Report on

Feasibility Studies for the Great Dacca City Planning

East Pakistan

October 1966

Government of Japan

Overseas Technical Cooperation Agency

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FOREWORD

Upon the request of the Government of Pakistan, the Government of Japan decided to send a survey mission to work at a land reclamation and city planning on the southern side of the Burhiganga river (Keraniganj district) which flows by Dacca City, the center of the politics, economics and social life of East Pakistan, which has seen a rapid development recently, with a large increase in its population.

Overseas Technical Cooperation Agency, Japan, entrusted by the Government of Japan, designated Dr. Yasusaburo Yoshida as the leader of the survey mission with city planning experts. The mission carried out the site investigation for the dry season from the beginning of January to the middle of February 1966, and for the rainy season from the end of August to the middle of September the same year. In spite of the strained situation immediately after the conflict between Pakistan and India, possible efforts were made to success by the survey mission members, being supported by the full cooperation of the competent authorities of the Government of Pakistan.

On return home in Japan, the survey mission applied to an analytic study the data collected in the investigation site, and compiled this feasibility report on the land reclamation and city planning.

It is more than our pleasure that this feasibility report should make a contribution to the progress of Dacca City to further the development of economic and social life of Pakistan, enhancing the mutual friendship between Pakistan and Japan at the same time.

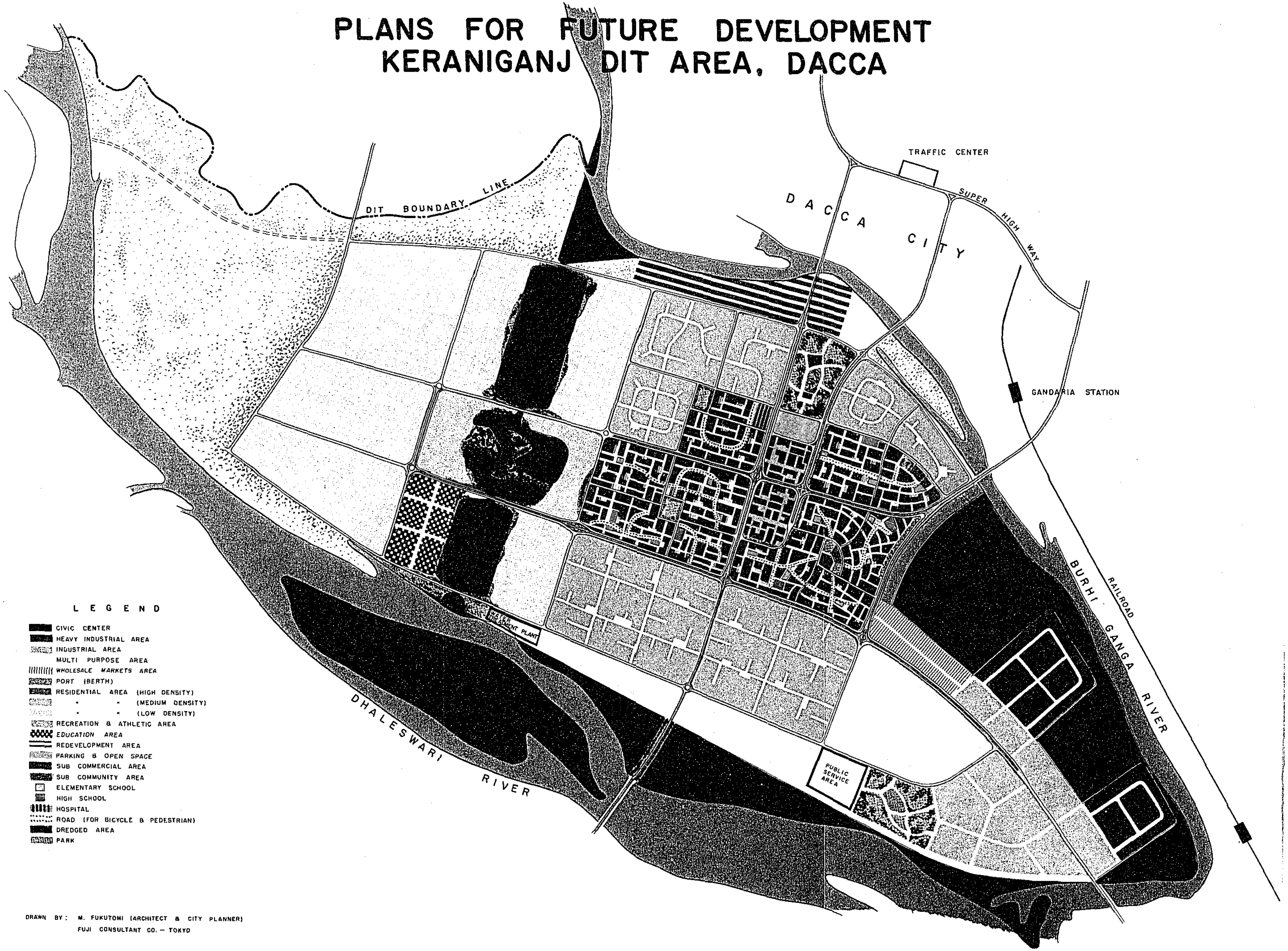
We should take this opportunity to extend our sincere gratitude to the Government of Pakistan and its authorities concerned for their generous cooperation with the survey mission in achieving its intended purpose.

S. Shibusawa

Shin-ichi Shibusawa
Director General
Overseas Technical Cooperation Agency,
Japan

CONTENTS

PLANS FOR FUTURE DEVELOPMENT
KERANIGANJ DIT AREA, DACCA



DRAWN BY : M. FUKUTOMI (ARCHITECT & CITY PLANNER)
FUJI CONSULTANT CO. — TOKYO

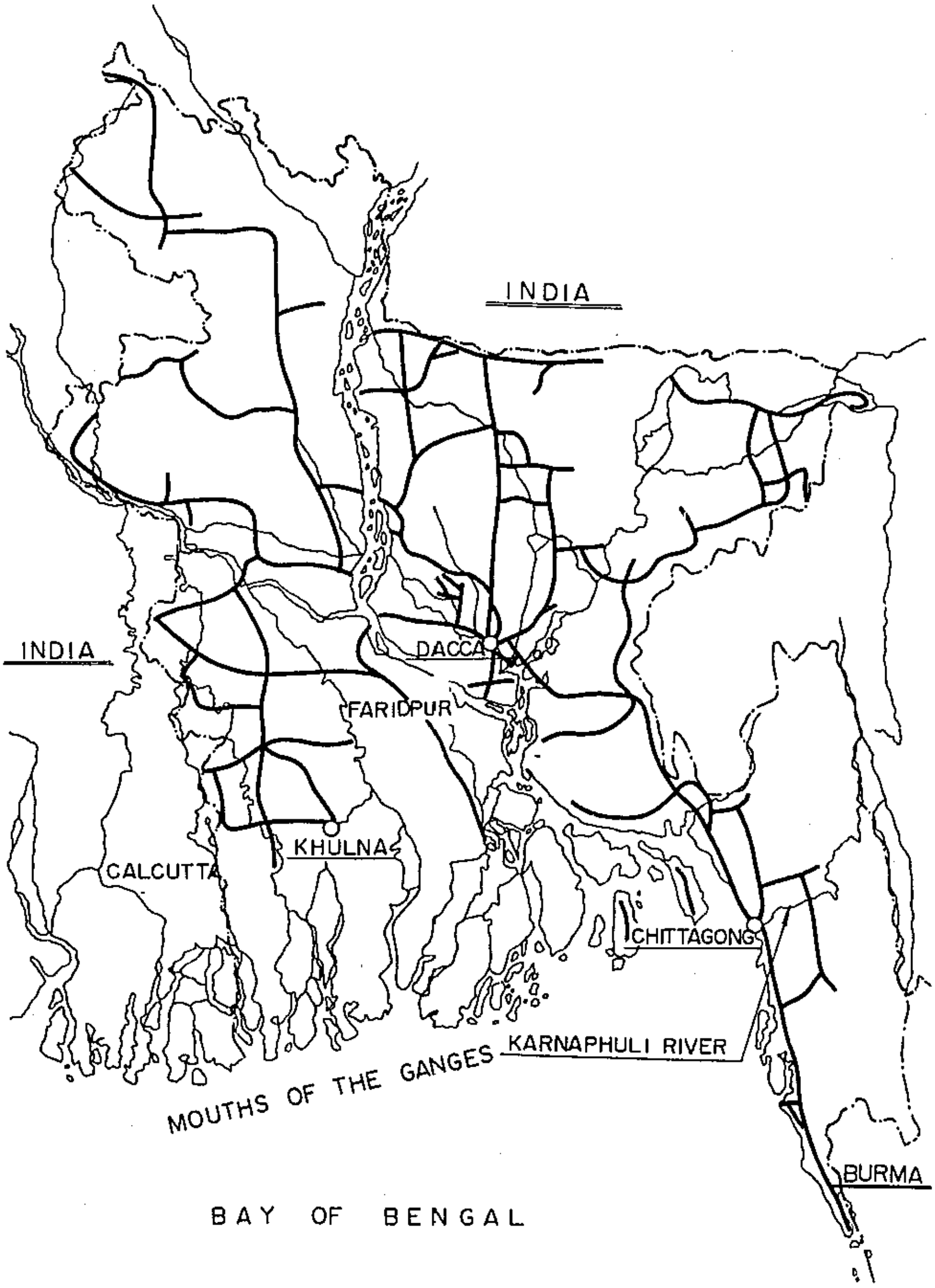
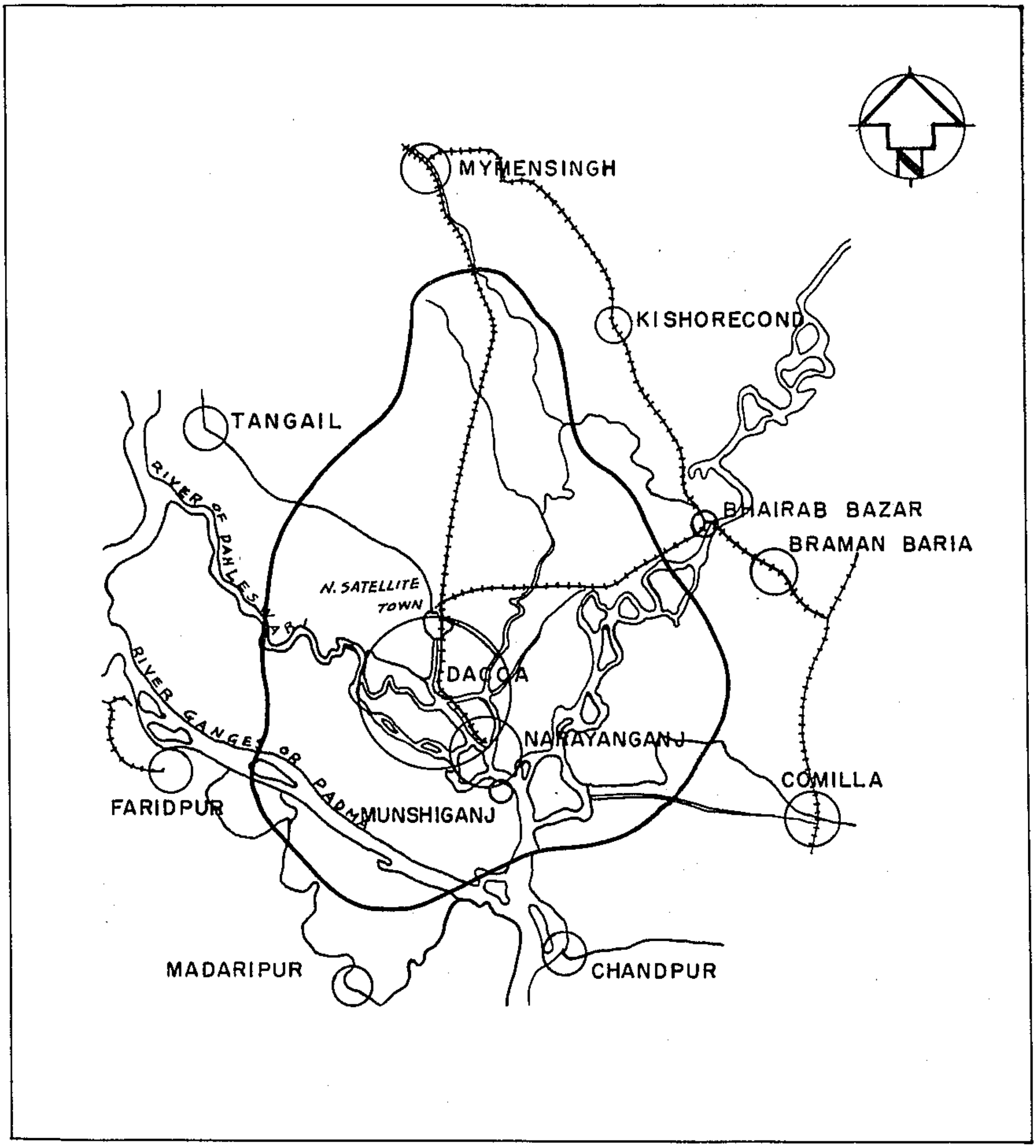


FIG - 1 LOCATION MAP OF EAST PAKISTAN

GREATER DACCA



PREFACE

Background.

The survey owed directly to the results from the Japan survey mission for the bridge construction over the Burhiganga river, East Pakistan, that was led by Mr. Y. Maeda and despatched in 1964 by Overseas Technical Cooperation Agency, Japan, an executive organization of the Japanese government. It was further tracked back to the Japan survey mission, led by Dr. K. Tatsugami, for the construction positions of East Pakistan in 1960, and the one, led by Mr. S. Inagaki, for the bridge construction scheme over the Burhiganga, Karnaphuli and Rupsa, East Pakistan, both of which were despatched by the Government of Japan itself.

According to the report of the survey mission of 1964, it was especially recommended that the development in the southern bank area should be taken up side by side with the bridge construction so as to bring about a mutual effect of individual developments. Based on the recommendation, the Government of Pakistan and Dacca Improvement Trust (DIT) as well requested the technical cooperation to the Government of Japan to develop the southern bank area (34, 000 acres of the objective land of planning) which should facilitate the bridge construction project at the same time.

The survey mission was organized by such members as listed below, carrying out the dry-season site investigation for a period of about one month from 10th January to 15th February, 1966. At the emphatic request of the Pakistani side, the rainy-season survey followed which continued for about three weeks from 22nd August to 10th September, 1966.

Organization of survey mission (for the dry season).

Leader	Dr. Yasusaburo Yoshida	Doctor of Engineering, Special Advisor, O.T.C.A. & Managing Director, Yachiyo Engineering Co., Ltd.
Member	Mr. Masanobu Kunugiza	Construction Specialist, Building Bureau of Housing, Ministry of Construction.
"	Mr. Yukio Murayama	Construction Specialist, City Planning Sect. Bureau of City Planning, Ministry of Construction.
"	Mr. Fumio Ishii	Asst. Chief, River Control Sect. Bureau of River Ministry of Construction.
"	Mr. Takeshi Aoki	President, Fuji Consultants Co., Ltd.
"	Mr. Masami Fukutomi	Vice President, Fuji Consultants Co., Ltd.
"	Mr. Yoichi Seki	Staff, O.T.C.A.
"	Mr. Susumu Makino,	Pacific Aero Survey Co., Ltd.
"	Mr. Kazuo Kuwamura	"
"	Mr. Kazuo Murakami	"
"	Mr. Mikio Tahara	"

Member (for the rainy season)
" Mr. Takashi Aoki President, Fuji Consultants Co., Ltd.

Purpose of Investigation:

The survey mission was despatched for the purpose of planning the land reclamation for 34,000 acres on the south area of Dacca City, and when it turned out feasible, further study should be made on its city planning, inclusive of land use, traffic facilities, green zone, and supply and disposal planning, all of which comprised one integral city planning as a whole. The technical and economical evaluation for the integral city planning were compiled into this feasibility report.

Outline of Investigation:

The site investigation was devided into two parts; one for the dry season and the other for the reainy season. The dry season survey was carried out for the period of about one month from 10th January 1966, covering Dacca City and its suburbs, to learn its present situation, to collect and study the existing data, to carry out various investigation and geological survey on the plan lot, and to make a map study on an aerial chart of 1/20,000 scale.

Especially for the investigation in the present city area, it was chiefly conceived at the planning stage to produce an ideal version of a city which would suit the Pakistani situation peculiar to itself, instead of drawing merely a picture of modern city, being taken into consideration the special features common to all South East Asian countries from the economic, cultural and social points of view.

In addition, an adequate attention was paid to cover the objectives of study that should afterwards be necessary for the preliminary designing in Japan.

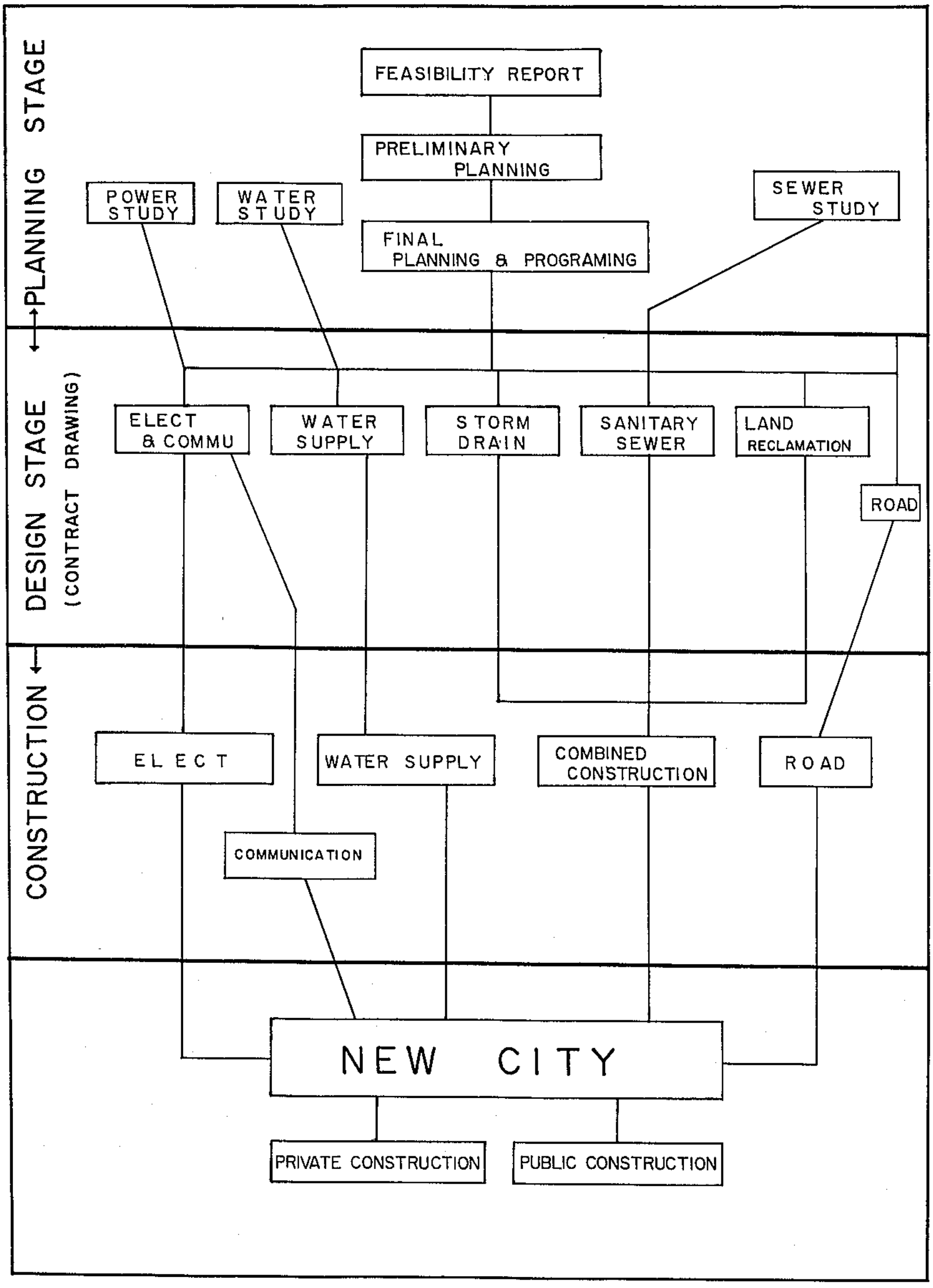
The rainy-season investigation was conducted for about half a month from 22nd August 1966, when a hydraulic survey on the river characteristics, (water level, discharge, and flow velocity,etc.) was carried out to see the high river stage which should largely affect the land reclamation project.

Acknowledgement:

We take this opportunity, to express our heart-felt thanks for the Government of Pakistan and DIT for their incessant supports which greatly contributed to the completion of the survey works in both seasons. The survey was conducted under the state of emergency in the wake of the Indo-Pakistani conflict, but in spite of such unfavourable circumstances many invaluable data were offered for our reference, thanks to the cooperation of East Pakistan Water and Power Development Authority, and Survey of Pakistan.

It is our sincere wishes that the survey should set up a nice foundation for the closer friendship between Japan and Pakistan, strengthening the tie-up in the future.

CHAPTER I INTRODUCTION


PLANNING STAGE
DESIGN STAGE
(CONTRACT DRAWING)
CONSTRUCTION
FEASIBILITY REPORT
PRELIMINARY PLANNING
POWER STUDY
WATER STUDY
SEWER STUDY
FINAL PLANNING & PROGRAMING
ELECT & COMMU
WATER SUPPLY
STORM DRAIN
SANITARY SEWER
LAND RECLAMATION
ROAD
ELECT
WATER SUPPLY
COMBINED CONSTRUCTION
ROAD
COMMUNICATION
NEW CITY
PRIVATE CONSTRUCTION
PUBLIC CONSTRUCTION

CHAPTER I INTRODUCTION

I. LAND RECLAMATION.

(1) Basic concept.

For the land reclamation to construct a new town, our survey mission has drawn its conclusion on the basis of the following plans:-

We had to study two ways of flood control, because the Keraniganj district, which was intended for the construction of the new town in question, is submerged under water to depth of 10 to 12 feet regularly in every rainy season. One is to reclaim the whole project site up to the height well above the water level and the other is to surround it with an embankment and install a drainage system to discharge the water. The former shall be hereafter called the Scheme 'A' and the latter the Scheme 'B'. These two schemes have been compared in respect of technical and economic feasibilities, and we have decided on adopting the Scheme 'A' for the following reasons:

1-1. It will suit better the function of the new town which is to include drainage water supply and sewage disposal systems, construction and maintenance of other underground utility facilities.

1-2. In the Scheme 'A', even a small portion of the project site, when it has been completed, could be utilized for the development of the new town, whereas in the Scheme 'B', the whole project site will remain unutilized until the whole embankment work is completed.

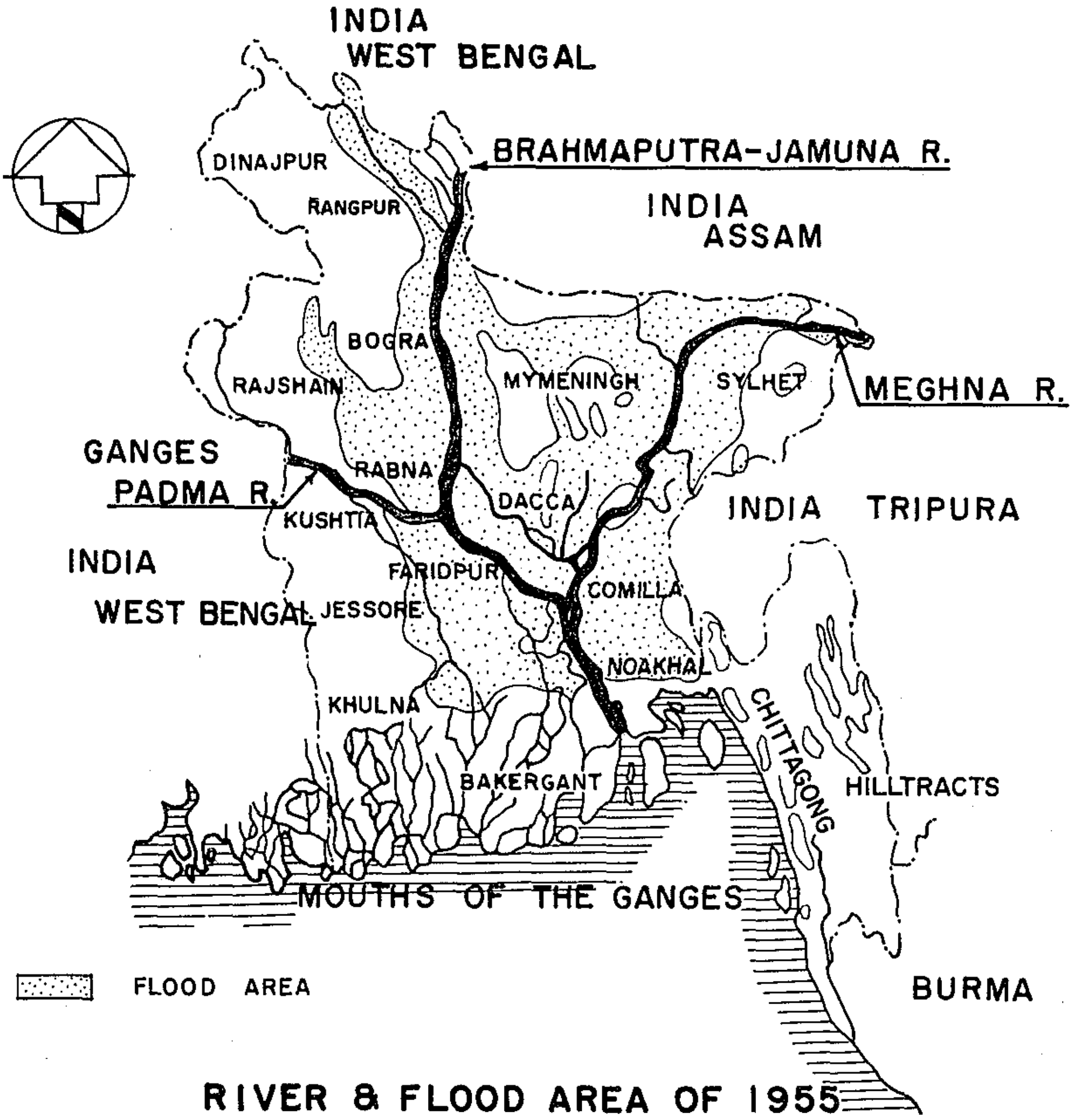
1-3. In the Scheme 'A', the function of the new town will not be affected by such accidents as will possibly result from drainage troubles. Furthermore, it will cost less in respect of maintenance.

1-4. Although the construction cost for a given unit of land is inexpensive in the Scheme 'B' which contains a substantial cost of embankment, the difference from the Scheme 'A' is so negligible that the greater safety in the Scheme 'A' will be preferred.

1-5. The higher ground level of the reclaimed land would be more attractive to the buyers of the land.

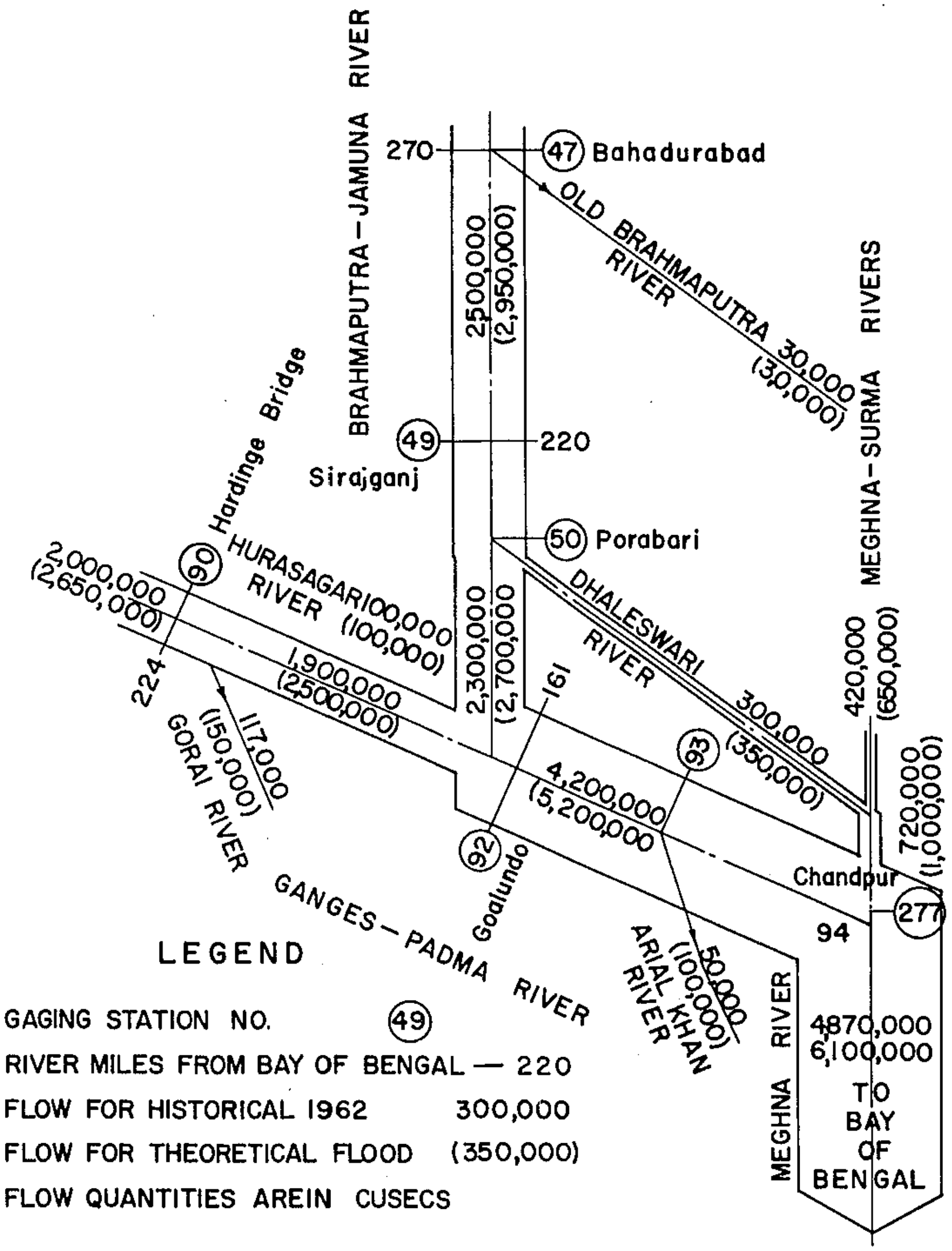
(2) The most fundamental factor in this new town project lies in the survey work for fixing the ground level which will remain unaffected by the annual flood.

As a result of our survey we have worked out the optimum ground level of 25 feet and we shall explain about it in details hereinafter. We have, however, worked out another Scheme 'C' which sets the ground level at 23 feet on the basis of the records on the previous floods and the estimates of the probable floods in the future as well as the present ground level of Dacca city. This is because the Scheme 'C' will save the construction cost. The reclamation of 23 feet is very close to the highest flood of 23.25 feet which was recorded in the past. (The Scheme 'C' is similar to the Scheme 'A' except in the elevation of the



RIVER & FLOOD AREA OF 1955

EAST PAKISTAN


BRAHMAPUTRA – JAMUNA RIVER
270
47 Bahadurabad
2500,000
(2,950,000)
OLD BRAHMAPUTRA RIVER 30,000
(30,000)
MEGHNA–SURMA RIVERS
49
Sirajganj
220
Hardinge Bridge
50 Porabari
90
2,000,000
(2,650,000)
HURASAGARI RIVER 100,000
(100,000)
2,300,000
(2,700,000)
DHALESWARI RIVER
420,000
(650,000)
224
1,900,000
(2500,000)
161
300,000
(350,000)
117,000
(150,000)
GORAI RIVER
93
720,000
(1,000,000)
4,200,000
(5,200,000)
92
Goalundo
Chandpur
277
94
GANGES – PADMA RIVER
50,000
(100,000)
ARIAL KHAN RIVER
MEGHNA RIVER
4870,000
6,100,000
TO BAY OF BENGAL
LEGEND
GAGING STATION NO. 49
RIVER MILES FROM BAY OF BENGAL — 220
FLOW FOR HISTORICAL 1962 300,000
FLOW FOR THEORETICAL FLOOD (350,000)
FLOW QUANTITIES AREIN CUSECS

FLOOD FLOWS

reclaimed land.) The difference between the Scheme 'A' & 'C' lies in the elevation of land reclamation: 'A' for 25 feet, and 'C' for 23 feet.

(3) Summary of each scheme

3-1. Scheme 'A' - Reclamation Elevation 25.0 ft.

	1st Stage	2nd Stage
Project area	234,000,000 sf (5,350 acre)	565,000,000 sf (13,000 acre)
Total length of embankment	28,000 yd	56,500 yd
Quantity of fill	130,000,000 cy	298,000,000 cy

The required volume of soil for the 1st stage, i.e. 130,000,000 cubic yards (99,200,000 cubic metres) will be converted from a dredged soil of 140,000,000 cubic yards or 104,500,000 cubic metres). (yield rate = 95% after compaction) The dredging operation will be carried out in the districts mentioned below;

(a) The catchment basin of the Burhiganga river
(b) The delta zones by reservoirs which lie in the midst of the residential area in the midwest portion of new town.
(c) The reservoir
(d) A block in the western part of the industrial zone

The soil from these four districts will amount to 152,000,000 cubic yards (116,550,000 cubic metres) which will be utilized for reclamation. The soil for the second stage will be taken from the Dhaleswari river and the volume of soil from this vast district will be more than sufficient for the project.

3-2. Scheme 'B' - Embankment Elevation 30.0 ft.

	1st Stage	2nd Stage	Remarks
Project area	234,000,000 sf (5,350 acre)	565,000,000 sf (13,000 acre)	
Total length of embankment	29,400 yd	58,000 yd	
Quantity of fill	7,600,000 cy	28,800,000 cy	Elevation 14.5 Heavy industrial zone to be reclaimed.

In the Scheme 'B', the reclamation will need only a smaller volume of soil which will be taken sufficiently from any source.

3-3. Scheme 'C' - Reclamation Elevation 23.0 ft.

	1st Stage	2nd Stage
Project area	234,000,000 sf (5,350 acre)	565,000,000 sf (13,000 acre)
Total length of embankment	28,000 yd	56,500 yd
Quantity of fill	113,000,000 cy	247,000,000 cy

(4) Estimated Cost of Construction

1. The 1st stage to cover the territory of 5,350 acres

Scheme 'A' - $90,333,000.- ($16,997 per acre)
Scheme 'B' - $77,678,000.- ($14,519 per acre)
Scheme 'C' - $82,594,000.- ($15,438 per acre)

The above amounts represent the grand total of direct cost respectively including (1) embankment cost, (2) reclamation cost and (3) storm drainage cost. From this you will see that the Scheme 'B' will be the most inexpensive and the Scheme 'C' is more inexpensive than the other Scheme 'A', but you will also note that the difference is not very large.

2. The 2nd stage to cover the territory of 13,000 acres.

Scheme 'A' - $212,977,000 ($16,383 per acre)
Scheme 'B' - $168,413,000 ($12,955 per acre)
Scheme 'C' - $188,422,000 ($14,494 per acre)

The above amounts represent the grand total of direct cost respectively including (1) embankment cost, (2) reclamation cost and (3) storm drainage cost.

Scheme 'A'

Direct Construction Cost & Incidentals

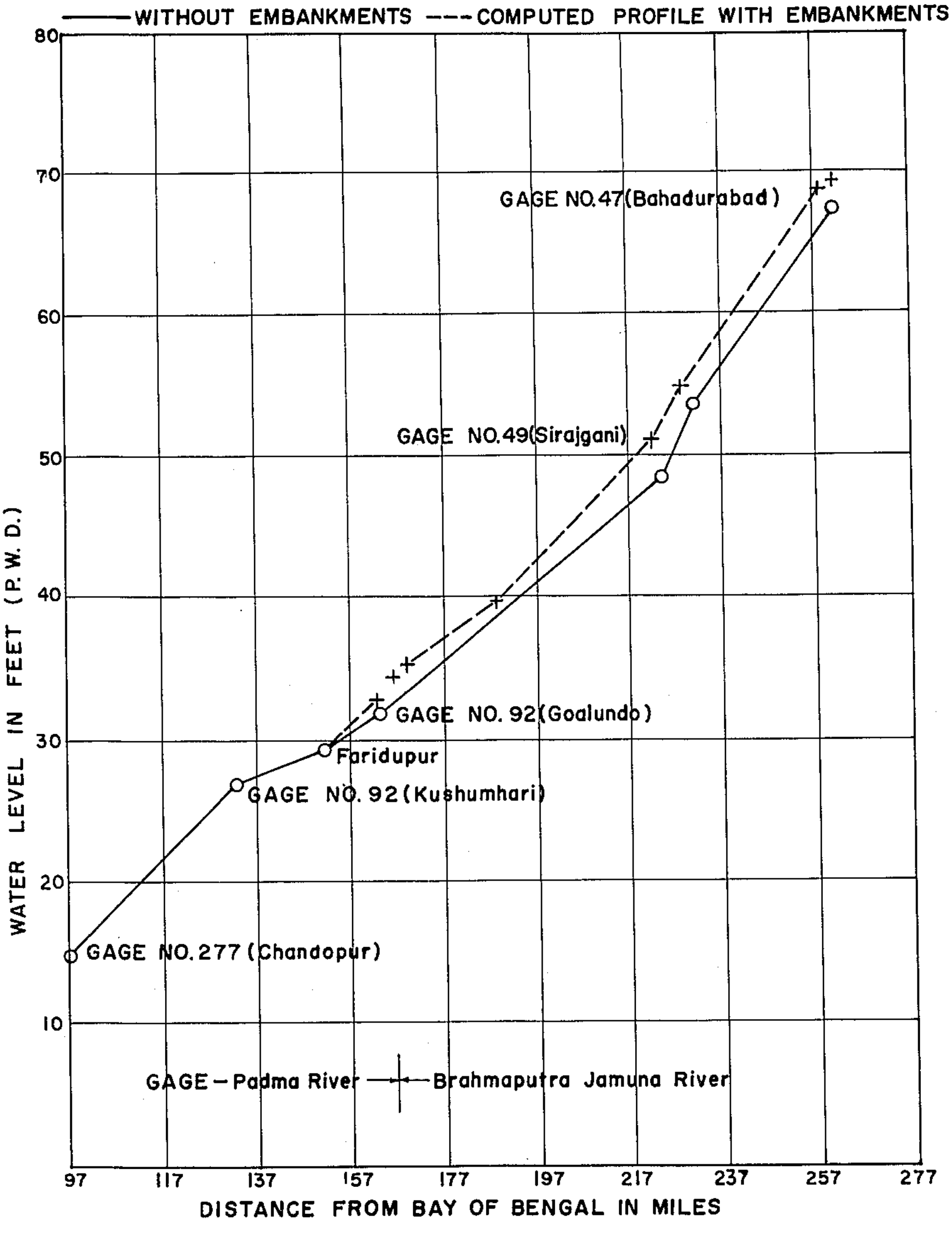
	Direct cost for land reclamation $	Total cost including indirect cost $	Cost for land purchase $	Cost for dredger shipbuilding & navigation charges $	Road construction cost $	Construction cost for sewerage plant & sewer $	Grand total $
1st Stage	90, 333, 000	109, 119, 000	30, 833, 000	21, 560, 000	879, 000	20, 547, 000	182, 938, 000
2nd Stage	212, 977, 000	255, 571, 000	58, 541, 000		7, 480, 000	36, 733, 000	358, 325, 000

Required Fund (1st Stage)

	Direct cost for land reclamation $	Administrative charges & design fee $	Cost for land purchase $	Cost for dredger shipbuilding & navigation charges $	Indirect cost (Reserves & interests) $		Grand total $
	4, 872, 000	4, 846, 500	30, 833, 000	21, 560, 000	487, 200		62, 598, 500
1st year	17, 711, 000	1, 211, 650			1, 771, 100		20, 693, 750
2nd year	22, 583, 250	1, 211, 650			2, 258, 325		26, 053, 225
3rd year	22, 583, 250	1, 211, 650			2, 258, 325		26, 053, 225
4th year	22, 583, 250	1, 211, 650			2, 258, 325		26, 053, 225
Total	90, 333, 000	9, 033, 300	30, 833, 000	21, 560, 000	9, 033, 300		160, 792, 600

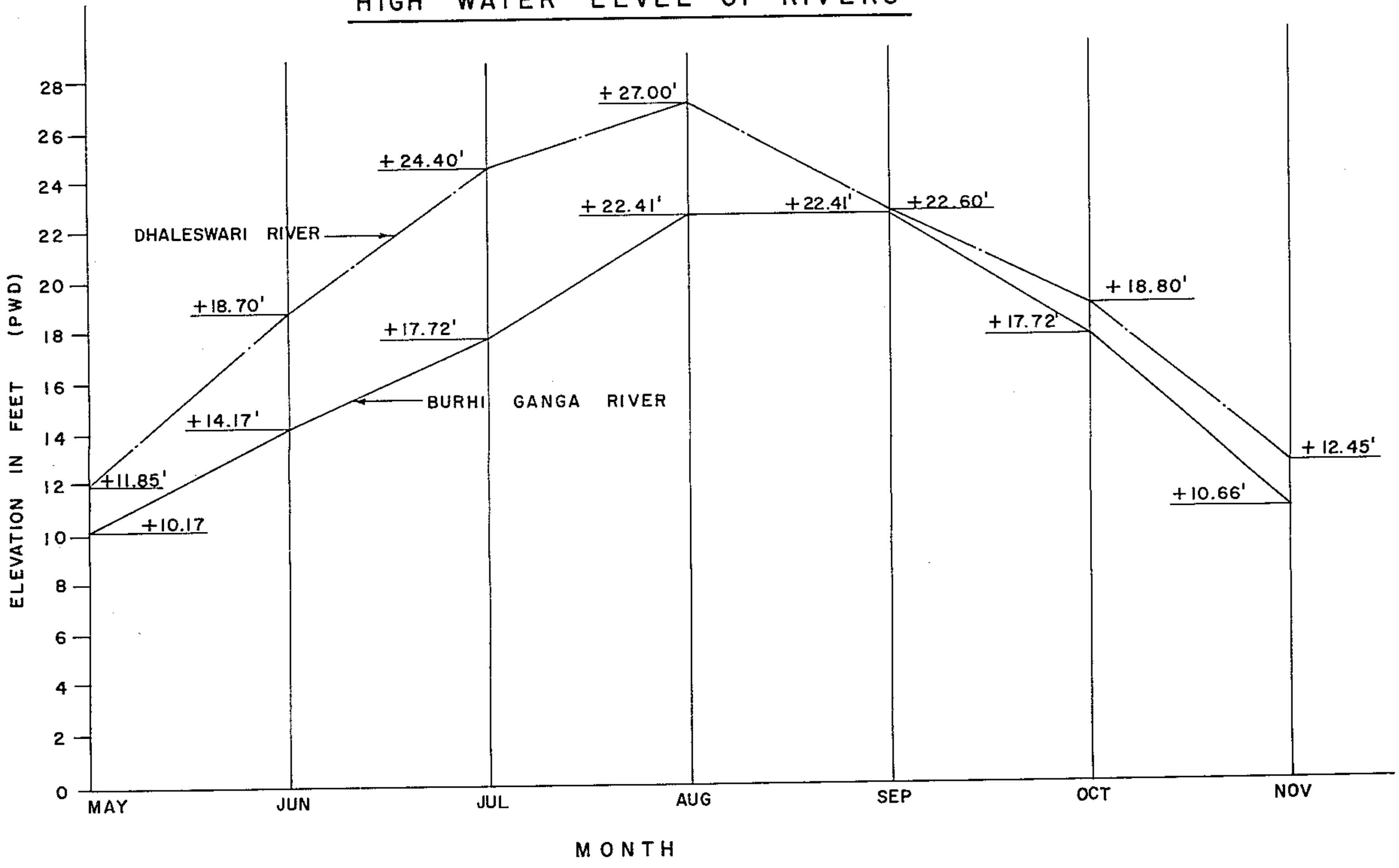
Public Investment Fund (1st Stage, 2nd Stage)

	Road construction cost	Construction cost for sewerage plant & sewer		Grand total
1st year		5, 139, 000		5, 139, 000
2nd year		5, 139, 000		5, 139, 000
3rd year		5, 139, 000		5, 139, 000
4th year		5, 139, 000		5, 139, 000
5th year	2, 087, 500	9, 183, 250		11, 270, 750
6th year	2, 087, 500	9, 183, 250		11, 270, 750
7th year	2, 087, 500	9, 183, 250		11, 270, 750
9th year	2, 087, 500	9, 183, 250		11, 270, 750
Total	8, 350, 000	57, 289, 000		65, 639, 000



SECTION OF MAIN RIVERS

HIGH WATER LEVEL OF RIVERS



(5) Land Cost.

5-1. The land cost for this portion of Jinjira district, south of Jinjira Market, which is free from the inundation is estimated at $7,400 per acre on the basis of our investigation made at the Survey of Pakistan.

5-2. This estimated cost of land will be raised to more than $20,000 per acre in the future when the urbanization programme has been fully realized with the bridges and all the relative construction works having been completed. This estimate of the future land cost has been made on the basis of the present urban area of Dacca city, although it is not quite easy to estimate the land cost because it is composed of various complex factors such as its final use, location, environments, transportation facilities and so forth.

5-3. Since the land space of Dacca city is not quite sufficient for the city's present functional demands as capital of East Pakistan, the land cost will further rise in proportion to the future inflow of population into the city. Therefore, this programme is considered very economical and essential.

5-4. Since this programme has been worked out on the basis of $15,000 to $16,000 per acre, we are convinced that it will pay well.

II. FLOOD CONTROL.

(1) Basic ideas for the flood control.

We could think of the following methods of the protection against inundation.

1-1. The ground level of the district intended for urbanization should be above the height of any possible inundation. It is, therefore, essential to fix the ground level at the point which will leave some free board over the highest possible water level of the anticipated high flood conditions.

1-2. If an embankment is to be constructed to assure a perfect protection even against the highest level of inundation, it is essential to determine its structure and height which should usually be 2 metres (6'-6") above the estimated maximum level of inundation.

(2) Determination of the ground level of the city and the height of the embankment.

On the basis of the above conditions, the Scheme 'A' fixes the ground level of the city at 25', whereas the Scheme 'B' does the height of the embankment at 30' by allowing for an additional height of 6'-6" plus 23.25' of the maximum height of inundation.

On the top of these two Schemes, we have worked out the Scheme 'C' which fixes the ground level at 23.25' for the maximum height of inundation with a protectional embankment for the total height of 25'. This height of 25' is intended to protect the city against the maximum height of inundation and against free board waves and the possible rise of the inundation level which may result from the future development of the new town.

(3) Factors for the determination of the highest flood level.

3-1. The highest flood level recorded in the past.

According to the data recorded by the Water Gauge Station at Mill Barracks, Dacca between 1905 and 1964, the highest flood level of 23.25' which has been taken as the basis of our survey work.

3-2. Estimated highest flood level.

Reference data are available from the reports on the investigation for the bridge construction works on Burhiganga river, the figures of which were worked out by Thomas' formula. In our survey of the probable highest flood level we have utilized these data. As a result, the figures obtained on the logarithmic normal distribution method indicate the value of 23.7 feet in a return period of 100 years. For further reference we have also calculated the highest flood level by Hazen's formula, logarithmic normal distribution method and Ganbellechou formula. The mean value obtained by these methods indicates a figure of 24.085 feet in a return period of 100 years.

3-3. Future trend of inundation.

As explained in the foregoing paragraphs of our report, an analysis of the inundation has only been made on the basis of the existing natural environments, but in view of the future development of the catchment area, which will eventually expand the territory to be protected against inundation, we can presume that the highest flood level could possibly be elevated further. About this possible elevation of flood level we could only make a assumption, but it is advisable to leave a sufficient free board in working out any construction programme.

