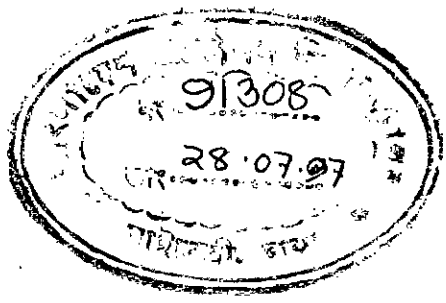
CAUSES OF WATER LOGGING IN DHAKA METROPOLITAN CITY



A Project Report

by

SAJIDUR RAHMAN

Submitted to the Department of Civil Engineering
Bangladesh University of Engineering & Technology, Dhaka
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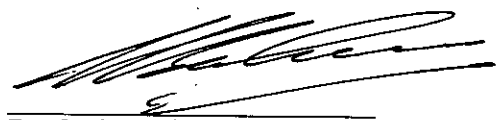

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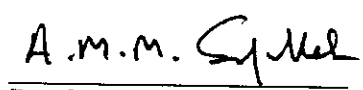

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ABSTRACT

Dhaka city is located on the southern edge of the Modhupur jungle terrace and is surrounded by rivers on all sides. Flood water from the rivers frequently inundates the low-laying areas of the city. Heavy rainfall causes water logging in many places within the city, creating manifold problems for its citizen. The rapid urbanization in the recent years has further worsened the water logging conditions of Dhaka city.

To cope with these problems, various flood protection and internal drainage plans have been proposed. It is anticipated that the water logging problem would have a more serious effect on the social, economic and industrial development activities.

This study attempts to identify the causes of water logging in Dhaka metropolitan city. Attempts and responsibilities of Government and various organizations have been examined and weaknesses identified.

Finally an attempt has been made to provide directions for the solution of water logging problem in Dhaka metropolitan city.

ACKNOWLEDGEMENT

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CONTENTS

ABBREVIATIONS

DPHE	:	Department of Public Health Engineering
DMIUDP	:	Dhaka Metropolitan Integrated Urban Development Project.
DWASA	:	Dhaka Water and Sewerage Authority
JICA	:	Japan International Co-operation Agency
BWDB	:	Bangladesh Water Development Board
DCC	:	Dhaka City Corporation
UDD	:	Urban Development Directorate
UNCHS	:	United Nations Centre for Human Settlements

CHAPTER - 1

INTRODUCTION

1.1 Background

Dhaka city, the capital of Bangladesh, is located on the flat deltaic plain of the three major international rivers, the Ganges, Brahmaputra and Meghna and is surrounded by their tributaries. Flood waters overflowing the river banks - frequently inundate the low-lying areas of the city. On the other hand, heavy monsoon rains cause water logging in many places within the city creating manifold problems for the citizens.

Rapid urbanization in recent years, rise in standard of living and concentration of living and social assets have increased the flood damage potential, in addition to flood vulnerability of Dhaka city. Encroachment of the natural drainage canals have further worsened the drainage problem of the city. It is anticipated that this situation would worsen in the future and the water logging problem would have a more serious effect on the social economic and industrial development activities.

1.2 Previous Studies

Since the mid 70's a number of crash programme for removing water logging from Dhaka city have been implemented. The first master plan was prepared by the Department of Public Health Engineering (DPHE) in 1968 to protect the developed area of 75 km^2 from flood waters and to drain internal storm waters. As a followup to the master plan, a detailed scheme was prepared by the Bangladesh Water Development Board (BWDB) in 1975 for an area of 145 km^2. Another scheme for internal drainage system was prepared by DPHE in 1976. Both the proposals, however, were not approved due to difficulty in financing. Instead, a crash programme for removing standing water from Dhaka City was recommended and has been implemented by DPHE since 1976.

The existing storm water drainage system is still inadequate for coping with the recurring heavy storms and floods. A recent 1981 study, the "Dhaka Metropolitan Integrated Urban Development Project", was completed in which a frame work for the future urban development of Dhaka was prepared and further detailed study for the drainage system improvement was recommended. The Department of Public Health Engineering (DPHE) and later the Dhaka Water and sewerage Authority (DWASA) have so far constructed about 140 km of small to large diameter sub-surface drains and re-excavated approximately 100 km of the canal system. In addition, another 120 kms. of surface and sub-surface drains are constructed and maintained by the Dhaka City Corporation (DCC). More projects of constructing drains are known to be in the pipe line.

In an effort to address the water logging problem of Dhaka city, a study on "Storm Water Drainage System Improvement Project in Dhaka city" was conducted by the Japan International Co-operation Agency (JICA) in collaboration with officials of the Government of Bangladesh from November, 1986 to October, 1987. After Dhaka suffered the worst flood in its history in 1988, the Government of Bangladesh (GOB) established a committee for flood control and drainage of Greater Dhaka, with the primary objective of preparing a flood control plan for the Greater Dhaka metropolitan area, based primarily on the 1987 JICA study on storm drainage system improvements for Dhaka city and the 1988 "Jansen Report" on causes of the 1988 flood and recommended solutions. In January, 1989 the Committee submitted a detailed scheme for phased investments in flood protection and drainage for Dhaka, Tongi, Narayanganj and Savar, which was approved by the Government in march, 1989.

The Government of Bangladesh prepared an urgent flood protection and drainage plan which included enclosing the Greater Dhaka area (about 260 square kilometers) with flood embankments, reinforced concrete walls, and drainage/flood regulation structures (sluices and pumping stations). In view of the high priority assigned to the Dhaka protection scheme, the Government immediately initiated Phase-I of the recommended works on a crash programme basis using their own resources. These works, which were designed to provide protection to about 136.50 sq.km. in the highly urbanized westerly part of the city, included construction of about 30 km of embankment and 7 km of flood protection wall along the westerly perimeter of the

city, complemented by about 2 km of new roads, 8.5 km of road raising to the east pipe sluices, cleaning and repair of internal drainage khals and sewerage systems. Additional works taken up at the same time included construction of a flood protection bound around Zia International Airport and 30 km of flood protection wall around the Dhaka - Narayanganj - Demra Zone to the south of the city. Implementation of the programme was a co-ordinate effort involving the BWDB, DCC, DWASA, RAJUK, CAAB and the Army. Construction activities commenced on a "Crash Programme" beginning in 1989.

The central part of the Dhaka city is developed on the high land with an elevation of 6 to 8m above mean sea level (G.T.S). The fringe areas are, however, located in the flood plains of the Buriganga and Balu Rivers with levels of 2 to 6m G.T.S. The fringe areas are constantly flooded. Average annual rainfalls in Dhaka is 2060 mm. The monsoon season extends from may to October during which period about 90% of the rainfall occurs. Floods in the surrounding rivers usually reach their peaks in August or September after a slow steady rise throughout the monsoon season. The maximum flood water level of the Buriganga River at Dhaka City in the past was 6.59m G.T.S. According to the latest population census, the population of the Dhaka metropolitan Area with an area of 402.5 km^2 was 2,068,000 in 1974 and 3,400,000 in 1981. The average annual growth rate during 1974 to 1981 was 7.54%. The cause of this high rate of growth is the large influx of people from the rural areas to Dhaka. Due to the pressure of the increasing population, the rate of the built-up area in the Dhaka city is also increasing day by day. It will result in further aggravation of the flood problems.

During the later part of August and early part of September, 1988, Bangladesh was devastated by the most disastrous flood that it has ever experienced. It is reported that of an unprecedented flood flow of the Brahmaputra that was synchronized with every high flows of the Ganges and Meghna. An approximately 80 thousand km^2 (56% of the total area of Bangladesh) and 47 million people (49% of the total population of Bangladesh) were adversely affected by the flood. Dhaka city also experienced its worst flood and suffered extreme damage. Vast areas of the country including the capital city of Dhaka with a population of about 4.8 million, were flooded to an unprecedented degree of flood levels 1.5 metres higher than normal for periods of upto four weeks. In Dhaka city alone it is estimated that about 200

sq.km. or 77% of the total area of 260 sq.km. were submerged to depths ranging between 0.3 to over 4.5 metres. About 2.5 million people or 60% of the city population were directly affected by these floods. City life was totally disrupted during this period. It is estimated that flood damages, which average about Tk.250.00 million in normal years, exceeded Tk.700.00 million in 1988. Based on the isohyetal data, it is reported that rainfall within the country was not a big factor in the 1988 flood. The monthly rainfall of Dhaka from August to September, 1988 was about half of that which is normal. The 1988 flood in Dhaka city was caused by external floods which although potentially of great magnitude have a very low frequency of occurrence and are consequently not used as the basis of the design for internal drainage facilities. The poor discharge capacity of the existing khals aggravated the length of the flood duration for inland areas and intensified the damage.

1.3 Objectives of the Present Study

The specific objectives of the present study are -

1. to assess the present overall situation of Dhaka Drainage System ;
2. to identify major causes of water logging in Dhaka city; and
3. to recommend feasible options to overcome these problems.

1.4 Methodology

To achieve the above objectives the following methodologies were considered within the limited scope of the present study :

a. field visits to see the situation of existing drainage system, e.g. khals, drainage pipe, culverts etc. ;

b. physical observation of existing flood protection works, e.g. sluice gates, embankment along the periphery of Dhaka city ;

c. identifying the locations of existing low lying areas within the city ; and

d. identifying other problems e.g., drain blockages, encroachment of natural channels etc., at various parts of the city.

