

**MASTER PLAN FOR WATER SUPPLY,
SEWERAGE AND DRAINAGE
CALCUTTA METROPOLITAN DISTRICT
1966-2001**

**SUMMARY, CONCLUSIONS
AND RECOMMENDATIONS**

**CALCUTTA METROPOLITAN PLANNING ORGANISATION
GOVERNMENT OF WEST BENGAL**

MASTER PLAN FOR WATER SUPPLY, SEWERAGE AND DRAINAGE
CALCUTTA METROPOLITAN DISTRICT (1966-2001)

Calcutta Metropolitan Planning Organisation 1966

This is a reprint of Part IV, Chapters 23 and 24, from
Volume One of the
MASTER PLAN FOR WATER SUPPLY, SEWERAGE AND DRAINAGE,
CALCUTTA METROPOLITAN DISTRICT (1966-2001)
prepared for the World Health Organisation
by the Engineering Consortium consisting of
Metcalf & Eddy, Ltd., of Boston, and Engineering-
Science, Inc., of Arcadia, Calcutta.

The "figures" referred to in the text are maps,
charts and tables that appear in Volume Two of
the Plan. The entire list of these figures, as
they appear in the original Volume Two, is given
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SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

PART 1: INTRODUCTION AND BASIC DATA

CHAPTER 1 - INTRODUCTION

The project entitled, "Survey of Water Supply Resources of Greater Calcutta, India-170," was initiated in May 1959 by the Government of India assisted by the World Health Organization, Southeastern Asia Regional Office.

The first phase included an investigation of sanitary conditions in greater Calcutta in 1959 by a World Health Organization (WHO) Consultant Team, which led to the preparation of a report entitled "Assignment Report on Water Supply and Sewage Disposal, Greater Calcutta: Project India-170," published by the WHO in January 1960.

Thereafter, a Plan of Operation was signed in September 1962 by the United Nations Development Programme, the World Health Organization, and the Government of India. Acting as Executive Agency under this plan, the WHO executed an agreement in December 1962 with an Engineering Consortium (EC), comprising Metcalf & Eddy Limited and Engineering-Science, Inc., to prepare a report upon water supply, sewerage, and drainage for the Calcutta Metropolitan District (CMD), with the Government of India furnishing supporting staff, expert services, equipment, maps, technical data, transportation, and office facilities.

The Calcutta Metropolitan Planning Organization (CMPO) was designated as the interim agent of the Government of India and the Government of the State of West Bengal for all matters relating to the technical engineering aspects of the project, and for all supporting services to be provided locally for the project.

The work was started in March 1963 and completed in mid-1966.

The present report forms an integral part of a CMPO comprehensive development plan which includes land planning, housing and urban renewal, traffic and transportation, economic and social development, fiscal planning, regional planning, municipal engineering, and other matters relating to development within the CMD. In recognition of this,

the EC coordinated its study and activities with numerous local agencies and published a series of interim reports, drafts, memoranda, etc., which were circulated, discussed, and subsequently revised in the light of comments received.

CHAPTER 2 - BASIC DATA

Geography and Geology

The Study Area is located in the eastern part of India in the State of West Bengal, and consists of about 450 square miles extending for a distance of some 50 miles along the Hooghly River to a depth of from one to 17 miles from the bank on either side. The boundaries of the Study Area are identical with those of the CMD and encompass 2 corporations, 33 municipalities, 34 non-municipal urban areas, and 4 miscellaneous areas. Greater Calcutta is the focal point of an extensive road, rail, and inland waterways transportation system connecting with other parts of India.

The Hooghly River (named the Bhagirathi River in its upper reaches) divides the CMD into an east bank area and a west bank area. The river is a principal diverging branch of the Ganga delta system, is tidal and navigable, thus permitting access to the Port of Calcutta by ocean-going vessels from the Bay of Bengal. The Study Area also contains many minor streams, canals, etc. The terrain is exceedingly flat and such natural slopes as exist are generally in a downward direction from relatively high ground along the banks of the Hooghly River.

The CMD is located within the lower deltaic plain of the Ganga River system. The region is underlaid with sediments deposited in successive stages by the Ganga and its tributaries, and consists of layers of clay, clay and calcareous concretions, peaty intercalations, sandy or silty clay, and silt and fine to coarse sand. It is believed that the thickness of the sedimentary fill is more than 10,000 ft. In the north of the area, the top soil is mainly sandy with some areas of stiff clay, while in the south, the top soil consists of clayey loam in the low areas, sandy loam, or pure loam.

Temperatures vary between a minimum monthly average of about 55 deg.F in December and January, to maximum monthly averages of nearly 100 deg.F in March, April, and May. Total annual rainfall amounts to about 64 inches, is at a minimum in December and January, and is heavy during the monsoon months of June, July, August, and September.

History

Over the past several decades metropolitan Calcutta has steadily grown and today is the major commercial and industrial complex in the eastern portion of India. It is the largest port and urban complex in the Indian Union and is numerically the second largest city in the British Commonwealth of Nations. Its assets and defects can be traced to its manner of development, much of which has occurred haphazardly

in response to economic stimuli and has resulted in industrial and commercial congestion interspersed with unplanned and equally congested residential areas.

Economics

An indication of the size of the economic hinterland served by Calcutta is shown in Figure 2-1. This area contains the States of West Bengal, Assam, Bihar, Orissa, Manipur, Tripura, portions of Madhya Pradesh, and Uttar Pradesh, the independent Kingdom of Nepal, and various Himalayan principalities and protectorates, comprising about half a million sq. miles with a population of some 180 million persons.

The hinterland is particularly rich in coal, iron, and manganese deposits, and has substantial reserves of copper bauxite, and other minerals. Principal agricultural products include rice, wheat, cotton, tea, jute, sugar cane, and tobacco. Industries processing these products include steel mills, manganese plants, jute and textile mills, sugar and tea processing, manufacture of paper and cement, and a wide variety of engineering organizations.

Of the six major ports in India, Calcutta handles about 40 percent of the nation's imports and about 45 percent of the exports, accounting for roughly 50 percent of the total foreign exchange earnings.

The availability of power, labor, and transportation has permitted the CMD to become one of the nations largest industrial complexes. Manufacturing activities include food processing, jute and other textiles, chemicals, nonferrous metal products, iron and steel products, and a wide variety of engineering products.

Being a center for distributed trades as well as a large industrial complex, commercial activities form a major component of the economy of the CMD and, as a group, constitute the largest single employer of labor. Principal activities are banking and insurance, distributive trades, transportation, and communications. Calcutta possesses one of the two financial markets in India and an active stock exchange. More than 40 percent of the nation's large joint-stock companies are located within the CMD.

Calcutta is also the seat of government for the State of West Bengal and contains a large number of universities, research institutions, and cultural organizations.

Population and Industrial Growth

In order to project gross population distribution, the CMD was divided into the ten population zones and population projections were established in accordance with the following tabulation:

CMD ZONAL POPULATION DISTRIBUTION, 1961-2001

Zone	Population (in thousands)		
	1961	1981	2001
I	549	1,067	1,677
II	192	492	927
III	2,913	3,231	3,401
IV	712	1,745	3,325
V	88	231	412
VI	545	687	962
VII	259	630	1,350
VIII	660	902	1,235
IX	242	332	712
X	377	562	787
Totals	6,537	9,879	14,788

Further detailed studies were then undertaken within each zone, resulting in design population distributions as shown in Figures 2-3, 2-4, and 2-5.

Projections of growth in industrial employment were made as an aid in determining the future total population within the CMD. Such projections were also used as a basis of estimating industrial water requirements and industrial waste water quantities.

PART II: WATER SUPPLY

CHAPTER 3 - GENERAL CONSIDERATIONS

A primary objective in developing engineering proposals leading to a safe and adequate water supply for the CMD is to reduce the present high incidence of cholera and other gastro-intestinal diseases among the inhabitants of the area. The secondary objectives include the provision of safe and reliable municipal supplies to industry, both as a means of increasing industrial efficiency and as a source of revenues to the authority providing such supplies. In addition, it is intended that municipal supplies will provide additional sources of water for fire-protection purposes to supplement existing facilities.

