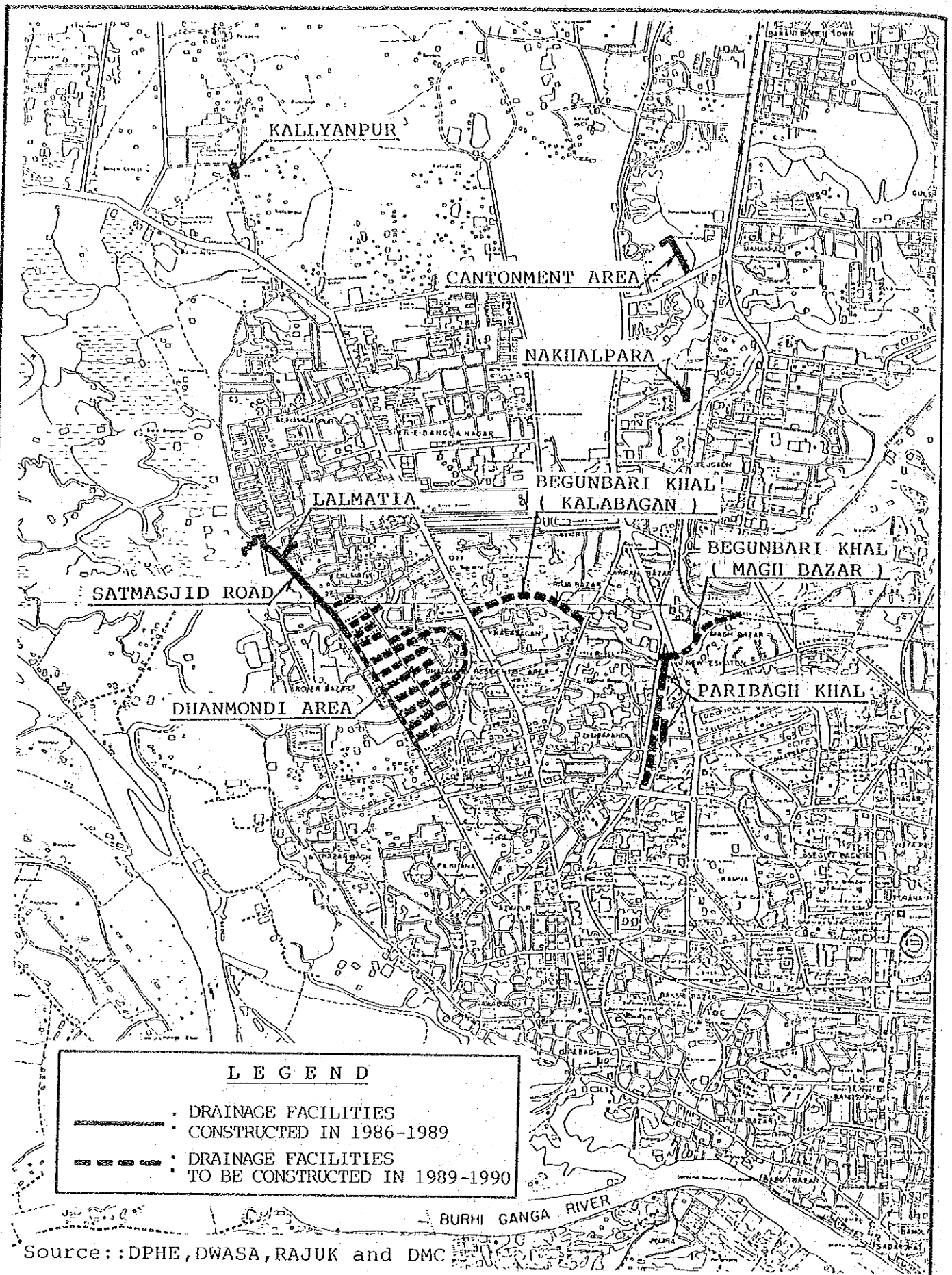

FIG. B. 10 LOCATION OF ADDITIONAL EXISTING AND PLANNED DRAINAGE FACILITIES

UPDATING STUDY ON STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY

JICA A.D 1990

SUPPORTING REPORT - C -

UPDATING THE PHASED PROGRAMME

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1 GENERAL

The previous JICA study proposed a phased implementation programme of drainage improvement measures for the Study Area (A = 137.5 km^2) consisting of three (3) phases at a total cost of about Tk 3.43 billion (1986 price). For the selected area of 31.3 km^2 (drainage zone B, C and F), the feasibility study was conducted as a Phase I Programme at a total cost of Tk 1.79 billion (1986 prices).

Since the Study Area of 137.5 km^2 will be enclosed by the flood protection dike proposed in the GDFCD Project, hydrological conditions of its surrounding areas will be changed. Moreover, some of facilities proposed in the previous JICA study will be built by related ongoing projects.

In this Chapter, the drainage plan of the Study Area will be reviewed and the Phased Programme will be revised, if necessary.

2. PLANNING POLICY AND DESIGN CRITERIA

2.1 Target Year

The target year will not be changed from that of the previous study. The plans should be prepared to meet the population and land use distribution in the year 2000.

2.2 Future Land Use

In the previous study, the future land use plan for the year 2000 was prepared based on the development policy proposed in the report of "Dhaka Metropolitan Area Integrated Urban Development Project (Bangladesh Government, ADB, UNDP, 1981)." The policy is a combination of the following two strategies :

- Continuing peripheral expansion of the city without comprehensive flood protection (see Alternative B in Fig. C.1)

- Expansion of the city to the north and west on land which does not require comprehensive flood protection (see Alternative C in Fig. C.1)

In the wake of the most serious flood in 1988, the Government of Bangladesh decided to implement the GDFCD Project. The government policy will be based on the following strategy :

- Future urbanization will be expanded in Greater Dhaka city area (approx. 265 km^2 including the JICA Study Area of 137.5 km^2) surrounded by the Buriganga, Turag and Balu rivers, and the Tongi khal (see Alternative A in Fig. C.1).

Even if the GDFCD Project is completed, changes to the future land use plan of the JICA Study Area prepared in the previous study will be negligible, because more than 80% of the Study Area was already estimated to be urbanized by the year 2000 as shown in Fig. C.2.

On the other hand, the surrounding lowland areas of approx. 128 km^2 will be developed disorderly and rapidly. Since the future land use plan for this area has not yet been prepared in the GDFCD Project, a feasibility study on the Greater Dhaka City Integrated Urban Development Project (a tentative project name) shall be made by RAJUK as soon as possible. No long-term infrastructural plans can be prepared without a future land-use plan.

2.3 Hydrological Design Criteria

(1) Design Flood Water Level

In the GDFCD Project, the design flood water level with a 500-year frequency (8.35 m in GTS) is applied for the design of flood protection works, e.g. dikes, walls, or sluice gates.

The frequent flood water level with 2-year return period is employed as the design outlet water level for internal drainage works, e.g. pump stations, khal improvements and drainage pipes. Two (2) following design flood water levels were applied for the Study Area:

- 5.36 m in GTS for the southern part including the Old Dhaka, Central Dhaka and Gulshan-Banani areas (see Fig. C.3).

- 6.00 m in GTS for the northern part including the Mirpur, Kallyanpur and Tongi areas (see Fig. C.3).

(2) Design Rainfall

As in the previous study, the rainfall intensity with a 5-year frequency was employed for the design of drainage pipes and khal improvements. The applied rainfall intensity-duration curves are illustrated in Fig. C.3

As in the previous study, a 2-days consecutive rainfall with a 5-year frequency was applied for the design of pump stations. In the event that a gigantic regulating pond capacity is expected, a weekly or monthly rainfall with a 5-year frequency is to be applied according to the pond capacity. Fig.C.4 shows the design rainfall for pump station.

(3) Runoff Calculation Method

Design discharge for the drainage pipes and khal improvements is calculated by the Rational Formula described below :

$$Q = C \cdot i \cdot A/360$$

where, Q : Peak discharge (km^3/s)
C : Runoff coefficient
i : Rainfall intensity during time of concentration (min.)
A : Drainage area (ha)

(4) Runoff Coefficient and Runoff Ratio

The following runoff coefficients are used for the calculation of flood runoff peak by the Rational Formula.

Land Use	Runoff Coefficient
Commercial Area	0.65
Industrial Area	0.55
High Class Residential Area	0.30
Middle & Low Class Residential Area	0.50
Green Zone and Others	0.20

The runoff ratio (total runoff/total rainfall) of 0.8 was employed in the estimate of flood runoff volume required for the calculation of pump capacity.

(5) Manning's Roughness Coefficient

Manning's roughness coefficients applied for the hydraulic calculations of drainage pipes, culverts and khal improvements are as follows :

Drainage pipe (brick)	:	0.015
Concrete Box Culvert	:	0.015
Khal Improvement (smooth section)	:	0.025
Khal Improvement (rough section)	:	0.035

(6) Drainage pipes are designed under the surcharge condition of storm water where the ground elevation is not high enough compared to the design outlet water level.

2.4 Scope of Structural Measures to be Prepared

In the previous study, the flood protection work (dikes, gates, and existing road raisings) and the internal drainage improvement work (pump stations, khal improvements, and drainage pipes) were proposed as structural measures, and are limited to major work required to meet a midterm range necessity with the limited financial resources.

There are three (3) related ongoing project, the World Bank Project, the GDFCD Project and the Khal Improvement Project, as described in the previous Chapter.

Main project component of the above projects are:

(1)	The World Bank Project :	Dholai Khal improvement work including construction of a New Narinda pump station.
(2)	The GDFCD Project :	Construction of flood protection dikes or walls with sluice gates and five (5) pump stations. However, construciton of a dike along the Balu River and 5 pump stations are proposed in the Phase II Programme.
(3)	The Khal Improvement Project :	Only the emergency reexcavation work of 13 khals by WASA.

Taking into account the above ongoing projects, flood protection work except for a sluice gate, Dholai Khal improvement and a New Narinda pump station were deleted from the Updating Study. Therefore, the scope of the structural measures to be proposed in this Study are :

(1) installation of a required pump station with sluice gate except a New Narinda pump station

(2) required khal improvements except the Dholai Khal in drainage zone B

(3) installation of trunk drainage pipe and sluice gate at its outlet , if necessary.

3. REVISION OF DRAINAGE PLAN

3.1 Drainage Zone

Revision of the drainage boundaries of zones A, B and H, was conducted, in correlation with the following two (2) ongoing projects:

- Dholai Khal Rehabilitation and Area Development Project (the World Bank Project)
- Greater Dhaka Flood Control and Drainage Project (the GDFCD Project)

(1) No. 1 revised area (Dholai Khal estuary area)

The Dholai Khal estuary area of 0.56 km^2 shall be incorporated into the B zone. The New Narinda pump station will be constructed at the mouth of Dholai Khal in the World Bank Project and will cover this area as the pump drainage area.

(2) No. 2 revised area (Kallyanpur and Mahammadpur area)

The Kallyanpur and Mohammadpur area of 4.82 km^2 was enclosed and protected by the embankment constructed by DMC in the GDFCD Project. This area shall be annexed to zone H from A.

(3) No. 3 revised area (Kallyanpur Khal estuary area)

The Kallyanpur Khal estuary area of 2.60 km^2 shall be excluded from zone A, because it is an outer area of the GDFCD Project.

The entire Study Area is revised from 137.45 km^2 to 134.km^2.

The revised area by each drainage zone is listed in Table C.1 and illustrated in Fig. C.5.

3.2 Pump Drainage Plan

(1) General

In the previous study, a pump drainage system was proposed for the following five (5) drainage zones having a total area of 35.42 km^2.

- Zone B : Old Dhaka and Gandaria areas of 5.92 km^2
- Zone C : Segunbagicha Khal area of 10.92 km^2
- Zone D : Bashabo area of 6.67 km^2
- Zone H : Kallyanpur area of 7.97 km^2
- Zone I : Katchukhet area of 3.94 km^2

Five (5) pump stations with a total capacity of 44.5 m^3/s (approx. 1.14 $m^3/s/km^2$) were proposed for pump drainage of the above zones. Also proposed were five (5) regulating ponds having a total area of 401 ha and a storage capacity of 4.94 million m^3. (see Fig.4.6)

The previous pump drainage plan shall be revised to correlate the two (2) on-going Projects, the World Bank Project and the GDFCD Project.

The Committee of the GDFCD Project proposed five (5) pumping stations, excluding the New Narinda pump station by the World Bank Project, as shown in Fig. C.6. This construction will be implemented in Phase II Programme.

(2) Drainage Zone A

The existing built-up area is mostly higher than the 30-year frequency flood level of 6.6 m in GTS. The area drains by gravity flow directly into the Buriganga River through the drainage pipes.

The installation of movable pumps having 150 mm diameters and capacities of 2.5 m^3/m is proposed at the outlets of the selected drainage pipes by taking into the following considerations :

- To drain storm water from a part of lowland that is being protected by the flood protection wall constructed by DMC in the GDFCD Project, and from the area that is under the frequent flood water level.

- To provide emergency measures for drainage during unexpected high flood water level periods of the Buriganga River.

(3) Drainage Zone B

The New Narinda pump station with a capacity of 80,000 m^3/h will be constructed at the mouth of the Dholai Khal in the World Bank Project; therefore pump station is proposed in this study.

(4) Drainage Zones C, D, E, F and G

The existing built-up areas of drainage zones E, F and G are mostly higher than the 30-year frequency flood water level of 6.60m in GTS. These areas can be drained by the gravity flow during a 2-year frequency flood water level of 5.36 m in GTS. even if a hydraulic loss of 1.5 m for the khal and drainage pipe is considered.

Drainage zones C and D are required to employ a pump drainage system based on newly urbanized areas with a ground elevation of 5.5 m in GTS. To cver the drainage improvement of inland areas, it is proposed that the HWL of khal outlets be 4.5 m in GTS.

After completing of the Phase II Programme of the GDFCD Project, these drainage zones will be integrated into one large zone of 167.95 km^2. The integrated drainage zone will be required to employ a pump drainage system.

The following two (2) alternatives for a pump drainage system are proposed :

Alternative I : The required pump station will be constructed at an east dike by the GDFCD Project and will drain into the Balu River.

Alternative II : To integrate with drainage zone B and to drain into the Buriganga River by the New Narinda pump station constructed in the World Bank Project.

Considering a gigantic effective storage volume of 136.5 x 10^6 m^3 (equivelent to almost 80% of a total inflow volume by 5-year frequency rainfall during a flood season between July and September) for the vast eastern lawland areas, the required pump capacity can be decreased by the long term pump operation.

The required pump capacities of both alternatives are calculated by the following formula:

$Qr = I/T$

$I = f\ A\ R$

where, Qr : required pump capacity (m^3/s)
I : inflow volume (m^3)
f : runoff raitio (0.8)
A : catchment are (m^3)
R : accumulated 5-year frequency rainfall during flood season (1.136m)
T : design pump operation time (3 months)

Alternative I

$$Qr = \frac{0.8 \times 167.95 \times 10^6 \times 1.136}{3 \times 30 \times 24 \times 60 \times 60}$$

$= 19.6\ m^3/sex$

Alternative II

$$Qr = \frac{0.8 \times 175.19 \times 10^6 \times 1.136}{3 \times 30 \times 24 \times 60 \times 60}$$

$= 20.5\ m^3/sex$

Construction cost of both alternatives are:

Alternative I : 19.6 m^3/sec x 24.5 million Tk/m^3 = 480.2 million Tk

Alternative II : 20.5 m^3/sec x 24.5 million Tk/m^3 = 502.3 million Tk

If the east lowland areas are not urbanized by the year 2000 and if the LWL of the regulating pond is maintained at 3.0~3.5 m in GTS, Alternative II is recommended, because the required pump capacity is estimated to be within the range of the New Narinda pump station of the World Bank Project.

When habitation is expanding into east lowland areas and the effective storage volume of lowland areas is decreasing, it may be necessary to adopt Alternative I where a pump station would be constructed at the Balu River by the GDFCD Project; the pump capacity would be increased gradually.

(5) Drainage Zone H

Considering the construction of a new flood protection dike by DMC in the GDFCD Project, the Kallyanpur pump station cum sluice gate is proposed to be relocated from the Mirpur Road to the mouth of the Kallyanpur khal.

The total area of the drainage zone H is 17.6 km^2. It consists of 10.8 km^2 of upland areas and 6.8 km^2 of lowland areas. Of the existing lowland areas, the northern parts from the Mirpur Road (approx. 3.3 km^2) and the western parts from the Mahammadpur (approx. 0.7 km^2) will be built-up in the near future by the rapid urbanization. Future upland and lowland areas are estimated to be 14.8 km^2 and 2.8 km^2 respectively.

The future effective storage capacity of the 3.36×10^6 m^3 of lowland area is only 18% of the total inflow volume by the long term rainfall. The 2-day consecutive design rainfall was applied for estimating the required pump and regulating pond capacities.

The required pump capacity and storage volume of regalating pond are estimated as follows ;

- required pump capacity : Qr

$$Qr = \frac{f \cdot A \cdot R}{T} = \frac{0.8 \times 17.60 \times 10^6 \times 0.245}{2 \times 24 \times 60 \times 60} = 20 \text{ m}^3/\text{s}$$

- required storage volume of requlating pond : Vr

$$Vr = (vi - vc/2) \times ti \times f \times A \times \frac{1}{360}$$

where, Vr : required storage volume of the regulating pond (m^3)
vi : average rainfall intensity during pump operation time (5.1 mm/h)
vc : specific pump discharge (Qr/A = 4.06 mm/h)
(4.06 mm/h)
ti : pump operation time (2 x 24 x 60 x 60 sec)
f : run-off ratio (0.8)
A : catchment area (1,760ha)

$$Vr = (5.1 - \frac{4.06}{2}) \times 172{,}800 \times 0.8 \times 1{,}760 \times \frac{1}{360}$$

$$= 2.08 \times 10^6 \text{ m}^3$$

The maintenance water levels, HWL and LWL of the regulating pond, are proposed to be 5.0 m and 4.0 m in GTS respectively, assuming that the minimum ground elevation of newly urbanized areas will be 5.50 m in GTS. Therefore, the reguired area of the regulating pond is estimated to be minimum of 208 ha.

However, since the existing effective storage volume of the lowland is expected to be more than two (2) times that in the future, a phased construciton plan shall be considered in the implementation schedule.

