JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

PEOPLE'S COMMITTEE OF HO CHI MINH CITY (PCHCMC)
MINISTRY OF PLANNING AND INVESTMENT (MPI)
THE SOCIALIST REPUBLIC OF VIET NAM

THE STUDY ON URBAN DRAINAGE AND SEWERAGE SYSTEM FOR HO CHI MINH CITY IN THE SOCIALIST REPUBLIC OF VIET NAM

FINAL REPORT

SUPPORTING REPORT [VOLUME I]

DECEMBER 1999

PACIFIC CONSULTANTS INTERNATIONAL

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LIST OF SUPPORTING REPORT

[Volume I]

APPENDIX A: TOPOGRAPHY AND GEOLOGY

APPENDIX B: POPULATION AND LAND USE

APPENDIX C: METEOROLOGY AND HYDROLOGY

APPENDIX D: WATER QUALITY AND ENVIRONMENT

APPENDIX E: URBAN DRAINAGE IMPROVEMENT

[Volume II]

APPENDIX F: SEWERAGE DEVELOPMENT

APPENDIX G: OPERATION AND MAINTENANCE

APPENDIX H: ENVIRONMENTAL IMPACT ASSESSMENT

APPENDIX I: SOCIAL IMPACT SURVEY

APPENDIX J: CONSTRUCTION PLAN, COST ESTIMATE AND IMPLEMENTATION PROGRAM

APPENDIX K: ORGANIZATION AND LEGAL FRAMEWORK

APPENDIX L: ECONOMY AND FINANCE

ABBREVIATIONS

1. ORGANIZATIONS

ADB	Asian Development Bank
CDM	Camp Dresser & McKee International Inc.
CEC	City Environment Company
CITENCO	Ho Chi Minh City Environmental Company
DARD	Department of Agriculture and Rural Development
DFP	Department of Finance-Pricing
DHI	Danish Hydraulics Institute
DOSTE	Department of Science, Technology, and Environment
DPI	Department of Planning and Investment
DTPW	Department of Transport and Public Works
ENCO	Environmental Committee (renamed recently to the Environmental Management Section)
GOJ	Government of Japan
GOV	Government of Viet Nam
HCMC	Ho Chi Minh City
IDA	International Development Association
JICA	Japan International Cooperation Agency
MARD	Ministry of Agriculture and Rural Development
MOC	Ministry of Construction
MOF	Ministry Of Finance
MOSTE	Ministry of Science, Technology, and Environment
MPI	Ministry of Planning and Investment
OWM	Office of Waterway Management
PC	People's Committee
PCHCMC	People's Committee of Ho Chi Minh City
PMU	Project Management Unit
SDC	Sewage and Drainage Company
SOE	State Owned Enterprise
UDC	Urban Drainage Company
UPI	Urban Planning Institute
URENCO	Urban Environment Company
USAID	United State International Assistance Department
WB	World Bank
WSC	Water Supply Company

2. TERMINOLOGY

ATP	Affordability to Pay	BOD	Biochemical Oxygen Demand
B/C	Benefit by Cost Ratio	cm	Centimeter

CIF	Cost, Insurance and Freight	COD	Chemical Oxygen Demand
DO	Dissolved Oxygen	FC	Foreign Currency
EIRR	Economic Internal Rate of Return	FOB	Free on Board
FIRR	Financial Internal Rate of Return	GIS	Geographic Information System
GRDP	Gross Regional Domestic Products	GDP	Gross Domestic Products
ha	Hectare	HH/HHs	Household or Households
IDF	Intensity-Duration-Frequency	kg	Kilogram
km	Kilometer	km^2	Square kilometer
kw	Kilowatt	l	Liter
m	Meter	m/s	Meter per second
m^2	Square meter	m^3	Cubic meter
m^3/s	Cubic meter per second	mg	Milligram
mg/l	Milligram per liter	mm	Millimeter
LC	Local Currency	NLTN	Nhieu Loc Thi Nghe
NPV	Net Present Value	O&M or O/M	Operation and Maintenance
s	Second	SCF	Standard Conversion Factor
SE	South East	SS	Suspended Solid
THBNDT	Tau Hu Ben Nghe Doi Te	THLG	Tan Hoa Lo Gom
TLBC	Thanh Long Binh chang	TQC	Total Quality Control
US$	United States Dollar	VND	Vietnamese Dong
¥	Japanese Yen	WTP	Willingness to Pay
%	Percent		

APPENDIX A
TOPOGRAPHY AND GEOLOGY

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDIX A TOPOGRAPHY AND GEOLOGY

1. Existing Topographical Condition of the Study Area

The Study Area with an area of about 650 km^2 is located from 106°35′ to 106°55′ east longitude and from 10°40′ to 10°55′ north latitude in the northeastern part of the Mekong Delta. The ground elevation ranges from about 0.5 to 30 m above MSL. The general ground slope of the area is from the north-northeast to the west-southwest. The regional topographic conditions are summarized as follows:

(a) West Bank of the Saigon and Nha Be Rivers

The west bank of the Saigon and Nha Be rivers is classified into four (4) regions having the different topographic characteristics. The western region is mostly low-lying area with its ground elevation from EL.0.7 to 1.0 m in Binh Chanh district. This region is mainly used as a paddy field. The central region is high land area including a hilly area of Hoc Mon (EL.8 - 10 m), Go Vap (EL.10 m) and the existing urban area (EL.2 - 8 m). This region is fully urbanized because of the geographical and topographical advantage. The east region along the Saigon River is low land area with an elevation of EL.0.6 - 0.8 m, where has been mostly developed as a paddy field. The southern region along the Nha Be River is mainly low-lying paddy field with an elevation of EL.0.6 - 1.2 m.

(b) East Bank of the Saigon River

This area consists of two regions; the north and south. The northern region is the high hilly land belonging to Thu Dud district with its ground elevation from 2 to 30 m above MSL. Recently, this region has being rapidly urbanized, according to the convenience of transport and the advantage of topography. The southern region is mostly low-lying area in District 2 and 9. The ground elevation of the area ranges from 0.6 to 1.5 m above MSL. This region has been developed mostly a paddy field protected by the dike from the flood of the Saigon and Don Nai rivers.

Figs. A.1.1, A.1.2 (1/2) and (2/2) show the topography of the Study Area.

2. Topographic Survey

2.1 General

The topographic survey has been carried out in order to obtain the necessary topographical data and information for the study on urban drainage improvement and sewerage development in Ho Chi Minh City (HCMC).

The topographic survey to be conducted includes the following works:

Master Plan Study Stage

(a) to collect the existing topographic map,
(b) to update the existing topographic map in the Study area,
(c) to conduct the longitudinal and cross sectional survey for the drainage canals in the Study area,
(d) to conduct the cross sectional survey of the Saigon River, and
(e) to execute the longitudinal and cross sectional survey for the existing sewers in inner city area.

Feasibility Study Stage

(f) Plane and Profile Survey of Tau Hu - Ben Nghe Canal
(g) Plane and Profile Survey of Drainage Pumping Stations
(h) Plane and Cross Sectional Survey of Treatment Plant Site
(i) Plane and Profile Survey of Sewage Pumping Station
(j) Profile Survey of Interceptor and Conveyance Sewers
(k) Profile Survey of Combined Sewer

2.2 Existing Topographic Maps Collected

The following topographic maps have been collected during the course of the study.

(a) Topographic map with scale of 1: 50,000 : 10 sheets
(b) Topographic map with scale of 1: 25,000 : 12 sheets
(c) Topographic map with scale of 1: 10,000 : 44 sheets

The index map of 1: 10,000 scale map is shown in Fig. A.2.1

2.3 Updating the Existing Topographic Map

The collected existing topographic maps have been made at rather old time and lacked the topographical information of new developments, such as road, residential and industrial areas and tourism facilities. So, topographic maps with scale of 1:10,000, the latest edition of 1991 have been updated by the field reconnaissance survey for 27 newly developed areas of approximately 37 km^2. The benchmark was used the national benchmark grade IV established by the General Department of Land (GDL), of which elevation is shown in meter above mean sea level at Mui Nai - Ha Tien. These investigated information has been digitized to improve the original GIS base map prepared by Urban Planning Institute (UPI), which is the most available base map for formulation of the Master Plan. Fig. A.2.2 shows the location of the updated areas in the Study area.

2.4 Longitudinal and Cross Sectional Survey for Drainage Canal

The longitudinal and cross sectional survey was planned to supplement the existing data. The survey has been carried out for the following 14 drainage canals:

SUMMARY OF PROFILE AND CROSS SECTIONAL SURVEY FOR CANAL

Zone	Name of Canal	Length of Profile (km)	No. of Cross Section (sections)
C - zone	R.Cau San - R. Tau Vam Tat	1.63	2
N - zone	R. Ben Da - Rach Ba Hong	6.03	3
W - zone	Rach Chua - Rach Nuoc Len	5.33	3
	Ben Luc River	6.50	3
	Canguioc River	4.07	4
S - zone	Kinh Cay Kho	3.34	3
	R. Cay Kho - Phuoc Khien R.	4.10	3
NE - zone	Rach Ong Dua	0	2
	Rach Thu Duc	0	2
SE - zone	Rach Da Do	0	3
	Rach Ong Nhieu	6.44	3
	Rach Kinh Ong Hong	3.96	2
	Rach Trau Trau	4.47	3
	Tac River	12.54	4
Total		58.41	40

Locations of the above canals are illustrated in Fig. A.2.3. The benchmark was used the same national one grade IV as the topographic survey. The longitudinal cross section survey was conducted at intervals of every 300 m along the canal. Elevations of the cross section of the canal were measured for the left and right banks, the canal bed at center and the deepest one.

2.5 Cross Sectional Survey for Saigon River

Cross sectional survey for the Saigon River has been executed at four (4) sites of confluence with the following canals:

(a) Rach. Ba Hong canal: Width: about 200 m, Depth: about 20 m
(b) Rach Ben Cat canal: Width: about 250 m, Depth: about 20 m
(c) Te canal: Width: about 380 m, Depth: about 19 m
(d) The estuary: Width: about 820 m, Depth: about 10 m

Locations of the survey sites are illustrated in Fig. A.2.3. The river bed elevations were measured at intervals of every 10 m in length by the echo sounder.

2.6 Longitudinal and Cross Sectional Survey for Existing Sewers

The longitudinal and cross sectional survey for the existing sewer lines has been executed. Total length of the surveyed sewers is approximately 130 km. The benchmark was used the national one grade IV. The items to be surveyed include ground elevation, invert elevation, sewer diameter at the manhole of the main road crossing. Sewer length and sewage flow direction were also surveyed. Routes of the sewers surveyed are shown in Fig. A.2.4.

2.7 Plane and Profile Survey of Tau Hu - Ben Nghe Canal

Plane and Profile survey of Tau Hu - Ben Nghe canal of 12.5 km long were conducted in order to get the more detailed information for canal improvement. Plane survey with a scale of 1/1,000 covered the area of about 183.0 ha with 12.2 km long and 150 m wide. Longitudinal profile of both sides of embankment was conducted every 200 m interval. Scale of the longitudinal survey is 1/1,000 for vertical scale and 1/100 for horizontal scale. Cross sectional survey with vertical and horizontal scale of 1/200 and 1/100 was conducted every 200 m interval.

2.8 Plane and Profile Survey of Drainage Pumping Station

Plane and Profile survey were conducted for proposed four (4) drainage pumping stations; Thanh Da, Vissan, Ben Me Coc 1 and Ben Me Coc 2. Plane and Profile survey of each drainage pumping station is as follows:

Thanh Da Pumping Station

(1)	Plane survey	:	Pumping Station of 1.0 ha
		:	Dike of 1.6 ha
(2)	Longitudinal survey	:	Dike of 600 m
		:	Drainage Pipe of 500 m
(3)	Cross sectional survey	:	2 section each 100 m width at Pumping Station
		:	9 section each 50 m width at Dike

Vissan Pumping Station

(1)	Plane survey	:	Pumping Station of 1.0 ha
		:	Dike of 3.4 ha
		:	Canal of 45 ha
			(4,500 m (L) x 100 m (W))
(2)	Longitudinal	:	Dike of 2,600 m
		:	Canal of 4,500 m
		:	Drainage Pipe of 2,200 m
(3)	Cross sectional survey	:	2 sections at Pumping Station with 100 m width
		:	2 sections of Dike with each 100 m long
		:	24 sections of Canal with each 70 -- 100 m long

Ben Me Coc 1 Pumping Station

(1)	Plane survey	:	Pumping Station of 0.75 ha
		:	Dike of 8.4 ha (20 m width x 4,200 m long)
(2)	Longitudinal Profile	:	Dike of 4,200 m length
(3)	Cross sectional survey	:	4 sections at Pumping Station with each 50 m long
		:	22 sections of Dike with each 20 m long

Ben Me Coc 2 Pumping Station

(1)	Plane survey	:	Pumping Station of 0.8 ha
		:	Dike of 6.8 ha (20 m wide x 3,400 m long)
		:	Pond of 6.4 ha
(2)	Longitudinal profile	:	Dike of 3,400 m long
		:	Drainage pipe of 740 m long
(3)	Cross sectional survey	:	19 sections of Dike with each 20 m long

The scale of each survey is as follows:

Plane Survey	:	Pumping Station = 1/200, Dike = 1/500, Canal = 1/1,000
Longitudinal Profile	:	Vertical scale = 1/500, Horizontal scale = 1/100
Cross Sectional Survey	:	Vertical scale = 1/100, Horizontal scale = 1/100

Survey results were compiled in the Data Book.

2.9 Plane and Cross Sectional Survey of Treatment Plant Site

Plane survey with a scale of 1/1,000 was conducted with covering the area of proposed treatment plant site of about 85 ha located in Ward Phuoc Loc in District Nha Be.

2.10 Plane and Profile Survey of Sewage Pumping Station

Plane survey with a scale of 1/200 covered the area of about 1.4 ha of the proposed intermitted sewage pumping station located in Ward 3 in District 8. Cross sectional survey of 2 sections of each 100 m long with vertical and horizontal scale of 1/200 and 1/100 was also conducted. The survey results were compiled in the Data Book.

2.11 Profile Survey of Interceptor and Conveyance Sewers

Longitudinal survey along the proposed interceptor sewer and conveyance sewer routes of about 50 km long was conducted. The vertical and horizontal scales were 1/2,000 and 1/100 respectively. The survey route is presented in Fig. A.2.5.

2.12 Profile Survey of Combined Sewer

Longitudinal profile survey along the proposed combined sewer improvement of about 12.5 km was conducted. And longitudinal survey for the proposed sewer system about 95 km in newly developed area in District 8 was conducted. The vertical and horizontal scales are 1/2,000 and 1/100 respectively.

3. Existing Geological Condition of the Study Area

3.1 South Viet Nam Geology

Viet Nam is characterized by mountains, delta, and coastal plains. The mountains and the delta are of primary interest, with the delta soils being the most important because of their intense cultivation. Specially, South Viet Nam is characterized by delta.

The delta, built up by Mekong River and three smaller rivers, occupies approximately 67,000 square kilometers. The region is generally flat and low, with an average elevation of from sea level to a few meters above. Scattered points are as high as 100 meters above sea level.

The delta area is a flat grassland consisting of alluvial soils overlying an ancient erosional rock surface. The alluvium is divided into two units, an Ancient Alluvium overlaid by a Recent Alluvium. Both the ancient Alluvium and Recent Alluvium are attributable principally to the Mekong River which enters the tectonic depressing south of the Annamite Mountains and flows southeast across it before turning east to discharge through several tributaries. The Mekong is believed to have been progressively titled to the south and west by a continental flexture which raised the northeastern part of South Viet Nam.

The Recent Alluvium is still being formed as the Mekong Delta extends rapidly by sedimentation. In some places, the coastline is advancing as much as 75 meters each year. The thickness of the Recent Alluvium is possibly increasing also, due to probable downwarping of the Ancient Alluvium under the sediment load.

3.2 Soil Condition of Study Area

The Study Area lies in the northeastern part of the Mekong Delta, and its geological features are primarily deltoid. The geology of the Study Area is basically the delta alluvial soils composed of unconsolidated or semi-consolidated deposits of fluvial origin and sediments of marine origin. An underlying ancient rock surface, which being to outcrop about 15 kilometers northeast of Ho Chi Minh, consists of rock which are igneous, sedimentary and metamorphic in origin and are reported to be Paleozoic and Mesozoic in age. The delta alluvial soils are composed of unconsolidated or semi-consolidated deposits of fluvial origin. Ho Chi Minh City rests on an island of Ancient Alluvium, surrounded by Recent Alluvium. Therefore, it is considered that the center of Ho Chi Minh is Ancient Alluvium, and the surburb of Ho Chi Minh is Recent Alluvium. This thing is ascertained by the soil data in Ho Chi Minh City of the past which it can get until now.

The following documents are collected as the soil investigation materials in Ho Chi Minh City:

1) The Preliminary Survey Report (JICA 1998)
2) SEWERAGE FEASIBILITY STUDY SAIGON, VIETNAM (1971)
3) The soil investigation materials to build Holiday Inn Saigon (1996)

Among these, the soil condition of Ho Chi Minh City center are shown with the soil boring log (Fig. A.3.1) and the soil property chart (Fig. A.3.2) by Holiday Inn Saigon's data as the latest of the soil data.

4. Geological Survey

4.1 General

4.1.1 Outline of Soil Survey

By the agreement on soil investigation, No.HCM04-1999 on the day of June 21st in the year 1999 between the Study Team of Japan International Cooperation Agency and Sub-Institute for Water Resources Planning.

The Study Team of Japan International Cooperation Agency is desirous that the Soil Investigation be rendered by The Sub-Institute for Water Resources Planning.

Soil investigation to be conducted for the Feasibility Study on Urban Drainage and Sewerage Development for Ho Chi Minh City in the Republic of Viet Nam shall cover the following sites:

(a) Drainage Pumping Station sites (Thanh Da, Vissan, Ben Me Coc 1 and Ben Me Coc 2)
(b) Wastewater treatment plant site
(c) Sewerage Pumping Station site
(d) Interceptor and Conveyance Sewer Line.

Location of geological survey is shown in Fig. A.4.1.

Works have been done is shown in Table A.4.1.

Schedule of soil investigation is shown in Fig. A.4.2.

4.1.2 General Nature of Soil Situation

Soil on the study area (up to 50.0 m deep) was composed by Holocene deposits, which the thickness is from 2.5 m to 35 m, covering Pleistocene deposits, which the thickness has not been determined yet (boreholes of 50.0 m depth did not excess these deposits), and some positions there is made ground on the surface with the thickness is from 0.5 m to 3.0 m. At the boreholes belong Ton Duc Thang, Ha m Nghi, Tran Hung Dao, Ben Chuong Duong, Tran Van Kieu, Van Don, Ton That Thuyet, Hung Phu, Pha m The Hien of the interceptor line, the thickness of Holocene deposits is s maller 10 m in 1, 4, 5 and 8 District but at the boreholes in 8 District, the thickness of Holocene deposits is more 20 m.

The Holocene deposits are very soft, soft, low or high plasticity organic clay, sandy clay (cohesive fine-grained soils) and sometimes they are very loose, loose clayey sand or silty sand. They have low bearing capacity.

The Pleistocene deposits are medium dense silty sand, sand or clayey sand (cohesioness coarse-grained soils) and sometimes they are stiff sandy clay, clay. They have high bearing capacity.

4.2. Drainage Pumping Station

4.2.1 Thanh Da Pumping Station

Based on in-situ survey, drilling documents and the results obtained from the soil tests, it is noticed that basic soil on the surveying site (up to 30.0 m deep) was composed by Holocene deposits of 21.5 m thick and Pleistocene deposits, which the thickness has not been determined yet (boreholes of 30.0 m depth did not excess these deposits), and on the surface there is made ground on the surface with the thickness 1.5 m. Fro m the surface downwards there are the following layers (The characteristic of layers see average value of the physico - mechanical properties)

1) Layer 1 : Made ground - Soft, blackish gray SANDY CLAY

This layer lies right on the surface found at all boreholes, with the thickness 1.5 m.

2) Layer 2 : Very soft, high plasticity blackish gray ORGANIC CLAY (OH)

It is covered by layer 1 with thickness from 17.0 m (UT-02) to 17.5 m (UT-01) and the bottom is from 17.5 m (UT-01) to 18.0 m (UT-02) deep. Standard penetration resistance N from 0 to 1. In total, 25 samples were taken from this layer, the obtained physico-mechanical properties of the samples have shown that, natural moisture is from 66.50 % to 105.59 %, wet density from 1.366 to 1.541 g/cm^3, liquid limit from 53.2 to 96.3 %, plasticity index from 22.8 to 48.4 %, high compressibility.

3) Layer 3 : Very loose, blackish gray CLAYEY SAND (SC)

Was found only at borehole UT-01. Thickness is 4.0 m and the bottom of layer is 23.0 m deep. Standard penetration resistance N = 1. In total, 2 samples were taken from this layer, the obtained physical, mechanical properties of the samples have shown that, natural moisture is from 20.96 % to 23.73 %, wet density from 1.946 to 1.949 g/cm^3, liquid limit from 20.8 to 21.6 %, plasticity index from 7.5 to 7.7 %.