Existing Facilities

Existing water supply facilities in the CMD are shown in Figure 3-1. Present sources of municipal supplies consist of the Hooghly River and ground waters exploited in the immediate vicinity of the areas they serve. Both these sources are also exploited directly by private industries and domestic consumers. There are presently six municipal waterworks within the CMD of which Palta (84 mgd) and Howrah (4 mgd) are the largest. Other plants are of substantially smaller capacity. In many areas, groundwaters are not treated; however, iron-eliminators

are employed at some wells, and at certain locations groundwaters are chlorinated prior to delivery to distribution systems.

Major transmission lines exist between Palta and the Howrah waterworks, and between their respective distribution systems. Storage facilities are located at Talla (27 mg) for the Calcutta system and at Howrah (0.65 mg) in addition to a large number of small elevated reservoirs.

Substantial portions of the Calcutta Corporation area are served by a large filtered water distribution system, and by a separate unfiltered water distribution system consisting of two inter-connected sub-systems. The filtered water system is supplied from Palta waterworks via transmission lines, and unfiltered water is obtained from the Hooghly River by means of the Mullickghat and Watgunge Pumping Stations where the water is pumped directly to the distribution sub-systems following chlorination.

Separate and relatively minor distribution grids serve parts of Howrah, Baranagar-Kamarhati, Uttarpara, Serampore, and Hooghly-Chinsurah with groundwater and also with surface waters from their respective waterworks. Distribution of groundwater in areas served exclusively by this source generally consist of a series of small, and sometimes interconnected, grids each supplied from a group of two or three wells.

In other parts of the CMD, presently outside the areas described above, developed sources of potable water are extremely meager. The inhabitants rely principally on portage of water from hand-pumped wells provided by local authorities, or on privately-owned wells. Considerable use is also made of untreated and undoubtedly contaminated surface water from canals, streams, and ponds.

Need for Improvements

Roughly 80 percent of total municipal supplies are delivered to the areas served by the Calcutta filtered water distribution grid. Within this area, intermittency of supply, maldistribution, and a high level of wastage by consumers, results in considerable shortages despite the fact that total supplies are reasonably adequate.

In other areas, nearly 4 million people receive a municipal supply averaging less than 10 gcd (gallons per capita per day), of which about half receive substantially less. Large numbers of the population resort to use of readily available (and undoubtedly polluted) surface water sources such as ponds and streams. There is an immediate and desperate need for substantial improvements in water treatment, transmission, and distribution throughout the CMD.

CHAPTER 4 - BASES FOR DESIGN

Domestic Requirements

Domestic consumers have been divided into two groups as follows:

Group I at 50 gcd (60 gcd in Calcutta and Howrah) for occupants of dwellings containing a variety of plumbing fixtures.

Group II at 20 gcd for occupants of dwellings containing minimal plumbing, or where supplies are obtained from communal facilities outside the building.

The proportion of Group I consumers is expected to increase with time such that average supplies will be as follows:

Up to 1971, 20 gcd in all areas except Calcutta and Howrah where higher values will apply.

1971 to 1981, 40 gcd in all areas except Calcutta and Howrah where 50 gcd will apply.

1981 to 2001, 50 gcd in all areas except Calcutta and Howrah where 60 gcd will apply.

Industrial Requirements

Proposed municipal supplies to industry are shown in the following tabulation (wherein the "A" areas represent zones of poor groundwater quality, with two-thirds of the demand assumed supplied by the municipality, and the "B" areas, acceptable groundwater quality, with only one-third supplied by the municipality):

MUNICIPAL SUPPLIES TO INDUSTRY

Popu- lation Zone	Industrial Area (Acres)	1981 Municipal Supply			2001 Municipal Supply		
		A Areas (mgd)	B Areas (mgd)	Design Allowance (gad)	A Areas (mgd)	B Areas (mgd)	Design Allowance (gad)
I	5,400	36.8		7,000	69.8		13,000
II	7,620	6.8		900	9.9		1,300
IIIA	1,670	5.0		3,000	5.0		3,000
IIIB	4,250	19.1		4,500	19.1		4,500
IV	15,300		21.8	1,400		45.8	3,000
V	2,400		1.3	500		2.4	1,000
VI	12,200		4.5	400		6.1	500
VII	11,100	14.1		1,300	26.6		2,400
VIII	7,360	11.5		1,500	22.1		3,000
IX	5,050		7.2	1,500		20.2	4,000
X	3,860		3.5	900		5.8	11,500
Sub-Total		93.3	38.3		152.5	80.3	
Total	76,270	131.6			232.8		

Peak Ratios of Domestic Flow

The following ratios, maximum to average day, have been adopted:

Maximum day = 1.25

Maximum hour = 1.6 to 2.0 (mean value 1.85)

Fire Allowances

Municipal supplies for fire-fighting purposes are at 50 per cent of total demand (the balance being obtained from ponds, rivers, etc.), to be available simultaneously with maximum-day domestic demand plus average-day industrial demand at a minimum hydrant pressure of 20 psi (pounds per square inch). The rate of such municipal supplies varies according to requirements of the various localities.

Figure 4-1 is a map which delineates proposed fire zones.

Other Design Criteria

Other design criteria are listed as follows:

Minimum pressure at service connection=20psi.

Minimum pressure in primary distribution mains (some exceptions)=35 psi.

Maximum pressure in primary distribution mains=90 psi.

Hazen-Williams' "C" values are as follows:

For Existing Pipes

8 to 9 inch diameter, filtered system = 60

8 to 9 inch diameter, unfiltered system = 50

12 to 16 inch diameter, filtered system = 75

12 to 16 inch diameter, unfiltered system = 60

18 to 54 inch diameter, filtered system = 80

18 to 54 inch diameter, unfiltered system = 70

60 to 72 inch diameter, filtered system = 90

60 to 72 inch diameter, unfiltered system = 80

For New Pipes

Below 16 inch diameter = 110 (assumed not lined)

16 to 20 inch diameter = 120 (assumed cement lined)

24 inch diameter and above = 130 (assumed cement lined)

Design Periods

Land acquisition for treatment plants, etc. = 40 years

Intake jetties and subaqueous facilities = 40 years

Major structures = 40 years

Equipment for pumping stations = 15 years

Major elements for water treatment plants = 15 years

Transmission facilities = 15 to 20 years

Primary distribution systems = 15 to 20 years

Secondary distribution systems = 40 years

Ground level reservoirs = 15 to 20 years

CHAPTER 5 - WATER REQUIREMENTS

This section deals with the projected total (industrial plus domestic) water demands of the CMD area, to be developed from surface or ground water supplies, and of water quality requirements for drinking water supplies, to be maintained within the distributions systems.

The anticipated total average daily (domestic plus industrial) water requirements of the CMD for the periods ending 1981 and 2001 are summarized in Table 5-1. For the period ending 1981, of a total demand of 667 mgd, 543 mgd is proposed to be furnished from municipal systems, including 412 mgd for domestic purposes. For the period ending 2001 (ultimate condition), the total water requirements is estimated to be 1,226 mgd, which includes 753 mgd for domestic purposes.

The recommended standards of quality for public water supply systems are those set forth in the WHO Drinking Water Standards dated 1963, which are considered to be within the reach of all countries throughout the world at the present time.

CHAPTER 6 - SOURCES OF SUPPLY

The three sources of supply considered in developing the Master Plan for water supply are the following:

- (1) The Hooghly River
- (2) The Damodar and Ajoy Rivers
- (3) Groundwater

The Hooghly River

Three distributaries of the Ganga (Ganges) River, the Bhagirathi River, the Jalangi River, and the Churni River, form the Hooghly River (Figure 6-2). About 400 years ago the main stream of the Ganga flowed south in the Bhagirathi-Hooghly River, and entered the Bay of Bengal southeast of Calcutta via the Adi Ganga River. The main flow of the Ganga has since shifted to the Padma River; hence the Bhagirathi-Hooghly River now gets its supply only during the monsoon when the level of the Ganga River is high. The Bhagirathi River, from its off-take at Giria to its terminus at Nadia has a length of about 150 miles; and a tributary area of about 7,500 acres.