(6) Drainage Zone I

A gravity drain system can be adopted for drainage zone I except for the Katchuket area of 3.94 km^2. Since the existing ground elevation of the Katchuket area of 6.2~6.5 m in GTS. is almost same as the design flood water level, a pump drainage system must be adopted. The location and required capacity of the proposed pump station with sluice gate are the same as those recommended in the previous study as shown below :

- Location : Ibrahimpur Khal at the Darus Salam Road.
- Required pump capacity : 4.5 m^3/s
- Required regulating pond
  - Capacity : 508×10^3 m^3
  - Area : 34 ha
  - HWL and LWL : 5.5m and 4.0m in GTS

(7) Drainage Zone J

The existing built-up area is high land. As in the previous study, no pump station is recommended.

Specific required pump and requlating pond capacities are illustrated in Fig. C.7.

3.3 Khal Improvement and Drainage Pipe

(1) General

In the previous study, 25 existing khal improvements and the installation of an additional 14 trunks of drainage pipe are recommended.

In view of the following points, the improvement of the above 25 existing khals are reviewed:

- Design discharge
- Khal length to be improved
- Khal improvement type : open or covered type
- Longitudinal and cross section including design water level.

Except for the installation of sluice gates at the outlets for the Bariganga and Trug rivers, no revision for 14 trunks of drainage pipe are to be conducted in this study. Location of the revised khal improvement is shown in Fig. C.8.

(2) Design Discharge

Of the proposed 25 khal improvements, the design discharges of seven (7) khals in the drainage zone H (shwon in Fig. C.9) are reviewed because of the changes in the drainage areas of each khal. Table C.2 presents the revised design discharges of the above khals estimated by the Rational formula.

Design discharges for the proposed 25 khal improvements are shown in Table C.5 and Fig. C.9.

(3) Khal Length to be Improved

The total length of the required khal improvement was revised from 39.7 km to 36.65 km by taking into account the following :

- 4.2 km long improvement work for the Dholai and Gandaria khals will be undertaken by the World Bank project; Therefore the work is not included in this study.

- The 0.5 km Segunbagicha khal improvement work between the Kamulapur-Saidabad Road and the confluence with the Gerani khal shall be included in the study in order to drain water into the Gerani khal smoothly during the dry season.

- The proposed Kallayanpur pump station is relocated from the Mirpur Road to the new dike constructed by DMC in the GDFCD Project. A 2.5 km long downstream stretche of the Kallyanpur khal shall be improved. On the other hand, the required khal improvement length of K19 and K20 shown in Fig.C.8 is reduced to 2.4 km as a result of the change in drain direction.

(4) Khal Improvement Type

Two types of khal improvements, (open and covered channel types) are conceived for the highly urbanized area.

In the previous study, the open channel type was proposed for the improvement of all stretches of the existing khals. The proposal was made after considering the ease of collecting storm water, the maintenance work and the low investment cost.

For khal improvement of the following sections located in the highly urbanized area, however, the covered channel type (box culvert) is recommended in the study.

- Segunbagicha khal : Bangladesh Bank Building to DPHE Store Circle, L=2,300m

- Begunbari khal : Tongi Diversion Rd. to Mirpur Rd., L=2800m

- Paribagh khal : New Elephant Rd. to New Eskatan Expansion Rd., L=700m

The major considerations for adopting the covered channel type for the khal sections mentioned above are as follows :

- Due to inflow of sewerage and illegal dumping of garbage in the khals located in highly urbanized areas, a sicky odor emanats from the khals during dry

seasons. The concerned Agencies have been strongly urged to solve this problem.

- The flow capacities of open channel khals have been decreasing due to deposition of garbages, encroachment of squaters, illegal earth filling and so on. This causes a worsening of the flood problems by increasing the flood duration as well as the flood area along the khals. Additionally, the Agencies have been given the difficult assignments of maintaining strick control of the discipline in kahl areas and for keeping the khals in good working order by providing the necessary maintenance.

- Through discussions with the Agencies concerned (DWASA, DPHE, DMC, RAJUK, etc.), they were informed that planning considerations have to meet social needs by adopting the covered channel method for the khal improvement in the highly urbanized areas.

- As a matter of fact, the covered channel type has been adopted for the khal improvement work executed by the concerned Agencies over the past three years.

(5) Longitudinal and Cross Section

Revisions have been made to the longitudinal sections of the Begunbari and Paribagh khals. The longitudinal slopes of the khals were revised from 1:3,000 to 1:2,000 for the Begunbari khal and 1:2,000 to 1:1,000 for the Paribagh khal by taking tnto account the following :

- By completing the GDFCD Project, the F drainage zone will be combined with zones C and D as a pump drainage area. The design HWL at the Rampura Bridge shall be revised from 5.36m to 4.50m in GTS.

- The proposed khal bed elevation of the khals shall be made even with that of the existing culvert near Sonargaon Hotel constructed by RAJUK in 1987.

Table C.3 shows the proposed khal bed slopes of the 25 khal improvements.

The proposed cross sections of the 25 khal improvements were reviewed by the Mainning's formula based on the design discharges, proposed khal bed slopes,

and coefficient of roughness for khal improvement type, e.g., open or box culvert type. Table C.3 shows the dimensions of the proposed cross sections of the 25 khal improvements.

(6) Correlation of the Canal System with the World Bank Project

The 1.8 km Gerani khal, connecting between the Segunbagicha and Dholai khals, shall be improved by dredging and providing slope protection work along a 1.0 km section. The khal bed elevation is proposed to be zero meter in GTS.

In the World Bank Project, the Dholai khal improvement work shall be considered to correlate with the khal improvement proposals of the upper stream stretches, the Gerani and Segunbagicha khals.

3.4 Proposed Drainage Plan

(1) Structural Plan

The proposed structural plan for internal drainage improvement work is as follows :

(a) Installation of sluice gates : Seven (7) sluice gates are to be installed at the outlets of the proposed khals and drainage pipes in the drainage zones A and B and at the proposed pump stations in zones H and I.

(b) Installation of drainage pipes : The additional trunk drainage pipes ranging from 1.5 to 3.7 m in diameter are to be installed in the 14 routes for draining a total catchment area of 12.45 km^2. The total installation length is 17.0 km, of which 14.07 km is for a brick pipe and the remaining 2.93 km is for a R.C box culvert.

(c) Khal improvement : The existing khals are to be widened or dredged in 25 stretches to drain a total catchment area of 48 km^2. The total improved length reaches 36.35 km, of which 5.8 km is for a box culvert section and remaining 30.55 km is for an open channel. The major work consists of dredging of 560×10^3 m^3, the construction of bridge culverts at 45 places, including construction of one railway bridge, and the installationof 8.8 km of brick protection.

(d) Installation of pump stations : Two (2) pump stations with a total discharge capacity of 24.5 m^3/s will be installed . The pump stations cover drainage zones H and I having a total area of 21.54 km^2.

(e) The above mentioned major works are proposed for A,C,D,F,G, H and I drainage zones, and are not recommended for E and J drainage zones. For drainage zone B, only the installation of 4.3 km of drainage pipes and one sluice gate are included.

The internal drainage improvement of the E and J zones will be attained by small-scale structural and non-structural measures.

The proposed facilities and their locations are presented in Tables C.4 to C.7 and Fig. C.10 respectively.

(2) Non-Structural Plan

(a) Reserving swampy areas totaling 242 ha for the proposed pump regulating ponds for the H and I zones.

(b) Strict enforcement of control to prevent any reduction of the proposed minimum khal sections which could cause flood flows to be obstructed and the water to back up in the upstream areas.

4. ESTIMATION OF PROJECT COST

4.1 Basis for Cost Estimates

The estimation of the project cost, consisting of (1) the facilities' construction cost, (2) contingency and engineering service fees, and (3) land acquisition cost, was conducted based on the following conditions :

(1) The estimates were made on the assumption that all construction work will be contracted to general contractors by international tender.

(2) All base costs are expressed under the economic conditions prevailing in September, 1989.

(3) The exchange rates of foreign currencies are considered as follows :
US $1.00 = Tk 32.30 = ¥139 (Tk. 1.00 = ¥ 4.3)

(4) A constant allowance of 25% is added to the direct construction costs for the contractor's overhead and profit.

(5) A contingency allowance and the engineering design/supervision fees are earmarked at 20% of the total construction cost.

4.2 Estimation of Unit Cost

The unit cost estimated in the previous study was updated based on the current prices prevailing in Dhaka. The escalation of construction material prices over the passed three years (generally ranging from 140% to 170%) greatly affected the increase of each unit cost.

The unit costs by work item were calculated from the material cost, labor cost and equipment cost by analyzing the data on the similar works implemented in recent years as well as by taking into consideration the local conditions in Dhaka.

4.3 Land Acquisition Costs

The price of land varies depending on its location and geographical condition. The unit land costs shown below are given for two typical land usages, i.e., urbanized area and non-urbanized area. Those costs are approximately ten times higher than the previous costs. The breakdown of the acquisition costs by each facility are shown in Table C.11.

Unit Cost for Land Acquisition

Area	Land Cost	
Lowland in Urbanized Area	4,800	Tk/m^2
Lowland in Non-urbanized Vicinity Area	1,200	Tk/m^2

Source : DWASA

4.4 Estimated Project Cost

The total project cost, including construction, engineering, land acquisition and contingencies, amounts to Tk. 4,478.7 million at 1989 prices as shown below. The breakdown of the estimated project cost are shown in Table C.8 to C.10.

Project Cost

Unit : million Tk

Item		Cost
A.	Construction Cost	3,468.6
	(1) Pump Station	624.5
	(2) Gate	135.5
	(3) Khal Improvement	1,933.1
	(4) Drainage Pipe	775.5
B.	Contingency and Engineering	693.7
C.	Land Acquisition	316.4
	Total	4,478.7

5. REVISED PHASED PROGRAMME

5.1 **Prioritization of Drainage Zone**

In the previous JICA report, priority sequences of the ten (10) drainage zones were discussed through the comparison of the seven (7) factors such as beneficial population, required project cost, required land acquisition, flood conditions, flood damage, hindrance to traffic, and land use grade. The decided priority sequences were :

. First Priority Zones : B, C, F
. Second Priority Zones : A, D (part), G, H
. Third Priority Zones : D (part), E, I, J

Considering the rapid changes in urbanization and the serious flood damages in 1988, however, the H-zone will be taken as the first priority area in this updating study. The particular considerations for this modification are given below :

- Since the H-zone adjoins the heart of the city and two major roads, namely Mirpur and Rokeya Sharoni roads that connect to the city core in both the east and west ends of the zone, progression of the urbanization of the zone is remarkably high. The population in the year 2000 is estimated at 670,000 for the H-zone while the population in the year 1988 is estimated at 440,000 by taking into account a 52% of population increase. The rapid urbanization has increased the flood damage potential as well as the flood vulnerability of the area.

- In addition, the urbanization is expanding in a disorderly fashion to the low land area in the H-zone. The survey result of the 1988 flood conducted by the JICA study team with assistance from DWASA shows that the H-zone flood situation was the most serious among the 10 zones in the study area. The flood covering 70% of H-zone lasted more than one month and had an average depth of 1.5 m . Especially in the lowland area, the flood depth reached to more than 3.0 m and one-story houses were completely submerged under the flood water.

- The GDFCD project has decided, therefore, that the west part of the city, including the H-zone, is defined as high priority area for implementation of the flood protection and has started to construct a dike to enclose the area in the earlier stage. As of September 1989, progress of the dike construction for this part is roughly estimated as being 70% complete, more or less.

In the light of foregoing discussion, the H-zone is included as a first priority area in addition to the B, C, and F zones. The remaining zones are second priority area in view of an attempt to balance the investment with the first priority area (see Fig. C.11).

. First Priority Zones : B, C, F, H
. Second Priority Zones : A, D, G, E, I, J

5.2 Phased Programme

A program consisting of two (2) phases is tentatively proposed in conformity with the priority sequence of the drainage zones decided above as well as the priority sequence

of proposed drainage facilities. The priority sequences of the drainage facilities are given considering the efficiency to mitigate flood damages as described below :

(1) Construction of the pump station (Kallyanpur) with the sluice gate will be given priority to cope with the flood protection dike constructed by the GDFCD project. By virtue of this work, the flood water level of the vast inner areas will be lowered and the internal drainage through the drains will be facilitated.

Owing to the fact that the available regulating pond is large enough at present comparing to future demand proposed in the facility plan, the capacity of pump station to be constructed will be 10 m^3/s in the first phase, which is a half of the future capacity proposed.

When habitation is expanding into the lowland areas and an effective storage volume of the areas is decreasing, the pump cupacity shall be increased gradually.

(2) Improvement of main khals, such as Segunbagicha, Paribagh, etc., will be given high priority in order to facilitate the internal drainage through the lateral drains in addition to lowering the flood water level along the khals.

(3) For financial reasons, the remaining sub-khals and sub-drainage pipes will be constructed stage by stage in the later phase.

Although the first priority for implementation is given to the drainage zone B, the construction of pump station, gate and khal improvement along Dholai khal will be deleted from the Phase I. These constructions will be undertaken by the Dholai Khal Rehabilitation and Area Development Project.

The proposed phased program is shown in Table C.12. The locations of the facilities proposed in the Phase-I program are shown in Fig. 4.11 and typical sections of khal improvement for the Segunbagicha , Gerani, Begunbari, Paribagh, and Kallyanpur khals are shown in Figs. C.13 and C.17.

TABEL C.1 AREA OF DRAINAGE ZONE

Name of Zone	Area (km^2)		Remarks
	Former	Rivised	
(A) Buriganga River Zone	15.23	7.25	0.56 km^2 to B zone 4.82 km^2 to H zone 2.60 km^2 out of zone
(B) Dholai Khal Zone	6.68	7.24	0.56 km^2 from A zone
(C) Segunbagicha Khal Zone	10.92	10.92	
(D) Basabo Zone	7.46	7.46	
(E) Northeast Edge Zone	13.93	13.93	
(F) Begunbari Khal Zone	13.70	13.70	
(G) Gulshan-Banani Zone	17.64	17.64	
(H) Kallyanpur Zone	12.78	17.60	
(I) North Zone	31.42	31.42	
(J) Trug River Bank Zone	7.69	7.69	
Study Area	137.45	134.85	
(K) Northwestern Area	-	25.85	Out of JICA Study Area
(L) Eastern Area	-	104.30	Out of JICA Study Area
Greater Dhaka City Area	-	265.0	

Note: (1) Former figures refer to the previous JICA Study Report (Supporting Report, page I-55)
(2) (K) (L) Areas are out of JICA Study Area

Table C.2 Design Discharge of Khals in Drainage Zone H

Condition : Inlet Time : 20min

Khal No	Drainage Area A(km2)	Runoff Coefficient f	Length L(m)	Velocity V(m/s)	Time of Concentration t(min)	Rainfall Intensity i(mm/hr)	Design Discharge Q(m3/s)
K14-1	7.90	0.48	5,000	1.0	104	58.47	61.6
K14-2	4.46	0.49	4,200	1.0	90	64.32	39.1
K15-1	3.49	0.5	3,400	1.0	77	70.91	34.4
K15-2	1.53	0.5	2,600	1.0	64	79.00	16.8
K16	0.67	0.41	900	1.0	35	105.94	8.1
K17-1	2.43	0.44	2,200	0.9	61	81.13	24.1
K17-2	0.83	0.51	1,600	1.0	47	92.84	11.0
K18	1.26	0.38	800	0.8	37	103.51	13.8
K19	0.90	0.52	1,400	1.0	44	95.80	12.5
K20	0.60	0.51	1,200	1.0	40	100.06	8.5