III. CITY PLANNING.

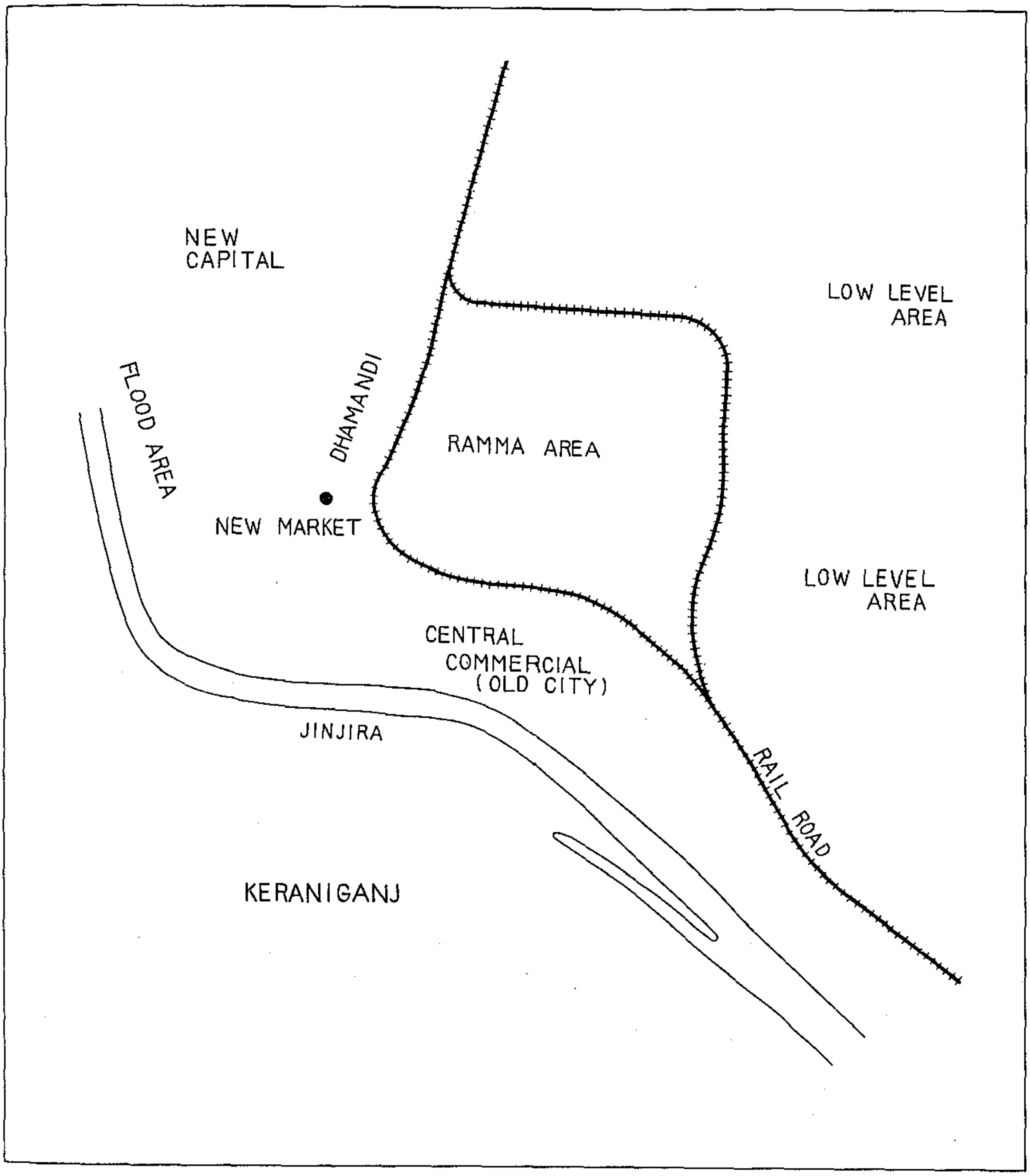
(1) Suitability of sites.

1-1. We have studied and investigated the existing conditions and future blaster plan of Dacca city. The commercial district located between the old railroad and the Burhiganga river is adjoined by Ramna district in the north, in which there are government offices, educational facilities, parks, etc. and it would limit any extensive development. In the northeast Dhamandi Extention and New Capital Area are now undergoing a progressive development which will be completed very soon. Further to the north, there is a military zone wherein is laid the airport, and the expansion of the city is limited in this part as well.

Therefore, we could only select the site for city planning in the district on the other side of the Burhiganga river provided it were not on a low ground level and with a bridge connection with the old city.

1-2. As we have explained in the previous paragraphs, the commercial district in the center of the old city is not suitable for this city planning for the reason that this confined district has no sufficient capacity for the future expansion of the city.

DACCA CITY


NEW CAPITAL
LOW LEVEL AREA
FLOOD AREA
DHAMANDI
RAMMA AREA
NEW MARKET
LOW LEVEL AREA
CENTRAL COMMERCIAL (OLD CITY)
JINJIRA
RAIL ROAD
KERANIGANJ

Therefore, there is no alternative but to seek for a clue to the question of land reclamation in the investigation of Keraniganj district, although it will involve an enormous amount of construction cost. Prior to our investigation, a master plan was worked out by English consultants who also planned to build a greater Dacca in Keraniganj district, and we also recommend to follow it for the expansion of the city and for the solution to the excessive congestion of the old city.

(2) Bounderies of the city planning and the future population of the city.

2-1. Scope of the plan.

In the original plan, made by English consultants in 1948, an area of 10, 000 acres in Keraniganj district was intended for the city planning, but the total area has now been expanded to 34, 000 acres. In this plan we shall take up 23, 000 acres out of the whole area, both for the 1st and 2nd stage of the construction work.

2-2. Population.

On the basis of the present increasing rate, the population of Dacca is estimated to reach 1. 5 million mark in 1985. Incidentally this will be an increase of 750, 000 over the population of Dacca in 1962. This area is intended to accommodate 500, 000 which is equivalent to two thirds of the population in 1962.

Area for 1st stage: 39, 800 houses for 199, 000 persons (5 per house)
Area for 2nd stage: 90, 000 houses for 495, 000 persons (5. 5 per house)

This Scheme contains, therefore, a programme for a city with half a million population.

(3) The new city in planning.

3-1. This portion of project land will be a new center of Dacca city, but it should be provided with port facilities so that it may also function as an industrial zone. This future industrial zone should of course be surrounded by the residential quarters, and in the long run the district should develop into a city adequate for commerce, industry and culture.

3-2. Traffic plan.

3-2-1. Highways.

At present the transportation of Dacca depends on railways and waterways, but it will be connected with other parts of the country by highways. Therefore, the new city should be penetrated by a highway which will lead to Dhaleswari river and extend further to Brahmaputra river where there will be ferryboat transportation available for a connection to Faridpur.

As previously suggested by the Japanese survey mission for the bridge construction, the trunk roads through Sadarghat, instead of functioning only as a transit highway, bridge should be designed to connect the centers of the old and new cities so that it will mitigate the congestion which will result from the increased internal traffic and transit movements. There is no planning of leading any rail-way into the new city.

3-3. Port facilities.

Up to now, Dacca has been dependent on water transportion, but there are no ports now similar facilities in the town except the floating pier and the boat terminal at Narayanganji about 20 km (12 mile) south of the city. The new city planning includes a construction of port facilities at the dredging area on Burhiganga river.

Since there is quite a large difference in water level between dry and rainy seasons, the Scheme intends to set up two piers.

3-4. Supply and disposal.

This Scheme includes only drainage which is closely connected with the reclamation. Besides drainage, the city will require the following supply and disposal facilities;

A. Supply of electric power
B. Waterworks and sanitary sewer facilities
C. Supply of gas
D. Communication facilities
E. Garbage disposal

IV. Conclusion and Recommendations.

(1) Conclusion.

As we explained in the foregoing paragraphs, the land reclamation has now proved feasible both in respect of technique and of economy. This will not only contribute to the development of Dacca, but it will also promote the industrialization of Pakistan and lay a firm foundation of the country's economic growth. This city planning has been, as a matter of fact, elaborated so as to serve these purposes well.

In conclusion we recommend the plan for reclamation (Scheme 'A') in preference to the other Scheme for embankment (Scheme 'B'), because the difference in cost is so negligible that it is well offset by the greater advantages of the reclamation plan. We have also worked out another Scheme 'C' in view of the function of the city and of other conditions, which is also a sort of reclamation but it is less expensive than the Scheme 'A'. This Scheme 'C' will also facilitate the function of the new town.

(2) Recommendations.

2-1. In the city planning, a special consideration should be given to consolidating the city's industrial zone which will be essential to the future growth of the city.

2-2. In respect of the electric power supply for the city, we recommend that a power plant should be built in the industrial zone at the confluence of Dhaleswari and Burhiganga rivers, if it is ever to be built in this district.

2-3. The treatment plants for water supply should be installed within this district. However, if the construction is to be achieved with a long interval between its first and second stage, an amendment should be made to the site for the treatment plants.

2-4. In respect of the construction of the bridge over Burhiganga river, which was previously planned by the survey mission for bridge construction, we recommend that the Scheme should be reviewed about the width of the bridge and that the construction of this bridge should be started prior to all the construction of other bridges.

2-5. The costs for the construction of supply and disposal facilities and of trunk roads should be considered as a part of social investment. These roads will not only facilitate the transportation within the district, but they will also bring the city into a closer connection with the other parts of the country. Since the supply and disposal facilities will serve the public welfare, they should also be part of the social investment.

2-6. The agricultural population in this district should be gradually transformed into an industrial population in proportion to the future development of the other industries. The brick manufacturing mills near the confluence of Burhiganga and Dhaleswari rivers should be moved outside the western boundery of this district.

2-7. Jinjira district has been designated for reconstruction, which will be started when the new reclaimed land has taken over all the facilities and functions from the old city. Jinjira district, when it has fully been reconstructed, will be absorbed by the new city.

(3) This reclamation work will need the hauling of an enormous volume of soil which cannot be be covered by manpower, and we recommend the adoption of sand fill system which will be most suitable for the geographic conditions of this district surrounded by rivers.

(4) This report contains only a brief and schematic outline for the city planning and further details should be elaborated at a later date.

CHAPTER II FLOOD CONTROL

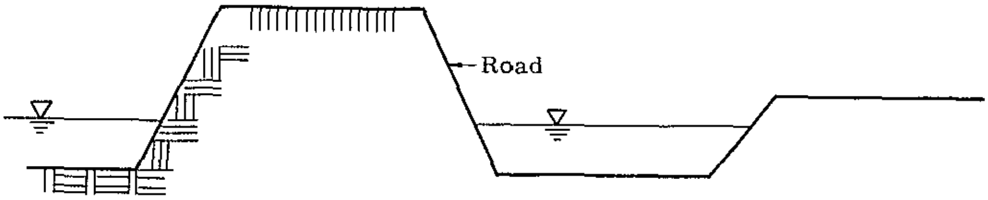
CHAPTER II FLOOD CONTROL

SECTION I. PROTECTION AGAINST FLOOD

I. Features of the Burhiganga river in Dacca district.

(1) The geography of Dacca.

Dacca is located about the middle of East Pakistan. This capital city has been developed on the average height of 20 to 25 feet, and its district spans on the left side of Burhiganga river which diverges from Dhaleswari river and flows westward. This district is surrounded by areas on a 10 feet level wherein are scattered reclaimed residential quarters. Trunk roads, reclaimed up to a 20 feet level and surfaced with bricks, run through this low lands. These roads are reclaimed with the soil taken from the both sides of the roads, which leaves puddles even in the dry season. The water level here moves from 2 feet in the dry season to 20 feet in the rainy season. In other words most oi these lands except the city area of Dacca are inundated during the rainy season and on these lands people grow only jute and paddy.



(2) Burhiganga river.

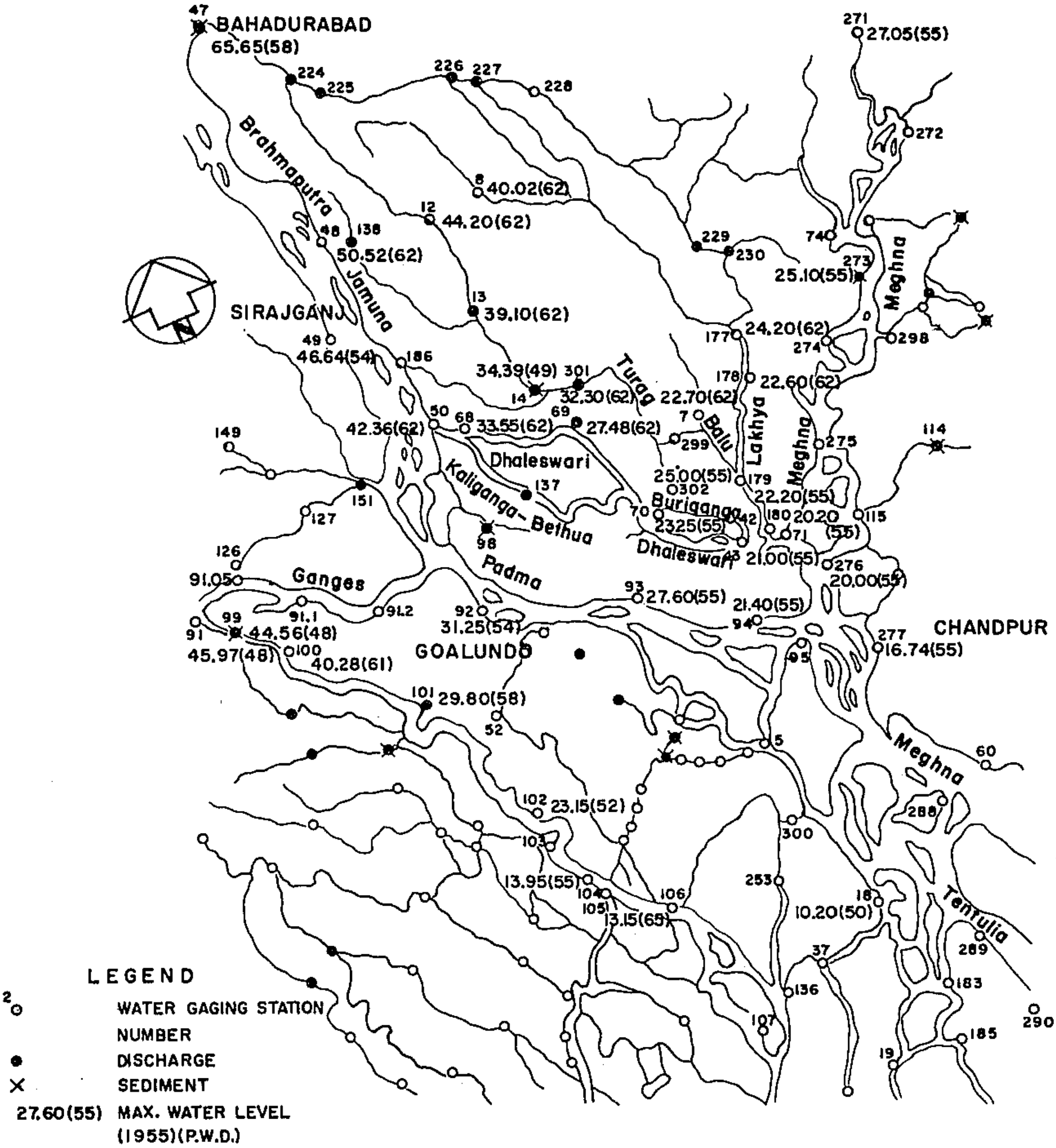
This river diverges at Sabhar from Dhaleswari river which branches off from Brahmaputra river at Porabar, but if flows into Dhaleswari river at Charbakiaball and further flows into Meghna river near Munshiganj. Therefore, the water level in Dacca area varies in proportion to that of the Meghna river. The highest water level in Dacca was recorded in 1955. The Turag river which joins the Dhaleswari and Burhiganga rivers recorded its highest water level in 1962.

The highest water levels in Dacca and its vicinity recorded by water metre (on P. W. D. basis) are all indicated in the figure W-1. The longitudinal section of the water levels of the rivers in 1955, when the highest water level was recorded in Dacca, is shown in the figure W-2. The surface slopes of the rivers in 1955 are considered to range between 1/20, 000 and 1/50, 000.

The section of the river between the water gauging station No. 43 at the junction of the Dhaleswari and Burhiganga rivers and the water gauging station No. 42 of Mill Barracks, Dacca has been calculated as below;

$$\frac{(23.25 - 21.00)\text{ ft.}}{8\text{ miles}} = \frac{2.25\text{ ft.}}{8 \times 5,280\text{ ft.}} \fallingdotseq \frac{1}{19,000}$$

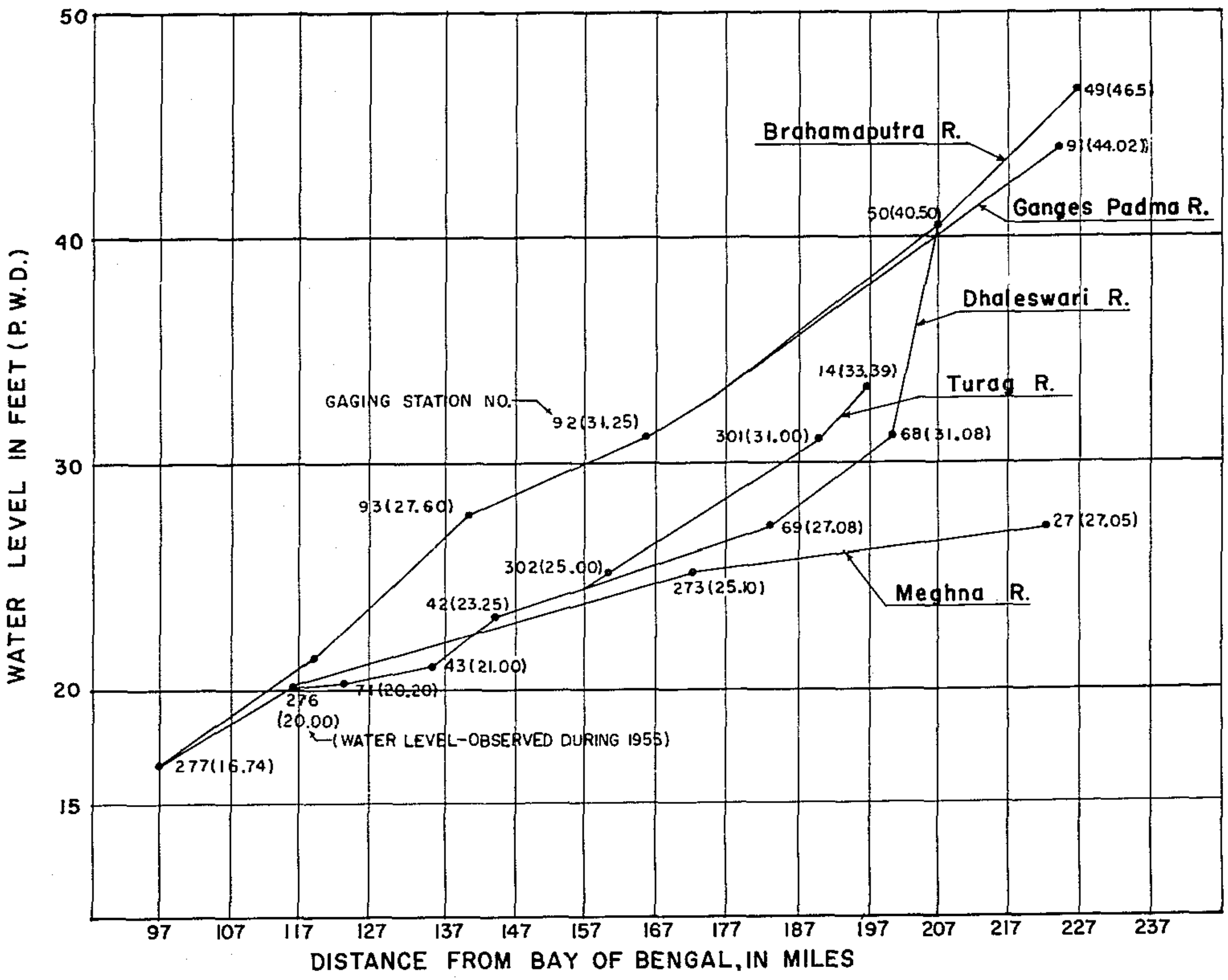
The section of the river between the water gauging station No. 42 at Mills Barracks and the water gauging station No. 302 at Mirpur on the Turag river is as follows;



LOCATION MAP OF WATER GAGING STATION
AND
HIGHEST WATER LEVEL AT PAST YEAR
CENTRAL EAST PAKISTAN

10 0 10 20 30 40
SCALE IN MILES

FIG-W-1



SECTIONS-HIGHEST WATER LEVEL IN 1955

FIG-W-2

$$\frac{(25.00 - 23.25)\text{ ft.}}{19\text{ miles}} = \frac{1.75\text{ ft.}}{16 \times 5,280\text{ ft.}} \doteqdot \frac{1}{48,000}$$

(3) The hydraulic data recorded by the Mill Barracks water gauging station on the Burhiganga river are as follows.

Since 1909, the E.P.W.A.P.D.A. water gauging station No. 42 of Mill Barracks, Dacca on the left side of the Burhiganga river has recorded all the highest figures. This water gauging station now has an automatic recording system. This water gauging station has given the following figures.

3-1. Annual highest water levels and the probable highest water levels.

The table 3 indicates the annual highest and lowest water levels between 1909 and 1964. On the basis of these figures, logarithmic probability figures have been worked out in Thomas formula for a return period of 50 and 100 years respectively. (Refer to Figure W-3.)

$$F = \frac{i}{N + I}$$

F : Probability function

N : The total number of observation data

i : a number in increasing order of data

According to the table, the existing condition of the river remains unchanged without new embankments, and the probable highest water levels are as follows;

The probable highest water level for a return period of 100 years	:	23.70 ft. (P.W.D.)
The probable highest water level for a return period of 50 years	:	23.10 ft. (P.W.D.)
The previous highest water level	:	23.25 ft. (1955)

From this, you could readily see that the water level reaches the 25 feet mark only once in 700 years. On this basis, we determined the safety level for the reclamation at 25.00 feet by considering the level-up which may be influenced by future embankment.

3-2. We have adopted the following formula to study the probable highest water level. This calculation is based upon the period of 30 years from 1934.

(A) Hazen formula.

n = 30 Coefficient variation $= \sqrt{\frac{\Sigma \text{COL } 8}{n - 1}}$

$$= \sqrt{\frac{0.203}{30 - 1}} = \sqrt{\frac{0.203}{29}} = \sqrt{0.007} = 0.084 \text{ (CV)}$$

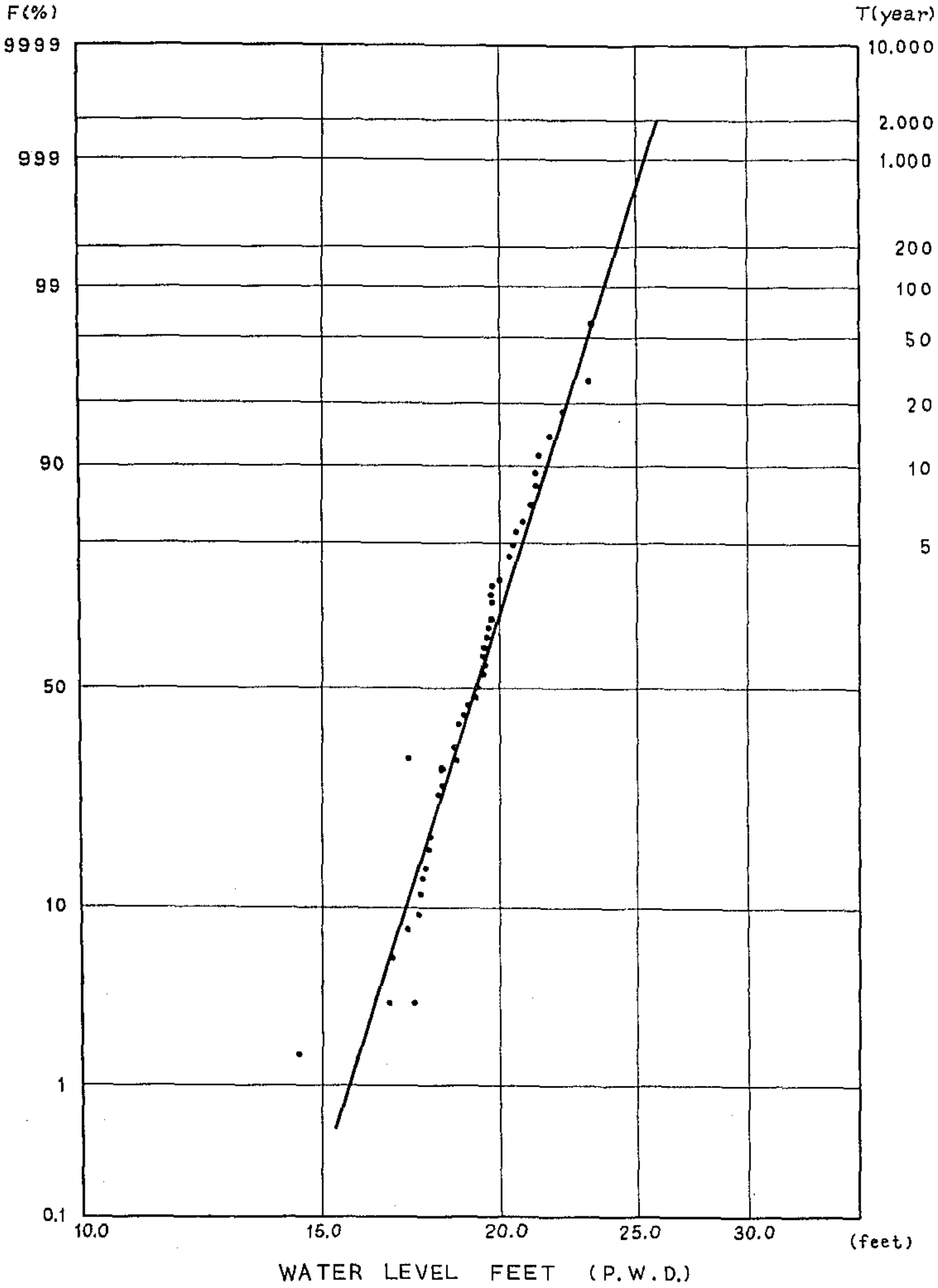
$$F = 1 + \frac{8.5}{n} = 1 + \frac{8.5}{30} = 1 + 0.0283 = 1.283$$

Coefficient & skew $= \frac{\Sigma \text{COL } 9 \times F}{(n-1)\,(cv)^3} = \frac{0.019 \times 1.283}{29 \times (0.084)^3}$

$$= \frac{0.025}{29 \times 0.00059}$$

$$= \frac{0.0252}{0.0171}$$

$$= 1.475 \text{ (CS)}$$



ESTIMATION OF MAXIMAM PROBABLE
WATER LEVEL FOR BURHIGANGA RIVER (MILL BARRACKS)

Ⓐ	Ⓑ	Ⓒ	Ⓓ	
% of Time	Skew Factor cs=1.475	Col Ⓑx cv cv=0.084	Col Ⓒ + 1.0	Col Ⓓx Mean
99	-1.41	-0.028	0.972	18.90
95	-1.19	-0.010	0.990	19.20
80	-0.81	-0.007	0.993	19.30
50	-0.22	-0.002	0.998	19.40
20	+0.69	+0.006	1.006	20.22
5	+1.99	+0.167	1.167	22.50
1	+3.59	+0.302	1.302	25.00
MEAN = 19.39				

TABULATION COMPUTATIONS (HAZEN'S METHOD)

①	②	③	④	⑤	⑥	⑦	⑧	⑨
Year	Items	Items in order of magnitude	Plotting position	Freq. in years	Ratio to mean	Col ⑥ Minus 1.0	Col ⑦ squared	Col ⑨ Cub & D
1934	19.45	23.25	1.67	60.0	1.21	0.21	0.041	0.0093
1935	19.80	23.15	5.00	20.0	1.20	0.20	0.040	0.0000
1936	19.35	22.15	8.33	12.0	1.15	0.15	0.023	0.0034
1937	18.30	21.66	11.67	8.6	1.13	0.13	0.017	0.0022
1938	21.00	21.15	15.00	6.7	1.10	0.11	0.010	0.0010
1939	19.10	21.00	18.33	5.5	1.09	0.09	0.008	0.0007
1940	17.25	20.70	21.67	4.6	1.08	0.08	0.006	0.0005
1941	17.70	20.00	25.00	4.0	1.04	0.04	0.002	0.0001
1942	18.80	19.90	28.33	3.5	1.03	0.03	0.001	0.0000
1943	17.75	19.80	31.67	3.1	1.03	0.03	0.001	0.0000
1944	16.80	19.80	35.00	2.86	1.03	0.03	0.001	0.0000
1945	19.80	19.70	38.33	2.6	1.03	0.003	0.001	0.0000
1946	19.90	19.50	41.67	2.4	1.01	0.01	0.0001	0.0000
1947	18.60	19.45	45.00	2.21	1.00	-	-	-
1948	20.70	19.35	48.33	2.07	1.00	-	-	-
1949	19.70	19.10	51.67	1.94	0.99	-0.01	0.000	-0.0000
1950	18.90	18.95	55.00	1.83	0.99	-0.01	0.000	-0.0000
1951	19.50	18.90	58.33	1.71	0.99	-0.01	0.000	-0.0000
1952	18.00	18.70	61.67	1.63	0.98	-0.02	0.000	-0.0000
1953	18.70	18.70	65.00	1.54	0.98	-0.02	0.000	-0.0000
1954	23.15	18.65	68.33	1.47	0.98	-0.02	0.000	-0.0000
1955	23.25	18.60	71.67	1.40	0.97	-0.03	0.001	-0.0000
1956	18.65	18.30	75.00	1.43	0.96	-0.04	0.002	-0.0001
1957	17.60	18.00	78.33	1.28	0.94	-0.06	0.004	-0.0002
1958	21.15	18.00	81.67	1.23	0.94	-0.06	0.004	-0.0002
1959	18.95	17.75	85.00	1.18	0.93	-0.07	0.005	-0.0003
1960	20.00	17.70	88.33	1.13	0.92	-0.08	0.006	-0.0005
1961	18.70	17.60	91.67	1.09	0.92	-0.08	0.006	-0.0005
1962	22.15	17.25	95.00	1.05	0.90	-0.10	-0.010	-0.0010
1964	21.66	16.80	98.33	1.01	0.88	-0.12	-0.014	-0.0027
SUM							0.203	0.0197
MEAN		19.39						

(B) Logarithm Orthogonal Distribution Method

$\log_{10} x_0 = 1.287 \qquad x_0 = 19.39 \qquad N = 30$

$$\sigma_0{}^2 = \frac{\sum_1^N (\log_{10} x_1 - \log_{10} x_0)^2}{N} = \frac{0.0368}{30} = 0.00122$$

$$\sigma_0 = 0.035$$

$$\begin{aligned}\log_{10} x = \sigma_0 \xi + \log_{10} x &= 0.035 \times 2.326 + 1.287 \\ &= 0.08141 + 1.287 \\ &= 1.36841 \\ x &= 23.36\end{aligned}$$

(C) Takase's Method (Modified Log. Orthogonal Dist. Method)

$N = 30 \qquad \sigma_\xi = 0.6923 \qquad \xi = 2.326\,(W(\xi)\ 1\%) \qquad \log_{10} x_0 = 1.287$

$$\log_{10} x = \frac{\xi \ \sigma_0}{\sqrt{2}\ \sigma_\xi} + \log_{10} x_0 = \frac{2.326 \times 0.035}{\sqrt{2} \times 0.6923} + \log_{10} x_0$$

$$= \frac{2.326 \times 0.035}{1.414 \times 0.6923} + \log_{10} x_0 = \frac{0.0815}{0.98} + 1.287$$

$$= 0.08 + 1.287 = 1.367$$

$$x = 23.43$$

$$\sigma_0 = \sqrt{\frac{\sum_1^N (\log_{10} x_i - \log_{10} x_0)^2}{N}}$$

$$= \sqrt{\frac{0.0368}{30}}$$

$$= \sqrt{0.00122}$$

$$= 0.035$$

(D) Gumbel-chow Method

$$\tilde{x} = \frac{\sum_1^N x_1}{N} = \frac{583.6}{30} = 19.45$$

$$\sigma = \sqrt{\frac{\sum_1^N (x_1 - x)^2}{N}} = \sqrt{\frac{79.60}{30}} = \sqrt{2.653} = 1.627$$

$$\begin{aligned}x = \sigma K + \tilde{x} &= 1.627 \times 3.137 + 19.45 \\ &= 5.1 + 19.45 \\ &= 24.55\end{aligned}$$

TABLE: σ_ξ

N	10	15	20	30	40	50	60	70	80	100
σ_ξ	0.6632	0.6778	0.6851	0.6923	0.6960	0.6982	0.6998	0.7007	0.7015	0.7027

TABLE: Logarithm Orthogonal Distribution and Probability W (ξ)

ξ	W (ξ)		ξ	W (ξ)	
3.2905	0.05%	1/2000	1.8808	3.0%	1/33.33
2.5758	0.5	1/200	1.7507	4.0	1/25
2.3263	1.0	1/100	1.6449	5.0	1/20
2.1701	1.5	1/66.67	1.2815	10.0	1/10
2.0537	2.0	1/50	0.8416	20.0	1/5
1.9600	2.5	1/40	0	50.0	1/2

TABLE: Frequency Factors

T(Year)	200	100	50	25	20	10	5	2
K	3.683	3.137	2.592	2.043	1.867	1.304	0.720	-0.164

As explained so far, the overflow probability in 100 years:

Hazen's formula : 25.00 ft.

Logarithm Orthogonal Distribution Method : 23.36 ft.

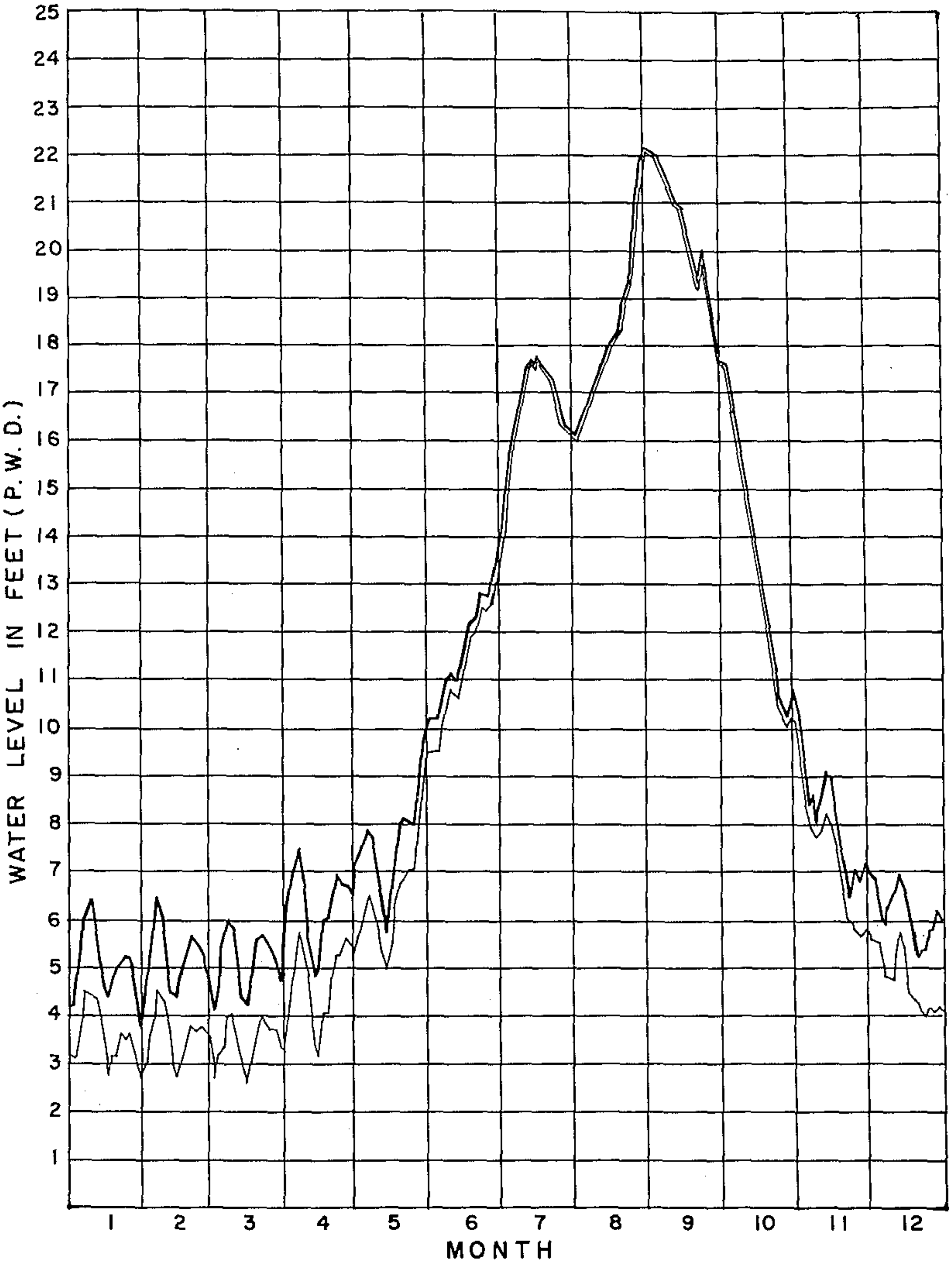
Takase's Method (Modified Log. Orthogonal Dist. Method) : 23.43 ft.

Gumbel-Chow's Method : 24.55 ft.

Therefore, the average is given : 24.085 ft.

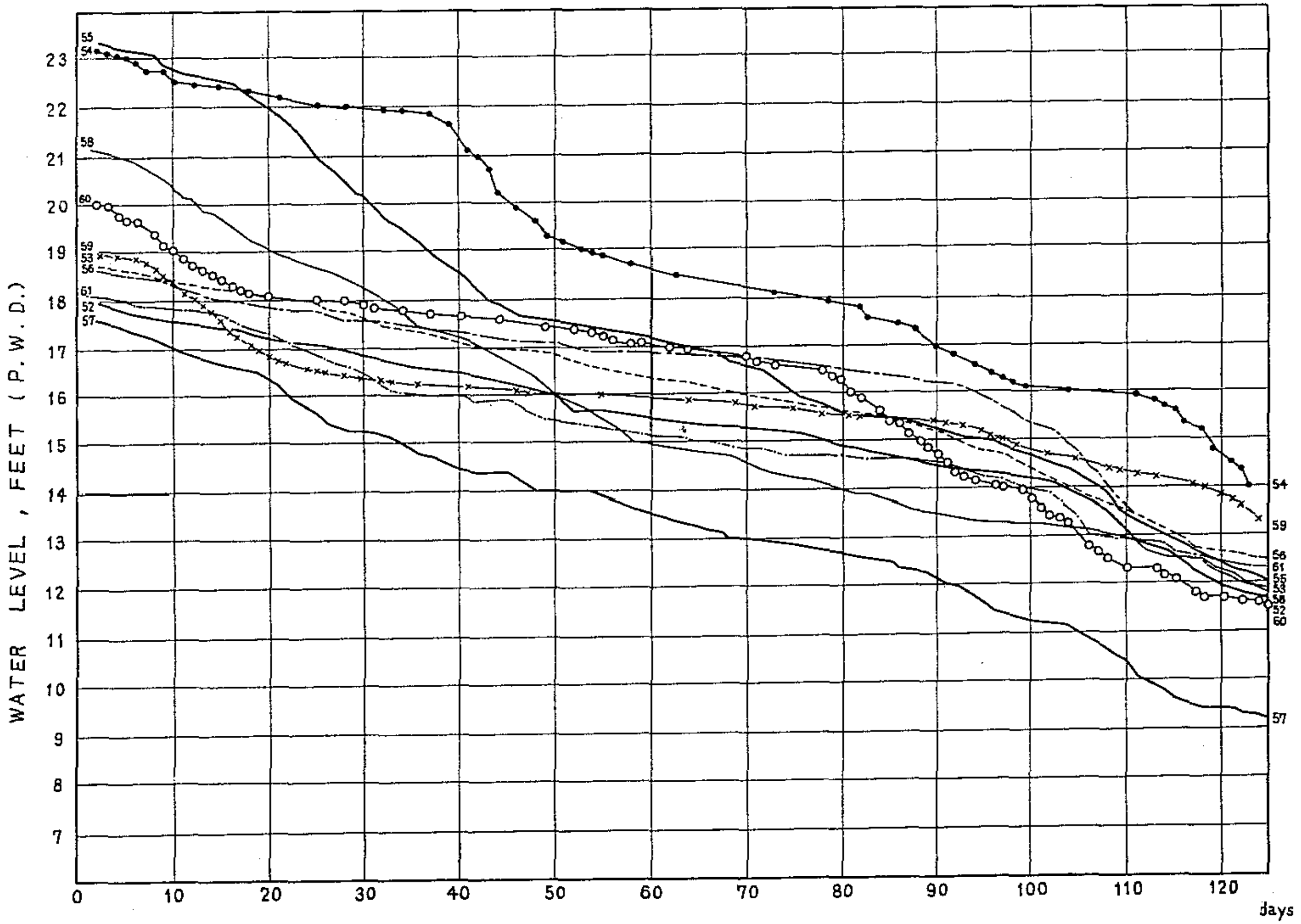
TABLE for Gumbel-Chow's Method:

1	2	3	4	5	6	7	8	9
i	x_i	$\frac{2_i - 1}{2N}$ %	$\log_{10} x_i$	$\frac{x_i}{x_0}$	$\log x_i - \log x_0$	$(\log x_i - \log x_0)^2$	$x_i - \tilde{x}$	$(x_i - \tilde{x})^2$
1	23.25	1.6	1.366	1.21	0.079	0.0062	3.90	15.21
2	23.15	5.0	1.364	1.20	0.077	0.0059	3.80	14.44
3	22.15	8.3	1.345	1.15	0.058	0.0034	2.80	7.84
4	21.66	11.6	1.335	1.13	0.048	0.0023	2.31	5.34
5	21.15	15.0	1.325	1.10	0.038	0.0014	1.80	3.24
6	21.00	18.3	1.322	1.08	0.035	0.0012	1.65	2.72
7	20.70	21.6	1.315	1.07	0.028	0.0008	1.35	1.82
8	20.00	25.0	1.301	1.04	0.014	0.0002	0.65	0.42
9	19.90	28.3	1.299	1.03	0.012	0.0001	0.55	0.30
10	19.80	31.6	1.297	1.02	0.010	0.0001	0.45	0.20
11	19.80	35.0	1.297	1.02	0.010	0.0001	0.45	0.20
12	19.70	38.3	1.294	1.02	0.007	0.0000	0.35	0.12
13	19.50	41.8	1.290	1.10	0.003	0.0000	0.15	0.02
14	19.45	45.0	1.289	1.10	0.002	0.0000	0.10	0.01
15	19.35	48.3	1.287	1.00	0.000	0.0000	0.00	0.00
16	19.10	51.6	1.281	0.99	-0.006	0.0000	-0.20	0.04
17	18.95	55.0	1.278	0.98	-0.009	0.0001	-0.40	0.16
18	18.90	58.3	1.276	0.98	-0.011	0.0001	-0.45	0.20
19	18.70	61.6	1.272	0.97	-0.015	0.0002	-0.65	0.42
20	18.70	65.0	1.272	0.97	-0.015	0.0002	-0.65	0.42
21	18.65	68.3	1.271	0.96	-0.016	0.0003	-0.70	0.49
22	18.60	71.6	1.270	0.96	-0.017	0.0003	-0.75	0.56
23	18.30	75.0	1.262	0.95	-0.025	0.0006	-1.05	1.10
24	18.00	78.3	1.255	0.93	-0.032	0.0010	-1.35	1.82
25	18.00	81.6	1.255	0.93	-0.032	0.0010	-1.35	1.82
26	17.75	85.0	1.249	0.92	-0.038	0.0014	-1.60	2.56
27	17.70	88.3	1.248	0.92	-0.039	0.0015	-1.85	3.42
28	17.60	91.6	1.246	0.91	-0.041	0.0017	-1.95	3.80
29	17.25	95.0	1.237	0.89	-0.050	0.0025	-2.10	4.41
30	16.80	98.3	1.225	0.87	-0.062	0.0038	-2.55	6.50
SUM	583.56					0.0368		79.60



HIGHEST & LOWEST WATER LEVEL-DAY IN 1962
AT MILLBARRACKS

FIG-W-4



WATER LEVEL AND DURATION CURVES FOR BURHIGANGA RIVER (1952-1961)

3-3. The highest water level in 1962.

The figure W-4 shows the daily highest and lowest water levels recorded for a year of 1962 at Mill Barracks.

From this table, you will see that the water level gradually starts moving up from 2 or 3 feet in May of the year up to the maximum level of about 20 feet around July through September until it suddenly drops to 2 or 3 feet in October or November. From June through October every year, there is little a difference between the highest and lowest levels of each day, whereas in the other months there is usually difference of about 2 feet, which is due to the low and high tides of the Bay of Bengal. In other words, when the water level stays above 10 feet (P. W. D.), it is not very much affected by the tides. Incidentally, the highest water level in 1962 was the third in the record.

3-4. The continuous hydrograph for 1952 ~ 1961, Fig-W-5, indicates a portion of those recorded by the water gauging station at Mill Barracks for 1952 ~ 1966. This figure illustrates that, for a third of the year, the water level stays above 12 feet. Therefore, Dacca on the right side of the Burhiganga river stands under water for about half a year, because its average height is about 10 feet.

(4) Flood control plan for Dacca area.

Outline of the flood control plan.

The development of Dacca, the Capital city, was initiated by the water transportation on the Burhiganga river. The left side of the river where the city stands now is on a level of 20 ~ 25 ft. (P. W. D.), whereas on the right side there remains an undeveloped land of about 10 feet high, where could only be made available for a new town area of the city, by way of reclamation as it is regularly inundated in a depth of 20 feet in every rainy season.

II. Formula for Flood Control.

(1) Needless to say, if the level of reclamation is higher than the highest flood level, the safety of the reclaimed land is assured. Therefore, in the reclamation plan, the most essential factor lies in the estimate of the highest flood level. Following are the factors which must be utilized for the estimate.

(a) The highest flood level in the previous records : 23. 25 ft. (P. W. D.) 1955.

(b) The probable highest flood in a return period of 100 years : 23. 75 ft.
(by Thomas formula).

(c) Free board wave about 2' (for a lake of 2 mile width).

(d) Elevation of flood level by wind.

(e) Rise in the water level in the future when the inundated area will be reduced owing to the reclamation and embankment being completed.

By interweaving all these factors, the reclamation should be at least 25 feet high. It is of course better if the reclamation level is higher, but we consider the minimum level should be 25 feet.

For further reference, the Steven formula is given below about the free board wave.

$h = 0.17 \quad VF + 2.5 - F$

h = Height of wave in feet.

V = Wind velocity in miles per hour

F = Unobstructed length of lake in statute miles

Zuider Zee formula about the possible elevation of water level by wind.

$$S = \frac{Y^2F}{1400D} \times \text{COS } A$$

S = Rise of water level above normal in feet

U = Wind velocity in miles per hour

F = Unobstructed length of lake in miles (Fetch)

D = Average depth of water in feet

A = Angle between fetch and direction of wind.

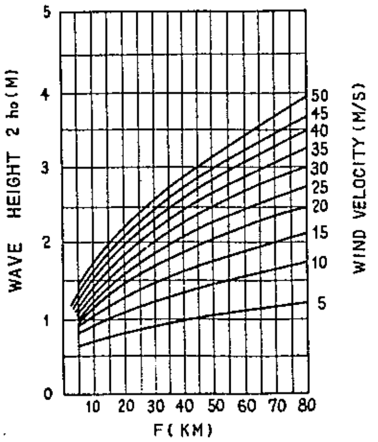


CHART FOR FREEBOARD WAVE (MOLITOR'S)

(2) In the embankment plan, the embankment should be strong and high enough to prevent the intrusion of the flood. Following are the factors for this plan:-

(a) Hydraulical factors are the same as (2-1).

(b) The strength of the embankment.

(c) The allowance of the height of the embankment over the highest flood level: about 2m = 6'-6".

(d) Drainage.

With all these factors taken together into consideration, the embankment should be over 30 feet high. Within the embankment, a mechanical drainage system would serve well to discharge the water. The details about this system are related in the chapter for the land reclamation projec

(3) Special remarks about the embankment work.

3-1. Since the soil of the project site is of sandy nature, cares should be taken to choose the construction materials for embankment by the penetration coefficient in the consolidation test.

3-2. Inside the embankment, there should be provided a structure to stand against the intrusion of water with a clayey core.

3-3. A protection work should be conducted on the front slope against the possible erosion by waves and against the tidal movements over a long period of inundation.

3-4. No trees nor electric poles should be planted on the inside slope of the embankment so as to prevent such disasters as may be caused by the cyclon or likewise.

3-5. The inside slope should not be exploited for cultivation.

3-6. No road construction should be permitted on the embankment.