The combined stream of the Jalangi and Bhagirathi Rivers is called the Hooghly River. The Hooghly River is generally divided into three reaches as follows:

- (1) Upper Hooghly, from Nadia to Jubilee Bridge
- (2) Lower Hooghly, from Jubilee Bridge to Hooghly Point
- (3) Estuary Hooghly, from Hooghly Point to Saugor

In the Upper Hooghly reach, only the central Hooghly River channel is now active. The lower Hooghly reach includes a major portion of the CMD, which is a highly industrialized and densely populated area. Presently within the CMD approximately 200 mgd (including the unfiltered water supply in Calcutta) is withdrawn from the river for water supply purposes. Tides in the Hooghly estuary are quite strong and over the years the intensity and frequency of bores has increased due to decreasing dry weather contributions from the Ganga, causing jeopardy to the Port of Calcutta's riverside berths, moorings, and jetties. The Hooghly is tidal for its entire length and in the dry season the tidal limit extends above Swarupganj (80 miles below Calcutta). With a good monsoon flow the tidal influence ceases to be felt at Akra (8 miles below Calcutta). The Hooghly River has a total catchment area of about 17,000 sq. miles, and average rainfalls in this area vary from 60 to 65 inches annually.

With its total catchment area of approximately 24,000 sq. miles, the Hooghly-Bhagirathi's average maximum discharge is about 195,000 cfs, and when all tributaries synchronize this flow is as high as 450,000 cfs. Flows in the Hooghly River are measured by the IWWD (Irrigation and Waterways Department), Government of West Bengal, at Kalna approximately 65 miles upstream from Calcutta. Flows in the Hooghly River at Kalna presently average about 80,000 cfs in the wet season and are reduced to 1,000 to 2,000 cfs in the dry season.

Typical physical and chemical water quality data, recorded at the Palta Waterworks, are presented in Table 6-2. With the exception of high chloride concentrations and turbidity, the waters of the Hooghly are of excellent quality. The MPN of coliform organisms of the river water ranges from 430 to 15,000 organisms per ml.

Because of the reduction in upland discharge brought about by the shift in the main course of the Ganga, the Hooghly River is presently subject to severe salinization which threatens its usefulness as a community water supply source. Further, these factors have brought about a heavy deposition of sediment which severely restricts river traffic to the Port of Calcutta. Under present conditions the waters of the Hooghly River, with proper treatment, are well suited for use as a community source except during the period of high salinity during March, April, May, and June. During this period the problem is now being solved partially by using the storage lagoon at Palta for holding raw water pumped continuously from the river, so that the delivered water represents the average salinity over a period of a day or more. Additional pumping capacity is planned which will permit selective pumping of raw water when salinities are lower.

Inasmuch as the dry weather flow of the Hooghly is comprised essentially of local runoff and subsurface flow (without significant contributions from the Ganga), salinity presently depends primarily on the extent of rainfall in the local drainage area during the previous monsoon. In the event of low local rainfall the salinity problem could be expected to become worse, and in such event emergency use of ground water might be required. If the present situation continues, the Bhagirathi-Hooghly will eventually be completely cut off from the Ganga and its capacity reduced to the point where it will carry only discharges of its own tributaries. If such a situation develops the Hooghly River could no longer function effectively as a major port or as a water supply source.

The main objective of the Farakka Barrage Project, now under way, is the preservation and maintenance of the Port of Calcutta and of the Bhagirathi-Hooghly River system by providing continuous and controlled quantities of fresh water upland flow. Officials of the Farakka Barrage Project (Government of India, Ministry of Irrigation and Power) have indicated that the Project should be in operation by 1970-71. The proposed program of water releases through the Barrage is as follows:

- 1st January to mid-March, 40,000 cfs
- Mid-March to mid-May, 20,000 cfs
- Mid-May to mid-September, 20,000 cfs to 40,000 cfs
- Mid-September to end December, 40,000 cfs

The releases from mid-May to the end of December, as shown above, are in addition to supplies to be drawn from the direct head of the Bhagirathi up to its capacity of about 80,000 cfs.

The water released from the Ganga into the Bhagirathi by the Farakka Barrage will be relatively silt free and will have chemical characteristics similar to the data presented in Table 6-7. With controlled upland discharge and consequent prolongation of the high flow period, the long term deterioration of the Hooghly will be stopped, intensity and frequency of bores reduced, and the water supply quality will be improved due to reduction in salinity.

Model studies on the effects of increased upland discharge on the salinity of the Hooghly River were carried out by the Ministry of Irrigation and Power. The results of these studies are presented in Figure 6-12, which show that with increased upland discharges there will be significant reductions in salt concentrations at Garden Reach, Cossipore, and Mulajore. Flows in the order of 20,000 to 30,000 cfs will reduce salinities to the desired limit of 250 ppm at the above locations. After the Farakka Barrage is in operation the fresh water limit should be decreased well below Garden Reach, most probably to Budge Budge or Uluberia.

Groundwater Sources

The groundwater studies carried out by the Engineering Consortium were directed towards obtaining as complete a picture as possible of the groundwater resources of the CMD area, and establishing those areas of the CMD where groundwater could be used as the primary source of supply.

The CMD area forms a part of the Bengal Basin. The Basin is a huge tectonic trough and is blanketed by a considerable thickness of quaternary alluvium which overlies a vast layer of tertiary and Mesozoic sediments believed to be not less than 10,000 ft thick. The Quaternary deposits are the principal repository of the groundwater in the Study Area.

The shallow groundwater exists in an unconfined state, i.e., under watertable conditions. In the deeper zones, which are overlain by an impervious confining layer, groundwater occurs in the non-flowing artesian state. Subsurface correlation of the alluvial material, made on the basis of the lithological study of bore holes drilled in the Greater Calcutta area, indicate that the major aquifer system consisting of coarse to medium grained sand, occasionally mixed with gravel, occurs generally within the depth-span of 150 to 450 ft below the land surface in the Calcutta and Howrah areas.

Aquifer constants, such as the transmissibility and the storage coefficient, have not been determined for most of the aquifers in the Greater Calcutta area. The limited data that are available are presented in Table 6-10. These data indicate that the coefficients of permeability for the aquifers tested are quite high, varying from 2,073 to 8,817 gallons per day per sq ft. All the aquifers tested were composed of coarse to medium sand and gravel. Discharge data available indicate that the zone between the depth range of from 150 to 450 ft is capable of yielding a copious supply of water. Yields of about

660 gpm for a drawdown of from 10 to 12 ft can be expected in properly constructed large diameter wells. The large regional extent of the aquifers in the northern part of the Greater Calcutta area and the conditions of storage and transmissibility indicate that this particular area holds a very good prospect for large-scale development of the groundwater resources.

There is no definite information on the gradient of the water table in the Greater Calcutta region. Because of the lack of adequate groundwater level data, water table contour maps could not be prepared. Also, because of the lack of data, estimates of groundwater recharge for the Greater Calcutta and adjoining regions were not possible. It is postulated that the aquifers of this area are receiving recharge from regions lying north and west of the Study Area. Inasmuch as estimates of recharge cannot be prepared, the specific yields of the various aquifers cannot be determined and it is not possible to estimate with any accuracy the quantity of groundwater available.

An evaluation of the chemical analyses of a very large number of wells indicates that the groundwater resources in the northern portion of the CMD are of acceptable quality for development as a public water source; however, large scale development of groundwater in the central and southern portions of the CMD is not considered feasible.

A detailed groundwater exploration program for further evaluation of the potentials of groundwater sources, in areas where available knowledge was found insufficient, was initiated in August 1964. The planning of the groundwater exploration program was a cooperative effort by the GSI, CMPO, PHE, and the Engineering Consortium. Twelve sites were selected for study (Figure 6-23). At each site the program was to include the drilling of an exploratory hole, construction of test wells and observation wells, and systematic testing of the aquifer zones encountered. Insofar as applicable to the Master Plan Project, the groundwater exploration program had to be concluded when five of the planned twelve test holes (those located at Budge Budge, Baruipur, Rajpur, Bansdroni, and Uluberia) were drilled and logged and the aquifer pump tests were completed.

