.

(4) Width of cross section was 100 m in principle, but incase of difficulty of measurement toward the cross section line where the line was blocked by buildings, fence etc., was shorter than 100 m.

4.2 Sounding

Sounding survey was carried out for Boeng Kak, Boeng Salang, Boeng Trabek and Boeng Tompun. Four lakes of water depth were measured along the East-West or North-South directions specified on the topographic map at a scale of 1:2,000 at an interval of 20 m pitch on the each specified line using total-station for direction control, and using rod for water depth measuring:

- Accuracy of the sounding was based on the reading less than 10 cm.
- Accuracy of distance measuring was less than 0.5 m.

4.3 Chart drawing

4.3.1 Cross-sections

Based on the Cross-sectional survey data, cross-section charts were produced by using CAD software, and plotted out at a vertical scale of 1:100 and horizontal scale of 1:100.

4.3.2 Longitudinal Profile

Based on the cross-sectional survey data, longitudinal profile charts were produced by using CAD software, and plotted out at a vertical scale of 1:100 and horizontal scale of

1:5,000. Plotting data for out-put was chosen height from each station as following manner:

(a) The highest elevation in each station for the Kop Srov Dike and Tompun Dike;

(b) The lowest elevation in each station for the channels such as Meanchey etc.;

(c) Road center elevation in each station for the Samdach Monireth and Jawaharlal Nehru roads; and

(d) Riverbank elevation in each station at the Sap Riverfront.

4.4 Topographic Mapping

Topographic mapping by offset survey using total-station was carried out for Tompun pumping station, Tum Nup Toel sluiceway, Samdach Monireth & Salang sluiceway and Svay Pak Sluiceway sites. Accuracy of measuring distance was 1/1,000 and accuracy of measuring elevation was less than 1cm. Map editing was carried out using field data and CAD software at a scale of 1:200 with contour lines at interval of 0.5 m output for each site.

4.5 Results of Survey Work

Following results were produced by topographic survey work in the feasibility study stage:

(a) Cross-section Chart : V = H = 1:100

(b) Longitudinal Profiling Chart : V = 1:100, H = 1:5,000

(c) Sounding Profile Chart : V = 1:100, H = 1:1,000

(d) Topographic Map : 1:200 scale with 0.5 m contour line interval

C5. Soil Mechanical Investigation in the Feasibility Study Stage

5.1 Work Items

Soil mechanics investigation at expected construction sites of the flood control and drainage improvement structures subject to the feasibility studies was carried out consisting of the following items:

(1) Borings with the standard penetration test (SPT) at intervals of 1 m or 1.5 m;

(2) Test pits with an area of 2 m by 2 m and depths of 1 to 2 m; and

(3) Laboratory physical tests to identify the following soil properties:

(a) Specific gravity,

(b) Moisture contents,

(c) Unit weight,

(d) Atterberg limits, and

(e) Grain size.

The investigation aims mainly at:

- Clarifying the subsoil strata and ground water levels,
- Measuring N-values by SPT to evaluate bearing capacities of subsoils for the design of proposed structures, and
- Taking soil samples for observation and the laboratory tests that exhibit the precise soil properties.

5.2 Results of Investigation

Boring was made at 11 locations (with SPT) whilst test pitting at 19 locations, both along with soil sampling followed by the laboratory test. The location map of boring and test pitting is shown in Figure C5-1, and quantities of each investigation are listed in Table C5-1, which is summarized as below:

Location of Borings and Test Pits

Area	Boring	Test Pit
Kop Srov Dike	5 locations (BH 1 to BH 5)	9 locations (KT 1 to KT 9)
City Core Area	3 locations (BH 6, BH 9 & BH 11)	2 locations (MT 3 & MT 8)
Tompun Area	3 locations (BH 7, BH 8 & BH 10)	6 locations (MT 1, MT 2 & MT 4 to 7)
Borrow Area	-	2 locations (BT 1 at Udon & BT 2 at Basset)
Total	11 locations	19 locations

The results of each investigation/test are put together into a table or a figure as follows:

(a) Boring logs : Figure C5-2

(b) Test pit logs : Figure C5-3 (No logs were prepared for the test pits at borrow areas)

(c) Laboratory test results : Table C5-2

5.3 Findings

Findings attained from the soil mechanics investigation are described hereunder. The description is made location by location, namely along Kop Srov Dike, in the City Core area and in the Tompun area, because the subsoil condition in each location is of its own stratificational characteristics or tendency.

5.3.1 Kop Srov Dike

Boring was performed at 5 locations from the Svay Pak Drainage Sluiceway site (BH 1) towards the west along Kop Srov Dike (BH 2 to BH 5). The results are summarized in the table below where findings through the test pitting and laboratory test are also reflected:

Summary of Soil Mechanics Investigation along Kop Srov Dike

Boring No.	Ground Level (EL. m)	Bearing Layer * (EL. m)	Ground-water Level (EL. m)	Soil Condition above the Bearing Layer					Remarks
				Classif-ication	N-value	W.L. (%)	W.P. (%)	W (%)	
BH 1	9.9	-16.6 Sandy clay	5.1	Clay	10-19	47-51	24-25	15-21	Upper 8m
				Sand	15-37	-	-	20-29	Lower 18.5m
BH 2	7.0	Lower than -8.5	6.5	Clay	2-24	34-55	17-26	26-52	Upper 13 m
				Clayey sand	17-26	24-26	12-13	14-17	Lower 2.5 m
BH 3	6.1	- 11.4 Sandy clay	5.4	Clay	7-26	30-65	18-24	19-28	17.5 m thick
BH 4	6.5	- 2.5 Sandy clay	4.2	Clay	10-29	31-50	14-17	18-21	9 m thick
BH 5	8.5	4.5 Sandy clay	7.5	Clay	7-24	41	16	20	4 m thick

* With N-values of over 30.

This table exhibits several soil-mechanical natures of the subsoil along Kop Srov Dike. These are enumerated hereunder to serve as basis for the design and construction of proposed structures therein.

(1) Bearing Layer

The ground levels of the boreholes range, in random order, between EL. 6.1 m and EL. 9.9 m with groundwater levels of EL. 4.2 to 7.5 m. In spite of such surface configuration, the bearing layer, defined as a layer with N-values of over 30, lies in such a manner that it slopes down constantly from west to east. It appears on EL. 4.5 m (4 m deep from the ground) at BH 5 near the western edge of Kop Srov Dike, while

EL. - 16.6 m (26.5 m deep from the ground) at BH 1 in front of the Tonle Sap River. The layer is unchangingly composed of sandy clay.

Proposed to be constructed in the area are Svay Pak Drainage Sluiceway, comprising 3 cells of box culverts (1.5 m wide and 2 m high), and Kop Srov Dike with heights of 3 to 4 m. No serious problems are expected from the appearance of the bearing layer mentioned above although the sluiceway will require foundation piles reaching the bearing layer with an approximate length of 20 m.

(2) Soil Condition above the Bearing Layer

The bearing layer is uniformly covered by a clay layer with thicknesses of 4 to 17.5 m provided that sand and clayey sand layers intrude between them at BH 1 and BH 2, respectively. The clay is commonly firm, over 10 of N-value in general, and of low to medium plasticity. This nature of the clay will allow shallow excavations without difficulties such as slop failure and hazardous seepage. However, this clay, almost pure clay, cannot apply to embankment material for Kop Srov Dike.

In stead, soils procured from the Udon and Basset borrow areas are considered for that purpose (see Table C5-2 (2/2)). The former borrow is approximately 30 km away from Kop Srov Dike through NR-5 (well paved in most stretch), and has supplied good quality of laterite for various projects. On the other hand, the latter borrow is within an about 15 km distance from the construction site, however the access roads are quite poor and the soil is too coarse for dike material. In this case, it is recommended that the embankment material for Kop Srov Dike be transported from the Udon borrow area.

5.3.2 City Core Area

Three borings (BH 6, BH 9 and BH 11) were worked out in the City Core area. Likewise in Subsection 5.3.1 above, the results are summarized as follows:

Summary of Soil Mechanics Investigation in City Core Area

Boring No.	Ground Level (EL. m)	Bearing Layer * (EL. m)	Ground-water Level (EL. m)	Soil Condition above the Bearing Layer					Remarks
				Classif-ication	N-value	W.L. (%)	W.P. (%)	W (%)	
BH 6	10.2	- 4.8 Sandy clay	5.0	Clay	3-31	29-45	11-20	20-26	15 m thick
BH 9	8.8	- 3.2 Clayey sand	4.8	Clay	4-10	34	14	20	Upper 4 m
				Sandy silt	9-44	23-24	15-17	22-26	Lower 8 m
BH 11	7.1	- 5.4 Sandy clay	5.6	Backfill	0	40	17	31	Upper 4.5 m
				Clay	10-43	27-44	14-16	15-18	Lower 8 m

* With N-values of over 30.