TABLE 1 - 2

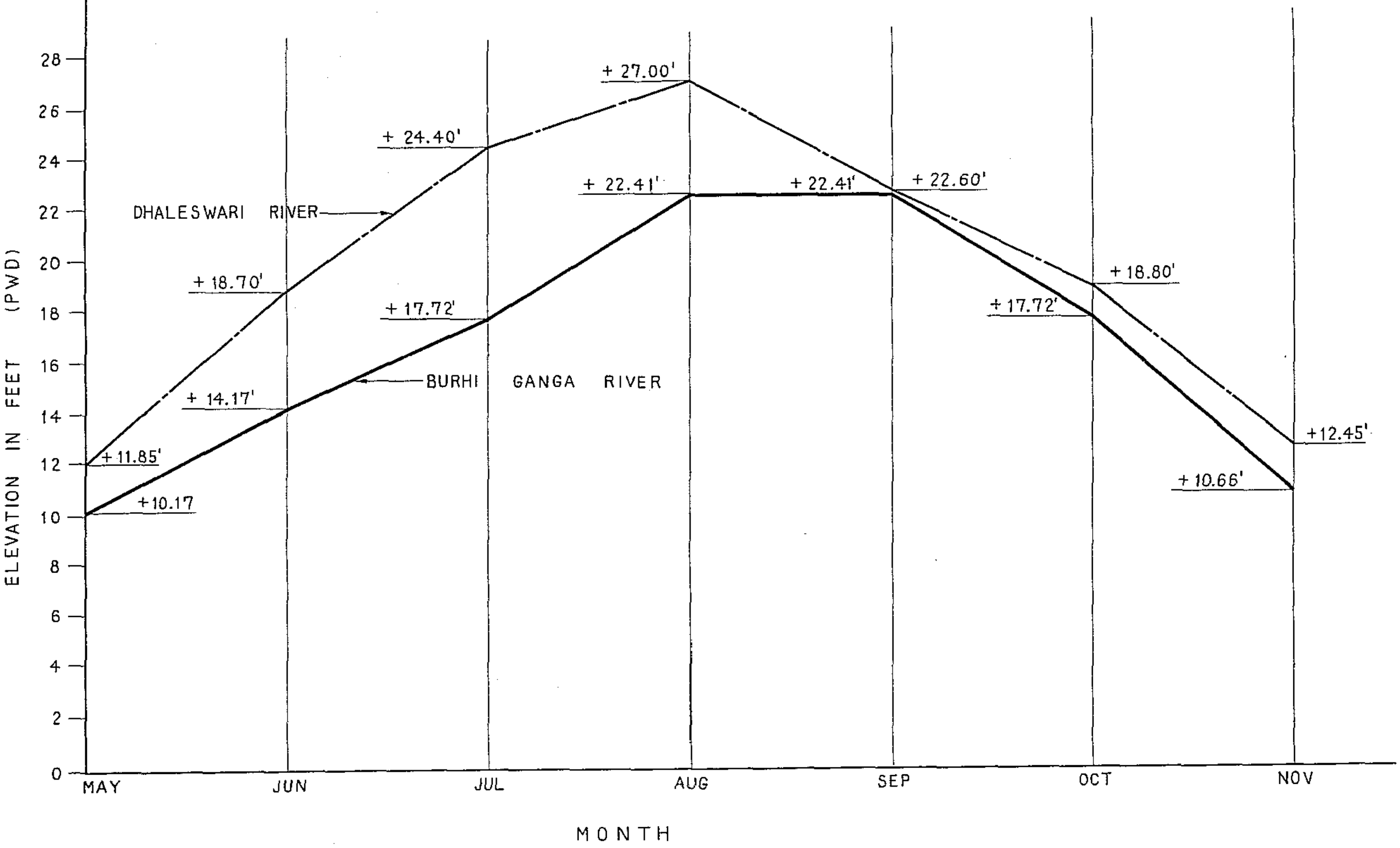
Tabulation of Highest Water Level and Lowest Water Level of Burhiganga River in Dacca By Year

From 1909 To 1964

on P. W. D. Level

Year	Highest Water Level		Lowest Water Level	
	Date	Water Level(ft.)	Date	Water Level (ft.)
1909	Sept. 5	19.35	Feb. 7	2.93
1910	Aug. 9	21.35	Feb. 3 - 4	3.53
1911	July 31, Aug. 1	19.95	March 25	2.75
1912	Aug. 31	18.65	Feb. 14	2.85
1913	Oct. 2 - 3	14.39	Feb. 10-11	2.85
1914	Aug. 26	17.79	March 5 - 6	2.09
1915	Aug. 31	21.19	Feb. 22	1.79
1916	Aug. 15 - 19	19.59	Feb. 15	2.09
1917	-	-	Feb. 3 - 4, 17, Mar. 3	2.49
1918	Sept. 1	20.64	Feb. 7	2.89
1919	Aug. 2	18.29	Jan. 30	1.59
1920	Sept. 16 - 17	18.19	Feb. 16	2.39
1921	July 28	19.89	Feb. 19	2.39
1922	Aug. 10	19.49	Jan. 31	2.49
1923	July 31	17.64	March 14	2.89
1924	Aug. 28 - 29	20.31	Feb. 14	1.57
1925	Sept. 8	20.01	March 5	2.39
1926	Aug. 15	19.60	Feb. 9	2.20
1927	Sept. 17	18.70	Feb. 27, Mar. 12 - 13	2.10
1928	Aug. 22	20.00	Feb. 16	2.20
1929	July 13	17.80	Feb. 21	2.00
1930	Sept. 12	18.65	Feb. 24	2.30
1931	Aug. 22	21.80	Feb. 28	2.20
1932	July 13 - 14	16.85	Feb. 18	1.80
1933	Sept. 7	17.80	Feb. 6	2.10
1934	Aug. 18	19.45	Mar. 26	2.40
1935	Sept. 1	19.80	Feb. 15	1.70
1936	Aug. 20 - 21	19.35	Mar. 3	1.90
1937	Sept. 7 - 9	18.30	Feb. 7	2.70
1938	Aug. 2	21.00	Feb. 25 - 26	2.40
1939	Aug. 3	19.10	Mar. 1	2.40
1940	Aug. 9	17.25	Jan. 20	2.00
1941	Sept. 10	17.70	Mar. 8	2.10
1942	Sept. 1	18.00	Feb. 11	2.60
1943	July 19 - 20	17.75	Feb. 15, Mar. 17	2.60
1944	Sept. 22 - 24	16.80	Mar. 4 - 5	2.30
1945	Aug. 19 - 20, 27	19.80	Mar. 10	2.70
1946	Aug. 1	19.90	Feb. 26	2.00
1947	Aug. 4 - 5	18.60	Feb. 16	1.90
1948	Aug. 11	20.70	Mar. 4 - 5	2.10
1949	Aug. 30, Sep. 1-2	19.70	Feb. 9, Mar. 10-11, 24	-2.20
1950	Sept. 2	18.90	Feb. 27	1.70
1951	July 31	19.50	Feb. 18	2.45
1952	Sept. 10-11	18.00	Apr. 5 - 6	1.70
1953	Aug. 5, Sep. 27	18.70	Jan. 26	1.90
1954	Sept. 2 - 3	23.15	Feb. 27	2.20
1955	Aug. 18, 20-21	23.25	Feb. 17	2.30
1956	July 3 - 4	18.65	Feb. 7 - 8	1.00
1957	Aug. 17	17.60	Mar. 12, 27 - 28	1.20
1958	Sept. 2	21.15	Feb. 1-2	1.10
1959	Aug. 23, 25	18.95	Feb. 19	2.40
1960	Sept. 25	20.00	Apr. 7	1.60
1961	Sept. 2	18.10	Feb. 11	1.60
1962	Aug. 31	22.15	Mar. 15 - 16	2.51
1963	-	-	Feb. 20	2.28
1964	Aug. 12	21.66	-	-

HIGH WATER LEVEL OF RIVERS



SECTION 2. LAND RECLAMATION

I. Standard Design Elements.

(1) Planned flood level and low water level.

As we stated in the chapter II for flood control, the following factors should be considered for determining the high and low water levels.

The Burhiganga river at Dacca station:-

HWL + 23'.25 (+7m087)(PWD) 18.20 $^{\xi}$ 21-8-(1955)
LWL + 1'.60 (+0m488)(") 9-3-(1964)

The Dhaleswari river at Sabhar station:-

HWL + 27'.0 (+8m260) (PWD) 10-8-(1955)
LWL + 2'.70 (+0m823) (") 12-2-(1950)

(2) The basic amount of rainfall.

In order to determine the capacity of mechanical drainage, the basic amount of the rainfall is taken such volume for the maximum as will be discharge within a lapse of 24 hours.

The maximum rainfall per day in the past: 8.08 in./day (205.7 mm./day)

Average rainfall per hour r = 9 mm./hr. (0.354 in./hr.)

(3) Formula on storm discharge.

$$Q = \frac{1}{3.6} frA$$

$Q = m^3/sec.$ Discharge
$f = 1$ Run off coefficient
$r = 9mm/hr.$ Hourly intensity of rainfall
$A = Km^2$ (Catchment area)

$Q = 2.5 m^3/sec./km^2 = 0.36$ cusecs/acre

(4) The interrelations between the outer and inner drainages.

Hourly rainfall curve recorded in the day of the maximum rainfall.

The biggest amount of daily rainfall was recorded on June 25th, 1954 at Narayangaji which indicated a figure of 8.08 inches per day (205.7 mm per day). This record, however, does not contain the amount of rainfall per hour and, it has been converted on terms of the rainfall per hour on the basis of the records of the rainfall on August 3rd and 4th, 1958, which indicated the figure of 181.4 mm per 24 hours.

Aug., 1958.	Modified Amount	1st stage of scheme 'A'			1st stage of scheme 'B'		
		Q (m^3/sec)	Rainfall (m^3/hr)	Aggregate amount of rainfall (Ton)	Q (m^3/sec)	Rainfall (m^3/hr)	Aggregate amount of rainfall (Ton)
Mar. 22	7.1mm	12.8	46,100	46,100	46.7	168,000	168,000
23	5.8	10.5	37,800	83,900	38.2	137,500	305,500
24	0.4	0.7	2,500	86,400	2.6	9,400	314,900
Apr. 1	0.4	0.7	2,500	88,900	2.6	9,400	324,300
2							
3	44.2	79.8	288,000	376,900	291.0	1,048,000	1,372,300
4	18.0	32.5	117,000	493,900	118.5	427,000	1,799,300
5	40.0	72.2	260,000	753,900	263.5	948,000	2,747,300
6	12.3	22.2	79,900	833,800	81.0	291,500	3,038,800
7	5.2	9.4	33,800	867,600	34.2	123,000	3,161,800
8	1.1	2.0	7,200	874,800	7.2	25,900	3,187,700
9	0.4	0.7	2,500	877,300	2.6	9,400	3,197,100
10							
11							
12							
13							
14	15.8	10.5	37,800	915,100	38.2	137,500	3,334,600
15	6.9	12.5	45,000	960,100	45.4	163,400	3,498,000
16	20.2	36.5	132,200	1,092,300	133.0	478,700	3,976,700
17	32.4	58.5	212,000	1,304,300	213.5	768,000	4,744,700
18							
19	2.0	3.6	13,000	1,317,300	13.2	47,500	4,792,200
20	0.9	1.6	5,800	1,323,100	5.9	21,200	4,813,400
21	2.6	4.7	16,900	1,340,000	17.2	61,900	4,875,300
For day	205.7mm	371.4	1,340,000		1,354.5	4,875,300	

1st stage of scheme 'A' : $Q_{A1} = \frac{1}{3.6} x 1 x \gamma^{mm/hr} x 6.5^{km^2} = 1.81^{m^3/sec.}$

2nd stage of scheme 'B' : $Q_{B1} = \frac{1}{3.6} x 1 x \gamma^{mm/hr} x 23.7^{km^2} = 6.58^{m^3/sec.}$

Dacca District, Annual Record of Max. Daily Rainfall

	DACCA		NARAYANGANJ	
	Daily Max. Rainfall in	Date	Daily Max. Rainfall in	Date
47	6.32	Oct. 13	5.33	May 23
48	2.96	May 26	4.17	June 19
49	3.21	July 22	4.33	Mar. 21
50	6.64	Aug. 2	7.20	Aug. 2
51	4.10	Aug. 27	5.86	June 15
52	2.90	May 22	3.27	Aug. 27
53	3.07	Aug. 20	4.34	Aug. 19
54	3.05	June 25	8.08	June 25
55	3.00	July 4	3.40	May 1
56	3.85	July 13	5.86	Apr. 26
57	2.94	June 30	2.44	June 30
58	Report not received		3.22	May 20
59	3.52	Oct. 2	5.29	Aug. 17
60	4.06	July 10	6.29	June 10
61	6.05	May 10	7.60	May 10

Monthly and Annual Rainfall in Dacca 1900 - 1964

These data have quoted from East Pakistan
Water and Power Development Authority
Hydrology Directorate, Dacca, 1960

ST.: - Dacca District - Dacca Inch

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total (Year)
1900-01	-	-	-	-	-	-	-	-	-	-	-	-	-
1902	-	-	2.82	21.01	12.60	18.53	8.05	10.02	11.58	0.87	0.03	0.04	-
1903	0.05	3.04	2.09	0.24	4.81	16.07	5.86	12.32	15.03	4.31	0.48	-	-
1904	-	1.28	0.39	4.04	9.07	5.39	9.97	9.08	8.33	6.10	1.41	0.06	-
1905	0.21	1.09	4.16	11.33	12.80	4.99	20.72	11.20	18.10	10.31	-	0.48	-
1906	0.42	2.68	4.36	0.66	12.80	10.45	14.58	17.58	17.75	2.65	0.23	0.00	84.17
1907	0.52	0.37	2.86	7.18	7.55	13.61	16.06	7.23	5.70	2.91	0.00	0.64	64.63
1908	0.94	0.05	0.91	2.62	15.82	12.92	20.98	7.87	3.90	1.20	0.23	0.00	67.44
1909	0.14	0.15	0.07	7.26	7.80	16.80	11.71	24.16	4.09	12.76	0.87	0.60	46.41
1910	0.22	0.02	1.11	5.75	10.56	15.24	17.24	14.68	10.50	12.54	0.00	0.00	87.88
1911	-	-	-	-	-	-	-	-	-	-	-	-	-
1912	-	-	-	-	-	23.40	-	-	-	-	-	-	88.19
1913	-	-	-	-	-	22.94	-	25.72	-	-	-	-	-
1914	-	-	-	-	-	-	15.67	-	-	-	-	-	72.41
1915	-	-	-	-	-	24.49	-	-	-	-	-	-	87.40
1916	-	-	-	-	-	-	-	-	-	-	-	-	-
1917	-	-	-	-	-	-	19.84	-	-	-	-	-	70.61
1918	-	-	-	-	-	-	-	18.87	-	-	-	-	77.49
1919	-	-	-	-	-	-	-	-	22.53	-	-	-	-
1920	2.5 0.10	82.3 3.24	240.0 9.45	113.0 4.45	254.8 10.03	416.7 15.62	366.8 14.44	417.6 16.44	480.8 18.93	278.9 10.98	0.00	0.00	2633.5 103.68 in
1921	-	-	-	-	-	16.27	-	-	-	-	-	-	74.20
1922	-	-	-	-	-	18.50	-	19.27	-	-	-	-	73.74
1923	-	-	-	-	-	-	-	15.65	-	-	-	-	58.78
1924	-	-	-	-	11.77	-	-	-	-	-	-	-	55.25
1925	-	-	-	-	-	11.73	-	-	-	-	-	-	65.02
1926	-	-	-	-	-	-	-	-	22.10	-	-	-	77.51
1927	-	-	-	-	11.77	-	-	-	-	-	-	-	55.25
1928	-	-	-	-	-	-	-	15.29	-	-	-	-	76.56
1929	-	-	-	-	-	-	-	12.26	-	-	-	-	59.47
1930	-	-	-	-	-	-	19.30	-	-	-	-	-	80.83
1931	-	-	-	-	-	-	15.12	-	-	-	-	-	77.73
1932	-	-	-	-	-	-	-	-	-	-	-	-	-
1933	-	-	-	-	-	-	-	19.29	-	-	-	-	78.05
1934	-	-	-	-	-	30.26	-	-	-	-	-	-	85.69
1935	-	-	-	-	-	14.76	-	-	-	-	-	-	47.13
1936	-	-	-	-	-	-	13.97	-	-	-	-	-	69.57
1937	-	-	-	-	-	-	-	22.56	-	-	-	-	69.12
1938	-	-	-	-	-	-	-	17.86	-	-	-	-	87.11
1939	-	-	-	-	-	-	25.79	-	-	-	-	-	82.53
1940	-	-	-	-	-	16.46	-	-	-	-	-	-	63.26
1941	-	-	-	-	-	22.11	-	-	-	-	-	-	85.30
1942	-	-	-	-	-	-	-	17.67	-	-	-	-	62.13
1943	-	-	-	-	-	18.03	18.04	-	-	-	-	-	74.72
1944	-	-	-	-	-	-	-	13.46	-	-	-	-	-
1945	-	-	-	-	-	17.70	-	-	-	-	-	-	68.36
1946	-	-	-	-	13.26	-	-	-	-	-	-	-	81.18
1947	-	-	-	-	-	-	-	19.33	-	-	-	-	-
1948	-	-	-	-	10.09	-	-	-	-	-	-	-	-
1949	0.03	0.07	3.39	15.89	14.55	8.94	9.33	14.24	8.47	5.47	0.00	0.00	80.38
1950	0.00	1.66	0.00	0.87	6.51	19.35	3.46	24.20	4.09	3.03	5.44	0.00	68.61
1951	0.00	0.00	2.97	4.92	6.45	26.32	11.37	27.75	7.56	11.08	2.59	0.00	101.01
1952	0.00	0.00	2.55	8.61	15.16	11.66	13.43	7.11	11.63	3.08	2.45	0.00	75.68
1953	0.34	0.25	3.63	2.84	8.64	15.36	15.84	14.53	12.81	1.39	0.35	0.00	75.98
1954	0.55	0.75	0.03	5.08	6.15	22.29	10.36	12.99	6.69	8.21	0.00	0.28	73.38
1955	0.00	0.00	2.36	7.39	7.98	8.02	14.32	9.84	0.00	0.00	0.20	0.00	50.11
1956	-	-	-	-	-	14.85	-	-	-	-	-	-	-
1957	-	-	-	-	-	15.57	15.98	-	-	-	-	-	-
1958	-	-	-	-	-	-	-	-	-	-	-	-	-
1959	-	-	-	-	-	-	-	-	-	16.70	-	-	-
1960	-	-	-	-	-	-	-	-	-	-	-	-	-
1961	-	-	-	-	-	-	-	-	-	-	-	-	-
1962	-	-	-	-	-	-	-	-	-	-	-	-	-
1963	-	-	-	-	-	-	-	-	-	-	-	-	-
1964	0.49	1.99	0.84	13.40	10.01	13.14	26.50	6.70	9.42	11.24	-	-	-

(20.65)

ST:- Sreepur

* 1) Max. Rainfall in 24 hours, 1964 7.20 inch
2) For the period between 1912 and 1948, the maximum daily rainfalls.

Hourly Rainfall for Dacca

(1957 - 1960)

Figures picked up for the hourly rainfall of more than 1 inch in the same data as quoted previously.

Year	Month & day	Hourly rainfall (inch)	For day rainfall (inch)
1957	Apr. 24	1.05	1.17
	Jun. 16	1.20	1.72
	Jun. 19	1.48	1.89
	Jun. 30	1.14	2.75
	Sep. 25	1.13	2.59
1958	Jul. 7	1.85	1.95
	Aug. 4	1.53	6.68
		1.39	
		1.13	
	Oct. 13	1.60	2.88
1959	Jun. 2	1.08	1.42
	Jun. 28	1.12	1.17
	Jul. 7	1.23	1.80
	Aug. 24	1.27	1.44
	Sep. 18	1.26	3.25
	Sep. 22 3	2.00	2.24
1960	Apr. 11	1.07	1.95
	May 19	1.77	1.94
	May 20 2	2.62	3.56
	May 22	1.63	3.36
	Jun. 9	1.46	2.89
	Jun. 16	1.40	1.50
	Jun. 17	1.11	1.51
	Jul. 9	1.43	5.21
	Jul. 18	1.18	2.98
	Sep. 16 1	2.84	3.13

(5) The structure of embankment.

5-1. The crest of the embankment is well protected against the maximum flood level estimated in this scheme, but when the final design is to be drawn, cares should also be taken to minimise any possible damage against any flood level which *might exceed the level* estimated by this scheme.

5-2. The surface of the embankment should be coated with concrete both on the levee crest and the back slope. Cares should also be given to the slope coefficient as well as to the scouring resistance.

5-3. Once the construction work has been commenced, necessary protectional steps should be taken for the old river and reservoir portions where a settlement is likely to occur.

Maximum Continuous Rainfall per Hour
(1957-1960)

by E. P. W. A. P. D. A. Water Supply Paper - 19
East Pakistan
Water & Power Development Authority
Hydrology Directorate, Dacca.

Year	1958		1959	1960				
Month	Aug.		Oct.	May		July		Sep.
Day	3	4	2	20	22	9	10	16
1	-	0.3	-	-	-	-	3.0	72.1
2	-	-	0.5	-	-	-	1.8	2.8
3	-	38.9	-	-	4.1	-	3.8	2.8
4	-	15.8	-	-	4.6	-	-	1.3
5	-	35.3	4.1	-	1.0	-	-	0.5
6	-	10.9	2.5	-	2.5	-	-	-
7	-	4.6	7.6	-	4.1	-	-	-
8	-	1.0	3.6	-	24.9	-	-	-
9	-	0.3	1.0	-	41.4	-	-	-
10	-	-	6.6	-	1.8	-	-	-
11	-	-	2.5	66.5	-	-	-	-
12	-	-	5.1	0.3	-	-	-	-
13	-	-	9.7	0.8	-	-	-	-
14	-	5.1	6.1	-	-	-	-	-
15	-	6.1	4.6	-	-	-	-	-
16	-	17.8	10.2	-	-	6.4	-	-
17	-	28.7	12.7	-	-	5.6	-	-
18	-	-	7.6	-	-	2.3	-	-
19	-	1.8	18.3	-	-	0.5	-	-
20	-	0.8	1.0	-	-	0.3	-	-
21	-	2.3	4.6	-	-	36.3	-	-
22	6.3	-	2.0	-	-	21.1	-	-
23	5.1	-	-	-	-	12.4	-	-
24	0.3	-	-	-	-	7.9	-	-
Total for day	175.4			67.6		101.4		79.5

II. Design Elements of Scheme 'A'.

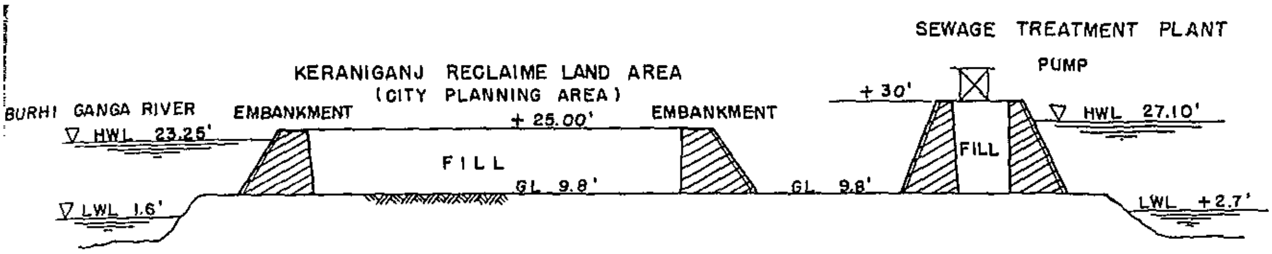
(1) Design elevation of embankment and reclamation.

EL + 25'00 (7.620 m) (PWD)

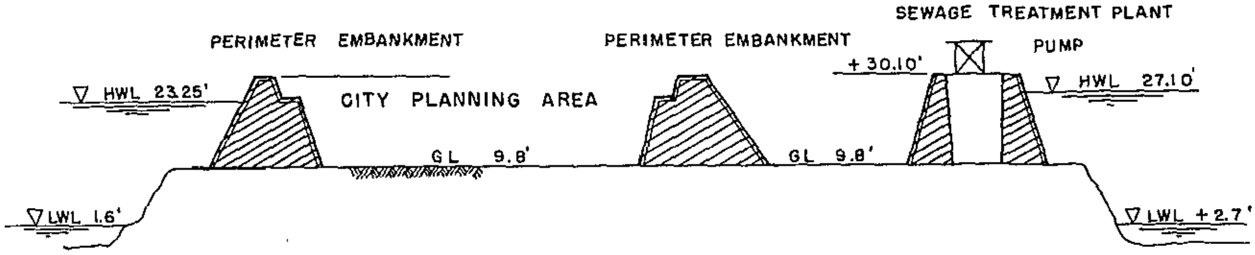
Note: Since the water level is higher on the side of Dhaleswari river than on the Burhiganga river, the secondary raising of embankment of 5'00 should be necessitated. Namely, the embankment height should be made:

EL = 25' + 5' = 30'00 (+9.144 m)

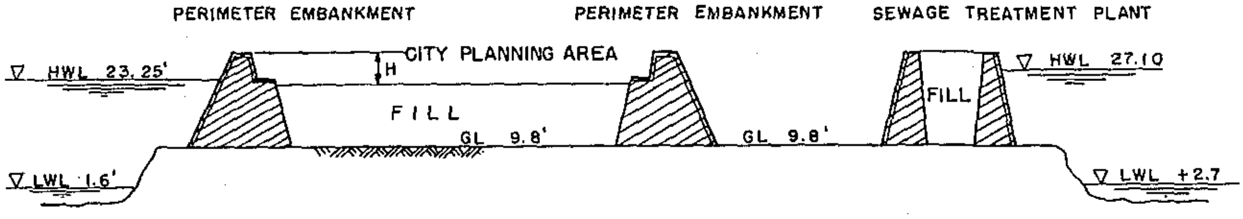
(See Fig-LR-1.)



SCHEME "A"



SCHEME "B"



SCHEME "C"

FIG-LR-1

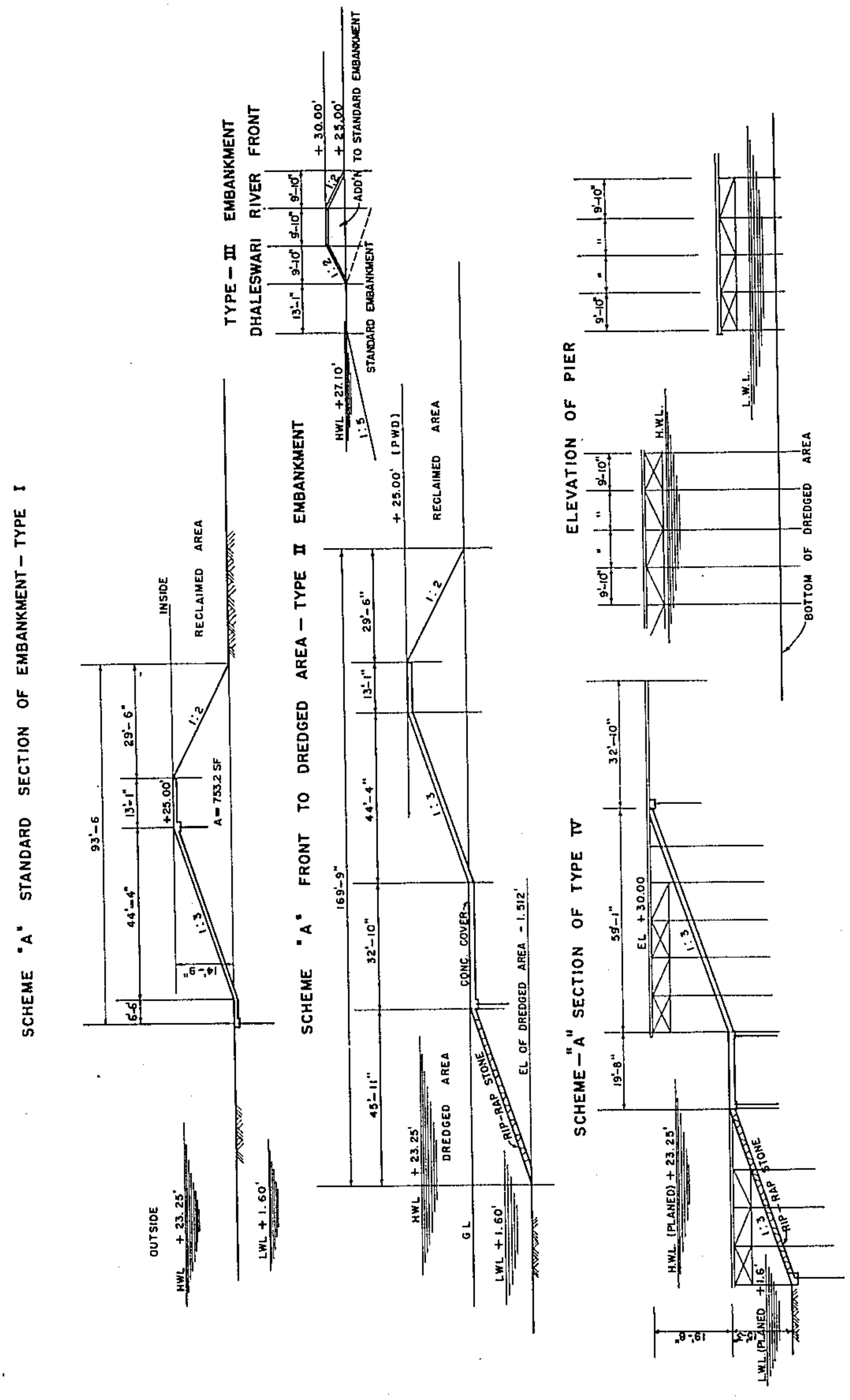

SCHEME "A" STANDARD SECTION OF EMBANKMENT – TYPE I
93'-6
6'-6"
14'-9"
44'-4"
13'-1"
29'-6"
+25.00'
A= 753.2 SF
1:3
1:2
INSIDE
RECLAIMED AREA
OUTSIDE
HWL + 23.25'
LWL + 1.60'
SCHEME "A" FRONT TO DREDGED AREA – TYPE II EMBANKMENT
169'-9"
45'-11"
32'-10"
44'-4"
13'-1"
29'-6"
1:3
1:2
+ 25.00' (PWD)
RECLAIMED AREA
CONC. COVER
RIP-RAP STONE
EL OF DREDGED AREA - 1.512'
HWL + 23.25'
DREDGED AREA
G L
LWL + 1.60'
TYPE – III EMBANKMENT
DHALESWARI RIVER FRONT
13'-1"
9'-10"
9'-10"
9'-10"
1:2
1:2
+ 30.00'
+ 25.00'
ADD'N TO STANDARD EMBANKMENT
STANDARD EMBANKMENT
HWL +27.10'
1:5
ELEVATION OF PIER
9'-10"
"
"
9'-10"
H.W.L.
L.W.L.
BOTTOM OF DREDGED AREA
SCHEME "A" SECTION OF TYPE IV
19'-8"
59'-1"
32'-10"
EL +30.00
1:3
1:3
RIP-RAP STONE
H.W.L. (PLANED) + 23.25'
L.W.L. (PLANED) +1.6'
19'-8"

FIG-LR-2

(2) Sectional type of embankment.

(See Fig-LR-2)

As seen in the drawing of Scheme 'A', the concrete coverage should be deposited only for the water front and crest, but the core of water block wall would not be constructed. The slope is to be 1 : 3.

2-1. Type I embankment.

This type of embankment would be constructed along the Burhiganga river, excluded the catchment along the heavy industrial zone.

2-2. Type II embankment.

This type of embankment should be constructed along the Dhaleswari river.

2-3. Type III - IV embankment.

These are meant for construction along the heavy industrial zone and retarding basin.

Type type IV is up for the pier construction.

(3) Extension of embankment.

(See Fig-LR-3)

1st stage.

Town area		
Type I	EL 25'-00	L = 9,300 yd.
Type II	EL 30'-00	L = 8,750 yd.
Type III	EL 25'-00	L = 2,660 yd.
Sewerage treatment plant		
Type II	EL 30'-00	L = 4,260 yd.
Water treatment plant		
Type II	EL 30'-00	L = 2,950 yd.
	Total :	L= 27,920 yd.

2nd stage.

Town area		
Type I	EL 25'-00	L = 6,380 yd.
Type II	EL 30'-00	L= 24,500 yd.
Type III	EL 25'-00	L= 29,000 yd.
Type IV (for pier)	EL 25'-00	L= 2,190 yd. (estimated length)
	Total :	L= 62,070 yd.

PLAN FOR LAND RECLAMATION SCHEME "A"

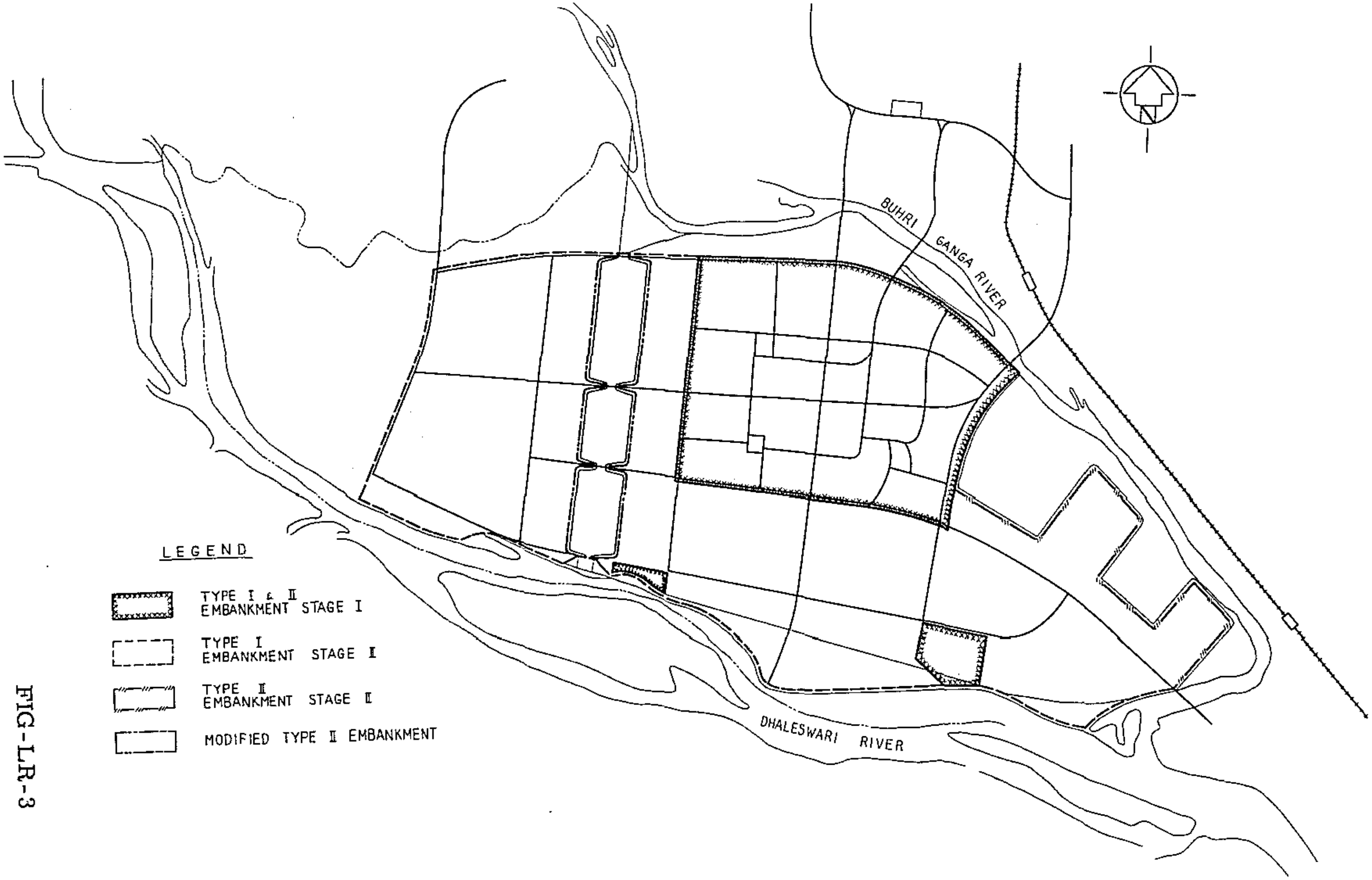


FIG-LR-3

(4) Reclamation area and quantity of fill.

		Reclamation area sy	Quantity of fill cy	cy/sy
1st stage	Urban area	EL 25'-00 25,590,000	120,500,000	4.7
	Sewerage treatment plant	EL 30'-00 1,122,000	7,450,000	6.7
	Water treatment plant	EL 25'-00 275,000	1,970,000	7.15
	Sub-total :	26,987,000	129,920,000	
2nd stage	Urban area	EL 25'-00 62,600,000	299,000,000	4.8
	Reservoir (Water control basin)	(3,600,000)	0	
	Sub-total :	62,600,000	299,000,000	
Total :		89,587,000	428,920,000	

(5) Drainage system.

5-1. All drains will consist of culverts and the sewerage will utilize a separate system.

5-2. The main sewerage plan is shown as in Fig-LR-4.

5-3. In the first stage, the drainage from the area 1 - 7 should be positively drained by natural flow into the Burhiganga river, and only those from the area 8 - 12 should be drained into the sewerage treatment plant to drain mechanically. In this case, Q = 16.3 m^3/sec, Head = 16.00 m

5-4. The other plan for the drainage from the area 8 - 12 would be likely that natural effluents would be drained out of the embankment at the points of C_8 - C_{12}, and that all drainage including those from the second stage area would be drained in the natural stream bed system. However, it is not accepted in this planning.

(6) Flow velocity in drain pipe.

According to Kutter formula, the surface slope should be all 0.5%.

(7) Length of drain pipe and storm drainage.

Length : 36,800 m 4,050 yd.
Drainage : 59 m^3/sec 2,080 cft/sec

(8) Estimating of appurtenant work cost.

The construction cost for the appurtenant works to the main sewers such as man holes, branch pipe lines and gullies would be calculated by using a factor of individual coefficients based on the established examples of sewage works.

SCHEME "A" STORM DRAINAGE SYSTEM – STAGE – I

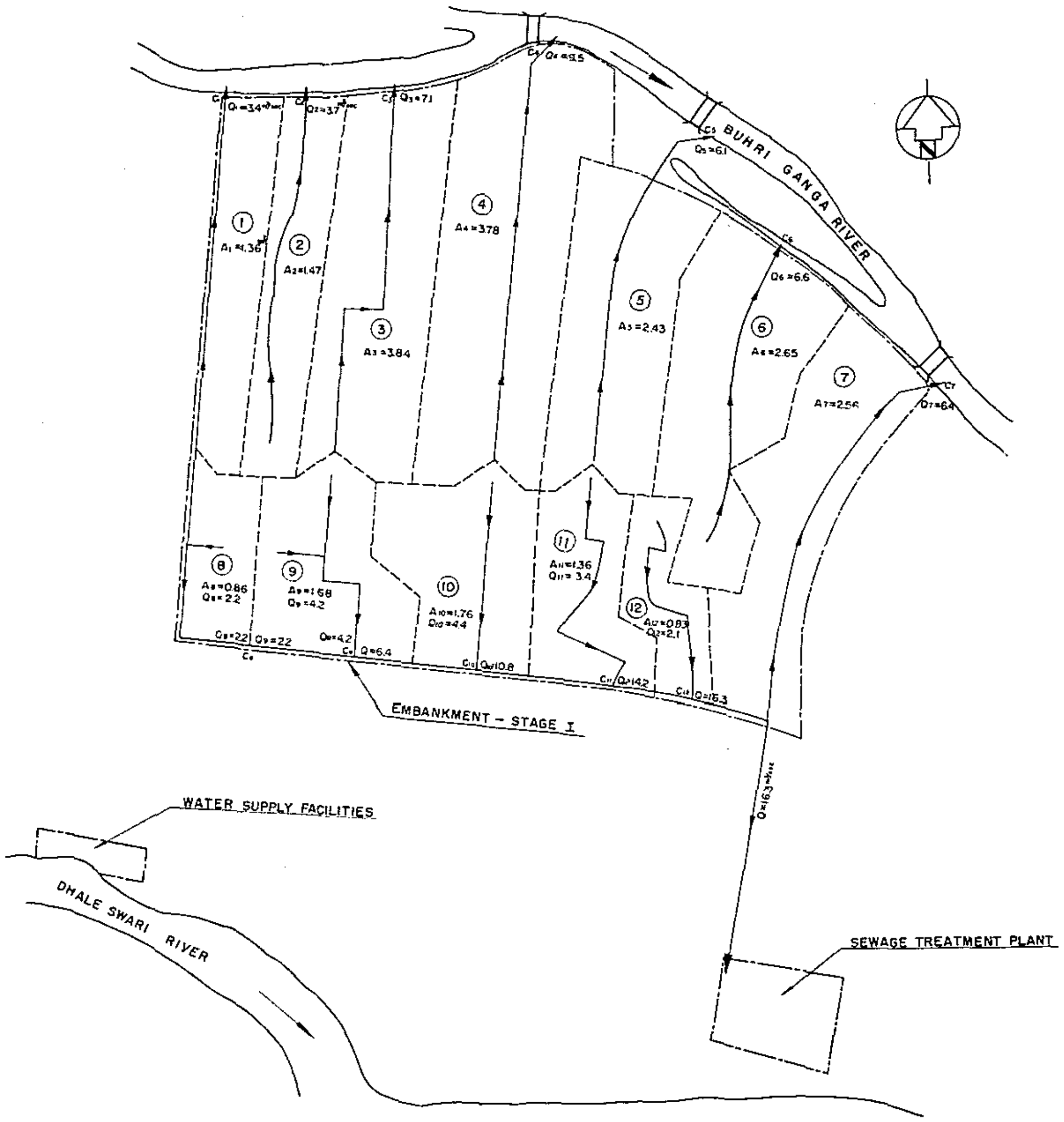


FIG-LR-4

III. Design Elements of Scheme 'B'.

(1) Design height of embankment crest.

Both Burhiganga river side and Dhaleswari side are 30'-00 (PWD) = 9.144m

(2) Sectional type of embankment.

(See Fig-LR-5.)

The sectional type of embankment in Scheme 'B' is that all is covered by concrete for both inner and outer slopes and for the crest. The core of the embankment will be of a creyey water block wall with sheet piles driven.

Flood might bring about the serious consequences upon the sewerage treatment plant and water treatment plant so the inside of the embankment should be all reclaimed up to the height of +30'-00.

(3) Length of embankment and reclamation area.

(See Fig-LR-6.)

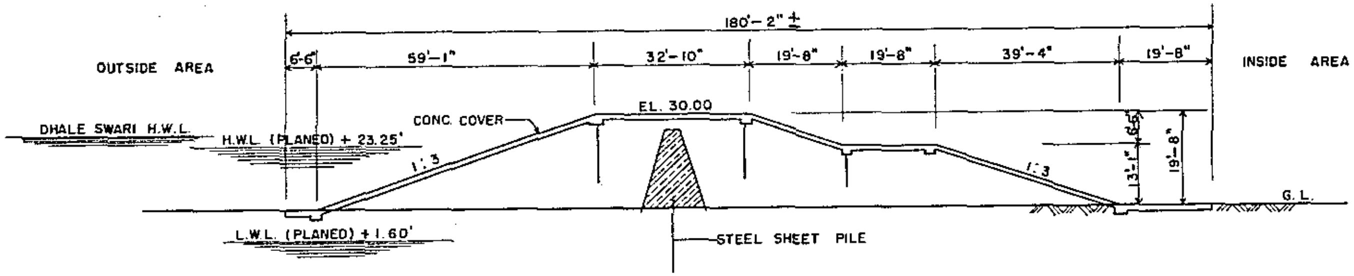
1st stage.

Type I	embankment	EL + 30'-00	Town area	21,420 yd.
Type II	embankment	EL + 30'-00	Heavy industrial zone & port area	2,880 yd.
Type III	embankment	EL + 30'-00	Water treatment plant & sewerage treatment plant	7,900 yd.
			Total :	32,200 yd.

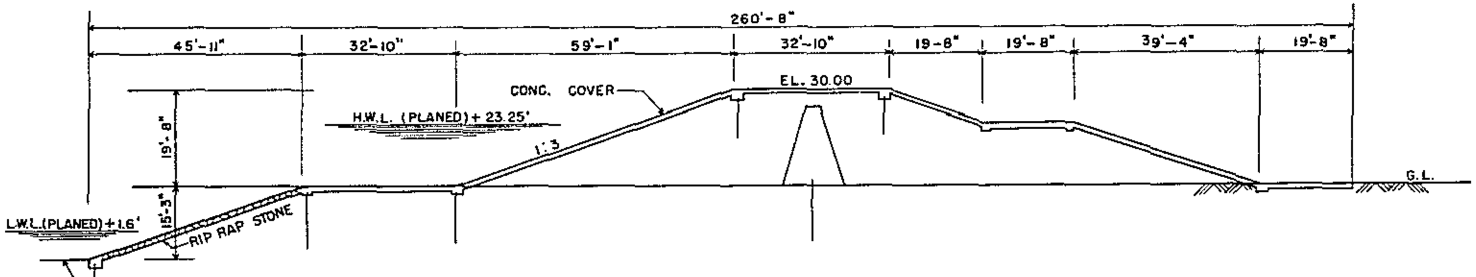
2nd stage.

Type I	embankment	EL + 30'-00		30,000 yd.
Type II	embankment	EL + 30'-00	Heavy industrial zone & port area	12,600 yd.
Type III	embankment	EL + 9'-72	West-side water control basin	18,500 yd.
Type I	embankment	EL + 25'-00	Heavy industrial zone & port area	2,150 yd.
Type IV	(Pier)	EL + 30'-00	Port area	2,400 yd.
			Total :	65,650 yd.

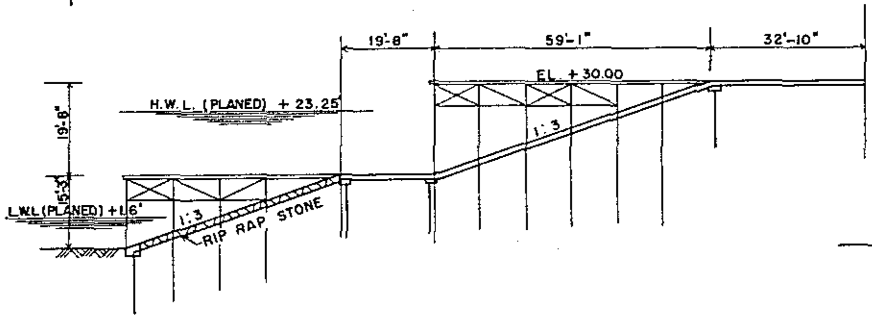
SCHEME- B STANDARD SECTION OF EMBANKMENT



SCHEME - B SECTION OF TYPE III - DREDGED AREA



SCHEME-B SECTION OF TYPE IV



ELEVATION OF PIER

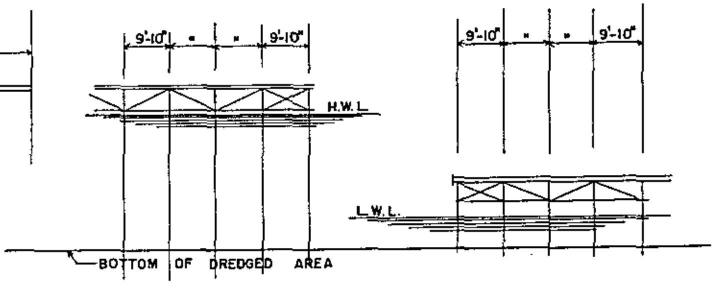


FIG-LR-5

PLAN FOR LAND RECLAMATION SCHEME "B"

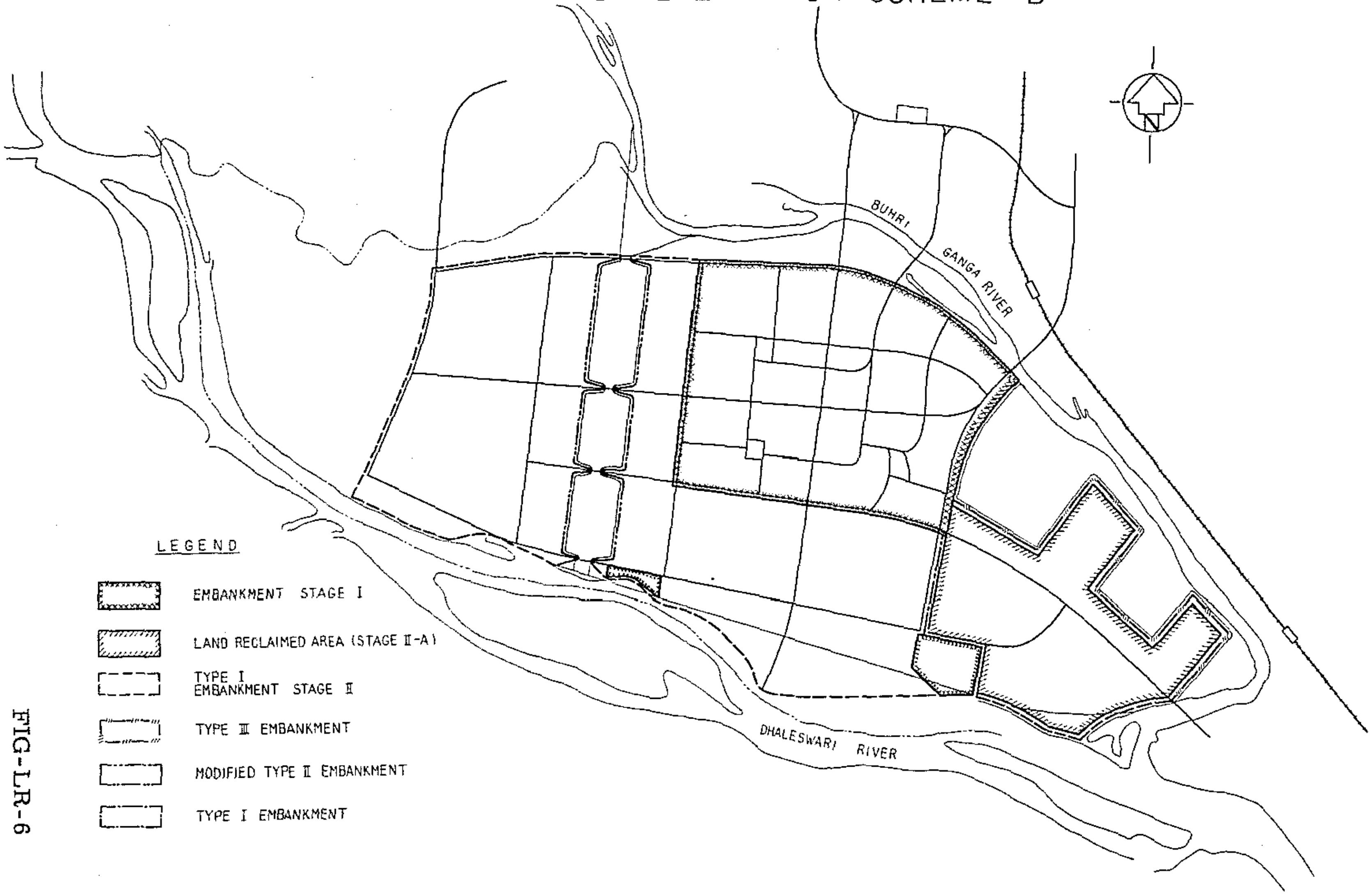


FIG-LR-6

(4) Reclamation area and quantity of fill.