The results of the exploratory program confirmed that there are no dependable groundwater resources in the Calcutta-Howrah area below the depth of 1,000 ft. Also, the test results have confirmed the presence of poor quality groundwater throughout the southern portion of the CMD area. Groundwater may still be considered a resource of value in these areas for interim use and as a reserve for emergencies at peak demands; however, the primary source of water supply will be the Hooghly River.

Damodar and Ajoy Rivers

Although the Hooghly River and local groundwater sources will be more than adequate to meet the ultimate water demands of the CMD, the Engineering

Consortium conducted preliminary investigations into the feasibility of using the Damodar and Ajoy Rivers as sources of water supply for the Calcutta area.

The general location of the Damodar and Ajoy River is shown on Figure 6-27. The total catchment area of the Damodar River is about 9,000 sq. miles, and the Ajoy River drains an area of about 2,400 sq miles. Rainfall in these areas averages about 55 inches annually, the substantial portion of which is confined to the monsoon season (mid-June through September). The majority of the runoff from the Damodar and Ajoy catchment areas occurs during the months of July, August, September, and October. Dry season runoff in these areas is practically nil.

Although no exact estimates are available it appears that the water requirements of the planned developments in the Damodar and Ajoy Valleys, when combined with the existing demands, will probably exceed the water resources available within these regions.

If an excess of water were to exist in the Damodar and Ajoy Valleys, proper development of the excess for use by the CMD would require the expenditure of hundreds of millions of rupees for the construction of storage reservoirs and aqueducts. Such expenditures are not necessary for use of the Hooghly River and local groundwater sources. Hence, use of the Damodar and Ajoy Rivers as a water supply source for the Greater Calcutta area would not presently, nor in the foreseeable future, be economically justifiable.

CHAPTER 7 - WATER TREATMENT CONSIDERATIONS

The purpose of this chapter is to determine the needs for treatment for transforming the raw water supplies to provide water for public use which is hygienically safe, aesthetically attractive, and palatable.

Two sources of public supply have been established, the Hooghly River and local groundwater, which differ considerably in their characteristics; hence the processes used in the treatment of river water will differ substantially from those used to treat groundwater, and plans for treatment have been developed for both types of supplies.

At present the principal difficulties encountered in treating Hooghly River are high silt and bacterial content and excessive salinity. With the completion of the Farakka Barrage and subsequent stabilization of river conditions (about 1975), impairment of the river supply by high salinity will no longer be a problem. Significant reductions in silt and bacterial content are not anticipated and treatment will be necessary to reduce these to the level necessary to produce a safe and potable public supply. In general river water turbidities range between 500 and 600 ppm and the MPN of bacteria in the river is well above 400 per ml. Treatment to reduce the silt and bacterial content to desirable levels can be most efficiently accomplished by means of the rapid sand

filtration process including flocculation, sedimentation, and filtration together with prechlorination and postchlorination as needed. Experience in the Calcutta area has shown that proper application of the above unit processes will provide a water of suitable quality for public use.

The groundwater found in the northern CMD areas is generally of acceptable quality. The principal groundwater impairment is high iron content (1 to 5 ppm). Iron removal by aeration/filtration processes, provided such systems are properly designed and maintained, will provide a satisfactory degree of iron removal. It is highly probable that the shallow aquifers are bacterially contaminated; hence, it is important the wells passing through this zone be sealed, both at the surface and for a sufficient distance below the surface. Also to insure proper public health protection, it is recommended that chlorine residuals be maintained throughout the distribution systems.

CHAPTER 8 - INTERIM GROUNDWATER SUPPLIES

In 1963 the CMPO prepared a report entitled, "The Interim (Emergency) Water Supply Scheme", proposing a system of temporary well supplies serving sixteen municipalities and fourteen nonmunicipal areas. This work is presently under implementation and it is planned that 60 per cent of the construction will be completed during 1966. An additional similar program is scheduled for completion during the Fourth Plan, which will extend pipe water supplies from groundwater sources to all municipal and non-municipal areas within the CMD by 1971.

Figure 8-1 shows those areas of the CMD covered by the interim program and planned per capita interim supply.

In general, the Interim Groundwater Supply Program consists of a series of independent (but interconnected) systems, each serving a population of about 25,000 persons. In areas of good-quality groundwater, a typical layout consists of two or three wells driven to a depth of between 450 and 650 ft. The headworks for each well is housed in a separate brick and concrete structure, suitably protected against vandalism and containing chlorination equipment. Balancing reservoirs are included having an elevated capacity varying from 60,000 gallons to 125,000 gallons. In areas where the iron content of groundwater is high, iron-eliminators are used. The distribution system consists of CI pipe ranging in size from 14 to 4-inch diameter, with secondary systems using steel pipe of 4 inch diameter and smaller.

As a result of a review by the EC, distribution grids were modified; fire protection was added; improved street supplies were recommended; the height of elevated reservoirs was increased; and certain other design modifications were suggested.

CHAPTER 9 - OUTLINE OF PLANNING PROGRAM

The CMD has been broken down into five service districts wherein

development is proposed to be carried out over the years in three phases, as follows:

- (a) Interim Phase: This represents work to be completed during the Government of India Fourth Plan (1 April 1966 to 31 March 1971).
- (b) Intermediate Phase: Work within this phase is scheduled to reach maturity by 1981.
- (c) Ultimate Phase: This includes works scheduled to reach maturity by the year 2001.

Detailed Work Program

A detailed listing of the works to be constructed or carried out during the several phases is as follows (the numbers used are those in Figures 9-1, 9-2, and 9-3):

Interim Phase:

- (1) Interim groundwater supplies at 20 gpd.
- (2) Groundwater supplies at 40 gpd.
- (3) Groundwater supplies at 50 gpd.
- (4) Additions and improvements at Palta waterworks.
- (5) Improvements to transmission lines.
- (6) Improvements to pumping and storage facilities at Talla.
- (7) Improvements to filtered water primary distribution grid in Calcutta.
- (8) Booster pumping stations for Calcutta filtered water distribution system.
- (9) Leakage surveys and corrective measures to Calcutta, unfiltered water primary distribution grid.
- (10) Garden Reach waterworks (Alternate B only).
- (11) Unfiltered water transmission line (Alternate B only)
- (12) Retire Mullickghat unfiltered water pumping station.
- (13) Retire Watgungé unfiltered water pumping station (Alternate B only).
- (14) Modify existing large diameter wells.

Intermediate Phase

- (4) Further additions at Palta waterworks.
- (7) Further additions to filtered water primary grid in Calcutta Service District.
- (8) Further additions to two booster pumping stations for Calcutta filtered water distribution system.
- (10) Garden Reach waterworks.
- (15) Additions at Baranagar-Kamarhati waterworks.
- (16) New Howrah waterworks.
- (17) Additions at Serampore waterworks.
- (18) Surface water distribution primary grid.
- (19) Complete integration of the northern portion of the Calcutta unfiltered water distribution system with the filtered water distribution system.

Ultimate Phase

- (4) Further additions at Palta waterworks.
- (7) Further additions to filtered water distribution facilities, Calcutta Service District.
- (10) Further additions at Garden Reach waterworks.
- (14) Place Calcutta groundwater supply facilities on standby basis.
- (15) Further additions at Baranagar-Kamarhati waterworks.
- (16) Further additions at New Howrah waterworks.
- (17) Further additions at Serampore waterworks.

- (18) Additions to surface water distribution primary grids.
- (20) Complete integration of filtered and unfiltered water system, Calcutta Service District.

Proposed Distribution System

Major distribution pipelines in urban areas are almost invariably located within streets. Since the general pattern of development within the Calcutta Service District is well established and contains streets of adequate width and alignment throughout most of the area, it has proved possible to plan additional distribution facilities at suitable locations and with reasonable accuracy. Thus, studies could be made of various well-defined alternatives to arrive at definite proposals which constitute the best solution to the problems involved.