Drainage Area and Runoff Coefficient by Each Khal

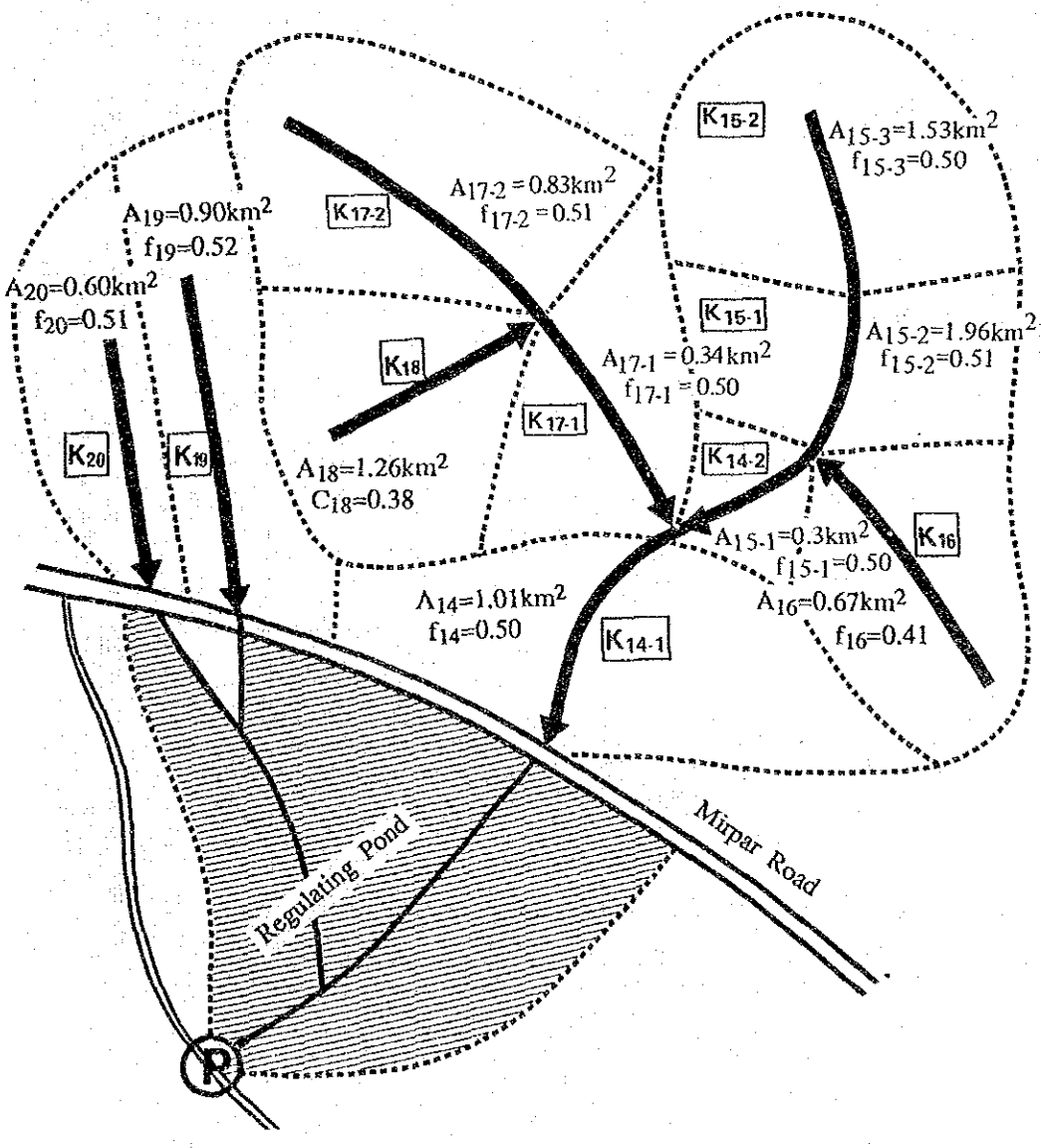


TABLE C.3 HYDRAULIC DESIGN OF KHAL INPROVEMENT

ZONE	KHAL NO.	TYPE	EESIGN DISCHARGE (m3/s)	DESIGN KHAL SECTION			COEFFICIENT OF ROUGHNESS N	FLOW AREA A (m2)	BED SLOPE I	WETTED PERIMETER P (m)	HYDRAULIC RADIUS R (m)	VELOCITY V (m/s)	DISCHARGE CAPACITY Q (m3/s)
				Bd (m)	Bu (m)	H (m)							
A	K1	TRAPEZOIDAL	10.4	3.0	9.0	2.0	0.035	12.00	1/1,000	1.20	1.18	1.01	12.12
B	K2-1	*	*	*	*	*	*	*	*	*	*	*	*
	K2-2	*	*	*	*	*	*	*	*	*	*	*	*
	K2-3	*	*	*	*	*	*	*	*	*	*	*	*
	K3	*	*	*	*	*	*	*	*	*	*	*	*
C	K4	TRAPEZOIDAL	-	6.0	19.5	4.5	-	-	-	-	-	-	-
	K5-1	DITTO	-	6.0	19.5	4.5	-	-	-	-	-	-	-
	K5-2	DITTO	52.2	6.0	19.5	4.5	0.035	57.38	1/2,000	22.22	2.58	1.20	68.96
	K5-3	BOX CULVERT	41.5	5.5	x	4.3	0.015	23.65	1/2,000	14.10	1.68	2.11	49.82
	K5-4	DITTO	37.9	5.0	x	4.3	0.015	21.50	1/2,000	13.60	1.58	3.02	43.48
	K5-5	DITTO	26.1	4.0	x	4.3	0.015	17.20	1/2,000	12.60	1.37	1.84	31.63
	K6	TRAPEZOIDAL	14.8	1.5	10.5	3.0	0.035	18.00	1/2,000	12.32	1.46	0.82	14.80
D	K7-1	DITTO	10.8	1.0	10.0	3.0	0.035	16.50	1/2,000	11.80	1.40	0.80	13.20
	K7-2	DITTO	9.7	1.0	7.0	3.0	0.025	12.00	1/2,000	9.50	1.26	1.05	12.50
	K8-1	DITTO	25.2	1.0	13.0	4.0	0.035	28.00	1/2,000	15.40	1.82	0.95	26.60
	K8-2	DITTO	25.2	1.0	13.0	4.0	0.035	28.00	1/2,000	15.40	1.82	0.95	26.60
	K8-3	DITTO	12.7	1.0	8.0	3.5	0.025	15.75	1/2,000	10.90	1.44	1.14	18.00
	K8-4	DITTO	5.2	1.0	7.0	3.0	0.025	8.75	1/2,000	8.07	1.08	0.94	8.24
E													
F	K9-1	BOX CULVERT	66.7	5.0 x 2	x	3.8	0.015	38.00	1/2,000	25.20	1.51	1.96	74.48
	K9-2	DITTO	55.0	4.5 x 2	x	3.8	0.015	34.20	1/2,000	24.20	1.41	1.87	63.95
	K10-1	DITTO	30.8	5.0	x	3.8	0.015	19.00	1/2,000	12.60	1.51	1.96	37.28
	K10-2	DITTO	28.6	4.5	x	3.8	0.015	17.10	1/2,000	12.10	1.41	1.87	31.98
	K11	DITTO	25.1	4.0	x	3.9	0.015	11.70	1/1,000	10.80	1.08	2.22	26.00
G	K12	TRAPEZOIDAL	20.8	5.0	14.0	3.0	0.035	28.50	1/3,000	15.82	1.80	0.77	22.00
	K13	DITTO	28.3	3.0	15.0	4.0	0.035	36.00	1/3,000	17.42	2.07	0.85	30.60
H	K14-1	DITTO	61.6	9.0	24.6	3.9	0.035	65.52	(1/3,000)	26.44	2.48	0.96	62.58
	K14-2	DITTO	39.1	5.0	19.8	3.7	0.035	45.88	(1/3,000)	21.55	2.13	0.86	39.61
	K15-1	DITTO	34.4	6.0	19.6	3.4	0.035	43.52	(1/3,000)	21.21	2.05	0.84	36.66
	K15-2	DITTO	16.8	2.0	14.4	3.1	0.035	25.42	(1/3,000)	15.86	1.60	0.71	18.16
	K16	DITTO	8.1	1.0	7.0	3.0	0.025	12.00	1/2,000	9.49	1.26	1.04	12.52
	K17-1	DITTO	24.1	2.5	13.0	2.5	0.035	49.38	1/2,000	5.81	3.34	1.43	27.71
	K17-2	DITTO	11.0	1.0	7.0	3.0	0.025	12.00	1/2,000	9.49	1.26	1.04	12.52
	K18	DITTO	13.8	1.0	7.0	3.0	0.025	15.75	1/2,000	10.90	1.44	1.14	17.96
	K19	DITTO	12.5	1.0	8.0	3.5	0.025	15.75	1/3,000	10.90	1.44	0.93	14.67
	K20	DITTO	8.5	1.0	7.0	3.0	0.025	15.75	1/2,000	10.90	1.44	0.93	14.67
I	K21	RECTANGULAR	34.5	6.0	x	4.0	0.015	41.77	1/3,000	14.00	1.71	1.74	41.77
		TRAPEZOIDAL		5.0	17.0	4.0	0.035	44.00	1/3,000	19.42	2.27	0.90	39.46
	K22	RECTANGULAR	17.3	4.0	x	4.0	0.015	23.59	1/3,000	12.00	1.33	1.47	23.59
		TRAPEZOIDAL		4.0	12.0	3.0	0.035	32.00	1/3,000	16.42	1.95	0.87	25.92
	K23	DITTO	13.1	3.0	12.0	3.0	0.035	22.50	1/3,000	13.82	1.63	0.72	16.26
	K24	DITTO	7.5	3.0	9.0	2.0	0.035	12.00	1/2,000	10.21	1.18	0.71	8.56
	K25	DITTO	11.3	2.0	9.5	2.5	0.035	16.88	1/2,000	12.02	1.40	0.80	13.50

NOTE: (1) THE FIGURES IN PARENTHESIS SHOW HYDRAULIC GRADIENT (THE BED SLOPE IS 1/1,500)
(2) Bd : MEANS DESIGN KHAL BOTTOM WIDTH
(3) Bu : MEANS DESIGN KHAL UPPER WIDTH
(4) H : MEANS DESIGN WATER DEPTH

TABLE C.4 SUMMARY OF PROPOSED FACILITIES

ZONE	PUMP STATION		GATE	KHALIMPROVEMENT							DRAIN		
	PUMP CAPACITY	REGULATING POND	SLUICE GATE	BOX CULVERT	RETAINING WALL CHANNEL	BRICK PROTECTION CHANNEL	SODDING PROTECTION CHANNEL	DREDGING	BRIDEG/ CULVERT	TOTAL KHAL LENGTH	BRICK PIPE	BOX CULVERT	TOTAL DRAIN LENGTH
	m3/s	ha	place	km	km	km	km	x 1000m3	places	km	km	km	km
A	-	-	4	-	-	-	0.30	2.7	1	0.30	3.80	-	3.80
B	*	*	1	*	*	*	*	*	*	*	2.05	2.23	4.28
C	-	-	-	2.30	-	1.50	2.50	198.1	3	6.30	4.11	0.70	4.81
D	-	-	-	-	-	1.40	3.05	42.2	12	4.45	0.70	-	0.70
E	-	-	-	-	-	-	-	-	-	-	-	-	-
F	-	-	-	3.50	-	-	-	56.8	-	3.50	3.41	-	3.41
G	-	-	-	-	-	-	2.90	43.4	4	2.90	-	-	-
H	20.0	208.0	1	-	-	5.90	6.10	129.7	7	12.00	-	-	-
I	4.5	34.0	1	-	0.80	-	5.90	87.5	18	6.90	-	-	-
J	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	24.5	242.0	7	5.80	0.80	8.80	20.75	560.4	45	36.35	14.07	2.93	17.00

Note : Facilities with (*) in the B-Zone are included in the World Bank Project.

TABLE C.5 PROPOSED KHAL IMPROVEMENT (I)

ZONE	KHAL No.	KHAL LENGTH km	REQUIRED HYDRALUIC SECTION Bb x Bu x H m x m x m	BRIDGE/BOX CULVERT places	BRIDGE/BOX CULVERT length(m)	RECTANGULAR CHANNEL Box Culvert km	RECTANGULAR CHANNEL Retaining Wall km	TRAPEZOIDAL CHANNEL Brick Protection km	TRAPEZOIDAL CHANNEL Sodding km	DREDGING 1,000m3	LAND ACQUISTION ha	REMARKS
A	K1	0.3	3.0 9.0 2.0	1	5	-	-	-	0.30	2.7	0.1	W/Flapgate
B	K2-1	*	*	*	*	*	*	*	*	*	*	Box Culvert
	K2-2	*	*	*	*	*	*	*	*	*	*	3-W2.8xH2.0
	K2-3	*	*	*	*	*	*	*	*	*	*	
	K3	*	*	*	*	*	*	*	*	*	*	
	Subtotal	*	*	*	*	*	*	*	*	*	*	
C	K4	1.80	6.0 19.5 4.5	1	10.0	-	-	1.00	0.80	54.0	1.1	
	K5-1	0.70	6.0 19.5 4.5	-	-	-	-	-	0.70	25.9	0.3	
	K5-2	0.50	6.0 19.5 4.5	2	36.0	-	-	-	0.50	20.0	0.4	
	K5-3	0.50	5.5x4.3	-	-	0.50	-	-	-	30.0	0.2	
	K5-4	1.40	5.0 x4.3	-	-	1.40	-	-	-	39.0	0.4	
	K5-5	0.40	4.0x4.3	-	-	0.40	-	-	-	19.2	0.2	
	K6	1.00	1.5 10.5 3.0	-	-	-	-	0.50	0.50	10.0	0.3	
	Subtotal	6.30	-	3	46.00	2.30	-	1.50	2.50	198.1	2.9	
D	K7-1	1.00	1.0 10.0 3.0	1	10	-	-	-	1.00	8.0	0.2	
	K7-2	0.40	1.0 7. 0 3.0	2	20	-	-	0.40	-	3.2	0.1	
	K8-1	1.05	1.0 13.0 4.0	1	10	-	-	-	1.05	11.6	0.3	
	K8-2	1.00	1.0 13.0 4.0	6	60	-	-	-	1.00	11.0	0.3	
	K8-3	0.65	1.0 8.0 3.5	2	20	-	-	0.65	-	5.9	0.2	
	K8-4	0.35	1.0 7.0 3.0	-	-	-	-	0.35	-	2.5	0.1	
	Subtotal	4.45	-	12	120.0	-	-	1.40	3.05	42.2	1.2	
E	-	-	-	-	-	-	-	-	-	-	-	
F	K9-1	0.40	5.0x3.8x2	-	-	0.40	-	-	-	7.2	0.2	
	K9-2	0.60	4.5x3.8x2	-	-	0.60	-	-	-	9.6	0.3	
	K10-1	0.80	5.0x3.8	-	-	0.80	-	-	-	8.0	0.2	
	K10-2	1.00	4.5x3.8	-	-	1.00	-	-	-	8.0	0.2	
	K11	0.70	4.0x3.9	-	-	0.70	-	-	-	24.0	0.2	
	Subtotal	3.50	-	-	-	3.50	-	-	-	56.8	1.1	
G	K12	1.5	5.0 14.0 3.0	2	50	-	-	-	1.50	21.0	0.6	
	K13	1.4	3.0 15.0 4.0	2	50	-	-	-	1.40	22.4	0.6	
	Subtotal	2.9	-	4	100	-	-	-	2.90	43.4	1.2	
H	K14-1	3.00	9.0x24.6x3.9	1	47	-	-	-	3.00	37.5	3.2	
	K14-2	0.30	5.0x19.8x3.7	-	-	-	-	-	0.30	12.0	1.1	
	K15-1	1.10	6.0x19.6x3.4	-	-	-	-	-	1.10	3.4	0.4	
	K15-2	1.10	2.0x14.4x3.1	-	-	-	-	-	1.10	21.1	0.8	
	K16	0.90	1.0 7.0 3.0	1	7	-	-	0.90	-	6.3	0.2	
	K17-1	0.60	2.5 13.0 2.5	-	-	-	-	-	0.60	4.2	0.4	
	K17-2	1.60	1.0 7.0 3.0	2	14	-	-	1.60	-	12.8	0.4	
	K18-1	0.80	1.0 7.0 3.0	1	7	-	-	0.80	-	6.4	0.2	
	K19	1.40	1.0 8.0 3.5	1	24	-	-	1.40	-	12.6	0.4	
	K20	1.20	1.0 7.0 3.0	1	24	-	-	1.20	-	8.4	0.3	
	Subtotal	12.00	-	7	123	-	-	5.90	6.1	129.7	7.4	
I	K21	1.80	5.0 17.0 4.0	6	90	-	0.3		1.40	30.6	0.8	
	K22	1.30	4.0 12.0 3.0	1	10	-	0.5		0.80	16.9	0.5	
	K23	1.00	3.0 12.0 3.0	1	10	-	-		1.00	12.0	0.3	
	K24	1.40	3.0 9.0 2.0	5	95	-	-		1.30	12.6	0.4	
	K25	1.40	2.0 9.5 2.5	5	50	-	-		1.40	15.4	0.4	
	Subtotal	6.90	-	18	25.5	-	0.80		5.90	87.5	2.4	
J	-	-	-	-	-	-	-	-	-	-	-	
	Total	36.35	-	45	649	5.80	0.80	8.80	20.75	560.4	16.3	

Note : Khal improvement with (*) are included in the World Bank Project.

TABLE C.6 KHAL IMPROVEMENT WORK (2) - BRIDGE/BOX CLUVERT

ZONE	KHAL NO.	EXISTING		REQUIRED	PROPOSED			REMARKS
		TYPE	SIZE (mxm)	SIZE (mxm)	TYPE	SIZE (mxm)	LENGTH (m)	
A	K1	Box Culvert	2.2x2.4	4.5x2.3	Box Culvert	4.5x2.3	5.0	
B	*	*	*	*	*	*	*	
C	K4	-	-	12.0x5.0	Box Culvert	6.0x5.0x2	10.0	
	K5-2	Box Culvert	9.6x5.2	12.0x5.0	Box Culvert	6.0x5.0x2	17.0	
	K5-2	Bridge	5.6x3.9	12.0x5.0	Bridge	L=12.0m	19.0	Railway
D	K7-1	Box Culvert	3.5x3.3	5.5x3.5	Box Culvert	5.5x3.5		
	K7-2	Box Culvert	3.5x3.3	5.5x3.3	Box Culvert	5.5x3.5	10.0	
	K7-2	Box Culvert	3.0x1.6	4.0x3.5		4.0x3.5	10.0	
	K8-1	Box Culvert	3.4x3.6	7.0x4.5	Box Culvert	7.0x4.5	10.0	
	K8-2	Box Culvert	4.5x2.4	7.0x4.5		7.0x4.5	10.0	
	K8-2	Box Culvert	5.4x2.3	7.0x4.5		7.0x4.5	10.0	
	K8-2	Box Culvert	4.6x2.8	7.0x4.5		7.0x4.5	10.0	
	K8-2	Box Culvert	3.5x3.1	7.0x4.5		7.0x4.5	10.0	
	K8-2	Box Culvert	4.2x3.0	7.0x4.5		7.0x4.5	10.0	
	K8-2	Box Culvert	3.0x2.3	7.0x4.5		7.0x4.5	10.0	
	K8-3	Box Culvert	4.5x3.4	4.5x3.5		4.5x3.5	10.0	
	K8-3	Box Culvert	1.6x1.9	4.5x3.5		4.5x3.5	10.0	
E	-	-	-	-	-	-	-	
F	-	-	-	-	-	-	-	
G	K12	Box Culvert	7.2x4.9	9.0x4.0	Box Culvert	4.5x4.0x2	40.0	
	K12	Box Culvert	3.0x4.8	9.0x4.0	Box Culvert	4.5x4.0x2	10.0	
	K13	Pipe	Dia=1.5	9.0x4.5	Box Culvert	4.5x4.5x2	40.0	
	K13	Pipe	Dia=1.5	9.0x4.5	Box Culvert	4.5x4.5x2	10.0	
H	K14-1	Box Culvert	6.0x5.5	10.0x4.5	Box Culvert	4.0x4.6	47.0	
	K16	Box Culvert	6.0x5.5	4.0x3.5	Box Culvert	4.0x3.5	7.0	
	K17-2	Box Culvert	6.0x5.5	4.0x3.5	Box Culvert	4.0x3.5	7.0	
	K17-2	Box Culvert	6.0x5.5	4.0x3.5	Box Culvert	4.0x3.5	7.0	
	K18-1	Box Culvert	6.0x5.5	4.0x3.5	Box Culvert	4.0x3.5	7.0	
	K19	Pipe	Dia=2.6	4.5x4.0	Box Culvert	4.5x4.0	24.0	
	K20	Pipe	Dia=0.8	4.0x3.5	Box Culvert	4.0x3.5	24.0	
I	K21	Box Culvert	3.3x2.4	11.0x4.5	Box Culvert	5.5x4.5x2	40.0	
	K21	Pipe	2xDia=2.4	11.0x4.5	Box Culvert	5.5x4.5x2	10.0	
	K21	-	-	11.0x4.5	Box Culvert	5.5x4.5x2	10.0	
	K21	-	-	11.0x4.5	Box Culvert	5.5x4.5x2	10.0	
	K21	-	-	11.0x4.5	Box Culvert	5.5x4.5x2	10.0	
	K21	-	-	11.0x4.5	Box Culvert	5.5x4.5x2	10.0	
	K22	-	-	8.0x3.5	Box Culvert	4.0x3.5x2	10.0	
	K23	-	-	7.5x3.5	Box Culvert	3.8x3.5x2	10.0	
	K24	-	-	6.0x2.5	Box Culvert	3.0x2.5x2	10.0	
	K24	-	-	6.0x2.5	Box Culvert	3.0x2.5x2	10.0	
	K24	-	-	6.0x2.5	Box Culvert	3.0x2.5x2	55.0	
	K24	-	-	6.0x2.5	Box Culvert	3.0x2.5x2	10.0	
	K24	-	-	6.0x2.5	Box Culvert	3.0x2.5x2	10.0	
	K25	-	-	6.0x2.5	Box Culvert	5.5x3.0	10.0	
	K25	-	-	6.0x2.5	Box Culvert	5.5x3.0	10.0	
	K25	-	-	6.0x2.5	Box Culvert	5.5x3.0	10.0	
	K25	-	-	6.0x2.5	Box Culvert	5.5x3.0	10.0	
	K25	-	-	6.0x2.5	Box Culvert	5.5x3.0	10.0	
J	-	-	-	-	-	-	-	
	Total	-	-	-	-	-	649.0	

Note : Khal improvement work with (*) are included in the Workd Bank Project.