		Reclamation area sy		Quantity of fill cy	cy/sy
1st stage	Town area	EL 9'-72	28,400,000	0	
	Sewerage treatment plant	EL 30'-00	1,121,000	5,050,000	4.5
	Water treatment plant	EL 30'-00	274,000	1,315,000	4.8
	Sub-total :		29,795,000	6,365,000	
2nd stage	Urban area		62,800,000	EL 15'-7 28,800,000 (Heavy industrial zone only)	
	Park (flood control basin)		(3,600,000)		
	Sub-total :		62,800,000	28,800,000	
Total :			92,595,000	35,165,000	

All the present little streams, moats and ponds are in principle to be reclaimed, and all the drainage will be discharged in the drain pipe system. Therefore, there is no need of giving any special treatment to the flow of little streams and the outer soil embankment.

(5) Basic idea for storm sewerage draining plan.

The ground level, where not reclaimed, is for the most part about GL: +9'-72 (+3.002 m) PWD. Even using 0.3% for the draining slope, the drainage is not so easy and the positive drainage would hardly be expected, as detailed in Fig-LR-7.

Considering the first stage area only, there should be installed a pumping plant at least somewhere around the central place. The final disposal of the sewerage treatment plant effluent should be all carried out mechanically. (See Fig-LR-8.)

The drainage capacity is as follows:-

1st stage

Intermediate pumping plant around C_5:

$Q = 2.5\ m^3/sec \times 13.7\ km^2 = 34\ m^3/sec$

Head = 12.00 m

Terminal storm drain pumping plant:

$Q = 2.5\ m^3/sec \times 23.7\ km^2 = 59\ m^3/sec$

Head = 21.00 m

2nd stage

Intermediate pumping plant required at 3 or 4 places.

Terminal storm drain pumping station:

$Q = 2.5\ m^3/sec \times 56.7\ km^2 = 142\ m^2/sec$

Head = 21.00 m

Such capacities as stated above must be taken up for the objectives of study.

SCHEME "B" STORM DRAINAGE SYSTEM - STAGE - I

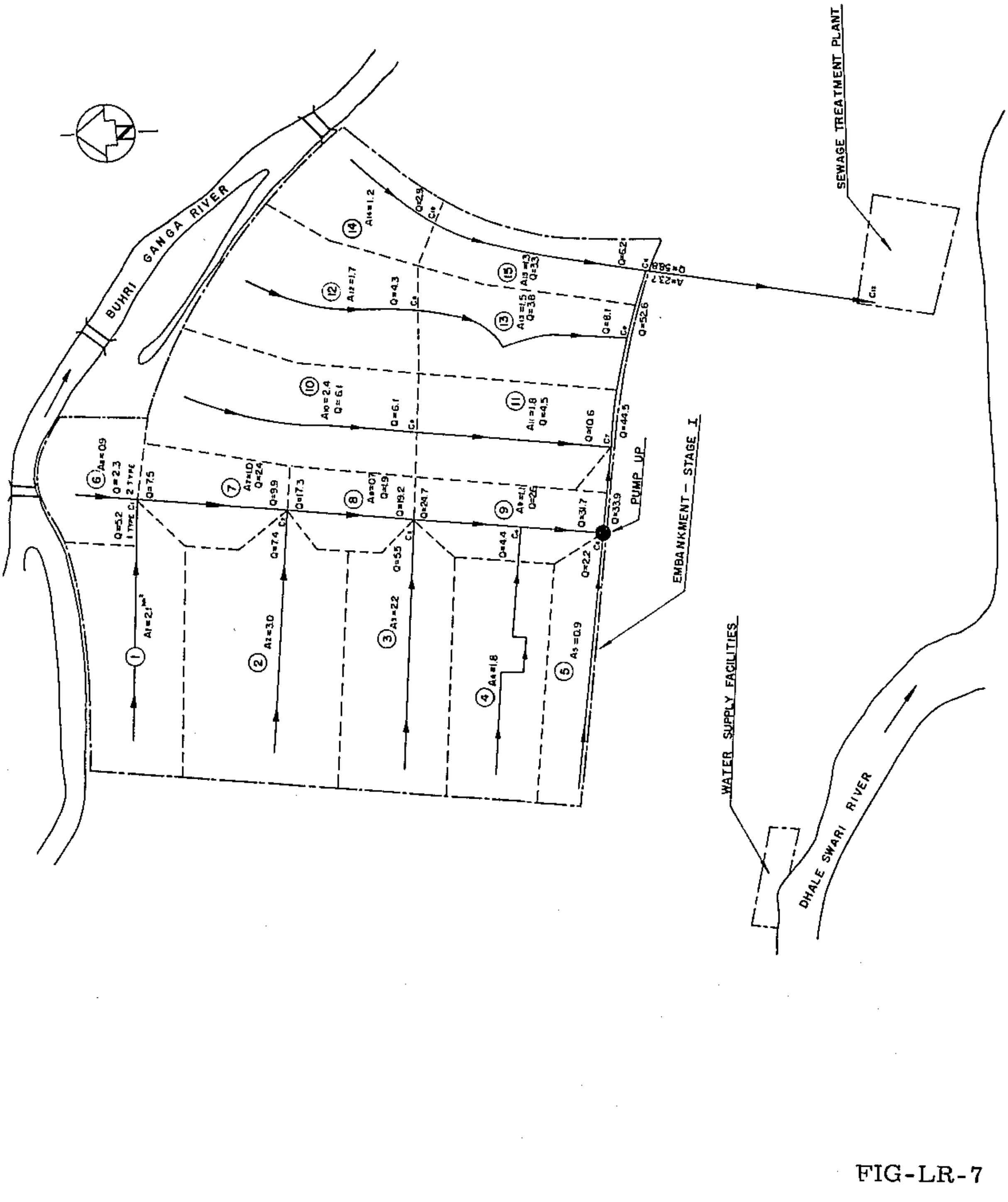
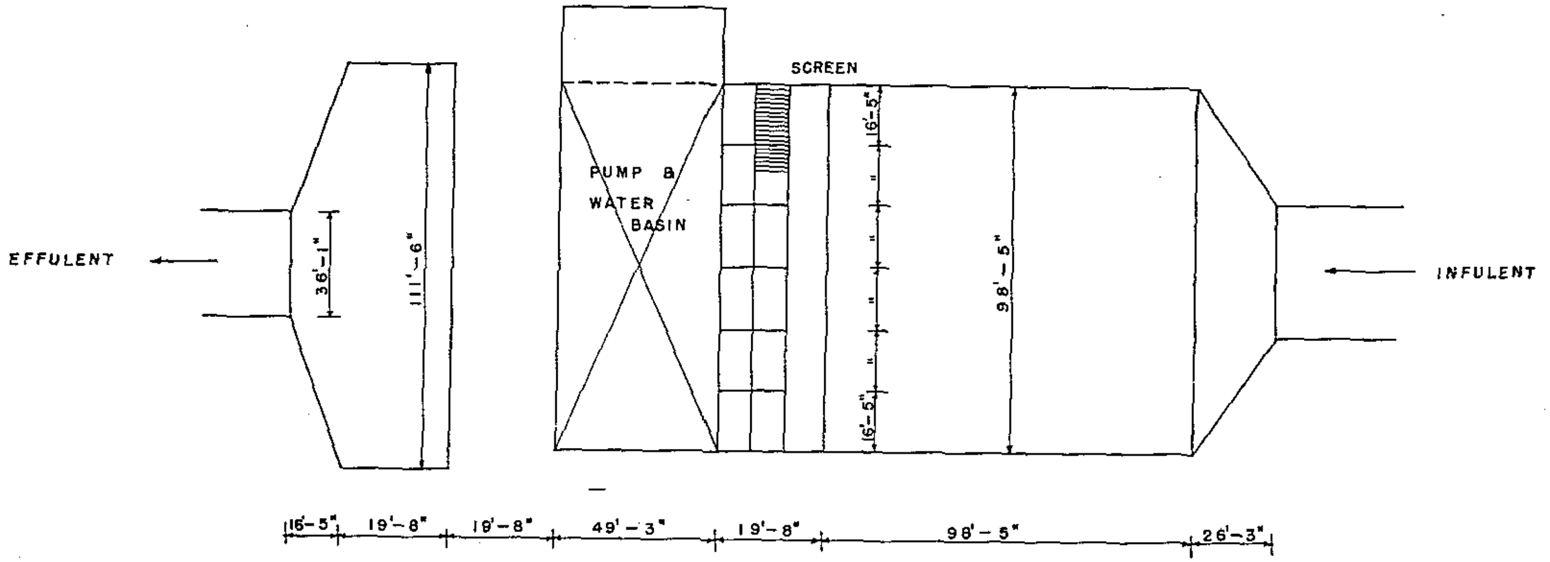
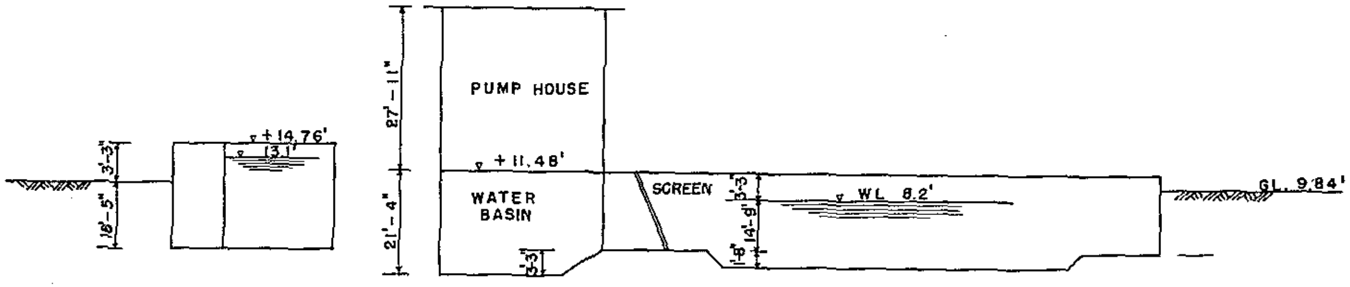


FIG-LR-7

INTERMEDIATE PUMPING STATION



FLOOR PLAN



SECTION

FIG-LR-8

WATER CONTROL GATE

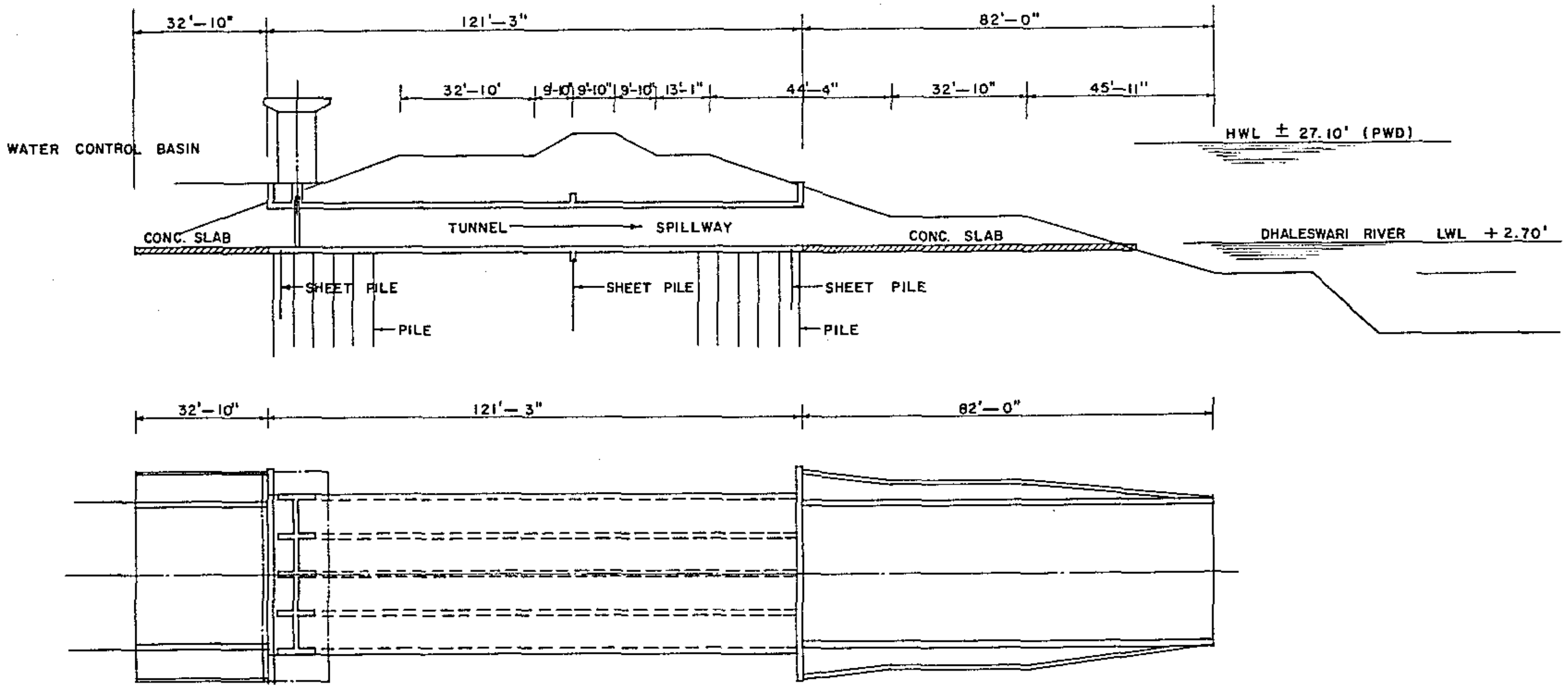


FIG-LR-9

WATER CONTROL GATE

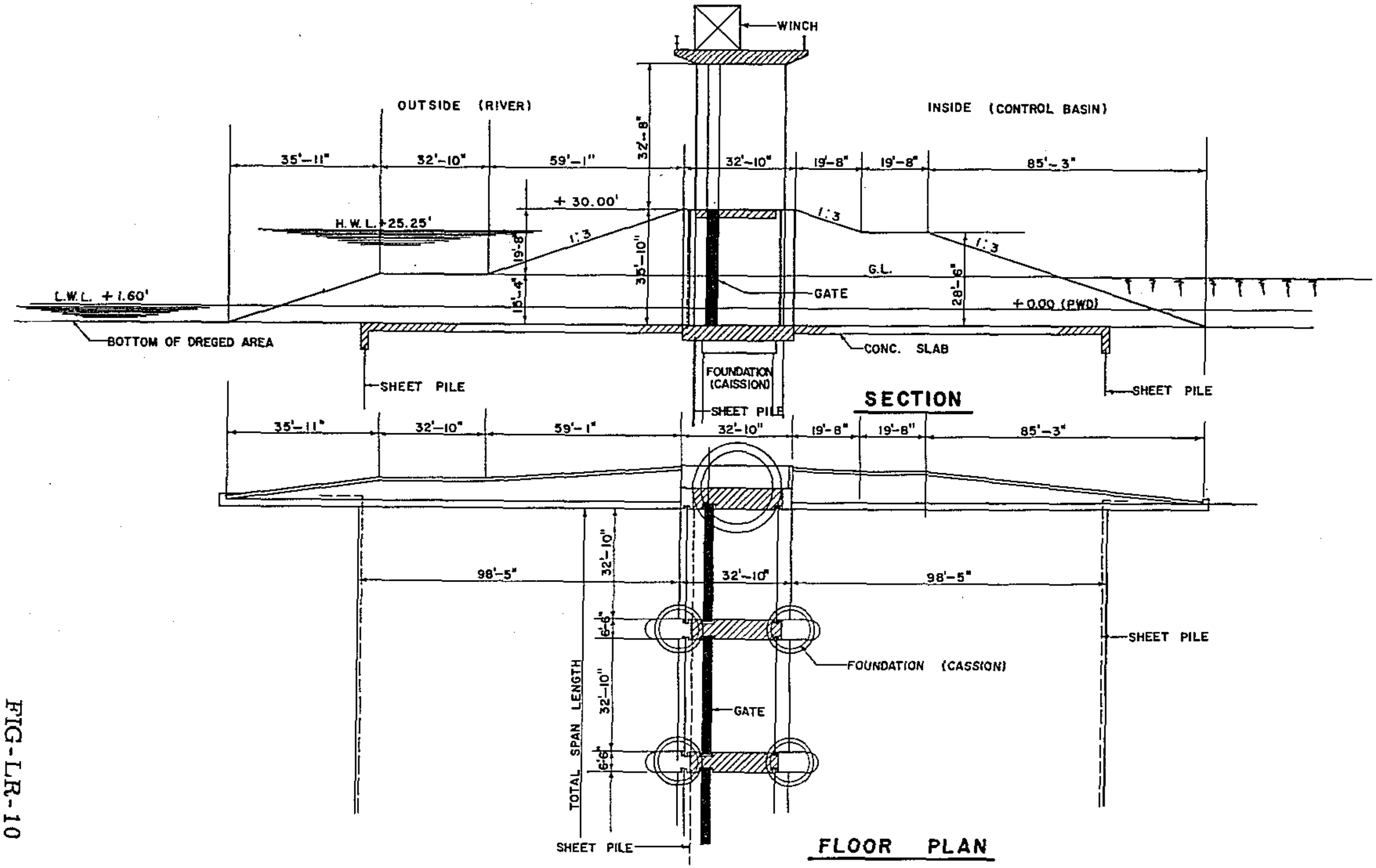


FIG-LR-10

(6) Principal concept for second stage plan.

6-1. As to the second stage plan to treat the double-purpose reservoir which serves for a reservoir and a retarding basin within the west side residential area (Borrow area), three methods may be acceptable: -

I. A sluiceway may be constructed at the place across the south-to-north soil embankment. No embankment, however, is made along the reservoir, but a protection work only upon the face of slope when dredged.

II. A soil embankment equivalent to Type II may be constructed along the reservoir, but no sluiceway.

III. The reservoir may be reduced to a smaller-size one which discards the purpose of serving for a retarding basin.

(Fig-LR-9 & 10.)

6-2. The sand and soil that would be taken from the dredging area along the heavy industrial zone, would be used for the fill-up work of all the proposed reclamation areas. Therefore, the fill-up level would be accordingly given by the dredged soil volume:

EL = +15'-7" (+4.800 m)

IV. Design Elements of Scheme 'C'.

(1) Planned height of embankment and fill-up.

All the other design elements remain as same as in Scheme 'A'.

(2) Reclamation area and quantity of fill.

	Reclamation area sy		Quantity of fill cy	sy/cy
Urban area	EL 23'-00	26,000,000	103,000,000	4.0
Sewerage treatment plant	EL 28'-00	1,130,000	6,690,000	5.9
Water treatment plant	EL 28'-00	276,000	1,780,000	6.5
Sub-total :		28,406,000	111,470,000	
Urban area	EL 23'-00	62,500,000	247,000,000	
Sub-total :		62,500,000	247,000,000	
Total :		90,906,000	358,000,000	

V. Mechanical Drainage Facilities in the First Stage of Scheme 'A'.

(1) Pumping plan.

1-1. Outline of plan.

For pumping facilities, the following mechanical and electrical equipments should be required:-

(See Fig-LR-11.)

Vertical shaft pump, ϕ 1,350 mm with accessaries ..	1 set
Diesel engine with accessaries	1 set
Auxiliary mechanical equipment....................	1 set
Overhead travelling crane with accessaries	1 set
Independent electric power plant	1 set
Appurtenant equipments...........................	1 set

1-2. Conditions for planning.

(a) Internal and outer water level.

Internal water level

Outer water level
(Water level of river)

H.H.W.L. + 8.260

H.W.L. + 7.80 (planning)

H.W.L. + 5.50

Ha = 3.6 m (Actual head planning)

L.W.L. + 4.20 (planning)

L.W.L. + 4.20

(See Fig-LR-12.)

(b) Planning discharge.

Total discharge Q_t = 16.25 m^3/s (Rainfall amount: 200 mm/day)

Discharge per unit pump q = 4.05 m^3/s

(c) Total head.

Actual head in plan Ha = 3.6 m

Loss through pump pipings $\Sigma hf = 0.6$ m (assumed)

Total head = Ha + Σhr = 3.6 + 0.6 = 4.2m

(d) Required number of pump units... 4 units

(e) Pump Diameter, Type and capacity.

Diameter	1,350 mm
Type	Vertical shaft, mixed flow pump
Capacity	4.05 m^3/s x 4.2m x 180 v/m x 350 HL.

(f) Prime mover. Diesel engine.

(g) Installation structure of pump. Double floor structure.

(2) Relative civil works and constructions.

2-1. Outline

In designing a sand sedimentation basin, the fact is that hardly expected is to use any electric motor. With a view of easy maintenance and control, it is designed to be a sand sedimentation basin, which at the same time, will serve as a retarding

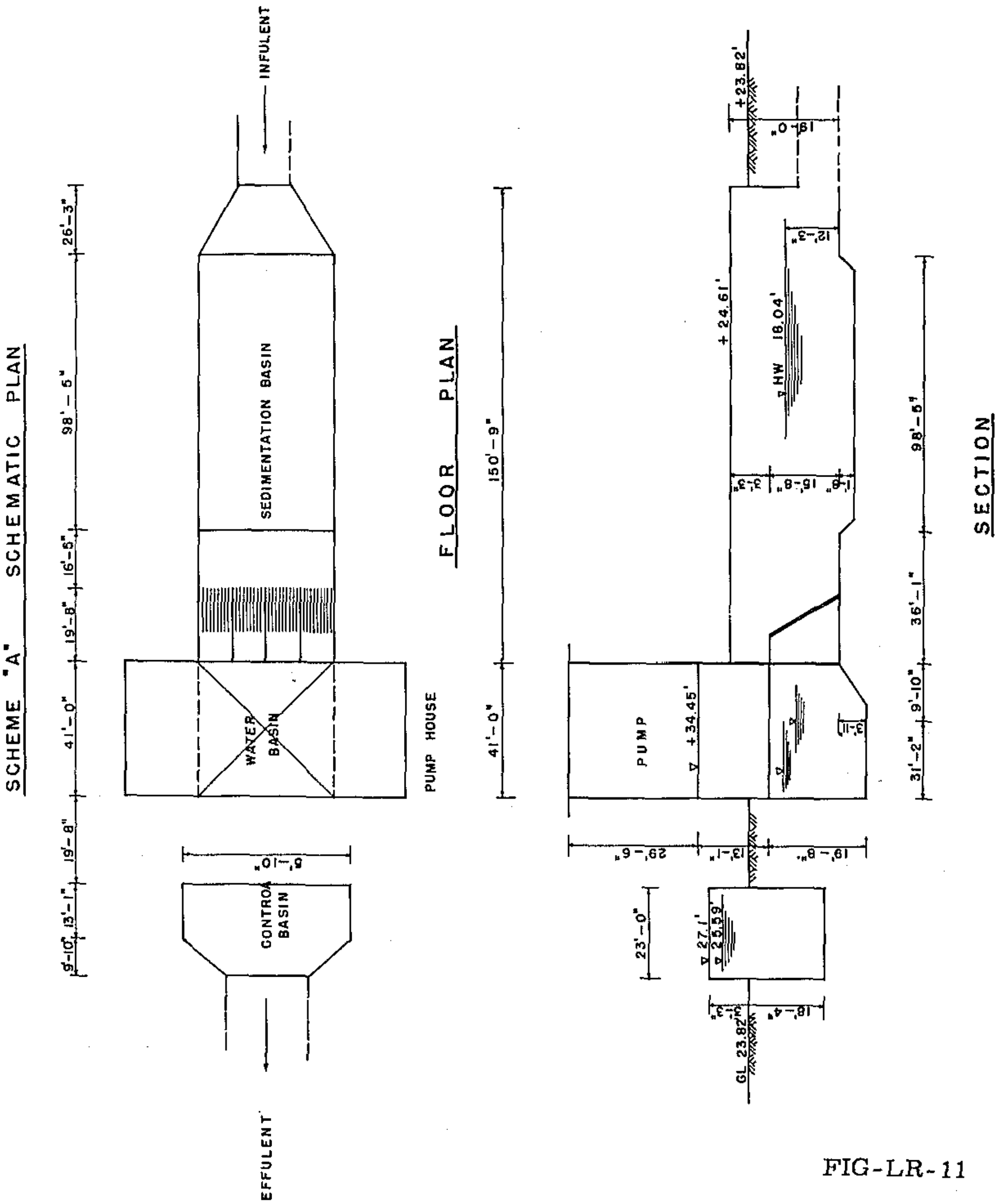

SCHEME "A" SCHEMATIC PLAN
INFULENT
EFFULENT
SEDIMENTATION BASIN
WATER BASIN
PUMP HOUSE
CONTROL BASIN
26'-3"
98' - 5"
16'-5"
19'-8"
41'-0"
19'-8"
13'-1"
9'-10"
5'-10"
FLOOR PLAN
150'-9"
41'-0"
PUMP
+34.45'
SECTION
+23.82'
18'-0"
12'-3"
+24.61'
HW 18.04'
3'-3"
16'-8"
1'-8"
3'-11"
98'-5"
36'-1"
9'-10"
31'-2"
29'-6"
13'-1"
18'-8"
23'-0"
27.1'
25.59'
3'-1"
18'-4"
GL 23.82'

FIG-LR-11

SCHEME – "A" STORM DRAINAGE SYSTEM
1ST STAGE

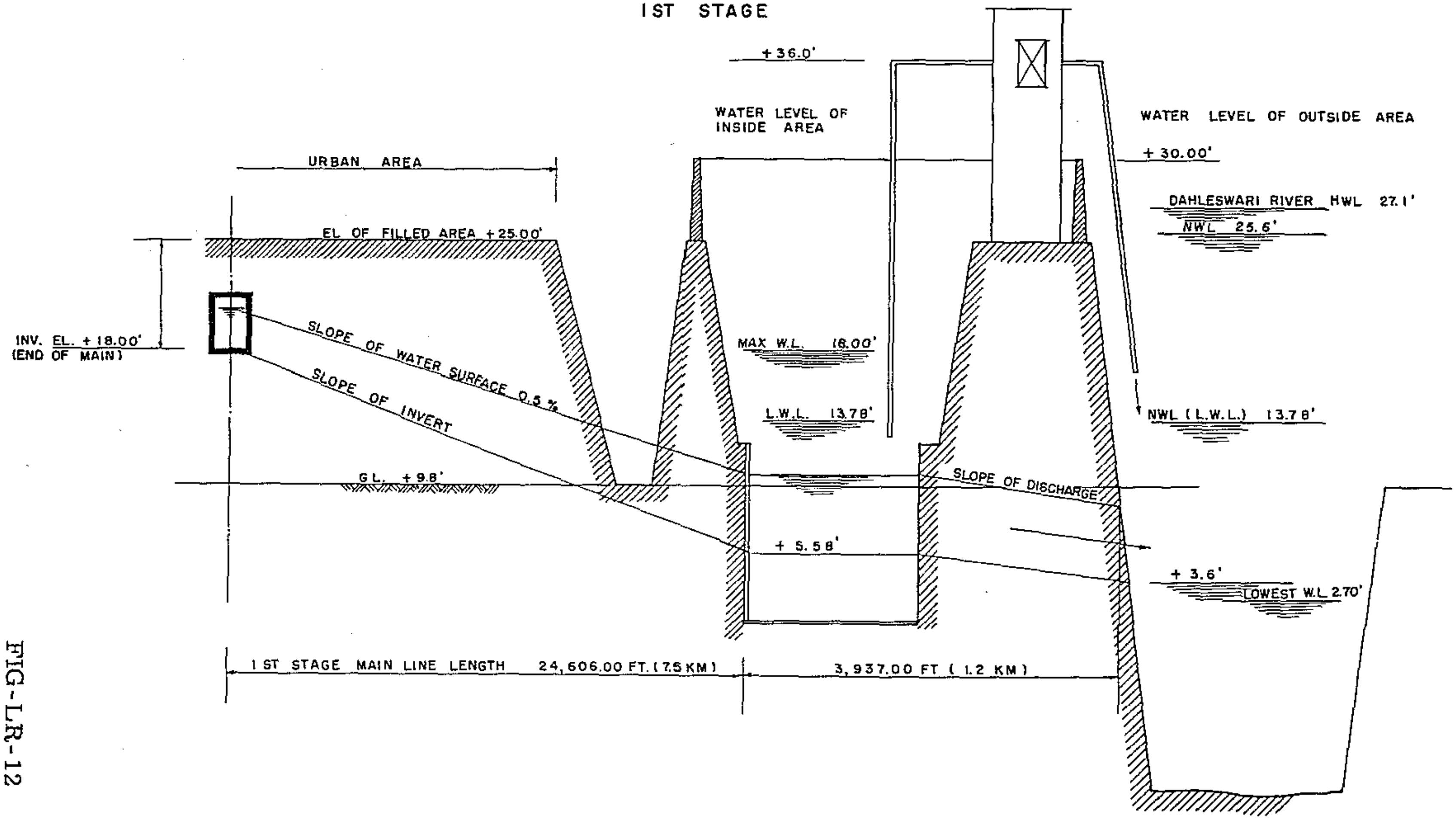


FIG-LR-12

basin. The method of removing settled sands would not be done in any mechanical way but would be done by manual operation periodically in the dry season.

2-2. Design of sand sedimentation basin:

$Q = 16.3\ m^3/sec$ (Rainfall)

$L = 30\ m$ (Effective length of sand sedimentation basin)

$H = 3.8\ m$ (Effective depth of sand sedimentation basin)

$A = 30\ m$ (Length) x 16.8 (Width) = $505\ m^2$ (Required area for water surface)

Average flow velocity:

$$V = \frac{Q}{W.H.} = \frac{16.3}{16.8 \times 3.8} = 0.255\ m/sec$$

Settling time of sand:

$$T = \frac{W.L.H.}{Q} = \frac{30 \times 16.8 \times 3.8}{16.3} = 118\ sec = 2.0\ min.$$

Sedimentation velocity of sand particles:

$$= \frac{Q}{L.W.} = \frac{16.3}{30 \times 16.8} = 0.032\ m/sec = 32\ mm/sec$$

According to the sedimentation curve, the sand particles down to 0.3 mm in diameter would probably be settled down in the basin. (Specific gravity 256)

The sand bed can be 50 cm deep.

VI. Storm Drainage Facilities in the First Stage of Scheme 'B'.

(1) Pumping plan.

1-1. Primary draining plant.

Vertical shaft pump, 1,600 mm with accessaries	1 set
Diesel engine with accessaries	1 set
Auxiliary mechanical equipments	1 set
Overhead travelling crane with accessaries	1 set
Independent electric power plant	1 set
Appurtenant equipments	1 set

1-2. Secondary draining plant.

Vertical shaft pump, 2,000 mm with accessaries	1 set
Diesel engine with accessaries	1 set
Auxiliary mecahnical equipments	1 set
Overhead travelling crane with accessaries	1 set
Independent electric power plant	1 set
Appurtenant equipments	1 set

(2) Conditions for planning.

2-1. Primary draining plant.

(a) Internal and outer water level.

SCHEME "B" STAGE-I STORM DRAINAGE SYSTEM

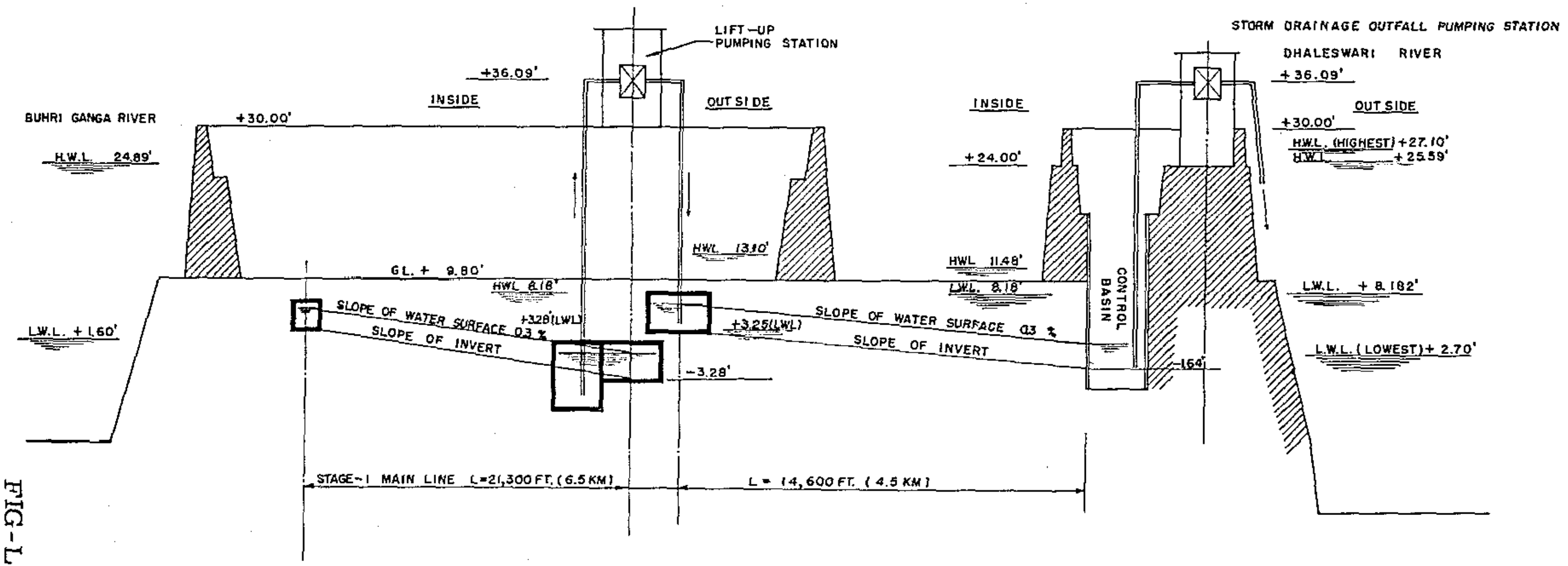
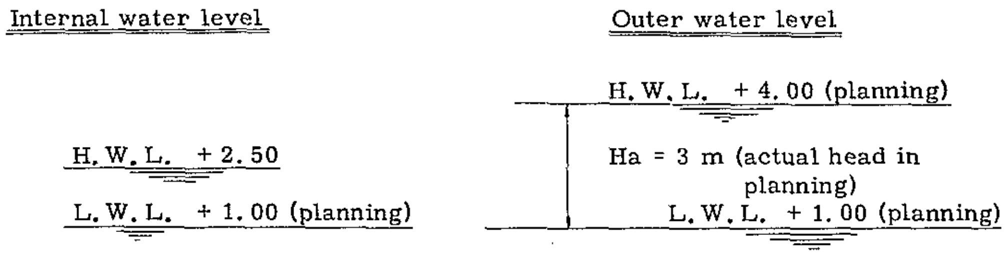


FIG-LR-13



(See Fig. =LR=13.)

(b) Pumping discharge.

Total discharge Q_t = 33. 9 m^3/s (Rainfall: 200 mm/day)

Discharge per pump unit q = 5. 67 m^3/c

(c) Total head.

Actual head in plan Ha = 3 m

Loss of head through pipe hf = 0. 7 m (assumed)

Total head $H_t = H_a + hf = 3\ m + 0.7\ m = 3.7\ m$

(d) Required number of pump units.................. 6 units

(e) Pump diameter, type and capacity.

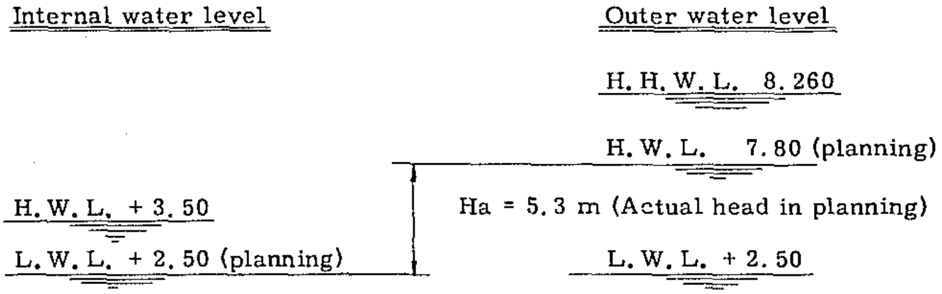
Diameter	1, 600 mm
Type	Vertical shaft, mixed flow pump
Capacity	5. 67 m^3/s x 3. 7 m x 135 m x 420 HL

(f) Prime mover..... Diesel engine.

(g) *Installation structure of pump* ..... Double floor structure.

2-2. Secondary draining plant.

(See Fig. -LR-14.)



(a) Pumping discharge.

Total discharge Q_t = 59 m^3/s (Rainfall: 200 mm/day)

Discharge per pump unit q = 9. 85 m^3/s

(b) Total head.

Actual head in pumping Ha = 5. 3 m

Loss through pump pipings hf = 0. 6 m (assumed)

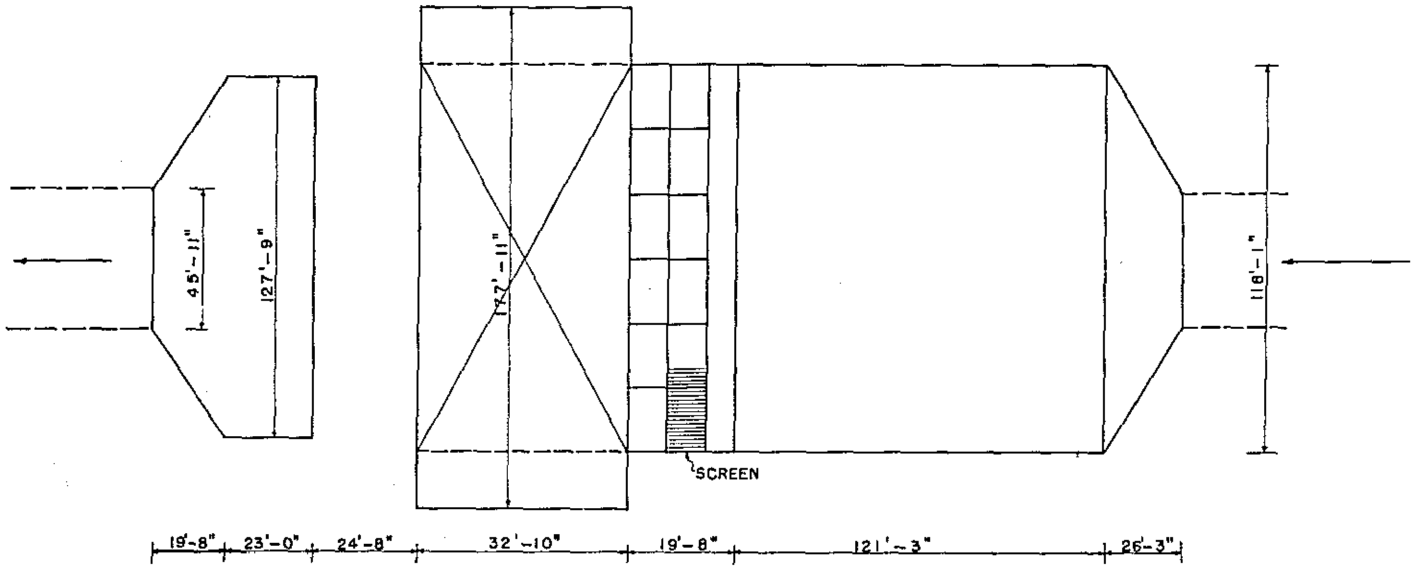
Total head $H_t = 5.3 + 0.6 = 5.9\ m$

(c) Required number of pump units ..... 6 units

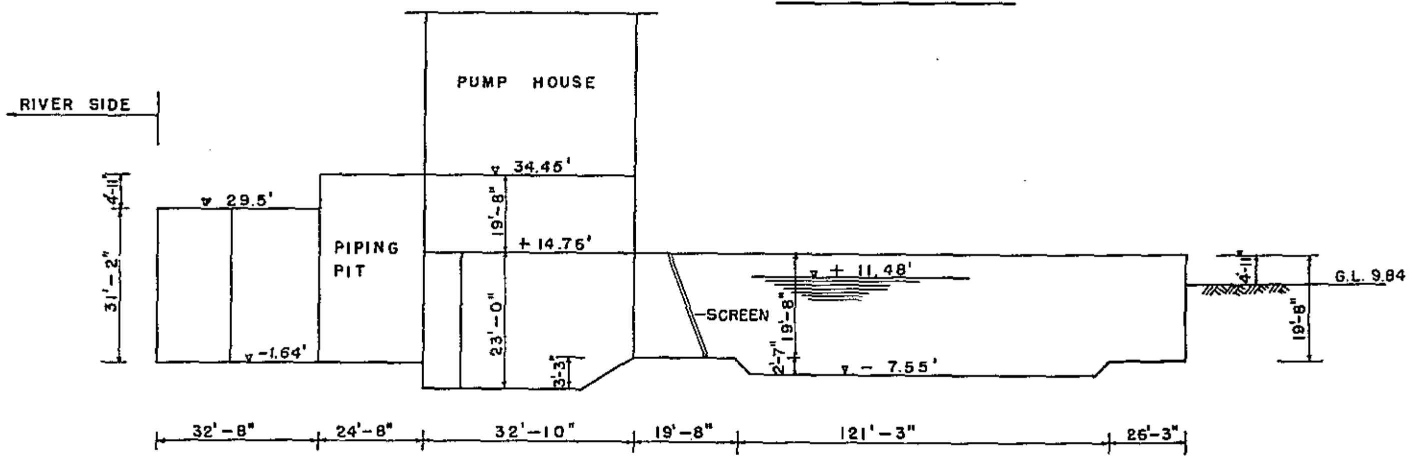
(d) Pump diameter, type and capacity.

Diameter 2, 000 mm

2 ND LIFT-UP PUMPING STATION



FLOOR PLAN



SECTION

FIG-LR-14

Type	Vertical shaft, mixed flow pump
Capacity	$9.85 \text{ m}^3/\text{s} \times 5.9 \text{ m} \times 140 \text{ V/m} \times 150 \text{ HL}$

(e) Prime mover .....Diesel engine.

(f) Installation structure of pump ..... Double floor structure.

2-3. Relative civil works and constructions.

(a) Transit sand sedimentation basin.

$Q = 34 \text{ m}^3/\text{sec}$

Dimention 30 m x 30 m x 4.5 m

Average flow velocity $V = \frac{34}{30 \times 4.5} = 0.252 \text{ m/sec}$

Settling time of sand $T = \frac{30 \times 30 \times 4.5}{34} = 119 \text{ sec} = 2 \text{ min.}$

Sedimentation velocity $= \frac{34}{30 \times 30} = 0.0378 \text{ m/sec}$

Diameter of settling sand ... 0.35 mm

Sand bed to be 50 cm deep.

(b) Terminal pumping plant. (Secondary draining plant)

$Q = 59 \text{ m}^3/\text{sec}$

Dimension 40 m x 36 m x 5.0 m

Average flow velocity $V = \frac{59}{40 \times 5.0} = 0.295 \text{ m/sec}$

Settling time of sand $T \approx \frac{40 \times 36 \times 5}{59} = 122 \text{ sec} = 2 \text{ min.}$

Sedimentation velocity $\approx \frac{59}{40 \times 36} = 0.041 \text{ m/sec}$

Diameter of settling sand ... 0.4 mm

Sand bed to be 80 cm deep.

VII. Outline of Construction Plan and Working Schedule of Time.

(1) Construction of First Stage of scheme 'A'.

1-1. Land purchase and evacuation in the planning area.
Required period: 12 months.

1-2. Surveying and additional boring work necessary for the final design, and detail design for land reclamation and appurtenant structures.
Required period: 6 months.

1-3. Construction of temporary soil embankment.
The necessary soil would be taken from the places nearest available for each planning area.

1-4. Foundation work of structures.
There are some structures related to the land reclamation and some buildings in the new town area that should be more advantageous to be completed before the land reclamation starts. They should be set to construction and completed before the reclamation work by pump dredgers begins.

1-5. Shipbuilding, navigation and operation of pump dredgers.

Period of shipbuilding: 1- months.

Period of navigation and test run: 3 months.

Required crew:

8, 000 HP Dredger	26 men
4, 000 HP Dredger	24 men

(2) Dredge & reclamation work by pump dredgers.

2-1. Quantity of fill required for reclamation.

First stage	
Urban area	97, 000, 000 m^3
Sewerage treatment plant	5, 700, 000 m^3
Water treatment plant	1, 500, 000 m^3
Sub-total :	104, 200, 000 m^3
Second stage	
Urban	229, 000, 000 m^3
Sub-total :	229, 000, 000 m^3
Total :	333, 200, 000 m^3

2-2. A study on the dredging capacity of the work in Dacca.

Soil nature: Silty sand or fine sand of which N Value is more than 10.

Dredging capacity & soil conveying distance:

Average soil conveying distance		Dredge volume per hour	Average operation hour
4, 000 HP	2, 000 m	800 m^3/h	4, 500 h
8, 000 HP	4, 000 m	1, 200 "	4, 500 h

Annual dredging capacity per ship.

4, 000 HP 4, 500 h x 800 m^3/h = 3, 600, 000 m^3/h

8, 000 HP 4, 500 h x 1, 200 m^3/h = 5, 400, 000 m^3/h

2-3. Plan of obtaining sand.

(a) Quantity of fill available from the Burhiganga river.

Present water depth	-5 m
Available dredging width	150 m
Length	10, 000 m
Available quantity of fill	10, 000 m x 150 m x 5 m = 7, 500, 000 m^3

(b) Delta zone that lies at the mouth to the retarding basin running from north to south through the west side residential area.

Present ground level +3. 5 m

Available quantity of fill 1, 300 m x 800 m x $\frac{1}{2}$ x 13. 5 m = 7, 050, 000 m^3

(c) Retarding basin in the west side residential area.

Present ground level +3. 5 m

Available quantity of fill 750 m x (2, 100 + 1, 200 + 1, 300) x 13. 5 = 48, 000, 000 m^3

(d) A certain block in the west side industrial zone.

Present ground level +3.5 m

Available quantity of fill 2,000 x 2,000 x 13.5 = 54,000,000 m^3

(d) Total available quantity of fill.

7,500,000 + 7,050,000 + 48,000,000 + 54,000,000 = 116,550,000 m^3

(3) Reclamation plan.

Since the soil nature is expected to be of silty sand and fine sand, the yield rate of dredging soil is presumably 95%. Accordingly, the total quantity of dredged fill given: 99,200,000 m^3 x 0.95 = 104,500,000 m^3.

Available quantity of fill 116,550,000 104,500,000 m^3

3-1. Soil conveying distance and the horse power of pump dredgers.

	Average distance	
Sand-digging place	2,000 m	4,000 m
a & b	12,000 m	
c	13,000 m	30,000 m
d	18,000 m	32,000 m
Total :	43,000 m	62,000 m

Required horse power of pump dredgers: 4,000 HP

3-2. Required number of pump dredgers.

Total working period for reclamation is planned to be 4 years.

4,000 HP pump dredger 43,000,000 m^3 3,600,000 x 4 years = 3 dredgers

8,000 HP pump dredger 62,000,000 m^3 5,400,000 x 4 years = 3 dredgers

(4) Time schedule for works.

The required period for shipbuilding would be 10 months per dredger at longest. The required number of pump dredger was calculated from the necessary reclamation period of 4 years. Therefore, a half of the embankment surrounding the reclamation area at least should be completed before starting the fill-up work. Furthermore, the priod for navigation and preparatory operation in Japan and Pakistan would be estimated for 6 months at the minimum.

(5) Mechanical drainage facilities.

Pump

5-1. The final determination on the required pump capacity and other factors would be left to the site investigation by specialist engineers in this field.

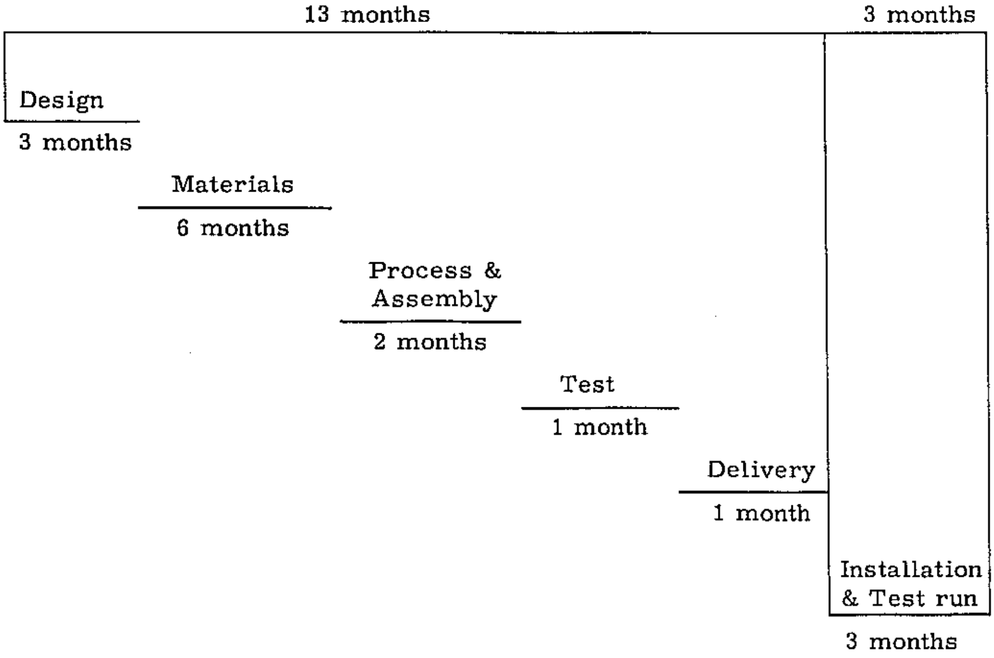
5-2. Electric power supply would not be expected and all mechanical facilities must depend on the non-utility electric generator.