In other districts, street layouts are presently unsatisfactory or have not as yet been established. This fact, together with anticipated large increases in population from a presently relatively modest base, renders it impossible to develop definite proposals with any assurance that actual development will occur as presently anticipated. Accordingly, the proposed distribution facilities shown for such areas are limited to major elements only. Once layout plans are finalized, it will be desirable to review and extend these proposals in the light of subsequently available information, with modification as and when necessary.

CHAPTER 10 - CALCUTTA SERVICE DISTRICT

The Calcutta Service District includes the entire area covered by the Calcutta Corporation plus a contiguous region to the east. The water treatment plant and transmission lines, although located in the Palta Service District, are described herein since their principal function under present conditions is to serve the Calcutta Corporation.

Palta Waterworks

The present waterworks at Palta consists of a slow sand filter plant with a capacity of 66 mgd, together with a battery of rapid sand filters having a capacity of 18 mgd, giving a total output of 84 mgd. A 60 mgd rapid sand filter addition is currently under construction.

Interim Phase: Interim phase proposals include a thorough engineering study of plant operations and enlargements to provide for a detailed development plan up to the conclusion of the Ultimate Phase. Upon completion of this plan, the following projects would be carried out:

- (a) Update and renovate raw water intake and pumping facilities.
- (b) Renovate or reconstruct settling tanks and related facilities, or develop alternate facilities.
- (c) Rehabilitate settled water storage reservoir.
- (d) Modernize slow sand filters and related facilities.
- (e) Modernize chlorination facilities.
- (f) Modernize high pressure pumping station
- (g) Revise and extend the plant interconnecting piping.
- (h) Improve plant transportation facilities.
- (i) Improve plant operation efficiency.

In addition to the above, construction of the 60 mgd plant addition should be completed and these units should be placed in operation. The construction costs of the proposed improvements are estimated at Rs.19.41 million.

Under proposed Interim Phase conditions, total plant output will be increased as follows:

Renovate slow sand filters	88 mgd
Existing rapid sand filters	18 mgd
Additional rapid sand filters	<u>60 mgd</u>
Total	166 mgd

Intermediate Phase: These proposals include additions to the plant to increase production as follows:

Calcutta Service District	160 mgd
Palta Service District	<u>21 mgd</u>
Total	181 mgd

Construction costs of Intermediate Phase proposals are estimated at Rs.3.1 million.

Ultimate Phase: These proposals include further increases to provide the following:

Calcutta Service District	160 mgd
Palta Service District	<u>121 mgd</u>
Total	281 mgd

Construction costs of Ultimate Phase proposals are estimated at Rs.25.92 million.

Transmission Facilities

Four pipelines presently transmit water from Palta to the Calcutta storage and pumping complex at Talla, and have the following nominal capacities:

42-inch CI main	6 mgd
48-inch CI main	24 mgd
60-inch steel main	56 mgd
72-inch steel main	90 mgd

With the exception of the 42-inch main, which operates essentially under gravity-flow conditions, all mains operate under pressure conditions from high pressure pumps at Palta. The 60-inch main requires extensive renovation as a result of external corrosive attack, and the construction of the 72-inch main has yet to be completed in a number of places.

Proposed Interim Phase measures include a thorough inspection of the 60-inch main to determine which of a number of possible measures should be adopted to convey 160 mgd from Palta to Talla. Smaller transmission mains can be removed from this service and incorporated in the Palta Service District distribution grid. Necessary engineering works (estimated at Rs.10.0 million) should then be undertaken.

No subsequent improvements will be required in the Intermediate and Ultimate Phases.

Distribution Facilities

The existing Calcutta distribution system consists of a filtered water distribution system and a separate unfiltered water distribution system, which are separately discussed.

Filtered Water Facilities: Existing storage facilities at Talla include buried reservoirs of 8 mg and 10 mg capacity, a 9 mg elevated reservoir, and a 7 mg reservoir presently under construction, providing a total storage of 34 mg. Total installed pumping capacity is 286 mgd, although much of the equipment is obsolete and in poor operating condition.

Because available supplies are insufficient to keep pace with demand, supply to the distribution system is on intermittent basis. Supplies from Palta are augmented by some 114 large diameter wells located throughout the distribution system. Additional water is obtained from about 4,500 shallow (60 to 80-ft) hand-operated wells and from privately-owned wells.

The filtered water primary distribution system consists largely of CI pipes and is presently divided into a number of service zones, each having essentially a separate supply from Talla. Secondary distribution grids consist of 6-inch, 4-inch, and smaller pipes of cast iron and galvanized steel.

Present operating difficulties consist of both a lack of adequate pressure and inadequate supplies. It would also appear that consumer wastage is widespread. Leakage does not appear to be a major problem.

Figure 10-3 shows Calcutta Service District Existing Filtered Water Facilities.

Unfiltered Water Facilities: Part of the Calcutta Service District is served by a large unfiltered water supply and distribution system, as shown by Figure 10-4. The original purpose of the unfiltered water system was to provide an auxiliary municipal supply for fire-protection and street-cleaning purposes. However, a practice gradually became established of providing service connections from this system for toilet flushing and other non-potable uses by domestic and commercial consumers. Because of the inadequacy and intermittent nature of the potable water supply, and because the unfiltered water supply is intended to be continuous, domestic consumption of unfiltered water has now become commonplace to an extent that the Calcutta Corporation estimates that there are presently some 65,000 service connections. However, the domestic demands made upon the unfiltered water system now exceed its capacity to maintain a continuous supply.

Pipes carrying unfiltered water are in places located in close proximity to combined sewers, and in a number of cases, the pipe actually passes through a combined sewer or manhold.

Operation of the unfiltered water system is complicated by the fact that Hooghly River water is heavily silt-laden, which results in blockages in the distribution system. To alleviate this problem

fire hydrants are partly opened to create flushing velocities within pipelines, which in turn necessitates continuous pumping and results in an insufficiency of supply for fire protection and domestic use. Water wasted through fire hydrants transports large quantities of silt to the combined sewer system where further maintenance problems occur.

Until 1963, the unfiltered water system constituted a serious hazard to public health because of the widespread presence of cholera vibrios in the raw water pumped from the Hooghly River. Chlorination at the pumping stations prior to distribution (a measure strongly supported by the EC while in Calcutta) is now in effect and has been demonstrated as a suitable means of controlling this hazard.

Summary of Supplies

The present supplies to the Calcutta distribution system are summarized as follows:

Supplies from Talla	80.5 mgd
Supplies from large diameter wells	20 mgd
Supplies from small diameter wells	4 mgd
Approximately 50 per cent of un- filtered supplies	<u>45</u> mgd
Total present supplies	149.5 mgd

The total of 149.5 mgd is equivalent to 56 gpd, which normally would be considered adequate, but does not in practice prove to be so on account of maldistribution and wastage.

Proposed Improvements (Alternate A)

As part of the Master Plan studies, various improvements and alternatives were investigated, resulting in the conclusion that two alternative solutions would be feasible, designated as Alternate A and Alternate B, with the choice to depend upon conditions at the time when final design is undertaken. The Alternate A proposals are as follows:

Interim Phase:

Filtered Water System:

- (a) Abandon zonal separation and provide interconnections between existing mains to create a unified distribution system.
- (b) Add proposed distribution piping as shown in Figure 10-5.
- (c) Provide additional pumping facilities, renovate selected existing pumps, renovate venturi meters, modernize and enlarge chlorination facilities, and undertake all necessary ancillary work at Talla.
- (d) Provide booster pumping stations at locations shown in Figure 10-5 with capacities given in Table 10-3.
- (e) Strengthen and renovate secondary distribution grids.
- (f) Provide additional filtered water street supplies.
- (g) Inspect and renovate existing steel mains as required.
- (h) Modify existing large-diameter wells.
- (i) Institute wastage survey and apply corrective measures.

Unfiltered Water System:

- (a) Commence integration of the filtered water system with that portion of the unfiltered water system now served by Mullickghat pumping station and abandon Mullickghat pumping station.