4) Layer 3a : Loose, greenish gray SILTY, CLAYEY SAND (SM-SC)

Was found only at the borehole UT-02. The thickness is 3.5 m and the depth of the layer bottom is 22.0 m. Standard penetration resistance from 2 to 4. In total, 2 samples were taken from this layer, the obtained physico-mechanical properties of the samples have shown that, natural moisture is from 19.81 % to 20.21 %, wet density from 2.051 to 2.080 g/cm^3, liquid limit 24.7 %, plasticity index is 6.8 %.

5) Layer 4 : Stiff, very stiff, green, brownish gray CLAY with SAND (CL)

Was found at all the boreholes. The thickness is more 8.0 m and the depth of the layer bottom is more 30.0 m. At the boreholes with 30.0 m depth, its thickness has not been determined yet. Standard penetration resistance from 11 to 24. In total, 8 samples were taken from this layer, the obtained physico-mechanical properties of the samples have shown that, natural moisture is from 19.81 % to 20.21 %, wet density from 2.051 to 2.080 g/cm^3, liquid limit 24.7%, plasticity index is 6.8 %.

6) Conclusion

With the above mentions, some following remarks can be made:

- Up to 30.0 m deep, the foundation is constructed by Holocene and Pleistocene deposit layers. The Holocene have low bearing capacity.

- According to load of construction, foundation can be put on the layer 2 after improving, may be to use cajeput pile foundation, sand pile foundation or draining plastic stripes (for small load construction) or use concrete pile foundation to transmit the construction load to Pleistocene deposit soil layers (layer 4)

Calculation for a concrete pile at borehole UT-01 with section (0.4 x 0.4 m) and length of 25.0 m has following results:

Qult = 24.336 T

The engineering geology cross section is shown in Fig. A.4.3.

The average value of physico-mechanical properties is shown in Table A.4.2.

4.2.2 Vissan Pumping Station

Based on in-situ survey, drilling documents and the results obtained from the soil tests, it is noticed that basic soil on the surveying site (up to 30.0 m deep) was composed by Holocene deposits of 17.5 m thick and Pleistocene deposits, which the thickness has not been determined yet (boreholes of 30.0 m depth did not excess these deposits), and on the surface there is made ground on the surface with the thickness 0.5 m. From the surface downwards there are the following layers: (The characteristic of layers see average value of the physico-mechanical properties)

1) Layer 1 : Made ground - Reddish brown sandy clay with cobbles of stone and brick

This layer lies right on the surface found at all boreholes, with the thickness 0.5 m.

2) Layer 2 : Very soft, high plasticity blackish gray ORGANIC CLAY (OH).

It is covered by layer 1 with thickness from 13.0 m (UV-02) to 17.5 m (UV-01) and the bottom is from 13.5 m (UV-02) to 18.0 m (UV-01) deep. Standard penetration resistance N from 0 to 1. In total, 23 samples were taken from this layer, the obtained physico-mechanical properties of the samples have shown that, natural moisture is from 56.04 % to 105.18 %, wet density from 1.351 to 1.471 g/cm^3, liquid limit from 52.1 to 96.7 %, plasticity index from 19.9 to 47.9 %, high compressibility.

3) Layer 3 : Stiff, high plasticity, brown spot green CLAY (CH)

Was found only at borehole UV-02. Thickness is 9.0 m and the layer bottom is 22.5 m deep. Standard penetration resistance N from 10 to 15. In total, 4 samples were taken from this layer, the obtained physico-mechanical properties of the

samples have shown that, natural moisture is from 27.33 % to 31.15 %, wet density from 1.895 to 1.924 g/cm^3, liquid limit from 50.7 to 51.3 %, plasticity index from 25.2 to 25.6 %.

4) Layer 3a : Medium dense, light yellowish brown CLAYEY SAND (SC)

Was found at all the boreholes. The thickness is 4.5 m and the depth of the layer bottom is from 22.5 m (UV-01) to 27.0 m (UV-02). Standard penetration resistance from 10 to 14. In total, 4 samples were taken from this layer, the obtained physico-mechanical properties of the samples have shown that, natural moisture is from 18.28 % to 22.17 %, wet density from 1.850 to 1.938 g/cm^3, liquid limit from 22.9 % to 24.0 %, plasticity index is from 7.28 % to 7.6 %.

5) Layer 3b : Medium dense, yellowish greenish gray SILTY SAND (SM)

Was found at all the boreholes. The thickness is more 7.5 m and the depth of the layer bottom is more 30.0 m. At the boreholes with 30.0 m depth, its thickness has not been determined yet. Standard penetration resistance from 10 to 15. In total, 6 samples were taken from this layer, the obtained physico-mechanical properties of the samples have shown that, natural moisture is from 21.75 % to 24.92 %, wet density from 1.851 to 1.934 g/cm^3.

6) Conclusion

With the above mentions, some following remarks can be made :

- Up to 30.0 m deep, the foundation is constructed by Holocene and Pleistocene deposit layers. The Holocene deposits have low bearing capacity.
- According to load of construction, foundation can be put on the layer 2 after improving, may be to use cajeput pile foundation, sand pile foundation or draining plastic stripes (for small load construction) or use concrete pile foundation to transmit the construction load to Pleistocene deposit soil layers (layer 3, layer 3a or layer 3b)

Calculation for a concrete pile at borehole UV-01 with section (0.4 x 0.4 m) and length of 25.0 m has following results :

Qult = 12.803 T

The average value of physico-mechanical properties is shown in Table A.4.3.

4.2.3 Ben Me Coc 1

Based on in-situ survey, drilling documents and the results obtained from the soil tests, it is noticed that basic soil on the surveying site (up to 30.0 m deep) was composed by Holocene deposits of more 30 m thick, which the thickness has not been determined yet (boreholes of 30.0 m depth did not exeess these deposits), and at borehole UB(1)-01 there is made ground on the surface with the thickness 0.4 m. From the surface downwards there are the following layers: (The characteristic of layers see average value of the physico-mechanical properties)

1) Layer 1 : Made ground - Soft, blackish gray SANDY CLAY

This layer lies right on the surface, only found at borehole UB (1)-01, with the thickness 0.4 m.

2) Layer 2 : Very soft, high plasticity blackish gray ORGANIC CLAY (OH)

It is lies right on the surface or covered by layer 1 with thickness from 17.1 m (UB (1)-01) to 18.0 m (UB (1)-02) and the bottom is from 17.5 m (UB (1)-01) to 18.0 m (UB (1)-02) deep. Standard penetration resistance N from 0 to 1. In total, 23 samples were taken from this layer, the obtained physical, mechanical properties of the samples have shown that, natural moisture is from 52.19 % to 104.32 %, wet density from 1.404 to 1.561 g/cm^3, liquid limit from 59.6 to 103.7 %, plasticity index from 27.3 to 49.4 %, high compressibility.

3) Layer 3 : Soft, high plasticity blackish gray ORGANIC CLAY (OH)

Was found at all the boreholes. Thickness is from 7.0 m (UB (1)-02) to more 12.5 m (UB (1)-01), at borehole UB (1)-01 with 30.0 m depth, its thickness has not been determined yet. Standard penetration resistance N from 2 to 3. In total, 11 samples were taken from this layer, the obtained physical, mechanical properties of the samples have shown that, that, natural moisture is from 38.58 % to 66.53 %, wet density from 1.401 to 1.695 g/cm^3, liquid limit from 50.4 to 92.0 %, plasticity index from 19.6 to 43.9 %, high compressibility.

4) Layer 3a : Soft, high plasticity blackish gray SANDY CLAY (CL)

Was found only at the borehole UB (1)-02. The thickness is 5,0 and the depth of the layer bottom is more 30.0 m, at borehole UB (1)-02 with 30.0 m depth, its thickness has not been determined yet. Standard penetration resistance N = 3. In total, 11 samples were taken from this layer, the obtained physical, mechanical properties of the samples have shown that, natural moisture is from 33.75 % to 36.84 %, wet density from 1.388 to 1.436 g/cm^3, liquid limit 41.7 %, plasticity index is 17.1 %.

5) Conclusion

With the above mentions, some following remarks can be made:

- Up to 30.0 m deep, the foundation is constructed by Holocene deposit layers, with thickness more 30 m (very soft - soft, Organic Clay), have low bearing capacity.

- According to load of construction, foundation can be put on the layer 2 after improving, may be to use cajeput pile foundation, sand pile foundation or draining plastic stripes (for small load construction) or use concrete pile foundation to transmit the construction load to Pleistocene deposit soil layers and in this case have to drill some more deeper boreholes into the Pleistocene deposit.

Calculation for a concrete pile at borehole UB (1)-01 with section (0.4 x 0.4 m) and length of 30.0 m has following results:

Qult = 8.226 T

The engineering geology cross section is shown in Fig. A.4.4.

The average value of physico-mechanical properties is shown in Table A.4.4.

4.2.4 Ben Me Coc 2

Based on in-situ survey, drilling documents and the results obtained from the soil tests, it is noticed that basic soil on the surveying site (up to 30.0 m deep) was composed by Holocene deposits of more 29.5 m thick, covering Pleistocene deposits, of which the thickness has not been determined yet (Boreholes of 30.0 m depth did not excess these deposits) and at all boreholes there are made ground on the surface with the thickness from 0.5 m to 0.8 m. From the surface downwards there are the following layers. Characteristic of the layer see table of the average value of physico-mechanical properties of layers.

1) Layer 1 : Made ground - Soft, blackish gray SANDY CLAY

This layer lies right on the surface, only found at all the boreholes with the thickness is from 0.5 m (UB (2)-2) to 0.8 m (UB (2)-3).

2) Layer 2 : Very soft, high plasticity blackish gray ORGANIC CLAY (OH)

It is lies right on the surface or covered by layer 1 with thickness from 21.4 m (UB(2)-01) to 24.5 m (UB(2)-02) and the bottom is from 22.0 m (UB(2)-01) to 25.0 m (UB(2)-02) deep. Standard penetration resistance N from 0 to 1. In total,

40 samples were taken from this layer, the obtained physical, mechanical properties of the samples have shown that, natural moisture is from 51.13 % to 99.69 %, wet density from 1.326 to 1.579 g/cm^3, liquid limit from 52.2 to 97.8 %, plasticity index from 21.2 to 53.6 %, high compressibility.

3) Layer 3 : Soft, high plasticity blackish gray ORGANIC CLAY (OH)

Was found only at the borehole UB (2)-02. The thickness is more 5.0 m and the depth of the layer bottom is more 30.0 m, at borehole UB (2)-02 with 30.0 m depth, its thickness has not been determined yet. Standard penetration resistance N from 3 to 4. In total, 3 samples were taken from this layer, the obtained physical, mechanical properties of the samples have shown that, natural moisture is from 63.97 % to 65.77 %, wet density from 1.466 to 1.501 g/cm^3, liquid limit 90.3 %, plasticity index is 43.9 %.

4) Layer 4 : Stiff, low plasticity whitish gray CLAY (CL)

Was found only at the borehole UB(2)-01. The thickness is 4.0 m and the depth of the layer bottom is 27.5 m. Standard penetration resistance N from 13 to 14. In total, with 2 samples were taken from this layer, the obtained physical, mechanical properties of the samples have shown that, natural moisture is from 20.22 % to 24.33 %, wet density from 1.929 to 1.943 g/cm^3, liquid limit from 22.2 %, to 26.8 %, plasticity index from 8.6 to 9.4 %.

5) Layer 4a : Medium dense, light brown CLAYEY SAND (SC)

Was found at the borehole UB (2)-01 and UB (2)-03. The thickness from 1.5 m UB (2)-01 to more 2.0 m and the depth of the layer bottom is from 23.5 m UB (2)-01 to more 30.0 m UB (2)-03. Standard penetration resistance N from 12 to 13. In total, 3 samples were taken from this layer, the obtained physical, mechanical properties of the samples have shown that, natural moisture is from 14.87 % to 40.91 %, wet density from 1.704 to 2.018 g/cm^3, liquid limit from 18.8 % to 33.5 %, plasticity index from 7.9 %, to 13.1 %.

6) Layer 4b : Medium dense, brownish gray well graded SAND with SILT (SW-SM)

Was found at the borehole UB(2)-01 and UB(2)-03. The thickness from 1.0 m UB(2)-01 to 4.0 m and the depth of the layer bottom from 28.0 UB(2)-03 to more 30.0 m UB(2)-01. Standard penetration resistance N from 12 to 33. In total, 3 samples were taken from this layer, the obtained physical, mechanical properties of the samples have shown that, natural moisture is from 15.33 % to 17.21 %, wet density from 1.779 to 1.979 g/cm^3.

7) Layer 4c : Dense, whitish gray poorly graded SAND with SILT (SP-SM)

Was found only at the borehole UB (2)-01. The thickness 1.5 m and the depth of the layer bottom 29.0 m. Standard penetration resistance N = 36. The sample was taken from this layer, the obtained physical, mechanical properties of the samples have shown that, natural moisture is 14.87 %, wet density 1.844 g/cm^3.

8) Conclusion

With the above mentions, some following remarks can be made:

- Up to 30.0 m deep, the foundation is constructed by Holocene deposit layers, with thickness more 30 m (very soft - soft, Organic Clay), have low bearing capacity.

- According to load of construction, foundation can be put on the layer 2 after improving, may be to use cajeput pile foundation, sand pile foundation or draining plastic stripes (for small load construction) or use concrete pile foundation to transmit the construction load to Pleistocene deposit soil layers and in this case have to drill some more deeper boreholes into the Pleistocene deposit at the borehole UB (2)-2.

Calculation for a concrete pile at borehole UB (2)-3 with section (0.4 x 0.4 m) and length of 26.0 m has following results :

Qult = 9.680 T

The average value of physico-mechanical properties is shown in Table A.4.5.

4.3 Wastewater Treatment Plant

Based on in-situ survey, drilling documents and the results obtained from the soil tests, we have noticed that basic soil on the surveying site (up to 50.0 m deep) was composed by Holocene deposits of 35 m thick, covering Pleistocene deposits, of which the thickness has not been determined yet (boreholes of 50.0 m depth did not excess these deposits), and some positions there is made ground on the surface with the thickness 0.5 m - 0.6 m. From the surface downwards there are the following layers (The characteristic of layers see average value of the physico-mechanical properties)

(1) Made Ground (Layer 1)

This layer lies right on the surface, only found at boreholes ST-01 to ST-06, ST-11 and ST-12, with the thickness from 0.5 m to 0.6 m.

(2) The Holocene deposits

The Holocene deposit is divided into two sections.

(a) Section 1 - The upper Holocene deposits (Layer 2 - OH)

It is lies right on the surface or covered by layer 1 with thickness from 16.5 m (ST-11) to 26.0 m (ST-08) and the bottom is from 24.3 m to 26.0 m deep. It is very soft, high plasticity, blackish gray organic clay. Standard penetration resistance N from 0 to 2. In total, 117 samples were taken from this layer, the obtained physical, mechanical properties of the samples have shown that, natural moisture is from 67.37 % to 123.38 %, wet density from 1.182 to 1.554 g/cm^3, liquid limit from 71.5 to 113.8 %, plasticity index from 22.8 to 63.9 %, high compressibility.

(b) Section 2 - The lower Holocene deposits :

It is covered by layer 2, consist layers from 3 to 3f, most of them are fine grained soils: soft organic clay, sandy clay sometime alternate coarse grained soil lenses

1) Layer 3 : Soft, high plasticity, blackish gray ORGANIC CLAY (OH)

Was found at most of the boreholes. Thickness is from 5.5 m (ST-01) to more 13.0 m (ST-04 and ST-11). At the boreholes with 30.0 m depth, its thickness has not been determined yet. Standard penetration resistance N from 2 to 4. In total, 28 samples were taken from this layer, the obtained physical, mechanical properties of the samples have shown that, that, natural moisture is from 42.18 % to 88.21 %, wet density from 1.030 to 1.668 g/cm^3, liquid limit from 56.0 to 89.0 %, plasticity index from 17.1 to 44.8 %, high compressibility.

2) Layer 3a : Soft, low plasticity, blackish gray ORGANIC CLAY (OL)

Was found only at the borehole ST-05. The thickness is 5.5 m and the depth of the layer bottom is 23.5 m. Standard penetration resistance N = 4.1 sample was taken from this layer, the obtained physical, mechanical properties of the samples have shown that, that, natural moisture is 29.45 %, wet density is 1.854 g/cm^3, liquid limit 46.2 %, plasticity index 16.3 %.

3) Layer 3b : Soft, high plasticity, blackish gray SANDY CLAY (CH)

Was found at the boreholes ST-01, ST-09 vao ST-10. Thickness are from 2.5 m (ST-10) to 5.5 m (ST-01 and ST-10), and the depth of the layer bottom is from 26.0 m (ST-10) to more 30.0 m (ST-09). At the boreholes with 30.0 m

depth, its thickness has not been determined yet. Standard penetration resistance N from 2 to 4. In total, 7 samples were taken from this layer, the obtained physical, mechanical properties of the samples have shown that, that, natural moisture is from 46.31 % to 67.25 %, wet density from 1.517 to 1.638 g/cm^3, liquid limit from 50.6 to 54.8 %, plasticity index from 24.5 to 30.0 %, high compressibility.

4) Layer 3c : Soft, low plasticity, blackish gray SANDY CLAY (CL)

Was found at the boreholes ST-02, ST-03, ST-06, ST-10 and ST-12. Thickness is from 3.5 m (ST-10) to 7.5 m (ST-03), and the depth of the layer bottom is from 26.5 m (ST-10) to more 30.0 m (ST-12). Standard penetration resistance N from 3 to 4. In total, 12 samples were taken from this layer, the obtained physical, mechanical properties of the samples have shown that, that, natural moisture is from 42.21 % to 68.19 %, wet density from 1.393 to 1.717 g/cm^3, liquid limit from 33.9 to 49.6 %, plasticity index from 15.4 to 22.6%, high compressibility.

5) Layer 3d : Loose, blackish gray CLAYEY SAND (SC)

Was found at the boreholes ST-06, ST-07, ST-09 and ST-10. Thickness is from 2.0 m (ST-09) to 4.0 m (ST-08), and the depth of the layer bottom is from 26.0 m (ST-09) to 32.5 m (ST-10). Standard penetration resistance N from 4 to 6. In total, 10 samples were taken from this layer, the obtained physical, mechanical properties of the samples have shown that, natural moisture is from 28.79 % to 44.06 %, wet density from 1.373 to 1.897 g/cm^3, liquid limit from 30.0 to 46.0 %, plasticity index from 9.6 to 20.1 %.

6) Layer 3e : Loose, blackish gray poorly graded SANDY (SP)

Was found at borehole ST-01 in the lensing . Thickness is 1.5 m and the depth of the layer bottom is 32.0 m. Standard penetration resistance N = 6.1 sample was taken from this layer, the obtained physical, mechanical properties of the samples have shown that, natural moisture is 68.19 %, wet density 1.717 g/cm^3, liquid limit.

7) Layer 3f : Loose, blackish gray SILTY SAND (SM)

Was found at the boreholes ST-05 and ST-10. Thickness is from 1.5 m (ST-05) to 2.0 m (ST-10), and the depth of the layer bottom is from 23.0 m (ST-10) to more 33.5 m (ST-05). Standard penetration resistance N from 5 to 6. In total, 2 samples were taken from this layer, the obtained physical, mechanical properties of the samples have shown that, natural moisture is from 26.21% to 54.53%, wet density from 1.631 to 1.931g/cm^3, liquid limit 41.3%, plasticity index 13.8%.

(3) The Pleistocene Deposits

Was found at the boreholes 50.0 m depth below the Holocene deposits consist layers 4 to 4f. Most of them are coarse grained soils : sand, silty sand and some fine grained soil lenses, total thickness more 17.5 m. At the boreholes with 50.0 m depth, its thickness has not been determined yet. The Pleistocene deposits were divided into clayers :

1) Layer 4 : Medium dense, light yellow SILTY SAND (SM)

Was found at the boreholes with 50 m depth. Thickness is from 3.0 m (ST-01) to more 8.5 m (ST-05), and the depth of the layer bottom is from 38.0 m to more 50.0 m. At the boreholes ST-05, ST-07 and ST-10, its thickness has not been determined yet. Standard penetration resistance N from 10 to 15. In total, 15 samples were taken from this layer, the obtained physical, mechanical properties of the samples have shown that, natural moisture is from 16.40 % to 22.41 %, wet density from 1.719 to 1.994 g/cm^3, flight compressibility.

2) Layer 4a : Medium dense, yellowish gray, poorly graded SAND with SILT (SP-SM)

Was found at the boreholes ST-01 and ST-05. Thickness is from 4.5 m (ST-05) to more 12.0 m (ST-01), and the depth of the layer bottom is from 38.0 m to more 50.0 m. At the borehole ST-05, its thickness has not been determined yet. Standard penetration resistance N from 10 to 19. In total, 9 samples were taken from this layer, the obtained physical, mechanical properties of the samples have shown that, natural moisture is from 11.32 % to 20.00 %, wet density from 1.838 to 2.188g/cm^3, flight compressibility.

3) Layer 4b : Stiff, high plasticity, yellowish gray CLAY (CH)

Was found at the borehole ST-05. Thickness is 3.5 m, and the depth of the layer bottom is 41.5 m. Standard penetration resistance N from 10 to 12. 1 sample was taken from this layer, the obtained physical, mechanical properties of the samples have shown that, natural moisture is 32.22 %, wet density 1.865 g/cm^3.