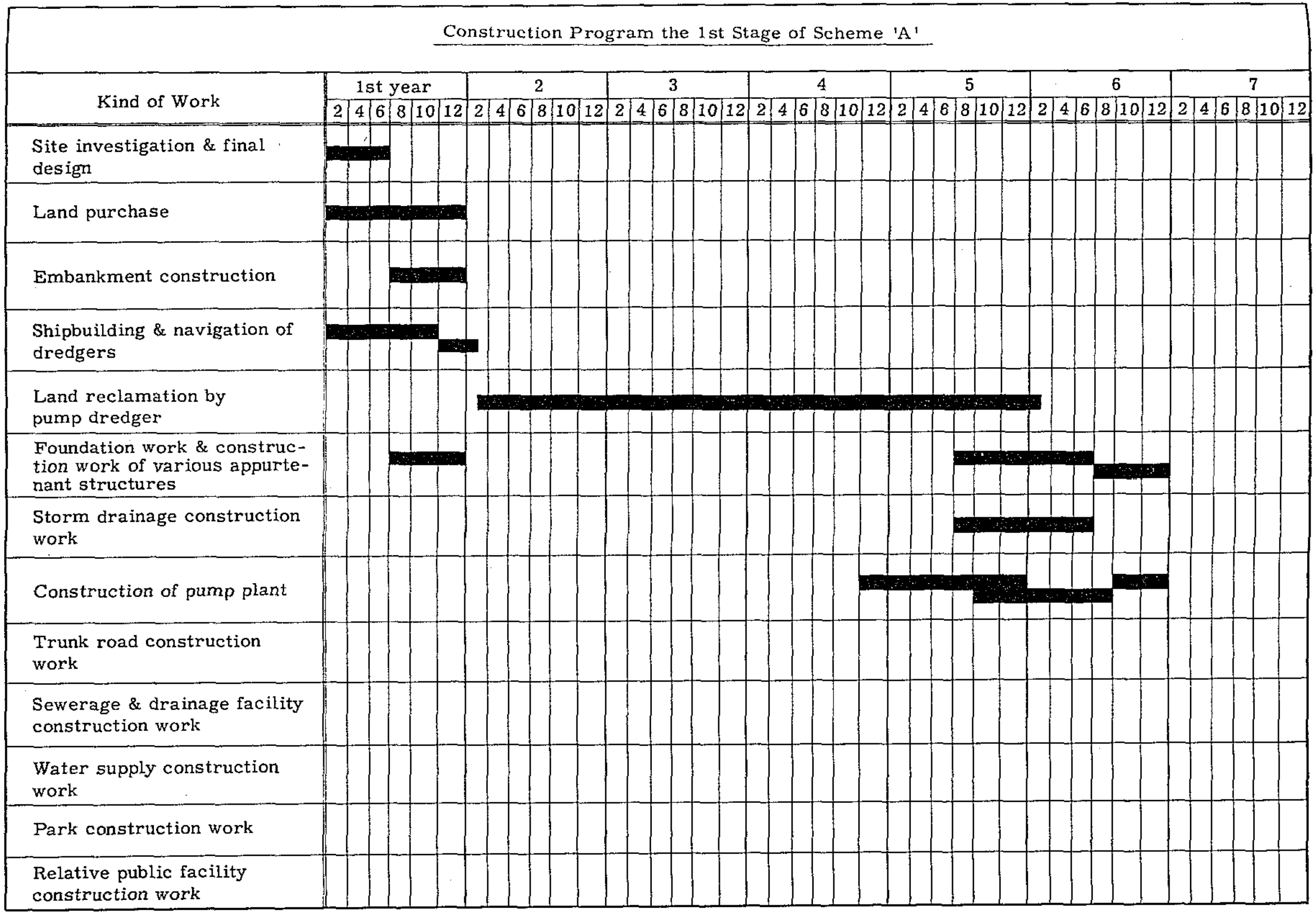
5-3. It is advantageous that all the pumps and accessaries should be ordered from established reputable manufacturers in this line.

5-4. The time schedule of manufacturing pumps should not be much concerned with the product's capacity.

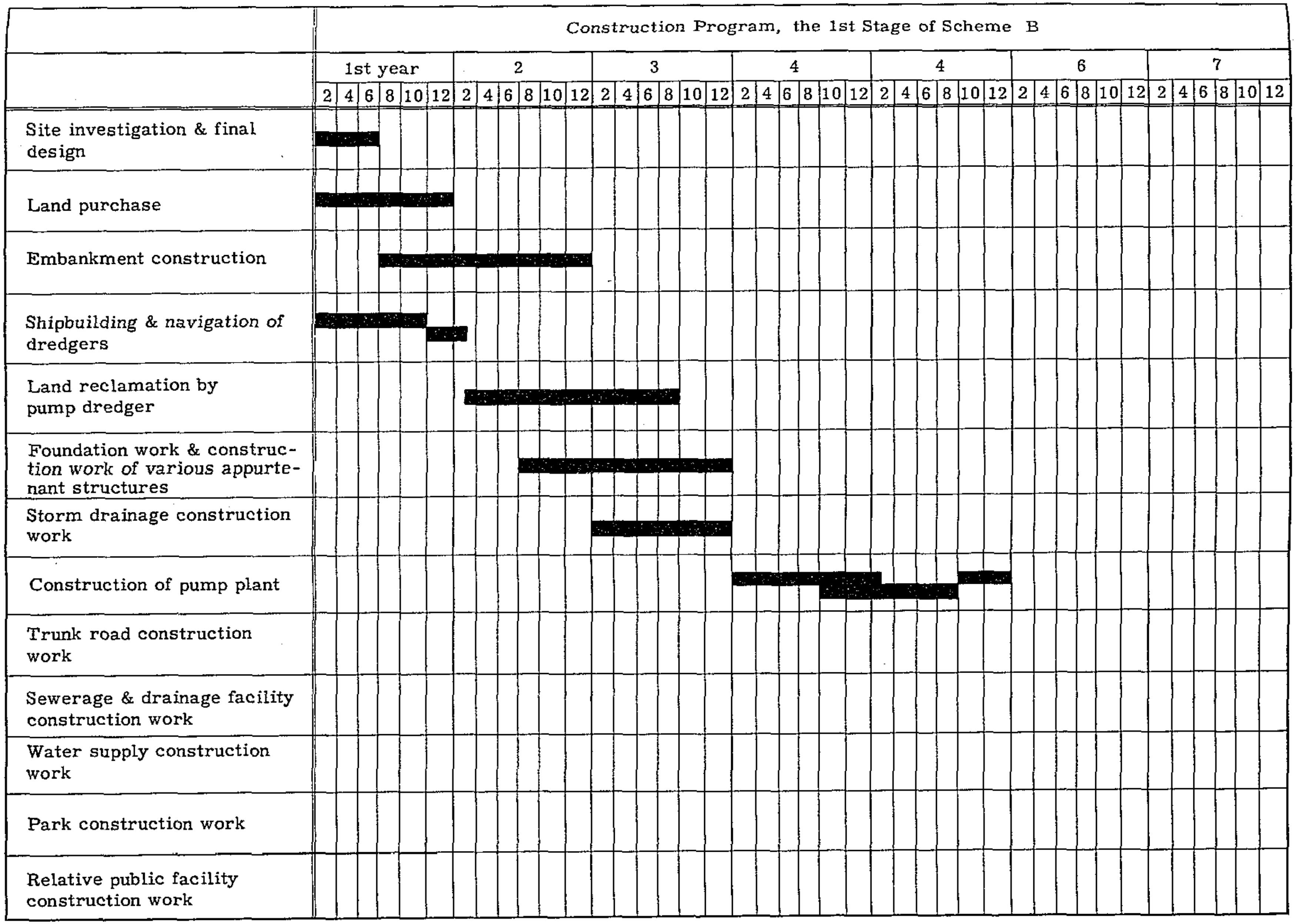
5-5. The installation work, maintenance and control of the pumping plants may even need foreign engineers at the early stage of operation, but the domestic engineering staff should be trained as soon as possible to take the place of the foreign engineers.

Pump delivery schedule: 1 year 4 months





Construction Program the 1st Stage of Scheme 'A'



Construction Program, the 1st Stage of Scheme B

A Table of Construction Cost for 1st Stage (Reclamation Area 5,350 acres)

	Scheme 'A' $	Scheme 'B' $	Scheme 'C' (Modified Plan 'A') $
1. Embankment work	9,744,000 (Extension 28,000 yd) (348 $/yd)	45,297,000 (Extension 29,400 yd) (1,580 $/yd)	9,744,000 (Extension 28,000 yd) (348 $/yd)
2. Reclamation & Fill-up work	59,254,000 ( ) (11,600 $/acre)	3,993,400 ( ) (7,400 $/acre)	58,915,000 ( ) (9,520 $/acre)
A. Reclamation & Fill-up work	57,725,000	3,900,000	49,386,000
B. Land adjustment	1,380,000	65,600	1,380,000
C. Appurtenant work	149,000	28,400	149,000
3. Storm drainage work	21,935,000 (Extension 40,300 yd)	28,427,000 (Extension 36,100 yd)	21,935,000
A. Main sewer work	15,681,000	19,822,000	
B. Appurtenant work such as man-hole etc.	722,000	980,000	
C. Catch basin & relative man-hole construction work	4,722,000	5,170,000	
D. Outlet (1-7) facilifacility construction work	97,000		
E. Mechanical drainage construction work	713,000	2,455,000	
Total direct cost :	90,933,000	77,718,000	82,594,000
4. Reserves (10%)	9,093,000	7,772,000	8,259,000
5. Design & administrative cost (10%)	9,093,000	7,772,000	8,259,000
Grand Total	109,119,000	93,261,400	99,112,000
Separate Construction			
1. Land purchase cost	30,833,000	30,833,000	30,833,000
2. Shipbuilding cost & navigation cost	21,560,000	21,560,000	21,560,000
3. Mechanical drainage maintenance & control cost per year	63,000	344,000	63,000
4. Road construction	879,000	879,000	879,000
5. Sewerage & drainage construction	20,547,000	20,547,000	20,547,000

A Table of Construction Cost for 2nd Stage (Reclamation Area 13,000 acres)

	Scheme 'A' $	Scheme 'B' $	Scheme 'C' (Modified plan 'A') $
1. Embankment work	26,784,000 (Extension	93,413,000	26,784,000
2. Reclamation & Fill-up work	139,444,000	17,611,000	114,889,000
A. Reclamation & Fill-up work	138,888,000		114,333,000
B. Drainage work	556,000		556,000
3. Storm drainage work	46,794,000	57,389,000	46,794,000
Mechanical drainage construction work			
Total direct cost	213,022,000	168,413,000	188,467,000
4. Reserves (10%)	21,297,000	16,841,000	18,842,000
5. Design & administrative cost (10%)	21,297,000	16,841,000	18,842,000
Grand Total	255,616,000	202,095,000	226,151,000
Separate Construction			
1. Land purchase cost	58,541,000	58,541,000	58,541,000
2. Mechanical drainage maintenance & control cost per year	611,000	1,111,000	611,000
3. Road construction			
4. Sewerage & drainage construction	36,733,000	36,733,000	36,733,000

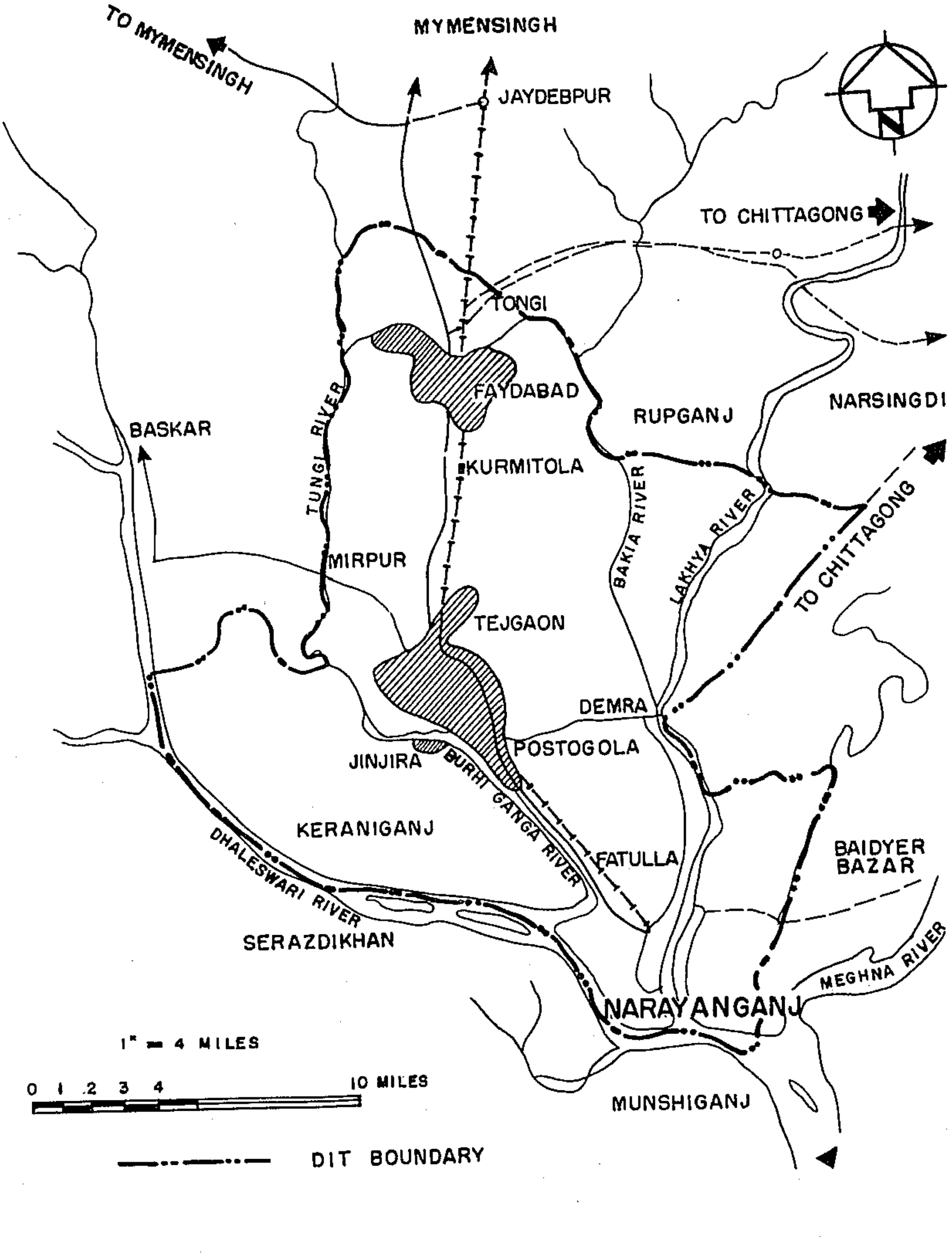
CHAPTER III CITY PLANNING

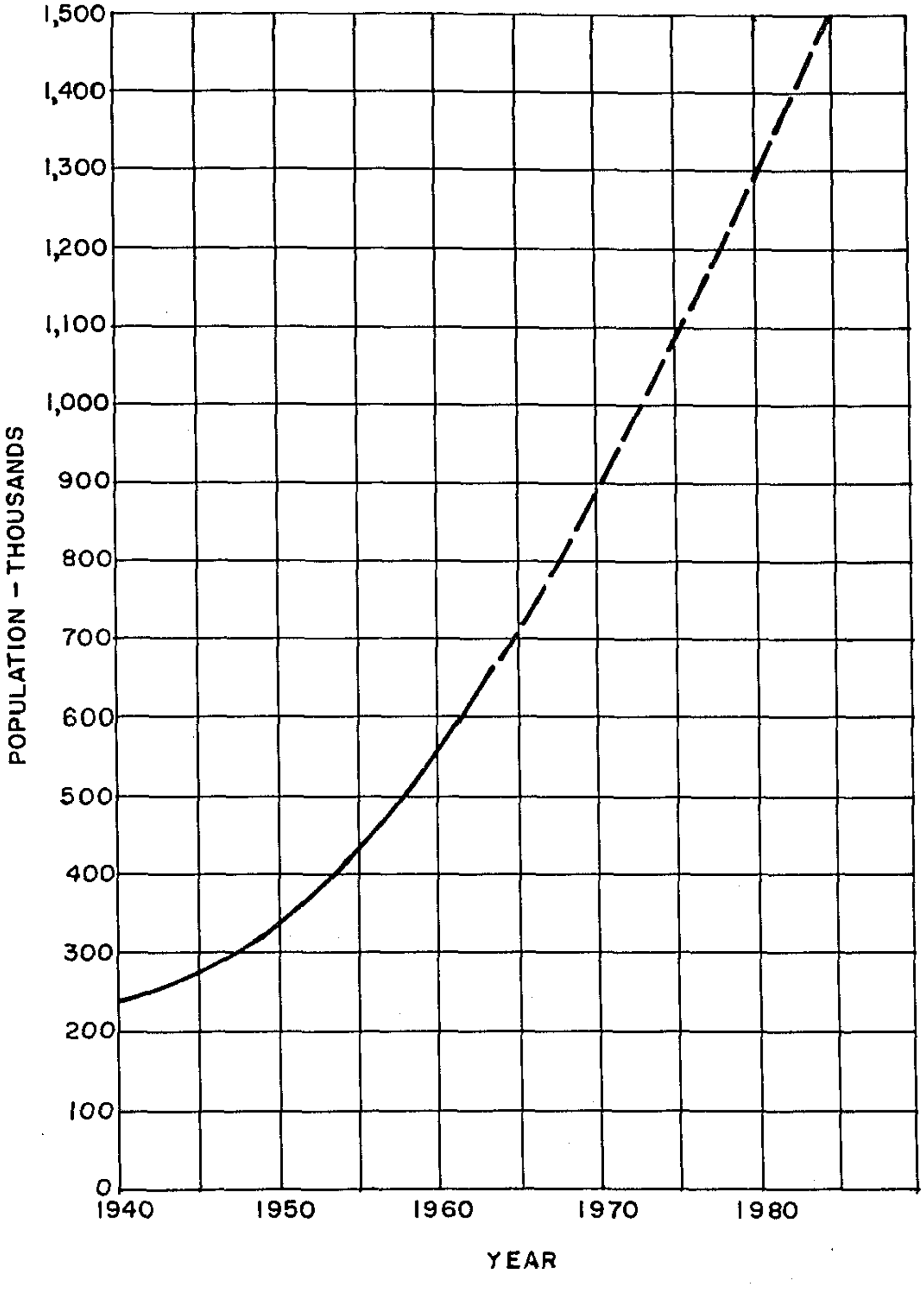
SECTION 1 LAND USE PLANNING

SECTION 2 TRAFFIC

SECTION 3 SEWERAGE SYSTEM

AREA OF DACCA IMPROVEMENT TRUST





PROJECTED POPULATION GROWTH OF DACCA

CHAPTER III CITY PLANNING

SECTION 1. LAND USE PLANNING

I. Future Population.

As referred to in the introduction, the population of Dacca is presumed to be 1. 5 million as of 1985. A new land area is required to absorb 700, 000 people that would be the increase from the population as of 1965. In this city planning, including both first and second stages, 50, 000 people will be able to be accommodated. With the population density of 130 persons per hectre at the new town area, 6, 000 hectre should be required to take in 700, 000 inhabitants. However, it is assumed that Keraniganj district as a whole should meet the total population.

In the new town area about Jinjira district is at present 170, 000 people to live in, and this plan treats Jinjira district as a re-development area, which means the place to be incorporated a new town and thereafter given a start for re-development. The village population would possibly tend to transfer to the industrial zone of the new town.

II. Land Use Plan.

Location of the civic center.

(1) The center of new town is to be located at the central part of the first stage area, and to be connected with old Dacca city by the trunk roads through the points that the Burhiganga River Bridge Construction Survey Mission recommended for the linkage.

(2) The center should represent itself as a secondary midtown of business area, where a part of city function of the present Dacca will be transferred to, and in addition to it some newly organized business establishments in lacking the present-day Dacca organized newly systematically. The development will not be commenced at once except for the Burhiganga river and the first stage area, but will be left for a green park area for the time being. The neighbouring areas to the other bridges will be developed, accordingly as the circumstances is ready for development. The building facilities within the business area will be all high-storied.

(3) Central residential area.
At the early stage of development, the residential area will be developed officially to be growing as high or middle density areas. In the area, high-storied or flat houses will be set in a good proportion with the public facilities. All the residential area will be separated into certain units by each community center.

(4) Low-density area.
The suburbs of the new town will be made low density residential area to have larger income earners build their own houses on their accounts. At the early stage of development, sufficient public facilities would not be provided in this area, but an encouraging policy should be taken as soon as possible so as to relieve the housing shortage and to facilitate the modernization of city.

(5) Industrial zone.

The south east area will be made out an industrial zone closely relating with the port area which comes out from the reclamation of the new town. Besides being it, the area will be developed as a multi-purpose zone including economic structures for wholesale, traffic center, etc.

(6) Educational area.

To keep up with the population increase and the advance of education and civilization, an educational center will be necessarily constructed in the new town area, and the educational area will be located at the south west of the area.

(7) Supply and disposal facilities.

The construction sites for supply and disposal facilities enough for the planned inhabitants will be located in the south area. Such facilities as can serve temporarily during the construction will be stage at the places where needs demand.

III. Residential Building Construction Plan.

It is expected that as of 1961 one family consists of 5. 5 persons on the average, but it is estimated in the planning to be 5. The number of necessary houses is 90, 000. Of the type of houses to be built are government or semi-government - funded residences for the most part, being fire-resistant flat type.

In the business area, the residential houses are high-storied, and flat type in the civil housing area.

(1) Classification standard for income & building type.

Class	High-storied	Flat	Total	Income
Low income	40, 000 (80%)	10, 000 (20%)	50, 000	below 3, 600 Rs.
Middle income	20, 000 (50%)	20, 000 (50%)	40, 000	3, 601 - 10, 800 Rs.
High income	1, 000 (10%)	9, 000 (90%)	10, 000	over 10, 801 Rs.

(2) Classification standard for building type & area.

	High-storied	Flat	Total
High-density area	95%	5%	100%
Medium-density area	70%	30%	100%
Low-density area	10%	90%	100%

(3) Required area per house type & family number per house.

	Average family per house	Gross floor area per house	Density per house	Population density
High-density area	5	183 m^2	55 houses/ha	275/ha
Medium-density area	5	345	29 "	150
Low-density area	6	735	14 "	84

Note: Required area for high-storied house (gross): 150 m^2
Required area for flat-type house: 800 m^2

(Example) Relation between income and estate scale.

Class	Yearly income (Rs)	Estate scale	Sqyd
Low income	- 3,600	100 - 200	(83 - 167 m^2)
Middle income	3,601 - 108,000	201 - 600	(168 - 500 m^2)
High income	10,800 over	401 - 600	(332 - 500 m^2)

Note: According to the report on North Satellite Town, June 1965.

(4) Population density, number of inhabitants, living area per residential area.

	Number of inhabitants	Living area
High-density area	15,000	54 ha.
Medium-density area	10,000	67 "
Low-density area	8,000	95 "

In this case and of secting the rate of building lot at 40%, the number of houses allowed in the central high-density area:

In case of making the rate of building lot to be 40%, the town area would be:-

High-density residential area	54 x 10/4 = 135 ha.	3,000 houses
Medium-density residential area	82 x 10/4 = 205 ha.	2,000 houses
Low-density residential area	95 x 10/4 = 238 ha.	1,330 houses

IV. Park and Park Road Plan.

(1) It comprises a central park, athletic park, children park, and those set in each area and its neighbourhood, and the green belt alongside the roads.

(2) A positive consideration would be given to the green belt arrangement in order to make clean the urban environments and to rise the city scenery.

SECTION 2. TRAFFIC

I. Wide-scoped Traffic Project.

(1) The future trans-continental highways are reportedly passing through the downtown of Dacca. In addition to it, a by-pass is to be constructed toward the northern part of the city with approach roads being well furnished.

(2) In the planning area, main highways are to run in the future, connecting Dacca city, Narayanganj, Khulna and other main towns. Based on the highway layout, a road network is planned as shown in the attached drawing. The planned roads are 4 or 6 lane, being 72' up to 106' wide.

(3) The connection between the planning area and Dacca city will be made by four new bridges. Within the territory of Dacca city, the urban super highways, inclusive of expressway and elevated motor way, should be constructed taking over the present railway site which will be removed in future as the planning progresses.
With these super urban highways, the traffic from the urban area will be introduced into Dacca city in a decentralized method. As a matter of course, it will be linked with the approach roads to the trans-continental highways, Narayanganj line of east bound, connecting the new bridges as well. The width of the roads are 4 or 6 lane.

(4) The new bridges are planned to connect the urban super highways, and the linkage will be 6 lane. Jinjira Bridge is meant for the traffic toward the south area; Sadarghat Bridge for the one within the first stage area, and at the same time serving as a connecting road with Dacca city. Of the traffic through both bridges, those running to the downtown of Dacca city will be connected with the super urban highways by side approach roads.

(5) A plan is necessarily drawn up that the railroad should be removed in the future and newly constructed to run further north away from Basar Bagh. On the other hand, the railroad traffic will not be introduced into the planning area.

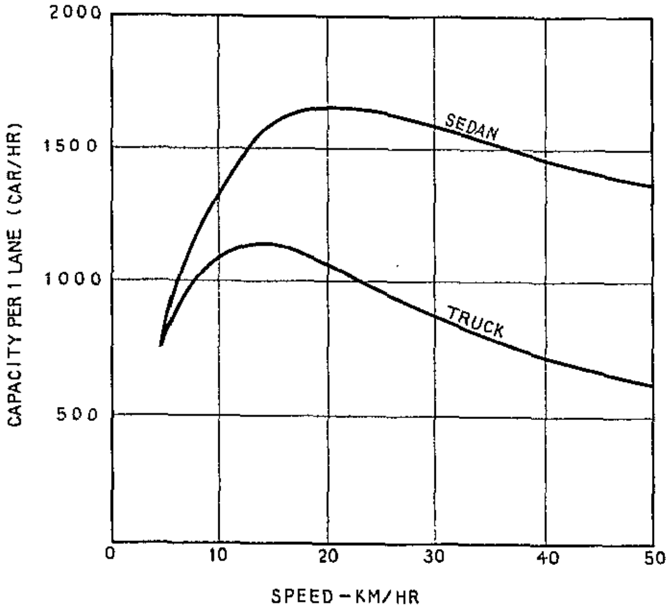
(6) A traffic center and relative facilities such as bus terminal and parking spaces will be constructed in the site of old tram depot, connecting the super highways.

(7) As the road network is gradually completed, there will be need of planning a traffic terminal stock area.

(8) To protect passengers against possible traffic accidents, footways (with trees alongside) should be constructed within and between the residential areas and commercial ones.

II. Details of Traffic Project.

This portion of the project is originally in the planning as a residential area of Dacca city, but furthermore it is intended to include new functions of industrial zone, civic center, circulation center for the port facilities.



Main traffics in the planning area are:-

(1) All throughout the planning area down to Dacca City, the largest traffic flow, including those going to office and school, and for daily and shipping works, will be seen during various stages of construction work.

(2) Civic center to Dacca City. The civic center is situated facing the present downtown of Dacca City just across the river. Therefore, it will be strongly tied up with the downtown in terms of business exchange and everyday life.

(3) Civic center to the planned residential areas.
The civic center is intended to be the heart of all planning areas, and the traffic from it will be busy with people to work in office and for shipping business.

(4) Circulation center.
The circulation center developed from the new port area will play a vital role in transportation of various materials to and from Dacca City.

(5) Industrial Zone.
It is important to make an easy traffic for those who work in the area, but no less important to secure the traffic between the civic center and suburban towns of Dacca. The main street network in the planning area is mapped up on the basic wide-range traffic creteria, given enough consideration to the scales of residential areas concerned and to the smooth transit being achieved on the abovementioned trunk roads.

The most essential of the trunk road net is to connect the civic center of the planning area with present downtown of Dacca through Narayanganj highway, in which the connection between the downtown, the civic center, circulation center and factory area will be made by a speed highway. Even in the residential area, such special blocks as expect a heavy traffic and is given unelevated roads of wider than 6-lane, will be also provided with speed highways respectively.

To determine the width of road, the demand for traffic should be estimated for each area. To keep the passing traffic out of the residential area, it is designed that no through way runs in the middle of residential area.

III. Basic Population for Estimate of Traffic Flow.

(1) Area and population in the planning.

1-1. The population density in the residential area is made a total gross 100 per ha. on the average. The approximately average value falls on 100 through 140 per ha., but the estimate takes 100 per ha. for the convenience of calculation.

1-2. The percentage of employment is taken 42.5% of the total population, both man and woman.

1-3. In the civic center, the building rate is 60%, and the mean bulk rate 40%.

1-4. Of all kinds of business in the civic center, the occupancy of area per employee is estimated to be 55 m^2.

1-5. The density of employee in the wholesale market area is estimated at 20 per ha.

1-6. In the industrial zone, the density of employee is 15/ha. for heavy industry; 40/ha. for light industry.

1-7. Such public facilities as shopping center, school, governmental office and bank evaluatedly require on employee for 30 residential population.

1-8. For a new market coming out in Keraniganj, the resident workers will take precedence of employment; however, 10% of the employment working in the residential area, and 20% in the other areas are estimated to come from the outside areas.

A table of area & population in Keraniganj district (K district)

	Area (km ^{2})	Population (in 1,000)	Working population	Employee	No. of employee from K district	No. of employee from K district
Civic Center	1.25			55,000		
				123,000	18,400	4,600
				211,000	8,800	2,200
				321,000	16,800	4,200
Park	3.69					
Parking space	0.32					
Circulation Center	1.10			2,200	1,760	440
R_1	2.93	29.3	12,430	975	877	98
R_2	2.71	27.1	11,500	900	810	90
R_3	2.06	20.6	8,750	685	616	69
R_4	1.66	16.6	7,050	551	496	55
R_5	1.95	19.5	8,280	649	584	65
R_6	1.89	18.9	8,020	628	565	63
R_7	1.72	17.2	7,300	571	514	57
R_8	1.93	19.3	8,200	641	577	64
R_z	2.16	30.0	12,720	1,000	900	100
Sub-Total	19.85	198.5	84,250	6,620	5,958	662
R_9	4.25	42.5	18,000	1,415	1,273	142
R_{10}	4.34	43.4	18,450	1,445	1,301	144
Sub-Total	8.59	85.9	36,450	2,860	2,574	286
R_{11}	4.30	43.0	18,600	1,430	1,287	143
R_{12}	1.90	19.0	8,060	634	571	63
R_{13}	2.30	23.0	9,750	767	690	77
R_{14}	6.05	60.5	25,700	2,020	1,818	202
R_{15}	1.25	12.5	5,300	417	375	42
R_{16}	1.61	16.1	6,840	537	483	54
Sub-Total	17.41	174.1	74,250	5,845	5,260	585
I_1	2.00			3,000	2,400	600
I_2	1.16			1,740	1,392	348
I_3	5.32			21,250	17,000	4,250
Sub-Total	8.48			25,990	20,792	5,198
Others	8.54					
Grand Total	69.21	458.5	194,950	98,510	80,344	18,167
				83,190 (working)		
				15,320		

MAP OF ROAD NUMBER & AREA NUMBER

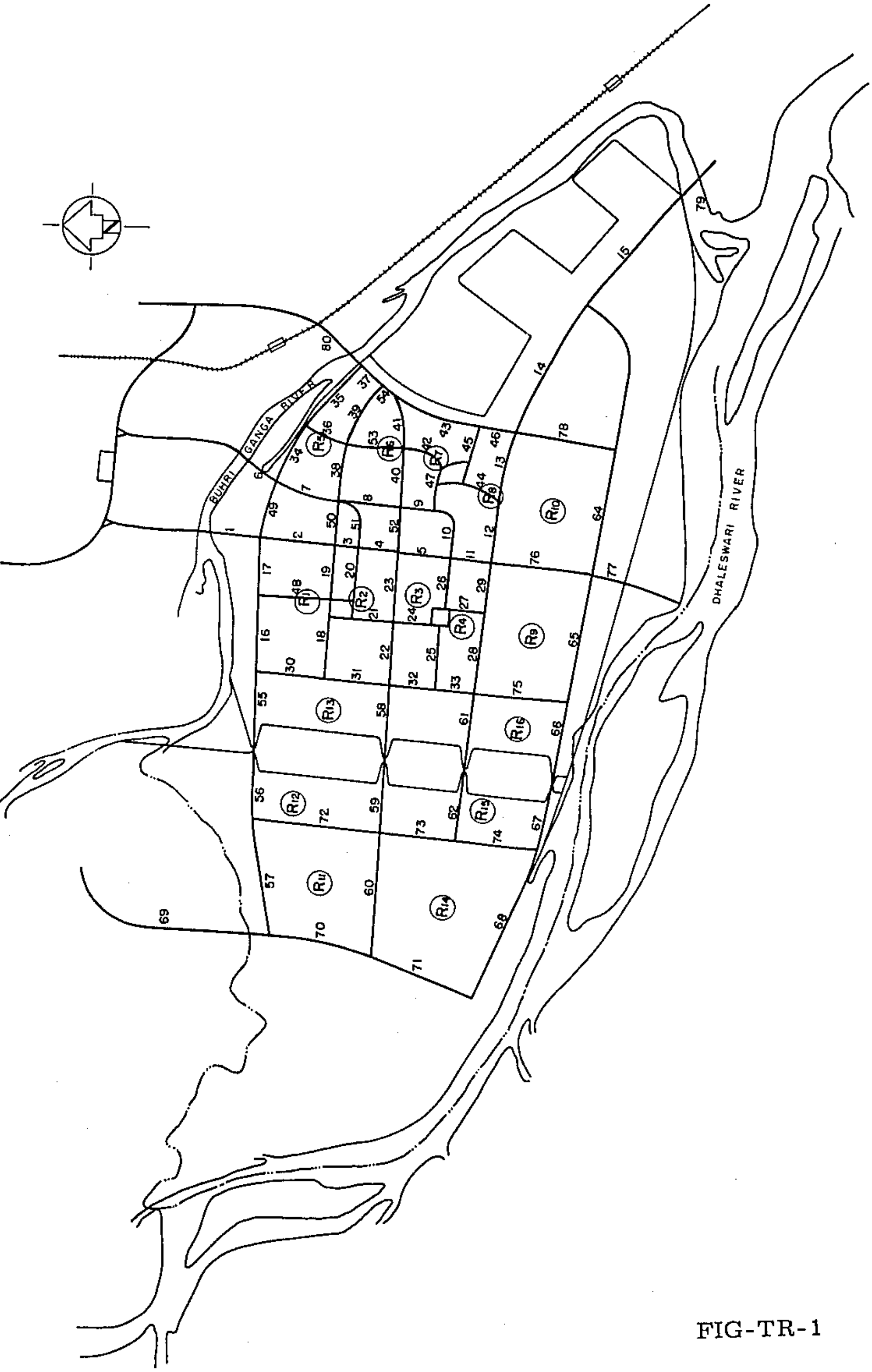


FIG-TR-1

(2) Working people classified by living area and working area of the planning.

Assumption:

1. The exployees in Keraniganj district shall be evenly distributed throughout this area.
2. However, the assumption (1) will be only acceptable for the houses and working places if both were completed at the same stage of the planning.
3. Those who not work in Keraniganj district are presumed to be employed in Dacca city. They are also considered in this planning to be evenly distributed in Keraniganj district.

The construction in Keraniganji district will be carried out to take three stages of plan. The progress in the construction of facilities will follow the table below.

	1st stage		2nd stage			3rd stage		
Civic center	23,000	42%	11,000	20%	62%	21,000	38%	100%
Circulation center	2,200	100	0	0	100	0	0	100
Heavy industry	0	0	2,840	60	60	1,900	40	100
Residential area	168,500	39	85,900	20	59	174,100	41	100

Table of distribution for commuting traffic by residential position

	Residential area	Civic center	Circulation center	Heavy industry	Light industry	Within residential area	Dacca city	Total
1st stage	R1	2,680	260			880	8,595	12,415
	R2	2,480	241			813	7,966	11,500
	R3	1,890	183			620	6,050	8,750
	R4	1,525	148			499	4,870	7,050
	R5	1,790	174			586	5,720	8,280
	R6	1,730	168			567	5,550	8,020
	R7	1,575	153			516	5,050	7,300
	R8	1,780	172			580	5,660	8,200
	RZ	2,780	266			900	8,800	12,720
	Sub total	18,230	1,765			5,961	58,261	84,235
2nd stage	R9	4,350	0	1,410	3,680	1,275	7,285	18,000
	R10	4,450	0	1,430	3,770	1,300	7,500	18,450
	Sub total	8,800	0	2,840	7,450	2,575	14,785	36,450

3rd stage	R11	5,175	0	469	3,140	1,290	8,256	18,600
	R12	2,285	0	207	1,500	570	3,498	8,060
	R13	2,770	0	251	1,820	690	4,219	9,750
	R14	7,300	0	661	4,800	1,815	11,125	25,700
	R15	1,500	0	136	988	375	2,300	5,300
	R16	1,940	0	175	1,270	483	2,972	6,840
	Sub total	20,970	0	1,899	13,788	5,223	32,370	74,250

IV. CLASSIFICATION OF TRAFFIC BY PURPOSE

The traffic occurred in Keraniganji District is generally classified as follows:-

(1) Going to office
(2) Going to school
(3) Shopping
(4) Social meeting
(5) Recreation
(6) Business
(7) Incoming material transportation
(8) Outgoing product transportation
(9) Delivery
(10) General transportation

The itemized (1) - (6) will be made by passenger car; (7) - (10) by cargo truck.

(1) & (2), The traffic flow will show a typical pattern of large peaks twice a day; one in the morning, the other in the evening, and the absolute number is large of all. The degree of concentration at the peak time is so high that it should give the largest factor to determine the road capacity where the car possession is rather prevailing.

(3), A certain pattern can be maintained. However, free from time binding, not so large degree of concentration will result. Moreover, it will hardly meet with the peak time of (1) and (2) in the morning. As for the peak time in the evening, it is independent but a small number of them will see the shopping people on foot in the neighbourhood.

(4) It is on the increasing tendency for the higher standard of living, but too irregular to be estimated.

(5) With the increase in income and leisure time, it is growing, but no regularity by time is not expected. Generally, this traffic flows the other direction from (1) and (2), so giving little influence on determining the road capacity.

(6)-(10) They may as well be called a business traffic as a whole. Very important is their qualitative meaning, and the congestion of it will be fatal to the business in Keraniganj District. The traffic concerning (7) and (8) differs from the kinds of factories in the area, but a certain definite pattern by time and direction. The Traffic in the circulation center has its destination in Keraniganj District, and mostly to Dacca

City. The traffic concerning wholesale market will occur in the early morning, but never join those going to office and school.

Since the analysis is not attempted at the evaluation of the qualitative traffic but the determination of given road width, the check-up on the main traffic at the peak times, that is, for the commuting and business traffic on given road section.

V. RELATION BETWEEN TRAFFIC FLOW AND ROAD

(1) Percentage of car possession

Dacca's car possession amounted to about 9,000 (including auto-rickshaw) as of 1962, when its population was approximately 600,000. The percentage of possession was 15 vehicles per 1000 heads. It is a well-known fact that the car possession is closely related with national income per head. (See Data 2.), but no smaller influence is made from the selling price and taxationoof cars.

In England and Japan, it is presumed that, no matter how high or low percentage of car possession a local town may be, that it should shift on a curve for a certain car possession rate. According to Japanese curve that will be applied theoretically for Pakistan, the future car possession rate in Keraniganj District will be:-

		All vehicles per 1000 heads	Passenger car per 1000 heads
1st stage	1980 year	180	120
3rd stage	2000 year	320	240

(2) Going to office by car

Of the family having a car, the number of trip by car to office is estimated at 0.75/vehicle/day at the first stage of the development, and down to 0.55/vehicle/day at the third stage, when some families possess a second or third car. However, in Dacca City where roads and parking spaces will not be able to be furnished as well as in the new Keraniganj District, the rate of trip by car is estimated 0.4/vehicle/day.

(3) Distribution by traffic media

Assumption:

1. Those who live within the distance of 0.5 miles to go to office shall be on foot for 100% of them.
2. Those who live within the distance of 0.5 upto 1 mile from office shall be on foot for 50% of them, by bycicle for 15%, and by car for 35%.
3. Those who live within the distance of 1 upto 1.5 miles from office shall be by bycicle for 15% of them, and by car 85%.
4. Those who live more than 1.5 miles away from office shall be by car for 100% of them.

5. Of those covered in (1) through (4) using cars:

1st stage: 32% by car and 68% by bus.
3rd stage: 27% by car and 73% by bus in Dacca City.
37% by car and 63% by bus in Keraniganj District.

At the first stage, the owned cars are 1,200, compared to 4,250 persons per bus for 1 km^2. Consequently, in case that the average number of people aboard a car is 1.5 (1st stage) and 1.2 (3rd stage), the percentage of those going to office by car will be given:

1st stage: 1,200 x 1.5 x 0.75/4,250 x 100 = 32%
In Dacca City: 240 x 1.2 x 0.4/4,250 x 100 = 27%
In Keraniganj District: 240 x 1.2 x 0.55/4,250 x 100 = 37%

		Traffic media	Distance from office (mile)			
			0～0.5	0.5～1	1～1.5	Over 1.5
1st stage		On foot	100%	50%	0	0
		Bicycle	0	15	15	0
		Car	0	11	27	32
		Bus	0	24	58	68
3rd stage	Dacca city	On foot	100%	50	0	0
		Bicycle	0	15	15	0
		Car	0	9.5	23	27
		Bus	0	25.5	62	73
	Keraniganj district	On foot	100%	50	0	0
		Bicycle	0	15	15	0
		Car	0	13	32	37
		Bus	0	22	53	63

(4) Traffic volume except that for commuters in 3rd stage.

4-1. Traffic in the residential areas.

(a) Footway

Residence center: 2 times/day/family = 2 times/day/4 heads
Neighbourhood center: 1 time/day/family = 1 time/day/4 heads

In the neighbourhood center, the objective population is made at 40,000 upto 60,000, and the traffic on foot 40,000 upto 60,000 x 1/4 = 10,000 upto 15,000.

a-1. The population of the suburbs for the neighbourhood center, mostly out from the residence center, will be given:

10,000 x 1/4 = 2,500

a-2. In case of the concentration rate at the peak time per hour being 22%, 30,000 upto 35,000 x 0.22 = 0.66 upto 0.77 (ten thousand people) per hour.

a-3. Taken that the approaches are made in four directions, it will be 1,600 or 2,000 per hour. The width of road in all directions would be enough to be 1.5 m. However, the roads are planned to be 15 upto 20 m wide along with flower beds and trees, being prospected over the future expansion of traffic. (See Data 5.)

The objective population at the residence center is 10 or 15 thousand, and the width of roads will be adequately given to be equivalent to those of the approaches to the neighbourhood center.

(b) Distribution road

b-1. Car: The trip occurred in individual families, including that for commuters is estimated at 2.9 trip/day/family; 0.55 of it for commuters, 0.55 for their return to home, and the rest 1.8 trip occurred in daytime. From the standpoint of its occurrence that is 0.9 trip, and if the concentration rate per hour is given 13%, the peak-time traffic density except for commuters would be: 40,000 upto 60,000 x 2,400 x 0.9 x 0.13 = 1,250 upto 1,880 vehicles/hours. The number of cars possessed is given:

3,200 x 3/4 = 2,400 vehicles per 10,000 heads.

On the other hand, the peak-time traffic density of commuters: 40,000 upto 60,000 x 2,400 x 0.55 x 0.5 = 2,640 upto 4,000 vehicles/hours.

Car traffic for business purpose occurred in the facilities within the residential area: 670 vehicles/floorage (ha.) Provided that one employee is given for 30 residents and that he occupies 40 m^2 of floor area: 40,000 upto 60,000 x 1/30 x 40/10,000 x 670 = 3,560 upto 5,250 vehicles/day = 780 upto 1,150 vehicles/hour.

b-2. Cargo truck

Provided that the trip made by trucks engaging in delivery work is 0.6 trip per house/day and that the peak-time concentration rate is 22%:-

40,000 x 60,000 x 0.6/4 = 6,000 upto 9,000 trip/day = 1,320 upto 2,000 vehicle/hour.

The number of trucks into the shopping center is 0.4 vehicles/m^2, and the shop floorage 2,000 m^2 per 10,000 heads: 40,000 upto 60,000 x 0.4 = 3,200 upto 4,800 vehicles/day = 480 upto 720.

b-3. Bus: The number of commuters is 4,250 out of 10,000 inhabitants, and 2,760 of them estimatedly take bus. Provided that the peak-time concentration rate is 50%, and that 50 persons can be aboard a bus on the average, (here presumed that about double number of capacity aboard a bus):

40,000 upto 60,000 x 2,760 x 0.5 - 50 x 2 = 221 upto 331 vehicles.

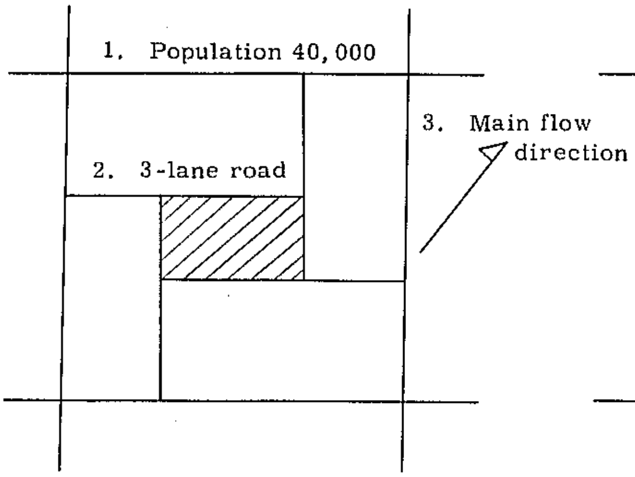
b-4. Traffic demand on distribution road

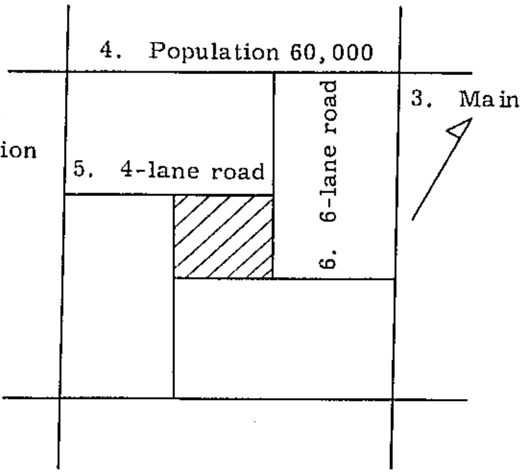
In each community surrounded by the truck roads, a distribution route is designed on each of 4 lines to make a right angle respectively with the trunk road. To prevent the through traffic from flowing into the community, 4 distribution roads coming up to the community center should so met to each other as to make a three-forked intersection. The distribution roads directing in the main traffic flow should afford 1/3 of the whole traffic occurred in the community. On the other hand, those running in such directions as the least traffic demand is expected, should be designed for the capacity of treating 1/4 of the whole traffic volume.