Construction costs for the overall Interim Phase program (Figure 10-5) are estimated at Rs. 28.07 million.

Intermediate Phase:

Filtered Water System:

- (a) Further improve the distribution grid.
- (b) Transfer booster pump capacity, provide storage facilities to meet maximum hour-demands, and add storage pumps.

Unfiltered Water System:

- (a) Complete integration of that portion of the unfiltered water system served by Mullickghat.
- (b) Provide Hooghly River intake, pumping capacity, and supply main.
- (c) Provide settling tanks, chlorination facilities, and high pressure pumps at proposed Garden Reach plant for capacity of 25 mgd.
- (d) Connect the proposed Garden Reach plant with the unfiltered system presently served by Watgunge by disconnecting the present 42-inch main from the filtered water system and incorporating this main into the unfiltered water system.
- (e) Abandon Watgunge Pumping Station.

Construction costs for the Intermediate Phase works (Figures 10-6 and 10-7) are estimated at Rs. 53.20 million.

Ultimate Phase

- (a) Expand Garden Reach and related intake facilities to provide 146 mgd of filtered and chlorinated water.
- (b) Complete integration of existing filtered and unfiltered water primary and secondary grids.
- (c) Extend the primary grid so as to serve Tollygunge and Panchannagram. Connect the secondary grid and related facilities (now under construction).
- (d) Provide additional reinforcing mains.
- (e) Reduce booster pumping capacity at Rajah S. Mullick and Minto booster stations.
- (f) Provide storage and pumping facilities at Cotton Street, Bhawanipore, North Panchannagram, and South Panchannagram.

Construction costs for these works (Figure 10-8) are estimated at Rs. 96.01 million.

Alternate B Proposals

The Alternate B proposals were developed to provide at the earliest possible date a supply of clarified (but not filtered) and chlorinated water from the proposed Garden Reach Water Works to the unfiltered water distribution system, thus permitting abandonment or modification of the existing pumping stations at Watgunge and Mullickghat. Such alternate proposals are summarized as follows:

Interim Phase:

Filtered Water System:

- (a) Abandon zonal separation and provide interconnections between existing mains to create a unified distribution system as for Alternate A.
- (b) Add proposed distribution piping as for Alternate A with the addition of a 20-inch replacement main in the southern section.

- (c) Provide additional pumping facilities, renovate selected existing pumps, renovate venturi meters, modernize and enlarge chlorination facilities, and undertake all necessary ancillary work at Talla.
- (d) Provide booster pumping stations at locations as for Alternate A.
- (e) Strengthen and renovate secondary distribution grids.
- (f) Provide additional filtered water street supplies.
- (g) Inspect and renovate existing steel mains.
- (h) Modify existing large-diameter wells
- (i) Institute wastage surveys and apply corrective measures.

Unfiltered Water System:

- (a) Construct treatment facilities at Garden Reach, recondition and transport the 42-inch main, construct additional pipelines, modify Mullickghat Pumping Station, and abandon Watgunge Pumping Station.
- (b) Commence integration of filtered water system with that portion of the unfiltered water system now served by Mullickghat Pumping Station.

Estimated construction costs for the Interim Phase works are Rs.75.10 million.

Intermediate Phase:

Filtered Water System:

As for Alternate A, except that transfer of 42-inch main and construction of 20-inch main will have been already completed during the Interim Phase.

Unfiltered Water System:

- (a) Complete integration of that portion of the unfiltered water system served from Mullickghat. Upon completion, place Mullickghat pumping station on a standby basis.
- (b) Transfer Garden Reach pumping capacity, settling tanks, chlorination, and other facilities previously supplying the northern Calcutta Service District unfiltered distribution grid, to service in the Garden Reach Service District. Construct additional facilities such that 25 mgd of unfiltered water is supplied to the former Watgunge grid.

Estimated construction costs for the above are Rs.28.10 million.

Ultimate Phase:

- (a) Expand Garden Reach and related intake facilities to provide 146 mgd of filtered and chlorinated water.
- (b) Complete integration of existing filtered and unfiltered water primary and secondary grids.
- (c) Extend the primary grids so as to serve Tollygunge and the Panchannagram incorporating the 60-inch and 36-inch mains constructed under Interim Phase Alternate B. Connect the secondary grid and related facilities (now under construction).
- (d) Provide additional reinforcing mains as for Alternate A.
- (e) Reduce booster pumping capacity at Rajah S. Mullick and Minto booster stations.
- (f) Provide storage and pumping facilities at Cotton Street, Bhawanipore, North Panchannagram, and South Panchannagram as proposed under Alternate A.

Estimated construction costs for these works are Rs. 101.34 million.

CHAPTER 11 - PALTA SERVICE DISTRICT

The general location of the Palta Service District (PSD) is shown in Figure 9-3. The present population of the PSD is about 1,345,000 and is expected to increase to 2,663,000 by the year 1981 and to 4,699,000 by the year 2001. Estimates of the total average daily water demands for the entire PSD are 47 mgd for the existing situation, 88 mgd for the Interim Phase, 129 mgd for the Intermediate Phase, and 277 mgd for the Ultimate Phase.

Approximately 1.9 mgd of surface water is presently being supplied within the PSD (1.5 mgd from the Baranagar-Kamarhati Waterworks and 0.4 mgd bulk sale from the Palta Waterworks). Existing piped municipal groundwater supplies provide an additional 12.9 mgd, hence the PSD presently receives a total piped supply of 14.8 mgd.

Interim Phase

Interim Phase water improvements are planned for all municipal and non-municipal urban areas within the PSD, and upon completion of this program it is anticipated that supplies to urban areas within the PSD will be at the rate of 20 gpd. A tabulation of total existing plus Interim Phase supplies is presented in Table 11-1. The total average daily Interim Phase supply is expected to be 52.7 mgd. It is proposed that well installations made during the Interim Phase, along with existing well water supplies, be maintained in service for the Intermediate Phase and placed on standby status in the Ultimate Phase. It is planned that the secondary distribution systems and elevated reservoirs constructed as a part of this phase be incorporated into the Intermediate and Ultimate Phase Master Plan surface supply grids.

Intermediate Phase

As of the beginning of the Intermediate Phase (1975), the Farakka Barrage is scheduled to be in operation, and thus, the quality of the Hooghly River within the CMD should be such that the river can be used as a source of supply. It is proposed that during the Intermediate Phase, surface water supplies be extended to those urban areas in the southern half of the PSD in which projected population densities exceed 25 ppa by the year 1981. The urban areas serviced by the proposed Master Plan surface supply grids during the Intermediate Phase are shown in Figure 11-1.

Because of the existence of extensive aquifers at relatively shallow depths and the generally acceptable quality of the water found in these aquifers, large scale development of groundwater is practicable in the northern half of the PSD. Hence, it is proposed that for those areas in the PSD lying north of Garulia local groundwater supplies be developed. Also it is proposed that groundwater supplies be developed in the less densely populated portions located on the easterly side of the southern sector of the PSD.

The average daily water demands from municipal surface supply systems for the Intermediate Phase service area of the PSD comprise 76 mgd for domestic use and 17 mgd for industrial use, totalling 93 mgd. Average daily domestic demands are based on per capita allowances of 40 gpd. Industrial demands are based on allowances of 1,400 gpd for those industrial areas within population Zone IV and 400 gpd for those areas in population Zone VI. Approximately 23 mgd of the average daily demand of the Intermediate Phase will be met by existing and Interim Phase groundwater supplies; hence within the Intermediate Phase service area, an additional average daily supply of 70 mgd must be provided by the proposed new surface supply system.

The proposed surface water system improvements for the Intermediate Phase are shown in Figure 11-1. It is planned that a maximum daily supply of 21 mgd be drawn from the Palta waterworks to service the northerly portion of the PSD. It is also proposed that the capacity of the existing Baranagar-Kamarhati waterworks be increased to 63.0 mgd (maximum daily supply) to service the easterly portions of the Intermediate Phase service area of the PSD.