Major findings are mentioned hereinafter.

(1) Bearing Layer

The three boreholes dug in the City Core area are EL. 7.1 to 10.2 m in ground level, EL. 4.8 to 5.6 m in groundwater level, and EL. - 5.4 to - 3.2 m in bearing layer (say, 12 to 15 m deep from the ground surface). By location, there exists less difference in each item. The soil of the bearing layer is sandy clay and clayey sand, which composition is similar to along Kop Srov Dike.

Structures planned in the City Core area in conjunction with the feasibility studies are Samdach Monireth, Jawaharlal Nehru and Salang drainage mains, and associated three drainage sluiceways at the outlets of Samdach Monireth and Salang drainage mains and at Tum Nup Toek. Most remarkable among them is the construction of box culverts, Samdach Monireth and Jawaharlal Nehru drainage mains, both underneath streets of the same name. The box culverts will be laid on the formation approximately between EL. 1 m and EL. 3 m (about 6 to 7 m deep under the street surfaces). To support the structure safely, piles shall be driven down to the bearing layer, however the lengths are expected to be not more than 8 m.

(2) Soil Condition above the Bearing Layer

The bearing layer is overlaid by a cohesive soil layer composed of clay, sandy silt and backfills with thicknesses of 12 to 15 m. The upper 3 to 4 m portion of the layer is relatively soft with N-values of 0 to 6, whilst the lower portion is firm with over 10 of N-value. This soil condition may pose no serious issues for shallow excavation and dredging anticipated along Salang Drainage Main and at the Tum Nup Toek Drainage Sluiceway site. However, the construction of box culverts beneath Samdach Monireth and Jawaharlal Nehru streets, with 6 to 7 m excavation, should incorporate temporary retaining walls of steel sheet piles in view of the considerably high groundwater level and low plasticity of the soil as well as mitigation of traffic interruption during construction.

On the other hand, the excavated materials, cohesive soils with quite low plasticity, are unsuitable for embankment and even backfilling but small-scale ones. Borrow material shall be procured for such purpose.

5.3.3 Tompun Area

In the Tompun area, three boreholes (BH 7, BH 8 and BH 10) were drilled to reveal the subsoil condition at the construction sites of Tompun Pumping Station and Regulation Pond as well as along Meanchey Drainage Main. The results are summarized in the following table:

Summary of Soil Mechanics Investigation in Tompun Area

Boring No.	Ground Level (EL. m)	Bearing Layer * (EL. m)	Ground-water Level (EL. m)	Soil Condition above the Bearing Layer Classif-ication	N-value	W.L. (%)	W.P. (%)	W (%)	Remarks
BH7	4.7	- 10.8 Sandy clay	2.5	Clay	9-12	37	11	-	Upper 4 m
				Clayey sand	6-32	28	12	-	Middle 3 m
				Clay	15-29	28-34	10-13	-	Lower 8.5 m
BH 8	5.0	- 9.5 Sandy clay	3.2	Silty clay	8-18	25	15	14	Upper 5 m
				Silty sand	14-42	26-44	11-15	14-22	Middle 7 m
				Clay	24-26	29	16	18	Lower 2.5 m
BH 10	5.5	Lower than - 21	3.3	Clayey sand	7-10	38	12	14	Upper 5 m
				Sandy clay	13-29	26	10	14	Upper middle 5 m
				Clayey sand	12-20	24	14	20	Lower middle 7 m
				Clay	16-32	34-40	16-17	19-20	Lower 9.5 m

* With N-values of over 30.

The investigation unveiled the subsoil condition in the Tompun area as follows.

(1) Bearing Layer

The results of two borings executed near Tompun Dike (BH 7 and BH 8) are alike, showing ground levels of EL. 4.7 m and EL. 5.0 m, groundwater levels of EL. 2.5 m and EL. 3.2 m, and bearing layers (sandy clay) of EL. - 10.8 m and EL. - 9.5 m, respectively. Tompun Pumping Station is proposed to be constructed between BH 7 and BH 8. To ensure the stability of the station, bearing piles shall be driven under the structure with an approximate length of 10 m.

In contrast, no bearing layer was confirmed at BH 10 correspondent to the upstream end of Tompun Regulation Pond even after drilling down to EL. - 21 m. However, heavy structures are not considered around the location, so that the deepness of the bearing layer can be ignored in designing work.

(2) Soil Condition above the Bearing Layer

On top of the bearing layer, there lies a relatively soft subsoil with thicknesses of approximately 15 m or more. Its N-values are 10 to 20 as a whole. Different from the areas along Kop Srov and in City Core, the subsoil in the Tompun area is characterized by its alternating stratification comprising cohesive layers, such as clay, silty clay and sandy clay layers, and sand layers such as clayey sand and silty sand layers. The cohesive layers are comparatively firm, but of low plasticity likewise in the City Core area.

Despite such alternation of cohesive and sand layers, the upper 5 m subsoil is supposed to be cohesive and slightly firm, in most places, taking into account the test pit results as well. Only exception is at BH 10 where a clayey sand layer appears in the depth. Shallow excavation planned in the project may thus not encounter serious problems. However, the excavated material is recommended to be hauled to adequate spoil banks, not to be used for backfilling or embankment.

Table C3-1 Ground Control Point (GPS) Final Coordinates

Station	Location	North(m)	East(m)	Height
NEW POINT				
GPS 0001	Prek Phnov V.	1,289,566.367	482,753.837	8.025
GPS 0002	Prek Phnov V.	1,287,613.785	484,682.055	6.843
GPS 0003	Tuol Sampov V.	1,285,553.248	482,373.166	7.995
GPS 0004	Chompar Meanrith Temple	1,284,092.081	479,267.860	8.916
GPS 0005	Chres Village	1,280,883.429	483,861.317	9.810
GPS 0006	Srae Rochcheak Vilage	1,281,131.992	478,152.803	12.253
GPS 0007	Don Auk Village	1,276,785.685	478,851.788	13.504
GPS 0008	Pochentong Airport	1,277,287.764	483,188.491	11.601
GPS 0009	Krang Doun tey Village	1,273,187.185	480,722.463	11.086
GPS 0010	Tuol Pong Ro Village	1,273,285.711	485,505.642	8.321
GPS 0011	Srae Nhoar Village	1,269,840.353	480,077.099	11.837
GPS 0012	Kveth Village	1,267,073.509	484,394.337	9.630
GPS 0013	Prey Sampor Village	1,266,106.651	478,421.751	13.507
REFERENCE POINT (IGN)				
n° 2	Russei Keo	1,286,422.422	487,484.855	8.36
n° 5	Dangkao	1,271,430.508	488,294.960	9.72
n° 9	Don Penh	1,279,279.323	491,088.087	11.12

Additional GPS Points for Radiation Leveling

Station	North(m)	East(m)	Height
1006	1,273,452.151	480,540.573	N/A
6001	1,281,128.444	478,478.160	N/A
1013	1,273,095.333	485,115.986	N/A
1011	1,273,675.997	484,680.894	N/A
98	1,276,811.216	484,996.663	N/A
2013	1,265,975.286	478,689.147	N/A
1001	1,270,261.455	480,081.880	N/A
2012	1,267,360.291	484,356.114	N/A

Other GPS Points (IGN)

Station No.	Station Name	North(m)	East(m)	Height
n° 03	KR□NG THNUNG I	1,281,465.081	483,159.386	12.02
n° 10	PREK PHNOU I	1,291,009.04	482,425.72	10.55
n° 11	PREK PHNOU II	1,288,953.34	484,169.72	10.32
n° 12	KOUK ROKA I	1,286,148.73	482,156.65	9.18
n° 13	KOUK ROKA II	1,284,379.89	480,764.09	10.27
n° 14	SVAY PAK II	1,284,286.56	485,037.32	8.71
n° 15	KHMUONH I	1,283,640.53	487,730.67	7.87
n° 16	RUSSEI KEO I	1,282,899.57	491,170.10	10.56
n° 17	PHNOM PENH THMEI I	1,280,751.05	485,806.81	9.21
n° 18	B2NG-KAK-I I	1,280,827.77	488,902.93	8.88
n° 19	KR□NG THNUNG II	1,278,583.85	482,686.13	10.24
n° 32	XH□OM CHAU I	1,273,314.16	486,252.78	9.08