Capacity on distribution road in main flow direction $\frac{2,600 \sim 4,000}{3}$ = 870 ~ 1,350 vehicles/hour

Capacity on distribution road in minimum flow direction $\frac{2,600 \sim 4,000}{4}$ = 650 ~ 1,000 vehicles/hours

Therefore, the width of distribution roads would be enough to be 4-lane wide in the main flow direction and 3-lane in the minimum flow direction. The layout of the distribution roads are given as follows:-





(5) Main traffic roads

5-1. Traffic demand

Fig-TR-2 and 3 show the peak-time traffic distribution density per hour of the commuters. In the civic center and its neighbourhood where non-commuting traffic is estimated at about 3/4 times as the commuting traffic even in the residential area, the traffic density of business and shopping is very large, and often amounts to the equivalent to that of commuting traffic. Especially, the business routes connecting the downtown of Dacca City and the civic center of the new town plays a vital part in quantity and quality, which should be given a higher priority in consideration.
Here in it lies the significance of the design that the traffic route No. 10 was not drawn to run straight from north to south. It is also because this important business traffic should not be disturbed by any through traffic occurred between Dacca City and the south side portion of the Dhaleswari River.
The proposed route extending to the bridge in the east end area also is provided the

ESTIMATED FUTURE TRAFFIC FLOW - STAGE I

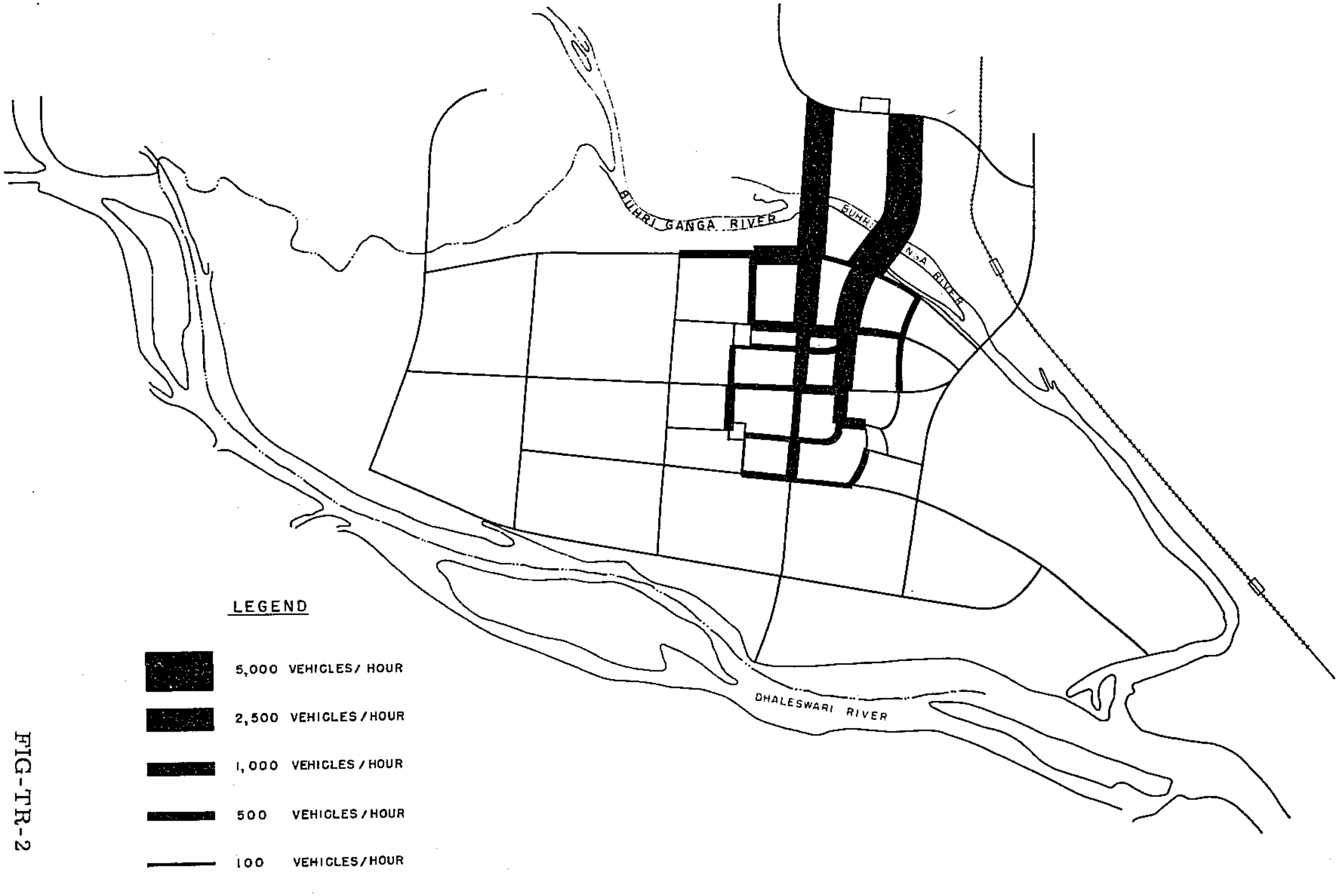


FIG-TR-2

ESTIMATED FUTURE TRAFFIC FLOW - STAGE II

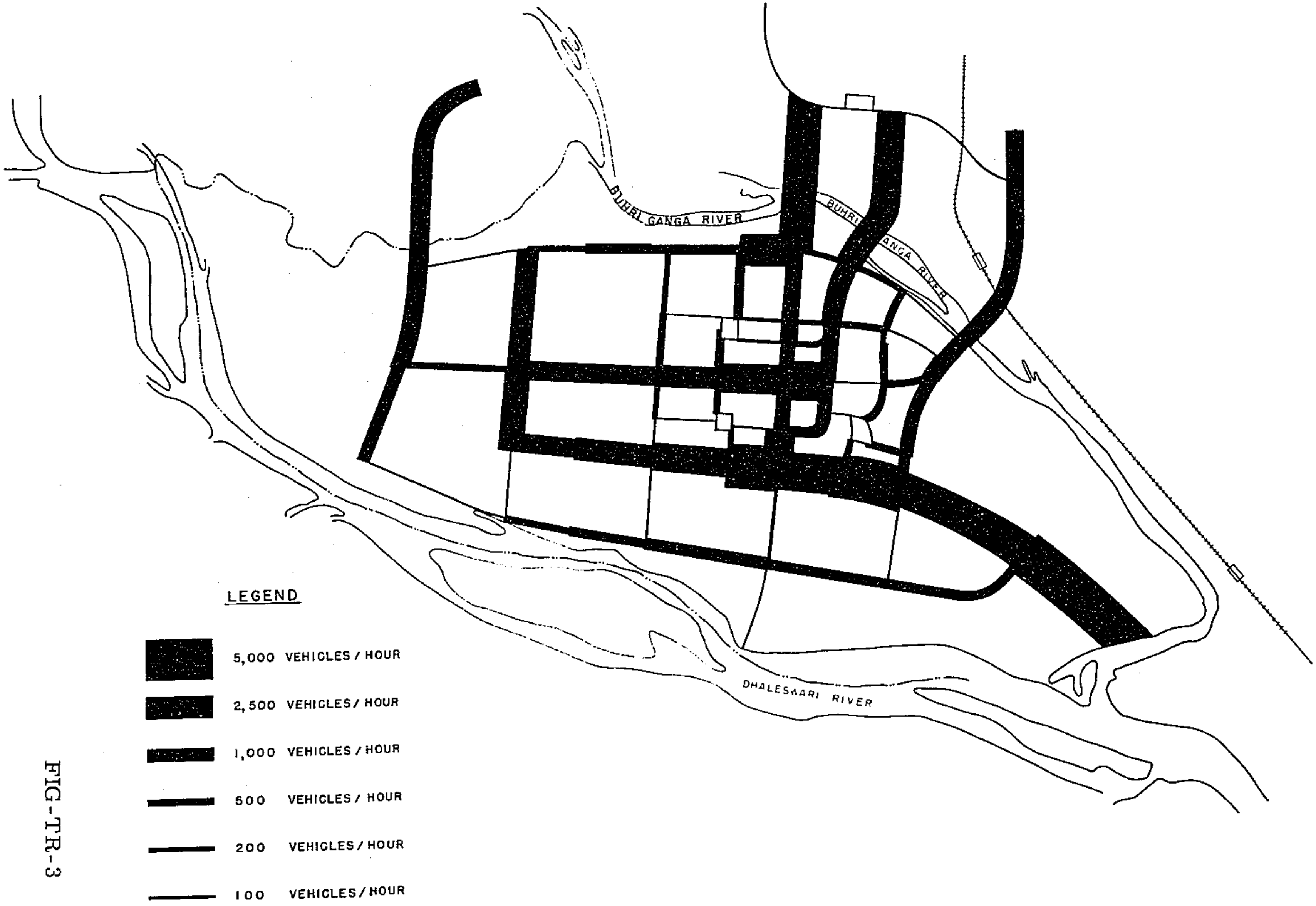


FIG-TR-3

ROAD MAP

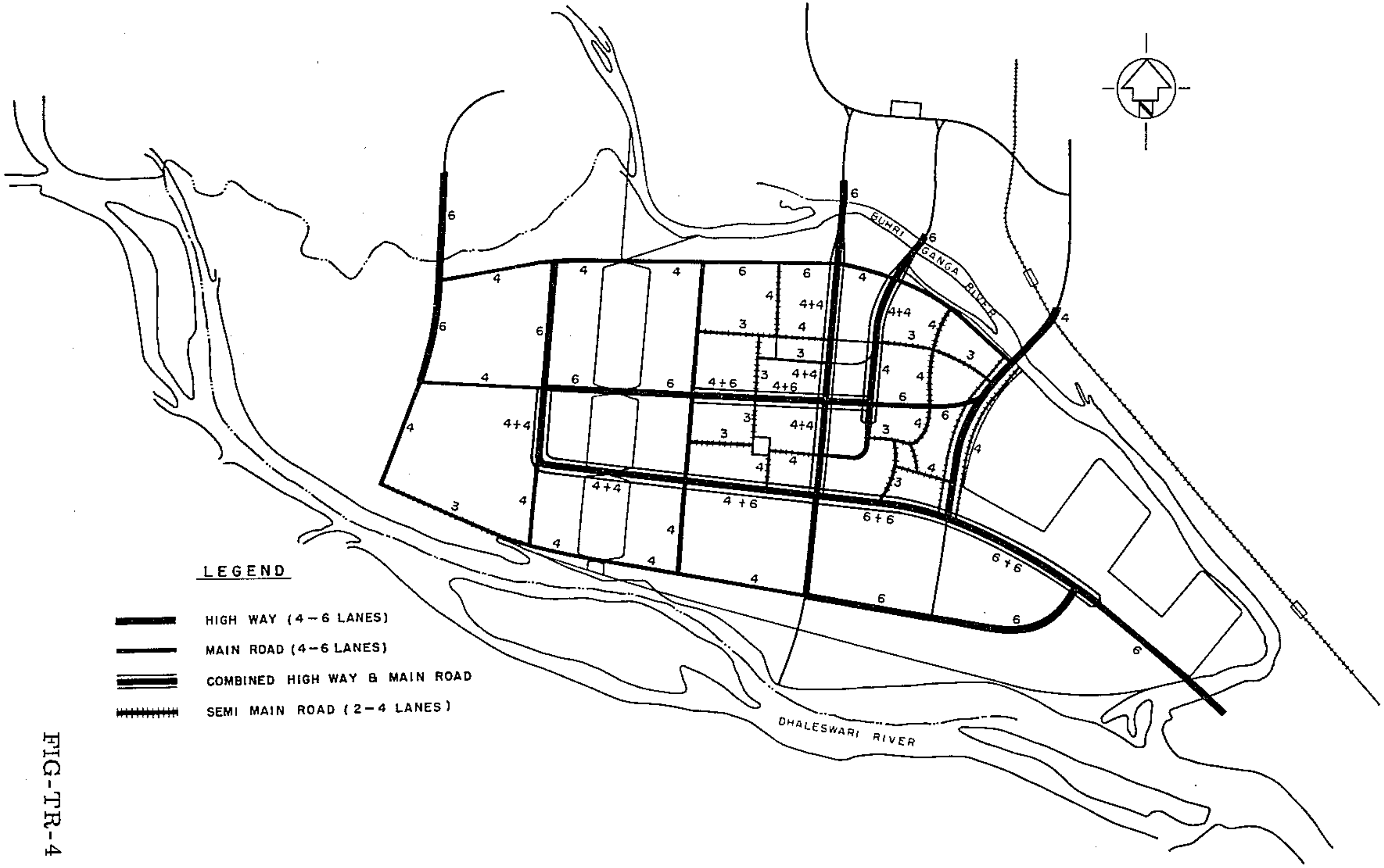


FIG-TR-4

capacity to exclude the traffic between the new industrial zone, Narayanganj and Dacca from the civic center.

5-2. Classification of main streets

(a) Speed highway within the new town: The planning is intending to make a perfect separation of the outgoing traffic and the incoming one, and a restriction posed on the in-and-out flow. The design velocity is set at 100 km/h.

(b) Main street: It is to make a perfect separation of the outgoing traffic and incoming one, and a partial restriction on the in-and-out flow. The design velocity at 80 km/h.

(c) Transit street: No separation is attempted at the outgoing traffic and incoming one, but a partial restriction on the in-and-out flow. The design velocity: 50 km/h.

(d) Block street: The restricted velocity is below 30 km/h. No sidewalk is constructed.

(e) Driveway and footway: Separated from the above (a), (b) and (c), the special roads are to be constructed for their intended purposes.

5-3. Width of driveway and number of lanes.

(a) and (b), Speed highways and main streets, are designed to be 12' wide for a lane, and the number of lanes will be made 4 or 6, depending on the traffic demand respectively.

(c) The distribution streets are 11' wide for a lane, and the number of lane is 3 or 4.

(d) The block streets are 11' wide for a lane, and the number of lanes is 2.

(e) The driveway is 11' wide for lane, and the number of lanes is 2 in principle.

5-4. Median zone

The median zone to be constructed on (a) and (b) is set at 14' wide in principle, but it may become narrow to be 4' on the elevated structure on the routes.

5-5. Shoulder or border

a. 10' on the speed highways
b. 10' on the main streets
c. 12' on the distribution streets
d. No shoulder on the block streets

5-6. Traffic capacity

The traffic capacity per lane will be given as follows:-

Speed highway:	1,400 vehicles/h.
Main street:	1,200 v/h with a partial in-and-out flow restriction. 600 v/h.
Distribution street:	600 v/h.
Block street:	200 v/h.

5-7. Composition of road width

In order to mitigate the noise and exhausted gas, the green belt will be constructed alongside the following roads.

(a) Speed highway

(b) Trunk road

5-8. Intersection

The construction of intersections will follow the methods principally as listed below, but a versatile design will be drawn up according as the traffic density changes in respective flow directions.

	a	b	c	d
a. Speed highway	Perfect interchange	Interchange Grade separation roundabout		
b. Trunk road		Grade separation roundabout Roundabout	Trumpet Roundabout Training system	
c. Distribution road			Signal	Sight distance secured Signal
e. Block street				Sight distance secured

VI. COST OF ROAD CONSTRUCTION

(1) Unit cost of road construction

	Unit cost per 1 km of length (in 1,000 dollar)
Speed highway, 6-lane	445
Speed highway, 4-lane	211
Trunk road, 6-lane	205
Trunk road, 4-lane	150
Distribution road, 4-lane	100
Distribution road, 3-lane	83
Interchange 1	149
Interchange 2	180
Interchange 3	890
Interchange 4	278
Interchange 5	613
Interchange 6	1,810

The unit costs shown in the list include those for fill-up, roadbed, subgrade, pavement of lane shoulder, surface drainage facilities, lighting and signal facilities, etc. It is estimated on the conditions that the interchange 3 will be elevated almost all the way and the interchange 6 for about about a half way of the total length.

(2) Cost of road construction

1st stage	Length (km)	Width (m)	Area (ha)	Unit cost (in $1000/km)	Construction cost (in $1000)	Note
Speed highway, 6-lane	1. 6	31. 5	5. 0	305	489	
Speed highway, 4-lane	3. 4(11. 1)	24. 5	8. 3(27. 2)	2, 110	755	
Interchange				149	695	
Trunk road, 6-lane	0. 9(10. 9)	27. 5(7)	2. 5(7. 7)	206 206	189	
Trunk road, 4-lane	28. 2	20. 5	57. 8	150	394	
Distribution road, 4-lane	11. 0	21. 0	23. 1	143	156	
Distribution road, 3-lane	9. 9	17. 75	17. 6	117	115	
Total	55. 0	152. 9			2, 793	

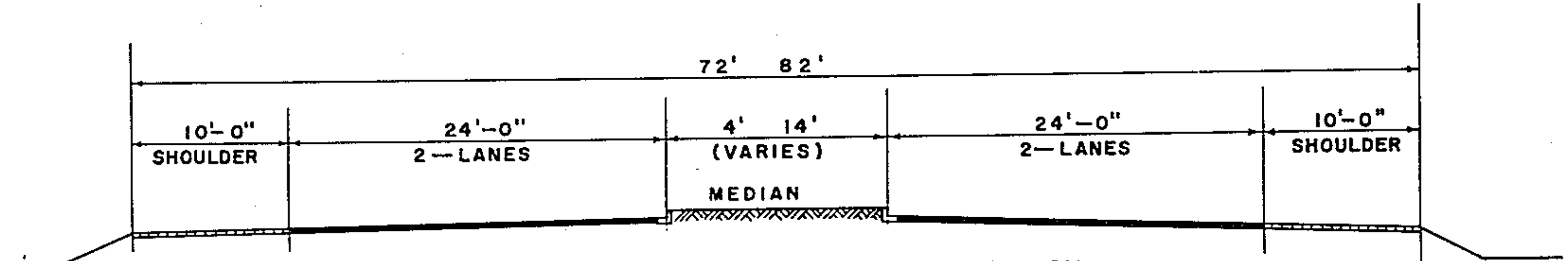
3rd stage

Speed highway, 6-lane	3. 2	31. 5	10. 1	305	988	
Speed highway, 4-lane	15. 4	24. 5	37. 8	222	3, 420	
Interchange		320 x 2 + 650 x 1 + 100 x 3 + 50 x 4			5, 050	
Trunk road, 6-lane	23. 9	27. 5	65. 6	211	5, 070	
Trunk road, 4-lane	23. 6	20. 5	48. 4	150	3, 550	
Distribution road, 4-lane	10. 1	21. 0	21. 2	143	1, 460	
Distribution road, 3-lane	10. 1	17. 75	17. 9	117	118	
	10. 9	7. 0	–	69	755	
Total	97. 2		210. 2		20, 411	

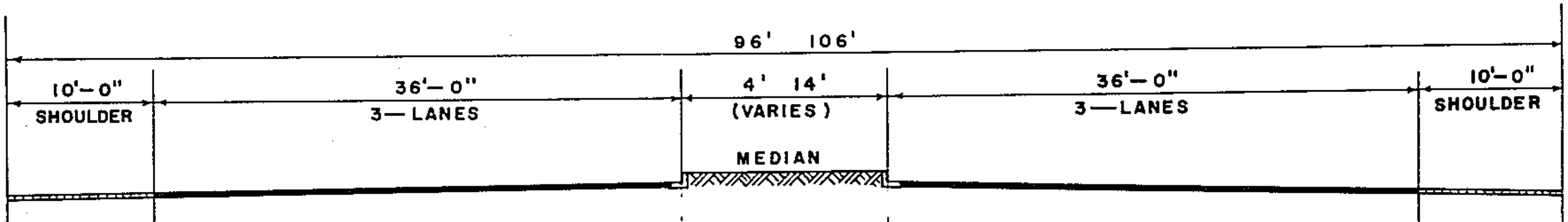
* The length and construction cost of the 3rd stage is given by deducting those corresponding to the 1st stage from the whole plan.

* As for the speed highways that are not to be construction due to few traffic volume but to secure their site only at 1st stage until 2nd and 3rd stages, and those 4-lane roads scheduled for future expansion into 6-lane ones, the areas of sites to be prepared are given in the parenthesis in the column of 1st stage's list.

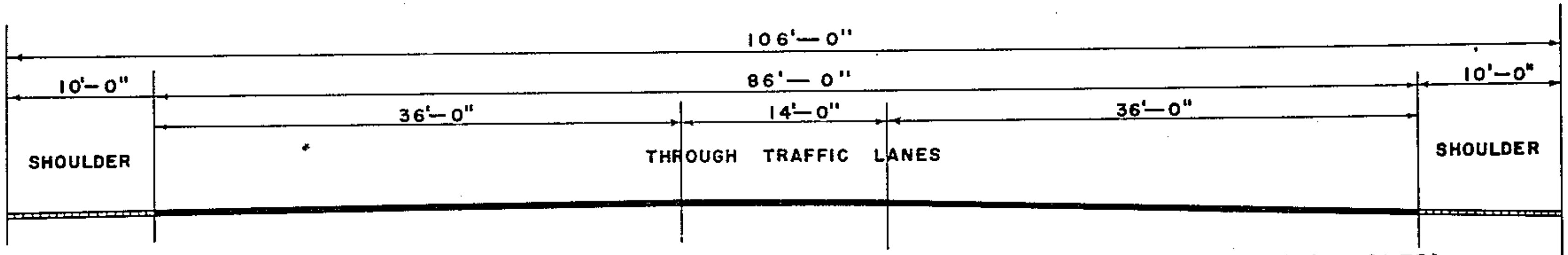
TYPICAL HIGHWAY SECTIONS



SECTION OF 4 LANES HIGHWAY



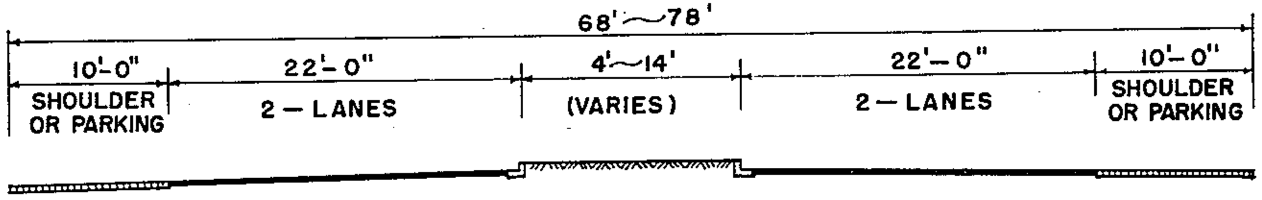
SECTION OF 6 LANES HIGHWAY



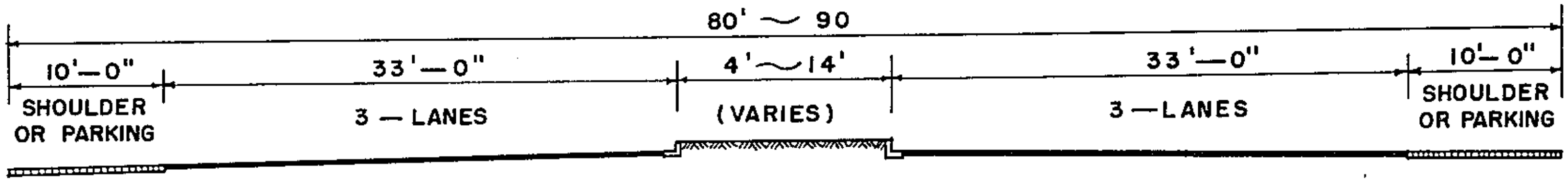
SECTION OF 6 LANES HIGHWAY (THROUGH TRAFFIC LANES)

FIG-TR-5

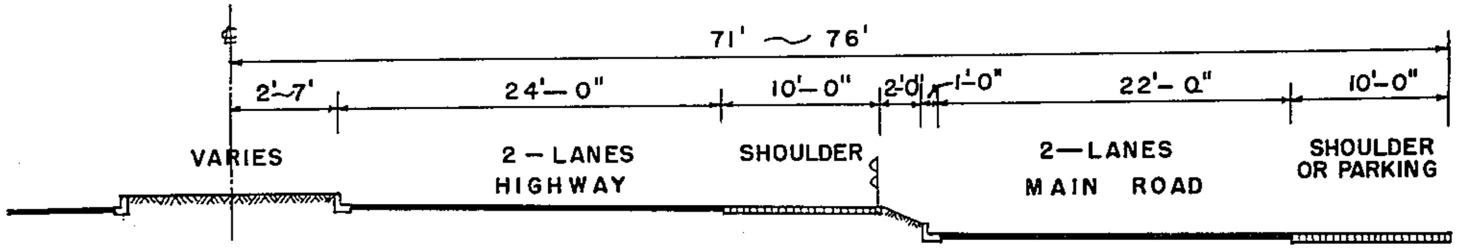
TYPICAL ROAD SECTIONS



SECTION OF MAIN ROAD (4-LANES)



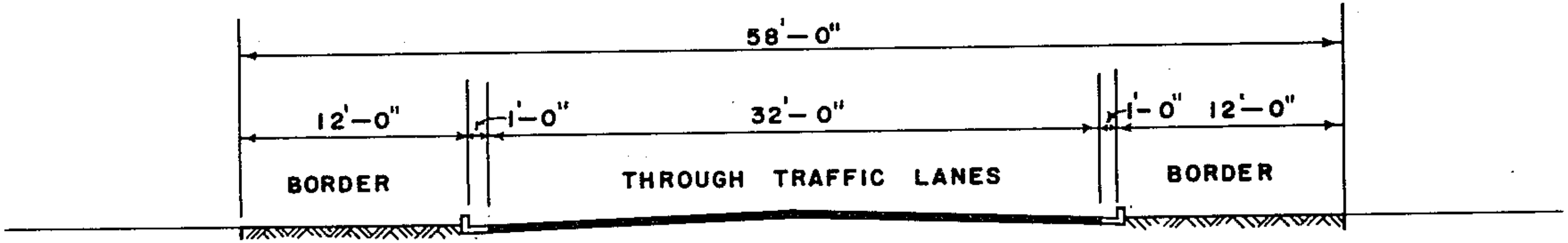
SECTION OF MAIN ROAD (6-LANES)



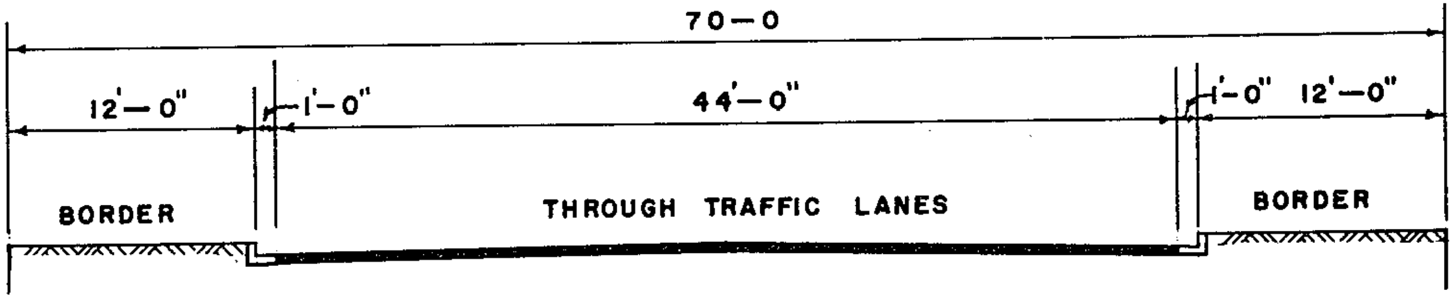
SECTION OF COMBINED HIGHWAY & MAIN ROAD

FIG-TR-6

TYPICAL SEMI — MAIN ROAD

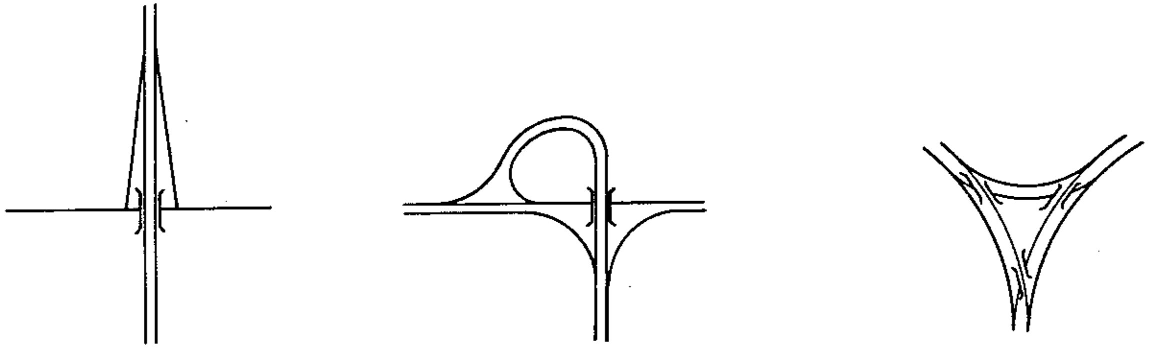


SECTION OF SEMI—MAIN ROAD

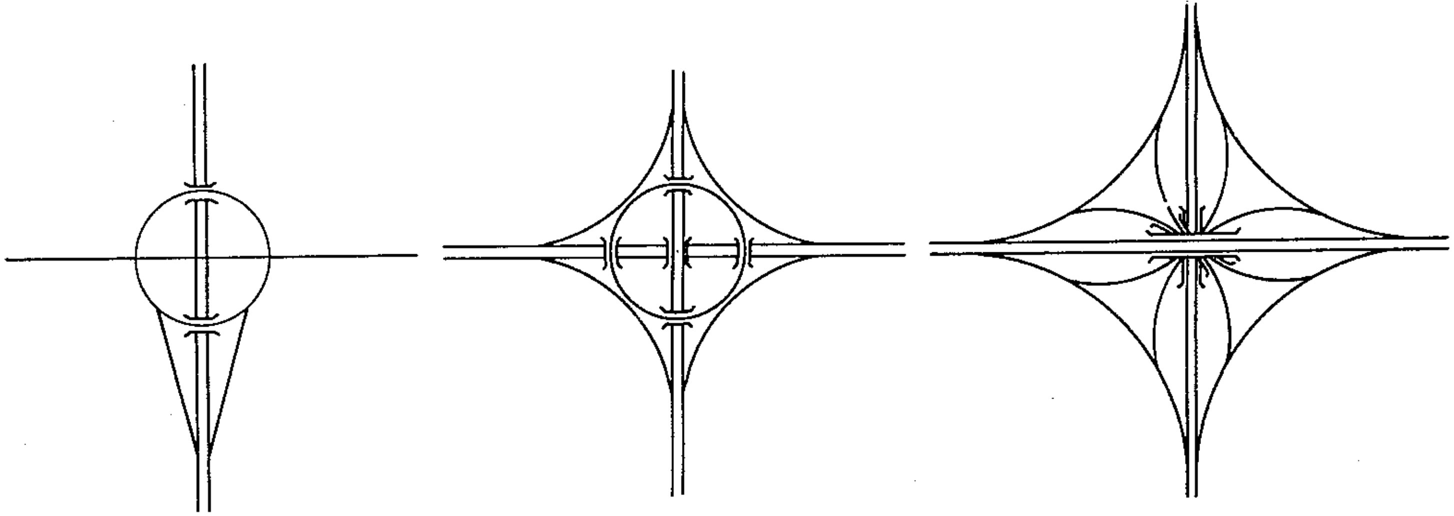


SECTION OF SEMI — MAIN ROAD (4 LANES)

FIG-TR-7



1. DIAMOND 2. TRUMPET 3. DIRECTIONAL—Y



4. DIAMOND & CIRCLE 5. DIRECTIONAL / CIRCLE 6. CLOVER LEAF

HIGHWAYS — INTERCHANGES

FIG-TR-8

SECTION 3. SEWERAGE SYSTEM

(1) Basic idea

Since the new town construction area is situated between the Burhiganga River and the Dhaleswari River, it is advantageous from an economical point of view that the drainage project would be carried out in a separate drain system for sewerage and rainwater respectively. Taking into consideration the developing stage of the new town construction and the topographical features, the sewerage will be devided in two parts: One is to cover the south half area that will be called the Burhiganga draingage area, and the other to take the north half that will be referred to as Dhaleswari drainage area. The sewerage treatment plants will be constructed in each area to finally discharge the treated sewerage into two rivers.

(2) Sewerage

2-1. Estimate on sewerage amount

(a) The population density is estimated at 140 per hectre in the residential areas. The same density will be presumably applied for the areas where a future expansion is expected and for the ones not designated in the planning at present stage. The average water supply per head a day (1961) of the principal cities in the world is such as shown in the Table 1. As to the project area of the planning, peculiar in its climate and temperature, the maximum sewerage amount is estimated at 300 1 per head a day; the maximum sewerage amount per hour at 600 1.

Table 1, Average Water Supply per head a day
of world's principal cities 1961

	Water supply(1)
Chicago	870
Los Angeles	715
New York	570
London	250
Rome	200
Yokohama	430
Osaka	430
Nagoya	350
Tokyo	340

(b) In the business center and commercial center where many buildings are made high-storied, the sewerage is estimated at about double as in the residential area.

(c) In the parks, green belts and parking spaces, the sewerage is 10% of that in the residential area.

(d) The water consumption in the industrial zone will depend on the kind of factory to be established in the boundary. In the meantime, the kind of industry is not designated yet in the planning, so the water consumption is estimated temporarily at 600 1 a day per hectre. Since the industrial zone is planned to locate around the junction of the Burhiganga River and the Dhaleswari River, a half of sewerage out of the zone can be let out as natural effluents into two rivers.

Table 2 indicates the mean value of the intake of industrial water, classified by the kind of industry in Japan.

Table 2: Intake of Industrial Water, classified by kind of industry

Kind of Industry		Intake of Water (l) per ha of site
Foodstuff:	Sugar refinery	3,136
	Fresh drink	1,288
	Marine product	1,611
Textile:	Filature	1,639
	Chemical fiber	2,040
	Flaxen fiber	214
	Rayon	1,278
Paper-making:	Pulp	1,741
	Paper	1,374
Chemicals:	Nitro-lime	656
	Phosporic acid	517
	Synthetic resins	120
	Fermentation	576
	Oil	2,426
	Rubber	1,339
	Cement	2,878
	Fire-proof materials	1,687
Steel:	Blast furnace	768
	Steel manufacture & rolling	438
	Cast iron & casting	90
Electric machinery:	Generater, transmitter & transformer	80
	Electric wire & cord	241
Transportation machinery:	Automobile parts	474
	Light automobile	40
	Shipbuilding	25
	Rolling stock	47
	Thermal power generater	2,167
	Gas	853

2-2. Sewerage drainage system

The slopes of the Burhiganga River and the Dhaleswari River are very slow to be 1/15,000 1/25,000. The land reclamation of new town, the fill-up method will be carried out up to the elevation with some allowance added on the highest water level

(H. W. L.). Furthermore, in the final design, the new town area will be reclaimed with about same slope in the east-to-west direction as the rivers, and a certain slope given in the north-to-south direction to the rivers, too.

The layout of main drains shall be determined with the deliberation given to not only the first stage planning but the second stage and future expansion planning. The sectional type shall also be determined to effect a gradual decrease of slope (1% 0.7%) and a gradual increase of flow velocity (about 1.00 m/sec 1.5 m/sec). An easy work for maintenance and control is an important factor to determine the sectional type of drain.

The estimate on the section for main drainage is such as shown in the next table.

From a viewpoint of the slope concerned, 2 or 3 transmitting pump stations shall be constructed at the places where the main drains lie underground 5 or 6 meter deep.

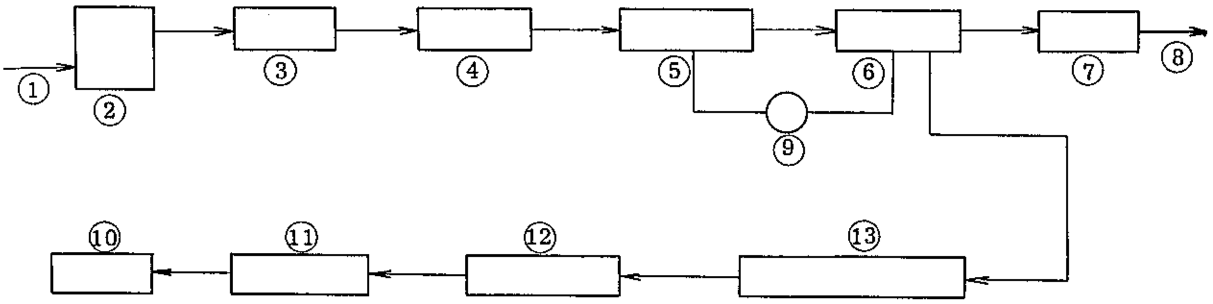
2 – 3 Estimate on main sewerage section

Name of area	Area km^2	Sewerage amount, l/sec	Sewerage amount added with underground-water, l/sec	Aggregated sewerage amount, l/sec	Section of drain, m^2	Flow volume, m^3/sec	Flow velocity, m/sec	Slope	Note
Burhiganga Drainage area									
E1	5.15	361	433	433	φ0.90	0.58	0.91		
R11	4.30	301	361	794	φ1.10	0.99	1.04	1.0	
R12	1.90	133	160	954					
R13	2.30	161	193	1,147	φ1.30	1.55	1.17		
R1	2.93	205	246	1,393					
R2	2.71	191	229	1,622					
E3	2.16	151	181	1,803					
R3	2.06	144	173	1,976					
R4	1.66	116	139	2,115	1.50x1.50	2.55	1.29		
P1	1.02	7	8	2,123				0.7	
Pk	0.32	2	2	2,125					
B1	0.54	76	91	2,216					
R5	1.95	137	164	2,380					
R6	1.89	132	158	2,538					
C1	0.71	99	119	2,657					
R7	1.72	120	144	2,801					
R8	1.93	135	162	2,963	1.80x1.80	4.14	1.45		
Total	35.25		2,963						
Dhaleswari Drainage area									
E2	3.01	217	260	260	φ0.80	0.42	0.83		
R14	6.05	424	509	769					
M2	1.25	88	106	875	φ1.20	1.25	1.11		
P3	1.12	8	10	885				1.0	
R15	1.25	88	106	991					
P2	1.52	10	12	1,003					
R16	1.61	113	136	1,139	φ1.30	1.55	1.17		
R1	4.25	298	358	1,497					
M3	1.51	106	127	1,624				0.7	
R10	4.34	304	365	1,989					
M4	2.33	163	196	2,185	1.65x1.65	3.24	1.37		
C2	1.10	154	185	2,370					
I1	2.00	700	840	3,210					
I2	1.16	406	487	3,697					
I3	5.32	1,862	2,234	5,931				0.7	
M1	2.26	158	190	6,121					
P4	1.78	12	14	6,135					
				(3,950)	2x1.50x1.50	5.10	1.29		C2 P4
Total	41.86		6,135		2.25x2.25	7.47	1.67		
Grand total	77.11		9,098						

2-4. Sewerage treatment plant

One each sewerage treatment plant will be constructed for Burhiganga drainage area and Dhaleswari drainage area. It is desirable that the structures in the plant should be laid at the intervals wide enough to make green-belted parks among them.

There are two kinds of treatment method; one is by the activated sludge process, and the other in the intermittent filter bed method, and here in the planning the former method is adopted. In the treatment plants where the terminal drain pipes of main sewerage flows go deep underground, the sewerage pumping stations will be necessarily constructed. A diagram of the active mud method is shown as follows:-



1. Inflowing sewage
2. Sewerage pump
3. Screening or crusher
4. Preliminary sedimentation tank
5. Aeration
6. Final sedimentation basin
7. Pasturizing room Chlorinating room
8. Outflow into river
9. Sludge returning pump
10. Sludge condensation tank
11. Sludge digester
12. Evaporation & Drying beds
13. To refuse dumping yard

2-5. Construction cost (for sewerage drainage facilities)

(a) Whole project

a-1. Amount of drain pipe

Kind	Length(m)	Unit cost $	Total cost $	Remarks
Main drainage (ϕ600 1,800x1,800^{mm})	38,000	83	3,100,000	
Auxiliary main drainage (ϕ400 600mm)	175,000	13	2,430,555	
Branch drainage (ϕ250 300^{mm})	942,000	8	7,850,000	
Total	1,155,000		13,447,222	ab. 150 m/ha

a-2. Amounts of facilities in treatment plants.

Name of plant treatment	Treatment amount(t/day)	Unit cost $	Total cost $	Remarks
Burhiganga treatment plant	259, 000	55	14, 388, 888	Drainage area 3, 525 ha
Dhaleswari treatment plant	530, 000	55	29, 444, 444	Drainage area 4, 186 ha
Sub total			43, 833, 333	7, 711 ha
Grand total			57, 280, 555	

(b) 1st stage plan

b-1. Amount of drain pipe

Kind	Length(m)	Unit cost $	Total cost $
Main drainage (1, 500x1, 500 1, 800x1, 800)	6, 300	125	787, 500
Auxiliary main drainage (ϕ400 600)	83, 700	13	1, 162, 500
Branch drainage (ϕ250 300)	505, 000	8	4, 208, 333
Total	595, 000		6, 158, 333

b-2. Amount of facilities in treatment plants

Name of plant treatment	Capacity (t/day)	Unit cost $	Total cost $
Burhiganga treatment plant	259, 000	55	14, 388, 888
Sub total			14, 388, 888
Grand total			20, 547, 222

SANITARY SEWER SYSTEM

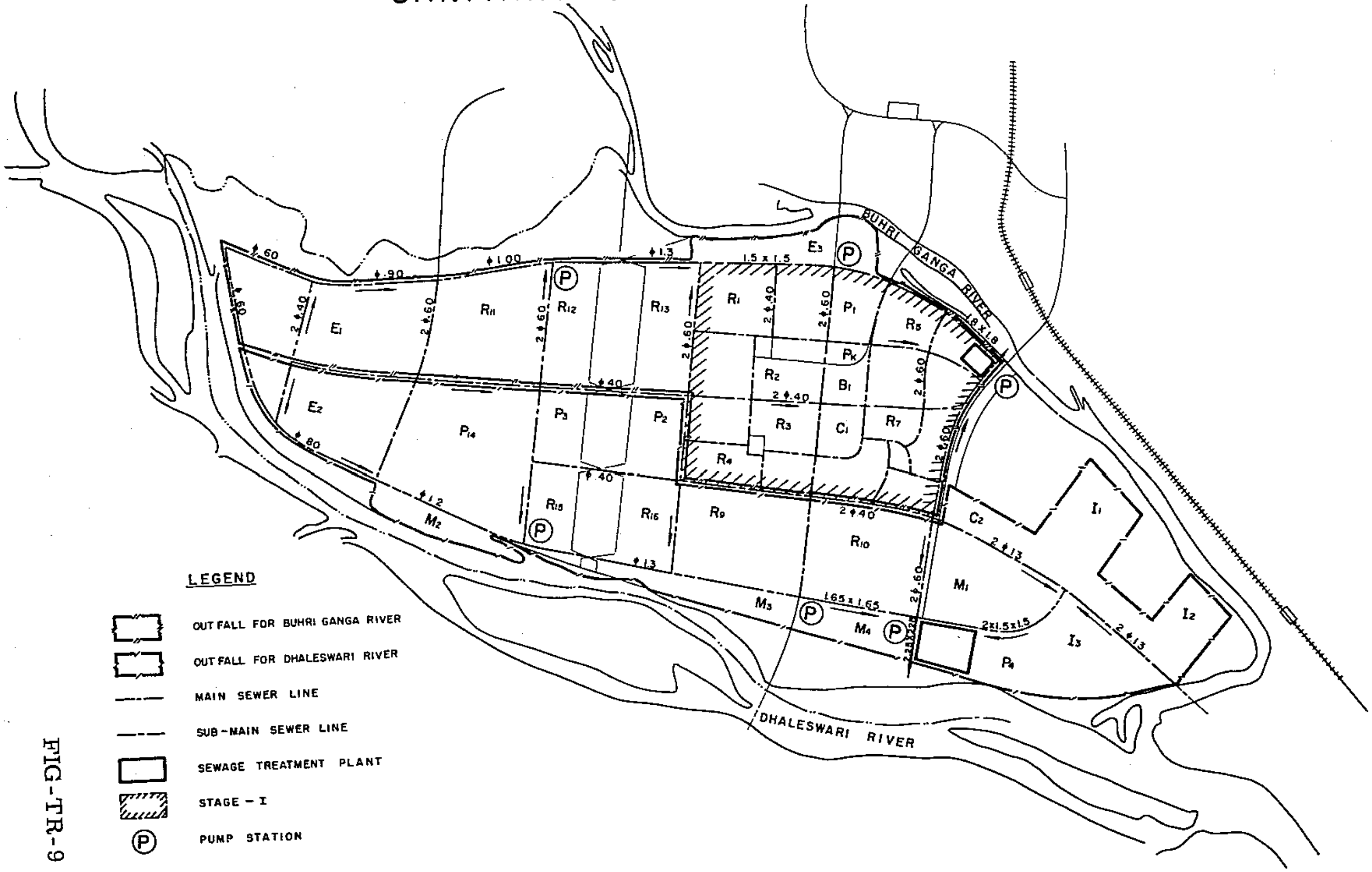


FIG-TR-9

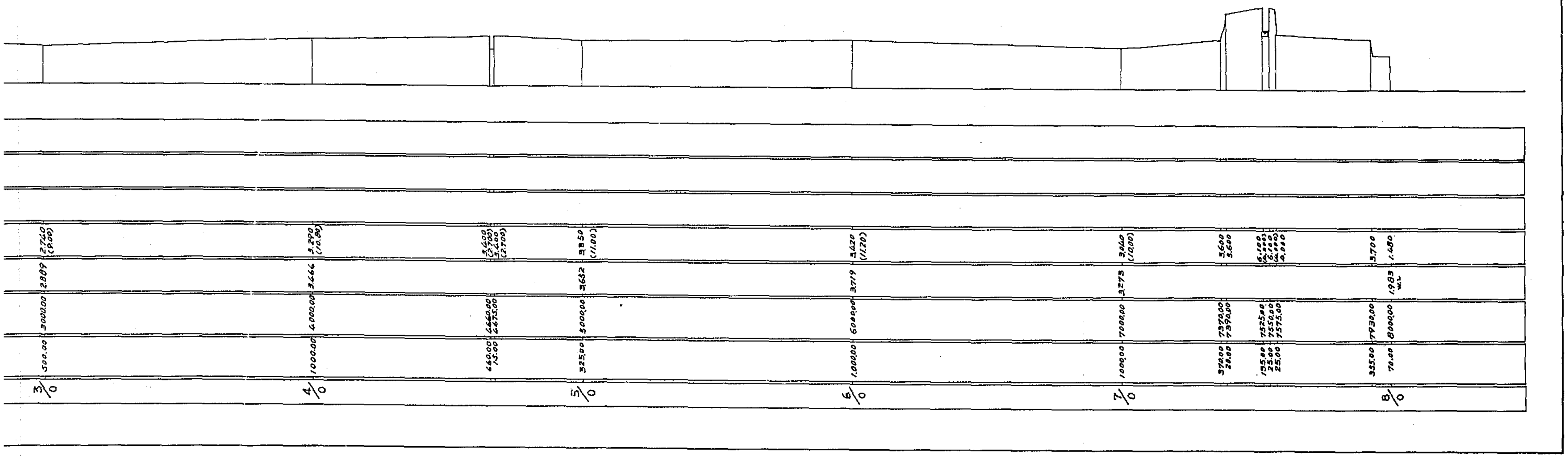
APPENDIX

NEW DACCA CITY PLANNING AREA MAP

PROFILE OF PROJECT AREA KERANIGA

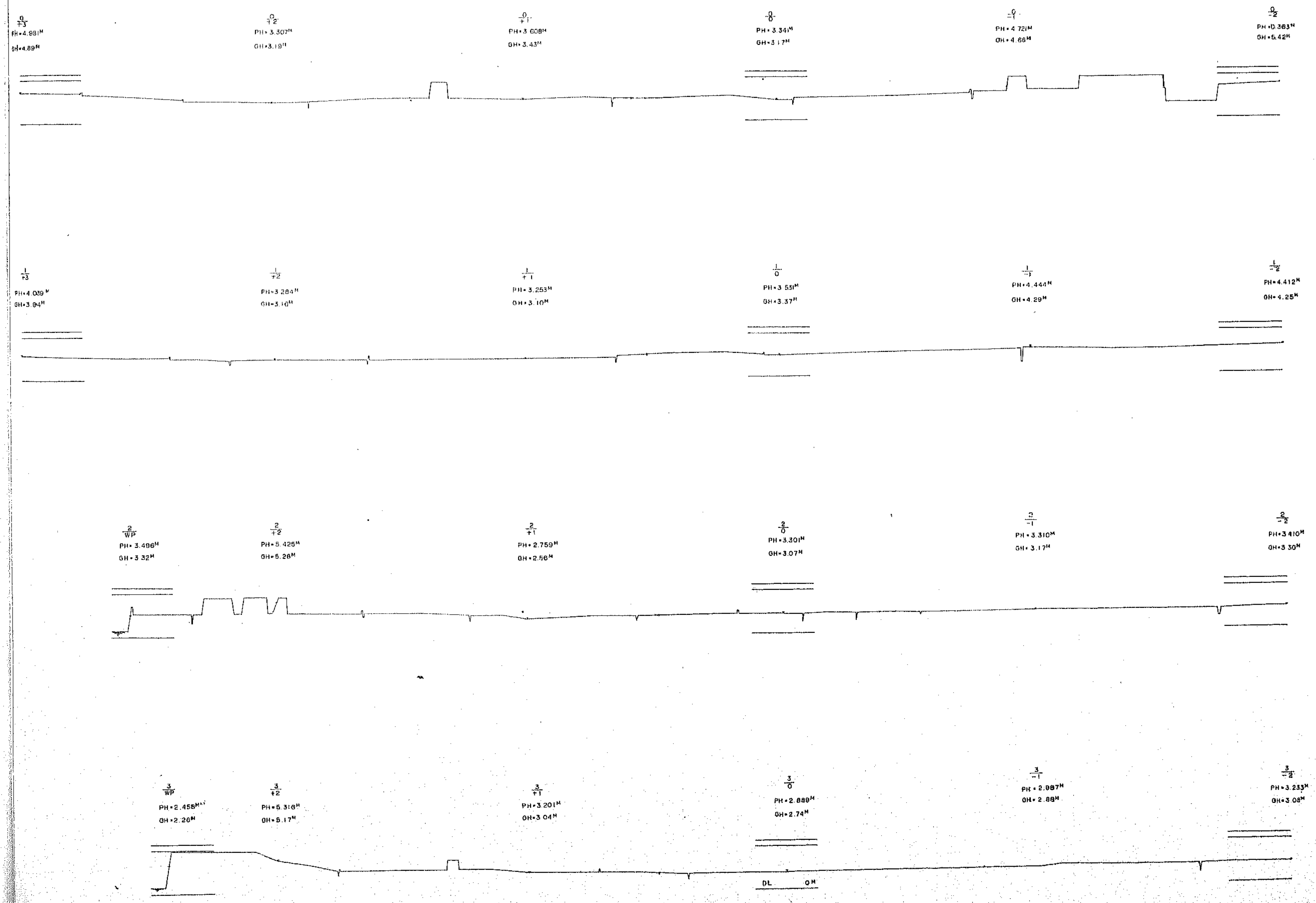
FIN. EL. 計画高										
GL. 地盤高	3.170 (10.4)	3.000 2.000 2.200 3.200	3.370 (11.11)	4.000 5.800 5.000 4.100 5.600 5.600 4.200	3.070 (10.10)	3.200 (1.800) 3.200 (1.800)	2.740 (9.00)	3.290 (10.80)	3.400 (2.700) 3.400 (2.700)	3.350 (11.00)
TOP EL. OF STICK 杭高	3.341		3.531		3.301		2.889	3.466		3.652
STATION 追加距離	0.00	527.00 530.00 538.00 543.00	1000.00	1200.00 1215.00 1235.00 1250.00 1265.00 1290.00 1305.00	2000.00	2485.00 2500.00	3000.00	4000.00	4660.00 4675.00	5000.00
DISTANCE 単距離	0.00	527.00 3.00 8.00 5.00	457.00	200.00 15.00 20.00 15.00 15.00 25.00 15.00	695.00	485.00 15.00	500.00	1000.00	660.00 15.00	325.00
POINT NO. 測点	0/0		1/0		2/0		3/0	4/0		5/0