TABLE C.7 PROPOSED DRAINAGE PIPE (BRICK PIPE & BOX CULVERT)

ZONE	DRAINAGE PIPE No	SECTION No	LENGTH m	EXIST PIPE m	PROPOSED DRAIN Type	PROPOSED DRAIN Size m	REMARKS
A	S-1	1	1000	-	Brick Pipe	3.1	
	S-2	1	600	-	Brick Pipe	1.9	With Sluice Gate
	S-3	1	1400	-	Brick Pipe	2.5	With Sluice Gate
	S-4	1	800	-	Brick Pipe	2.1	With Sluice Gate
B	S-5	1	100	3.0	R.C.Box Culvert	3.1	Additional Construction
	DARINDA	2	650	3.0	R.C.Box Culvert	2.9	Additional Construction
	(Main)	3	450	3.0	Brick Pipe	2.8	Additional Construction
		4	350	2.7	Brick Pipe	2.6	Additional Construction
		5	750	-	Brick Pipe	1.9	
	(Branch)	6	500	-	Brick Pipe	2.2	With Sluice Gate
		Subtotal	2800	-			
	S-6 NARINDA (Diversion	1	1480	-	R.C.Box Culvert	2.2x2.86	
C	S-7	1	700	-	R.C.Box Culvert	2.6x3.0	
	Old Railway Rd.	2	650	-	Brick Pipe	3.0	
	& Old Govt.	3	650	-	Brick Pipe	2.3	
	House Rd.	4	500	-	Brick Pipe	1.9	
		Subtotal	2500				
	S-8 Circular Rd.	1	540	1.5	Brick Pipe	1.5	Additional Construction
	S-9	1	480	-	Brick Pipe	2.7	
	DIT Av.	2	240	-	Brick Pipe	1.9	
		Subtotal	720				
	S-10 SANTINAGAR	1	530	1.2	Brick Pipe	2.7	Additional Construction
		2	520	0.8	Brick Pipe	2.2	Additional Construction
		Subtotal	1050				
D	S-11	1	700	-	Brick Pipe	3.1	Reconstruction
F	R-12	1	550	0.9	Brick Pipe	2.4	Reconstruction
	NAYATARA	2	550	0.6	Brick Pipe	2.8	
		Subtotal	1100				
	S-13 DHANMANDI	1	450		Brick Pipe	1.8	
	S-14	1	300	-	Brick Pipe	2.7	
	DHAKA Univ.	2	450	-	Brick Pipe	2.9	
	(Nain)	3	550	-	Brick Pipe	2.4	
	(Branch)	4	560	-	Brick Pipe	2.1	
		Subtotal	1860				
	TOTAL	Brick Pipe	17000 [14070]				
		R.C. Box Culvert	[2930]				

TABLE C.8 PROJECT COST

Unit : Million Tk 1989 Price

Drainage Zone	Sluice Gate (places)	Pump Station (m/s)	Khal Improvement (km)	Drainage Pipe (km)	Construciton Cost	Contingency & Engineering Super vision	Land Acquisition (ha)	Total Project Cost
A	4 63.5	-	0.30 6.3	3.80 127.5	197.3	39.5	0.10 4.8	241.6
B	1 6.0	*	*	4.28 295.2	301.2	60.2	*	361.4
C	-	-	6.30 611.4	4.81 206.3	817.7	163.5	2.90 84.8	1,066.0
D	-	-	4.45 80.9	0.70 29.5	110.4	22.1	1.20 19.2	151.7
E	-	-	-	-	-	-	-	-
F	-	-	3.52 755.3	3.41 117.0	872.3	174.5	1.10 36.8	1,083.6
G	-	-	2.90 44.0	-	44.0	8.8	1.20 19.2	72.0
H	1 50.9	20.0 453.4	12.00 231.1	-	735.4	147.1	8.40 114.4	996.9
I	1 15.1	4.5 171.1	6.90 204.1	-	390.3	78.1	3.10 37.2	505.6
J	-	-	-	-	-	-	-	-
Total	7 135.5	 624.5	36.37 1,933.1	17.0 775.5	3,468.6	693.7	18.0 316.4	4,478.7

Note : (1) Costs with (*) in the B zone are included in the World Bank Project
(2) Upper figure in the cell shows quantity of work. Lower figure is construction cost.

TABLE C.9 SUMMARY OF CONSTRUCTION COST

Unit : Million Tk (1989 Price)

ITEM	ZONE	DESCRIPTION	CONSTRUCTION COST	REMARKS
A. Pump Station				
P1	H	20.0m3/s	453.4	
P2	I	4.5m3/s	171.1	
Subtotal			624.5	
B. Gate				
G1	A	3.2x3.2x66.5(m)	18.5	
G2	A	2.2x2.2x66.5(m)	15.0	
G3	A	2.2x2.2x66.5(m)	15.0	
G4	A	2.2x2.2x66.5(m)	15.0	
G5	B	2.5x2.5x20.0(m)	6.0	
G6	H	2.5x2.5x2x66.5(m)	50.9	
G7	I	2.0x2.0x66.5(m)	15.1	
Subtotal			135.5	
C. Khal Improvement				
K1	A	L=300m	6.3	
K4	C	L=1800m	53.2	
K5	C	L=3500m	540.7	
K6	C	L=1000m	17.5	
K7	D	L=1400m	19.5	
K8	D	L=3050m	61.4	
K9	F	L=1000m	294.3	
K10	F	L=1816m	337.5	
K11	F	L=700m	123.5	
K12	G	L=1500m	21.3	
K13	G	L=1400m	22.7	
K14	H	L=3300m	24	
K15	H	L=2200m	7.3	
K16	H	L=900m	29.5	
K17	H	L=2200m	54.2	
K18	H	L=800m	26.4	
K19	H	L=1400m	48.7	
K20	H	L=1200m	41.2	
K21	I	L=1800m	85.2	
K22	I	L=1300m	75.6	
K23	I	L=1000m	5.8	
K24	I	L=1400m	24.8	
K25	I	L=1400m	12.7	
Subtotal		L=36366m	1933.1	
D. Drainage Pipe				
S1	A	L=1000m	42.1	
S2	A	L=600m	16.3	
S3	A	L=1400m	46.6	
S4	A	L=800m	22.5	
S5-1	B	L=2300m	134.7	
S5-2	B	L=500m	15.2	
S6	B	L=1480m	145.3	
S7	C	L=2500m	135.7	
S8	C	L=540m	12.4	
S9	C	L=720m	23.6	
S10	C	L=1050m	34.6	
S11	D	L=700m	29.5	
S12	F	L=1100m	38.3	
S13	F	L=450m	11.6	
S14-1	F	L=1300m	51.4	
S14-2	F	L=560m	15.7	
Subtotal		L=1700m	775.5	

TABLE C.10 CONSTRUCTION COST OF KHAL IMPROVEMENT

Unit : Million Tk. (1989 Price)

Zone	Khal No.	Protection Works	Bridge & Box Culve	Dredging	Total
A	K1	0.2	0.7	5.4	6.3
	Subtotal	0.2	0.7	5.4	6.3
C	K4	37.5	4.9	10.8	53.2
	K5-1	0.4		5.2	5.6
	K5-2	0.3	24.0	4.0	28.3
	K5-3	116.6		6.0	122.6
	K5-4	299.7		7.8	307.5
	K5-5	72.9		3.8	76.7
	K6	15.5		2.0	17.5
	Subtotal	542.9	28.9	39.6	611.4
D	K7-1	0.6	1.9	1.6	4.1
	K7-2	11.5	3.3	0.6	15.4
	K8-1	0.6	3.0	2.3	5.9
	K8-2	0.6	17.8	2.2	20.6
	K8-3	19.1	3.5	1.2	23.8
	K8-4	10.6		0.5	11.1
	Subtotal	43.0	29.5	8.4	80.9
F	K9-1	135.7	6.6	1.4	143.7
	K9-2	148.7		1.9	150.6
	K10-1	152.0		1.6	153.6
	K10-2	182.3		1.6	183.9
	K11	118.7		4.8	123.5
	Subtotal	737.4	6.6	11.3	755.3
G	K12	0.9	16.2	4.2	21.3
	K13	0.8	17.4	4.5	22.7
	Subtotal	1.7	33.6	8.7	44.0
H	K14-1	1.8	12.1	7.5	21.4
	K14-2	0.2		2.4	2.6
	K15-1	0.4		1.7	2.1
	k15-2	1.0		4.2	5.2
	K16	27.1	1.1	1.3	29.5
	K17-1	0.4		0.8	1.2
	K17-2	48.1	2.3	2.6	53.0
	K18	24.0	1.1	1.3	26.4
	K19	41.7	4.5	2.5	48.7
	K20	35.6	3.9	1.7	41.2
	Subtotal	180.1	25.0	26.0	231.1
I	K21	42.2	36.9	6.1	85.2
	K22	69.3	2.9	3.4	75.6
	K23	0.6	2.8	2.4	5.8
	K24	0.8	21.5	2.5	24.8
	K25	0.8	8.8	3.1	12.7
	Subtotal	113.7	72.9	17.5	204.1
	Total	1,618.9	197.3	116.9	1,933.1

TABLE C.11 COST FOR LAND ACQUISITION

(1989 Price)

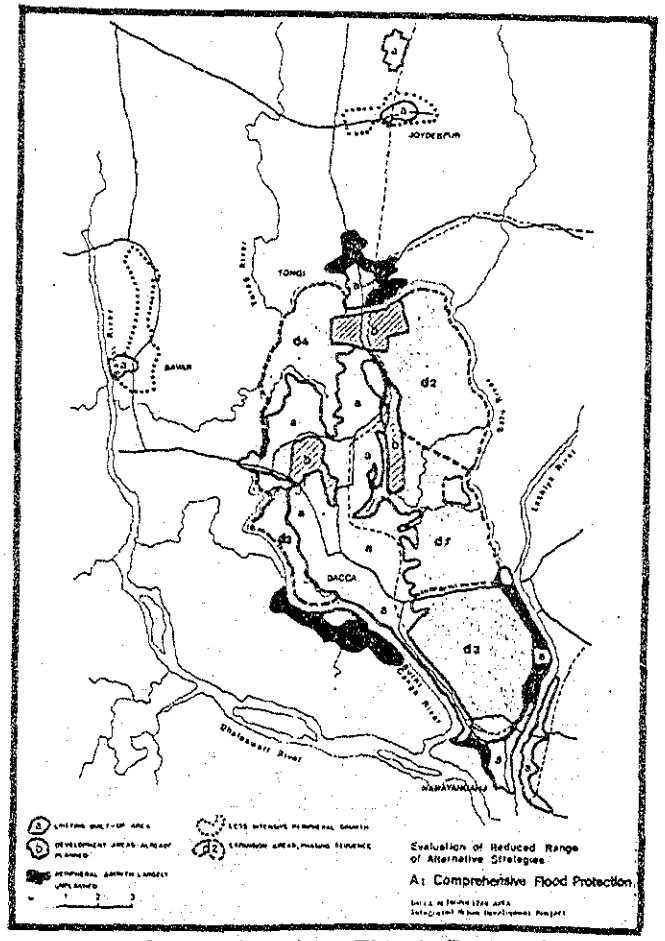
	Item	Zone	Area (ha)	Unit Price (Million Tk)	Land Acquisition (Million Tk)
A.	Pump Station				
	P1	H	1.0	12.0	12.0
	P2	I	0.7	12.0	8.4
B.	Khal Improvement				
	K1	A	0.1	48.0	4.8
	Subtotal		0.1		4.8
	K4	C	1.1	16.0	17.6
	K5-1	C	0.3	16.0	4.8
	K5-2	C	0.4	16.0	6.4
	K5-3	C	0.2	64.0	12.8
	K5-4	C	0.4	64.0	25.6
	K5-5	C	0.2	64.0	12.8
	K6	C	0.3	16.0	4.8
	Subtotal		2.9		84.8
	K7-1	D	0.2	16.0	3.2
	K7-2	D	0.1	16.0	1.6
	K8-1	D	0.3	16.0	4.8
	K8-2	D	0.3	16.0	4.8
	K8-3	D	0.2	16.0	3.2
	K8-4	D	0.1	16.0	1.6
	Subtotal		1.2		19.2
	K9-1	F	0.2	16.0	3.2
	K9-2	F	0.3	16.0	4.8
	K10-1	F	0.2	48.0	9.6
	K10-2	F	0.2	48.0	6.6
	K11	F	0.2	48.0	9.6
	Subtotal		1.1		36.8
	K12	G	0.6	16.0	9.6
	K13	G	0.6	16.0	9.6
	Subtotal		1.2		19.2
	K14-1	H	3.2	12.0	38.4
	K14-2	H	1.1	16.0	17.6
	K15-1	H	0.4	16.0	6.4
	K15-2	H	0.8	16.0	9.6
	K16	H	0.2	16.0	3.2
	K17-1	H	0.4	16.0	6.4
	K17-2	H	0.4	16.0	6.4
	K18-1	H	0.2	16.0	3.2
	K19	H	0.4	16.0	6.4
	K20	H	0.3	16.0	4.8
	Subtotal		7.4		102.4
	K21	I	0.8	12.0	9.6
	K22	I	0.5	12.0	6.0
	K23	I	0.3	12.0	3.6
	K24	I	0.4	12.0	4.8
	K25	I	0.4	12.0	4.8
	Subtotal		2.4		28.8
	Total		18.0		316.4

TABLE C.12 PROPOSED PHASED PROGRAM

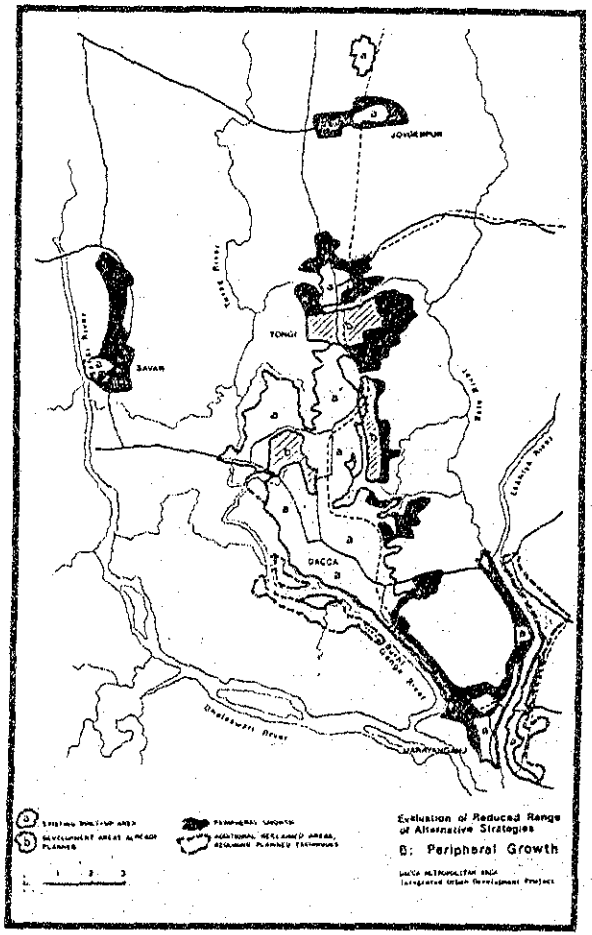
Unit : MIllion Tk at 1989 price

ZONE	WORKS	PHASE I		PHASE II		REMARKS
A	(1)Drainage Pipe			L=3.80km	127.5	.S1,S2,S3,S4
	(2)Khal Improvement	-		L=0.30km	6.3	.K1
	(3)Sluice Gate			n=4places	63.5	
	(4)Land Acquisition			A=0.10ha	4.8	
B	(1)Drainage Pipe			L=4.28km	295.2	.S5,S6
	(2)Khal Improvement	*				.K2,K3
	(3)Pump Station	*				
	(4)Sluice Gate	*		n=1place	6.0	
	(5)Land Acquisition	*				
C	(1)Drainage Pipe			L=4.81	206.3	.S7,S8,S9,S10
	(2)Khal Improvement	L=5.30km	593.9	L=1.00km	17.5	.I=K4,K5,II=K6
	(3)Land Acquisition	A=2.60ha	80.8	A=0.3ha	4.8	
D	(1)Drainage Pipe			L=0.70km	29.5	.S11
	(2)Khal Improvement	-		L=4.45km	80.9	.K7,K8
	(3)Land Acquisition			A=1.20ha	19.2	
E		-				
F	(1)Drainage Pipe			L=3.41km	117.0	.S12,S13,S14
	(2)Khal Improvement	L=3.50km	755.3			.K9,K10,K11
	(3)Land Acquisition	A=1.10ha	36.8			
G	(1)Khal Improvement	-		L=2.90km	44.0	.K12,K13
	(2)Land Acquisition			A=1.20ha	19.2	
H	(1)Khal Improvement	L=3.30km	24.0	L=8.70km	207.1	.I=K14,II=K14
	(2)Pump Station	L=10.0m3/s	226.7	Q=10.0m3/s	226.7	K15,K16,K17
	(3)Sluice Gate	n=1place	50.9			K18,K19,K20
	(4)Land Acquisition	A=5.30ha	68.0	A=3.10ha	46.4	
I	(1)Khal Improvement			L=6.9km	204.1	.K21,K22,K23
	(2)Pump Station	-		Q=4.5m3/s	171.1	K24,K25
	(3)Sluice Gate			n=1place	15.1	
	(4)Land Acquisition			A=3.1ha	37.2	
J		-		-		
	. Sub-Total	1835.6		1949.4		
	. Contingency and Engineering	336.4		357.3		
	TOTAL	2172.0 Million Tk		2306.7 Million Tk		4478.7 M.Tk

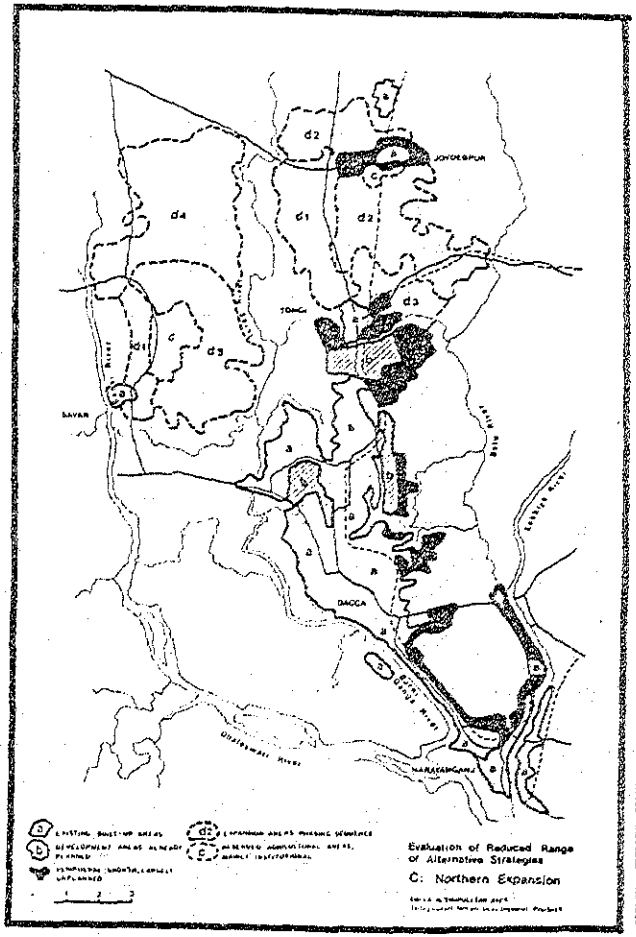
Note : Proposed works with (*) in the B-Zone are included in the World Bank Project.