4) Layer 4c : Loose, yellowish brown well graded SAND with SILT (SW-SM)

Was found at borehole ST-07. Thickness is 8.0m and the depth of the layer bottom is 44.0m. Standard penetration resistance N from 8 to 10. In total, 4 samples were taken from this layer, the obtained physical, mechanical properties of the samples have shown that, natural moisture is from 16.10 % to 17.20 %, wet density from 1.813 to 1.920 g/cm^3, flight compressibility.

5) Layer 4d : Medium dense, yellowish brown poorly graded SAND (SP)

Was found at the borehole ST-07. Thickness is 7.0m, and the depth of the layer bottom is 47.0m. Standard penetration resistance N from 10 to 11. In total, 3 sample was taken from this layer, the obtained physical, mechanical properties of the samples have shown that, natural moisture is from 17.47 % to 19.00 %, wet density from 1.506 to 1.901 g/cm^3, flight compressibility.

6) Layer 4e : Medium dense, light yellow SILTY, CLAYEY SANDY (SM-SC)

Was found at the borehole ST-10. Thickness is 6.5m, and the depth of the layer bottom is 42.5 m. Standard penetration resistance N from 10 to 12. In total, 3 sample was taken from this layer, the obtained physical, mechanical properties of the samples have shown that, natural moisture is from 19.57 % to 20.69 %, wet density from 1.965 to 1.971 g/cm^3, flight compressibility.

7) Layer 4f : Stiff, low plasticity, reenish gray SANDY CLAY (CL)

Was found at the borehole ST-10. Thickness is 3.5 m, and the depth of the layer bottom is 36.0 m. Standard penetration resistance N from 9 to 11. In total, 2 sample was taken from this layer, the obtained physical, mechanical properties of the samples have shown that, natural moisture is from 25.79 % to 26.98 %, wet density from 1.892 to 1.905 g/cm^3, flight compressibility.

8) Conclusion

With the above mentions, some following remarks can be made:

- Up to 50.0 m deep, the foundation is constructed by Holocene deposit layers, with thickness to 35m (very soft - soft fine - grained soil or loose coarse -grained soils), have low bearing capacity and the Pleistocene deposits have higher bearing capacity.

- According to load of construction, foundation can be put on the layer 2 after improving, may be to use cajeput pile foundation, sand pile foundation or draining plastic stripes (for small load construction) or use concrete pile foundation to transmit the construction load to Pleistocene deposit soil layers.

Calculation for a concrete pile at borehole ST-05 with section (0.4 x 0.4 m) and length of 45.0 m has following results :

Qult = 38.639 T

The engineering geology cross section is shown in Fig. A.4.5.

The average value of physico-mechanical properties is shown in Table A.4.6.

4.4. Sewerage Pumping Station

Based on in-situ survey, drilling documents and the results obtained from the soil tests, we have noticed that basic soil on the surveying site (up to 50.0 m deep) was composed by Holocene, Pleistocene and Pliocene deposits and on the surface there is made ground on the surface with the thickness 0.5 m. From the surface downwards there are the following layers (The characteristic of layers see average value of the physico-mechanical properties)

1) Layer 1 : Made ground - Brownish gray clayey sand

This layer lies right on the surface found at boreholes from SP-02 to SP-04, with the thickness is from 0.5m (SP-02 and SP-04) to 0.9m (SP-03).

2) Layer 2 : Very soft, high plasticity blackish gray ORGANIC CLAY (OH).

It lies right on the surface or is covered by layer 1 with thickness from 2.1m (SP-03) to 4.5m (SP-01 and SP-04) and the bottom is from 3.0m (SP-03) to 5.0m (SP-04) deep. Standard penetration resistance N from 0 to 1. In total, 10 samples were taken from this layer, the obtained physico-mechanical properties of the samples have shown that, natural moisture is from 74.31 % to 111.87%, wet density from 1.367 to 1.489 g/cm^3, liquid limit from 76.4 to 115.2 %, plasticity index from 32.4 to 63.7 %, high compressibility.

3) Layer 3 : Stiff, low plasticity, brown greenish gray CLAY (CL)

Was found only at borehole SP-04. Thickness is 1.5m and the layer bottom is 6.5m deep. Standard penetration resistance N = 3. With 1 samples was taken from this layer, the obtained physico-mechanical properties of the samples have shown that, natural moisture is 22.48 %, wet density 1.947 g/cm^3, liquid limit 36.3 %, plasticity index 15.8 %.

4) Layer 3a : Very loose, blackish gray CLAYEY SAND (SC)

Was found only at borehole SP-03. Thickness is 1.8m and the layer bottom is 8.0m deep. Standard penetration resistance N from 0 to 3. With 1 samples was taken from this layer, the obtained physico-mechanical properties of the samples have shown that, natural moisture is 47.34 %, wet density 1.618 g/cm^3, liquid limit 47.1 %, plasticity index 20.0 %.

5) Layer 4 : Medium dense, yellowish gray CLAYEY SAND (SC)

Was found at the boreholes from SP-01 to SP-03. The thickness is from 2.8 (SP-02) to 4.0 m (SP-01) and the depth of the layer bottom is from 7.5 m (SP-02) to 8.5 m (SP-01). Standard penetration resistance from 11 to 20. In total, 7 samples were taken from this layer, the obtained physico-mechanical properties of the samples have shown that, natural moisture is from 14.00 % to 20.24 %, wet density from 1.837 to 2.116 g/cm^3.

6) Layer 4a : Medium dense, reddish brown, yellowish brown SILTY, CLAYEY SAND (SM-SC)

Was found at all the boreholes. The thickness is from 5.5 (SP-04) to 21.0m (SP-01) and the depth of the layer bottom is from 12.0m (SP-04) to 32.0m (SP-01). Standard penetration resistance from 12 to 24. In total, 29 samples were taken from this layer, the obtained physico-mechanical properties of the samples have shown that, natural moisture is from 14.43 % to 21.23 %, wet density from 1.913 to 2.040 g/cm^3, liquid limit from 17.4 to 20.5 %, plasticity index from 4.1 to 6.9 %.

7) Layer 4b : Medium dense, reddish brown, yellowish brown SILTY, SAND (SM)

Was found at all the boreholes. The thickness is from 6.5 (SP-02) to more 13.0 m (SP-03) and the depth of the layer bottom is to 39.0 m (SP-01). Standard penetration resistance from 13 to 18. In total, 22 samples were taken from this layer, the obtained physico-mechanical properties of the samples have shown that, natural moisture is from 12.93 % to 19.21 %, wet density from 1.825 to 2.043 g/cm^3, liquid limit from 16.9 to 17.4 %, plasticity index from 3.5 to 3.9 %.

8) Layer 4c : Medium dense, yellowish brown poorly graded SAND with Silt (SP-SM)

Was found at the boreholes SP-02 and SP-03. The thickness is 1.5m and the depth of the layer bottom is 25.5m. Standard penetration resistance from 18 to 21. In total, 2 samples were taken from this layer, the obtained physico-mechanical properties of the samples have shown that, natural moisture is from 12.80 % to 14.78 %, wet density from 1.904 to 1.963 g/cm^3.

9) Layer 4d : Medium dense, reddish brown well graded SAND with Silt (SW-SM)

Was found at the boreholes SP-01, SP-02 and SP-04. The thickness is 2.0 m and the depth of the layer bottom is from 24.5 m (SP-04). Standard penetration resistance from 13 to 19. In total, 3 samples were taken from this layer, the obtained physico-mechanical properties of the samples have shown that, natural moisture is from 11.76 % to 15.86 %, wet density from 1.832 to 1.966 g/cm^3.

10) Layer 5 : Hard, high plasticity brownish gray CLAY (CH)

Was found at only the boreholes SP-01. The thickness is more 7.5m and the depth of the layer bottom is more 50.0m. At the boreholes with 50.0m depth, its thickness has not been determined yet. Standard penetration resistance from 36 to 46. In total, 3 samples were taken from this layer, the obtained physico-mechanical properties of the samples have shown that, natural moisture is from 18.96 % to 22.60 %, wet density from 2.051 to 2.080 g/cm^3, liquid limit from 56.7 to 62.5 %, plasticity index from 34.0 to 37.3 %.

11) Conclusion

With the above mentions, some following remarks can be made :

- Up to 50.0 m deep, the foundation is constructed by Holocene, Pleistocene and Pliocene deposit layers. The Holocene deposits have low bearing capacity.

- According to load of construction, foundation can be put on the layer 2 after improving, may be to use cajeput pile foundation, sand pile foundation or draining plastic stripes (for small load construction) or use concrete pile foundation to transmit the construction load to Pleistocene deposit soil layers.

Calculation for a concrete pile at borehole CP-02 with section (0.4 x 0.4m) and length of 6.0m has following results :

Qult = 6.330 T

and for example , a square shallow footing with depth and width of foundation are 2.0m has Qult = 5.430 T/m^2.

The engineering geology cross section is shown in Fig. A.4.6.

The average value of physico-mechanical properties is shown in Table A.4.7

4.5. Interceptor Sewer Line

Based on in-situ survey, drilling documents and the results obtained from the soil tests. We have noticed that basic soil on the surveying site (up to 30.0m deep) was composed by Holocene and Pleistocene deposits. Thickness of the Holocene Deposits is from 2.5m to 19.0m and more 30.0m and Pleistocene deposits, which the thickness has not been determined yet (boreholes of 30.0m depth did not excess these deposits). There is made ground on the surface with the thickness is from 0.5m to 3.0m. From the surface downwards there are the following layers: (The characteristic of layers see average value of the physico-mechanical properties)

1) Layer 1 : Made ground - Clayey sand or gravelly sand with cobbles of stone, brick, concrete

This layer lies right on the surface found at all boreholes, with the thickness is from 0.5m(SS-23) to 3.0m (SS-11).

2) Layer 2 : Very soft, high plasticity blackish gray ORGANIC CLAY (OH)

It is covered by layer 1 with thickness from 2.5m (SS-09) to 18.5m (SS-30) and the layer bottom is from 3.5m (SS-09) to 19.0m (SS-30) deep. Standard penetration resistance N from 0 to 2. In total, 80 samples were taken from this layer, the obtained physico-mechanical properties of the samples have shown that, natural moisture is from 44.97 % to 106.21 %, wet density from 1.307 to 1.748 g/cm^3, liquid limit from 52.3 to 101.0 %, plasticity index from 22.5 to 50.3 %, high compressibility.

3) Layer 3 : Soft, high plasticity blackish gray ORGANIC CLAY (OH)

It was found at boreholes SS-14 and SS-30. Thickness is from 5.6m (SS-30) to 13.0m (SS14) and the layer bottom is from 24.0m (SS-30) to more 30.0m (SS-14) deep. Standard penetration resistance N from 2 to 3. In total, 6 samples were taken from this layer, the obtained physico-mechanical properties of the samples have shown that, natural moisture is from 57.28 % to 81.54 %, wet density from 1.429 to 1.509 g/cm^3, liquid limit from 52.3 to 81.4 %, plasticity index from 23.4 to 40.2 %.

4) Layer 3a : Very soft, low plasticity blackish gray CLAY (CL)

It was found at all the boreholes SS-03, SS-18, SS-21 and SS-22. The thickness is from 4.3 m (SS-03) to 4.3 m (SS-22) and the depth of the layer bottom is from 3.5 m (SS-03) to 23.0 m (SS-18). Standard penetration resistance from 0 to 2. In total, 7 samples were taken from this layer, the obtained physico-mechanical properties of the samples have shown that, natural moisture is from 39.48 % to 55.89%, wet density from 1.609 to 1.758 g/cm^3, liquid limit from 39.2 % to 48.2 %, plasticity index is from 19.5 % to 23.4 %.

5) Layer 4 : Stiff, low plasticity yellowish brown, gray CLAY (CL)

Was found at most of the boreholes. The thickness is from 2.5m (SS-26) to 5.5m (SS-07 and SS-09) and the depth of the layer bottom is from 6.5m (SS-05 and SS-09) to more 30.0m, at the boreholes SS-01, SS-18, SS-26 and SS-31 with 30.0m depth, its thickness has not been determined yet. Standard penetration resistance from 8 to 15, sometimes to 28. In total, 24 samples were taken from this layer, the obtained physico-mechanical properties of the samples have shown that, natural moisture is from 16.70 % to 36.22 %, wet density from 1.706 to 2.095 g/cm^3, liquid limit from 23.2 % to 49.3 %, plasticity index is from 8.7 % to 25.7 %.

6) Layer 4a : Stiff, high plasticity brownish gray CLAY (CH)

Was found at the boreholes SS-04, SS-05, SS-12 and SS-31). The thickness is from 1.5 m (SS-12) to 6.5 m (SS-31) and the depth of the layer bottom is from 16.5 m (SS-12) to 25.0 m (SS-31). Standard penetration resistance from 11 to 15. In total, 6 samples were taken from this layer, the obtained physico-mechanical properties of the samples have shown that, natural moisture is from 27.74% to 69.01%, wet density from 1.559 to 1.890 g/cm^3, liquid limit from 51.6 % to 74.0 %, plasticity index is from 24.1 % to 42.5 %.

7) Layer 4b : Medium dense, whitish gray, yellowish brown CLAYEY SAND (SC)

Was found at most of the boreholes (except the boreholes SS-14, SS-16 to SS-20 and SS-30). The thickness is from 2.0m (SS-31) to 16.0m (SS-23) and the depth of the layer bottom is from 7.0m (SS-22) to more 30.0m. Standard penetration resistance from 10 to 19 (sometimes smaller 10). In total, 80 samples were taken from this layer, the obtained physico-mechanical properties of the samples have shown that, natural moisture is from 12.35 % to 25.49 %, wet density from 1.740 to 2.165 g/cm^3, liquid limit from 20.2 % to 48.6 %, plasticity index is from 13.0% to 24.6 %.

8) Layer 4c : Medium dense, brownish yellow SILTY, CLAYEY SAND (SM-SC)

It was found at the boreholes SS-01, SS-07, SS-09, SS-17 and SS-20). The thickness is from 2.0 m (SS-01 and SS-07) to 11.0m (SS-09) and the depth of the layer bottom is from 21.0 m (SS-17) to more 30.0 m (SS-07, SS-16 and SS-20). Standard penetration resistance from 13 to 18. In total, 10 samples were taken from this layer, the obtained physic-mechanical properties of the samples have shown that, natural moisture is from 15.56 % to 20.84 %, wet density from 1.863 to 2.046 g/cm^3, liquid limit from 17.3 % to 22.0 %, plasticity index is from 4.0 % to 6.5 %.

9) Layer 4d : Medium dense, yellowish brown SILTY SAND (SM)

Was found at most of the boreholes (except the boreholes SS-19 and SS-30). The thickness is from 2.5 m (SS-24) to 19.5 m (SS-02) and the depth of the layer bottom is from 16.0 m (SS-04) to more 30.0 m (SS-02). Standard penetration resistance from 10 to 22 (sometimes smaller 10). In total, 91 samples were taken from this layer, the obtained physico-mechanical properties of the samples have shown that, natural moisture is from 12.57 % to 26.53 %, wet density from 1.767 to 2.196 g/cm^3, liquid limit from 15.3 % to 21.1 %, plasticity index is from 3.0 % to 5.3 %.

10) Layer 4e : Medium dense, light yellow, poorly graded SAND with SILT (SP-SM)

Was found at the boreholes SS-06 and SS-07). The thickness is from 8.0m (SS-07) to 10.5 m (SS-06) and the depth of the layer bottom is from 21.0 m (SS-07) to 23.5 m (SS-06). Standard penetration resistance from 11 to 16. In total, 8 samples were taken from this layer, the obtained physico-mechanical properties of the samples have shown that, natural moisture is from 12.18 % to 19.37 %, wet density from 1.841 to 2.041g/cm^3.

11) Layer 4f : Medium dense, yellowish brown well graded SAND with SILT (SW-SM)

It was found at most of the boreholes. The thickness is from 1.5m (SS-09) to 6.0m (SS-02) and the depth of the layer bottom is from 13.0m (SS-28) to more 30.0m (SS-22). Standard penetration resistance from 10 to 18 (sometimes smaller 10). In total, 20 samples were taken from this layer, the obtained physico-mechanical properties of the samples have shown that, natural moisture is from 10.31 % to 20.34 %, wet density from 1.603 to 2.121 g/cm^3, liquid limit is 20.6 %, plasticity index is 7.1 %.

12) Layer 4g : Medium dense, brownish yellow well graded SAND (SW)

It was found at the boreholes SS-24 and SS-27. The thickness is from 3.5 m (SS-24) to 5.0 m (SS-27) and the depth of the layer bottom is from 14.0 m (SS-27) to more 30.0 m (SS-24). Standard penetration resistance from 14 to 18. In total, 3 samples were taken from this layer, the obtained physico-mechanical properties of the samples have shown that, natural moisture is from 13.05 % to 17.35 %, wet density from 1.866 to 2.085g/cm^3.

13) Layer 4h : Medium dense, brownish yellow poorly graded SAND (SP)

It was found at the boreholes SS-25, SS-27, SS-28 and SS-29. The thickness is from 3.5m (SS-27 and SS-29) to 9.0m (SS-28) and the depth of the layer bottom is from 13.0m (SS-29) to more 30.0m (SS-25, SS-27 and SS-28). Standard penetration resistance from 10 to 19. In total, 5 samples were taken from this layer, the obtained physico-mechanical properties of the samples have shown that, natural moisture is from 14.27 % to 22.46 %, wet density from 1.700 to 1.960 g/cm^3.

14) Layer 4l : Stiff, high plasticity greenish gray SILT (MH)

It was found only at the borehole SS-19. The thickness is 11.5 m and the depth of the layer bottom is more 30.0 m. Standard penetration resistance from 14 to 15. In total, 4 samples were taken from this layer, the obtained physico-mechanical properties of the samples have shown that, natural moisture is from 29.09 % to 32.78 %, wet density from 1.686 to 1.809 g/cm^3.

15) Conclusion

With the above mentions, some following remarks can be made :

- Up to 30.0 m deep, the foundation is constructed by Holocene and Pleistocene deposit layers. The Holocene deposits have low bearing capacity.
- According to load of construction, foundation can be put on the layer 2 after improving, may be to use cajeput pile foundation, sand pile foundation or draining plastic stripes (for small load construction) or use concrete pile foundation to transmit the construction load to Pleistocene deposit soil layers .
- Calculation for a continues footing with depth and width of foundation are 2.0m has following result :

  Qult = 3.39 T/m^2

The engineering geology cross section is shown in Fig. A.4.7.

The average value of physico-mechanical properties is shown in Table A.4.8.

4.6. Conveyance Sewer Line

Based on in-situ survey, drilling documents and the results obtained from the soil tests, we have noticed that basic soil on the surveying site (up to 30.0m deep) was composed by Holocene deposits with thickness from 1.8m (SC-03) to more 30.0m (SC-12), Pleistocene deposits which the thickness has not been determined yet (boreholes of 30.0m depth did not excess these deposits), and at some boreholes there is made ground on the surface with the thickness from 0.5m to 1.5m. From the surface downwards there are the following layers (The characteristic of layers see average value of the physico-mechanical properties)

1) Layer 1 : Made ground - Soft, blackish gray SANDY CLAY

   This layer lies right on the surface, found at all the boreholes with thickness from 0.5m (SC-06, SC-08 to SC-12) to 1.5m (SC-01).

2) Layer 2 : Very soft, high plasticity blackish gray ORGANIC CLAY (OH).

   It is covered by layer 1 with thickness from 1.8m (SC-03) to 28.0m (SC-11) and the depth of the layer bottom is from 2.8m (SC-03) to more 30.0m (SC-09). Standard penetration resistance N from 0 to 2. In total, 56 samples were taken from this layer, the obtained physical, mechanical properties of the samples have shown that, natural moisture is from 53.57 % to 116.78 %, wet density from 1.281 to 1.602 g/cm^3, liquid limit from 52.0 to 100.5 %, plasticity index from 22.5 to 52.5 %, high compressibility.

3) Layer 3 : Soft, low plasticity blackish gray SANDY CLAY (CL).

Was found only at the borehole SC-12. The thickness is 3.6 m and the depth of the layer bottom is 25.1 m. Standard penetration resistance N from 2 to 3. With 1 sample was taken from this layer, the obtained physical, mechanical properties of the samples have shown that, natural moisture is 38.27 %, wet density is 1.678 g/cm^3, liquid limit 46.2 %, plasticity index 19.9 %.

4) Layer 3a : Loose, blackish gray CLAYEY SAND (SC).

Was found only at the borehole SC-12. The thickness is more 4.9m and the depth of the layer bottom is more 30.0m, at borehole SC-12 with 30.0m depth, its thickness has not been determined yet. Standard penetration resistance N = 4. With 1 samples was taken from this layer, the obtained physical, mechanical properties of the samples have shown that, natural moisture is 35.51 %, wet density is 1.778 g/cm^3, liquid limit 30.0 %, plasticity index is 8.8%.

5) Layer 4 : Stiff, low plasticity yellowish gray CLAY (CL)

Was found at boreholes SC-01, SC-02, from SC-06 to SC-09. Thickness is from 1.8m (SC-06) to 7.0 m (ST-09) and the depth of the layer bottom is from 2.8 m (SC-03) to 22.5 m (SC-08). Standard penetration resistance N from 8 to 15. In total, 12 samples were taken from this layer, the obtained physical, mechanical properties of the samples have shown that, natural moisture is from 16.11 % to 30.12 %, wet density from 1.795 to 2.053 g/cm^3, liquid limit from 20.9 to 45.4 %, plasticity index from 7.2 to 22.6 %.