Apart from field observations, visits were made to various relevant organisations such as Dhaka WASA, Water Development Board and Dhaka City Corporation to collect data, literature and other useful information which were subsequently analysed and used in preparing this report and suggesting future recommendations for the improvement of the drainage system in Dhaka.

CHAPTER - 2

DRAINAGE SYSTEM OF DHAKA CITY

2.1 Existing Drainage Facilities

The existing major drainage facilities are drainage pipes, khals, pump station, and related structures of culverts and bridges (Figures 2.1 & 2.2). According to the JICA (Japan International Co-operation Agency) major existing drainage facilities in Dhaka city consist of about 110 km of drainage pipe ranging in size from 0.3m to 3.0m in diameter, approximately 437 km of Khals and two pumping stations one located in old Dhaka (Narinda) and another at Kallyanpur.

Drainage pipe

The city area is provided with drainage pipes having a total length of 110 km and a diameter ranging 0.3m to 3.0m. (Begunbari Khal zone is installed with the rate of 2.7 km of pipe line per km^2 followed by Dholai Khal zone with a rate of 2.5 km of pipe line per km^2 and Segunbagicha Khal zone with a rate of 2.20 km of pipe line per km^2. The drainage pipes are made of brick with diameters of from 1.20 to 3.0m and of reinforced concrete with diameter below 1.20m. There are no drainage pipes with diameters above 3.0m. There are a number of khals in Dhaka city totalling 437 km in length. Major khals included are Dholai Khal, Segunbagicha Khal, Gerani Khal and Begunbari Khal. The total length including tributaries and catchment areas of the above khals are as shown below :

Name of Khal	Total Length (km)	Catchment Area (km^2)
Dholai Khal	4.00	16.80
Segunbagicha Khal	3.40	06.70
Gerani Khal	3.50	08.30
Begunbari Khal	6.50	37.70

(Source : Japan International Cooperation, Agency, 1987)

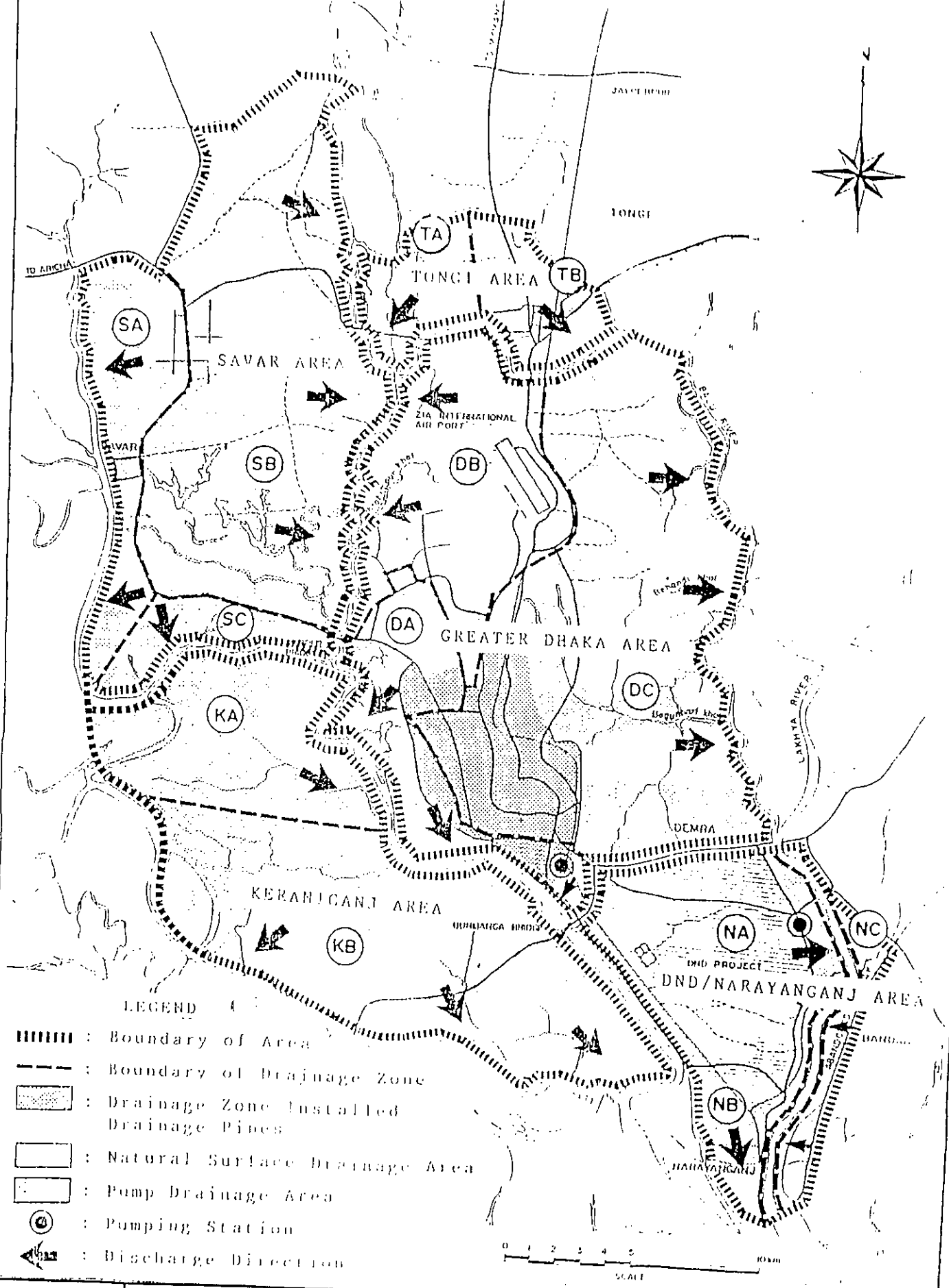


Figure 2.1	Existing Stormwater Drainage Area and System
	Source : JICA (1990)

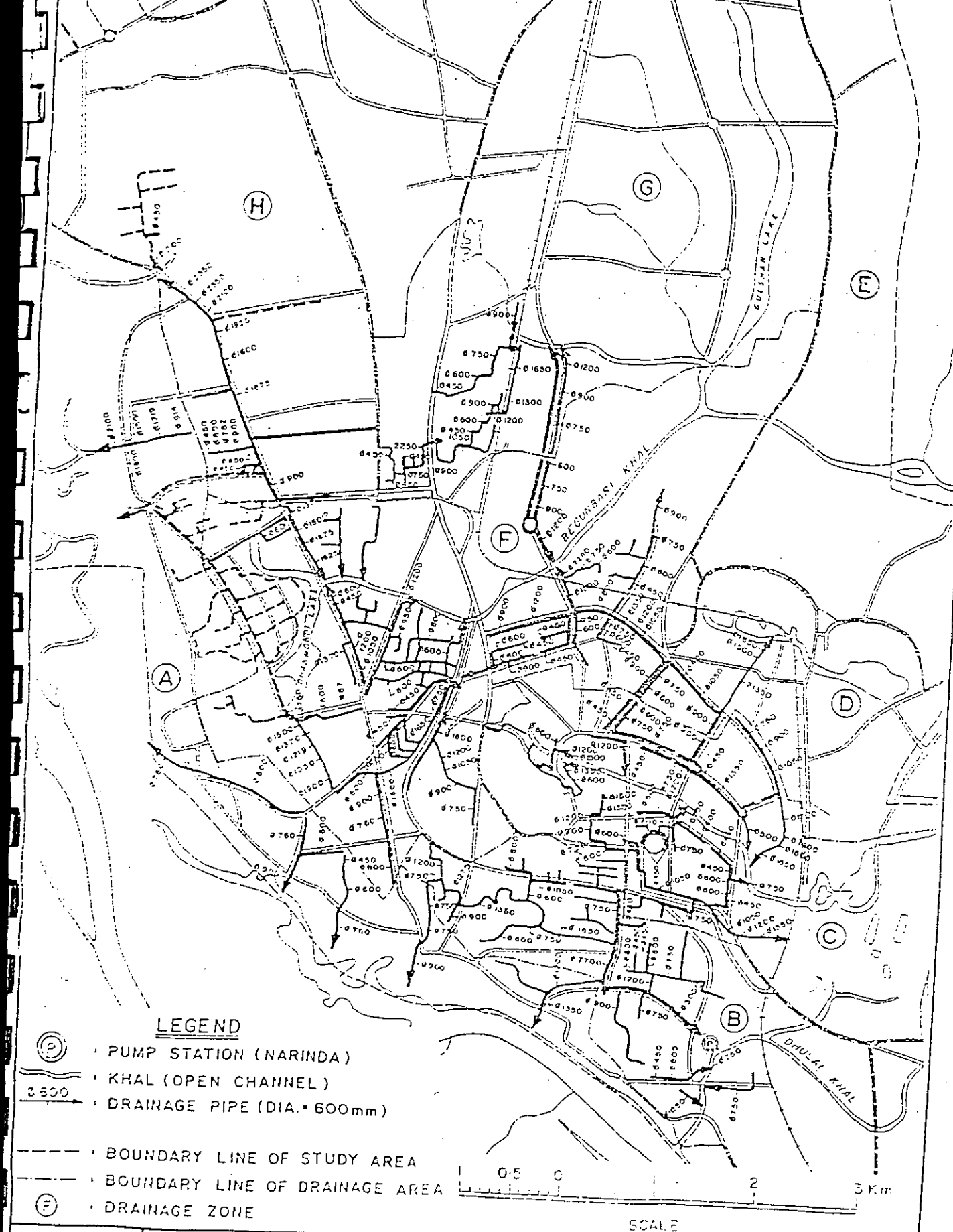


Figure 2.2 Existing Drainage Facilities

Source : JICA (1990)

There are 2 (two) existing pump stations. One pump station is at Narinda. It drains all of old Dhaka with a catchment area of 4.23 km^2. It is equiped with 4 (four) main pumps, each with a diameter of 1000 mm. The total discharge capacity is 9.60 m^3/sec. Another pump station is at Kallyanpur. Its capacity is 10m^3/sec. Culverts and bridges are installed in the sections of the khals where roads and railways cross.