A : Comprehensive Flood Protection



B : Peripheral Growth



C : Northern Expansion

Source: Final Report on Dhaka Metropolitan Area Integrated Urban Development Project by ADB/UNDP

FIG. C 1 ALTERNATIVE STRATEGIES OF DHAKA METROPOLITAN AREA INTEGRATED URBAN DEVELOPMENT PROJECT

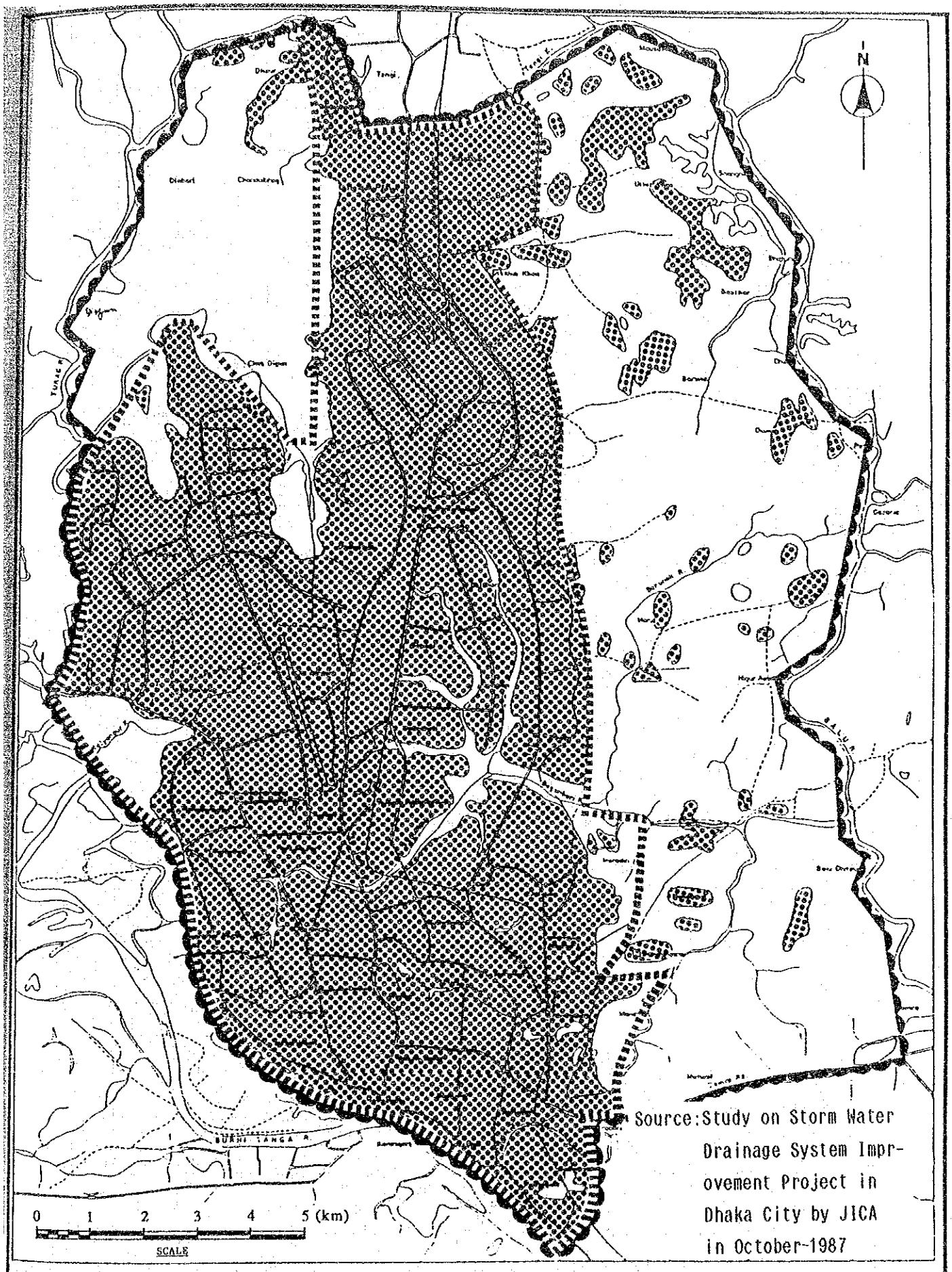
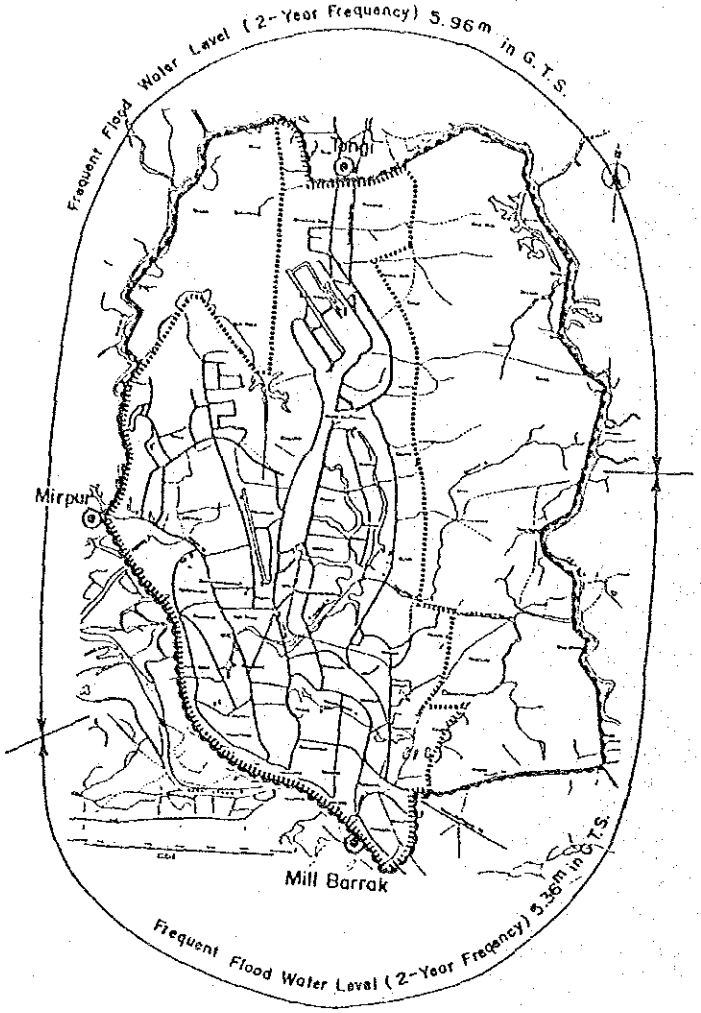
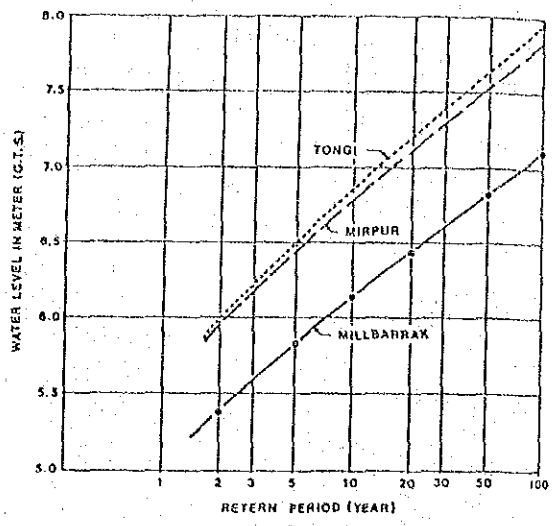


FIG. C. 2 BUILT-UP AREA IN 2000

UPDATING STUDY ON STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY



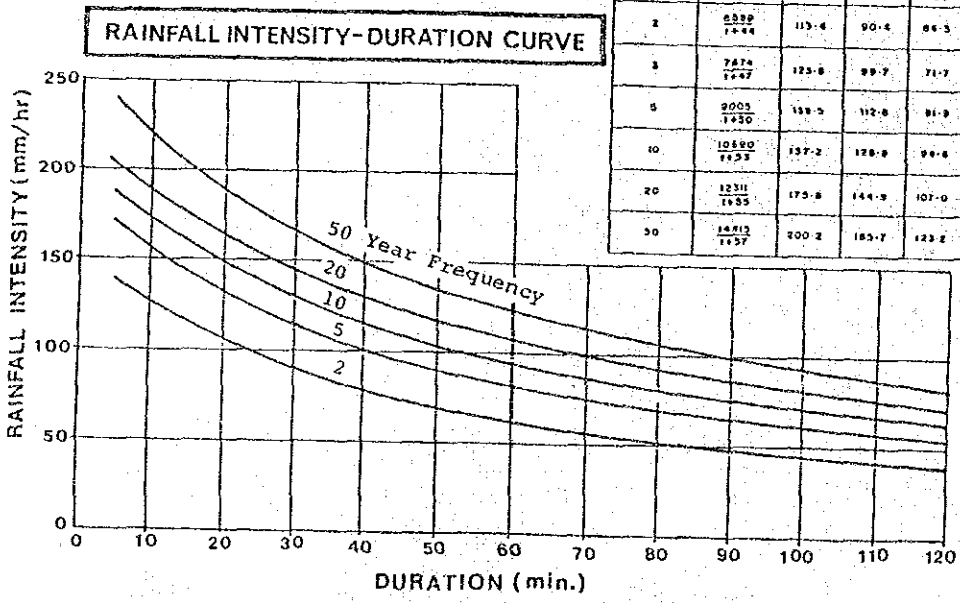


W.L. (m) : G.T.S

Return Period in Year	MILL BARRAK	MIRPUR	TONGI
2	5.36	5.96	6.00
3	5.58	6.18	6.24
5	5.83	6.45	6.51
10	6.13	6.79	6.87
20	6.43	7.12	7.21
30	6.60	7.30	7.40
50	6.81	7.54	7.65
100	7.10	7.85	7.97

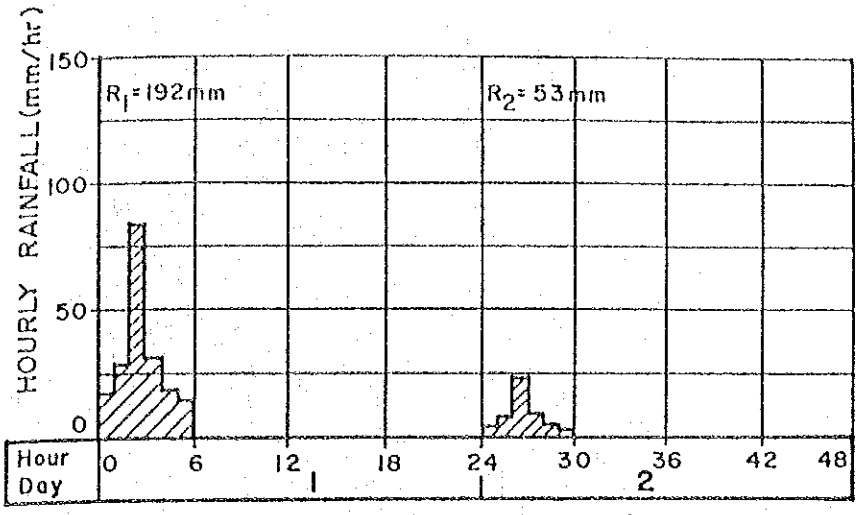
RAINFALL INTENSITY-DURATION FORMULA

RETURN PERIOD	EQUATION	RAINFALL INTENSITY			
		15	30	60	120
2	$\frac{6388}{t+44}$	113·6	90·4	66·5	46·6
5	$\frac{7674}{t+47}$	125·8	99·7	71·7	48·0
5	$\frac{9005}{t+50}$	138·5	112·8	81·9	53·0
10	$\frac{10690}{t+53}$	137·2	128·8	94·6	61·8
20	$\frac{12511}{t+55}$	175·8	144·9	107·0	70·3
30	$\frac{14413}{t+57}$	200·2	165·7	123·2	81·4



Source:Study on Storm Water Drainage System Improvement Project in Dhaka City by JICA in October 1987

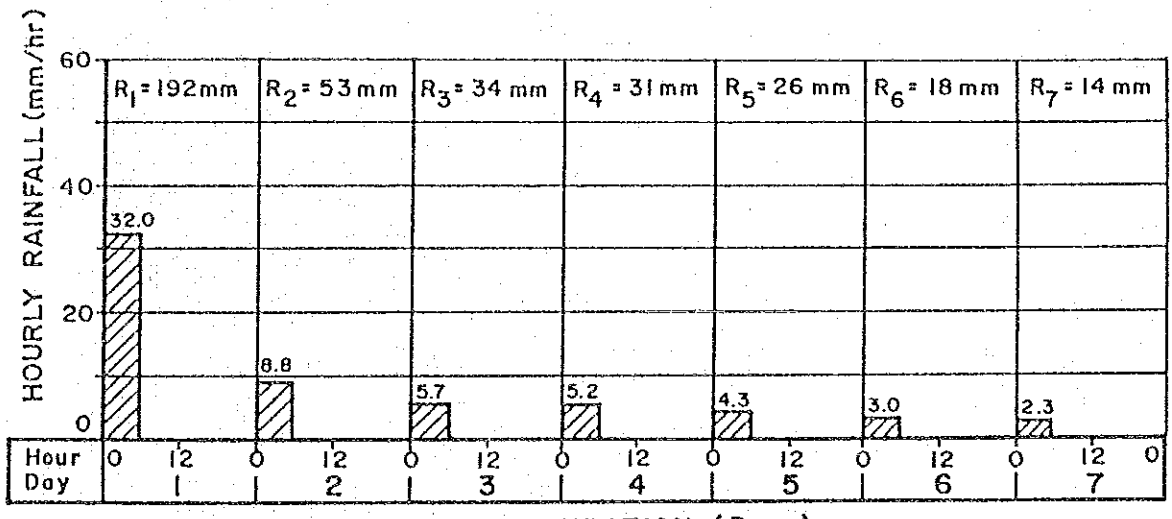
FIG. C. 3 DESIGN FREQUENCY OF FLOOD WATER LEVEL AND DESIGN RAINFALL FOR KHAL IMPROVEMENT/DRAINAGE PIPE



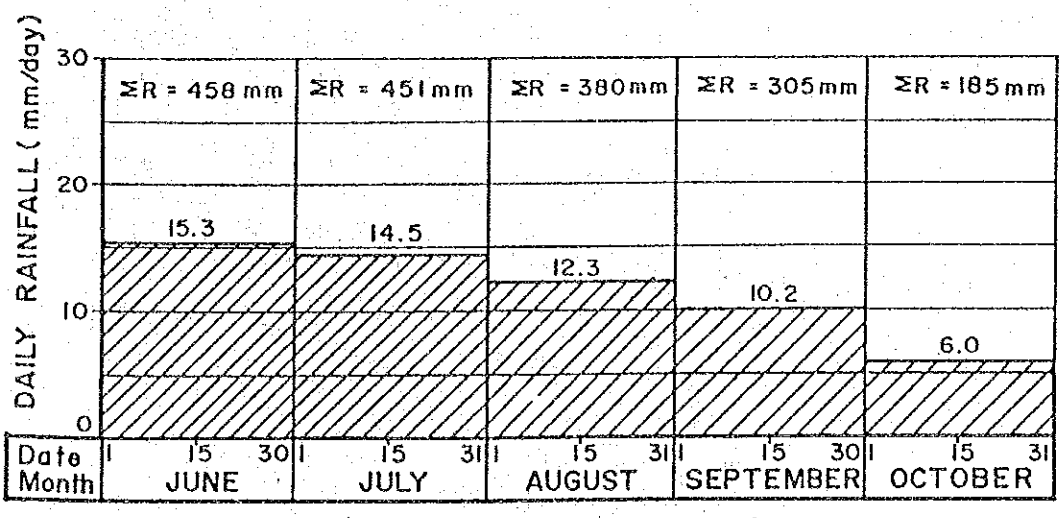
HOURLY DISTRIBUTION

hr	%	R1	R2
1	9	17.4	4.8
2	15	28.3	8.0
3	44	82.8	23.2
4	16	30.6	8.5
5	9	18.0	5.0
6	7	14.9	3.5
TOTAL	100	192.0	53.0