6) Layer 4a : Stiff, high plasticity yellowish gray CLAY (CH)

Was found at boreholes SC-09, SC-10 and SC-11. Thickness is from 1.5 m (SC-11) to more 10.0 m (ST-09) and the depth of the layer bottom is more 30.0 m, the boreholes with 30.0 m depth, its thickness has not been determined yet. Standard penetration resistance N from 9 to 13. In total, 5 samples were taken from this layer, the obtained physical, mechanical properties of the samples have shown that, natural moisture is from 21.07 % to 28.05 %, wet density from 1.840 to 1.968 g/cm^3, liquid limit from 50.6 to 57.1 %, plasticity index from 21.7 to 26.7 %.

7) Layer 4b : Medium dense, brownish gray CLAYEY SAND (SC)

Was found at boreholes SC-02, SC-03 and from SC-05 to SC-07. Thickness is from 1.5m (SC-02, SC-07) to 4.7m (ST-03) and the depth of the layer bottom is from 7.5m (SC-03) to 15.5m (SC-02). Standard penetration resistance N from 10 to 16. In total, 11 samples were taken from this layer, the obtained physical, mechanical properties of the samples have shown that, natural moisture is from 17.98 % to 22.61 %, wet density from 1.921 to 2.082 g/cm^3, liquid limit from 24.8 to 32.0 %, plasticity index from 8.4 to 13.8 %.

8) Layer 4c : Medium dense, yellowish brown SILTY, CLAYEY SAND (SMSC)

Was found at boreholes from SC-01 to SC-07. Thickness is from 1.5 m (SC-04) to 19.0 m (ST-01) and the depth of the layer bottom is from 13.0 m (SC-04) to more 30.0 m (SC-01, SC-02, and SC-03). Standard penetration resistance N from 10 to 18. In total, 57 samples were taken from this layer, the obtained physical, mechanical properties of the samples have shown that, natural moisture is from 13.86 % to 24.85 %, wet density from 1.572 to 2.137 g/cm^3 , liquid limit from 17.2 to 23.0 %, plasticity index from 4.1 to 7.0 %.

9) Layer 4d : Medium dense, yellowish brown SILTY SAND (SM)

Was found at boreholes SC-01 and from SC-03 to SC-08. Thickness is from 2.0 m (SC-01) to 19.5 m (ST-04) and the depth of the layer bottom is from 14.0 m (SC-05) to more 30.0 m (SC-05, SC-06 and SC-07). Standard penetration resistance N from 10 to 17. In total, 35 samples were taken from this layer, the obtained physical, mechanical properties of the samples have shown that, natural moisture is from 13.60 % to 22.95 %, wet density from 1.865 to 2.090 g/cm^3, liquid limit from 16.2 to 21.5 %, plasticity index 3.9 %.

10) Layer 4e : Medium dense, yellowish brown poorly graded SAND with SILT (SP-SM)

Was found at boreholes SC-02 and SC-06. Thickness is 2.0 m and the depth of the layer bottom is from 20.0 m (SC-02) to more 26.0m (SC-02). Standard penetration resistance N from 13 to 15. In total, 3 samples were taken from this layer, the obtained physical, mechanical properties of the samples have shown that, natural moisture is from 12.80 % to 19.02 %, wet density from 1.881 to 2.078 g/cm^3.

11) Layer 4f : Medium dense, pinkish yellow well graded SAND with SILT (SW-SM)

Was found at boreholes SC-02, SC-04, SC-05 and SC-08. Thickness is from 2.0 m (SC-03) to 4.0 m (SC-05) and the depth of the layer bottom is from 23.0 m (SC-03) to more 30.0 m (SC-04 and SC-08). Standard penetration resistance N from 15 to 17. In total, 7 samples were taken from this layer, the obtained physical, mechanical properties of the samples have shown that, natural moisture is from 11.57 % to 16.82 %, wet density from 1.634 to 2.119 g/cm^3.

12) Layer 4g : Medium dense, yellowish brown well graded SAND (SW)

Was found at borehole SC-02. Thickness is 3.5 m and the depth of the layer bottom is 23.5 m. Standard penetration resistance N from 14 to 15. In total, 3 samples were taken from this layer, the obtained physical, mechanical properties of the samples have shown that, natural moisture is from 18.84 % to 21.32 %, wet density from 1.693 to 1.886 g/cm^3.

13) Layer 4h : Medium dense, yellowish brown poorly graded SAND (SP)

Was found at borehole SC-02. Thickness is 2.0 m and the depth of the layer bottom is 25.5 m. Standard penetration resistance N from 15 to 16. The sample was taken from this layer, the obtained physical, mechanical properties of the samples have shown that, natural moisture is 15.92 %, wet density 1.931 g/cm^3.

14) Conclusion

With the above mentions, some following remarks can be made :

- Up to 30.0 m deep, the base is constructed by Holocene deposit layers, with thickness from 1.8 m to more 24.5 m (very soft - soft, Organic Clay), have low bearing capacity.

- Foundation can be put on the layer 2 after improving, may be to use cajeput pile foundation, sand pile foundation or draining plastic stripes.

- Calculation for a continues footing with depth and width of foundation are 2.0 m has following results :

  Qult = 3.29 T/m^2.

The engineering geology cross section is shown in Fig. A.4.8.

The average value of physico-mechanical properties is shown in Table A.4.9.

Table A.4.1 Number of Sampling and Laboratory Test

No	Location	Mechanical Boring				SPT (Times)		Laboratory test (Sample)	
		No		Total (m)					
		Con.	HBD	Con.	HBD	Con.	HBD	Con.	HBD
1	Drainage Pumping Stations	9	9	270	270	270	270	130	163
	Thanh Da	2	2	60	60	60	60	30	37
	Vissan	3	2	90	60	90	60	40	37
	Ben Me coc 1	2	2	60	60	60	60	30	37
	Ben Me coc 2	2	3	60	90	60	90	30	52
2	Wastewater Treatment Plant	12	12	440	440	440	440	200	216
3	Sewerage Pumping Station	4	4	140	140	140	140	60	78
4	Interceptor Sewer Line	31	31	930	930	930	930	600	354
5	Conveyance Sewer Line	12	12	360	360	360	360		192
	Total	**68**	**68**	**2410**	**2410**	**2410**	**2410**	**990**	**989**

Table A.4.2 AVERAGE VALUE OF PHYSICO - MECHANICAL PROPERTIES OF LAYERS (Thanh Da Pumping Station)

No	Property		Sign	Layer 2 : Very soft, high plasticity blackish grey ORGANIC CLAY	Layer 3 : Very loose, bLackish grey CLAYEY SAND	Layer 3a : Loose, greenish grey SILTY, CLAYEY SAND	Layer 4 : Stiff, very stiff, low plasticity greenish brownish grey CLAY with SAND
1	Sieve Analisis, % Passing						
	3/4" (19 mm)						
	1/2" (12.5 mm)						
	3/8" (9.5 mm)						
	#4 (4.75 mm)						100.0
	#8 (2.36 mm)				100.0	100.0	99.7
	#16 (1.18 mm)				95.1	97.0	97.4
	#30 (0.6 mm)				86.5	94.0	94.7
	#50 (0.3 mm)			100.0	66.1	78.1	88.1
	#100 (0.15 mm)			99.4	43.8	39.7	79.5
	#200 (0.075 mm)			96.0	37.0	28.9	71.6
	< 0.005 mm			67.4	21.7	18.2	46.8
2	Natural moisture content	(%)	w	88.68	22.35	20.01	20.71
3	Natural unit weight	(g/cm^3)	g	1.435	1.948	2.066	1.986
4	Dry unit weight	(g/cm^3)	g_d	0.765	1.592	1.721	1.647
5	Specific gravity		Gs	2.591	2.657	2.664	2.693
6	Porosity		n	0.70	0.40	0.35	0.39
7	Void ratio		e_o	2.461	0.669	0.548	0.639
8	Degree saturation	(%)	S	94.9	88.7	97.4	87.7
9	Liquid limit	(%)	LL	80.1	21.2	24.7	33.9
10	Plastic limit	(%)	LP	42.2	13.6	17.9	20.2
11	Plastic index	(%)	PI	37.9	7.6	6.8	13.7
12	Water plasticity ratio	(%)	B	1.27	1.15	0.28	0.01
13	Unconfined compression	(Kg/cm^2)	qu	0.121	0.111	0.336	
14	Compression index		Cc	1.136		0.0785	
15	Coefficient of consolidation	(cm^2/Kg)	Cv	2.21E-04		7.15E-04	
16	Preconsolidation pressure	(kg/cm^2)	Pc	0.835		0.691	
17	Coefficient of volumn compressibility	(cm^2/g)	Mv	1.35E-04		2.42E-05	
18	Permeability	(cm/sec)	k20	3.27E-08		1.46E-08	

Table A.4.3 AVERAGE VALUE OF PHYSICO - MECHANICAL PROPERTIES OF LAYERS (Vissan Pumping Station)

No	Property		Sign	Layer 2 : Very soft, high plasticity blackish grey ORGANIC CLAY	Layer 3 : Stiff, high plasticity brown spot, green CLAY	Layer 3a : Medium dense, light yellow, brown CLAYEY SAND	Layer 3b : Medium dense, yellowish, greenish grey SILTY SAND (SM)
1	Sieve Analisis, % Passing						
	3/4" (19 mm)						
	1/2" (12.5 mm)						
	3/8" (9.5 mm)						
	#4 (4.75 mm)			100.0			
	#8 (2.36 mm)			99.9	100.0	100.0	100.0
	#16 (1.18 mm)			99.5	99.6	90.1	96.8
	#30 (0.6 mm)			99.3	99.4	84.9	95.4
	#50 (0.3 mm)			99.0	99.2	66.3	87.8
	#100 (0.15 mm)			98.3	98.6	35.9	31.9
	#200 (0.075 mm)			94.6	94.6	27.9	21.4
	< 0.005 mm			68.9	62.0	13.1	7.1
2	Natural moisture content	(%)	w	87.62	29.78	20.34	22.58
3	Natural unit weight	(g/cm^3)	g	1.413	1.905	1.883	1.897
4	Dry unit weight	(g/cm^3)	g_d	0.757	1.468	1.565	1.547
5	Specific gravity		Gs	2.593	2.693	2.662	2.653
6	Porosity		n	0.71	0.45	0.41	0.42
7	Void ratio		e_o	2.448	0.835	0.702	0.725
8	Degree saturation	(%)	S	92.5	96.0	77.2	83.8
9	Liquid limit	(%)	LL	79.2	51.0	23.6	
10	Plastic limit	(%)	LP	42.2	25.6	16.9	
11	Plastic index	(%)	PI	37.0	25.4	7.4	
12	Water plasticity ratio	(%)	B	1.25	0.14	0.49	
13	Unconfined compression	(Kg/cm^2)	qu	0.136	1.566		
14	Compression index		Cc	1.282	0.0723		
15	Coefficient of consolidation	(cm^2/Kg)	Cv	2.08E-04	7.91E-04		
16	Preconsolidation pressure	(kg/cm^2)	Pc	0.876	0.577		
17	Coefficient of volumn compressibility	(cm^2/g)	Mv	1.16E-02	1.56E-05		
18	Permeability	(cm/sec)	k20	2.22E-08	1.13E-08		

Table A.4.4 AVERAGE VALUE OF PHYSICO - MECHANICAL PROPERTIES OF LAYERS
(Ben Me Coc (1) Pumping Station)

No	Property		Sign	Layer 2 : Very soft, high plasticity blackish grey ORGANIC CLAY	Layer 3 : Soft, high plasticity, bLackish grey ORGANIC CLAY	Layer 3a : Soft, low plasticity SANDY CLAY
1	Sieve Analisis, % Passing					
	3/4" (19 mm)					
	1/2" (12.5 mm)					
	3/8" (9.5 mm)					
	#4 (4.75 mm)					
	#8 (2.36 mm)			100	100	100
	#16 (1.18 mm)			98.9	98.5	98.7
	#30 (0.6 mm)			97.1	97.6	97.6
	#50 (0.3 mm)			96.2	95.0	96.2
	#100 (0.15 mm)			92.8	87.7	89.4
	#200 (0.075 mm)			55.1	70.3	55.2
	< 0.005 mm			80.7	41.6	29.1
2	Natural moisture content	(%)	w	1.47	51.08	35.05
3	Natural unit weight	(g/cm^3)	g	0.822	1.583	1.417
4	Dry unit weight	(g/cm^3)	g_d	2.592	1.051	1.049
5	Specific gravity		Gs	0.683	2.630	2.643
6	Porosity		n	2.184	0.601	0.603
7	Void ratio		e_o	95.200	1.520	1.520
8	Degree saturation	(%)	S	81.40	88.70	61.0
9	Liquid limit	(%)	LL	81.4	69.7	41.7
10	Plastic limit	(%)	LP	43.2	39.3	24.6
11	Plastic index	(%)	PI	38.2	31.7	17.1
12	Water plasticity ratio	(%)	B	0.99	0.37	0.54
13	Unconfined compression	(Kg/cm^2)	qu	0.102	0.097	
14	Compression index		Cc	1.200	0.694	
15	Coefficient of consolidation	(cm^2/Kg)	Cv	2.55E-04	3.68E-04	
16	Preconsolidation pressure	(kg/cm^2)	Pc	0.996	0.904	
17	Coefficient of volunm compressibility (cm^2/g)		Mv	1.36E-04	9.79E-05	
18	Permeability	(cm/sec)	k20	3.60E-08	3.05E-08	

Table A.4.5 AVERAGE VALUE OF PHYSICO - MECHANICAL PROPERTIES OF LAYERS
(Ben Me Coc (2) Pumping Station)

No	Property		Sign	Layer 2 : Very soft, high plasticity blackish grey ORGANIC CLAY	Layer 3 : Soft, high plasticity blackish grey ORGANIC CLAY	Layer 4 : Stiff, low plasticity whitish grey CALY	Layer 4a : Medium dense, light brown CLAYEY SAND	Layer 4b : Medium dense, brownish grey well graded SAND with SILT	Layer 4c : Dense, whitish grey poorly graded SAND with SILT
1	Sieve Analisis, % Passing								
	3/4" (19 mm)								
	1/2" (12.5 mm)								
	3/8" (9.5 mm)								
	#4 (4.75 mm)								
	#8 (2.36 mm)			100.0		100.0	100.0	100.0	100.0
	#16 (1.18 mm)			99.5		97.5	97.5	77.9	94.7
	#30 (0.6 mm)			99.1		94.4	92.1	45.2	60.6
	#50 (0.3 mm)			98.3		90.0	55.7	17.7	21.0
	#100 (0.15 mm)			96.6	100.0	84.5	27.2	10.1	12.3
	#200 (0.075 mm)			93.2	97.4	79.8	22.1	8.1	10.9
	< 0.005 mm			57.8	72.2	35.7	14.4	3.5	7.3
2	Natural moisture content	(%)	w	81.77	64.88	22.28	23.90	16.35	14.87
3	Natural unit weight	(g/cm^3)	g	1.543	1.485	1.936	1.906	1.871	1.844
4	Dry unit weight	(g/cm^3)	g_d	0.804	0.901	1.584	1.562	1.608	1.605
5	Specific gravity		Gs	2.579	2.600	2.676	2.653	2.645	2.648
6	Porosity		n	0.69	0.65	0.41	0.41	0.39	0.39
7	Void ratio		e_o	2.261	1.888	0.690	0.749	0.647	0.650
8	Degree saturation	(%)	S	93.9	89.4	86.2	82.2	67.7	60.6
9	Liquid limit	(%)	LL	78.6	90.3	24.5	26.2		
10	Plastic limit	(%)	LP	41.8	46.4	15.5	15.7		
11	Plastic index	(%)	PI	36.8	43.9	9.0	10.5		
12	Water plasticity ratio	(%)	B	1.15	0.44	0.75	1.69		
13	Unconfined compression	(Kg/cm^2)	qu	0.148					
14	Compression index		Cc	1.129					
15	Coefficient of consolidation	(cm^2/Kg)	Cv	2.12E-04					
16	Preconsolidation pressure	(kg/cm^2)	Pc	0.754					
17	Coefficient of volunm compressibility	(cm^2/g)	Mv	1.41E-04					
18	Permeability	(cm/sec)	k20	3.17E-08					

Table A.4.6 Average Value of Physico - Mechanical Properties of Layers (Wastewater Treatment Plant)

No	Property		Sign	Layer 2 : Very soft, high plasticity blackish grey ORGANIC CLAY	Layer 3 : Soft, high plasticity blackish grey ORGANIC CLAY	Layer 3a : Soft, low plasticity blackish grey ORGANIC CLAY	Layer 3b : Soft, high plasticity blackish grey SANDY CLAY	Layer 3c : Soft, low plasticity blackish grey SANDY CLAY	Layer 3d : Loose, blackish grey CLAYEY SAND	Layer 3e : Loose, blackish grey POORLY GRADED SAND	Layer 3f : Loose, blackish grey SILTY SAND	Layer 4 : Medium dense, light yellow SILTY SAND	Layer 4a : Medium dense, yellowish grey poorly graded SAND with SILT	Layer 4b : Stiff, high plasticity yellowish grey CLAY	Layer 4c : Medium dense yellowish brown well graded SAND with SILT	Layer 4d : Medium dense yellowish brown poorly graded SAND	Layer 4e : Medium dense light yellow well graded SAND with SILTY CLAY	Layer 4f : Stiff, low plasticity greenish grey SANDY CLAY
1	Sieve Analisis, % Passing																	
	3/4" (19 mm)																	
	1/2" (12.5 mm)																	
	3/8" (9.5 mm)																	
	#4 (4.75 mm)																	
	#8 (2.36 mm)				100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	#16 (1.18 mm)				98.8	98.4	98.7	97.9	97.3	98.9	89.8	95.4	92.2	85.2	91.2	98.2	96.6	96.4
	#30 (0.6 mm)			100.0	96.8	94.0	95.0	95.2	93.8	76.1	77.3	87.4	72.2	84.7	75.0	87.6	86.3	94.2
	#50 (0.3 mm)			99.9	91.6	79.9	84.3	84.1	76.8	15.0	54.7	50.4	31.6	83.9	29.1	39.9	47.6	89.0
	#100 (0.15 mm)			99.9	83.0	75.0	67.9	68.6	46.0	6.5	34.6	25.3	14.3	81.7	13.5	7.7	26.2	81.5
	#200 (0.075 mm)			97.0	77.2	72.5	61.9	60.9	37.5	3.5	31.0	17.1	9.8	79.2	10.7	4.3	22.2	75.0
	< 0.005 mm			65.5	48.0	54.1	43.3	38.9	26.1	3.0	22.4	6.6	3.9	54.7	3.4	3.0	11.3	31.7
2	Natural moisture content	(%)	w	96.42	62.91	29.45	56.08	52.40	35.43	20.99	40.37	18.40	16.35	32.22	16.65	18.39	20.10	26.39
3	Natural unit weight	(g/cm^3)	g	1.401	1.519	1.854	1.592	1.550	1.649	1.696	1.781	1.910	1.950	1.865	1.885	1.768	1.968	1.899
4	Dry unit weight	(g/cm^3)	g_d	0.716	0.940	1.224	1.023	1.021	1.222	1.402	1.293	1.614	1.678	1.411	1.616	1.492	1.639	1.502
5	Specific gravity		Gs	2.600	2.621	2.604	2.618	2.640	2.634	2.656	2.642	2.646	2.649	2.633	2.642	2.645	2.641	2.659
6	Porosity		n	0.725	0.641	0.530	0.609	0.613	0.536	0.472	0.510	0.391	0.366	0.464	0.388	0.436	0.380	0.435
7	Void ratio		e_o	2.662	1.844	1.128	1.571	1.611	1.192	0.895	1.116	0.644	0.585	0.867	0.636	0.791	0.614	0.770
8	Degree saturation	(%)	S	94.51	90.46	68.00	93.26	86.46	83.48	62.31	95.65	76.36	74.78	97.89	69.24	65.13	86.56	91.12
9	Liquid limit	(%)	LL	92.4	69.1	46.2	52.8	43.2	40.1		41.3			53.0				30.2
10	Plastic limit	(%)	LP	47.9	37.1	29.9	25.5	24.7	24.5		27.5			21.8				17.1
11	Plastic index	(%)	PI	44.5	32.0	16.3	27.3	18.5	15.6		13.8			31.2				13.1
12	Water plasticity ratio	(%)	B	1.16	0.75	-0.03	1.15	1.47	0.75		1.96			0.33				0.66
13	Unconfined compression	(Kg/cm^2)	qu	0.170	0.140		0.094	0.153	0.039				0.412					0.158
14	Compression index		Cc	1.1870	0.7145		0.7137	0.5896	0.4674		0.4299	0.0519	0.0045		0.0832			0.1125
15	Coefficient of consolidation	(cm^2/Kg)	Cv	2.09E-04	3.36E-04		2.86E-04	4.59E-04	3.13E-04		3.77E-04	4.95E-04	3.97E-04		5.75E-04			7.15E-04
16	Preconsolidation pressure	(kg/cm^2)	Pc	0.610	0.726		0.927	0.629	1.146		1.010	1.203	1.266		1.666			0.995
17	Coefficient of volum compressibility	(cm^2/g)	Mv	1.63E-04	1.05E-04		1.22E-04	8.49E-05	3.21E-04		7.44E-05	2.23E-05	1.39E-04		2.37E-04			1.93E-04
18	Permeability	(cm/sec)	k20	2.72E-08	3.18E-08		3.53E-08	3.93E-08	2.29E-08		4.97E-08	1.45E-08	3.43E-08		1.29E-08			1.14E-08