Table C3-2 Aerial Triangulation Adjusted Coordinates

Northern Area (block 1)					Southern Area (block 2)				
Point No.	North (m)	East (m)	Height (m)	ID	Point No.	North (m)	East (m)	Height (m)	ID
1	1,289,566.38	482,753.84	8.03	0	9	1,273,187.19	480,722.46	11.09	0
2	1,287,613.45	484,711.92	8.59	1	10	1,273,285.71	485,505.64	8.32	0
3	1,285,553.25	482,373.17	8.00	0	11	1,269,840.35	480,077.10	11.84	0
4	1,284,092.08	479,267.86	8.92	0	12	1,267,073.51	484,394.34	9.63	0
5	1,280,883.43	483,861.32	9.81	0	13	1,266,106.65	478,421.75	13.51	0
6	1,281,131.99	478,152.80	12.25	0	14	1,286,422.42	487,454.86	8.36	0
7	1,276,785.69	478,851.79	13.50	0	15	1,271,430.51	488,294.96	9.72	0
8	1,277,287.76	483,168.49	11.60	0	16	1,279,297.32	491,088.09	11.12	0
101	1,287,552.40	483,947.10	10.67	2	202	1,269,175.66	479,430.84	12.85	2
102	1,286,182.11	482,140.27	10.91	2	203	1,266,832.02	479,552.37	14.00	2
103	1,284,883.84	480,439.14	10.60	2	204	1,267,476.31	480,148.83	14.28	2
104	1,283,976.65	479,248.83	10.55	2	205	1,267,371.62	482,960.78	11.90	2
105	1,283,351.94	478,899.46	10.55	2	206	1,269,131.63	483,221.47	9.83	2
107	1,280,963.45	478,196.82	13.15	2	207	1,269,917.26	483,813.44	10.19	2
108	1,279,912.43	478,508.82	13.68	2	208	1,270,483.08	484,343.67	10.04	2
109	1,278,581.42	478,981.79	13.89	2	210	1,272,311.67	484,627.42	9.33	2
110	1,277,467.15	479,150.76	14.42	2	213	1,271,736.75	480,272.71	13.58	2
111	1,278,179.44	480,485.04	12.29	2	215	1,271,244.57	486,257.85	9.16	2
112	1,278,069.93	482,728.75	10.47	2	34381	1,274,103.93	486,792.08	7.00	3
115	1,279,465.20	484,067.95	9.45	2	34382	1,271,314.01	487,161.00	6.54	3
116	1,280,289.75	484,019.67	9.29	2	34383	1,268,845.35	487,025.58	8.30	3
117	1,281,085.23	484,013.30	10.68	2	34391	1,273,893.32	484,302.49	8.07	3
120	1,284,347.00	485,042.66	7.69	2	34392	1,271,737.16	484,719.46	8.32	3
121	1,285,833.82	484,252.83	9.10	2	34393	1,269,283.08	484,541.40	8.36	3
1000	1,278,230.80	485,395.10	8.18	3	34401	1,273,996.30	482,048.94	8.68	3
1001	1,278,233.96	485,293.65	8.92	3	34402	1,271,293.53	482,082.58	10.96	3
1002	1,282,058.72	485,745.53	9.85	3	34403	1,268,864.86	481,820.55	11.29	3
1021	1,286,180.74	482,138.10	10.88	3	34411	1,273,530.74	479,418.32	11.71	3
1171	1,281,085.71	484,013.46	10.02	3	34412	1,271,116.18	479,269.02	13.00	3
2001	1,287,623.38	484,697.04	6.84	2	34413	1,269,609.16	479,706.77	11.85	3
32241	1,285,907.77	476,913.84	5.11	3	34751	1,269,910.65	477,201.30	12.86	3
32242	1,283,325.68	477,196.98	6.49	3	34752	1,267,306.70	477,097.25	12.09	3
32243	1,281,427.12	477,605.85	12.58	3	34753	1,265,080.47	477,036.24	11.14	3
32250	1,286,176.31	479,677.24	7.91	3	34761	1,269,533.52	479,874.41	11.64	3
32251	1,285,530.65	479,858.37	7.87	3	34762	1,267,778.10	479,812.34	12.25	3
32252	1,283,593.86	479,703.08	11.07	3	34763	1,265,417.96	479,996.90	11.79	3
32253	1,281,457.44	480,090.17	11.62	3	34771	1,269,552.65	482,875.45	10.06	3
32261	1,286,169.31	482,376.75	7.01	3	34772	1,267,154.98	482,816.47	11.60	3
32262	1,283,801.80	482,019.69	9.41	3	34773	1,264,988.42	482,769.36	10.90	3
32263	1,281,554.02	482,531.74	10.59	3	34781	1,269,769.75	485,381.47	8.11	3
32270	1,284,845.84	484,614.69	6.12	3	34782	1,267,482.21	485,438.28	8.62	3
32271	1,286,286.62	484,421.07	7.51	3	34783	1,265,001.68	485,306.78	7.74	3
32273	1,281,503.30	484,930.08	8.84	3	55511	1,269,840.54	480,076.15	11.60	3
33082	1,279,402.86	485,467.80	5.96	3					
33083	1,276,945.60	485,032.59	5.37	3					
33092	1,279,850.67	483,163.02	8.51	3					
33093	1,276,763.13	482,688.58	10.02	3					
33102	1,279,602.29	480,429.15	12.13	3					
33103	1,277,242.08	480,572.39	12.34	3					
33112	1,279,549.34	477,741.57	12.40	3					
33113	1,276,735.31	477,924.64	13.84	3					
33243	1,281,427.11	477,606.06	11.89	3					
51911	1,289,640.91	480,763.39	3.92	3					
51912	1,287,397.23	480,618.69	6.97	3					
51913	1,286,002.48	480,915.68	7.77	3					
51914	1,285,342.21	480,372.97	8.08	3					
51921	1,290,222.73	482,981.54	7.49	3					
51922	1,287,248.82	483,201.48	8.30	3					
51923	1,285,150.04	483,384.09	8.17	3					
51931	1,289,826.06	485,628.18	4.87	3					
51932	1,287,253.15	485,870.04	6.10	3					
51933	1,284,943.61	485,639.17	6.43	3					
999111	1,278,179.08	480,486.28	9.92	4					
999112	1,278,066.97	482,733.92	1.18	4					

Table C3-3 AutoCAD and KORK Feature Codes

AutoCAD		KORK	
Color	Layer	Fea. Code	Feature
Black	SU1	1000	Paved Road
	SU2	1002	Unpaved Road
	SU3	1011	Bridge
	SU4	1021	Sports Field
	SU5	1024	Small Embankment
	SU6	1030	Top of Concrete Embankment
	SU7	1041	Wall
	SU8	1042	Closure, Barrier, Fence
	SU9	1100	Retaining Wall
	SU10	1120	Line of Trees
	SU11	1103	Levee, Dyke,(Earth)
	SU12	1204	Path, Trail
Blue	G1	1301	Approximate Edge for Tie Sheets
Light Green	SL1	1304	Bush, Scrub Area Line
	ST1	1320	Top of Medium Embankment
	ST2	1330	Hedge
	ST3	1400	Rail Road
	ST4	1900	Bottom of All Embankments
	ST5	2000	Building
	ST6	2003	Cultivation Line
	ST7	2110	Water Tank
	ST8	2150	Cemetery
	ST9	2201	Ruin
	ST10	2301	Top of Large Embankment
Dark Blue	MT1	2302	Church
	MT2	2303	Public Building
	MT3	2309	Buddhist Temple
	MT4	3100	Shore Line, River
	MT5	3103	Basin (Dry Pond)
	MT6	3150	Lake or Pond with Elevation
	MT7	3200	Drainage Course
	MT8	3201	Canal
	MT9	3350	Swamp Line
	MT10	4000	Tree Area
	MT12	1060	Water Tower
		KORK SYMBOLS	
Cyan	W1	1303	Well
	W2	1337	Temple
	W3	3420	Swamp
	W4	4011	Single Tree
		KORK TEXT	
Blue	MT10	1005	"Standard" Correction Text
	MT11	5100	"Standard"

Table C5-1 Quantities of Soil Mechanics Investigation

(1) Boring

No.	Depth (m)	No. of SPT	No. of Samples	Interval of SPT
(a) Syay Pak Drainage Sluiceway				
BH 1	27.45	26	9	Every 1.5m till 3m deep, and 1m to downward
(b) Kop Srov Dike				
BH 2	15.45	14	7	Every 1.5m till 3m deep, and 1m to downward
BH 3	18.45	17	5	Every 1.5m till 3m deep, and 1m to downward
BH 4	10.45	10	4	Every 1m deep
BH 5	7.45	7	3	Every 1m deep
(c) Meanchey and Samdach Monireth Drainage Mains				
BH 6	14.45	13	4	Every 1.5m till 3m deep, and 1m to downward
(d) Tompun Pumping Station				
BH 7	15.45	15	6	Every 1m deep
BH 8	14.45	14	5	Every 1m deep
(e) Samdach Monireth and Jawaharlal Nerhu Drainage Mains				
BH 9	13.45	13	4	Every 1m deep
(f) Meanchey Drainage Main and Tompun Regulation Pond				
BH 10	26.45	26	5	Every 1m deep
(g) Salang Drainage Main				
BH 11	12.45	11	4	Every 1.5m till 3m deep, and 1m to downward
Total	175.95	166	56	