2-DAY CONSECUTIVE DESIGN RAINFALL



WEEKLY DESIGN RAINFALL



MONTHLY DESIGN RAINFALL

FIG. C. 4 DESIGN RAINFALL FOR PUMP DRAINAGE

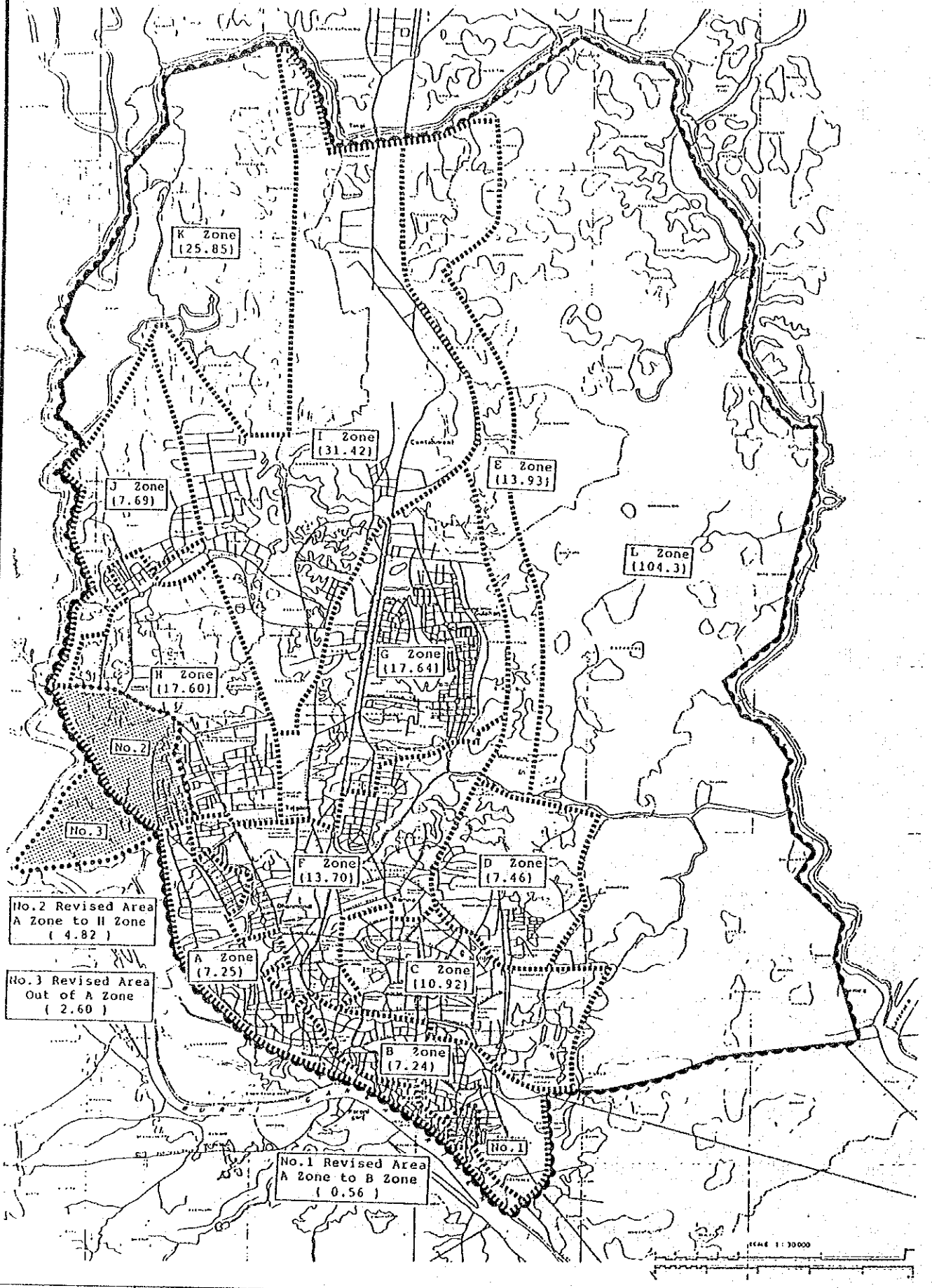
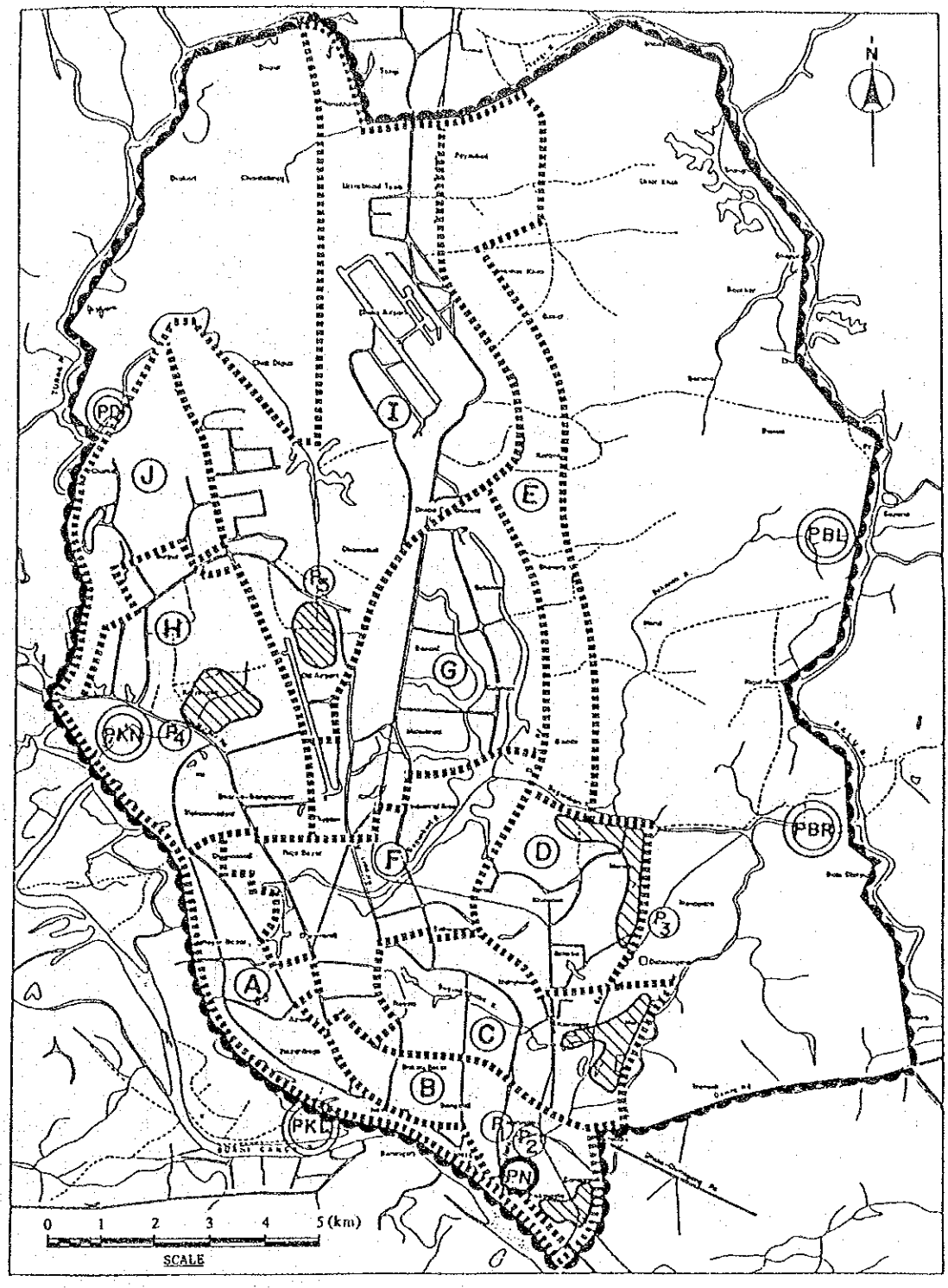


FIG. C. 5 REVISED DRAINAGE AREA

UPDATING STUDY ON STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY

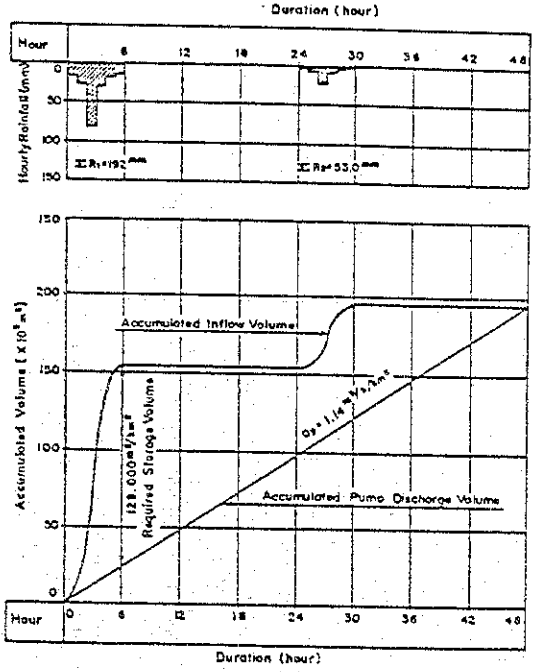
JICA A.D 1990



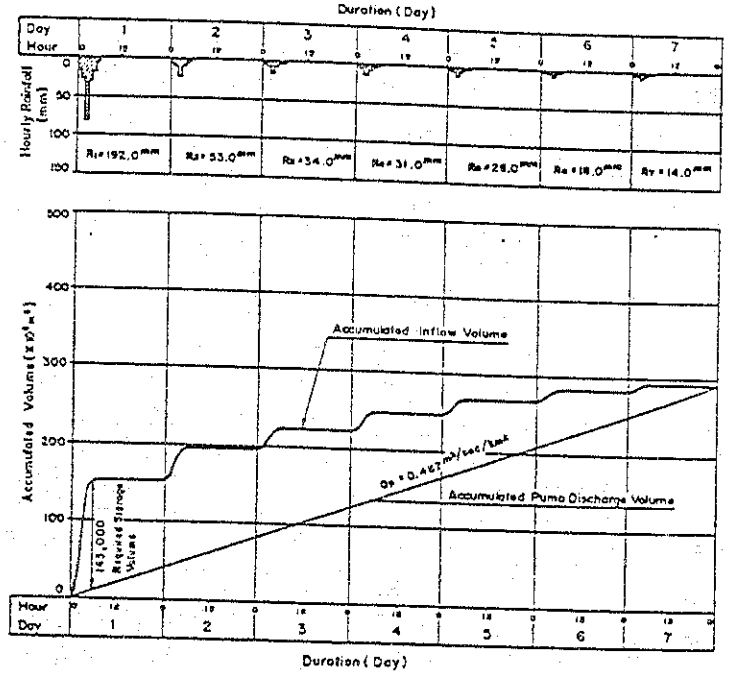
LEGEND

- (A)~(J) : Drainage Zone
- (P1)-(P5) : Pump Station Proposed by Previous JICA Study
- : Regulating Pond Proposed by Previous JICA Study
- (PD) : Pump Station Proposed by GDFCD Project
- (PN) : Pump Station Proposed by World Bank Project