E OF PROJECT AREA KERANIGANJ, DACCA

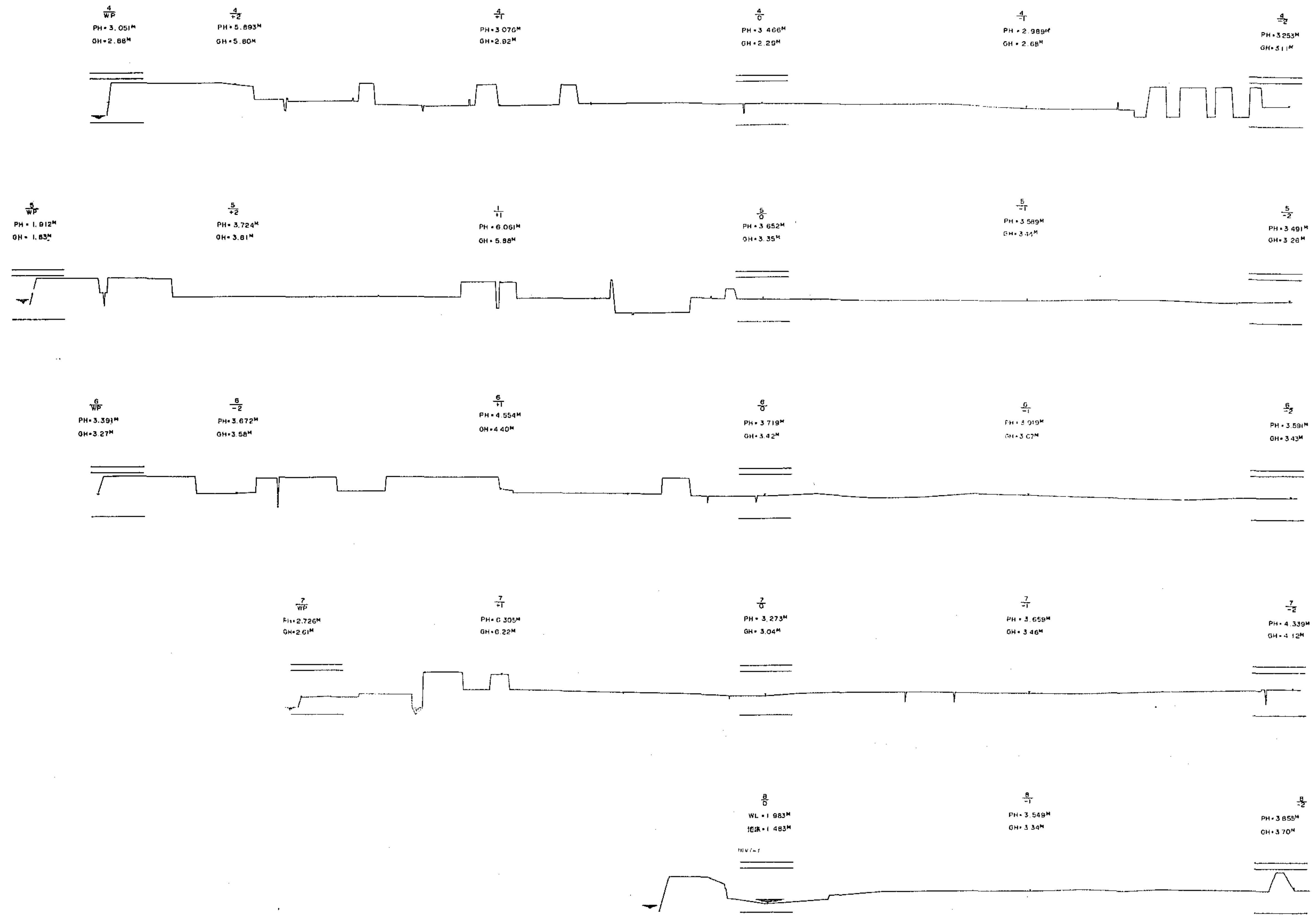


CROSS SECTION OF PROJECT AREA KERANIGANJ, DACCA

(1 OF 2)



(2 OF 2)


$\frac{4}{WP}$ PH=3.051^{M} GH=2.68^{M}
$\frac{4}{+2}$ PH=5.893^{M} GH=5.80^{M}
$\frac{4}{+1}$ PH=3.076^{M} GH=2.92^{M}
$\frac{4}{0}$ PH=3.466^{M} GH=2.29^{M}
$\frac{4}{-1}$ PH=2.989^{M} GH=2.68^{M}
$\frac{4}{-2}$ PH=3.253^{M} GH=3.11^{M}
$\frac{5}{WP}$ PH=1.912^{M} GH=1.83^{M}
$\frac{5}{+2}$ PH=3.724^{M} GH=3.81^{M}
$\frac{1}{+1}$ PH=6.061^{M} GH=5.88^{M}
$\frac{5}{0}$ PH=3.652^{M} GH=3.35^{M}
$\frac{5}{-1}$ PH=3.589^{M} GH=3.44^{M}
$\frac{5}{-2}$ PH=3.491^{M} GH=3.28^{M}
$\frac{6}{WP}$ PH=3.391^{M} GH=3.27^{M}
$\frac{6}{-2}$ PH=3.672^{M} GH=3.58^{M}
$\frac{6}{+1}$ PH=4.554^{M} GH=4.40^{M}
$\frac{6}{0}$ PH=3.719^{M} GH=3.42^{M}
$\frac{6}{-1}$ PH=3.919^{M} GH=3.07^{M}
$\frac{6}{-2}$ PH=3.591^{M} GH=3.43^{M}
$\frac{7}{WP}$ PH=2.726^{M} GH=2.61^{M}
$\frac{7}{+1}$ PH=6.305^{M} GH=6.22^{M}
$\frac{7}{0}$ PH=3.273^{M} GH=3.04^{M}
$\frac{7}{-1}$ PH=3.659^{M} GH=3.46^{M}
$\frac{7}{-2}$ PH=4.339^{M} GH=4.12^{M}
$\frac{8}{0}$ WL=1.983^{M} 河床=1.483^{M}
$\frac{8}{-1}$ PH=3.549^{M} GH=3.34^{M}
$\frac{8}{-2}$ PH=3.855^{M} GH=3.70^{M}

STANDARD PENETRATION TEST RESULT

Project : Great Dacca City Planning

Location : Keraniganj Side

Japanese City Planning
Survey Mission

BORING No. 1

Boring Site 0/+1

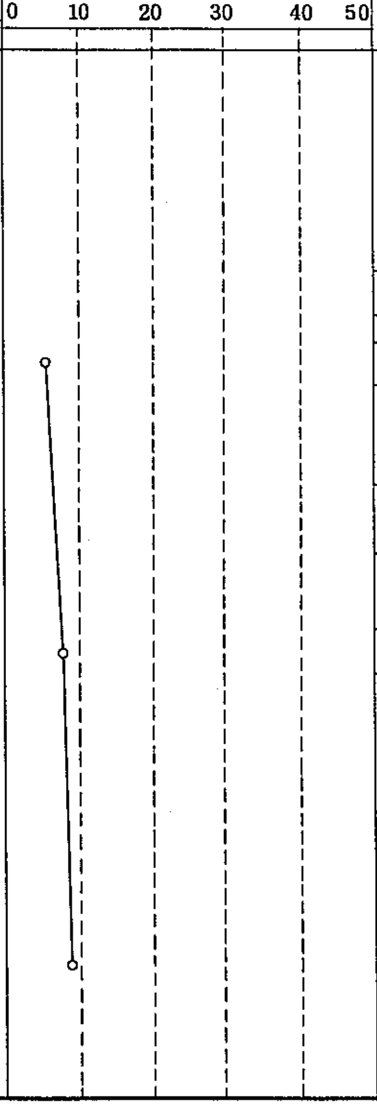
Elevation 6.131M

Ground Water Level 6.00

Operator T. Makino

Survey Period 25/1/1966

Scale m.	Scale ft.	Depth m.	Thickness of strata m.	Soil Profil	Colour	Soil Classification By on the spot survey	Observations	Standard Penetration Test Depth m.	Standard Penetration Test Number of Blows Blows/cm	Sampling
1 2 3	1 2 3 4 5 6 7 8 9 10	3.00	3.00	▤	BROWN	CLAY		2.00 2.30	6/30	① 1.5–1.8 ② 2.0–2.3
4 5 6 7	11 12 13 14 15 16 17 18 19 20 21 22 23	6.50	3.50	▨	BROWN	SANDY SILT		4.00 4.30	8/30	③ 3.0–3.5 ④ 4.0–4.3
								6.20 6.50	9/30	⑤ 6.2–6.5



STANDARD PENETRATION TEST RESULT

Project : Great Dacca City Planning

Location : Keraniganj Side

Japanese City Planning
Survey Mission

BORING No. 2

Boring Site 0/-1

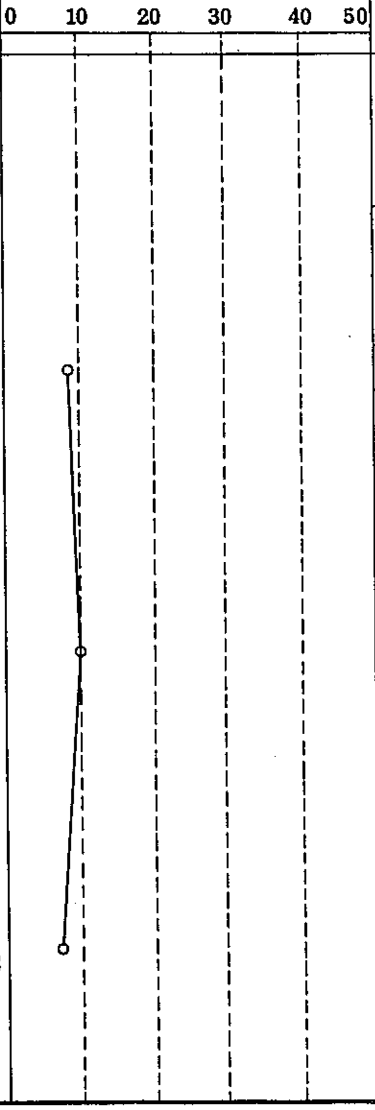
Operator T. Makino

Elevation 3.736 M

Ground Water Level 4.50

Survey Period 25/1/1966

Scale m.	Scale ft.	Depth m.	Thickness of strata m.	Soil Profil	Colour	Soil Classification By on the spot survey	Observations	Standard Penetration Test Depth m.	Number of Blows Blows/cm	N - Value	Sampling
	1, 2	0.80	0.80		BROWN	CLAY					
1	3, 4, 5, 6										① 1.0–2.0
2	7							2.00–2.30	9/30		② 2.0–2.3
3, 4	8–14				BROWN	SANDY SILT		4.00–4.30	10/30		③ 4.0–4.3
5, 6	15–21							6.00–6.34	8/32		④ 6.0–6.3
7	22, 23	6.8 0	6.00								



STANDARD PENETRATION TEST RESULT

Project : Great Dacca City Planning

Location : Keraniganj Side

Japanese City Planning
Survey Mission

BORING No. 3

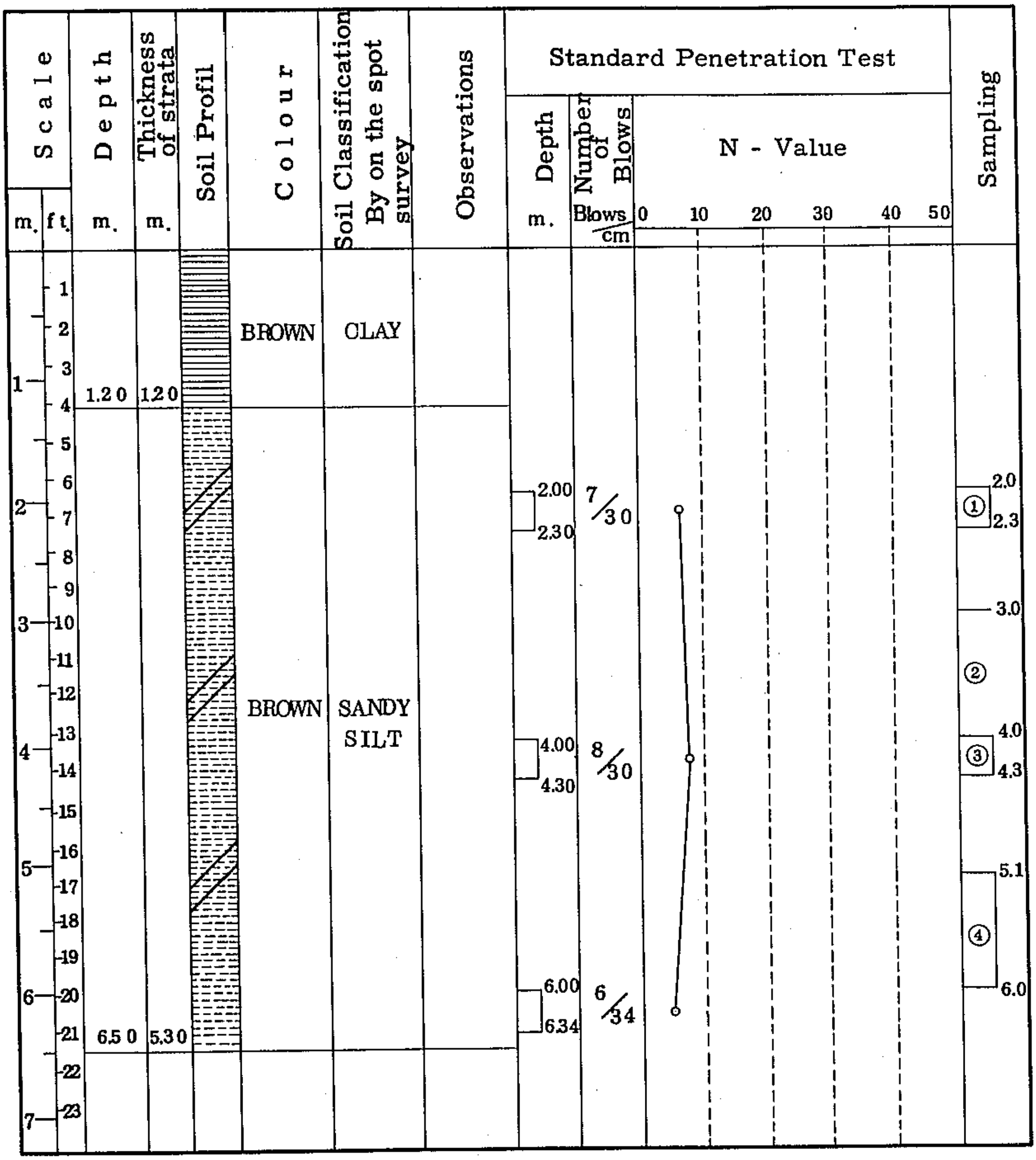
Boring Site 2/+2

Operator T. Makino

Elevation 3.658M

Ground Water Level 3.0 0

Survey Period 25/1/1966



STANDARD PENETRATION TEST RESULT

Project : Great Dacca City Planning

Location : Keraniganj Side

Japanese City Planning
Survey Mission

BORING No. 4

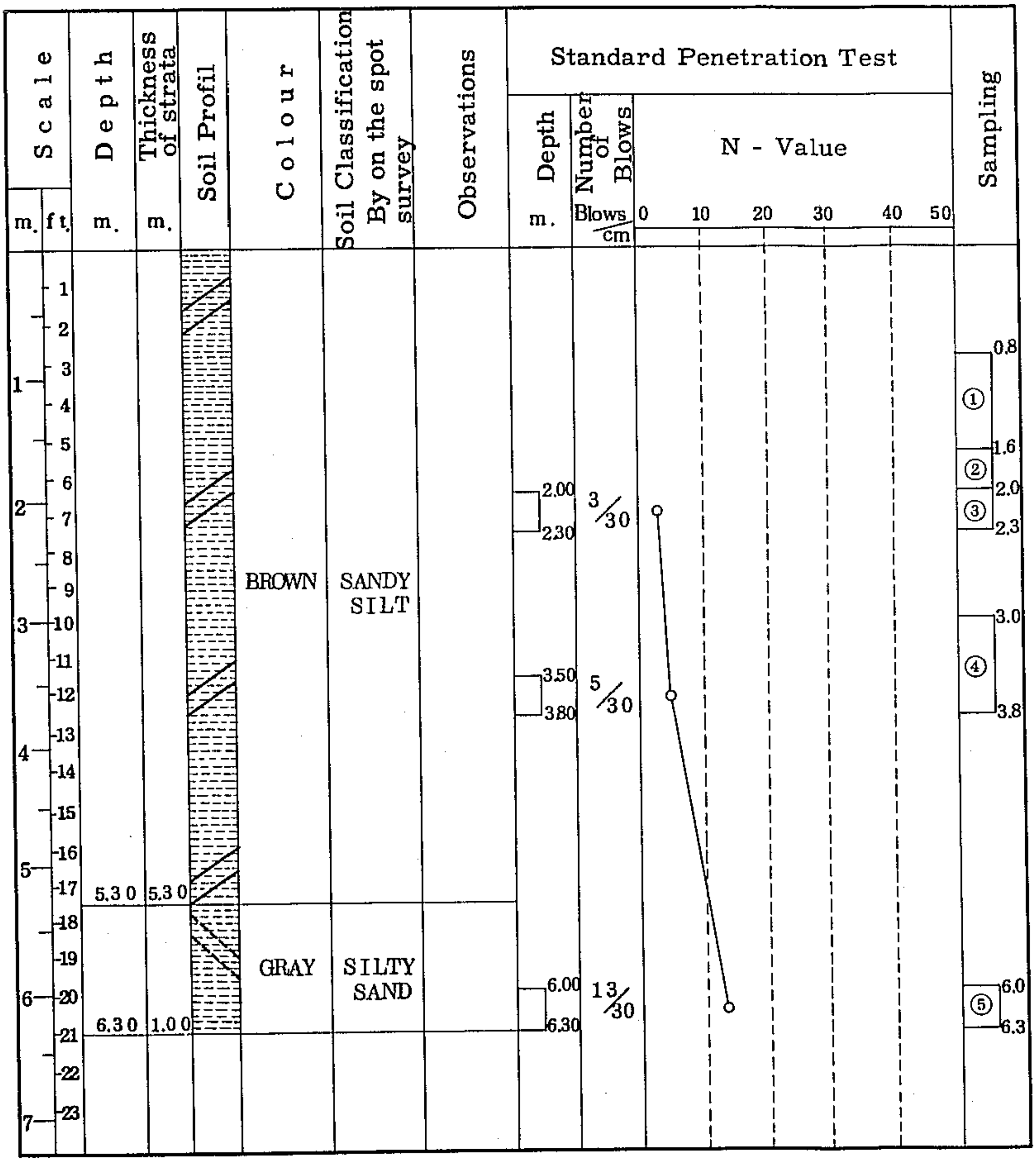
Boring Site DHALESWARI RIVERSIDE

Operator T. Makino

Elevation 5.353M

Ground Water Level 2.70

Survey Period 26/1/1966



Depth m.	Thickness of strata m.	Colour	Soil Classification By on the spot survey	Observations
5.30	5.30	BROWN	SANDY SILT	
6.30	1.00	GRAY	SILTY SAND	

Standard Penetration Test Depth m.	Number of Blows Blows/cm
2.00 2.30	3/30
3.50 3.80	5/30
6.00 6.30	13/30

Sampling	
①	0.8 1.6
②	1.6 2.0
③	2.0 2.3
④	3.0 3.8
⑤	6.0 6.3

STANDARD PENETRATION TEST RESULT

Project : Great Dacca City Planning

Location : Keraniganj Side

Japanese City Planning
Survey Mission

BORING No. 5

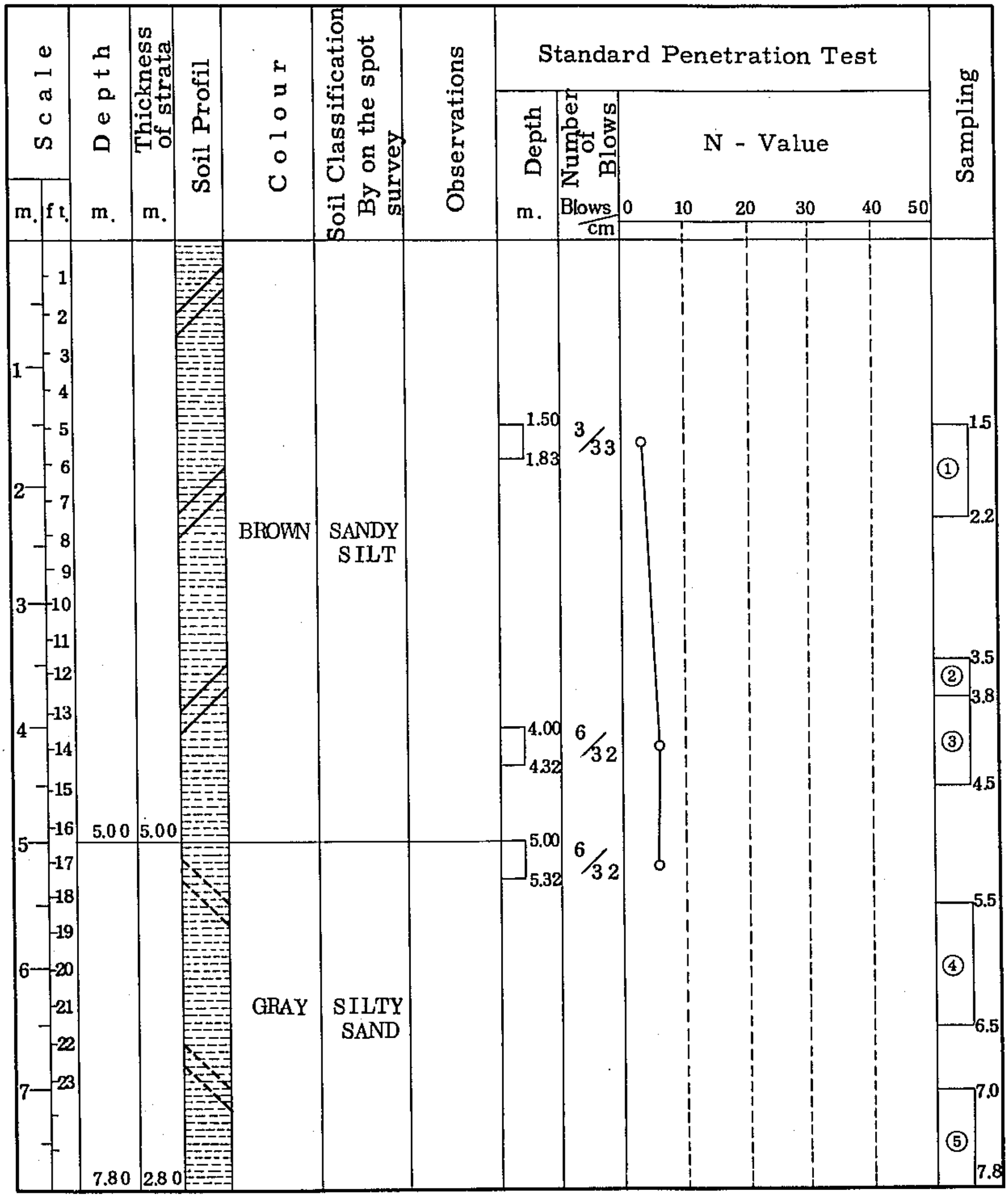
Boring Site 2/-2

Elevation 3.292M

Ground Water Level 3.30

Operator T. Makino

Survey Period 26/1/1966



Depth m.	Thickness of strata m.	Colour	Soil Classification By on the spot survey
5.00	5.00	BROWN	SANDY SILT
7.80	2.80	GRAY	SILTY SAND

Standard Penetration Test Depth m.	Number of Blows Blows/cm
1.50 1.83	3/33
4.00 4.32	6/32
5.00 5.32	6/32

Sampling	
①	1.5 2.2
②	3.5 3.8
③	3.8 4.5
④	5.5 6.5
⑤	7.0 7.8

STANDARD PENETRATION TEST RESULT

Project : Great Dacca City Planning

Location : Keraniganj Side

Japanese City Planning
Survey Mission

BORING No. 6

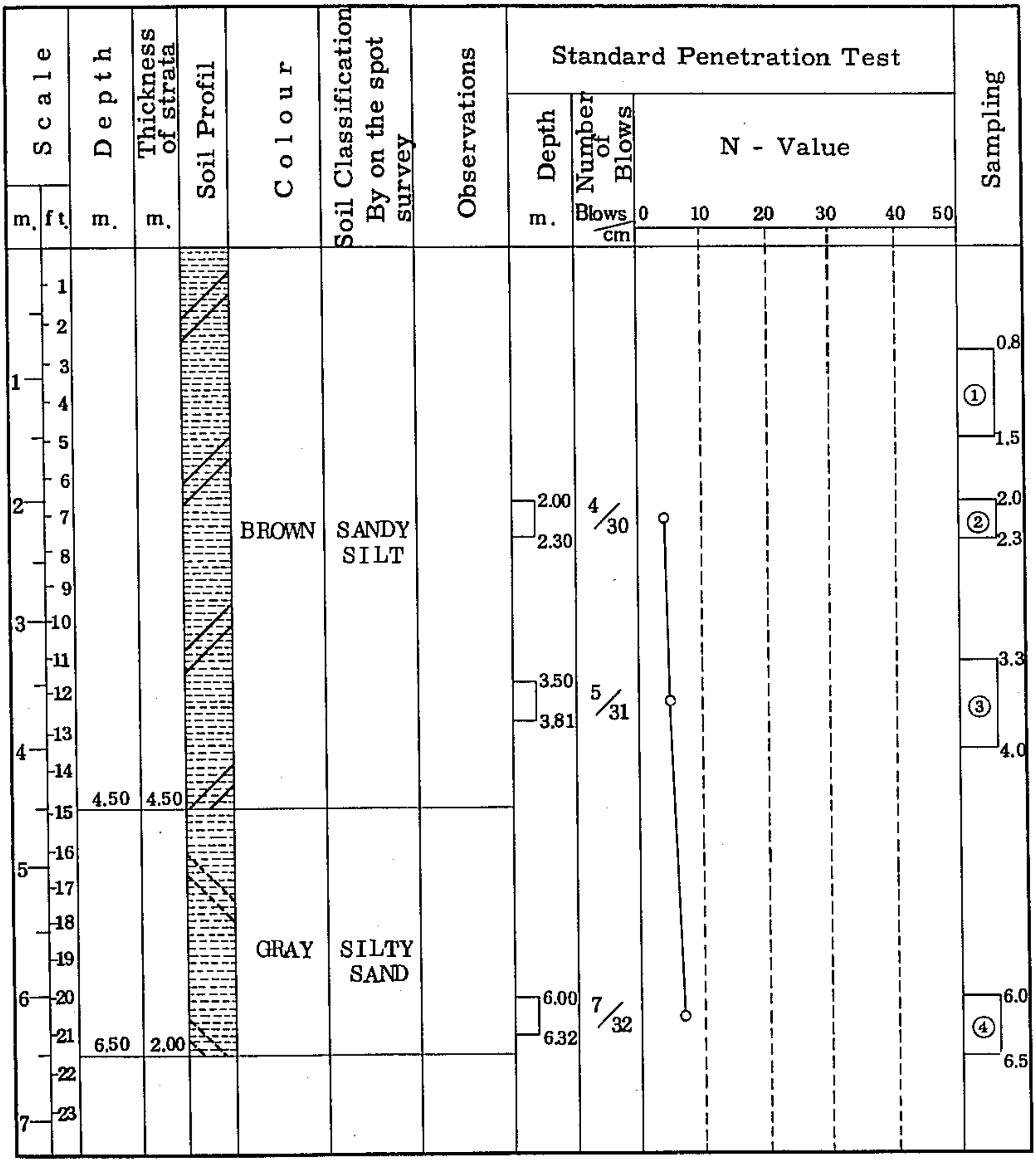
Boring Site 4⁄–2

Operator T. Makino

Elevation 3.353M

Ground Water Level 2.85

Survey Period 26⁄1⁄1966



STANDARD PENETRATION TEST RESULT

Project : Great Dacca City Planning

Location : Keraniganj Side

Japanese City Planning
Survey Mission

BORING No. 7

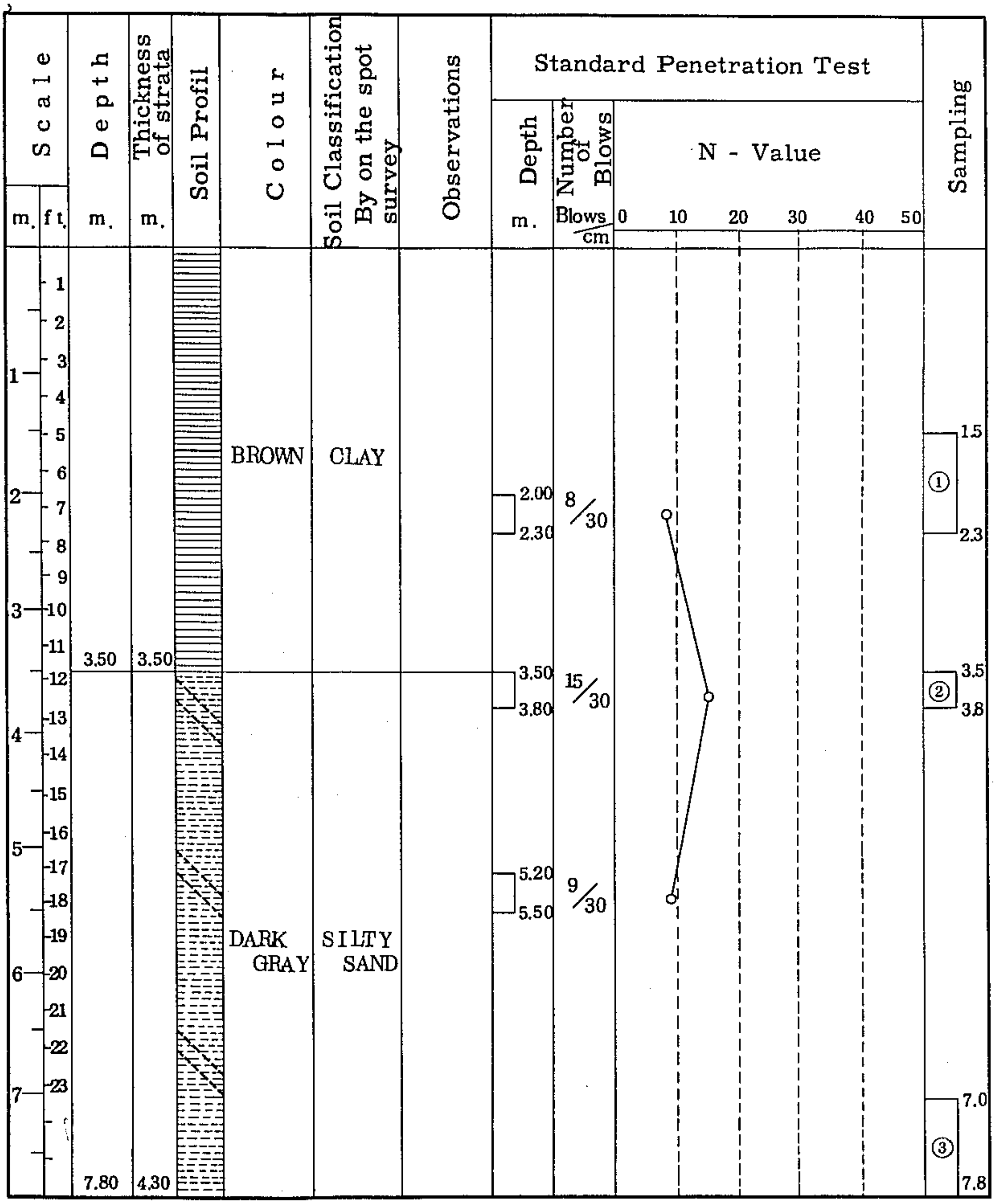
Boring Site 3/+2

Elevation 4.292 M

Ground Water Level 3.50

Operator T. Makino

Survey Period 27/1/1966



Depth m.	Thickness of strata m.	Colour	Soil Classification By on the spot survey	Observations	Standard Penetration Test Depth m.	Number of Blows Blows/cm	Sampling
3.50	3.50	BROWN	CLAY		2.00 2.30	8/30	① 1.5 2.3
7.80	4.30	DARK GRAY	SILTY SAND		3.50 3.80	15/30	② 3.5 3.8
					5.20 5.50	9/30	③ 7.0 7.8

STANDARD PENETRATION TEST RESULT

Project : Great Dacca City Planning

Location : Keraniganj Side

Japanese City Planning
Survey Mission

BORING No. 8

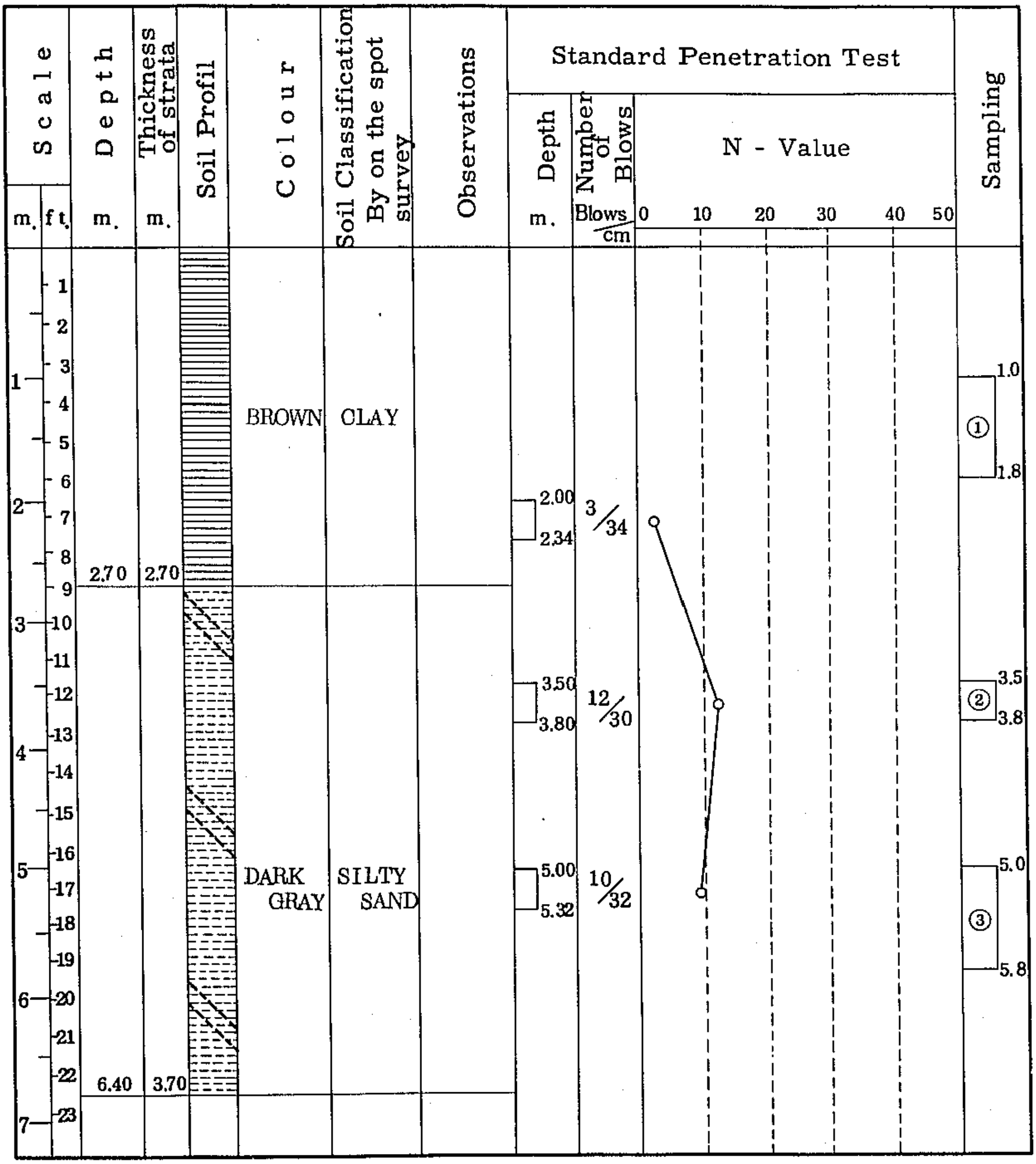
Boring Site 1/+3

Operator T. Makino

Elevation 3.901M

Ground Water Level 1.30

Survey Period 27/1/1966



STANDARD PENETRATION TEST RESULT

Project : Great Dacca City Planning

Location : Keraniganj Side

Japanese City Planning
Survey Mission

BORING No. 9

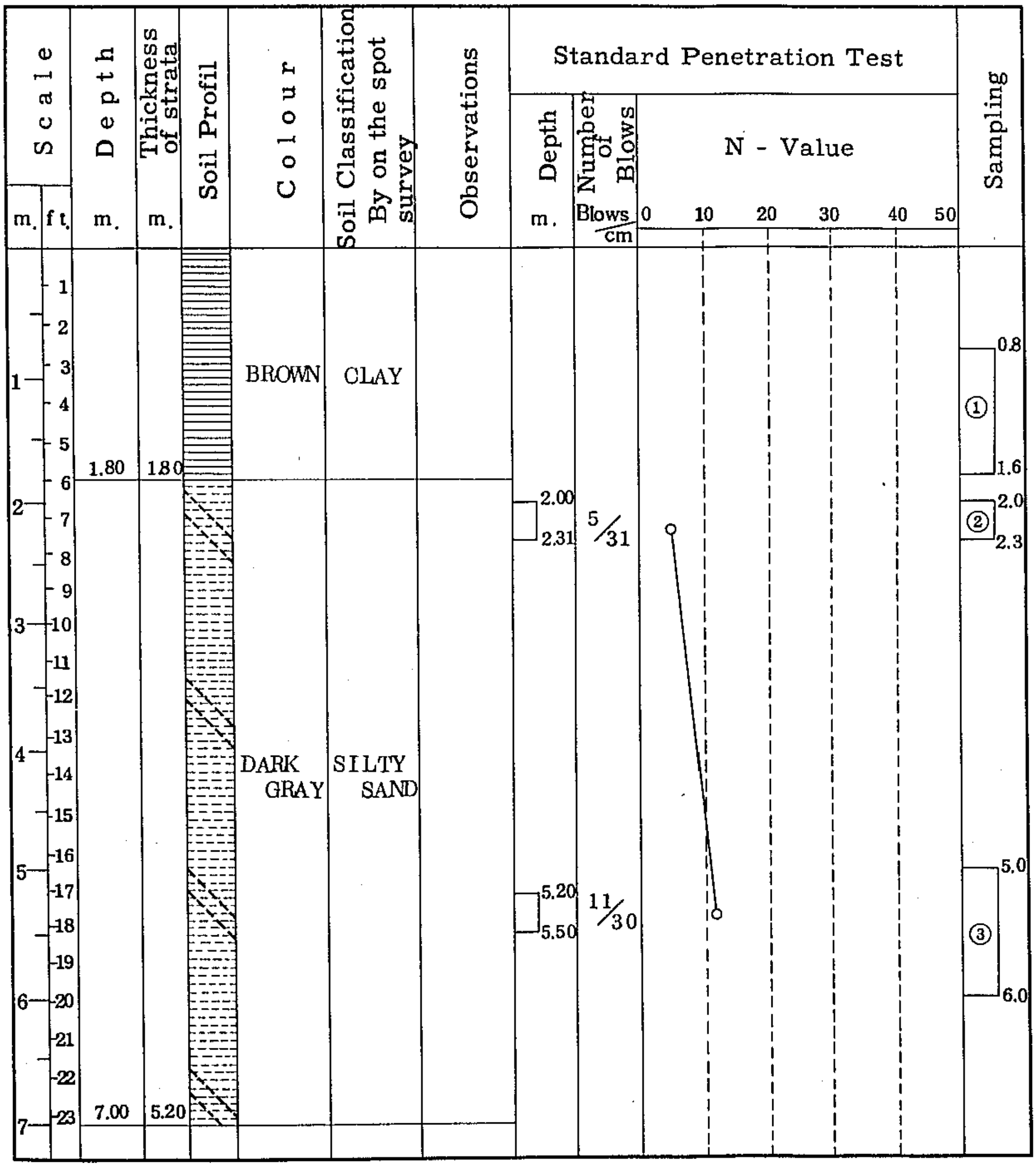
Boring Site 0/+3

Operator T. Makino

Elevation 4.877 M

Ground Water Level 2.50

Survey Period 27/1/1966



Scale m.	Scale ft.	Depth m.	Thickness of strata m.	Soil Profil	Colour	Soil Classification By on the spot survey	Observations	Standard Penetration Test Depth m.	Standard Penetration Test Number of Blows Blows/cm	Standard Penetration Test N - Value (0 10 20 30 40 50)	Sampling
0–1.80	1–5	1.80	1.80		BROWN	CLAY					① 0.8–1.6
1.80–7	6–23	7.00	5.20		DARK GRAY	SILTY SAND		2.00–2.31	5/31		② 2.0–2.3
								5.20–5.50	11/30		③ 5.0–6.0

STANDARD PENETRATION TEST RESULT

Project : Great Dacca City Planning

Location : Keraniganj Side

Japanese City Planning
Survey Mission

BORING No. 1 0

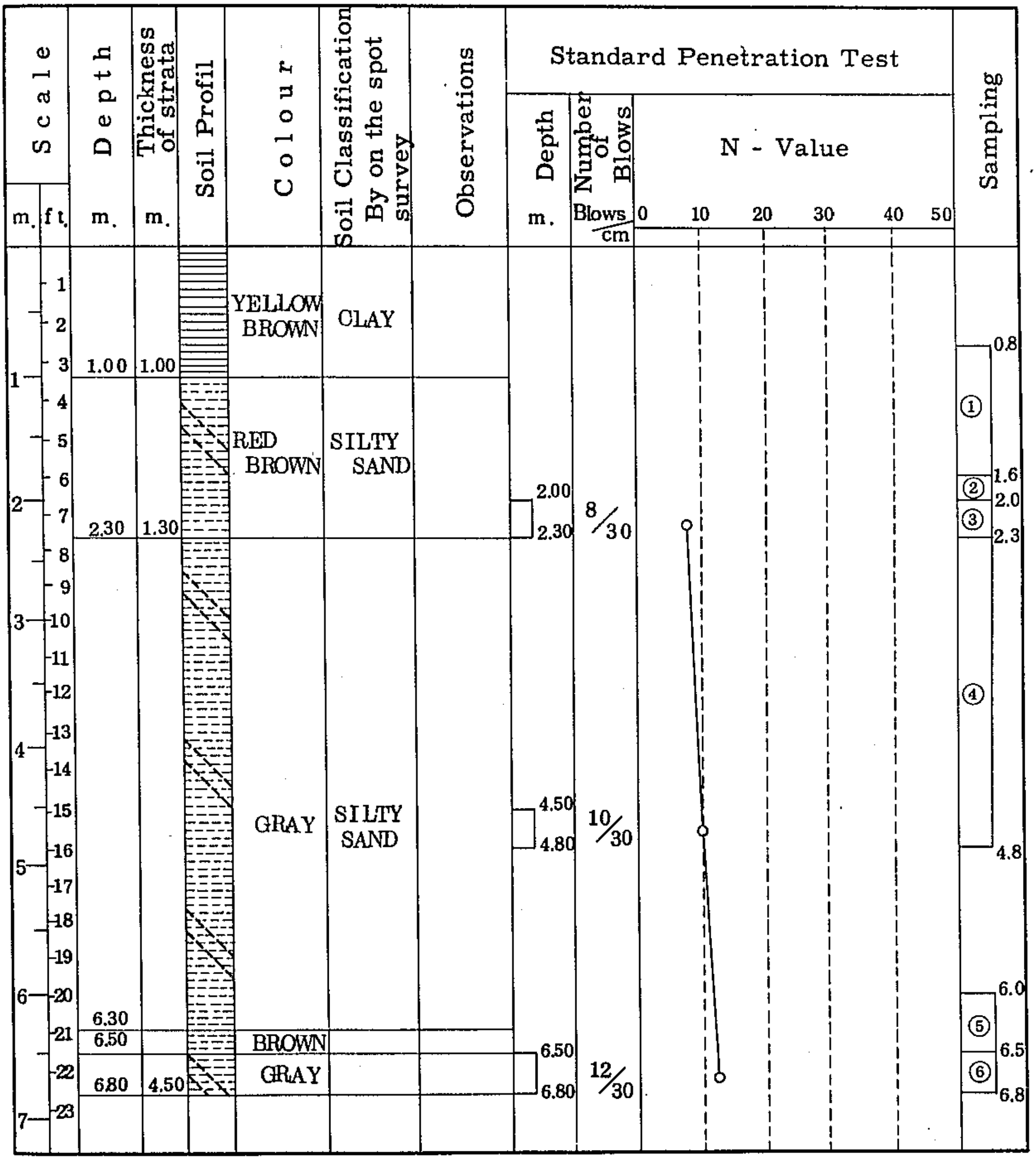
Boring Site 2/0

Operator T. Makino

Elevation 3.043 M

Ground Water Level 1.00

Survey Period 28/1/1966



Depth m.	Thickness of strata m.	Colour	Soil Classification By on the spot survey	Observations	Standard Penetration Test Depth m.	Number of Blows (Blows/cm)	Sampling
1.00	1.00	YELLOW BROWN	CLAY				① 0.8–1.6
2.30	1.30	RED BROWN	SILTY SAND		2.00 2.30	8/30	② 1.6–2.0 ③ 2.0–2.3
6.30		GRAY	SILTY SAND		4.50 4.80	10/30	④ 2.3–4.8 ⑤ 6.0–6.5
6.50		BROWN					
6.80	4.50	GRAY			6.50 6.80	12/30	⑥ 6.5–6.8

STANDARD PENETRATION TEST RESULT

Project : Great Dacca City Planning

Location : Keraniganj Side

Japanese City Planning
Survey Mission

BORING No. 11

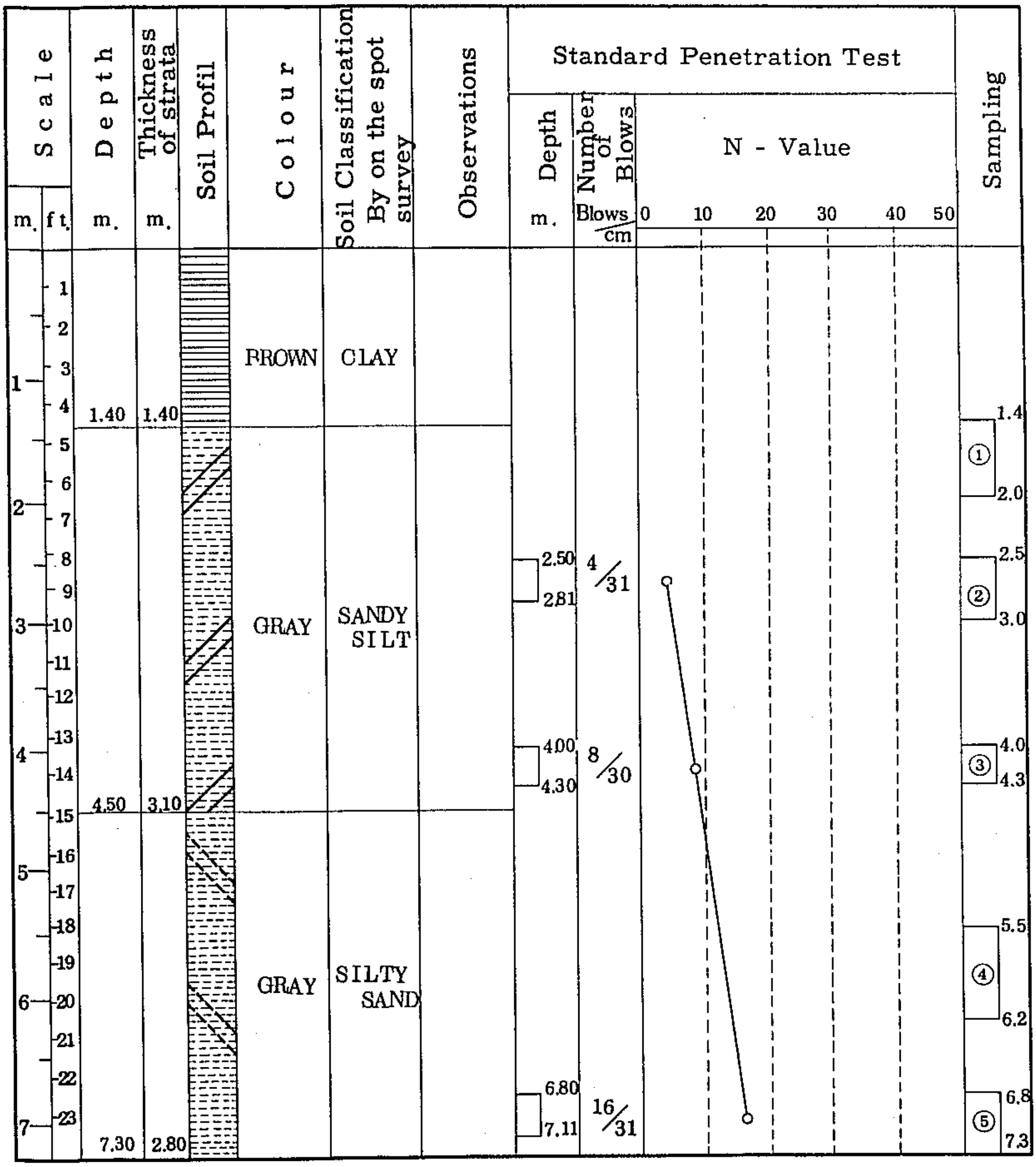
Boring Site 4/0

Elevation 3.261M

Ground Water Level 3.10

Operator T. Makino

Survey Period 28/1/1966



Depth m.	Thickness of strata m.	Colour	Soil Classification By on the spot survey	Observations
1.40	1.40	BROWN	CLAY	
4.50	3.10	GRAY	SANDY SILT	
7.30	2.80	GRAY	SILTY SAND	