(2) Test Pitting

No.	Depth (m)	Depth of Sampling (m)	Remarks
(a) Kop Srov Dike			
KT 1	2.0	1.8 - 2.0	
KT 2	2.0	1.8 - 2.0	
KT 3	2.0	1.8 - 2.0	
KT 4	2.0	0.8 -2.0	
KT 5	2.0	1.8 - 2.0	
KT 6	2.0	1.8 - 2.0	
KT 7	2.0	1.2 – 1.4	
KT 8	2.0	1.4 - 1.6	
KT 9	1.7	1.5 – 1.7	
(b) Meanchey Drainage Main			
MT 1	2.0	0.6 – 0.8 1.6 – 1.8	
MT 2	2.0	1.0 - 1.2	
MT 3	2.0	1.8 – 2.0	
(c) Tompun Dike			
MT 4	2.0	1.8 - 2.0	
MT 5	2.0	0.4 – 0.6 1.3 – 1.5	
MT 6	2.0	1.3 – 1.5	
(d) Tompun Regulation Pond			
MT 7	1.0	0.3 – 0.5 0.8 – 1.0	
(e) Salang Drainage Main			
MT 8	2.0	0.5 – 0.7	
(f) Borrow Areas			
BT 1	2.0	0.0 – 0.5 0.5 – 1.5 2.0	in Udong borrow area
BT 2	-	-	in Baset borrow area

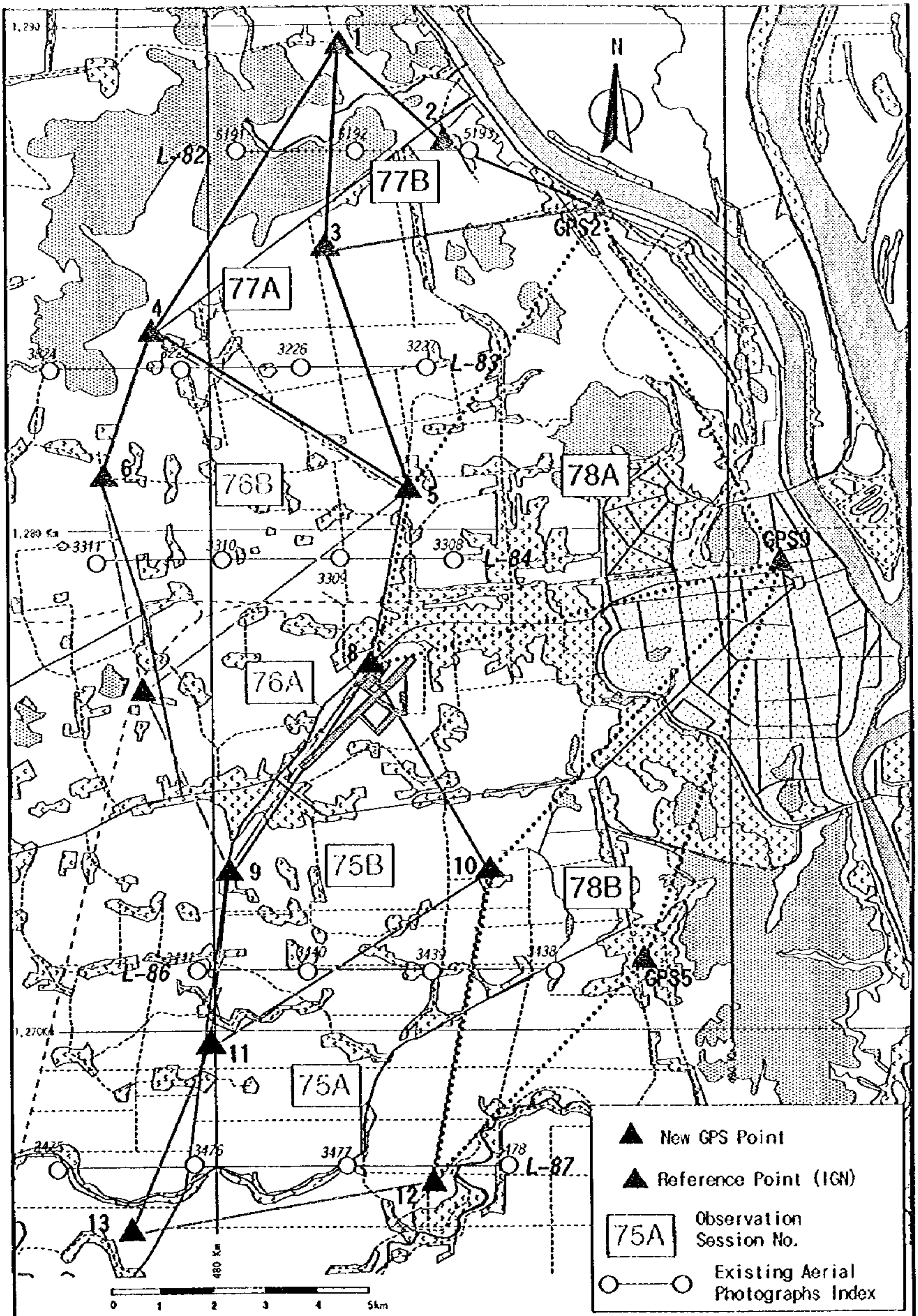
Table C5-2 Laboratory Test Results (1/2)