Table A.4.7 Average Value of Physico - Mechanical Properties of Layers

(Sewerage Pumping Station)

No	Property	Sign	Layer 2 : Very soft, high plasticity blackish grey ORGANIC CLAY	Layer 3 : Soft, low plasticity blackish grey SANDY CLAY	Layer 3a : Very loose, blackish grey CLAYEY SAND	Layer 4 : Medium dense, yellowish grey CLAYEY SAND	Layer 4a : Medium dense, reddish brown, yellowish brown SILTY CLAYEY SAND	Layer 4b : Medium dense, reddish yellowish brown SILTY SAND	Layer 4c : Medium dense, yellowish brown poorly graded SAND with SILT	Layer 4d : Medium dense, reddish brown well graded SAND with SILT	Layer 5 : Hard, high plasticity brownish grey CLAY
1	Sieve Analysis, % Passing										
	3/4" (19 mm)						100.0				
	1/2" (12.5 mm)						99.4			100.0	
	3/8" (9.5 mm)						98.6			99.7	
	#4 (4.75 mm)						96.2			98.3	
	#8 (2.36 mm)		100.0	100.0	100.0	100.0	94.3		100.0	95.0	
	#16 (1.18 mm)		99.7	99.5	97.8	91.6	90.6	100.0	84.1	75.8	100.0
	#30 (0.6 mm)		98.3	98.6	97.1	75.5	80.5	94.6	63.8	53.5	99.9
	#50 (0.3 mm)		97.6	95.1	94.7	49.1	42.9	78.2	27.6	22.7	99.8
	#100 (0.15 mm)		95.9	83.2	72.0	37.0	23.4	38.3	14.6	11.1	99.5
	#200 (0.075 mm)		91.5	74.5	48.8	31.8	18.5	19.0	11.4	8.8	97.3
	< 0.005 mm		66.9	45.7	23.1	19.1	8.6	14.5	3.3	3.6	78.2
2	Natural moisture content (%)	w	99.27	22.48	47.34	19.26	17.58	16.98	13.79	13.97	20.73
3	Natural unit weight (g/cm^3)	γ	1.410	1.947	1.618	1.956	1.969	1.953	1.394	1.893	2.061
4	Dry unit weight (g/cm^3)	γ_d	0.746	1.590	1.098	1.669	1.675	1.670	1.700	1.662	1.708
5	Specific gravity	Gs	2.589	2.688	2.677	2.663	2.654	2.647	2.636	2.643	2.687
6	Porosity	n	0.71	0.41	0.59	0.37	0.37	0.37	0.36	0.37	0.36
7	Void ratio	e_o	2.498	0.691	1.438	0.600	0.586	0.586	0.552	0.593	0.574
8	Degree saturation (%)	S	93.2	87.5	88.1	77.4	79.7	76.8	65.9	62.2	97.0
9	Liquid limit (%)	LL	94.0	36.3	47.1	24.2	18.9	17.1			59.9
10	Plastic limit (%)	LP	48.5	20.5	27.1	14.1	13.3	13.4			24.6
11	Plastic index (%)	PI	45.4	15.8	20.0	10.1	5.5	3.7			35.4
12	Water plasticity ratio (%)	B	0.99	1.01	1.01	0.22	0.67	0.76			-0.11
13	Unconfined compression (Kg/cm^2)	qu	0.106	0.313		1.075	0.901	0.715			
14	Compression index	Cc	1.199			0.121	0.121	0.138		0.3784	
15	Coefficient of consolidation (cm^2/Kg)	Cv	1.94E-04			1.08E-03	9.94E-04	6.09E-04		5.35E-04	
16	Preconsolidation pressure (kg/cm^2)	Pc	0.633			1.056	1.684	1.878		2.378	
17	Coefficient of volumn compressibility (cm^2/g)	Mv	1.58E-04			2.96E-05	2.60E-05	2.60E-05		2.68E-05	
18	Permeability (cm/sec)	k20	3.28E-08			2.54E-08	2.31E-08	1.27E-08		1.37E-08	

Table A.4.8 Average Value of Physico - Mechanical Properties of Layers (Interceptor Sewer Line)

No	Property		Sign	Layer 2 : Very soft, high plasticity blackish grey ORGANIC CLAY	Layer 3 : Soft, high plasticity blackish grey ORGANIC CLAY (OH)	Layer 3a : Very soft, low plasticity blackish grey CLAY	Layer 4 : Stiff, low plasticity yellowish grey CLAY	Layer 4a : Stiff, high plasticity brownish grey CLAY	Layer 4b : Medium dense, whitish grey, yellowish brown CLAYEY SAND	Layer 4c : Medium dense, brownish brown SILTY, CLAYEY SAND	Layer 4d : Medium dense, yellowish brown SILTY SAND	Layer 4e : Medium dense, light yellow poorly graded SAND with SILTY	Layer 4f : Medium dense, yellowish brown well graded SAND with SILT	Layer 4g : Medium dense, brownish yellow well graded SAND	Layer 4h : Medium dense, brownish yellow poorly graded SAND (SP)	Layer 4i : Stiff, high plasticity greenish grey SILT
1	Sieve Analisis, % Passing															
	3/4" (19 mm)												100.0			
	1/2" (12.5 mm)										100.0		99.9			
	3/8" (9.5 mm)										99.9		99.6			
	#4 (4.75 mm)					100.0	100.0	100.0	100.0		99.5		99.2		100.0	
	#8 (2.36 mm)			100.0	100.0	99.2	99.6	99.9	99.9	100.0	98.9	100.0	96.6	100.0	97.3	100.0
	#16 (1.18 mm)			99.9	100.0	97.3	97.1	96.9	97.0	97.3	93.2	82.6	77.8	68.5	92.6	99.9
	#30 (0.6 mm)			99.8	100.0	92.4	93.6	90.9	91.1	91.8	82.5	62.3	53.3	27.7	80.4	99.8
	#50 (0.3 mm)			99.7	100.0	87.3	86.2	66.1	66.3	66.7	45.2	22.9	24.3	16.3	26.0	99.3
	#100 (0.15 mm)			99.2	100.0	85.1	79.0	37.7	37.9	30.8	23.4	13.9	12.6	6.3	6.5	96.8
	#200 (0.075 mm)			95.5	99.9	82.7	72.7	29.3	29.4	22.3	17.8	10.9	9.0	2.7	1.1	90.8
	< 0.005 mm			58.1	76.8	55.8	42.2	16.3	16.4	9.5	7.3	3.9	3.3	0.9	0.0	52.2
2	Natural moisture content	(%)	w	84.59	81.54	48.98	22.17	19.65	19.62	18.13	17.22	16.74	15.10	14.76	17.36	31.15
3	Natural unit weight	(g/cm^3)	g	1.461	1.509	1.649	1.963	1.980	1.980	1.962	1.962	1.939	1.946	1.979	1.875	1.765
4	Dry unit weight	(g/cm^3)	g_d	0.796	0.952	1.109	1.612	1.656	1.656	1.661	1.668	1.660	1.693	1.725	1.598	1.346
5	Specific gravity		Gs	2.608	2.631	2.646	2.679	2.656	2.656	2.647	2.650	2.646	2.649	2.650	2.647	2.627
6	Porosity		n	0.69	0.68	0.58	0.40	0.38	0.38	0.37	0.37	0.37	0.36	0.35	0.40	0.49
7	Void ratio		e_o	2.309	2.130	1.393	0.675	0.607	0.607	0.595	0.592	0.595	0.574	0.540	0.661	0.954
8	Degree saturation	(%)	S	95.6	99.6	92.8	88.2	86.4	86.3	81.0	79.6	75.1	70.5	73.4	70.2	86.1
9	Liquid limit	(%)	LL	80.4	81.4	45.0	38.0	26.4	26.4	20.0	18.5		20.6			62.4
10	Plastic limit	(%)	LP	42.8	41.2	24.1	20.9	16.2	16.2	14.6	14.5		13.5			35.7
11	Plastic index	(%)	PI	37.6	40.2	21.0	17.1	10.2	10.2	5.4	4.1		7.1			26.6
12	Water plasticity ratio	(%)	B	1.10	1.21	1.16	0.17	0.37	0.37	0.66	1.13		0.48			-0.17
13	Unconfined compression	(Kg/cm^2)	qu	0.175	0.520	0.290	1.202	0.928	0.928		0.416					0.906
14	Compression index		Cc	1.274		0.683	0.181	0.155	0.155	0.127	0.131					
15	Coefficient of consolidation	(cm^2/Kg)	Cv	2.65E-04		4.60E-04	6.38E-04	9.28E-04	9.28E-04	6.28E-04	7.23E-04					
16	Preconsolidation pressure	(kg/cm^2)	Pc	1.281		1.595	1.705	1.307	1.307	0.824	1.334					
17	Coefficient of volunm compressibility	(cm^2/g)	Mv	1.36E-04		1.25E-04	2.50E-05	4.12E-05	4.12E-05	2.04E-05	1.86E-05					
18	Permeability	(cm/sec)	k20	5.15E-05		5.36E-08	5.44E-08	7.86E-05	7.86E-05	1.07E-08	1.33E-05					

Table A.4.9 Average Value of Physico - Mechanical Properties of Layers (Conveyance Sewer Line)

No	Property		Sign	Layer 2 : Very soft, high plasticity blackish grey ORGANIC CLAY	Layer 3 : Soft, low plasticity blackish grey SANDY CLAY	Layer 3a : Loose, blackish grey CLAYEY SAND	Layer 4 : Stiff, low plasticity yellowish grey CLAY	Layer 4a : Stiff, high plasticity greenish grey CLAY	Layer 4b : Medium dense, brownish grey CLAYEY SAND	Layer 4c : Medium dense, yellowish brown SILTY, CLAYEY SAND	Layer 4d : Medium dense, yellowish brown SILTY SAND	Layer 4e : Medium dense, yellowish brown poorly graded SAND with SILTY	Layer 4f : Medium dense, pinkish yellow well graded SAND with SILT (SW-SM)	Layer 4g : Medium dense, yellowish brown well graded SAND	Layer 4h : Medium dense yellowish brown poorly graded SAND
1	Sieve Analisis, % Passing														
	3/4" (19 mm)														
	1/2" (12.5 mm)						100.0						100.0		
	3/8" (9.5 mm)						99.4						99.7		
	#4 (4.75 mm)						98.0		100.0	100.0	100.0		98.5		
	#8 (2.36 mm)			100	100	100	96.3	100.0	99.9	99.8	98.9	100.0	96.1	100.0	100.0
	#16 (1.18 mm)			99.8	91.0	88.0	94.1	99.7	98.6	96.1	93.6	86.6	77.1	78.5	88.1
	#30 (0.6 mm)			99.3	70.8	65.4	92.7	98.8	95.3	88.8	82.9	66.6	50.9	58.4	77.7
	#50 (0.3 mm)			99.0	58.6	49.5	87.0	94.9	76.6	59.5	46.7	24.5	21.6	25.8	34.6
	#100 (0.15 mm)			98.5	56.3	45.1	74.4	87.1	50.0	28.7	24.4	12.6	12.6	7.4	8.9
	#200 (0.075 mm)			94.6	54.8	43.1	64.1	82.3	41.6	22.7	18.3	10.1	9.0	1.3	3.2
	< 0.005 mm			58.0	36.3	32.6	36.6	51.1	28.0	11.8	6.5	2.7	2.7	0.0	2.9
2	Natural moisture content	(%)	w	82.73	38.27	35.51	22.06	25.07	20.34	19.37	17.46	16.89	13.65	20.45	15.92
3	Natural unit weight	(g/cm^3)	g	1.446	1.678	1.778	1.974	1.904	2.004	1.953	1.983	2.009	1.958	1.801	1.931
4	Dry unit weight	(g/cm^3)	g_d	0.795	1.220	1.312	1.619	1.524	1.666	1.636	1.689	1.718	1.723	1.496	1.666
5	Specific gravity		Gs	2.607	2.633	2.641	2.663	2.655	2.661	2.646	2.641	2.645	2.645	2.645	2.648
6	Porosity		n	0.70	0.54	0.50	0.39	0.43	0.37	0.38	0.36	0.35	0.35	0.43	0.37
7	Void ratio		e_o	2.318	1.158	1.013	0.650	0.746	0.599	0.622	0.565	0.540	0.544	0.773	0.590
8	Degree saturation	(%)	S	93.7	87.0	92.6	90.8	89.3	90.6	83.4	81.7	83.8	68.7	70.6	71.5
9	Liquid limit	(%)	LL	82.2	46.2	30.0	32.9	52.8	28.3	20.1	18.0				
10	Plastic limit	(%)	LP	43.1	26.3	21.2	18.4	28.4	17.2	14.8	14.1				
11	Plastic index	(%)	PI	39.1	19.9	8.8	14.6	24.4	11.2	5.3	3.9				
12	Water plasticity ratio	(%)	B	1.07	0.60	1.63	0.25	-0.14	0.30	0.75	1.38				
13	Unconfined compression	(Kg/cm^2)	qu	0.168			1.351		0.846	0.567					
14	Compression index		Cc	0.997			0.214		0.156	0.103	0.129				
15	Coefficient of consolidation	(cm^2/Kg)	Cv	2.19E-04			6.70E-04		5.83E-04	7.82E-04	5.78E-04				
16	Preconsolidation pressure	(kg/cm^2)	Pc	0.740			1.455		1.648	1.262	1.596				
17	Coefficient of volunm compressibility	(cm^2/g)	Mv	1.27E-04			2.95E-05		1.18E-04	2.26E-05	6.79E-05				
18	Permeability	(cm/sec)	k20	6.36E-07			1.72E-08		2.14E-08	1.54E-08	1.21E-08				

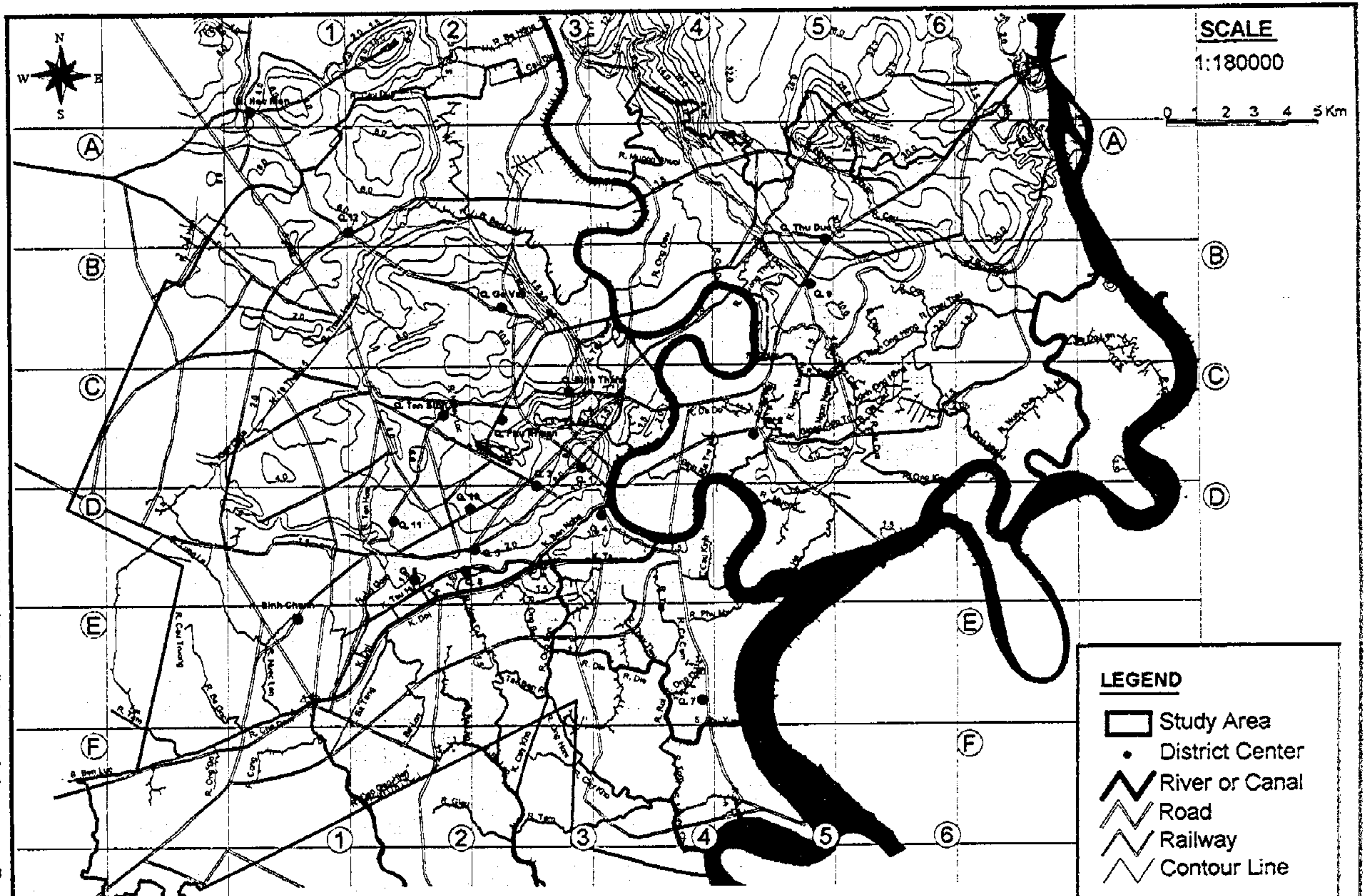

Fig. A.1.1 Topography of the Study Area

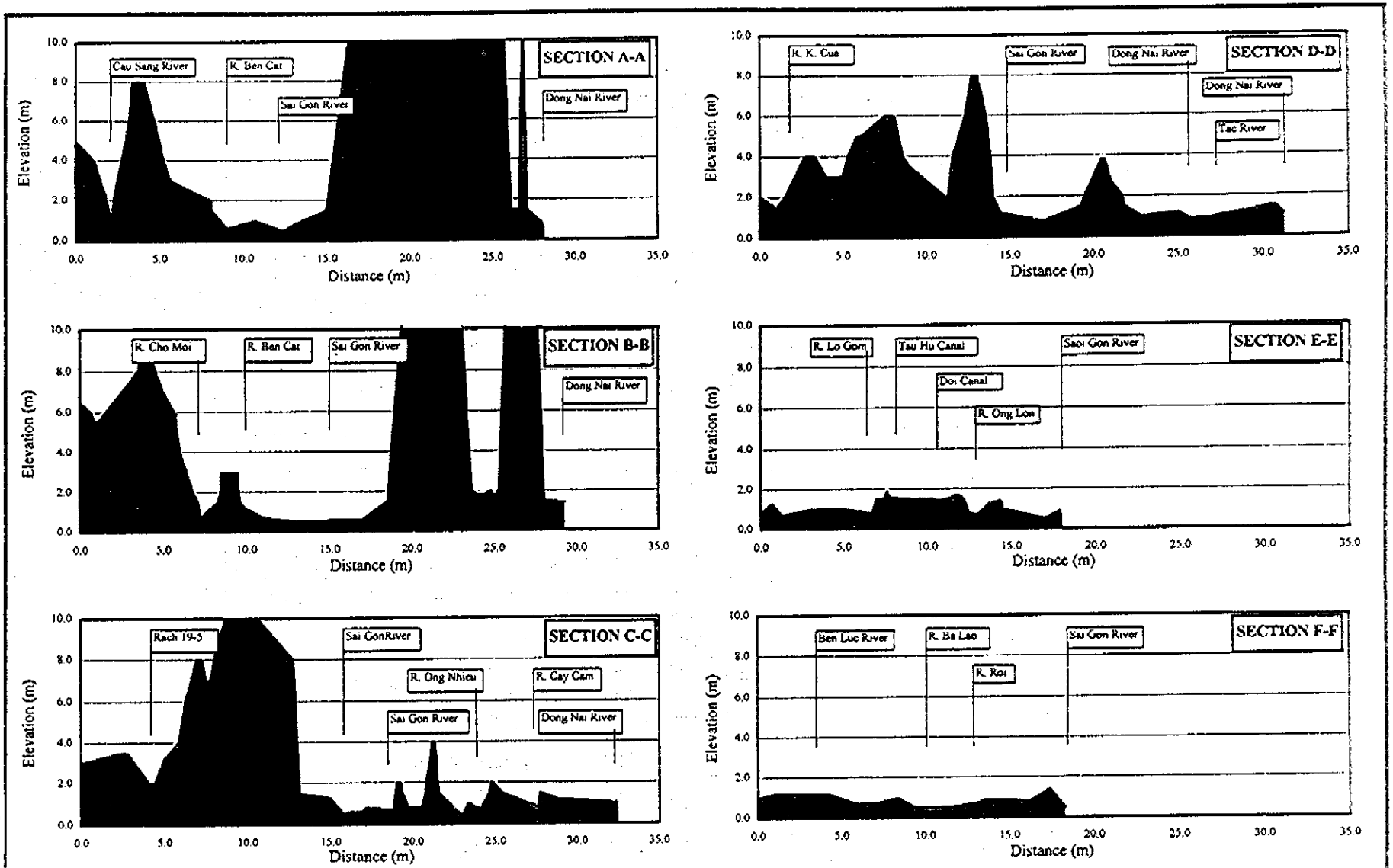

Fig. A.1.2 (1/2) Cross Section of the Study Area (East to West)