2.2 Description of different Drainage Zones

Drainage Area and Drainage System in central Dhaka City (Figure 2.3) are described below:

Buriganga River Bank Zone (12.85 km^2)

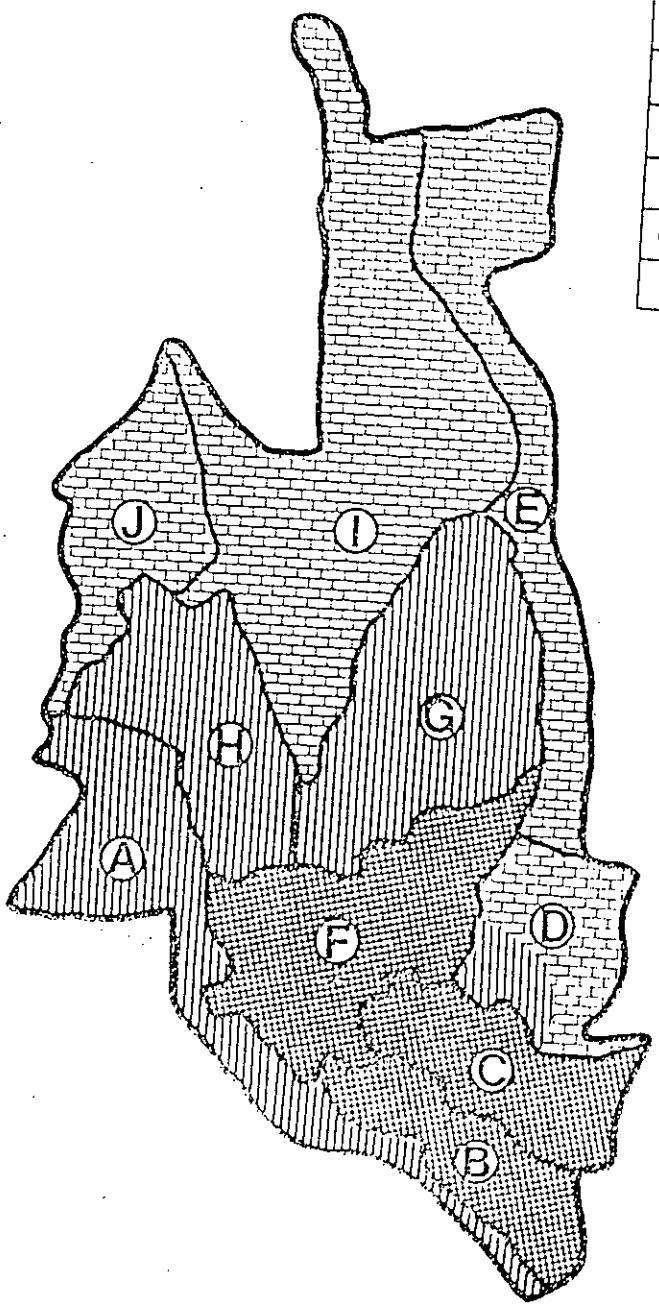
This zone consists of a narrow strip of the built-up area at the western edge of Dhaka city and a part of the flood plain on the left side of the Buriganga River. The total area is 12.85 km^2. In 1986, the built-up area was 6.75 km^2, occupying 53% of the total area. The built-up area is projected to be 10.79 km^2 (84%) in 2000. The population was estimated to be 442 x 10^3 in 1968 and 570 x 10^3 in 2000. The existing built-up area is high in elevation and is not affected by the Buriganga River floods. The Buriganga river flood plain area will be developed before 2000 and its fill-up elevation is expected to be above flood water level of the river. The area drains directly into the Buriganga river. Drainage pipes are provided in some limited areas.

Dholai Khal Zone

This zone has many small commercial and institutional lots huddled together. Institutional and educational facilities are also located here. The area covers the entire old Dhaka and adjoining Gandaria areas. The total area is 7.76 km^2 of which 7.43 km^2 (96%) was already built-up as of 1986. The population is estimated to be 598 x 10^3 in 1986 and 650 x 10^3 in 2000. Dholai Khal runs through the area from north to south, draining the whole area. It is 2.00 km long and approximately 30.0m wide.

The area is divided into two sub-areas according to the existing drainage system. One is the old Dhaka area with a catchment area of 4.23 km^2, equivalent to 55% of the total area. Storm water is collected and conveyed through the drainage pipes to Narinda for final discharge, by pump, into Dholai Khal. The provided trunk drainage pipes are 8.8 km in total length. The pump station has design discharge

DRAINAGE ZONE	AREA
(A) BURIGANGA RIVER BANK ZONE	12.85 km^2
(B) DHOLAI KHAL ZONE	7.76 km^2
(C) SEGUNBAGICHA KHAL ZONE	9.04 km^2
(D) BASABO ZONE	8.32 km^2
(E) NORTH-EAST EDGE ZONE	13.93 km^2
(F) BEGUNBARI KHAL ZONE	16.02 km^2
(G) GULSHAN-BANANI ZONE	17.64 km^2
(H) KALLYANPUR ZONE	12.78 km^2
(I) NORTH ZONE	31.42 km^2
(J) TURAG RIVER BANK ZONE	7.69 km^2
TOTAL AREA	137.45 km^2



LEGEND

: PHASE - II

: PHASE - III

Figure 2.3 Drainage Zones in Dhaka City

Source : JICA (1990)

capacity of 9.6 m^3/s. The other system is the remaining area of 3.53 km^2 which drains by gravity into Dholai Khal. This sub-area is frequently affected by the flooding of the Buriganga River which backs up through the Dholai Khal during flood season.

Segunbagicha Khal Zone

This zone includes the most important business and Government Office areas of Dhaka city. Paddy fields are spread out at the eastern edge of this zone. The total area is 9.04 km^2, of which 6.42 km^2 (71%) was, in 1986, built-up area, it is expected to increase to 6.57 km^2 (73%) in 2000. The population was estimated to be 307 x 10^3 in 1986 and is expected to increase to 388 x 10^3 in 2000. The area consists of 2 (two) sub-areas : upstream high elevation area of 6.2 km^2 and low-lying fringe area of 2.84 km^2 ; they are distinctly separated by the Bangladesh Railway. The upstream area is above 6.0m G.T.S. in elevation and is generally free from external river floods, while the low-lying fringe area is habitually flooded.

The upstream area collects storm water by drainage pipes and drains it through Segunbagicha Khal. The low-lying fringe area drains directly to the surrounding swamp lands. Segunbagicha Khal flows a distance of 3.4 km through the centre of the area. It is provided with some reserved ponds but is extremely narrow at the culverts of crossing roads and where building encroachment has taken place. The existing drainage pipes serve a considerable part of the upstream area; the total length reaches 20.30 km.

Bashabo Zone

This zone covers part of the south-east low-lying fringe area including Bashabo and Khilgaon. The total area is 8.32 km^2 of which the built-up area shared 4.91 km^2 (59%) in 1986. This built-up area is expected to sprawl outwardly to a large extent in the future. As a result, the total built-up area will reach 5.91 km^2 (71%) by 2000. The population was estimated to be 329 x 10^3 in 1986 and is expected to increase to 616 x 10^3 in 2000. The elevation of the built-up area is not very high and the area frequently suffers from external river floods. The inner part of the area is drained through tributaries of Gerani Khal, while the other parts are drained directly into the surrounding swamp ponds. Drainage pipes are hardly provided at all.

Northeast edge Zone

This zone consists of a narrow strip extending along the fringe of the Dhaka terrace from Begunbari Khal to Tongi Khal. The total area is 13.93 km^2. Urban Development is under way by fill up in the northern part and is also expected in the other parts. The built up area will increase from 7.58 km^2 (54%) in 1986 to 10.35 km^2 (74%) in 2000. The population was estimated to be 68 x 10^3 in 1986 and is expected to be 244 x 10^3 in 2000. The existing built up area is high enough to be free from external river floods and the future urban development areas are also expected to be filled up high enough. The existing built up area drains directly into the east low-lying areas. No drainage pipes are provided.