Boring No.	Depth (m)	D>2mm (%)	2>D>0.08 (%)	D<0.08mm (%)	WL (%)	WP (%)	PI (%)	W (%)	Soil class	Depth of SPT (m)	Unit Weight (g/cm3)	Specific Gravity (g/cm3)
BH1	1.50-3.00	0.3	1.5	98.2	47	25	22	15.0	A-7-6	1.50-1.95		2.574
	4.00-5.00	0.1	0.8	99.1	51	24	27	20.6	A-7-6	4.00-4.45		2.588
	9.00-10.00	2.7	84.7	12.6	ES	v:28.3	p:24.9	27.2	A-3	9.00-9.45		2.609
	12.00-13.00	1.3	88.3	10.4	ES	v:56.3	p:45.7	19.8	A-3	12.00-12.45		2.601
	15.00-16.00	2.6	88.1	9.3	ES	v:63.2	p:51.1	29.1	A-3	15.00-15.45		2.602
	17.00-18.00	8.3	84.4	7.3	ES	v:72	p:54.3	24.5	A-3	17.00-17.45		2.594
	24.00-25.00	3.4	88.6	8.0	ES	v:72.8	p:58.6	27.1	A-3	24.00-24.45		2.596
	25.00-26.00	17.7	77.7	4.6	ES	v:76.8	p:61.2	21.1	A-3	25.00-25.45	2.077	2.604
	26.00-27.00	22.3	24.3	53.4	49	18	31	17.9	A-7-6	26.00-26.45		2.574
BH2	1.50-3.00	0.9	2.2	96.9	54	21	33	26.0	A-7-6	1.50-1.95	2.079	2.640
	6.00-7.00	0.0	0.5	99.5	55	22	33	28.0	A-7-6	6.00-6.45	2.071	2.628
	8.00-9.00	0.2	0.8	99.0	52	26	26	52.3	A-7-6	8.00-8.45	1.726	2.449
	11.00-12.00	4.1	2.3	93.6	34	17	17	30.6	A-6	11.00-11.45	1.944	2.491
	13.00-14.00	4.0	76.8	19.2	24	12	12	16.8	A-2-6	13.00-13.45		2.578
	14.00-15.00	28.9	41.5	29.6	26	13	23	14.4	A-2-6	14.00-14.45		2.549
										15.00-15.45		2.568
BH3	1.50-3.00	8.6	2.9	88.5	45	20	25	18.7	A-7-6	1.50-1.95	2.095	2.655
	7.00-8.00	0.1	5.0	94.9	30	18	12	27.0	A-6	7.00-7.45	1.995	2.640
	10.00-11.00	6.3	18.3	75.4	51	24	27	28.0	A-7-6	10.00-10.45	1.963	2.621
	14.00-15.00	0.2	2.6	97.2	65	21	24	25.6	A-7-5	14.00-14.45		
	16.00-17.00				35	14	21	19.9	A-6	17.00-17.45	2.108	2.567
	17.00-18.00	6.8	37.0	56.2	33	15	18	21.1	A-6	18.00-18.45	2.150	2.606
BH4	2.00-3.00	0.4	2.8	96.8	50	17	33	18.4	A-7-6	2.00-2.45	2.044	2.490
	5.00-6.00	0.7	17.4	81.9	31	14	17	21.1	A-6	5.00-5.45	2.077	2.526
	8.00-9.00	2.7	38.8	58.5	41	12	29	14.5	A-7-6	8.00-8.45	2.211	2.524
	9.00-10.00	20.5	37.7	41.8	40	14	26	14.9	A-6	10.00-10.45	2.261	2.541
BH5	2.00-3.00	7.9	10.3	81.8	41	16	25	20.3	A-7-6	2.00-2.45	2.170	2.517
	4.00-5.00	6.4	51.7	41.9	36	11	25	13.2	A-6	4.00-4.45	2.245	2.635
	6.00-7.00	8.3	41.3	50.4	32	13	19	13.2	A-6	6.00-6.45	1.918	2.494
BH6	4.00-5.00	3.1	4.6	92.3	45	20	25	22.2	A-7-6	4.00-4.45	2.080	2.536
	6.00-7.00	1.2	6.1	92.7	29	17	12	25.6	A-6	6.00-6.45	2.061	2.566
	10.00-11.00	5.9	7.9	86.2	39	12	27	20.5	A-6	10.00-10.45	2.066	2.606
	13.00-14.00	0.6	7.9	91.5	33	11	22	19.6	A-6	14.00-14.45	2.235	2.597
BH7	2.00-3.00	0.4	16.4	83.2	37	11	26		A-6	2.00-2.45	1.969	2.500
	4.00-5.00	23.0	48.9	28.1	28	12	16		A-6	4.00-4.45	2.271	2.540
	7.00-8.00	3.7	39.6	56.7	28	10	18		A-6	7.00-7.45	2.094	2.425
	10.00-11.00	10.4	30.3	59.3	34	13	21		A-2-6	10.00-10.45	2.232	2.524
	12.00-13.00									12.00-12.45	2.138	2.400
	14.00-15.00									15.00-15.45	2.137	2.450
BH8	3.00-4.00	3.4	40.5	56.1	25	15	10	14.0	A-4	3.00-3.45	2.170	2.384
	5.00-6.00	7.7	48.0	44.3	30	11	19	13.7	A-6	5.00-5.45	2.172	2.543
	9.00-10.00	0.8	64.1	35.1	26			22.3	A-2-4	9.00-9.45	2.065	2.456
	11.00-12.00	22.2	41.1	36.7	44	15	29	13.6	A-7-6	11.00-11.45	2.241	2.535
	13.00-14.00	0.6	34.2	65.2	29	16	13	18.3	A-6	14.00-14.45	2.110	2.502
BH9	2.00-3.00	3.5	18.4	78.1	34	14	20	20.0	A-6	2.00-2.45	2.089	2.585
	6.00-7.00	1.0	38.8	60.2	24	17	7	22.4	A-4	6.00-6.45	1.947	2.589
	9.00-10.00	6.0	23.0	71.0	23	15	8	26.1	A-4	9.00-9.45	1.967	2.615
	12.00-13.00	0.4	53.4	46.2	19	16	3	26.9	A-4	13.00-13.45		2.628
BH10	3.00-4.00	8.4	69.1	22.5	38	12	26	14.2	A-2-6	3.00-3.45	2.165	2.567
	5.00-6.00	2.0	29.5	68.5	26	10	16	14.1	A-6	5.00-5.45	2.163	2.544
	11.00-12.00	1.5	63.8	34.7	24	14	10	20.3	A-2-4	11.00-11.45	2.141	2.535
	17.00-18.00	0.3	7.2	92.5	34	17	17	19.2	A-6	18.00-18.45	2.242	2.531
	25.00-26.00	0.2	5.7	94.1	40	16	24	19.7	A-6	26.00-26.45		
BH11	3.00-4.00	0.2	19.9	79.9	40	17	23	31.1	A-6	3.00-3.45	1.683	2.338
	6.00-7.00	0.3	19.9	79.8	37	14	23	17.4	A-6	6.00-6.45	1.988	2.605
	9.00-10.00	6.9	23.0	70.1	44	16	23	15.3	A-7-6	9.00-9.45	1.839	2.579
	11.00-12.00	1.0	9.5	89.5	27	14	13	17.7	A-6	12.00-12.45	1.996	2.568

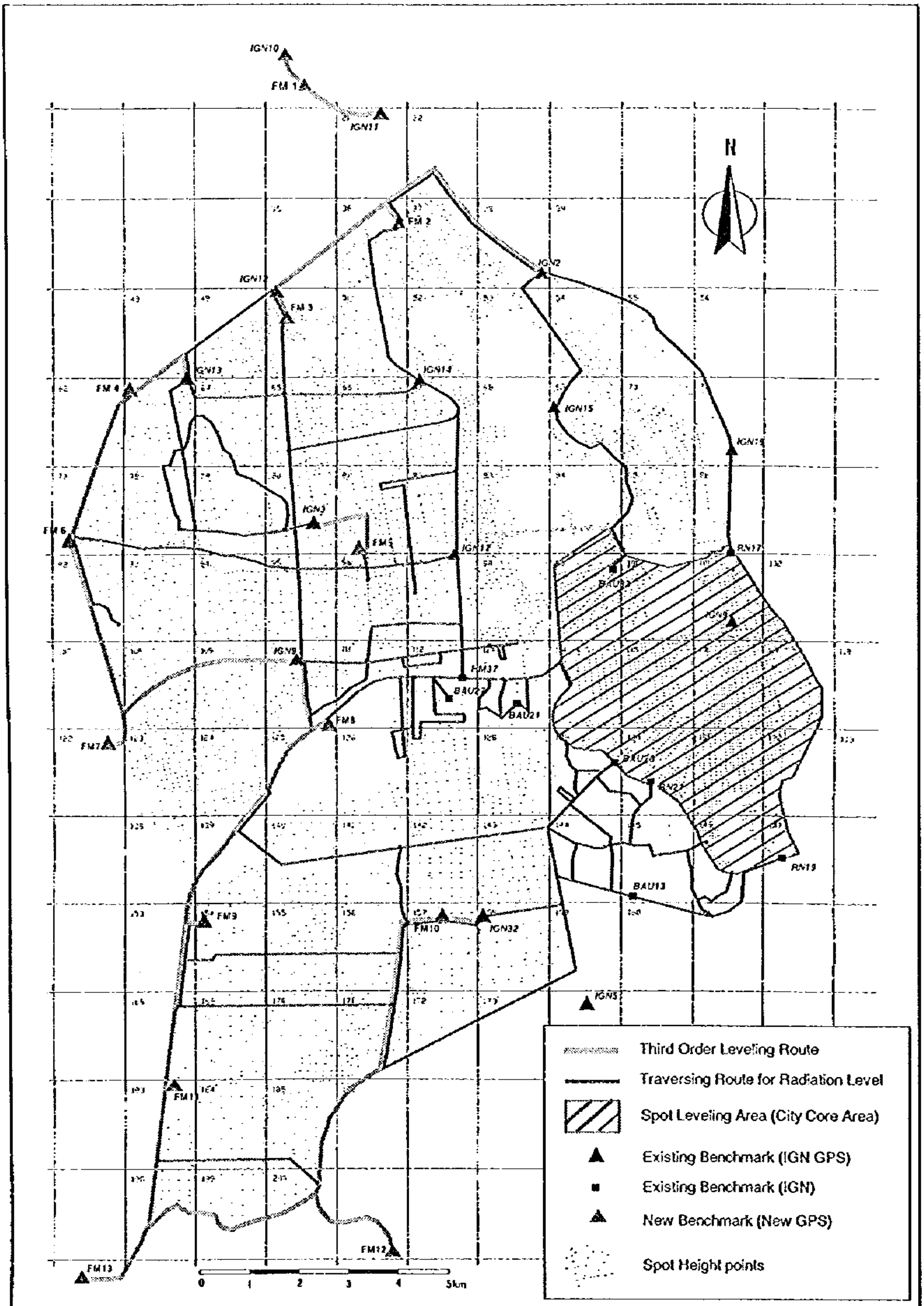
Table C5-2 Laboratory Test Results (2/2)