It is intended that the existing 48-inch Palta-Talla transmission line (located in Barrackpore Trunk Road) be used as a part of the Intermediate Phase primary grid. Capacities of the pumping stations included in the project are as follows:

Location	Reservoir Capacity (mgd)	Pump Station Capacities			
		From Storage		Booster Pumps	
		Capacity (mgd)	Head (ft)	Capacity (mgd)	Head (ft)
South Dum Dum	5.0	7.4	218	17.3	134
Talla (use existing reservoir)	2.5	6.3	218	16.2	134

Ultimate Phase

During the Ultimate Phase it is proposed to extend the primary surface water supply grid to those areas of the PSD in which projected population densities exceed 25 ppa by the year 2001. The Ultimate Phase service area of the PSD surface supply grid is shown in Figure 11-2. In the remainder of the PSD it is planned that groundwater be utilized as the primary source of supply.

During the Ultimate Phase the existing and Interim Phase groundwater supplies of the PSD are to be placed on standby status; hence, the entire water demand of the Ultimate Phase service area is to be supplied from the Palta and Baranagar-Kamarhati waterworks. The average daily water demand of the Ultimate Phase service area of the PSD includes 193 mgd for domestic use and 50 mgd for industrial use, totaling 243 mgd.

The domestic demand is based on a per capita allowance of 50 gpd and the industrial demand on per acre allowances of 3,000 gpd, 1,000 gpd, and 500 gpd for the industrial areas of population zones IV, V, and VI, respectively

The water supply improvements for the Ultimate Phase service area of the PSD are shown in Figure 11-2. In the Ultimate Phase it is proposed that the capacity of the Baranagar-Kamarhati waterworks be increased to provide a maximum daily supply of 171 mgd. The total Ultimate Phase capacity of the Palta Waterworks is 281 mgd, 121 mgd of which will be supplied to the PSD, and the remaining 160 mgd to Calcutta.

During the Ultimate Phase the Interim Phase grids are to be strengthened by the addition of several parallel supply lines, and the primary supply grid is to be extended eastward to service Barasat Municipality, the Nabapalli and Madhyamgram non-municipal urban areas, and Barasat police district.

Three ground-level storage reservoirs are planned, at Panihati, Salt Lake Township, and New Barrackpore. The details of these reservoirs and appurtenant booster stations are presented in Table 11-2.

A second ground-level reservoir, with a capacity of 2.0 mg, is proposed at the South Dum Dum site. Thus, during the Ultimate Phase, the storage capacity of the South Dum Dum reservoir complex will total 7.0 mg. It is proposed that the capacity of the South Dum Dum reservoir pumping station be increased to 18.2 mgd with a TDH of 218 ft, and that the capacity of the booster station be increased to 23.3 mgd with a lift of 134 ft.

It is planned that the storage capacity at Talla be increased to 7.0 mg. No increase in the pumping station appurtenant to the reservoir is planned. However the capacity of the PSD Talla booster station is to be increased to 39.3 mgd with a TDH of 134 ft.

Estimated Construction Costs

The proposed improvements for the Intermediate and Ultimate Phase surface water supply systems provide only for those portions of the PSD served by surface supplies. The estimated construction costs are as follows:

<u>Intermediate Phase Improvements</u>		<u>Millions of Rs</u>
(1)	Primary grid, reservoirs, and booster stations	5.18
(2)	Secondary grid	188.56
(3)	Water treatment plant (Baranagar-Kamarhati)	19.30
<u>Ultimate Phase Improvements</u>		
(1)	Primary grid, reservoirs, and booster stations	25.71
(2)	Secondary	80.98
(3)	Water treatment plants (Baranagar-Kamarhati)	29.77
Total		349.50

The cost of water treatment plant at Palta has been included in the cost estimates for the Calcutta Service District.

CHAPTER 12 - GARDEN REACH SERVICE DISTRICT

The general location of the Garden Reach Service District (GRSD) is shown in Figure 9-3. The present population of the GRSD is about 580,000, which is expected to increase to 1,360,000 by the year 1981 and to 2,122,000 by the year 2001. The estimates of the average daily water

demands for the entire GRSD for the existing situation and for the Interim, Intermediate, and Ultimate Phases are 21, 55, 90, and 182 mgd respectively. Approximately 7.4 mgd is presently being supplied within the GRSD from existing piped municipal supplies.

Interim Phase

Interim Phase water improvements are planned for all municipal and non-municipal urban areas within the GRSD, and upon completion of this program it is anticipated that supplies and urban areas within the GRSD will be at the rate of 20 gpd. The total average daily Interim Phase supply is expected to be 12.0 mgd. It is proposed that well installations made during the Interim Phase, along with existing well water supplies, be maintained in service for the Intermediate Phase and placed on standby status in the Ultimate Phase. It is planned that the secondary distribution systems and elevated reservoirs constructed as a part of this phase be incorporated into the Intermediate and Ultimate Phase Master Plan surface supply grids.

Intermediate Phase

It is proposed that during the Intermediate Phase, surface water supplies be extended to those urban areas in the GRSD in which projected population densities exceed 25 ppa by the year 1981. The urban areas serviced by the proposed Master Plan surface supply grids during the Intermediate Phase are shown in Figure 12-1.

The average daily water demands from municipal surface supply systems for the Intermediate Phase service area of the GRSD include 39 mgd for domestic use plus 25 mgd for industry, totalling 64 mgd. The domestic demand is based on per capita allowances of 40 gpd. Industrial demands are based on allowances of 7,000 gpd for those industrial areas within population zone I and 900 gpd for those areas in population zone II.

Approximately 10 mgd of the average daily demand of the Intermediate Phase will be met by existing and Interim Phase groundwater supplies; hence within the Intermediate Phase service area an additional average daily supply of 54 mgd must be provided by the proposed new surface supply system. The proposed surface water system improvements for the Intermediate Phase service area of the GRSD are shown in Figure 12-1.

In the Intermediate Phase it is planned that a maximum daily supply of 60 mgd be drawn from the Garden Reach waterworks to serve the GRSD. It is proposed that primary supply mains be located in Garden Reach Road, New Taratala Road, Taratala Road, Diamond Harbour Road, Old Tollygunge Road, Biren Roy Road, and Budge Budge Road. Two ground level storage reservoirs are planned, each having a capacity of 5.0 mg. Pump stations at each reservoir will be necessary to lift the water required to meet peak demands from ground storage to the gradient of the pipeline system.

Ultimate Phase

During the Ultimate Phase it is proposed to extend the primary surface water supply grid to those areas of the GRSD in which projected population densities exceed 25 ppa by the year 2001. The Ultimate Phase service area of the GRSD surface supply grid is shown in Figure 12-2. In the remainder of the GRSD it is planned that groundwater be utilized as the primary source of supply.

During the Ultimate Phase the existing and Interim Phase groundwater supplies of the GRSD are placed on standby status; hence, the entire water demand of the Ultimate Phase service area of the GRSD is to be supplied from the Garden Reach waterworks. The average daily water demand of the Ultimate Phase service area of the GRSD includes 97 mgd for domestic use and 68 mgd for industry, totaling 165 mgd. The domestic demand is based on a per capita allowance of 50 gpd and the industrial demand on per acre allowances of 13,000 gpd, and 1,300 gpd for the industrial areas of population zones I and II respectively.

The water supply improvements for the Ultimate Phase service area of the GRSD are shown in Figure 12-2. In the Ultimate Phase it is planned that about 190 mgd (maximum daily demand) be drawn from the Garden Reach waterworks to supply the Ultimate Phase GRSD service area. The primary supply grid is to be strengthened by the addition of several parallel mains, and the grid is extended to serve the southeasterly portions of the GRSD. A third 5.0 mg reservoir is planned and three booster pump stations are proposed. It is planned to locate a booster station at each of the three reservoir sites (Figure 12-2).

Estimated Costs

The estimated costs of the Intermediate and Ultimate Phase surface water supply system improvements are tabulated below:

Intermediate Phase Improvements

	<u>Millions of Rs.</u>
(1) Primary grid, reservoirs, and booster stations	25.96
(2) Secondary grid	0.04
(3) Water treatment plant	17.16

Ultimate Phase Improvements

(1) Primary grid, reservoirs and booster stations	31.82
(2) Secondary grid	0.07
(3) Water treatment plant	27.44

Total 102.49

Note that the costs for the Intermediate Phase secondary grid do not include the costs for the Emergency Water Supply (Interim Phase) scheme.