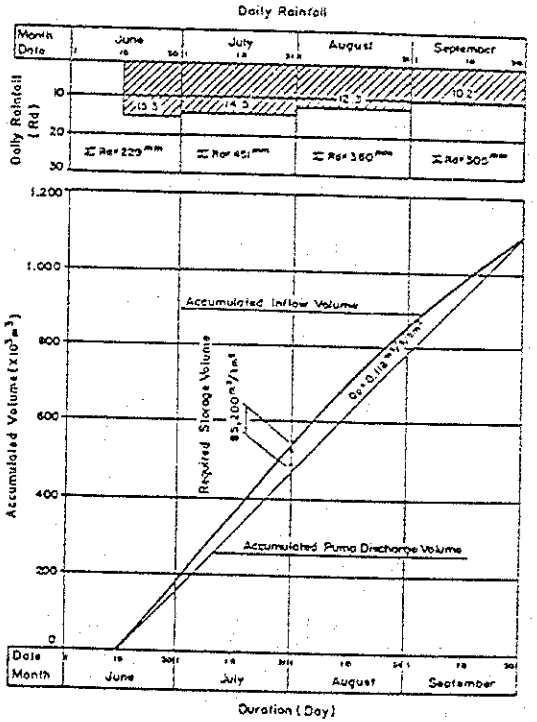
FIG. C. 6 LOCAITONS OF PUMP STATIONS PROPOSED BY RELATED ONGOING PROJECT



2-DAY CONSECUTIVE RAINFALL
WITH 5-YEAR FREQUENCY



WEEKLY RAINFALL
WITH 5-YEAR FREQUENCY



MONTHLY RAINFALL
WITH 5-YEAR FREQUENCY

FIG. C. 7	SPECIFIC REQUIRED PUMP AND REGULATING POND CAPACITIES

UPDATING STUDY ON STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY

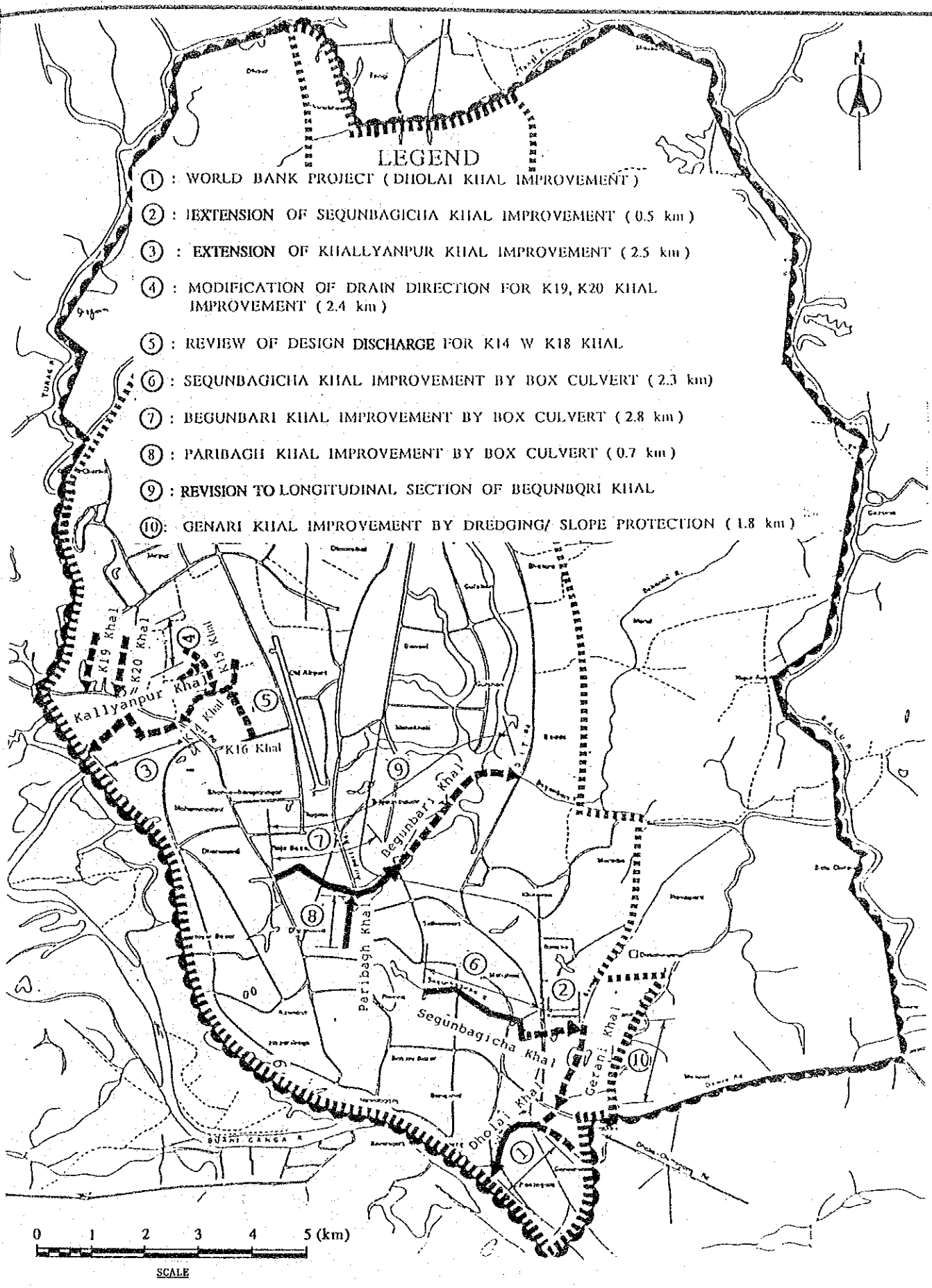


FIG. C. 8 LOCATION OF REVISED KHAL IMPROVEMNENT

UPDATING STUDY ON STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY

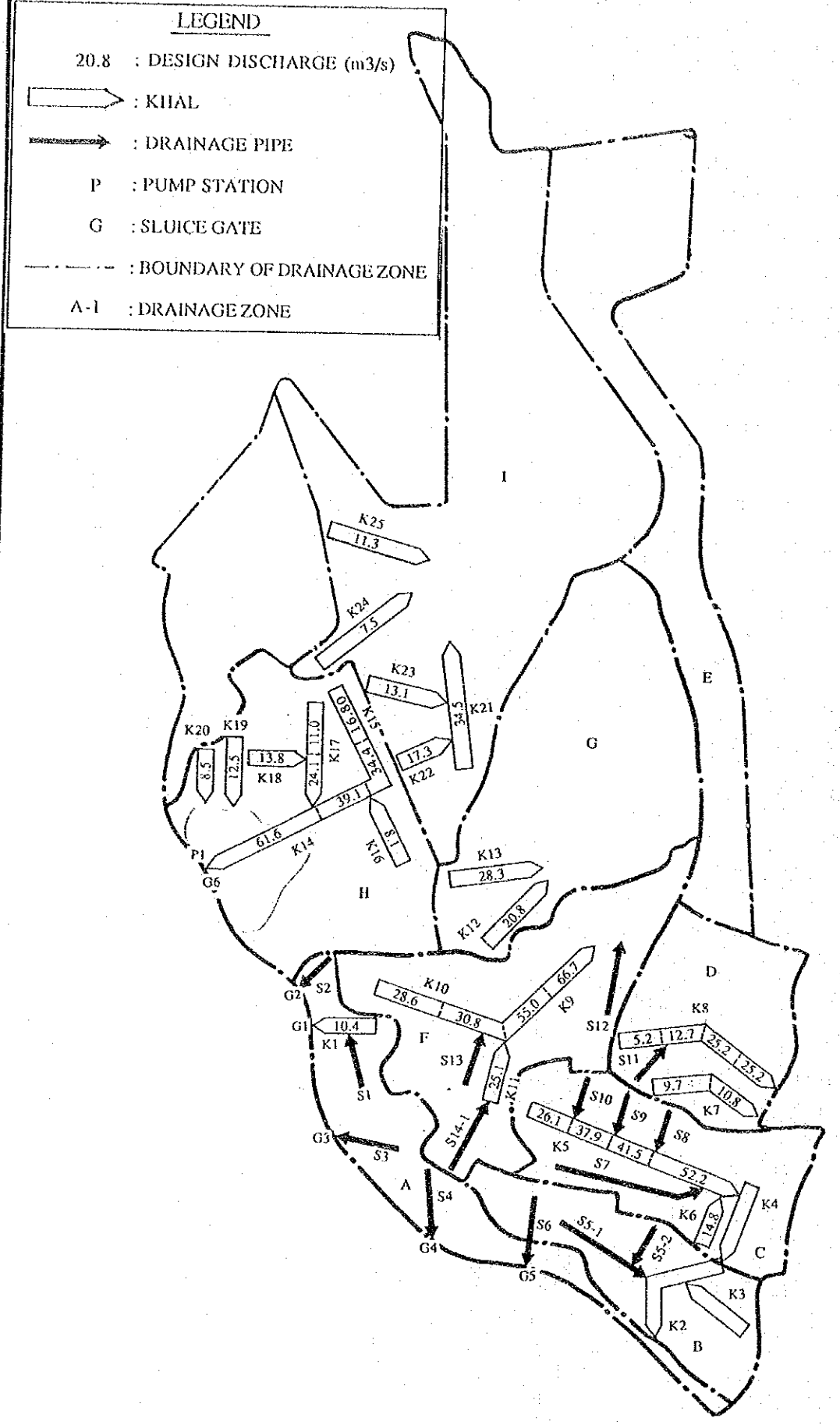


FIG. C. 9	DESIGN DISCHARGES OF KHAL IMPROVEMENT

UPDATING STUDY ON STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY

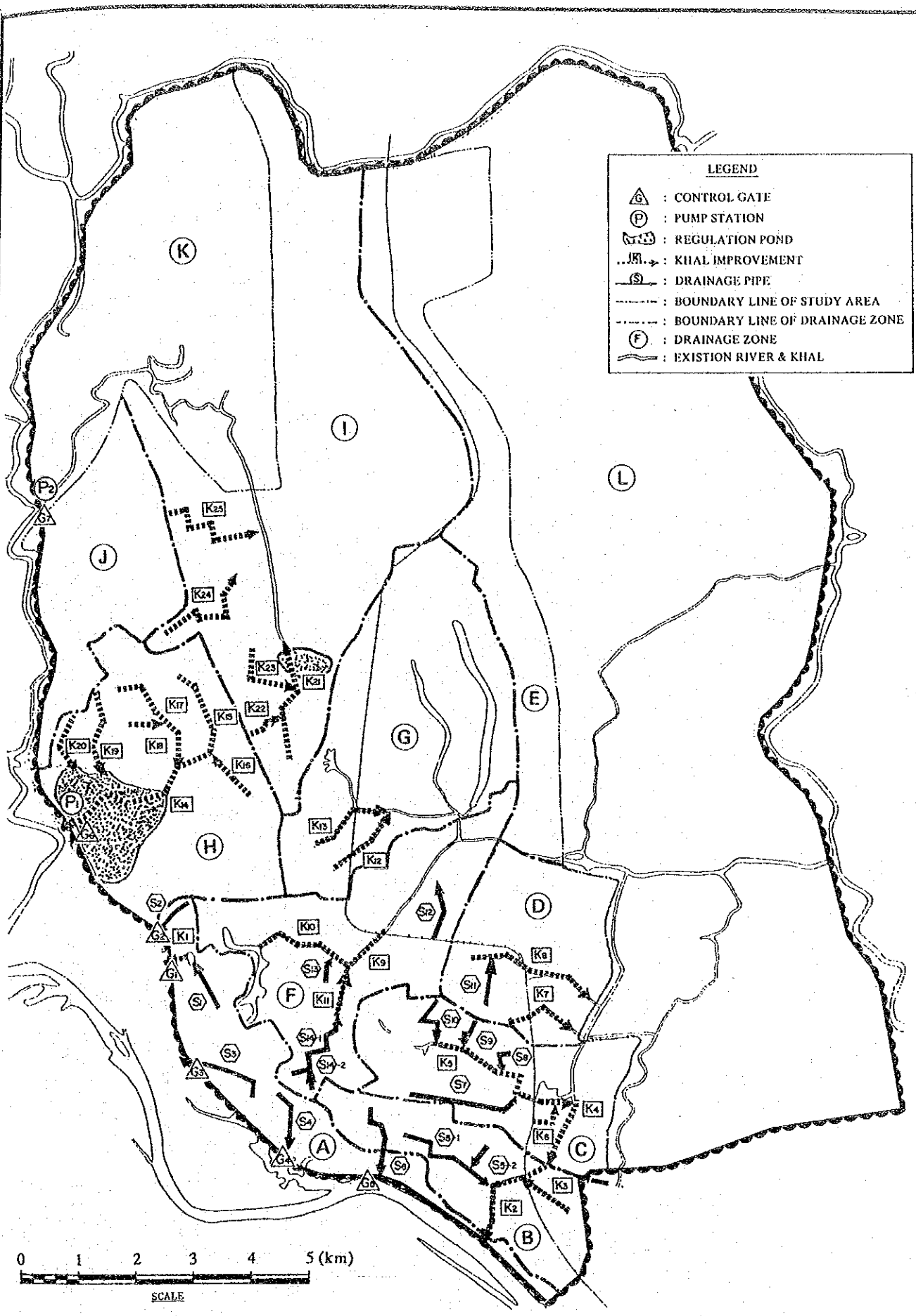
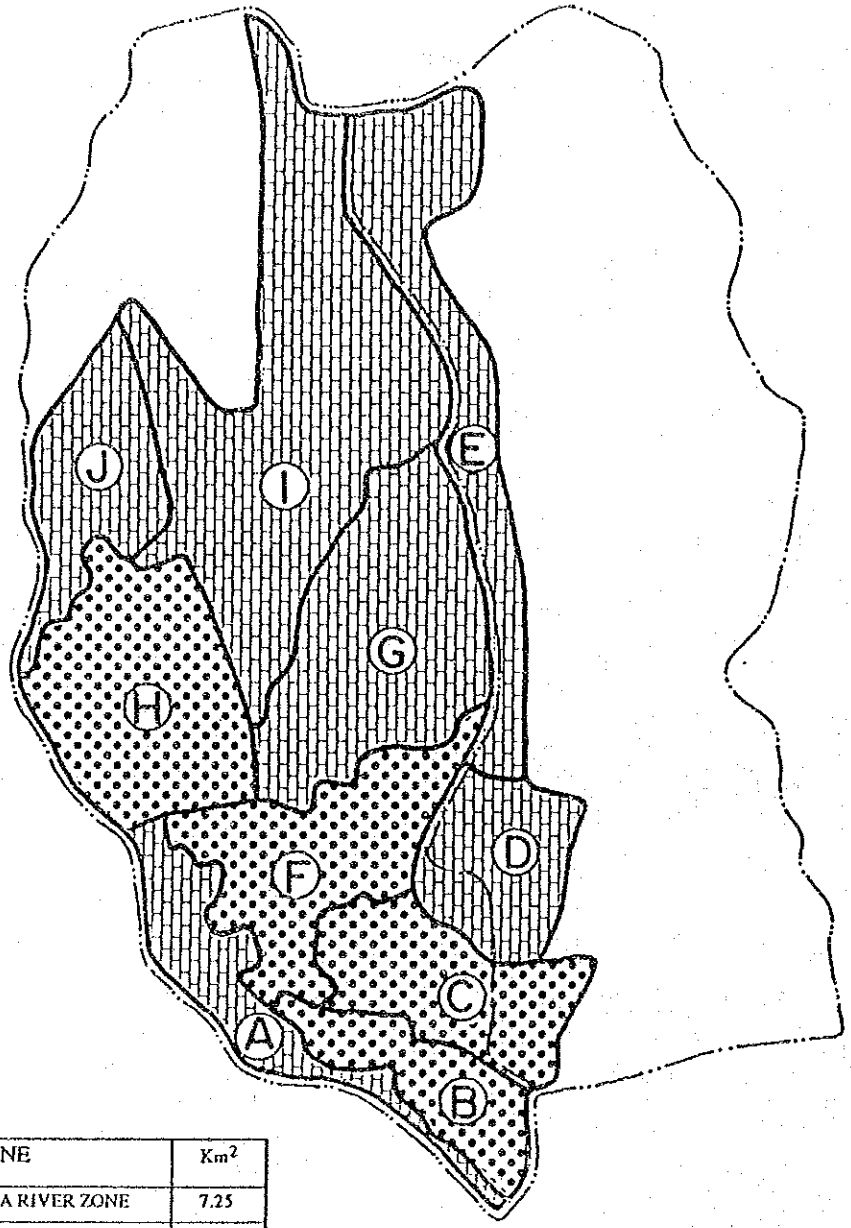


FIG. C. 10 PROPOSED FACILITIES

UPDATING STUDY ON STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY



DRAINAGE ZONE		Km^2
A	BURIGANGA RIVER ZONE	7.25
B	DHOLAI KHAL ZONE	7.24
C	SEGUNBAGICHA KHAL ZONE	10.92
D	BASHABO ZONE	7.46
E	NORTH EAST EDGE ZONE	13.93
F	BEGUNBARI KHAL ZONE	13.70
G	GULSHAN-BANANI ZONE	17.64
H	KALLYANPUR ZONE	17.60
I	NORTH ZONE	31.42
J	TURAG RIVER BANK ZONE	7.69
	TOTAL DRAINAGE AREA	134.85

LEGEND

: First Priority Area

: Second Priority Area

FIG. C. 11 PRIORITY SEQUENCE OF DRAINAGE ZONE

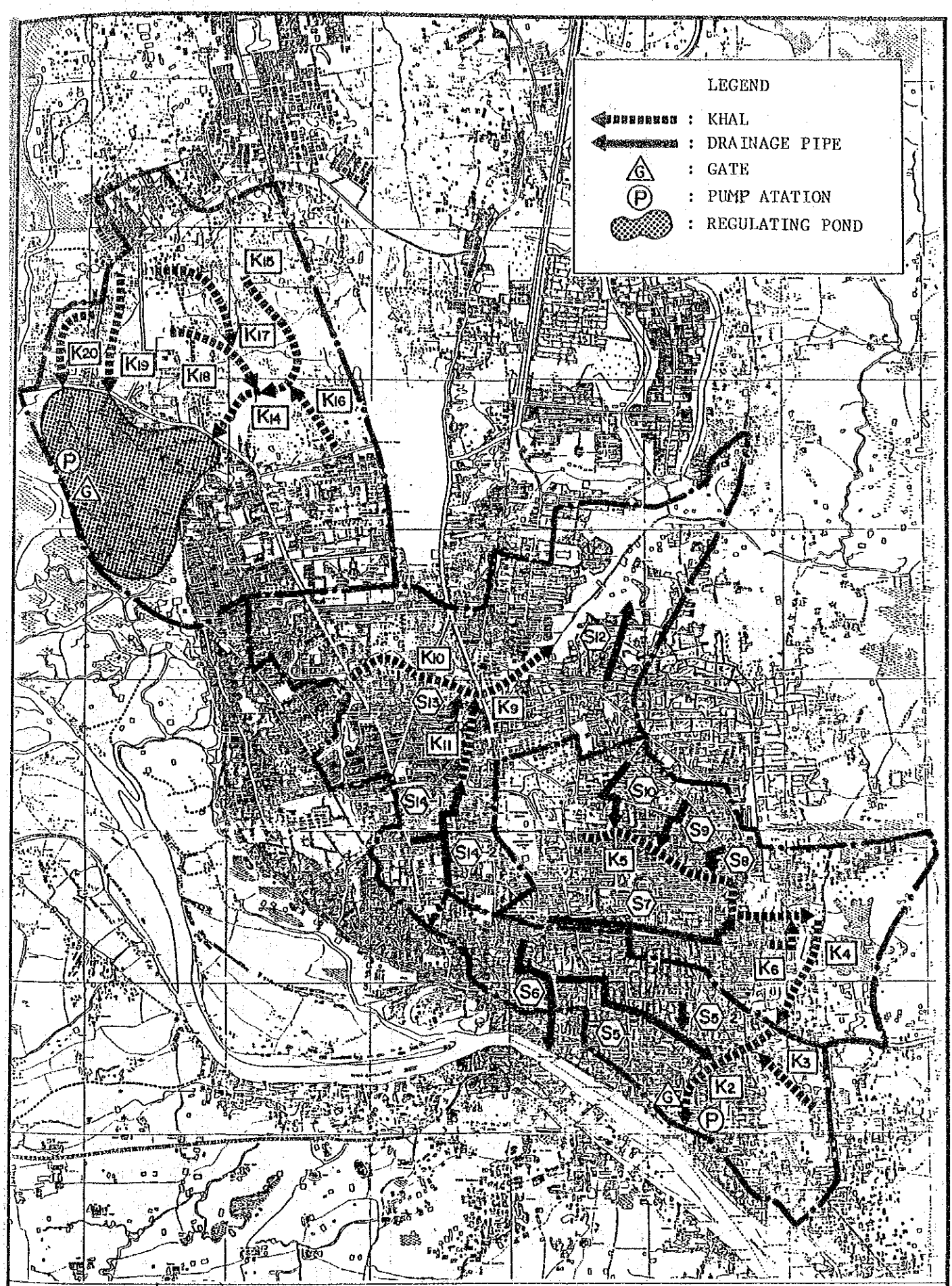


FIG. C. 12 LOCATIONS OF PROPOSED DRAINAGE FACILITIES IN PHASE - I PROGRAMME

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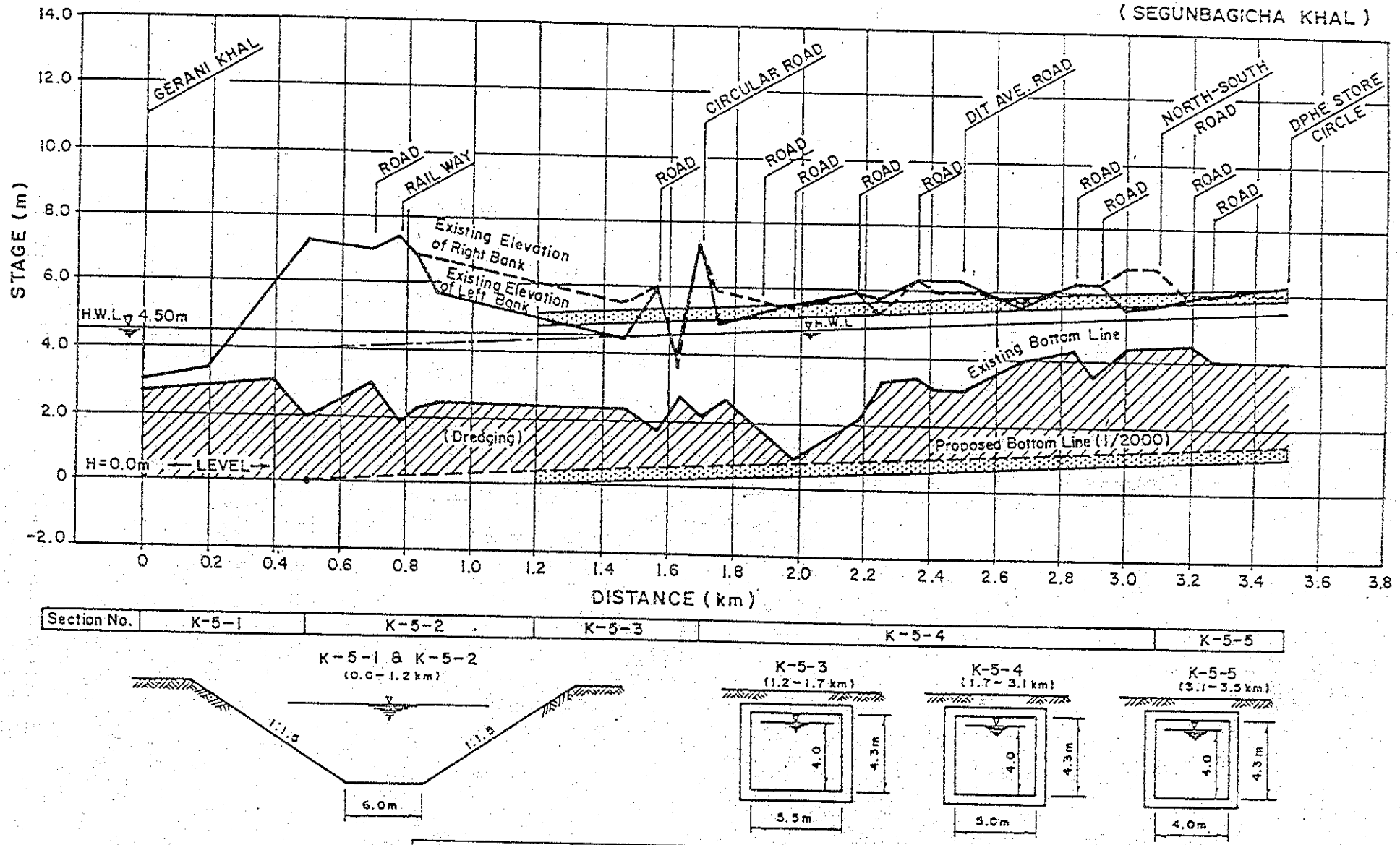