Test Pit No.	D>2mm (%)	2>D>0.08 (%)	D<0.08mm (%)	WL (%)	WP (%)	PI (%)	W (%)	Unit Weight (g/cm3)	Specific Gravity (g/cm3)	Remark
KT1	5.8	1.5	92.7	55	39	16	24.1	2.034	2.665	
KT2	0.7	4.7	94.6	45	18	27	26.3	1.962	2.540	
KT3	3.5	5.0	91.5	35	15	20	17.0	1.982	2.436	
KT4	0.1	0.8	99.1	36	16	20	11.0	2.098	2.589	
KT5	4.0	1.0	95.0	40	24	25	17.9	1.995	2.581	
KT6	0.1	0.8	99.1	48	18	30	21.5	1.919	2.624	
KT7	0.0	0.3	99.7	35	12	23	7.0	1.933	2.508	
KT8	0.4	66.6	33.0	47	15	32	11.3	2.207	2.557	
KT9	1.2	10.2	88.6	ES	v-21.4		10.5		2.577	
					p-15.3					
MT1	0.3	1.2	98.5	25	13	12	14.1	2.117	2.441	0.6 - 0.8m
	4.3	6.2	89.5	20	11	9	9.9			1.6 - 1.8m
MT2	0.6	1.2	98.2	42	18	24	4.8	1.837	2.481	1.0 - 1.2m
MT3	3.1	13.1	83.8	39	14	25	20.7	1.895	2.544	1.8 - 2.0m
MT4	3.3	3.4	93.3	43	18	25	25.2	1.842	2.551	1.8 - 2.0m
MT5	1.9	30.5	67.6	34	11	23	20.6			0.4 - 0.6m
	2.8	41.2	56.0	33	12	21	15.8	1.978	2.515	1.3 - 1.5m
MT6	1.1	15.0	83.9	33	10	23	15.4	2.080	2.481	1.3 - 1.5m
MT7	1.9	4.2	93.9	48	17	31	17.0	1.929	2.491	0.3 - 0.5m
	2.3	3.8	93.9	39	13	26	13.6			0.8 - 1.0m
MT8	0.4	1.3	98.3	35	15	20	19.6	1.885	2.568	0.5 - 0.7m
	0.3	1.0	98.7	56	17	39	22.7	1.893	2.540	1.2 - 1.4m

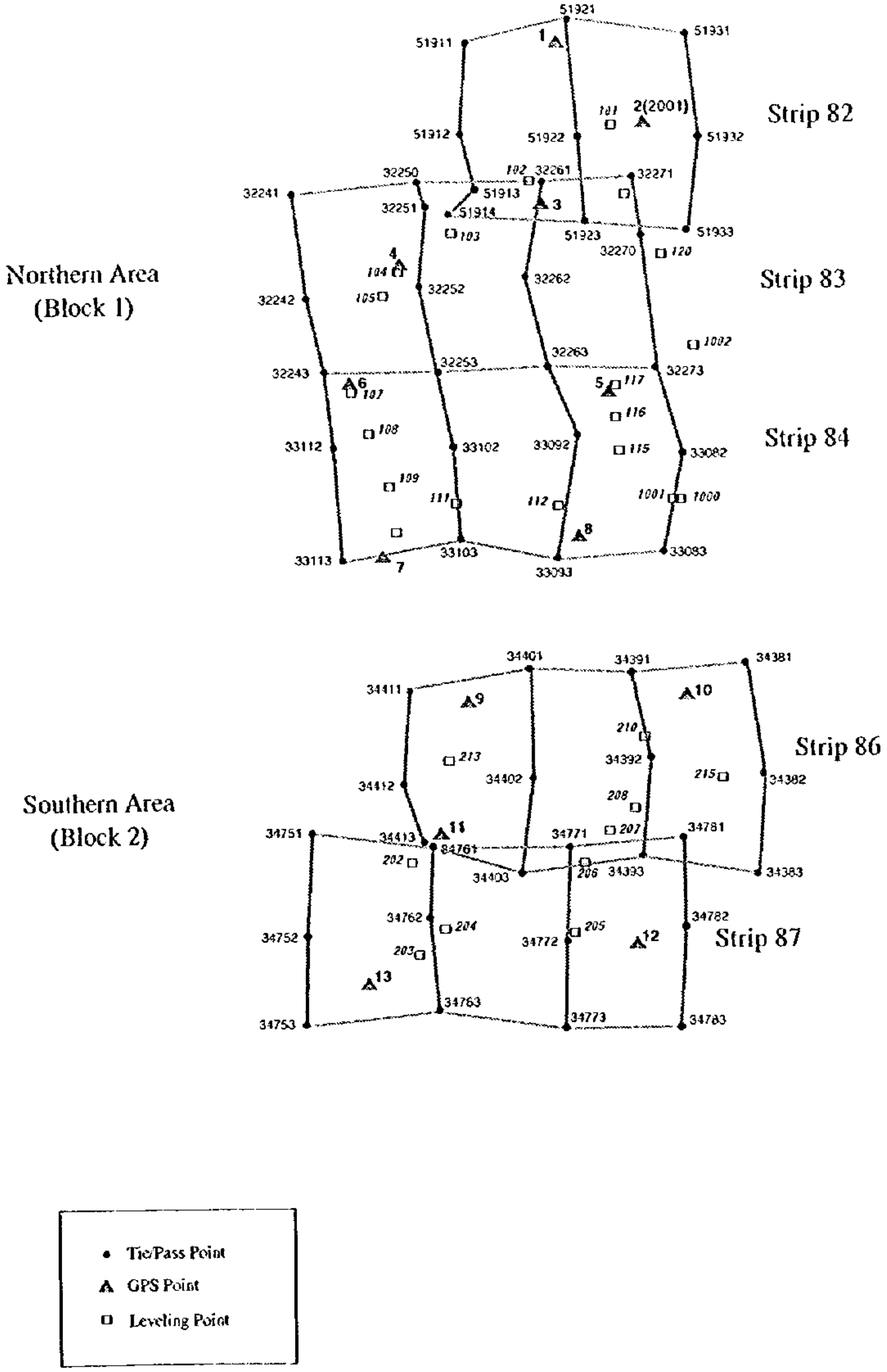
Borrow Pit No.	Depth (m)	D<0.08mm (%)	2>D>0.08 (%)	20>D>2 (%)	D>20mm (%)	WL (%)	WP (%)	PI (%)	W (%)	Specific Gravity (g/cm3)
TB.1 Udong Borrow Area	0.00-0.50	57.0	6.8	36.2	0.0	47	20	27	6.6	2.600
	0.50-1.50	11.0	8.0	74.7	6.3	25	16	9	3.1	2.614
	2.00	39.0	26.9	34.1	0.0	26	16	10	3.2	2.352
TB.2 Baset Borrow Area	0.00-1.50	12.6	15.4	43.4	28.6	30	14	16	1.8	2.544



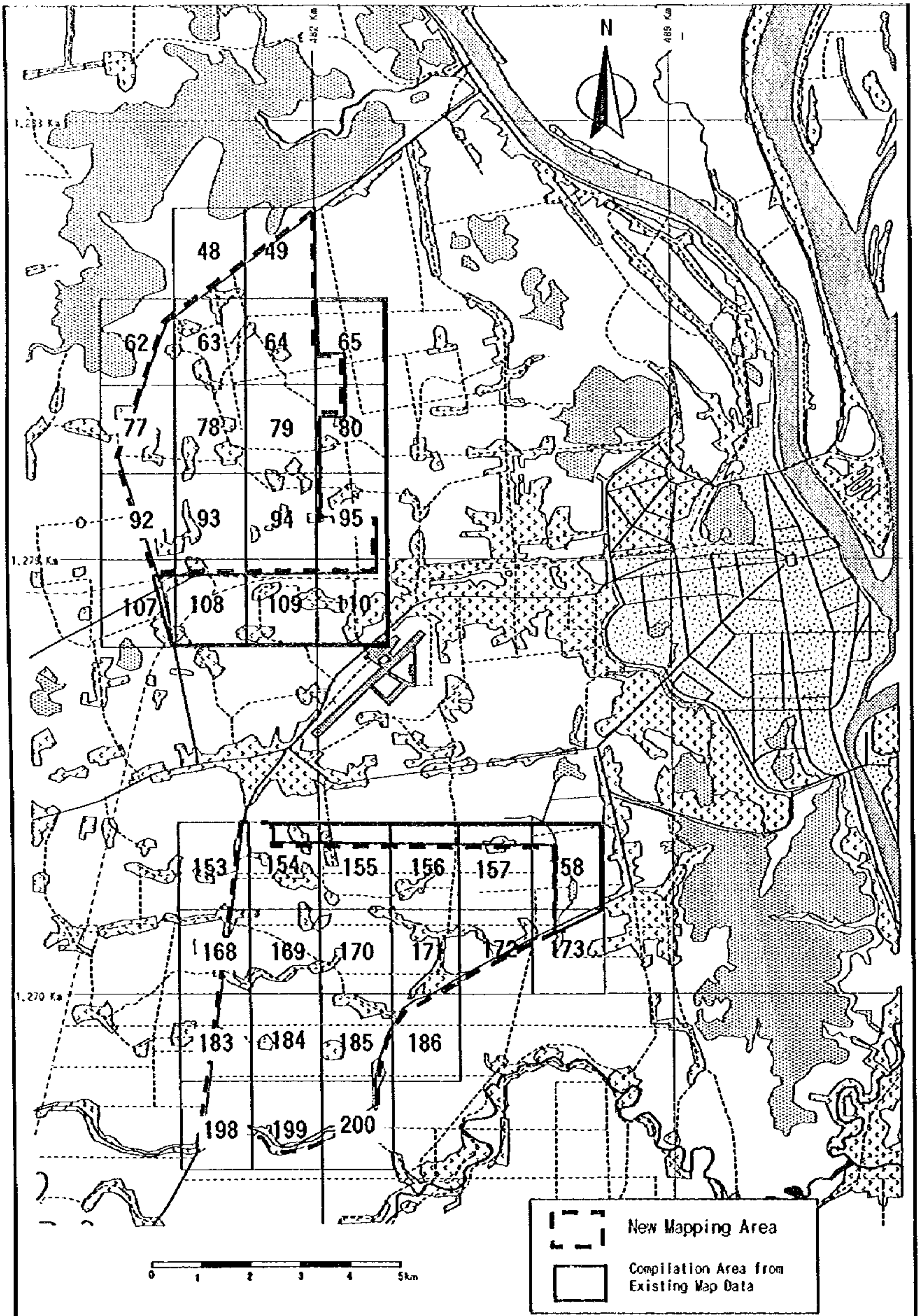
The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh JICA - CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	Figure C3-1 Ground Control Survey (GPS) Network