Begunbari Khal Zone

This zone covers a large central part of Dhaka city including Dhanmondi Residential and Tejgaon Industrial areas. The total area is 16.02 km^2 of which the built up area was in 1986, estimated to be 13.78 km^2 (86%) and will be 14.92 km^2 (93%) in 2000. The population was estimated to be 481 x 10^3 in 1986 and is expected to be 632 x 10^3 in 2000. Begunbari Khal flows a distance of 5.30 km from the Dhanmondi Lake to DIT Road through the centre of the area. The built up areas are comparatively high and therefore are rarely affected by external river floods, even through the flood waters back up to the inner part of the area through Begunbari Khal. The entire area drains into Begunbari Khal from all directions through drainage pipes in some areas and directly surface flow in other areas. The khal is still reserved widely in the lower reaches. On the contrary, in many sections of the upper reaches, it has become narrow and shallow because of building encroachment.

Gulshan - Banani Zone

This zone contains the high income residential areas of Gulshan and Banani and part of the Tejgaon Industrial area. The total area is 17.64 km^2 of which the built up area was estimated to be 13.42 km^2 (76%) in 1986 and 14.50 km^2 (82%) in 2000. The population was estimated to be 228 x 10^3 in 1986 and is expected to be 337 x 10^3 in 2000. The whole area is high enough to be free from external river floods. The area is divided into many sections by the tributaries of Begunbari Khal. The area is provided with a system of small rectangular roadside ditches. The area drains well into the tributary khals through those roadside ditches. There are no drainage pipes.

Kallyanpur Zone

This zone consists of the new capital area in the southern part and medium and low density residential areas in the northern part. The total area is 12.78 km^2. The built up area is expected to increase from 7.88 km^2 (62%) in 1986 to 11.64 km^2 (91%) in 2000. The population is estimated to be 231 x 10^3 in 1986 and 456 x 10^3 in 2000. The area drains into the Turag River through pumps. However, the low-lying residential areas located in the north part are vulnerable to floods of the Turag River. Drainage pipes exist only in some limited area.

North Zone

This zone contains Tongi development area, Cantonment area and mirpur area. The new Airport is in this zone. The total area is 31.42 km^2 of which 17.39 km^2 (55%) was the built up area in 1986. more than 70% of the built up area is occupied by the institutional areas including an international airport and an army base. The built up area in 2000 is projected to be 19.34 km^2 (62%). The population was estimated to be 344 x 10^3 in 1986 and is expected to be 613 x 10^3 in 2000. The existing built up areas are generally high enough to be free from external river floods except for the Katchukhet area in the southern most part. Future urban development areas are also expected to be filled up enough except for the southern most area. The area drains into the Turag River through its tributaries and natural water courses. There are no drainage pipes.

Turag River Bank Zone

This zone contains the western edge of mirpur area. The total area is 7.69 km^2. The built up area was estimated to be 3.17 km^2 (41%) in 1986 and 3.64 km^2 (47%) in 2000. The population is estimated to be 119 x 10^3 in 1986 and is expected to be 272 x 10^3 in 2000. The existing built up areas are generally high and not affected by floods of the Turag River. The area drains directly into the Turag River. There are no drainage pipes.

2.3 Adequacy of Existing Drainage System

Old Dhaka main drainage area and other Seven major drainage areas

The main drainage pipe of old Dhaka covers a catchment area of 4.23 km^2 and conveys storm water a distance of 4.10 km to the Narinda pump station. The

drainage pipe, with a diameter varying from 1.20 to 3.0m, is installed at an average gradient of 1/1000. The estimated discharge capacity ranges from 1.0 m^3/S to 12.0 m^3/S according to the pipe size. The estimated specific discharge capacities are 1.40 $m^3/S/km^2$ to 3.80 m^3/km^2, which are too small compared with the required capacities of about 7 $m^3/S/km^2$.

The seven major drainage system cover the high density area that are affected by severe floods. The discharge capacities of these pipes are to be in the range of from 0.20 m^3/S to 4.50 m^3/S according to the pipe sizes. The specific discharge capacities are mostly less than 3.0 $m^3/S/km^2$, which are too small compared with the required ones of 8 to 15 $m^3/S/km^2$.

Segunbagicha Khal

Segunbagicha khal originating in the Ramna lake flows a distance of 2.8 km in open channel to the Bangladesh Railway crossing, where it covers a drainage area of 4.95 km^2. The average gradient of stream for this stretch is estimated to be 1/5000. Some distance is converted to box culvert.

The khal is crossed by roads and railways at 13 sections in this stretch. The khal is extremely narrow at the road and railway crossings. The discharge capacities of these bottleneck sections are estimated. The estimated capacities are mostly less than 5.0 m^3/s. The specific discharge capacities of the sections are mostly less than 3 $m^3/s/km^2$, which are too small compared to the required ones of 6 $m^3/s/km^2$ to 8 $m^3/s/km^2$.

Begunbari Khal and Paribagh Khal

The main Begunbari Khal starts from the outlet of the Dhanmondi Lake and runs through the central developed area of Dhaka city to the DIT Road crossing in the eastern most part.

The catchment area at the DIT Road crossing is 16.02 km^2. The total length of this stretch is 5.30 km of which 2.5 km is upstream from the new Airport Road crossing and 2.80 km down stream from the same road crossing. The khal sections are wide enough in the downstream reaches. On the other hand, those in the upstream

reaches are narrowed at several places by roads and railway crossings. Some distance is converted to box culvert.

Discharge capacities at the narrow sections are estimated to be mostly less than 30.0 m^3/s. The specific discharge capacities of the sections are mostly less than 5 $m^3/s/km^2$, which are small compared to the required ones of 5 $m^3/s/km^2$ to 7 $m^3/s/km^2$. Paribagh khal is one of the tributaries of the Begunbari Khal, which joins with the main khal between Airport road and old railway road crossings. The catchment area at the confluence is 3.41 km^2. The total khal length is 1.00 km. The average khal width is 10m, more or less. The khal bed gradient is estimated to be 1/3300 on an average. The discharge capacity at the narrow sections are estimated to be 1 m^3/s to 3 m^3/s The specific discharge capacities of the sections are less than 1 $m^3/s/km^2$, which are too small compared to the required ones of 9 $m^3/s/km^2$ to 10 $m^3/s/km^2$.

Dholai Khal

Dholai Khal drains an area of 16.8 km^2. The khal stretches approximately 3.0 km from Jatrabari to the confluence with the Buriganga River. The khal is connected with the Gerani Khal in the upstream, which flows in the opposite direction, i.e. northerly. The khal sections with natural trapezoidal shape are rather wide ranging (10 m to 30 m). However the depth are shallow from 2.0 m to 4.0 m. The average gradient of the khal bed is estimated to be 1/10,000. Discharge capacities of the sections are estimated to be 3 m^3/S to 50 m^3/S.

Status of Narinda Pumping Station

A new pump station will be constructed at the confluence of the dholai khal with the Buriganga river. Its capacity will be 22.2 m^3/sec and the existing Narinda pump station (capacity 9.6 m^3/sec) will be removed.

2.5 Operation and Maintenance of Drainage Facilities

The regular operation and maintenance of all drainage facilities are the responsibilities of DWASA, which took over the responsibility from DPHE in March, 1989. The major task of operation and maintenance include the cleaning and dredging of the khals, cleaning of drainage pipes, and the operation of the pump stations and sluice gates.

All of the khals and drainage pipes are supposed to be cleaned one time per year. The cleaning is to be done by both cleaning machines and manual operations. In order to achieve satisfactory results in cleaning operations, strengthening of the existing organization is necessary both in terms of equipment and man power. Equipment used for maintenance includes trucks, numerous pieces of cleaning equipment and small pumps for dewatering.

2.5 Future Programmes

Altogether, the city's internal drainage system is capable of serving only 30% of its population, largely in western and old Dhaka. The Dhaka Master Plan Project, funded by UNDP and implemented by RAJUK, proposes drainage plan which incorporates an drainage projects under implementation. DWASA is executing a drainage project under the Dhaka Integrated Flood Protection with ADB assistance. On completion of the project in 1996, the drainage system in Dhaka will serve 70% of the city population. A JICA-assisted drainage project is expected to serve the remaining 30% of the population in the eastern part of the city. JICA has additional projects to address water logging at Uttara, Badda and portions of Mirpur.

CHAPTER - 3

CAUSES OF WATER LOGGING

3.1 Major Causes Identified

Extensive field observations in and around Dhaka city, long discussions with officials of relevant organisations and analyses of available data suggest the followings to be the major causes of water logging in Metropolitan Dhaka.

(1) Poor discharge capacity of existing drainage pipes and Khals.

(2) Clogging of existing drainage pipes due to inadequate collection of solid wastes, street sweepings and lack of maintenance.

(3) Impediment of khal waters due to encroachment of buildings and by problems caused by road and railway crossings.

(4) Insufficiency of drainage pipe length.

(5) Electrical breakdown of equipment at the existing pump stations.

(6) Encroachment of the natural drainage channels.