FIG. C. 13 PROPOSD LONGITUDINAL AND CROSS SECTIONS OF SEGUNBAGICHA KHAL

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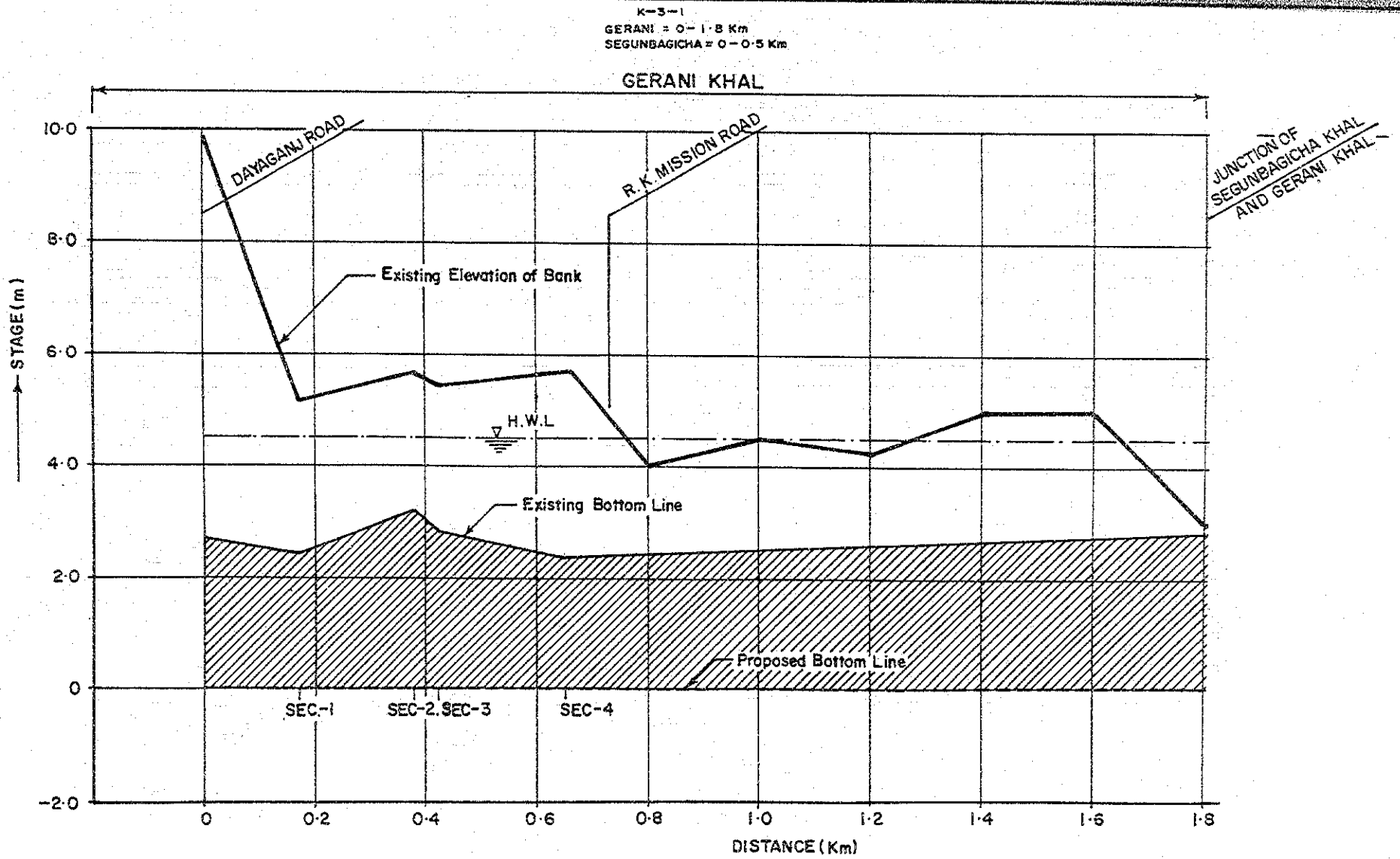

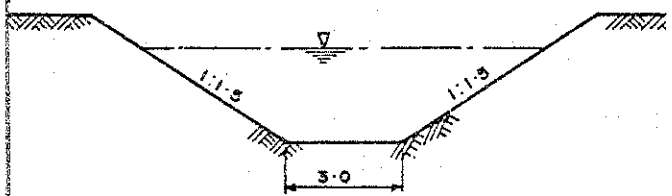

FIG. C. 14 PROPOSED LONGITUDINAL AND CROSS SECTION OF GERANI KHAL

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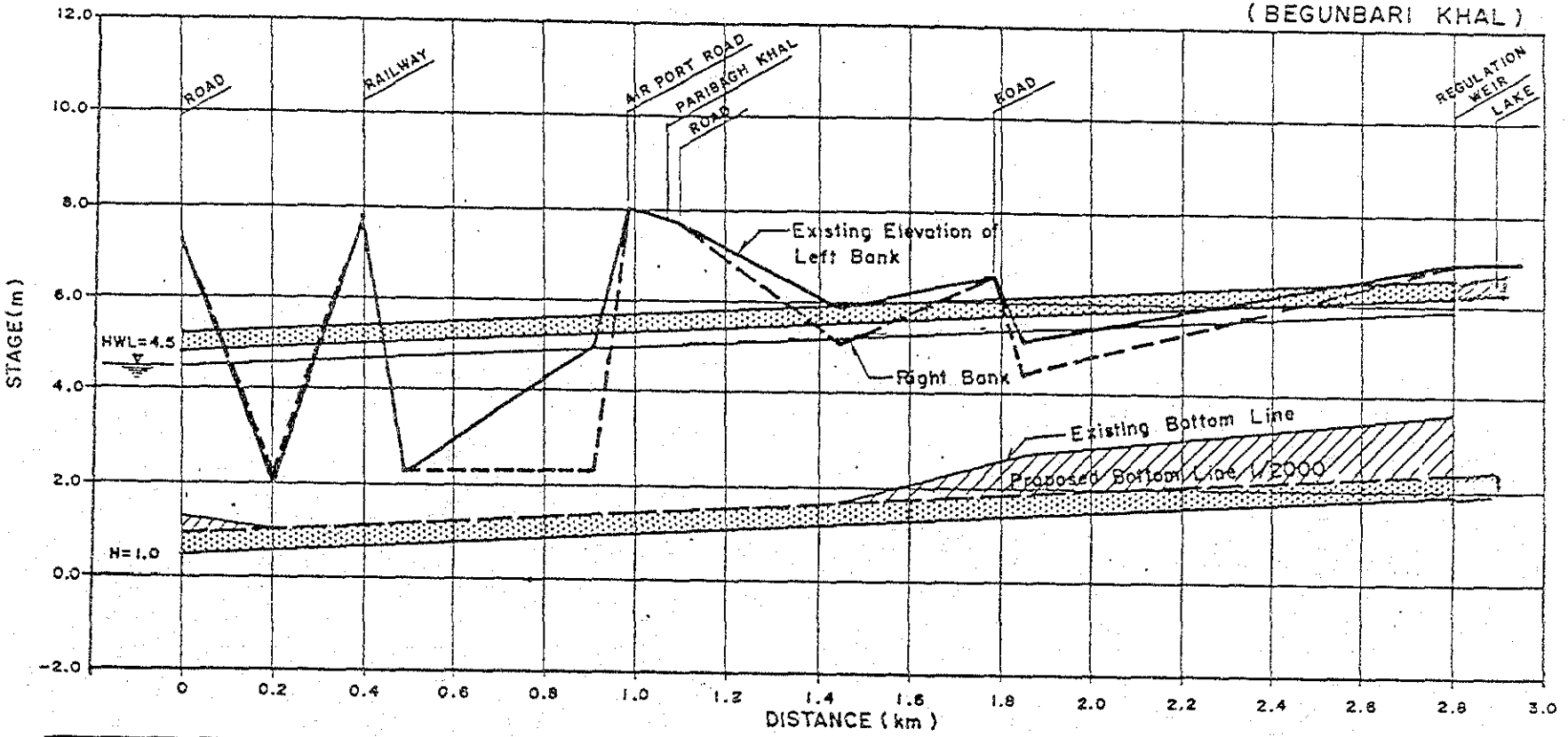


Section No.	K-14-1	K-14-2	K-14-3	K-14-4

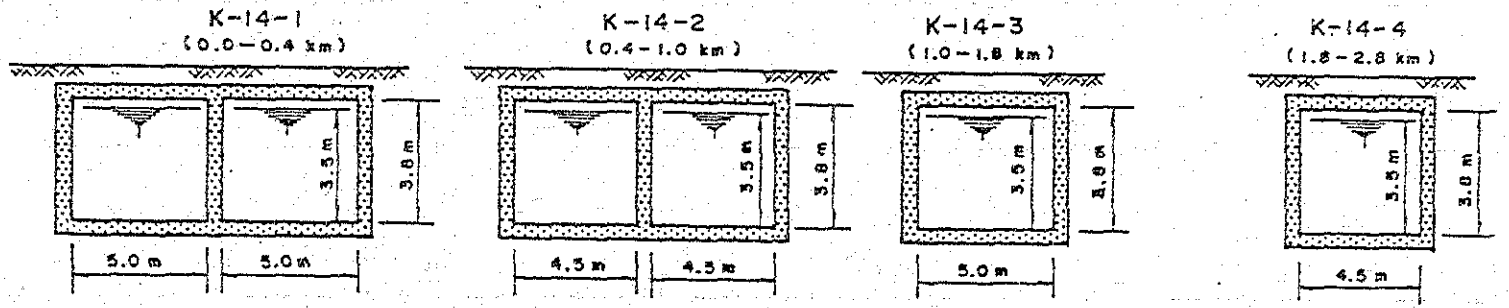


FIG. C. 15 PROPOSED LONGITUDINAL AND CROSS SECTIONS OF BEGUNBARI KHAL

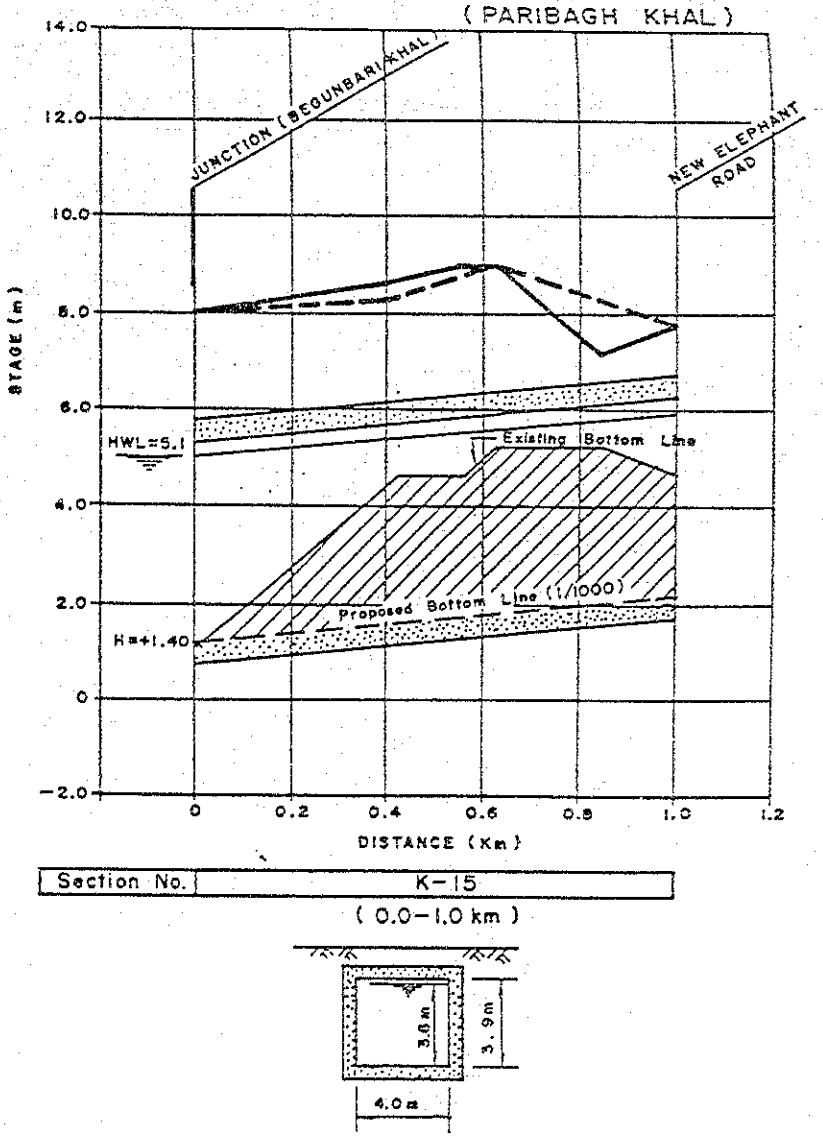
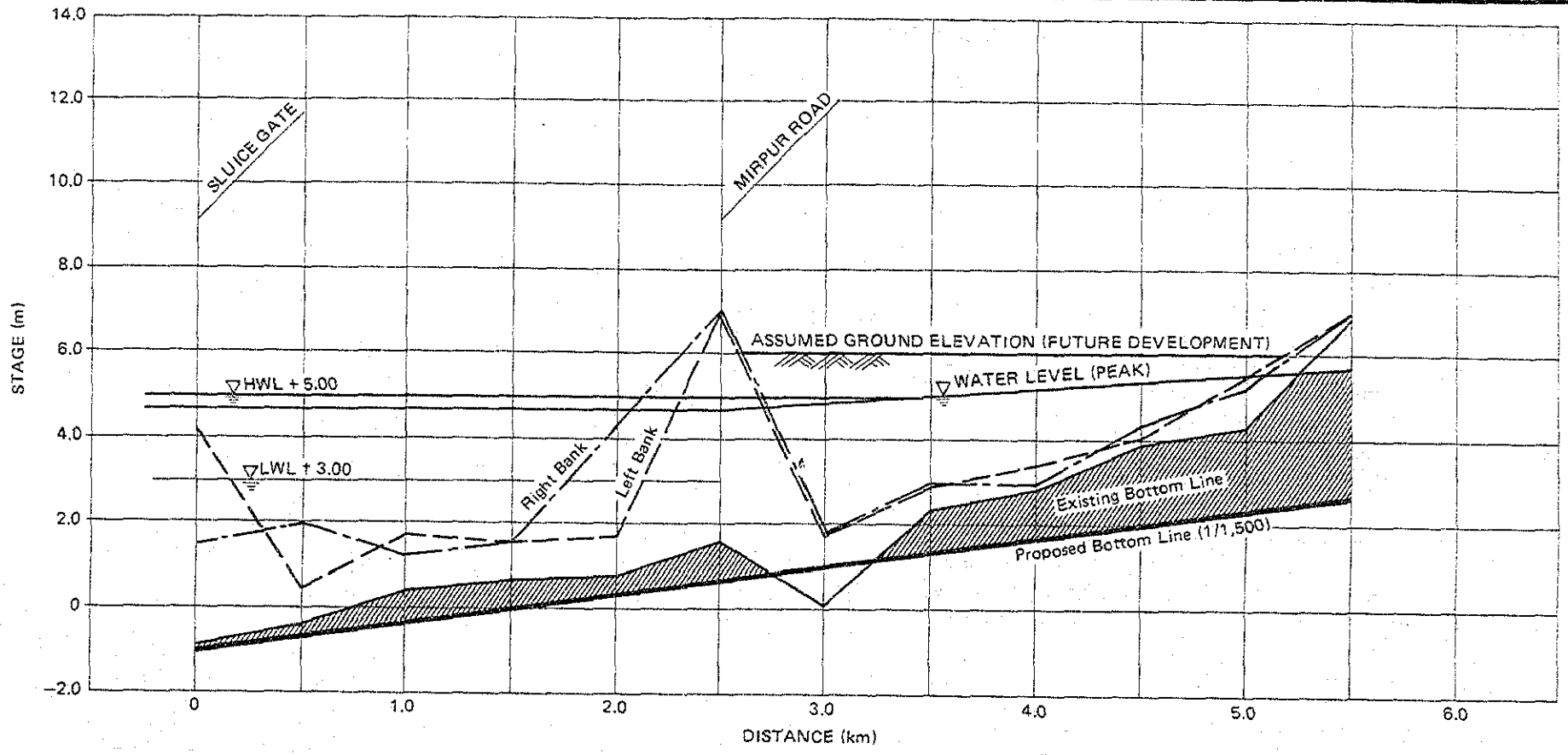


FIG. C. 16 PROPOSED LONGITUDINAL AND CROSS SECTIONS OF PARIBAGH KHAL

UPDATING STUDY ON STORM WATER DRAINAGE SYSTEM IMPROVEMENT PROJECT IN DHAKA CITY



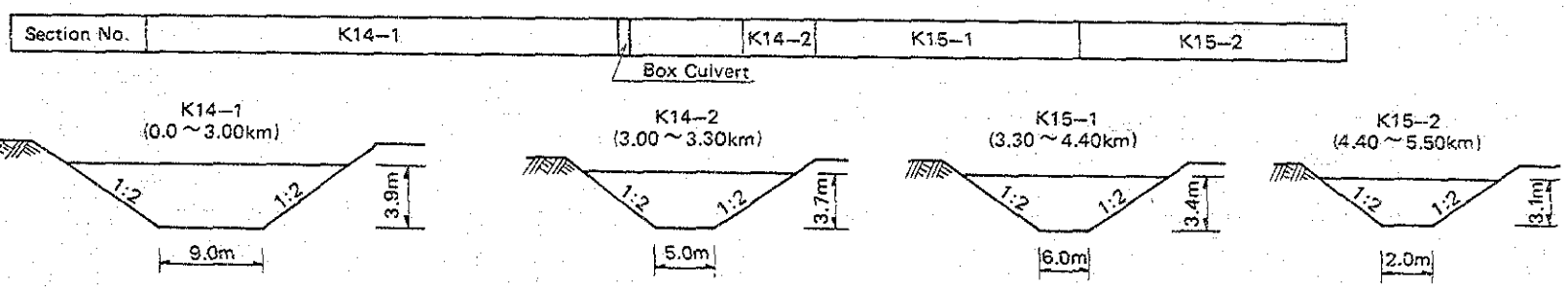


FIG. C. 17 PROPOSED LONGITUDINAL AND CROSS SECTIONS OF KALLYANPUR

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