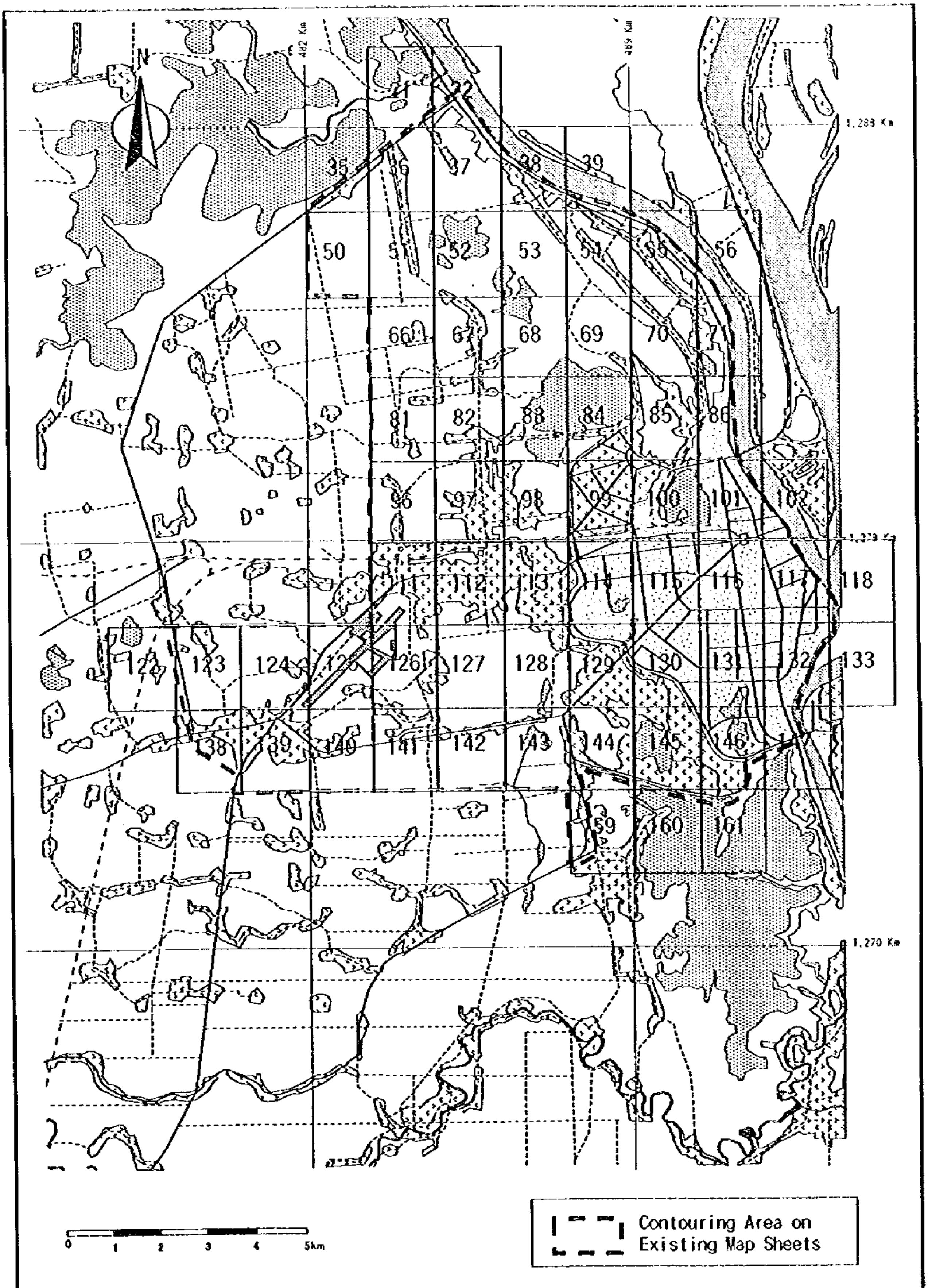
The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh JICA - CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	Figure C3-2 Leveling Network Chart & Spot Height Point Distribution



The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh JICA - CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	Figure C3-3 Aerial Triangulation Point Index Chart



The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh JICA - CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	Figure C3-4 Digital Mapping Sheet Index



The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh JICA - CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	Figure C3-5 Contour Line Map Sheet Index on Existing Map