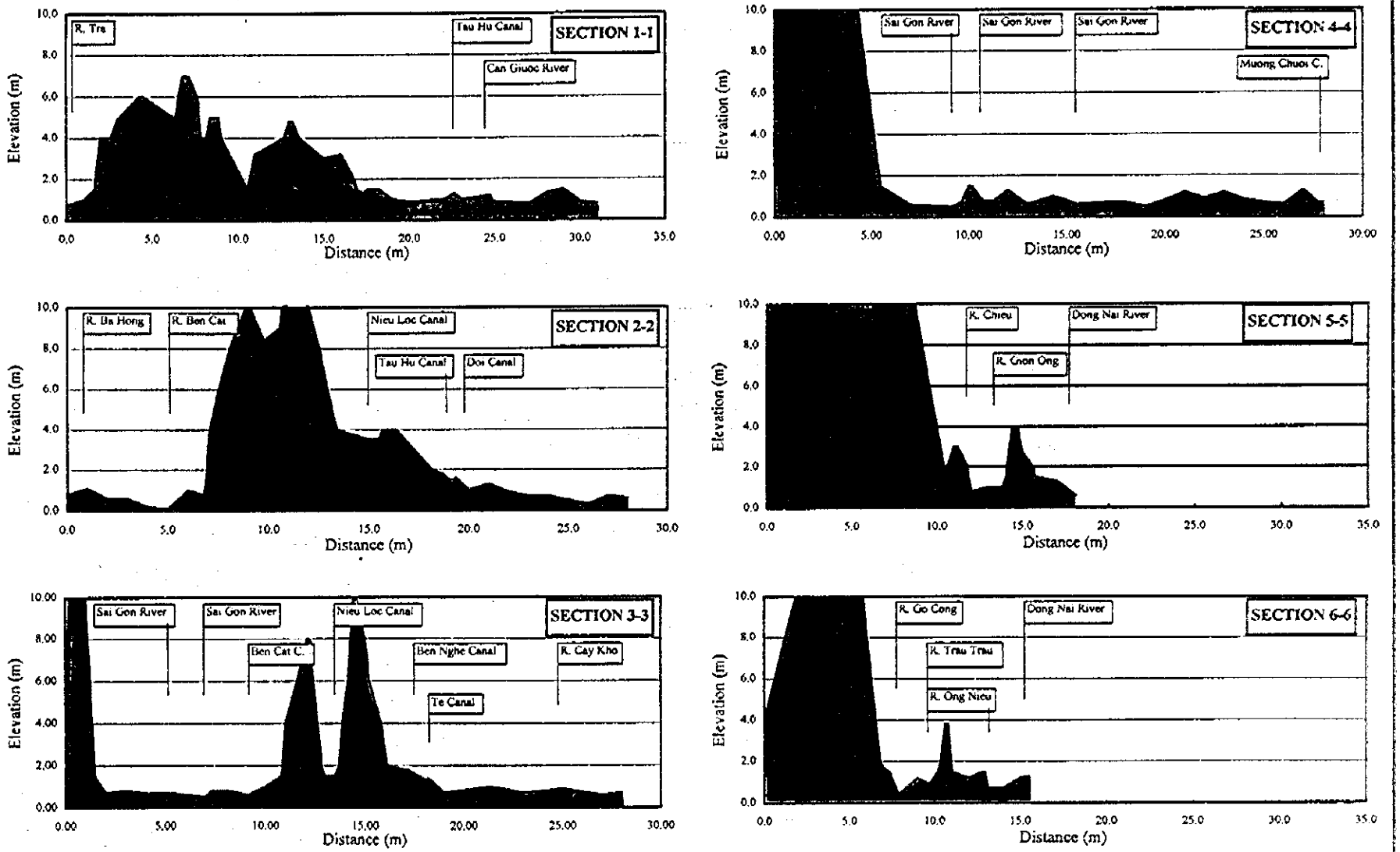

Fig. A.1.2 (2/2) Cross Section of the Study Area (North to South)