(7) The East Bengal Building Construction ordinance 1951 was declared in 1951 for the control of Building construction and excavation work in the city. But nothing has been mentioned in that ordinance about the control of filling of low land of the city. This ordinance has not been corrected still today. As a result with the indirect co-operation of some bureacrates, multistoried building has been constructed here and there filling low lands of the city. In the last few years real estate housing have been developed in the fixed place

for water basin of flood action zone of greater Dhaka. This was possible with the help of some bureacrates and evil people of the society. The owner of real estate housing are implementing and expanding their projects according to their wish. They have no headache about the development of greater Dhaka.

(8) The 1959/60 master Plan has continued to serve as a guide line for development in Dhaka. Even though it has not been officially updated since preparation, the major development agencies have used it as a guidance in the planning of urban infrastructure expansions, and market forces have followed. But in many cases this master plan is not followed.

At the present time there is no formal urban development policy in effect, there is no urban development strategy, there are no zoning regulations, there are no formal land conversion regulations and there is no policy for addressing the problems of slum and squatter settlements. Although UDD/ UNCHS prepared a draft physical planning (land use) and development control ordinance in 1985 under the National Physical Planning Project, it has never been adopted. The only quasi-effective controls in effect are those exercised through RAJUK, which has the authority to regulate and control formal development applications for the construction and expansion of permanent structures under the provisions of the East Bengal Building construction Act of 1952 and has a review and approval procedure for doing so. There are no effective control mechanisms in place to either guide, assist or regulate the proliferation of the numerous slum and squatter settlements in Dhaka.

The development controls which are exercised are largely done in an informal manner through the provision of extended infrastructure by the Government and utility agencies, e.g. where roads go, people follow, public, private and informal sector developments follows. RAJUK exercises a degree of control on the permanent developments through approval of building applications. There are no controls over low income, non permanent constructions and there are no controls (other than economic ones) over the conversion of agricultural land to urban uses.

Some of the key problems which have contributed to the lack of effective land use management include :

(a) The absence of a cohesive urban development policy to provide clear directions for the basic issues of urban development including National urban development strategies, urban planning and management strategies and alleviation of urban property.

(b) The lack of an up-to-date Master Plan and structure plans for long term planning and guidance of the growth and development of the city.

(c) The lack of effective legislation to guide/control land use and establish appropriate development standards.

(d) A lack of co-ordination amongst sectoral development agencies in providing forward planning to meet the demands and needs of the growing population.

(e) The absence of a clear Government policy regarding effective use of vacant and under utilized public lands.

(f) The absence of any mechanism for application or collection or development surcharges to assist in financing the essential public infrastructure and services which must be provided to sustain development.

(g) An extreme shortage of serviced land for meeting the ongoing growth demands, particularly for the low income and poor groups.

(h) Rapid and uncontrolled growth of slum and squatter communities.

(i) Inadequate provision of access to the basic sanitation services, particularly for the poor, including clean water, sanitation, drainage, solid waste, health and education.

(j) Sustained environmental degradation due to uncontrolled discharges of wastes (both human and industrial)

(k) Deteriorating public health conditions, particularly for the poor.

(l) Inadequate solid waste disposal system.

(m) Inadequate protection of drainage facilities, resulting in obstruction clogging and indiscriminate in filling of drains, khals and ponds and leading to increased frequency and severity of local flooding.

(n) Indiscriminate and uncontrolled in filling of low lands, which would potentially form an essential part of a planned flood control scheme for the city.

(o) Excessive demands on inadequate public infrastructure, utilities and services (e.g. water supply, sewerage, drainage, electricity, telephone and gas services) due to increasing densification in older serviced areas.

(p) Increasing traffic congestion due to inadequate provision of roads and appropriate traffic controls.

(q) Failure to provide appropriate park lands and open spaces particularly for private developments.

(r) Inadequate financial resources for public bodies to provide essential services.

(s) Lack of basic Education and Sanitation Sense.

(t) Unplanned filling of low-lying areas

(u) Filling of natural reservoirs within city

(v) Rapid unplanned urbanization.

(9) The dry khals have penetrated deep into the urban areas and now cover a wide area of low areas. With the increase of the pressure from the increasing population, the construction of houses on earthfill and/or raised floor houses on stilts will continue, and if this trend is not controlled, the dry khals in the urban areas of outer periphery will disappear. The function of the dry khal, at the present time, is for controlling the storm drainage and is highly appraised for its value in the rainy season to retard flood run off and it is planned to include the dry khals in the future land use plan.

(10) There are major drainage khals in the city :

(i)	Digun	-	Ibrahimpur Khal
(ii)	Gulshan	-	Banani, Begunbari, Mahakhali Khal and
(iii)	Dholai	-	Gerani, Segunbagicha Khal.
(iv)	Kallyanpur Khal		
(v)	Abdullahpur, Diabari		

Many portions of these khals were occupied by encroachment without proper sanction, earth filling, deposition of city garbage and buildings and roads. It is clear that this is one of the major causes of water logging in Dhaka City.

(11) Shortage of drainage khals is one of major causes of water logging in Dhaka city. Once there were 25 to 30 khals (small & large in size) connecting Dhaka city with Buriganga in the south, Turag in the west, balu in the east. City water was drained through these khals directly into the surrounding rivers. Also there were existence of pandu or Kawran khal upto the Balu and Turag river in the east and west of the city. Now most of these khals have been filled up. Once width of Dholai khal was 136'-0". Now this width has been reduced remarkedably. City water was drained into the surrounding river through 30 number of smaller to large size khals such as Dholia khal, Segunbagicha khal, Khilgaon, Basaboo khal, Gandaria khal, Mahakhali khal, Ibrahimpur khal, Kathalbagan khal, Paribag khal, Begunbari khal etc. Also

there were storm drainage line (118 km) of different sizes in the city. Lake, Jheel - pond and lower areas of Dhaka city performed the function of balanced water container. But these lower areas were filled up gradually due to construction of unplanned housing.

(12) Surface and underground storm water drainage system in Dhaka city were built up using unspecified and dissimilar sizes of drainage pipes. As a result the flow system of city water becomes inward rather than outward.

(13) Sewerage line and water drainage line merge in many places resulting one line. Manholes becomes inactive and creates water logging.

(14) At present only 18% people of Dhaka city avails the sewerage facility of WASA. The remaining people are draining sewerage at their own arrangement like septic tank, pit latrine etc. Moreover water logging is created due to improper operation, cleaning and maintenance of sewerage drains.

(15) Water logging problems, becomes acute due to cutting of road every now and then, due to filling of drains and due to setting of sewerage line, water line, gas line, electricity and telephone line etc. in an unplanned manner.

(16) Dhaka city corporation is installing storm sewer lines without design and without co-ordination with WASA system.

(17) The river bed of Buriganga, Balu, Turag and Sitalakha become up due to deposition and siltation of poly. As a result the water containing capacity of these river have been reduced to a large extent. So water cannot drain quickly and creates water logging problem.

(18) City garbage purification and processing system has not been developed even after long time. People do not care about rules during disposal of wastage and garbage. They follow the system "We care none". We will not maintain any system and discipline".

(19) Drains become functionless due to deposition of shopping bag, polythene bag filled with garbage and wastage on the mouth of manhole over drains, here and there of roads.

(20) Unconsciousness and irresponsibilities of city citizens has made the water logging problem more acute.

(21) Faults are found in integrated flood protection project. Construction of embankment around Dhaka city and pump setting work were started as per plan of Flood Action Plan-8. But after completion of 80% work of FAP-8 it is seen that water from lower areas of Dhaka city do not drain. It was found that proper importance was not given for the disposal and purification of industrial waters, sewerage drain, and family garbage. Considerations have not been taken for the proper provision of drainage structure like sluice gate in the embankment around Dhaka city.

(22) Sufficient number of pumping station has not been constructed.

(23) Want of temporary pumping station.

(24) Proper attempt has not been taken for the recovery of previous drainage khals which were illegally captured by some evil people. No effective Govt. action has been taken in this regard

3.2 EXAMPLES OF INADEQUATE DRAINAGE CAPACITIES

The design calculations have been presented to demonstrate that the existing drainage systems capacity is inadequate.

(a) Design calculation of storm sewer from central Govt. School to Kamalapur

Area scale out from 1:20000 scale

$$\text{Area} = (70\text{x}20)\,(20\text{x}20) = \frac{560000}{10000} = 56 \text{ ha}$$

Average run-off co-efficient for mid and low density & institutional area is 0.5

Tn = Overland flow, C = run off co-efficient

Tt = Travel time, i = intensity of rainfall mm/hr

Ti = initial time, A = drainage area (ha)

$$Tn = \frac{600}{3x60} = 33.33 \text{ min.}$$

$$Tt = \frac{1400}{1x60} = 23.33 \text{ min.}$$

$$Ti = \text{initial time} = 10 \text{ min.}$$

$$\therefore t = 66.66 \text{ min.}$$

$$i = \frac{9005}{66.66+50} = 77.19 \text{ min.}$$

$$\text{Peak flow, } Q = \frac{C\,i\,A}{360} = \frac{.5x77.19x56}{360} = 6 \text{ m}^3\text{/sec.}$$

$$A = \frac{Q}{V} = \frac{6}{1} = 6 \text{ m}^2$$

for circular sewer

$$A = \frac{A\,D^2}{4}$$

$$D = \sqrt{\frac{6 \times 4}{3.14}} = 2.764 \text{ m or } 2800 \text{ mm dia}$$

The existing line is 1700 mm dia. So another parallel storm sewer line is required to accommodate the peak discharge.