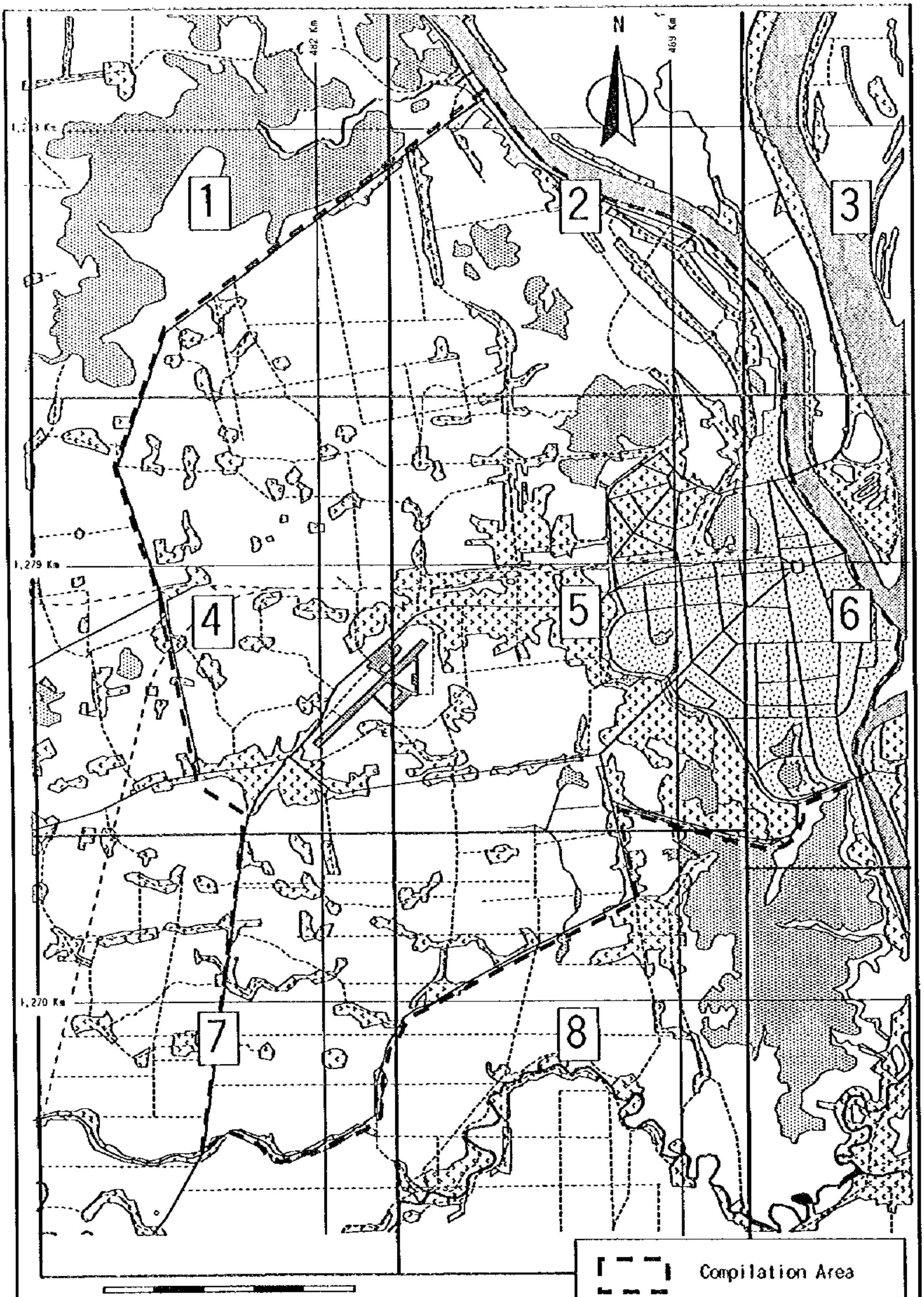


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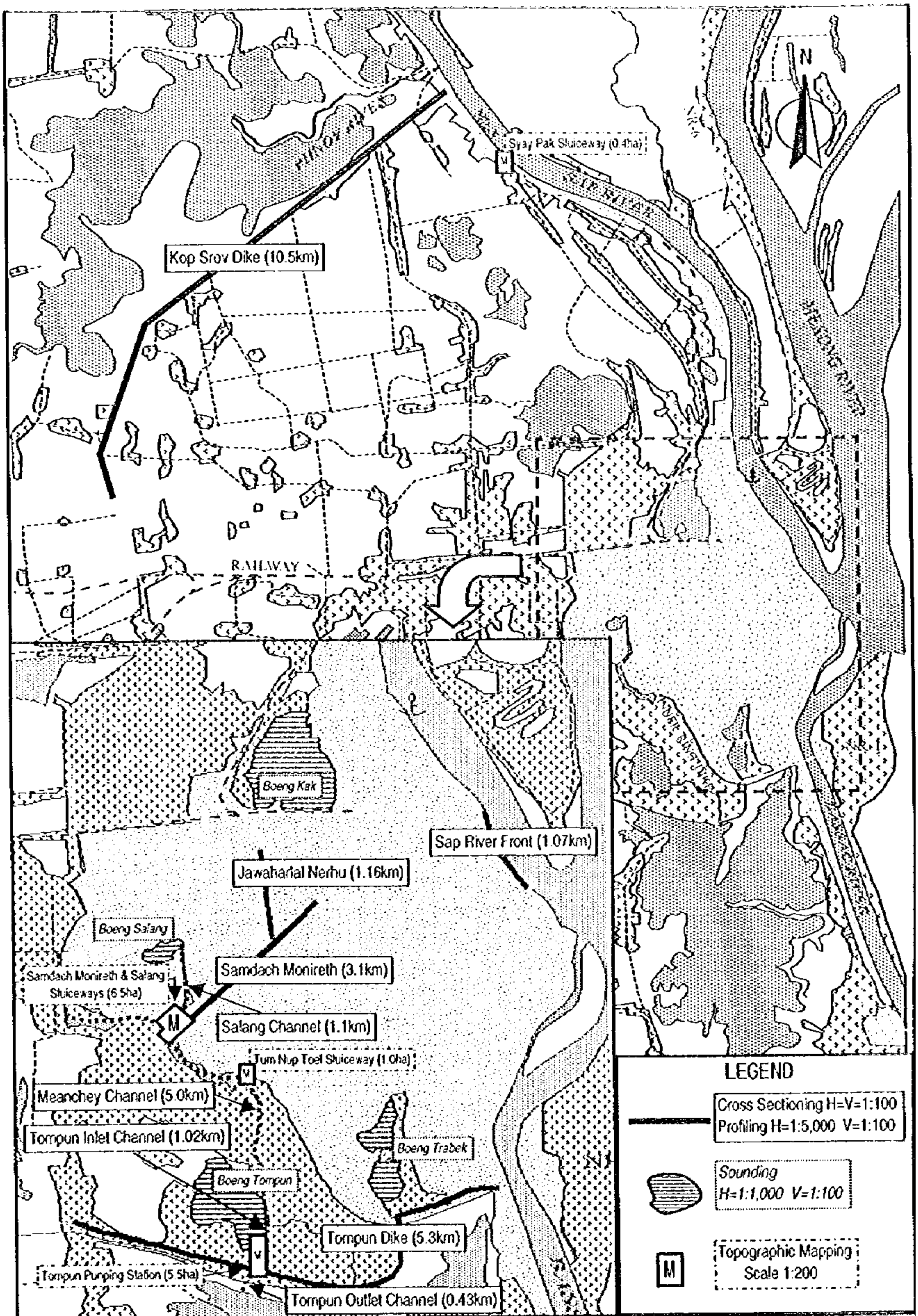
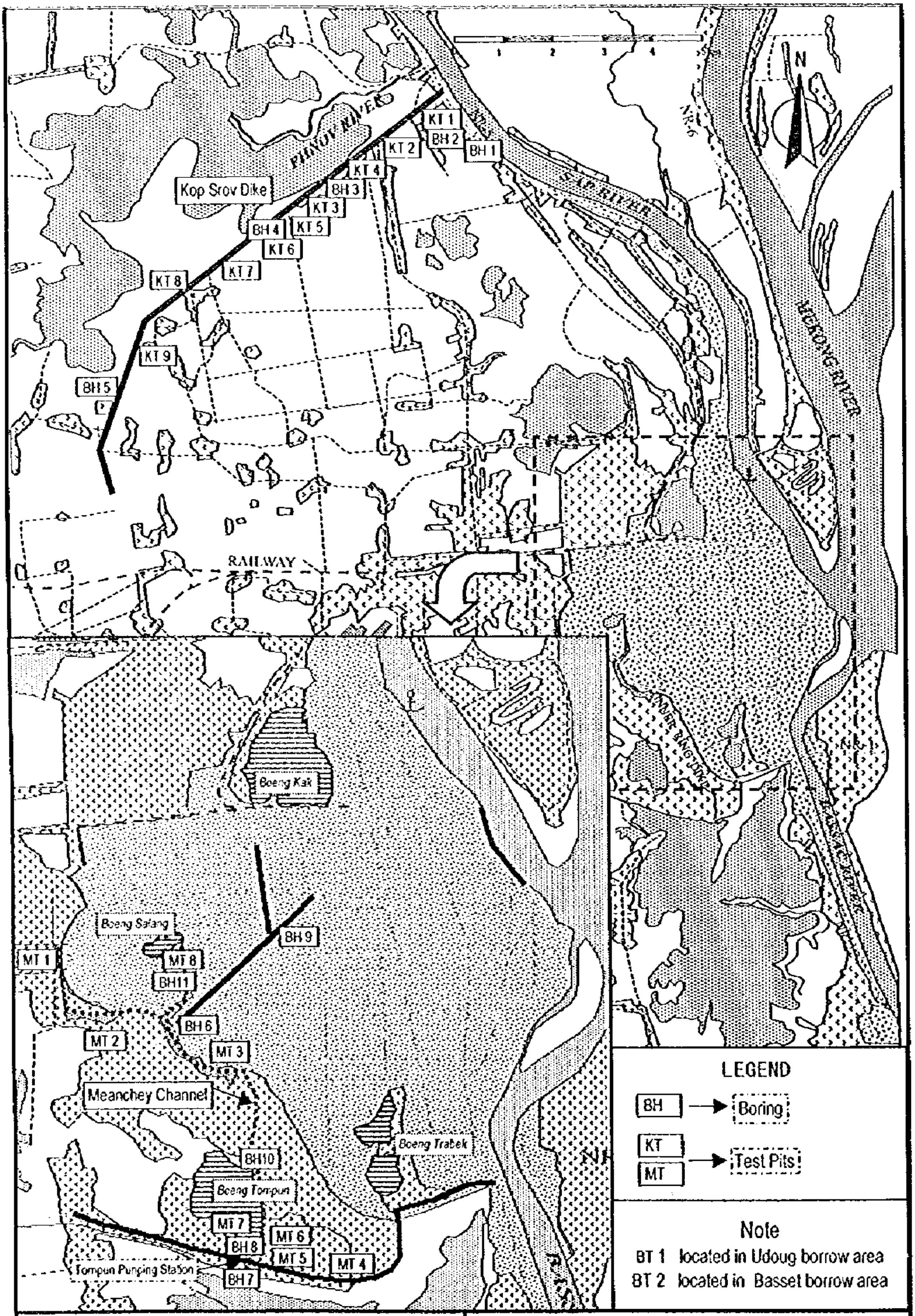
Figure C3-6
1/10,000 Compilation Map Sheet Index



The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh JICA - CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	Figure C4-1 Location map of the Survey Work in the Feasibility Study Stage



The Study on Drainage Improvement and Flood Control in the Municipality of Phnom Penh JICA - CTIE International Co., Ltd. - Nippon Koei Co., Ltd.	Figure C5-1 Location Map of Borings and Test Pits