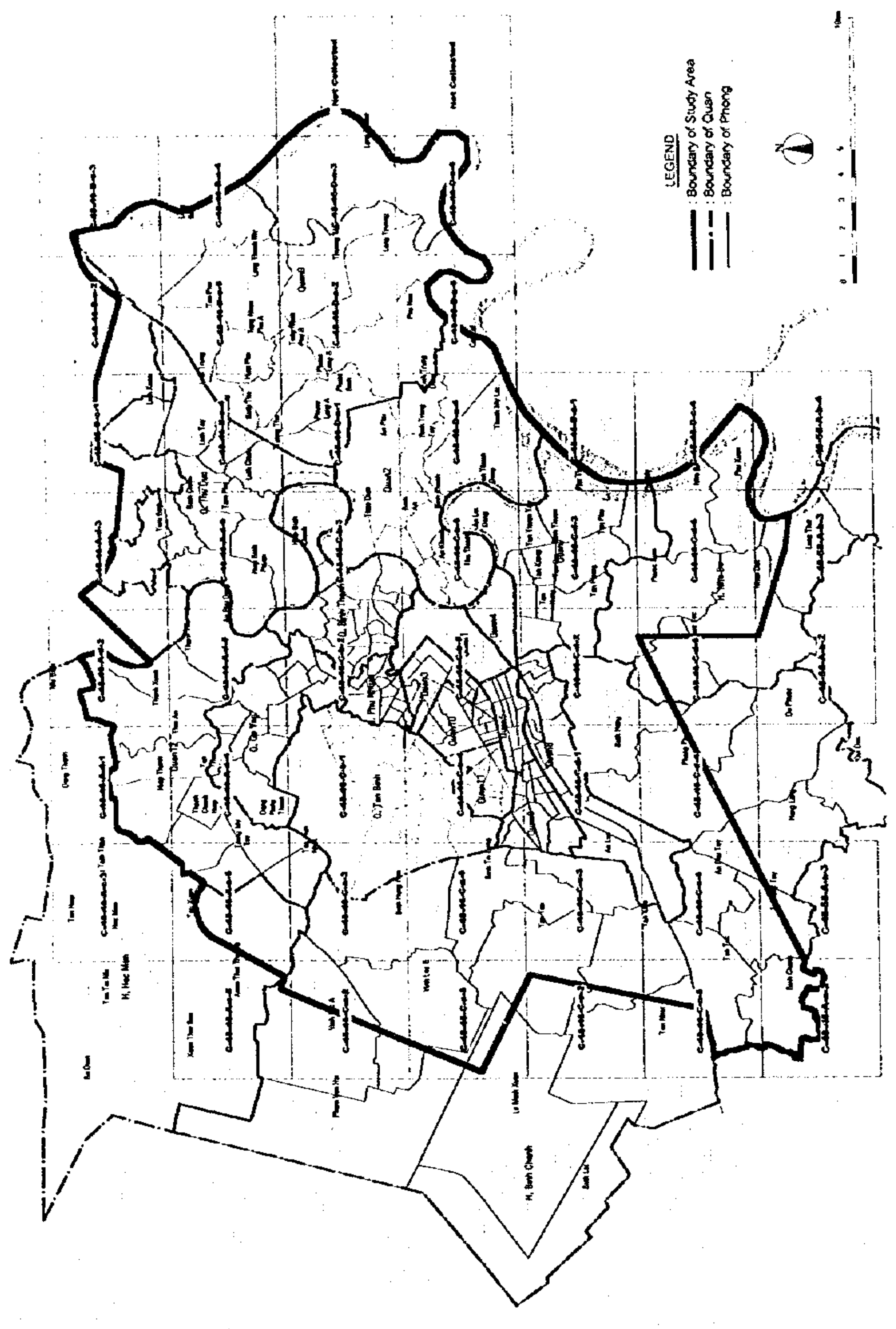

Fig. A.2.1 Index Map of 10,000 Scale Map

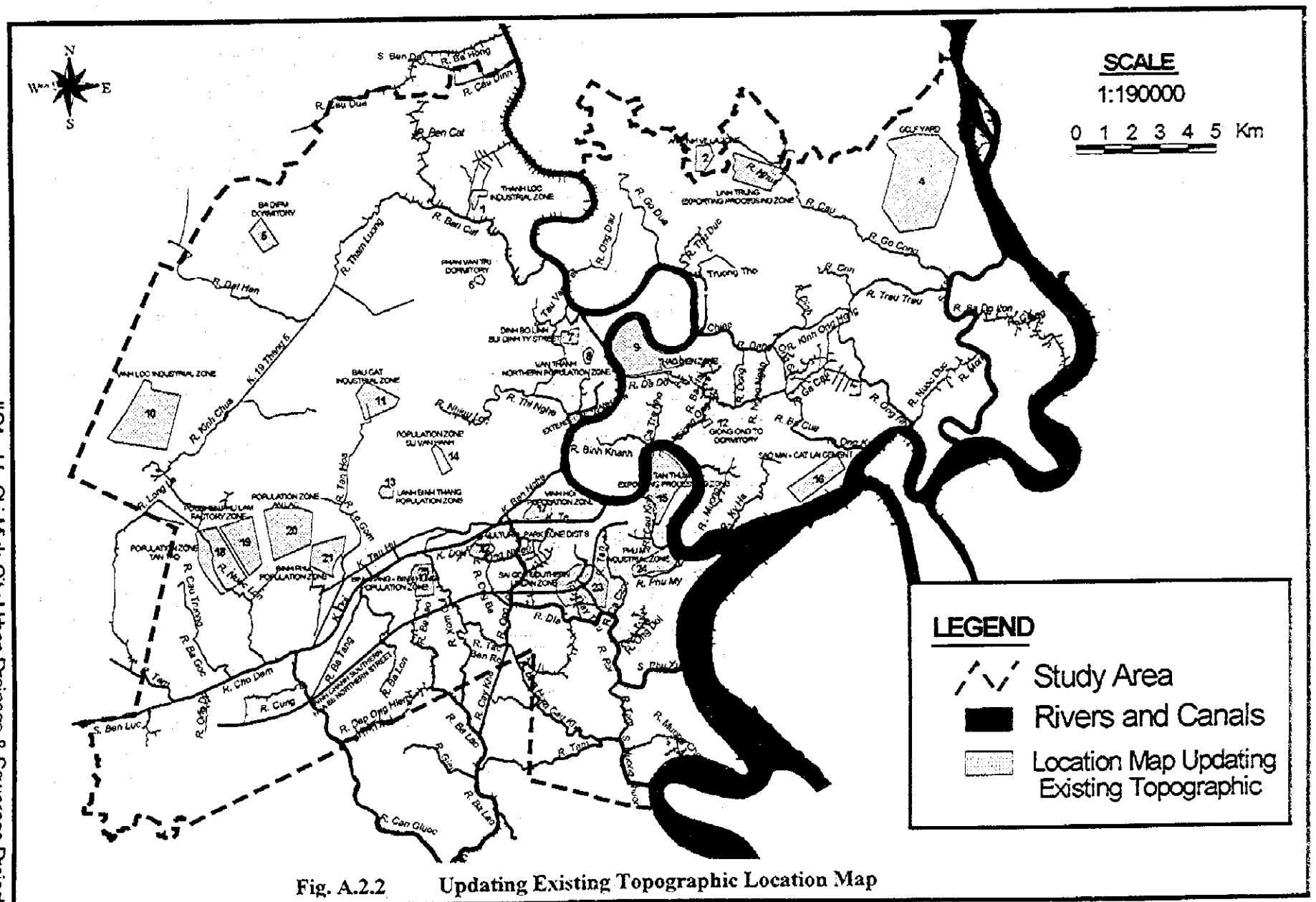

Fig. A.2.2 Updating Existing Topographic Location Map

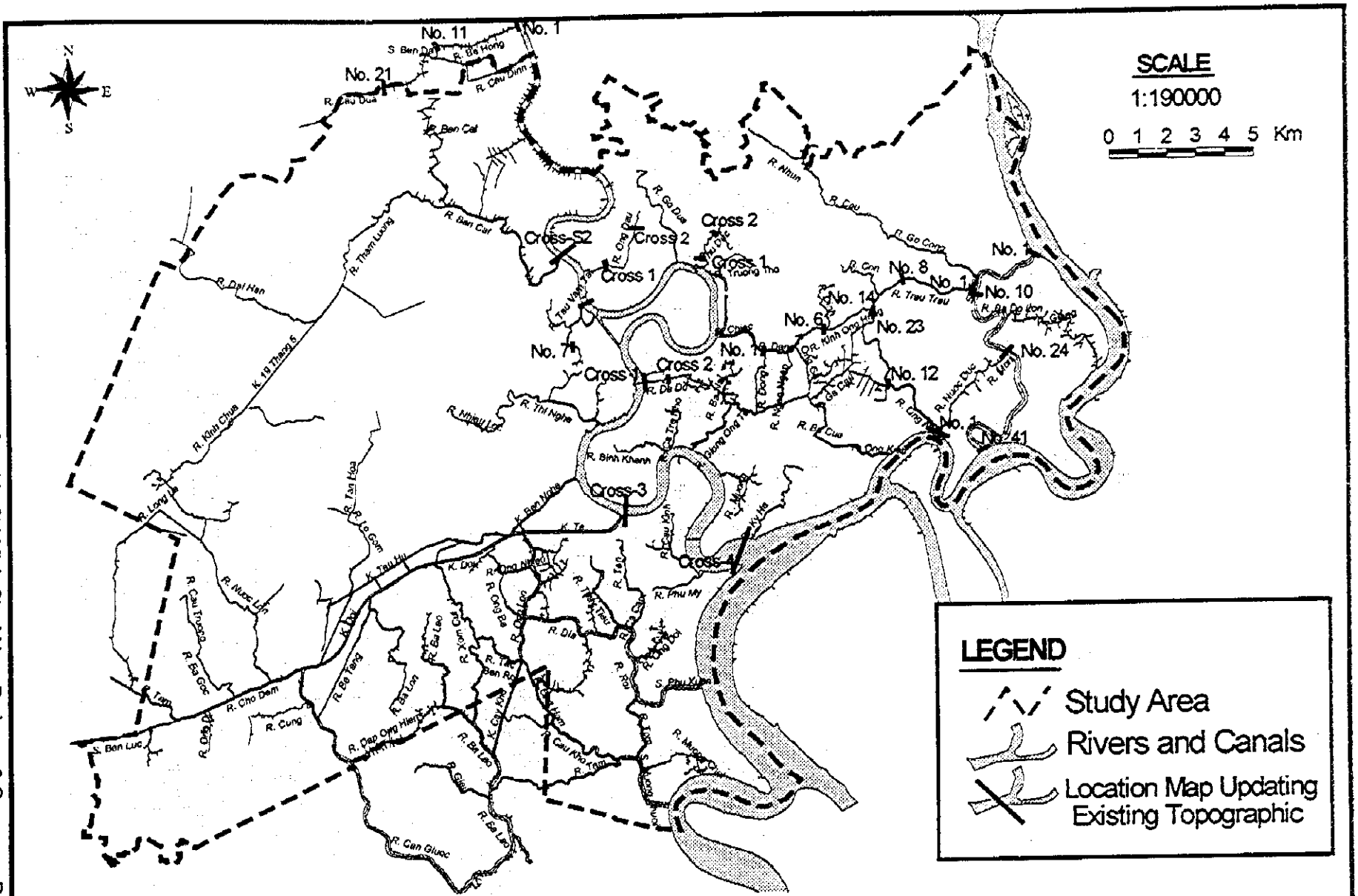

Fig. A.2.3 Cross Sectional Survey of Saigon River and Drainage Canals

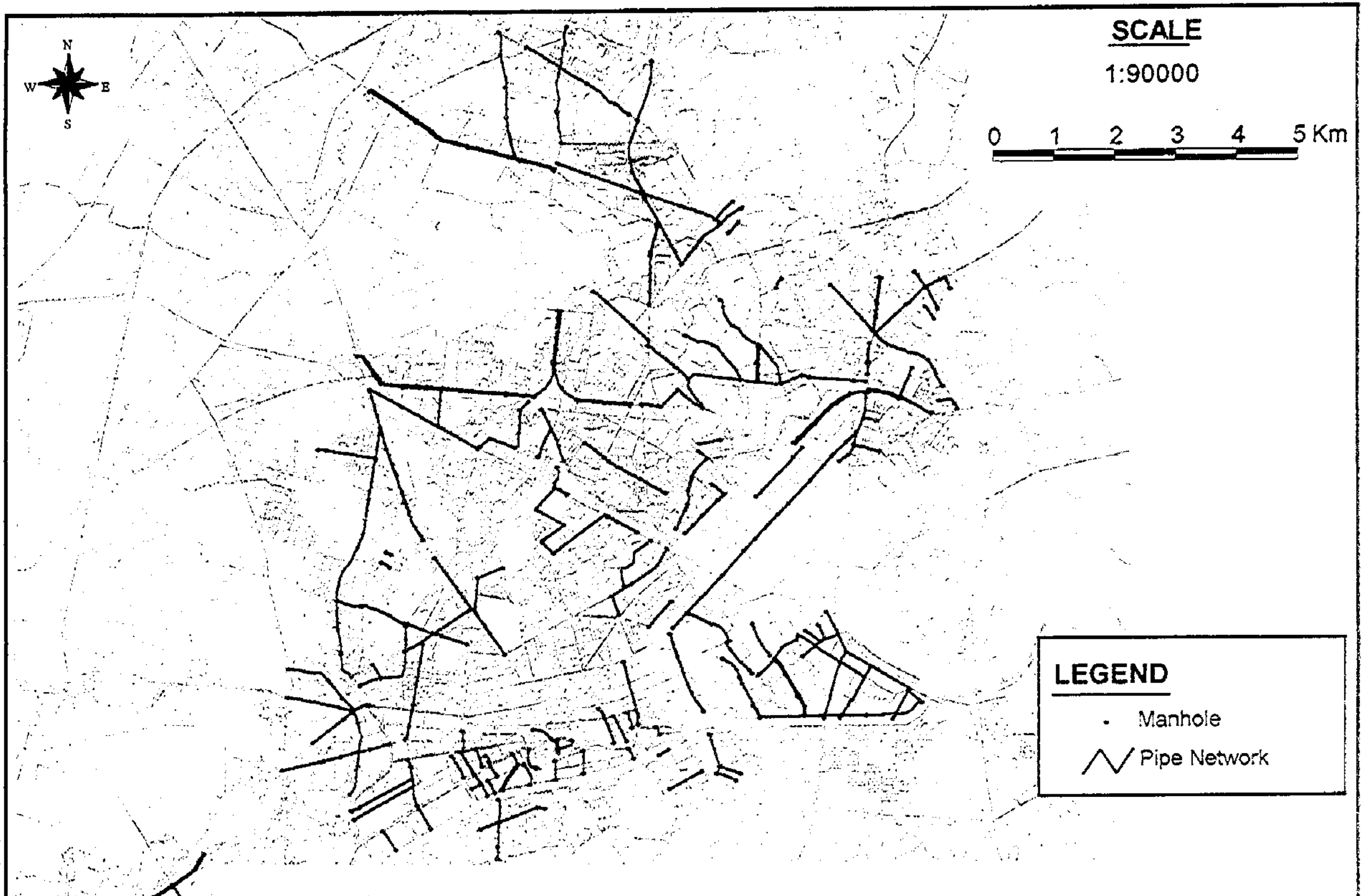

Fig. A.2.4 Existing Main Drainage Pipe Network

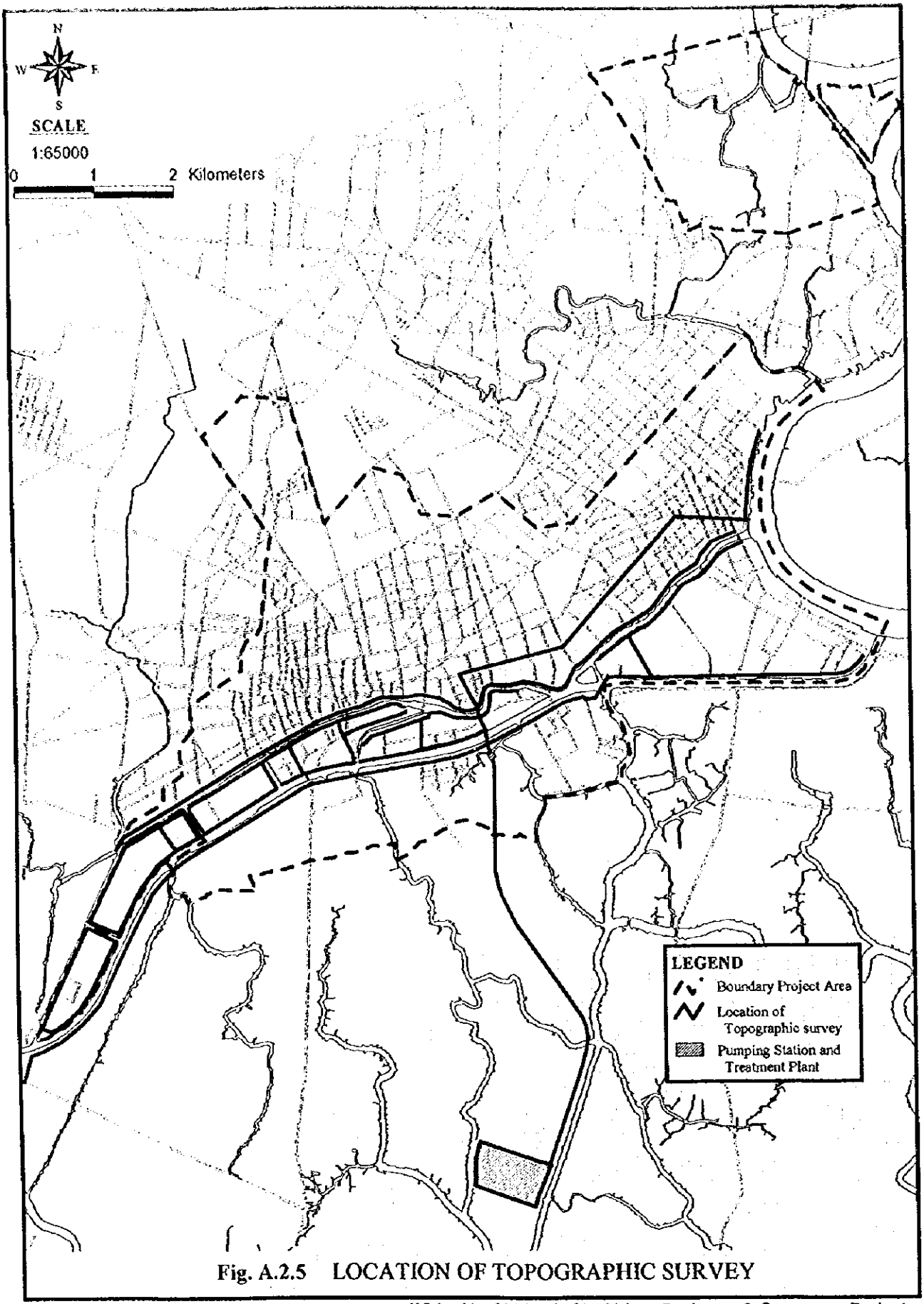

Fig. A.2.5 LOCATION OF TOPOGRAPHIC SURVEY

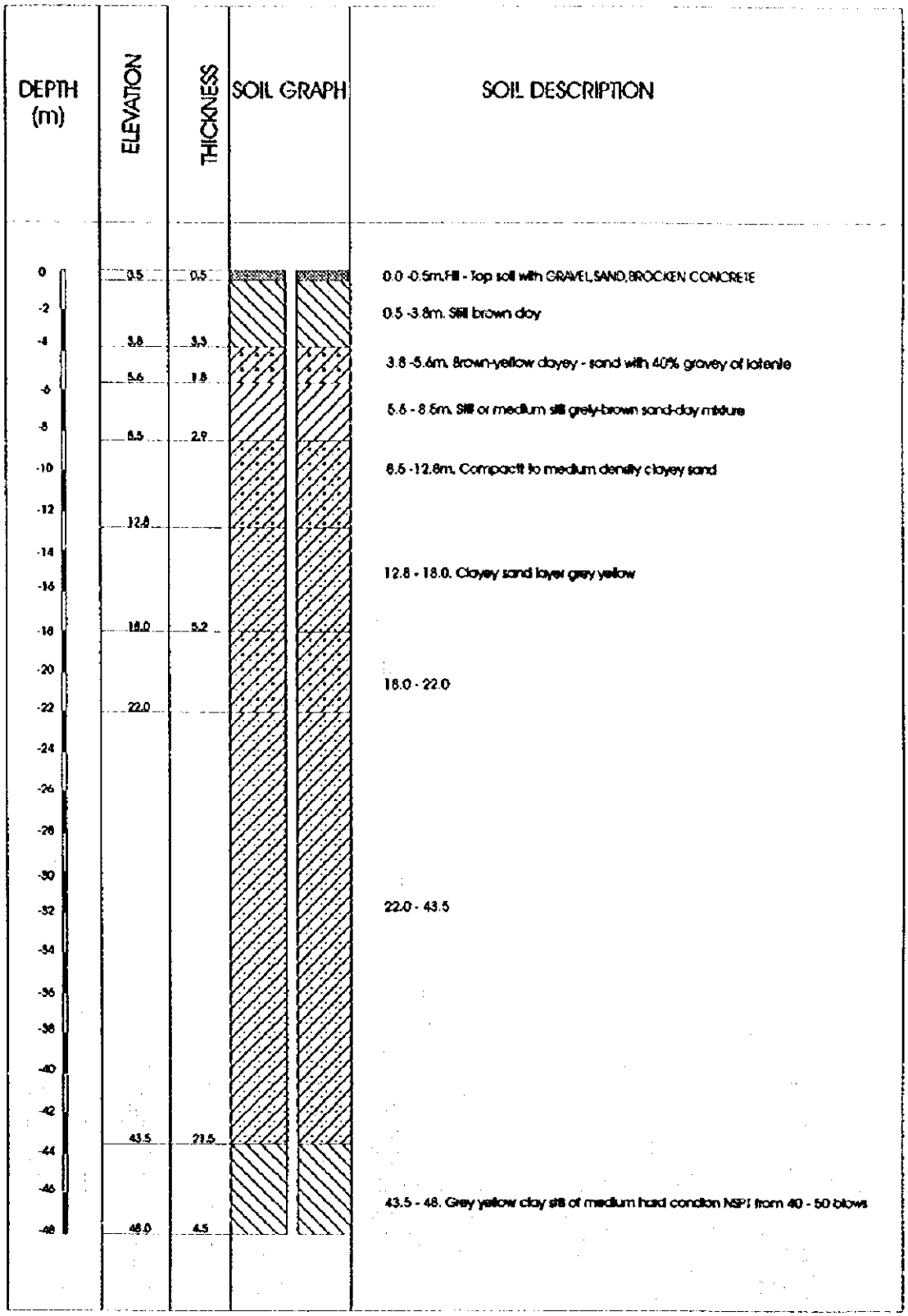

Fig. A.3.1 Soil Boring Log

CENTER OF HO CHI MINH CITY
THE SOIL PROPERTY CHART

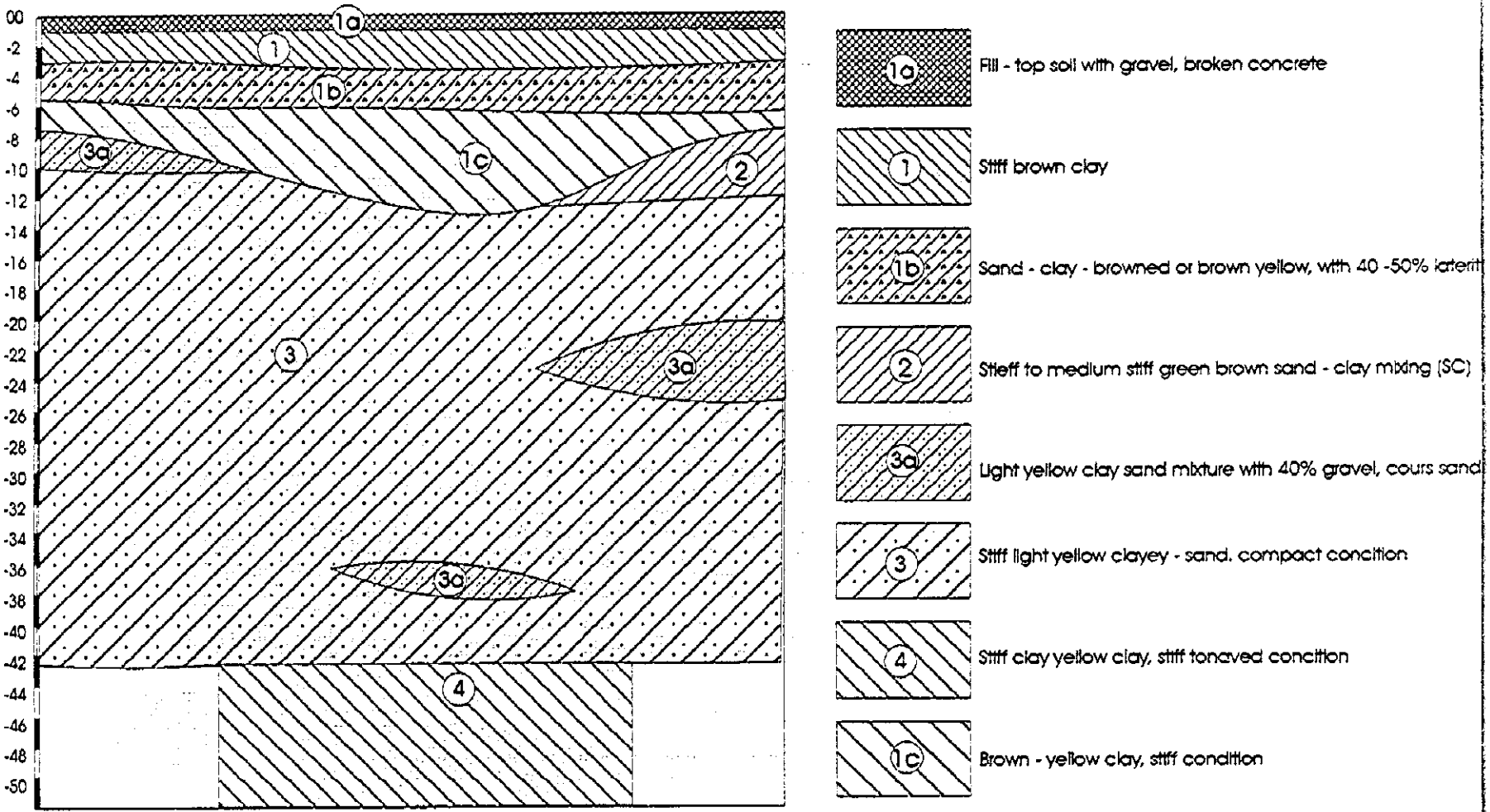

Fig. A.3.2 Soil Property Chart

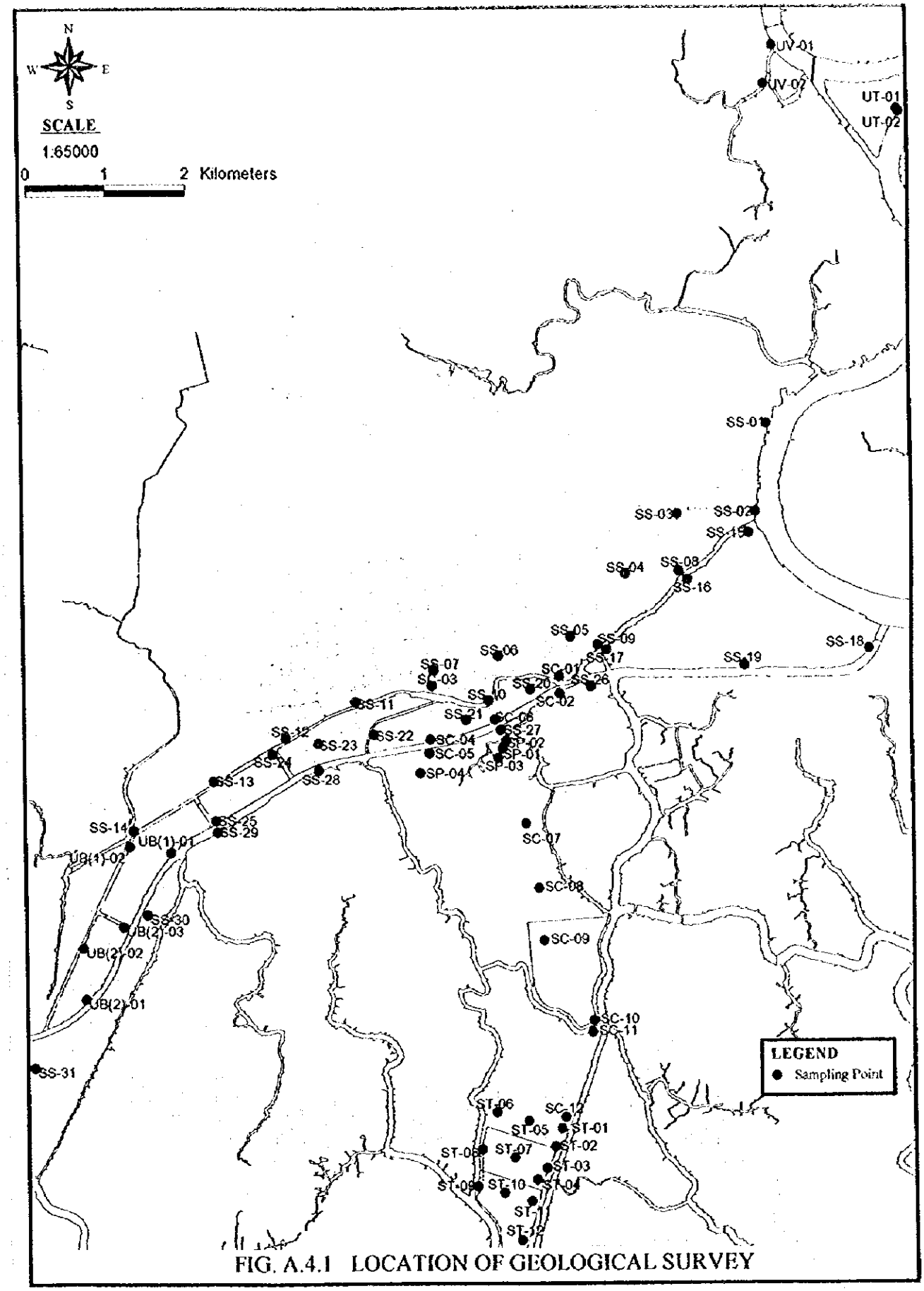

FIG. A.4.1 LOCATION OF GEOLOGICAL SURVEY

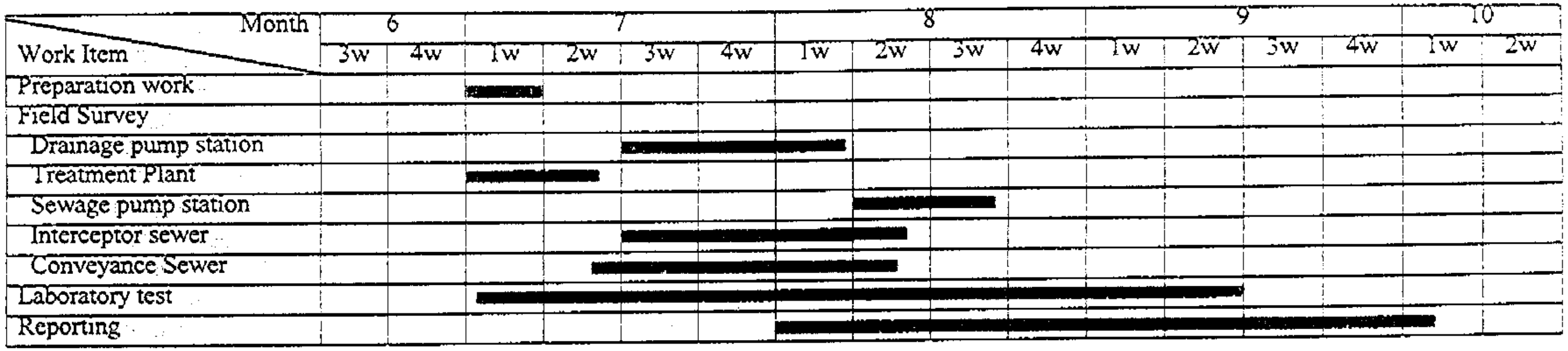

Fig. A.4.2 SCHEDULE OF SOIL INVESTIGATION

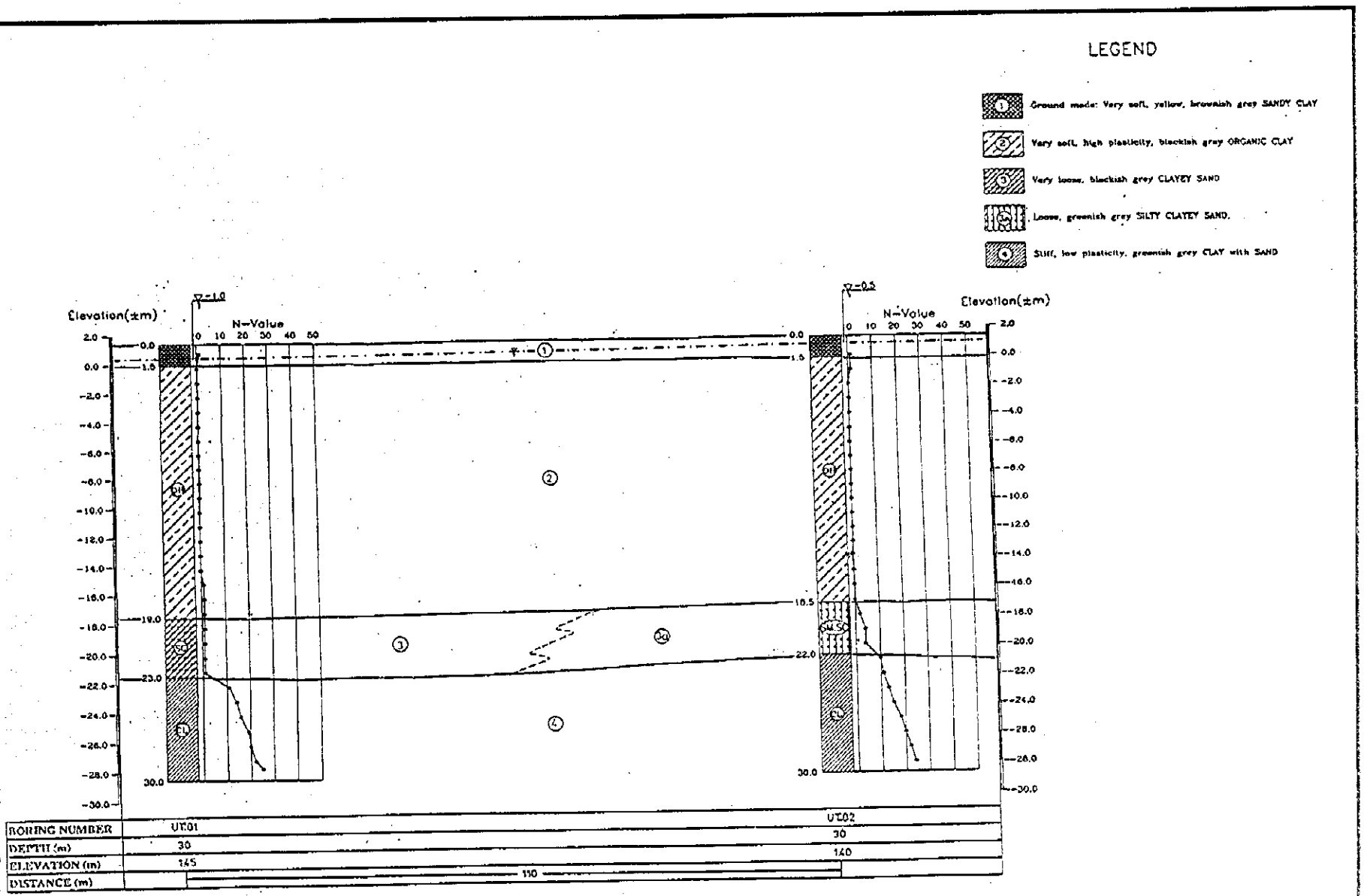

Fig. A.4.3 Engineering Geological Cross Section
(Drainage Pump Station – Thanh Da)