(b) Design calculation for Segunbagicha Khal

Length = 3.00 km

Area scale out from, 1:20000 scale

$$A = (150 \times 20)\ (80 \times 20) = \frac{4800000}{10000} = 480 \text{ ha}$$

Land use

Mid & low density area	Commercial area	Institutional area	open area	
320	45	80	35	
67%	9%	17%	7%	
Run-off Co-efficient	.5	0.65	.3	.2
	.335	.059	.051	0.014

∴ Average run-off co-efficient = .46

Time of concentration = Tc

$$Tc = Tn + \frac{L}{V}$$

$$Tn = \frac{600}{.3 \times 60} = 33.33 \text{ min.}$$

$$Tt = \frac{3000}{1 \times 60} = 50 \text{ min.}$$

Ti = initial time = 10 min.

∴ t = 93.33 min.

i = intensity of rain fall mm/hr. t = duration in minutes for 5- yr. frequency

$$i = \frac{9005}{t + 50}$$

$$= \frac{9005}{93.33 + 50} = 62.82 \text{ Say } 63 \text{ min.}$$

Using Rational Formula

Q = Peak discharge (m^3/sec.)

C = Run-off co-efficient

i = Av. rainfall intensity (mm/hr)

A = Drainage area (ha)

$$\therefore Q = \frac{.46 \times 63 \times 480}{360} = 38.64 \ m^3/sec.$$

$$A = \frac{Q}{V}$$

$$= \frac{38.64}{1} = 38.64 \text{ sq.meter}$$

Section design of box culvert

A = H x W

A = area

H = 5.5 + .3 = 5.8 m

W = width

$$W = \frac{38.64}{5.5} = 7.02 = \text{Say 7 meters}$$

The section is given below

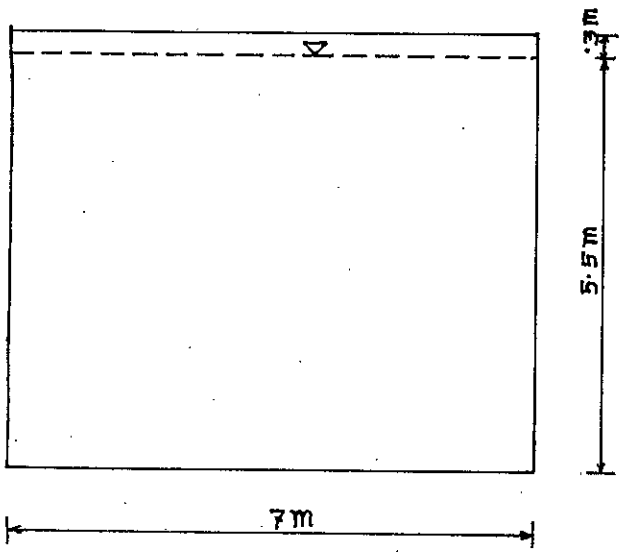


Figure 3.1
Typical cross-section of proposed Box-Culvert

To calculate slope use manning's formula

$$V = \frac{1}{n} R^{\frac{2}{3}} S^{\frac{1}{2}}$$

$$\therefore S^{\frac{1}{2}} = \frac{n.V}{R^{\frac{2}{3}}} = \frac{.015 \times 1}{2.138^{\frac{2}{3}}}$$

$$\therefore S = \frac{.015^2}{2.138^{\frac{4}{3}}} = .00008$$

To accommodate the peak discharge of Segunbagicha Khal, a cross-sectional area of 38.64 m^2 is required. Whereas, an average of only 0.81 m^2 cross-sectional area with an average of 0.8 m/sec is available throughout the 3.0 km long khal. That is why water remain stagnant for hours together and sometimes days together within the Segunbagicha Khal zone area. So to accommodate the present flow, 38.64 sq.meter area box culvert is suggested by WASA with 300 mm free board. Since the area is already densely populated and encroached by many illegal occupants, open channel system could not be provided in this zone.

However, for a successful drainage system employing box culverts instead of open khals, the responsible authorities as well as the beneficiaries must be aware that such systems would not be effective unless these are maintained properly.

CHAPTER - 4

RECOMMENDATIONS FOR THE IMPROVEMENT OF THE DHAKA DRAINAGE SYSTEM

In order to improve the present situation of the Dhaka stormwater drainage system, the following recommendation are made :

1. For the efficient removal of surplus water, a phase program will have to be prepared based on the following planning policies and design criteria.

   a. The city area will have to be divided into some drainage zones. The plans will include not only the structural measures but also the non-structural measures.

   b. The proposed plans will be prepared to meet the population and land use forecasted for certain year.

   c. The structural measure to be proposed will be limited to major works required to meet a mid-term range recessity for flood protection and internal drainage improvements with the limited financial resources. Lateral drains and branch drainage pipes can be excluded from the phase program. They may be laid after completion of the main scheme, as and when necessary.

   d. The flood protection plan will be prepared for all the low-lying built up areas below the design flood water level. The proposed area will cover not only the existing developed areas but also the future development areas. The flood water level with a 30 year frequency can be applied for the design of flood protection works.

e. The internal drainage improvement will be attained by installation of additional trunk drainage pipes, improvement of the existing khals and installation of drainage pumps. The rainfall intensity with a 5-year frequency can be employed for the design of drainage pipes and khal improvements. For the design of pump stations, the two days consecutive rainfall with a 5 year frequency can be used.

In addition to the structural measures, the following non-structural measures are recommended to improve the flood protection and drainage system.

Reserving swampy areas for the pump regulating pond.

Strict enforcement of controls to prevent any reduction of minimum khal sections which could cause flood flows to be impeded and backing up of water in the up-stream areas.

Raising of low-laying fringe areas with land fill sufficiently higher than the design flood level for future developments, except in the proposed flood protection areas.

2. Proper operation and maintenance of drainage facilities should be ensured. The major task of operation and maintenance will be the cleaning and dredging of the khals, cleaning of drainage pipes and the operation of the pump station and sluice gate. The operation and maintenance programme shall include the following major activities.

a. Dredging of deposits and removal of garbage from both open and closed khals.

b. Cleaning of existing pipes.

c. Operation and maintenance of pump station with sluice gate.

d. Land use control, in cooperation with the agencies concerned to maintain the regulating pond and khal areas, and to assure the required elevation of new land development.

All of the khals and drainage pipes should be cleaned one time per year. The cleaning is to be done by both cleaning machines and manual operations. In order to achieve satisfactory results in cleaning operation, strengthening of the existing organization is necessary both in terms of equipment and man power.

Equipment needed for efficient maintenance includes various trucks, numerous pieces of cleaning equipment, small pumps for dewatering and a number of vehicles for supervision. In terms of man, the staff should include sufficient number of engineers along with additional auxiliary staff.

In addition to normal operation and maintenance operation, necessary land use control measures should include the preservation of regulating pond area. There should be strict control of the use of land adjacent to the khals and land fill prior to development in the low lying areas.

3. The dry khals have penetrated deep into the urban areas, and now cover a wide area of low areas. With the increase of the pressure from the increasing population, the construction of houses on earth fill and/or raised floor houses on stilts will continue, and if this trend is not controlled, the dry khals in the urban areas of outer periphery will disappear. The function of the dry khal, at the present time, is for controlling the storm drainage and is highly appraised for its value in the rainy season to retard flood run off, and it is planned to include the dry khals in the future land use plan.

4. For the metropolitan development the earth borrow areas should be controlled beforehand, and the existing khals and lakes should be retained for the drainage of the surrounding areas to retain the waters. They should be kept to maintain the greenery and the water. Bodies of water are rivers, khals and lakes. These bodies of water serve to retard the flow of storm water and also have an additional function of storing water and are supplemental to the incomplete storm drainage facilities.Existing bodies of water should be preserved to the greatest extent possible. Even in the development areas, there will be some of the existing low wet areas (water retained only in the rainy season converted to hold water the year round). These bodies of water also recharge the ground water.

5. There are 3(three) groups of major drainage khals in the city.

Digun-Ibrahimpur-Kallyanpur khal, Gulshan-Banani-Begunbari-Dhanmondi khal and Dholai-Gorain-Segunbagicha khal. Many portions of these khals were occupied by encroachment without proper sanction, earth filling, deposition of city garbage and buildings and roads. It is clear that this is one of the major causes of floods in Dhaka city. There should be strict enforcement of controls to prevent any reduction of the minimum cross sectional area of the khals. This rule should be applied for all other khals.

6. A project should be prepared by DWASA for the demarcation of land acquisition, eviction or resettlement of unauthorized houses or structures.

7. Khal improvement work can be done by using box culvert type for certain commercially important busy places. It can also be done by retaining wall and open channel.

8. Dhaka City can be protected from external flood by constructing embankments along Buriganga-Turag and Balu rivers and Tongi khal with sufficient provision of drainage structures like sluice gates etc. and pumping stations.

9. There should be formal urban development policy, urban development strategy, zoning regulations, formal land conversion regulations and policy for addressing the problems of slum and squatter settlements. The 1959/60 master Plan has continued to serve as a guide line for development in Dhaka. It has not been officially updated since preparation. So for proper guidance of development the 1959/60 master plan have to be revised on the basis of present and future land development strategies.