Standard Penetration Test Depth m.	Number of Blows Blows/cm
2.50 2.81	4/31
4.00 4.30	8/30
6.80 7.11	16/31

Sampling	
①	1.4 2.0
②	2.5 3.0
③	4.0 4.3
④	5.5 6.2
⑤	6.8 7.3

STANDARD PENETRATION TEST RESULT

Project : Great Dacca City Planning

Location : Keraniganj Side

Japanese City Planning
Survey Mission

BORING No. 12

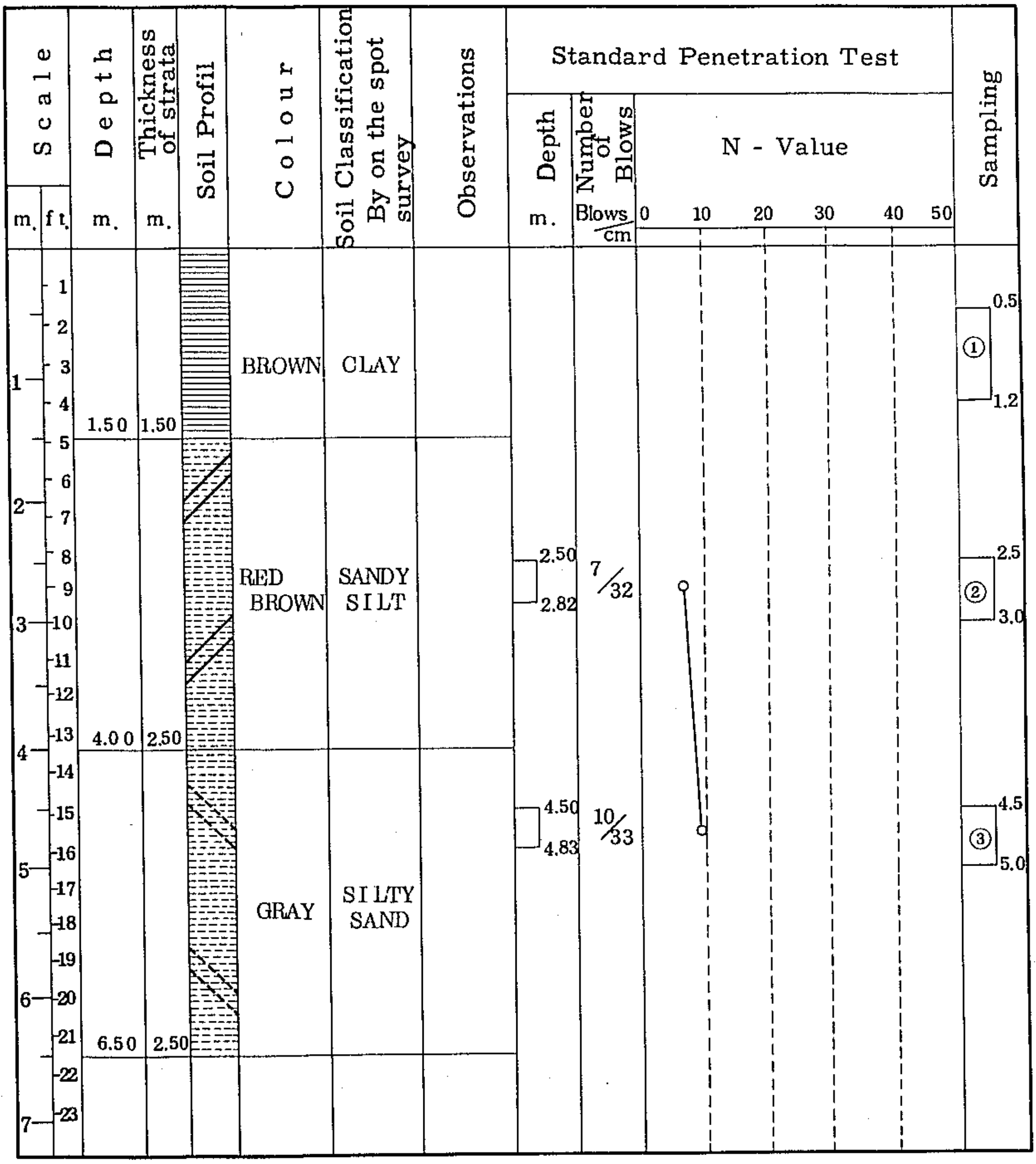
Boring Site 6/-2

Operator T. Makino

Elevation 3.078M

Ground Water Level 2.90

Survey Period 28/1/1966



Depth m.	Thickness of strata m.	Colour	Soil Classification By on the spot survey	Observations	Standard Penetration Test Depth m.	Number of Blows Blows/cm	Sampling
1.50	1.50	BROWN	CLAY				① 0.5–1.2
4.00	2.50	RED BROWN	SANDY SILT		2.50–2.82	7/32	② 2.5–3.0
6.50	2.50	GRAY	SILTY SAND		4.50–4.83	10/33	③ 4.5–5.0

STANDARD PENETRATION TEST RESULT

Project : Great Dacca City Planning

Location : Keraniganj Side

Japanese City Planning
Survey Mission

BORING No. 13

Boring Site 4/+2

Operator T. Makino

Elevation 4.243M

Ground Water Level 1.90

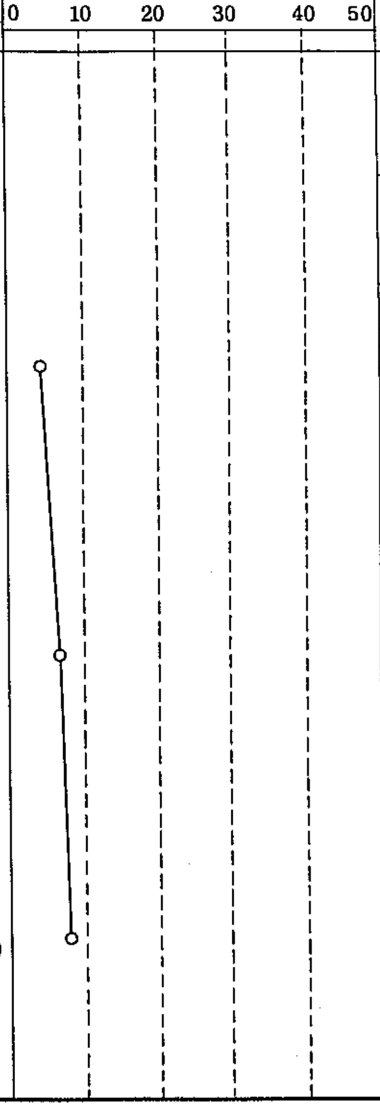
Survey Period 29/1/1966

Depth m.	Thickness of strata m.	Colour	Soil Classification By on the spot survey	Observations
1.90	1.90	YELLOW BROWN	CLAY	
3.70	1.80	RED BROWN	SILTY SAND	
4.80	1.10	BLACK	SANDY SILT	
6.30	1.50	GRAY	SANDY SILT	

Standard Penetration Test

Depth m.	Number of Blows (Blows/cm)
2.00 2.30	4/30
4.00 4.30	6/30
6.00 6.30	7/30

N - Value



Sampling

①	0.8 1.6
②	1.9 2.0
③	2.0 2.3
④	2.3 3.0
⑤	4.0 4.5
⑥	5.5 6.3

STANDARD PENETRATION TEST RESULT

Project : Great Dacca City Planning

Location : Keraniganj Side

Japanese City Planning
Survey Mission

BORING No. 1 4

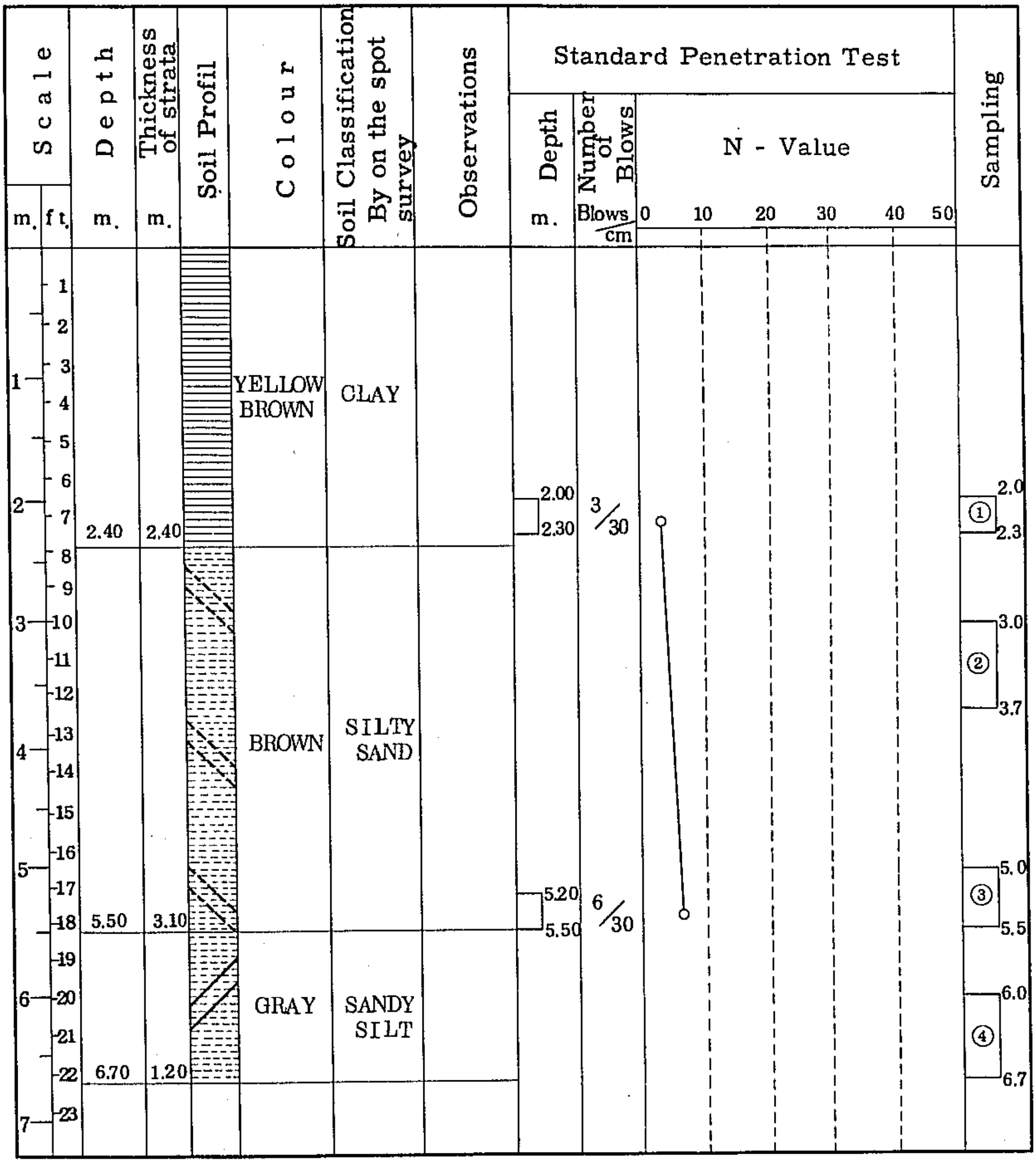
Boring Site $^5/_{+2}$

Operator T. Makino

Elevation 3.566 M

Ground Water Level 1.80

Survey Period $^{29}/_{1}/1966$



Depth m.	Thickness of strata m.	Colour	Soil Classification By on the spot survey	Observations	Standard Penetration Test Depth m.	Number of Blows Blows/cm	Sampling
2.40	2.40	YELLOW BROWN	CLAY		2.00 2.30	3/30	① 2.0 2.3
5.50	3.10	BROWN	SILTY SAND		5.20 5.50	6/30	② 3.0 3.7 ③ 5.0 5.5
6.70	1.20	GRAY	SANDY SILT				④ 6.0 6.7

STANDARD PENETRATION TEST RESULT

Project : Great Dacca City Planning

Location : Keraniganj Side

Japanese City Planning
Survey Mission

BORING No. 15

Boring Site $^6/_{+2}$

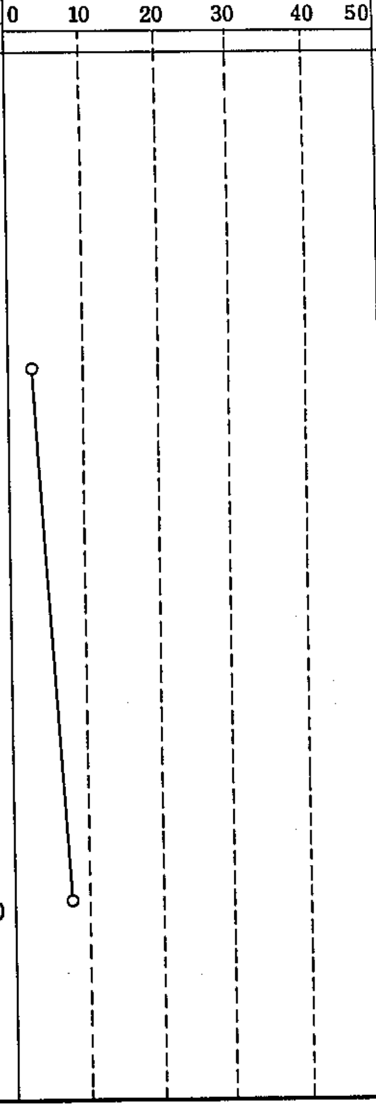
Elevation 4.420M

Ground Water Level 1.80

Operator T. Makino

Survey Period $^{29}/_{1}$/1966

Scale m.	Scale ft.	Depth m.	Thickness of strata m.	Soil Profil	Colour	Soil Classification By on the spot survey	Observations	Standard Penetration Test Depth m.	Number of Blows Blows/cm	N - Value	Sampling
0–4	1–13	4.20	4.20	▤	RED BROWN	CLAY		2.00 2.30	3/30	3	① 1.5–2.3 ② 3.3–4.0
4–7	14–23	7.30	3.10	▨	GRAY	SANDY SILT		5.70 6.00	8/30	8	③ 5.5–6.0



STANDARD PENETRATION TEST RESULT

Project : Great Dacca City Planning

Location : Keraniganj Side

Japanese City Planning
Survey Mission

BORING No. 16

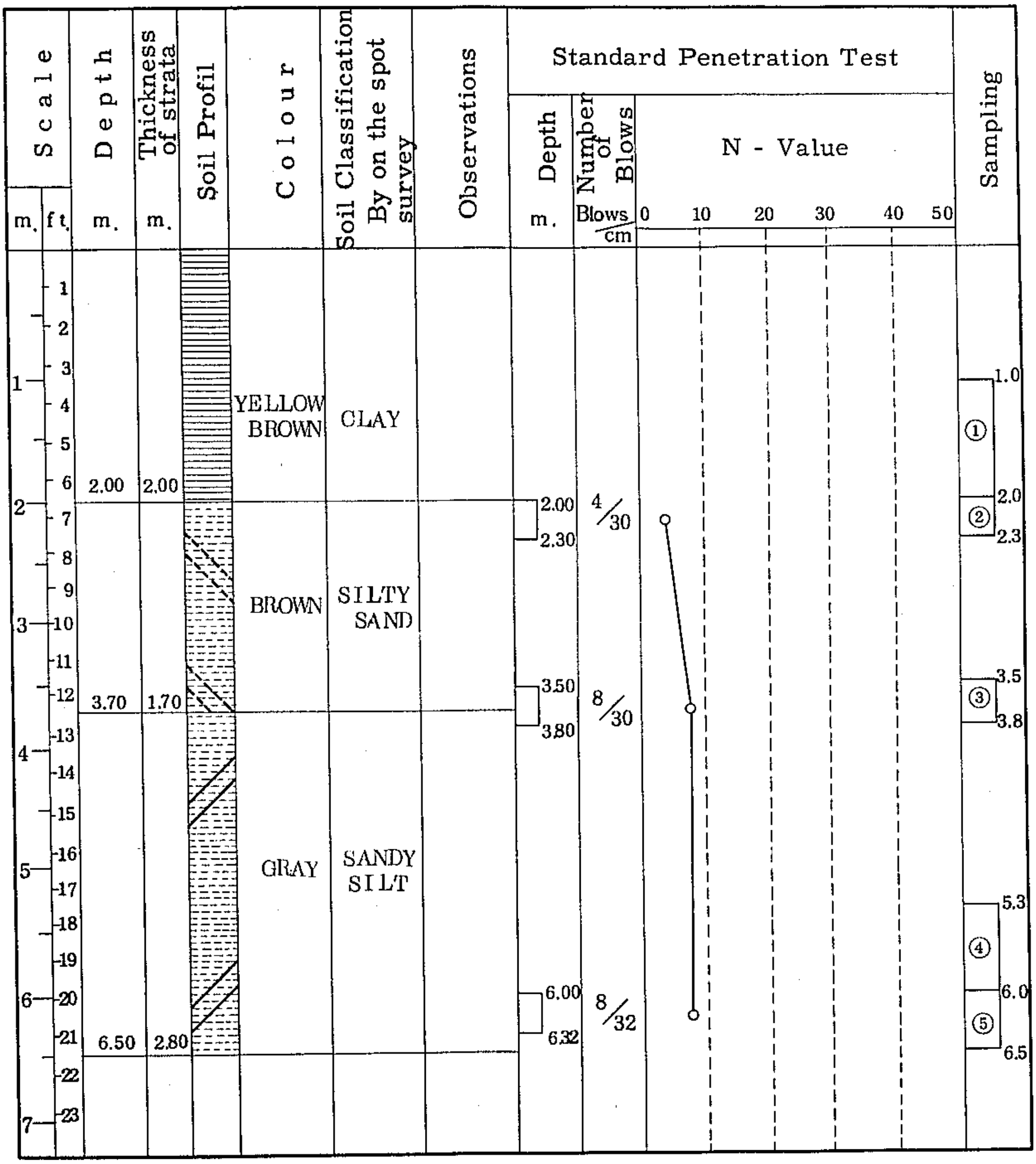
Boring Site 6/0

Elevation 3.314 M

Ground Water Level 2.00

Operator T. Makino

Survey Period 30/1/1966



Depth m.	Thickness of strata m.	Colour	Soil Classification By on the spot survey	Observations	SPT Depth m.	Number of Blows (Blows/cm)	Sampling
2.00	2.00	YELLOW BROWN	CLAY				① 1.0–2.0
3.70	1.70	BROWN	SILTY SAND		2.00–2.30 3.50–3.80	4/30 8/30	② 2.0–2.3 ③ 3.5–3.8
6.50	2.80	GRAY	SANDY SILT		6.00–6.32	8/32	④ 5.3–6.0 ⑤ 6.0–6.5

STANDARD PENETRATION TEST RESULT

Project : Great Dacca City Planning

Location : Keraniganj Side

Japanese City Planning
Survey Mission

BORING No. 17

Boring Site 7/-1

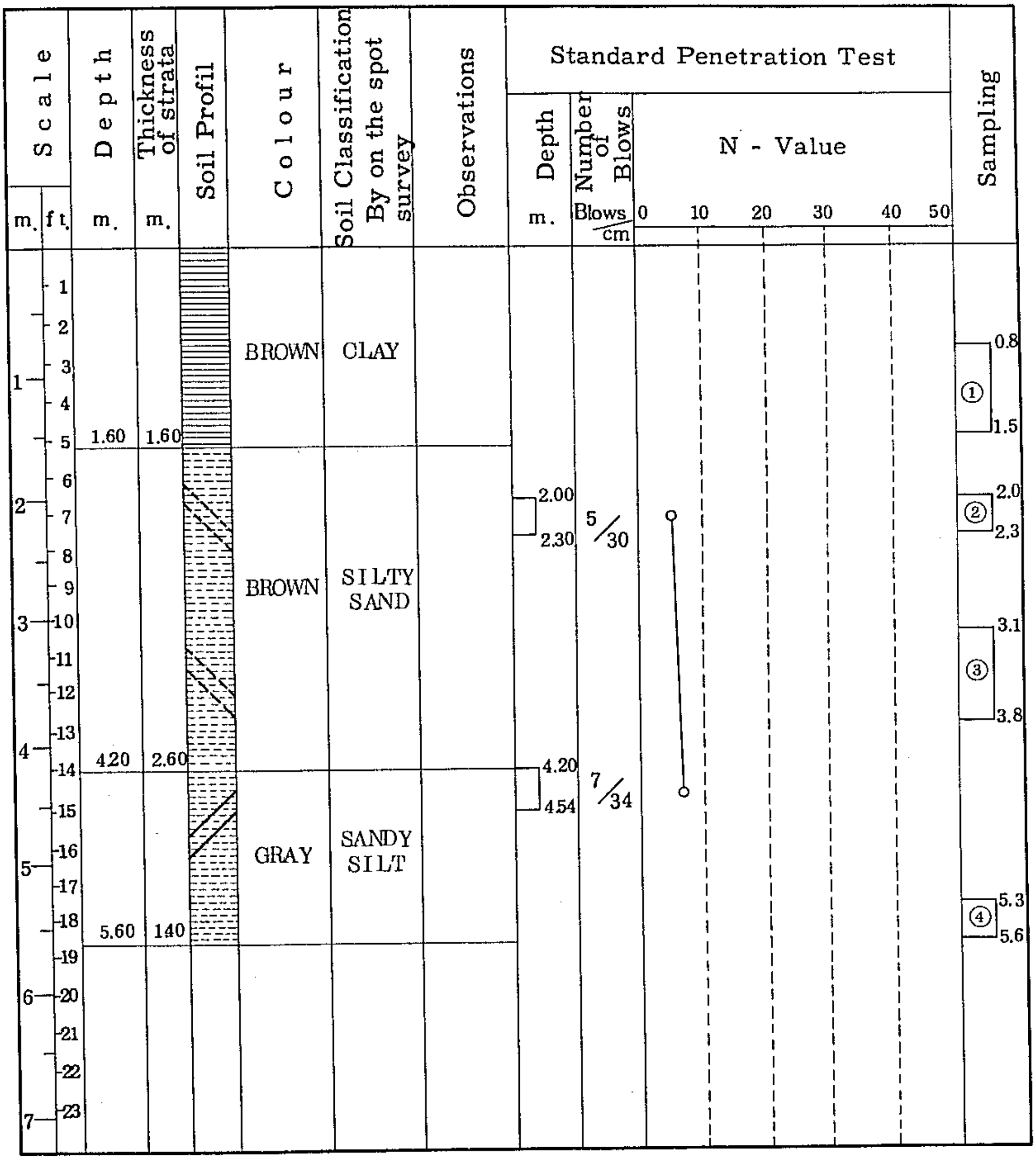
Operator T. Makino

Elevation 4.023M

Ground Water Level 3.00

Survey Period 30/1/1966

Scale m.	Scale ft.	Depth m.	Thickness of strata m.	Soil Profil	Colour	Soil Classification By on the spot survey	Observations	Standard Penetration Test Depth m.	Number of Blows Blows/cm	N - Value 0 10 20 30 40 50	Sampling
		1.60	1.60		BROWN	CLAY					① 0.8–1.5
		4.20	2.60		BROWN	SILTY SAND		2.00 2.30	5/30		② 2.0–2.3 ③ 3.1–3.8
		5.60	140		GRAY	SANDY SILT		4.20 4.54	7/34		④ 5.3–5.6



STANDARD PENETRATION TEST RESULT

Project : Great Dacca City Planning

Location : Keraniganj Side

Japanese City Planning
Survey Mission

BORING No. 18

Boring Site 8/0

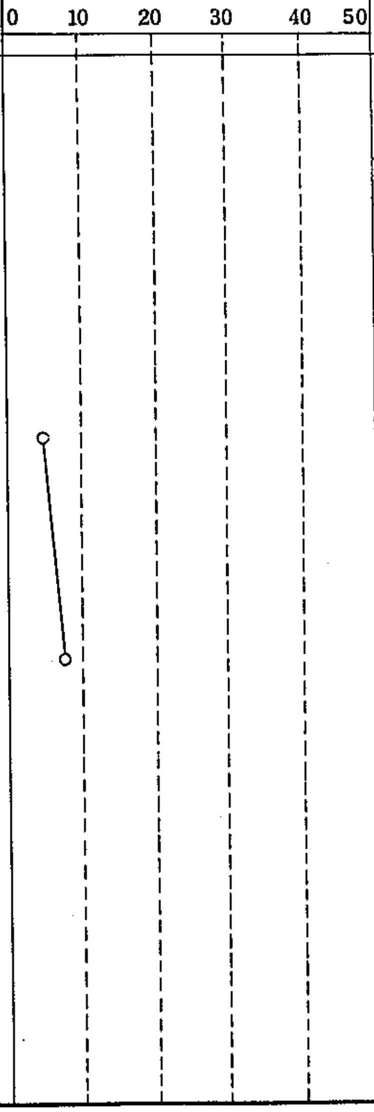
Operator T. Makino

Elevation 2.621M

Ground Water Level 1.30

Survey Period 30/1/1966

Scale		Depth	Thickness of strata	Soil Profil	Colour	Soil Classification By on the spot survey	Observations	Standard Penetration Test			Sampling
								Depth	Number of Blows	N - Value	
m.	ft.	m.	m.					m.	Blows/cm	0 10 20 30 40 50	
		1.00	1.00		BROWN	CLAY					① 0.7 1.0
		2.80	1.80		BROWN	SILTY SAND		2.50 2.80	5/30		② 2.5
		6.30	3.50		GRAY	SANDY SILT		4.00 4.32	8/32		③ 4.0 4.5



STANDARD PENETRATION TEST RESULT

Project : Great Dacca City Planning

Location : Keraniganj Side

Japanese City Planning
Survey Mission

BORING No. 19

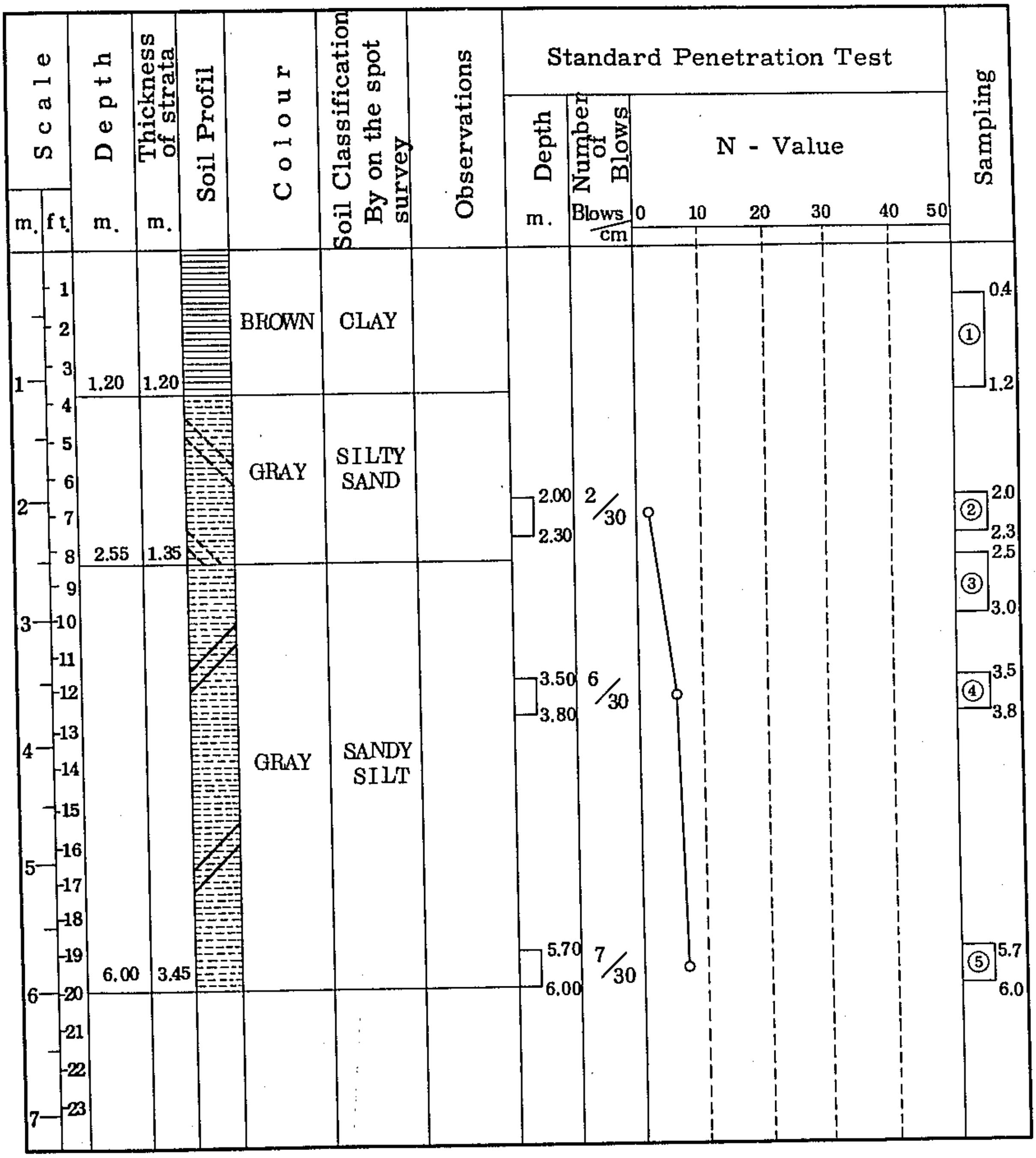
Boring Site 8/+2

Elevation 2.563M

Ground Water Level 2.47

Operator T. Makino

Survey Period 31/1/1966



Depth m.	Thickness of strata m.	Colour	Soil Classification By on the spot survey	Observations	Standard Penetration Test Depth m.	Number of Blows (Blows/cm)	Sampling
1.20	1.20	BROWN	CLAY				① 0.4–1.2
2.55	1.35	GRAY	SILTY SAND		2.00–2.30	2/30	② 2.0–2.3
							③ 2.5–3.0
6.00	3.45	GRAY	SANDY SILT		3.50–3.80	6/30	④ 3.5–3.8
					5.70–6.00	7/30	⑤ 5.7–6.0

STANDARD PENETRATION TEST RESULT

Project : Great Dacca City Planning

Location : Keraniganj Side

Japanese City Planning
Survey Mission

BORING No. 20

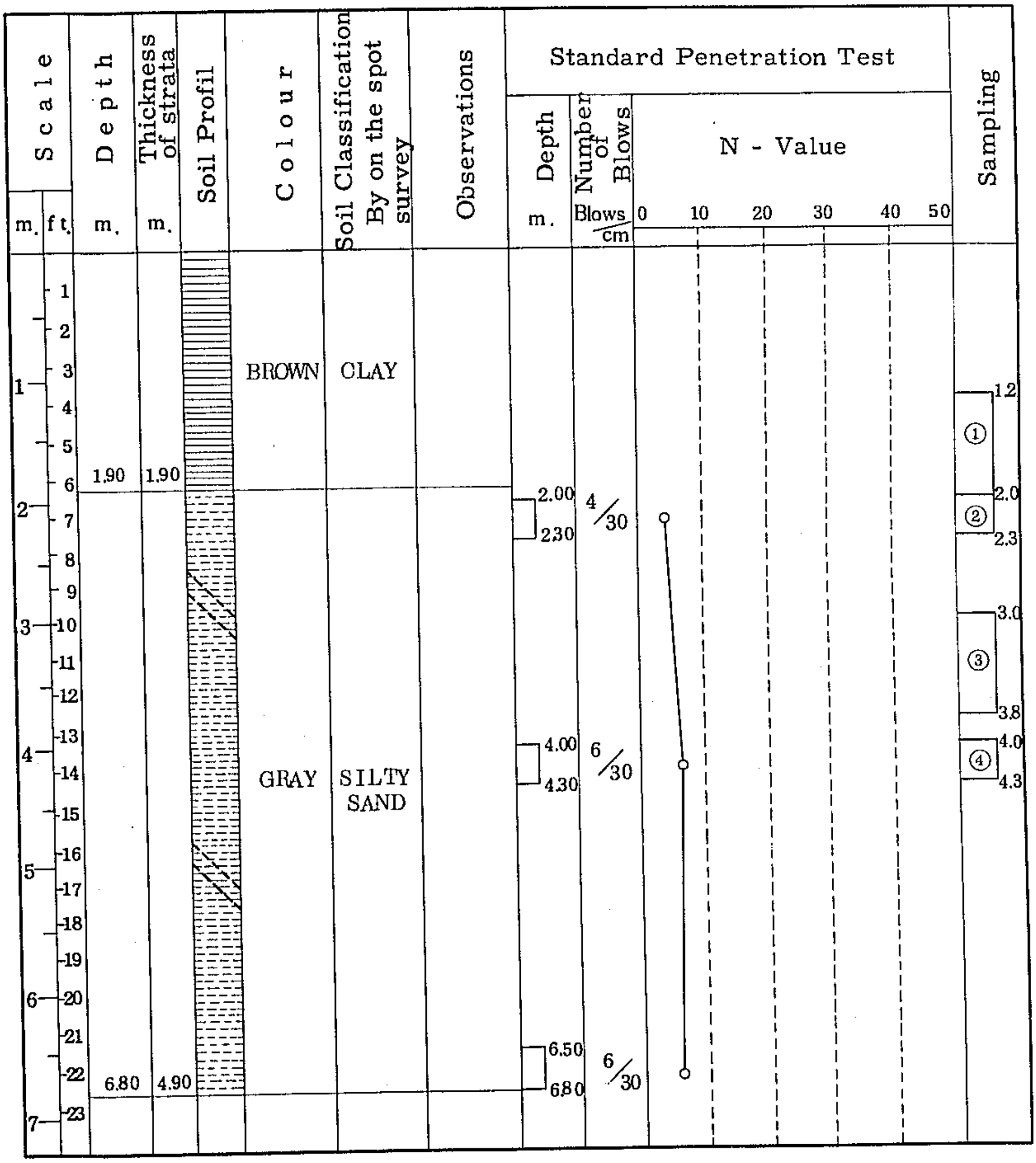
Boring Site 7/+2

Elevation 3.109M

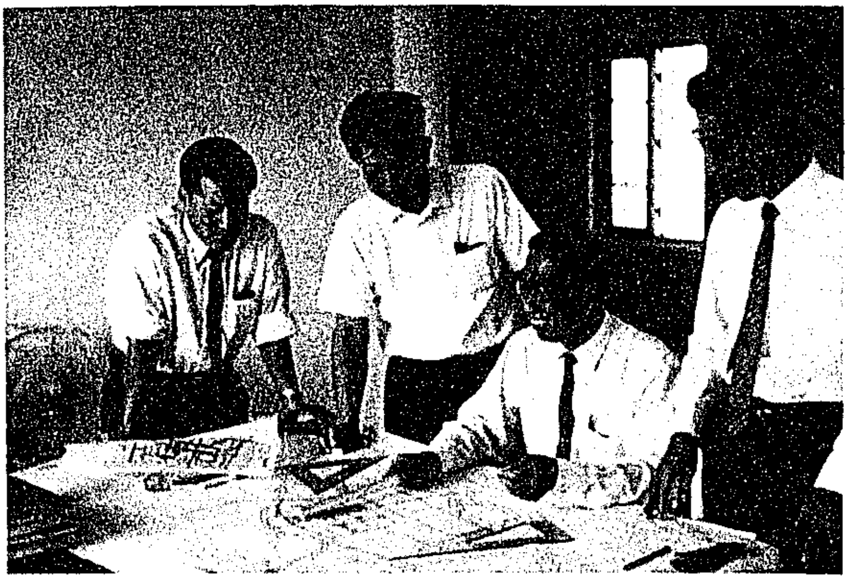
Ground Water Level 2.00

Operator T. Makino

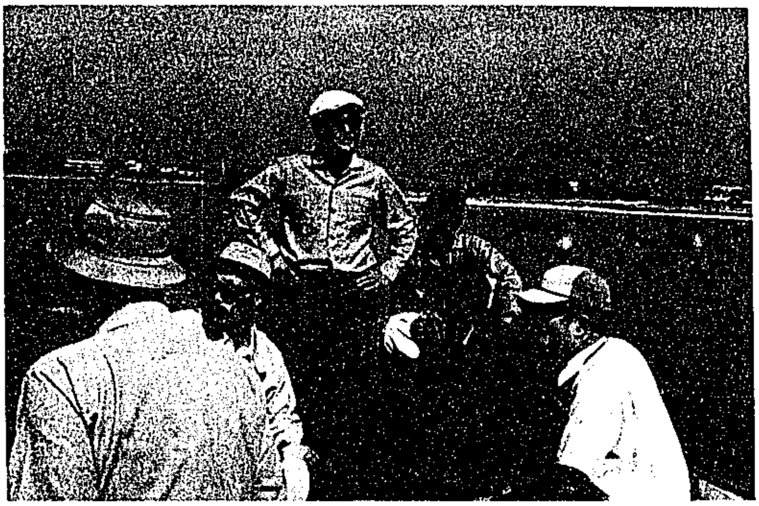
Survey Period 31/1/1966



Scale m.	Scale ft.	Depth m.	Thickness of strata m.	Soil Profil	Colour	Soil Classification By on the spot survey	Observations	Standard Penetration Test Depth m.	Standard Penetration Test Number of Blows Blows/cm	Standard Penetration Test N - Value	Sampling
		1.90	1.90		BROWN	CLAY					1.2 ① 2.0
		6.80	4.90		GRAY	SILTY SAND		2.00 2.30 4.00 4.30 6.50 6.80	4/30 6/30 6/30		2.0 ② 2.3 3.0 ③ 3.8 4.0 ④ 4.3

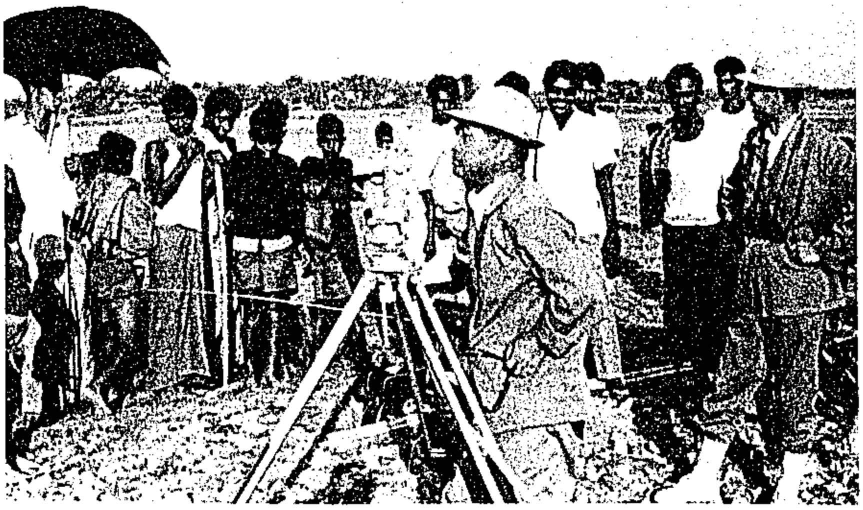


Map review at D. I. T. office



Surveying
on the Burhiganga river

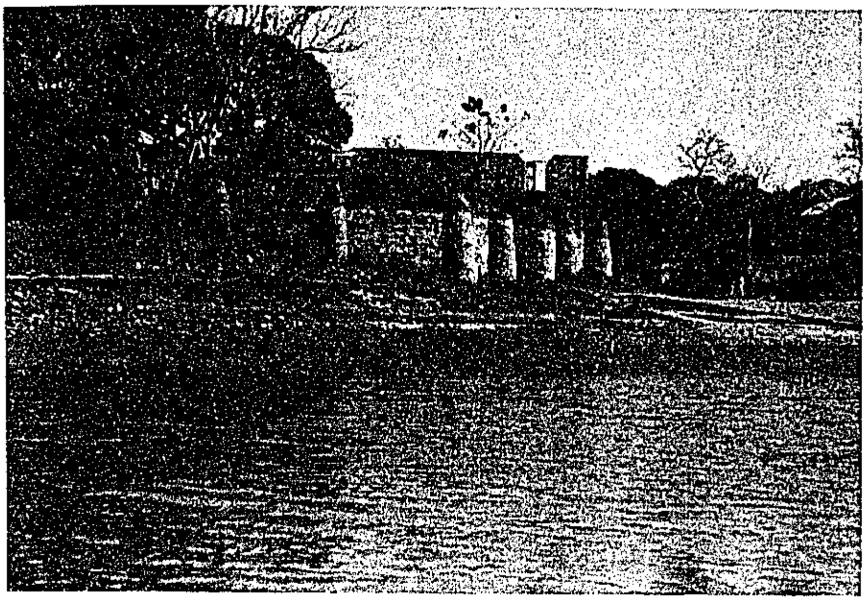
Sadarghat B. M.



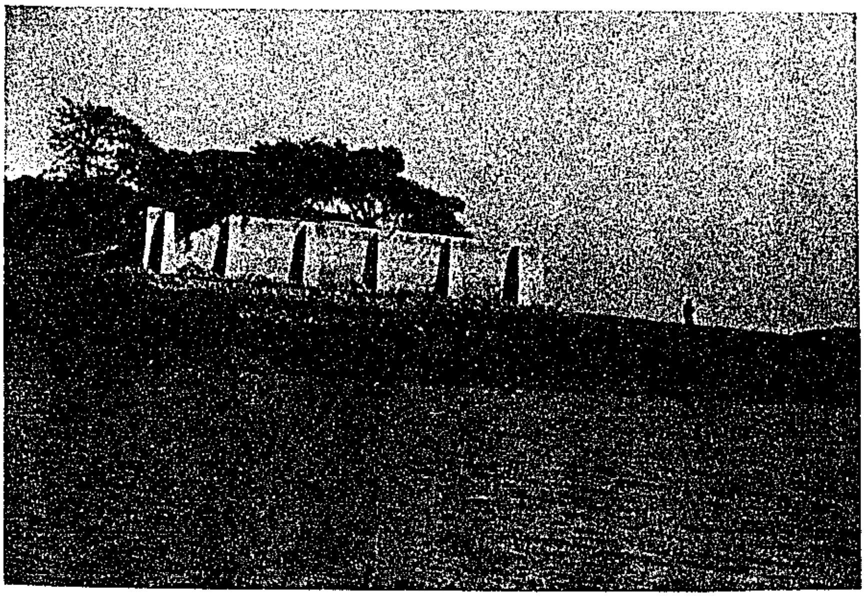
Surveying at Keraniganj

Soil survey at Keraniganj

Soil survey at Keraniganj

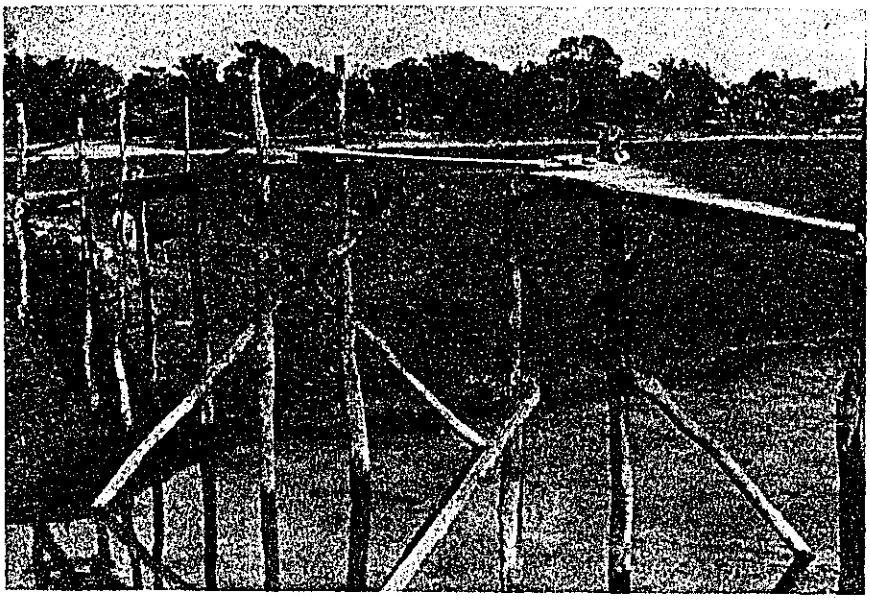


The Burhiganga river
in rainy seasons

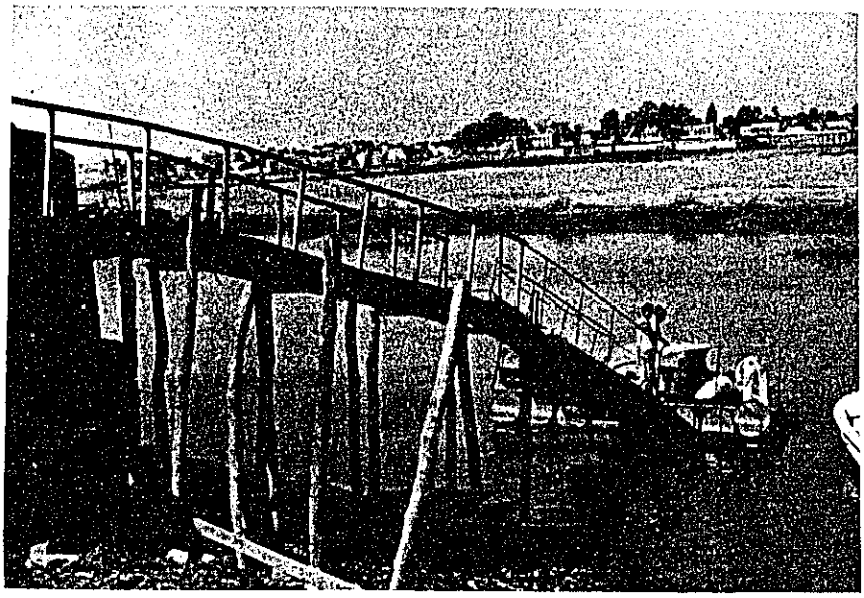


Houses
by the Burhiganga river

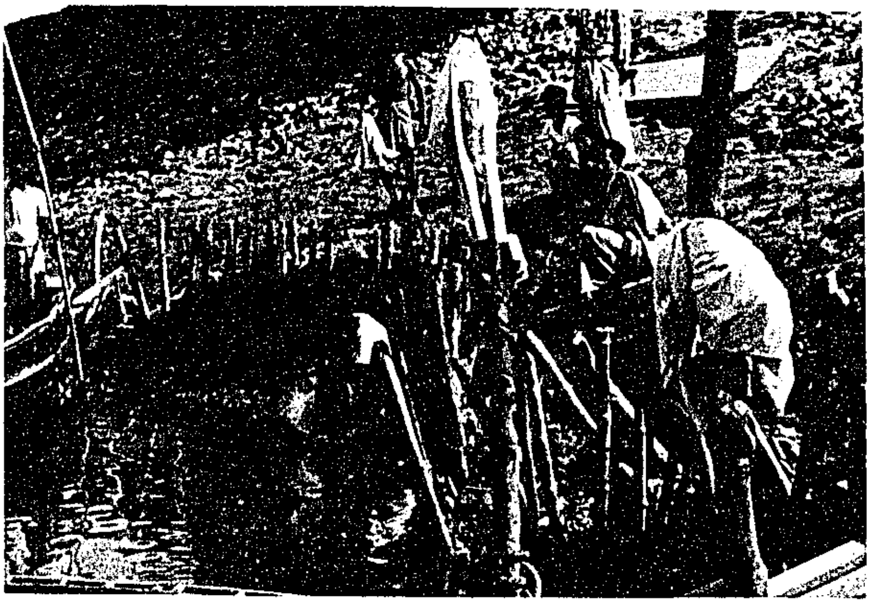
Scoured embankment



A bridge at Jinjira district



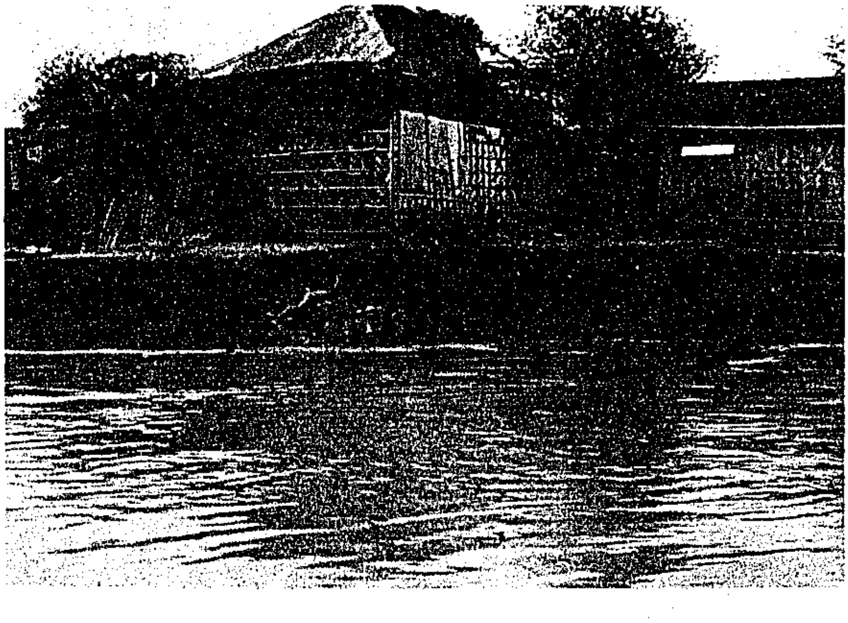
Floating pier at Keraniganj



Ferry at Jinjira district

The Burhiganga river
in the rainy season

Vicinity of Sonakanda
in the rainy season



The Dhaleswari river
in the rainy season

The vicinity of Diddpur
in the rainy season

The vicinity of Jinjira
in the rainy season

Public road at Keraniganj