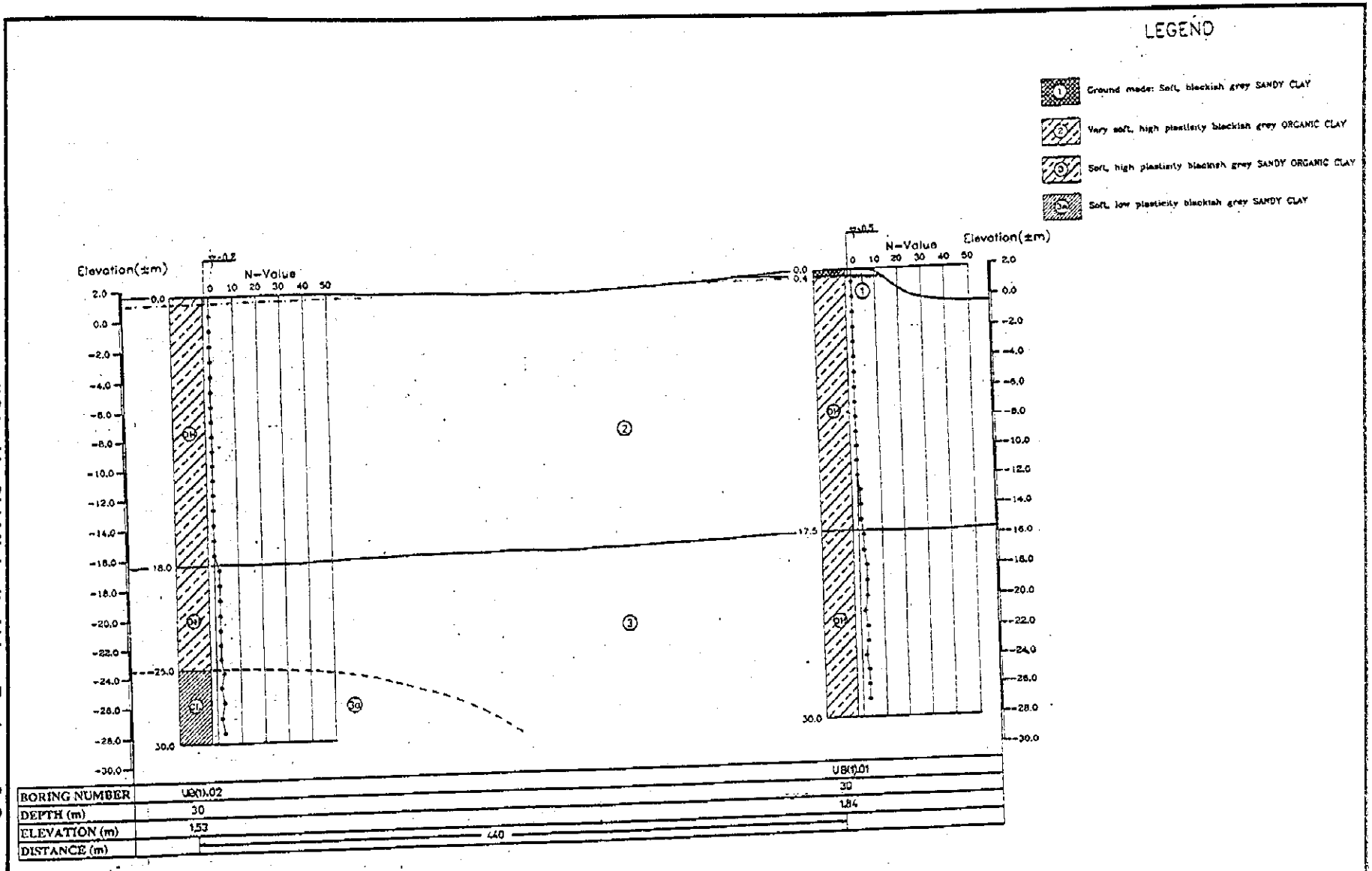

Fig. A.4.4 Engineering Geological Cross Section
(Drainage Pump Station – Ben Me Coc (1))

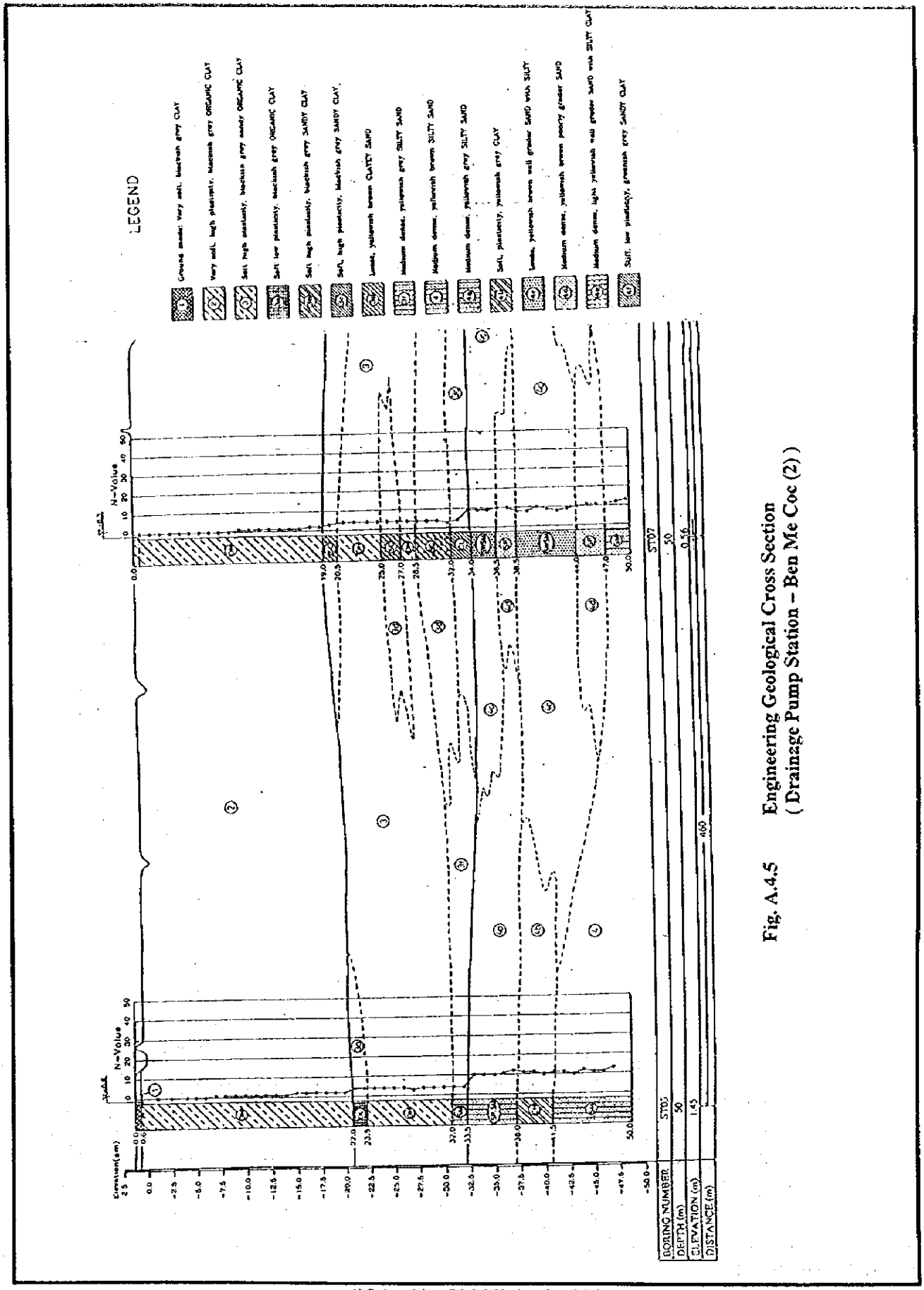

Fig. A.4.5 Engineering Geological Cross Section
(Drainage Pump Station – Ben Me Coc (2))

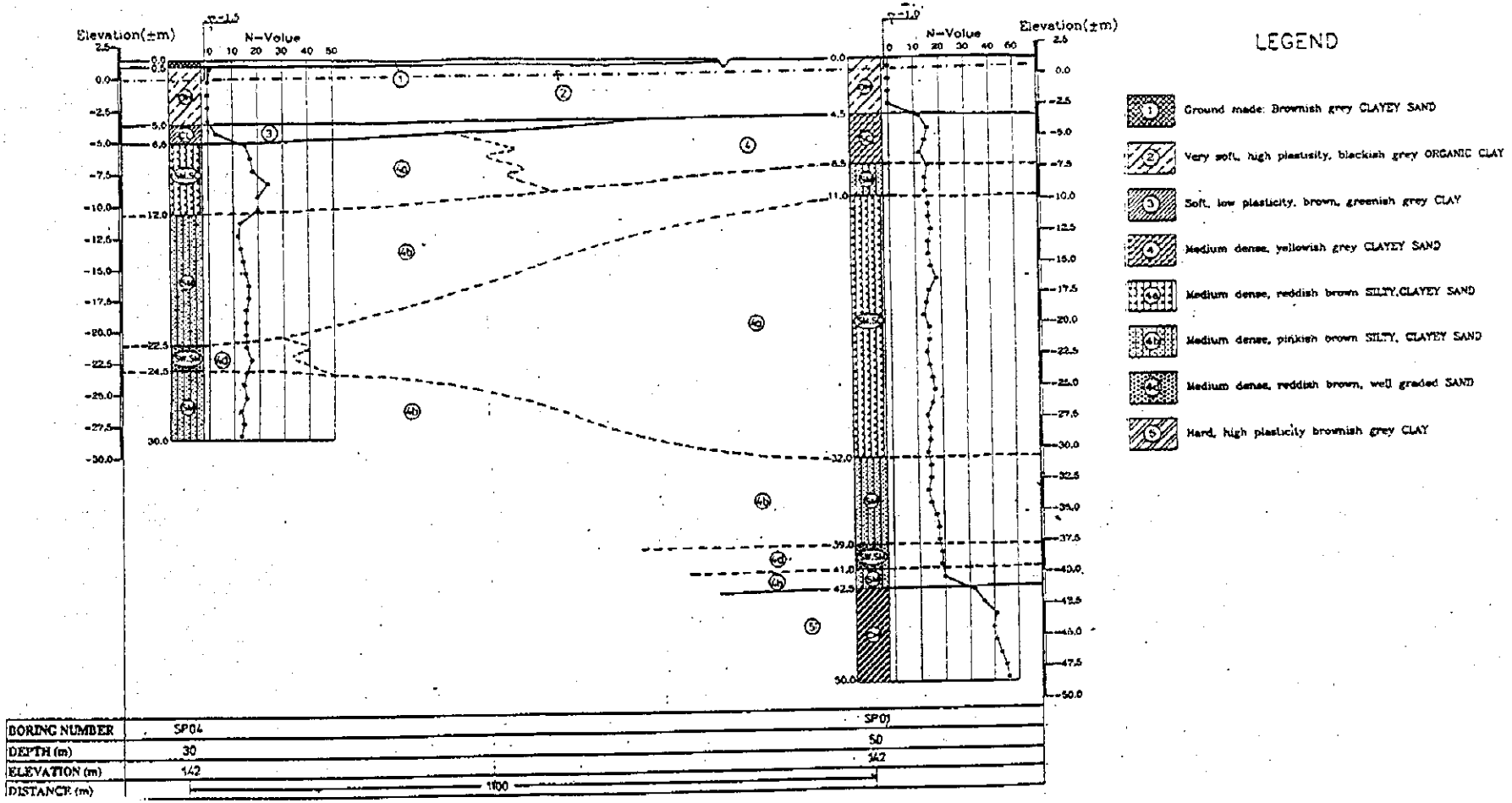

Fig. A.4.6 Engineering Geological Cross Section (Sewerage Pump Station)

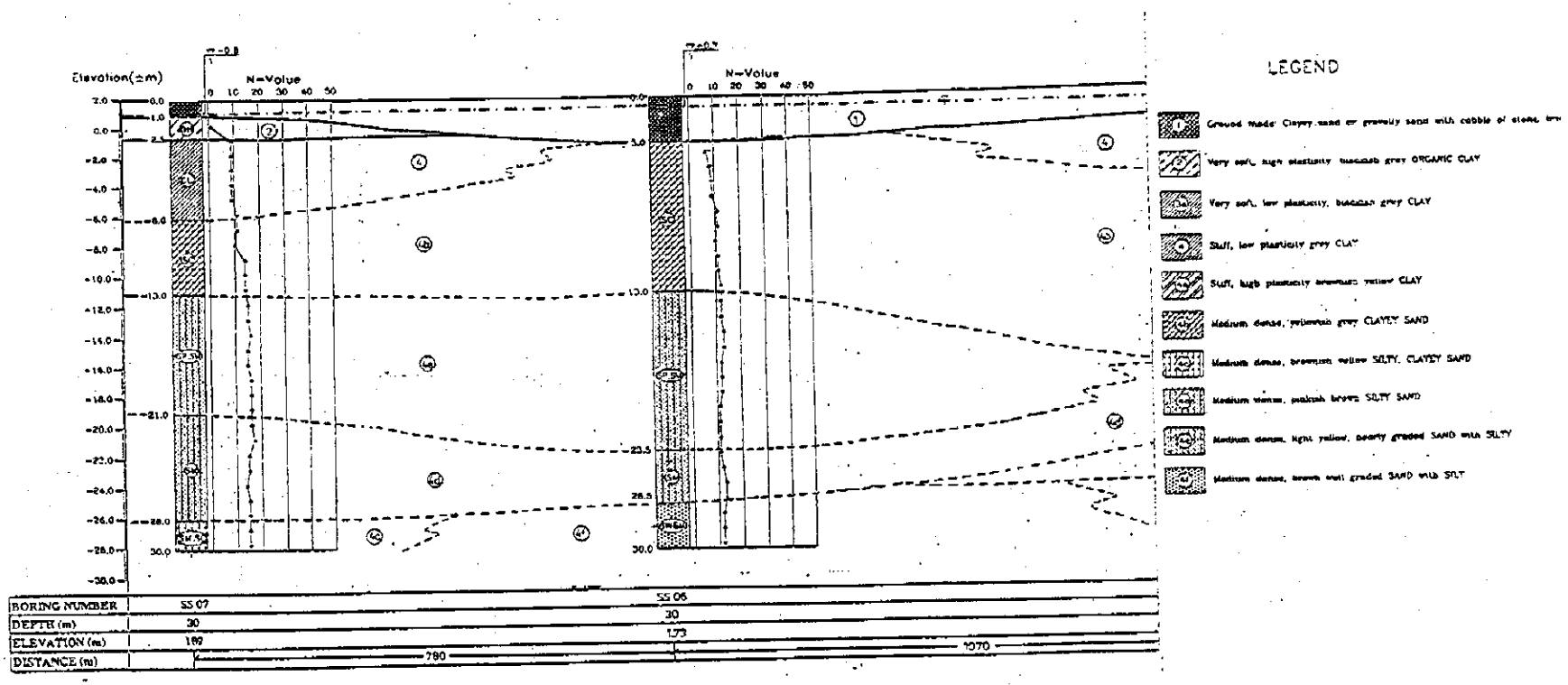

Fig. A.4.7 Engineering Geological Cross Section
(Interceptor Sewer Line)

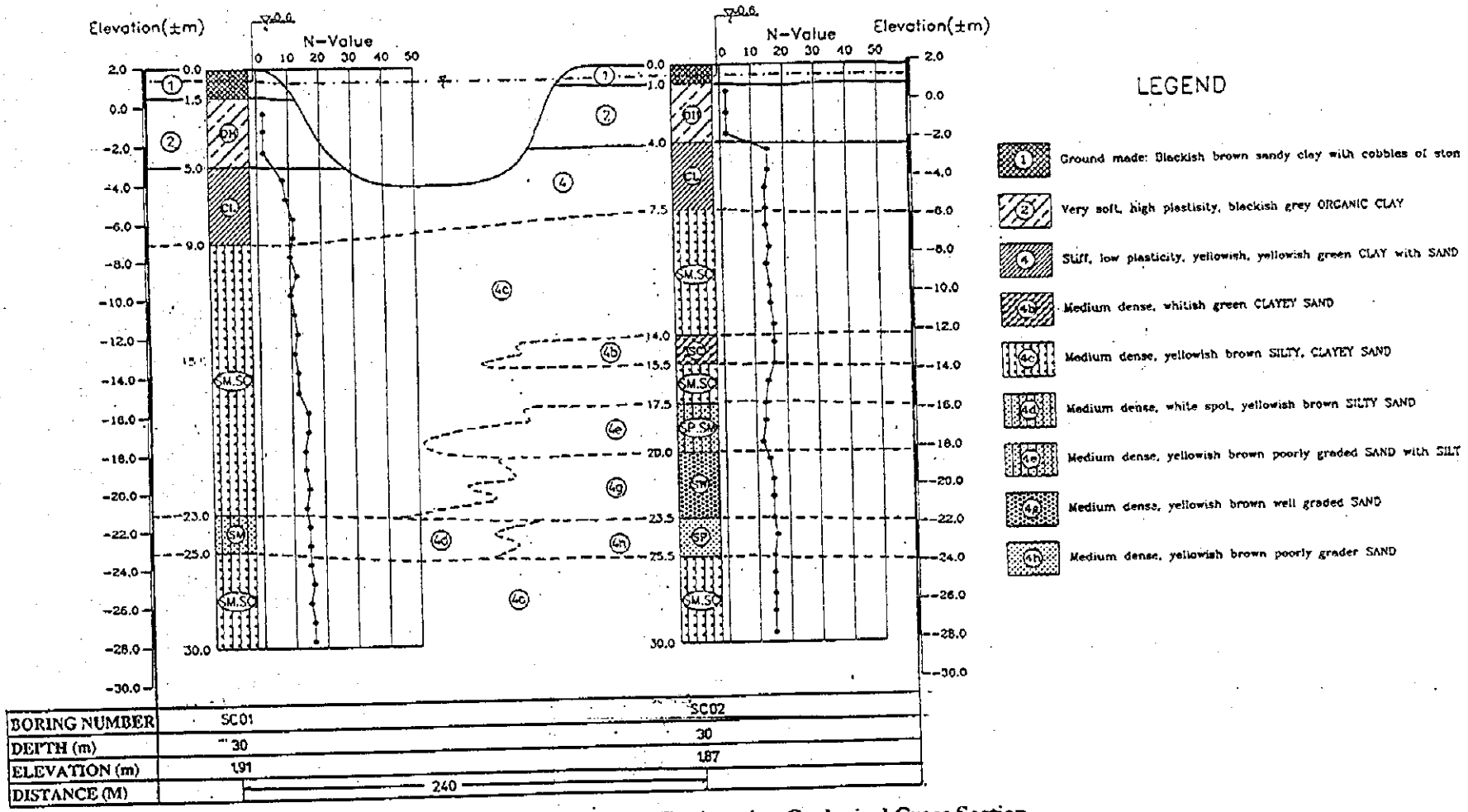

Fig. A.4.8 Engineering Geological Cross Section (Conveyance Sewer Line)

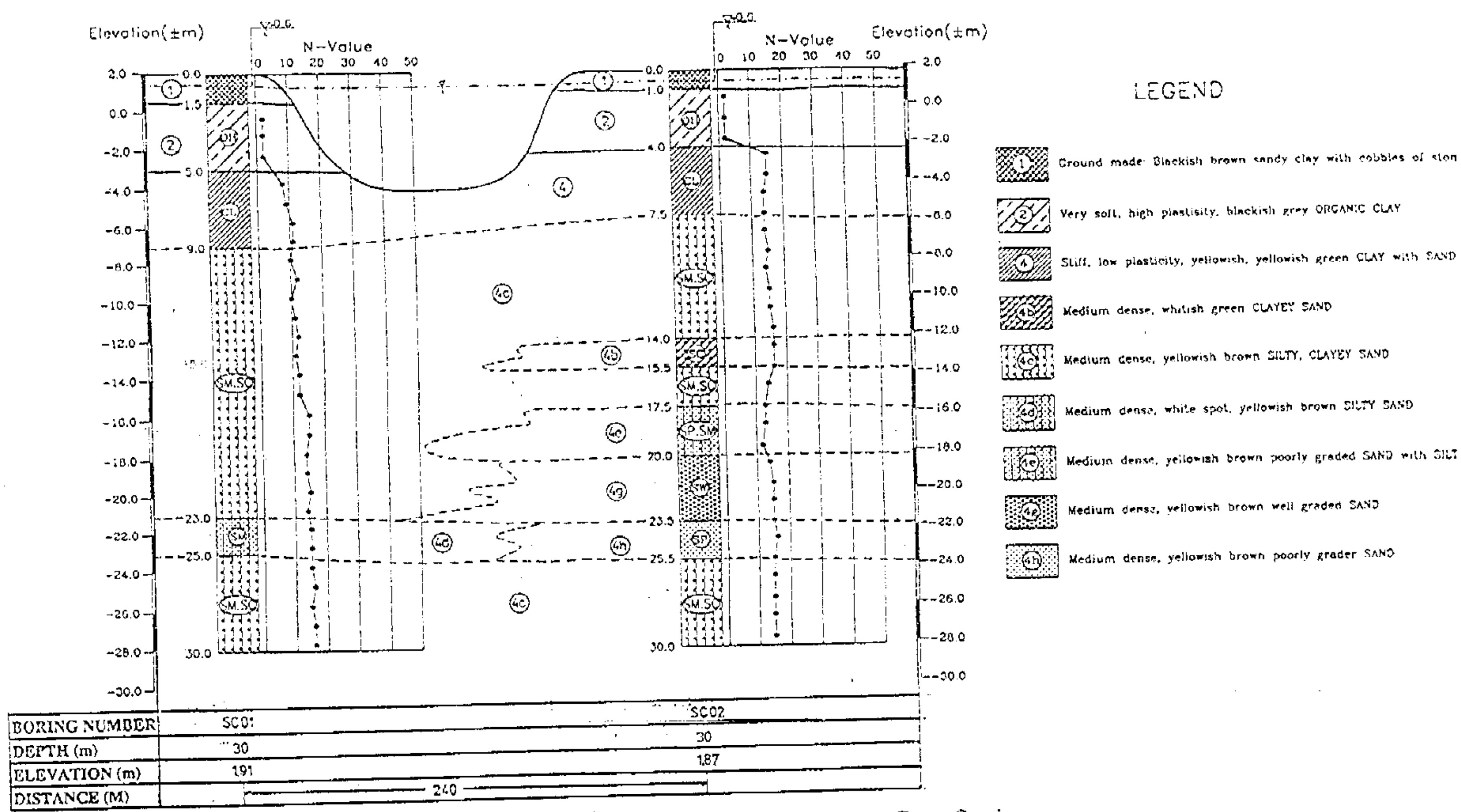

Fig. A.4.8 **Engineering Geological Cross Section (Conveyance Sewer Line)**