At present RAJUK is preparing a Master Plan for Dhaka city which is expected to be completed by the end of 1995. If it is accepted by the government, it is should be enforced.

10. In order to improve land use management, it is essential that the Government should recognize the nature of the problems and take effective actions to develop and adopt appropriate legislation to correct the problems. Weak legislation is the

primary cause of to-days problems, and although it may benefit a few influential land owners and developers in the short term, in the long term it harms all the residents in Dhaka.

11. A national policy for providing clear direction on urban development policies and strategies and elevation of urban poverty should be prepared and adopted.

12. Physical planning and land use control legislation for effective control of land use and development should be reviewed, approved and adopted.

13. Upto date master plan and structure plans for long term guidance and strategies planning for the growth and development of the City should be prepared.

14. Long term needs for drainage, flood plans, transportation, solid waste disposal, park land and open space areas should be identified and appropriate controls should be included in the legislation to restrict/control development within these Zones.

15. In connection with the preparation of long term flood control and drainage plans for Dhaka city, appropriate provisions should be made in the master plan preparation, the detailed engineering designs, in the operation and maintenance plans and in the land use controls and regulations to :

- o preparation/adopt drainage and flood control master plan for provision of facilities.
- o develop a surface water management system and enact legislation to protect the drainage, detention pond and flood plain reserves based on the management system and related master plan provisions.
- o establish non-structural measures for flood management and mitigation, including standards on minimum road crest elevation, lot development elevation, plinth levels. Enact legislation which prohibits construction of permanent structures with grade elevations below the designated level.

16. Existing drainage pipes and khals should be cleaned to increase the discharge capacity.

17. Length of drainage pipe should be sufficient.

18. Government should develop rules to control filling of low lands in the City. With the indirect cooperation of some bureaucrats, multi-storied building have been constructed here and there filling low lands of the city. In the last few years real estate housing have been developed in the fixed place for water basin of flood action zone of greater Dhaka. The owners of real estate housing are implementing and expanding their projects according to their wish. So, Government should take proper action against them.

19. Proper measures should be taken where impediment of khal water due to encroachment of buildings and by problem caused by road and railway crossings occurs.

20. Existing khals shall be resectioned to increase the discharge capacity.

21. Many portions of previous and existing khals were occupied by encroachment without proper sanction, earth filling, deposition of city garbage and buildings and roads. So, Government should take proper step to recover these lands and to ensure required khal section undisturbed.

22. "Surface and underground storm water drainage system" in Dhaka city should be built up using specified and corrected sizes of drainage pipes so that the flow system of city becomes outward.

23. Sewerage line and water drainage system should be properly placed and maintained.

24. Sewerage line, water line, gas line, electricity line and telephone line should be set in a planned manner so that water logging is not created due to these. Cutting of road should be done in a planned way.

25. The river bed of Buriganga, Balu, Turag and Sitalakha become up due to deposition and siltation of poly. As a result the water containing capacity of these river have been reduced to a large extent. So, water cannot drain quickly. Hence dredging of river should be done to increase the water holding capacity of river.

26. City garbage disposal and processing system should be developed. Concerned department should take necessary step to develop public consciousness so that they do not dispose wastage and garbage here and there in the city.

27. Drains become unfunctional due to deposition of polythene bag, shopping bag filled with garbage on the mouth of manhole, over drains, here and there of roads. Hence, people should be more conscious so that they deposit their garbage in dust bin or specified place.

28. Proper importance should be given for the disposal and purification of industrial wastes, sewerage drain and garbage.

29. Sufficient number of pumping station temporary or permanent should be installed.

30. Local Consultant should be appointed and local technology should be adopted and dependency on foreign Consultant should be reduced.

31. Lake has to be excavated in the lower areas of the City in a planned manner, so that it can be used as water retention pond and city can be expanded utilizing the soil from these lakes.

32. Proper consideration have to be given for the provision of sufficient drainage structure like sluice gate etc. in the embankment around Dhaka city so that people do not become aquarium fish remaining within the embankment.

CHAPTER - 5

CONCLUDING REMARKS

Water logging is an old and acute problem of Dhaka city. This problem have serious effect on the social, economic and industrial development activities. Till 1960 there were so many natural drains, such as khals, lakes, low lands etc. which could drain water within shortest possible time. Now most of those drainage systems are occupied by encroachment without proper sanction, earthfilling, deposition of city garbage and buildings and roads. Additional drainage systems to drain the storm water from these areas have not been constructed in lieu of those. Now these problems need to be solved socially, technically and economically. These need a huge monetary fund. So if the government alone is unable to finance for this, foreign financial aid shall be obtained. In addition to Government effort, people have to come forward to solve this problem. They have to be more conscious to keep the drainage system clean and well functioning.

To solve water logging problem there should be formal urban development policy, urban development strategy, zoning regulations, formal land conversion regulations and policy for addressing the problems of slum and squatter settlements. An integrated master plan of drainage for greater Dhaka is urgently needed. Unless an integrated drainage system is developed, the water logging problem of Dhaka city will continue and will deteriorate further.

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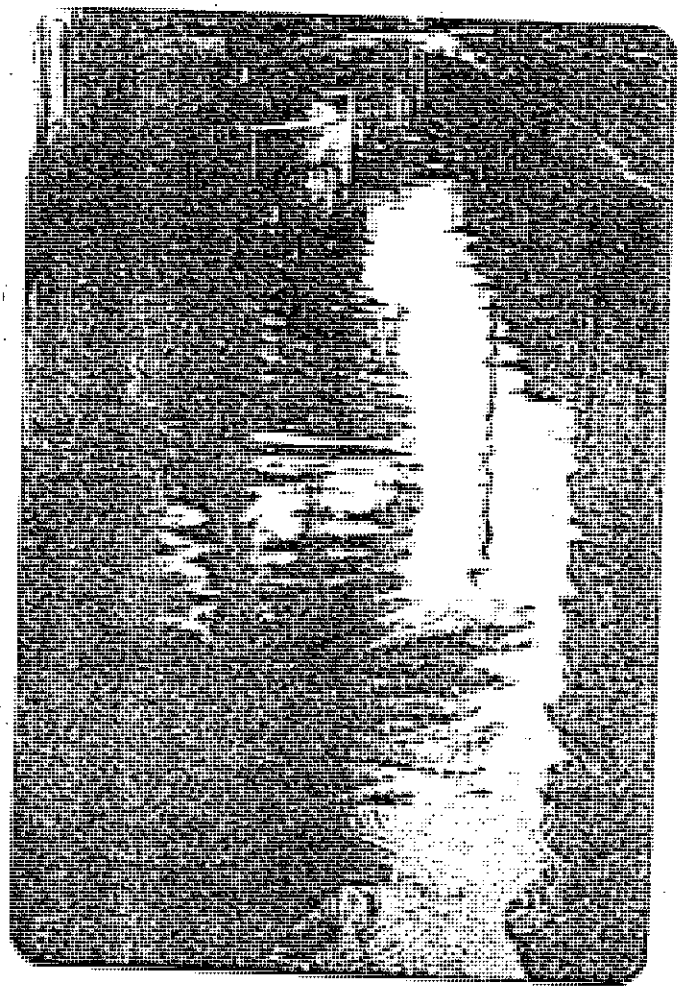
APPENDIX - A

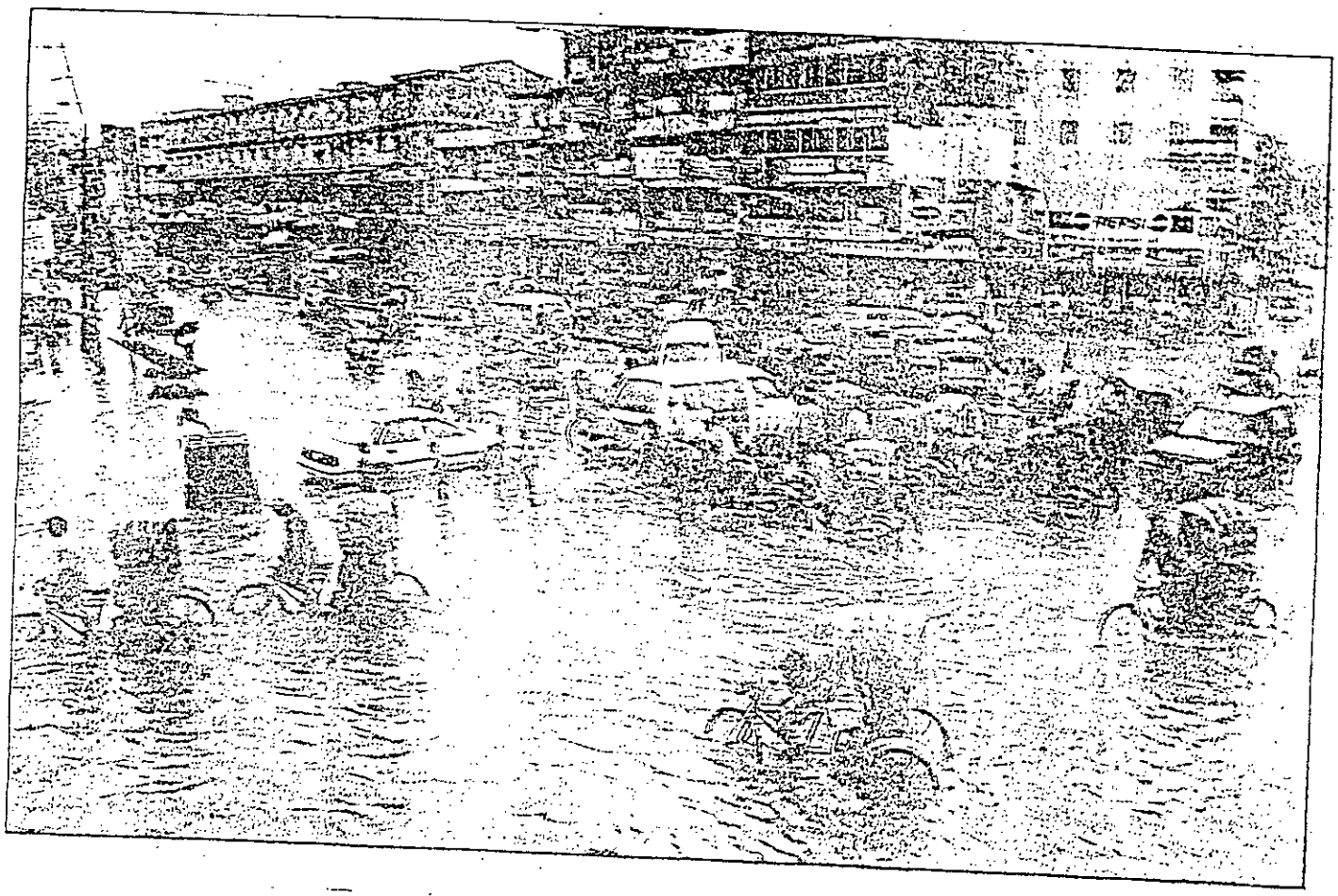
The appendix includes some photographs taken during monsoon (1995) showing different areas with the Dhaka Metropolitan area which are severely water logged after moderate to heavy showers.

Picture - 1



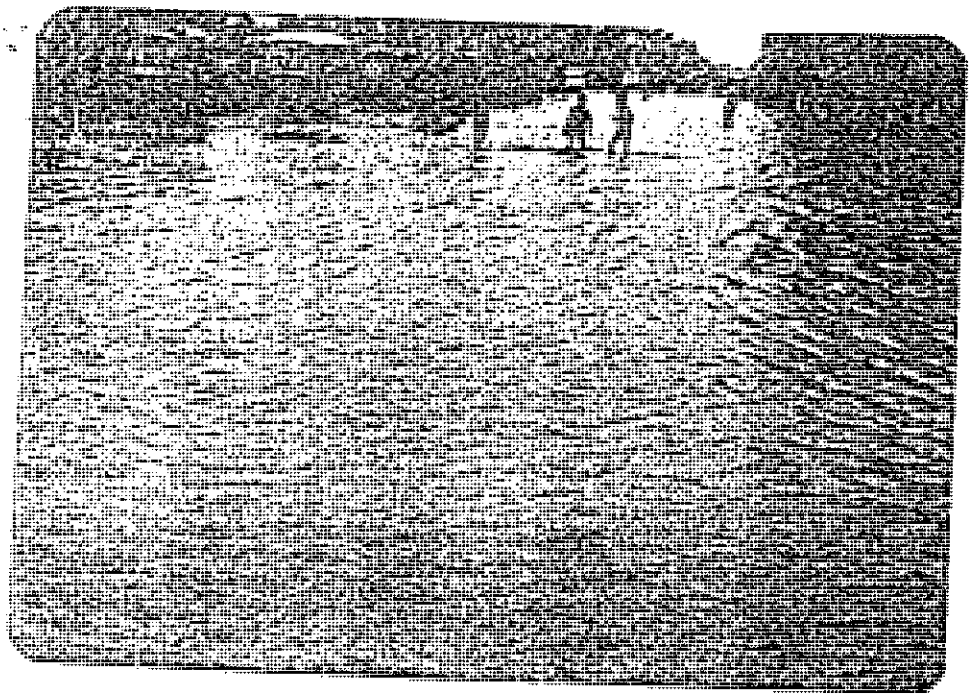
PLAN SHOWING EFFECTIVE WATER FLOWING AREA (WHITE ZONE) OF SEGUNBAGICHA KHAL. THE BLACK PART IS FILLED UP WITH EARTH, CITY GARBAGE ETC.

Picture - 2



Water Logging in the Shantinagar Area

Picture - 3

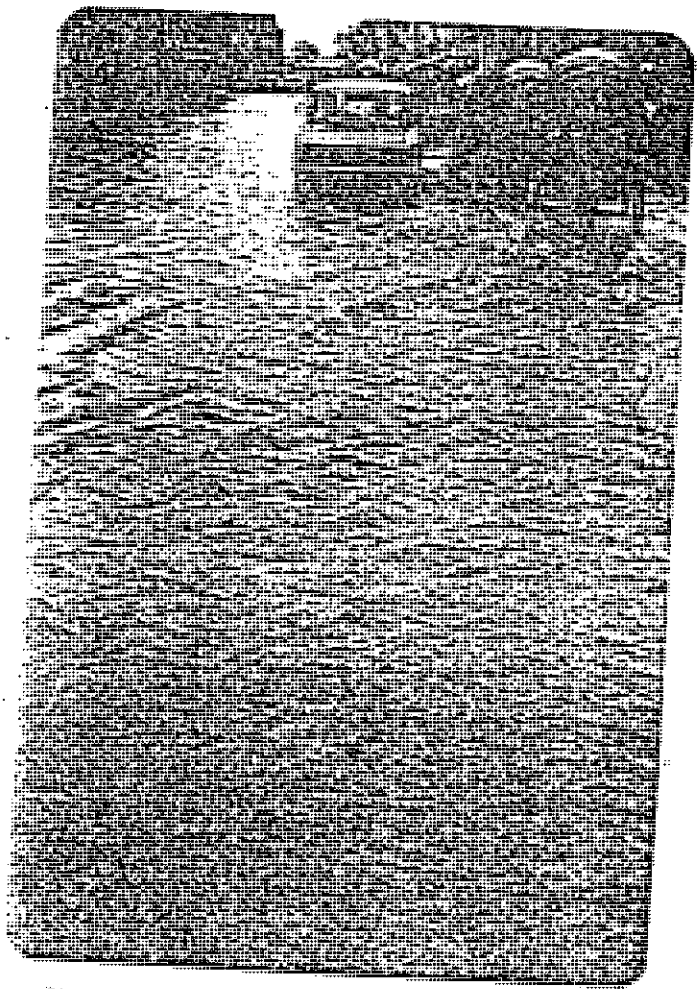


WATER LOGGING ON MIRPUR
ROAD NEAR NEWMARKET

Picture - 4

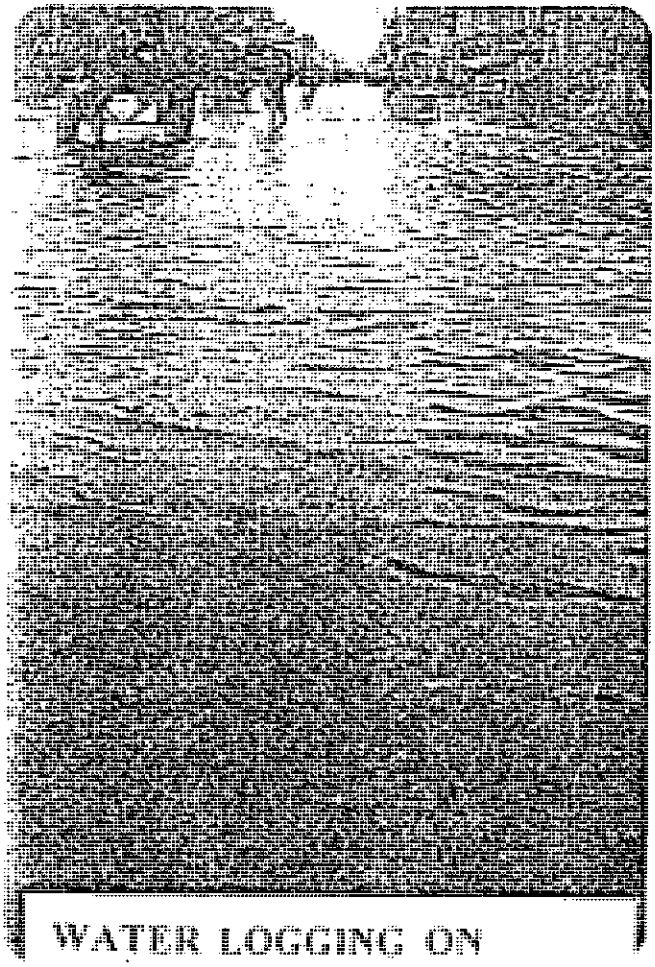
WATER LOGGING
ON GREEN ROAD

Picture - 5



WATER LOGGING NEAR
SHANTINAGAR ROAD

Picture - 6



WATER LOGGING ON
MIRPUR ROAD