CHAPTER 13 - SERAMPORE SERVICE DISTRICT

The general location of the Serampore Service District (SSD) is shown in Figure 9-3. The present population of the SSD is about

619,000 and is expected to increase to 894,000 by the year 1981 and to 1,499,000 by the year 2001. The estimates of the average daily water demands for the entire SSD for the existing situation and for the Interim, Intermediate, and Ultimate Phases are 21, 33, 44 and 97 mgd respectively.

Approximately 2.1 mgd of surface water is presently being supplied within the SSD (1.0 mgd from the Serampore waterworks, 0.7 mgd from the Hooghly-Chinsurah waterworks, and 0.4 mgd from the Uttarpara waterworks). Existing piped municipal groundwater supplies provide an additional 7.0 mgd; hence, the SSD presently receives a total piped supply of about 9.1 mgd.

Interim Phase

Interim Phase improvements are planned for all municipal and non-municipal urban areas within the SSD, and upon completion of this program it is anticipated that supplies in urban areas within the SSD will be at the rate of 20 gpd, with the exception of Chandernagore Corporation where this allowance is increased to 40 gpd. A tabulation of total existing plus Interim Phase supplies is presented in Table 13-1. The total average daily Interim Phase supply of the SSD is expected to be 17.2 mgd. It is proposed that well installations made during the Interim Phase, along with existing well water supplies, be maintained in service for the Intermediate Phase and placed on standby status in the Ultimate Phase. It is planned that the secondary distribution systems and elevated reservoirs constructed as a part of this phase be incorporated into the Intermediate and Ultimate Phase Master Plan surface supply grids.

Intermediate Phase

As of the beginning of the Intermediate Phase (1975) the Farakka Barrage is scheduled to be in operation, and it is proposed that surface water supplies be extended to those urban areas in the southern half of the SSD in which projected population densities exceed 25 ppa by the year 1981. The urban areas serviced by the proposed Master Plan surface supply grids during the Intermediate Phase are shown in Figure 31-1. Because of the existence of extensive aquifers at relatively shallow depths and the generally acceptable quality of the water found in these aquifers, large scale development of groundwater is practicable in the northern half of the SSD. Hence, it is proposed that for those areas in the SSD lying north of Baidyabati, local groundwater supplies be developed. Also it is proposed that groundwater supplies be developed in the less densely populated portions located on the westerly side of the southern sector of the SSD.

The average daily water demands from municipal surface supply systems for the Intermediate service area of the SSD include 19 mgd for domestic use and 6 mgd for industry, totaling 25 mgd. The domestic demand is based on a per capita allowance of 40 gpd. Industrial demands are based on allowances of 1,500 gpd for those industrial areas within population zone IX and 900 gpd for those areas within population zone X.

Approximately 8.0 mgd of the average daily demands of the Intermediate Phase will be met by existing and Interim Phase groundwater supplies; hence within the Intermediate Phase service area an additional average daily supply of 17 mgd must be provided by the proposed new surface supply system.

The proposed surface water system improvements for the Intermediate Phase service area of the SSD are shown in Figure 13-1. It is planned to locate the new Serampore waterworks in the southern part of Serampore Municipality just west of the Eastern Railway line. The capacity (maximum day) of the new Serampore waterworks is 20 mgd; however, it is recommended that sufficient land (about 150 acres) be acquired to construct a plant of Ultimate Phase capacity (78 mgd). The intake for the new Serampore waterworks is located in the vicinity of the old Howrah waterworks.

The proposed primary distribution grids for the SSD are fairly extensive (Figure 13-1). Because of the relatively short distances involved, the Intermediate Phase proposals do not include provisions for booster pumping. Two ground-level reservoirs are planned, each having a capacity of 2.5 mg. It is necessary to provide pumping facilities at each reservoir to lift the excess water required to meet peak hourly/fire flows from ground level storage to the gradient of the distribution system.

Ultimate Phase

During the Ultimate Phase it is proposed to extend the primary surface water supply grid to those areas of the SSD in which projected population densities exceed 25 pp/a by the year 2001. The Ultimate Phase service area of the SSD surface supply grid is shown in Figure 13-2. In the remainder of the SSD it is planned that groundwater be utilized as the primary source of supply.

During the Ultimate Phase the existing and Interim Phase groundwater supplies of the SSD are placed on standby status; hence, the entire water demand of the Ultimate Phase service area of the SSD is to be supplied from surface water sources. The average daily water demand of the Ultimate Phase service area of the SSD includes 47 mgd for domestic use and 19 mgd for industry, totaling 66 mgd. The domestic demand is based on a per capita allowance of 50 gcd and the industrial demand on per acre allowances of 4,000 gad and 1,500 gad for the industrial areas of population zones IX and X respectively.

The water supply improvements for the Ultimate Phase service area of the SSD are shown in Figure 15.2. It is proposed that the capacity of the new Serampore waterworks be increased to handle a maximum daily demand of 78 mgd. New intake facilities and a parallel 44-inch diameter feeder line are proposed. Also, the existing Intermediate Phase grids are strengthened by the addition of several parallel supply mains, and the supply grid is extended to serve the westerly portions of Uttarpara Police District. A second 2.5 mg ground level reservoir is to be added at both the Cripier Road and Bhagar Road sites. Thus each of the reservoir installations will have a total of 5.0 mg of ground level storage capacity.

Estimated Costs

The proposed improvements for the Intermediate and Ultimate Phase surface water supply systems make provision only for those portions of the SSD served by surface supply. The estimated construction costs are as follows:

Intermediate Phase

	<u>Estimated Millions of Rs.</u>
(1) Primary grid, reservoirs, and booster stations	13.23
(2) Secondary grid	70.96
(3) Water treatment plants	6.92

Ultimate Phase

(1) Primary grid, reservoirs, and booster stations	17.24
(2) Secondary grid	20.89
(3) Water treatment plants	<u>23.22</u>
Total	152.46

CHAPTER 14 - HOWRAH SERVICE DISTRICT

The general location of the Howrah Service District (HSD) is shown in Figure 9-3. The present population of the HSD is about 919,000 and is expected to increase to 1,532,000 by the year 1981 and to 2,585,000 by the year 2001. The estimates of the average daily water demands for the entire HSD for the existing situation and for the Interim, Intermediate, and Ultimate Phases are 47, 67, 86, and 184 mgd respectively. In addition, certain of the HSD transmission facilities and the new HSD treatment plant must be designed to include provisions for the supply of the new Port of Haldia. This provision is limited to the planning for a specific quantity of water at a time designated by the Government of West Bengal (CMPO).

Approximately 4.0 mgd of surface water is presently being supplied within the HSD from the existing Howrah Waterworks. Existing piped municipal groundwater supplies provide an additional 4.9 mgd; hence, the HSD presently receives a total piped supply of 8.9 mgd.

Interim Phase

Interim Phase water improvements are planned for all municipal and non-municipal urban areas within the HSD, and upon completion of this program it is anticipated that supplies in urban areas within the HSD will be at the rate of 20 gpd, with the exception of Howrah municipality where this allowance is increased to 50 gpd. A tabulation of total existing plus Interim Phase supplies is presented in Table 14-1. The total average daily Interim Phase supply is expected to be 39.3 mgd. It is proposed that well installations made during the Interim Phase, along with existing well water supplies, be maintained in service for the Intermediate Phase and placed on standby status in the Ultimate Phase. The secondary distribution systems and elevated reservoirs constructed as a part of this phase are to be incorporated into the Intermediate and Ultimate Phase Master Plan surface supply grids.

Intermediate Phase

As of the beginning of the Intermediate Phase (1975) the Farakka Barrage is scheduled to be in operation, and surface water supplies are to be extended to those urban areas in the HSD in which projected population densities exceed 25 ppa by the year 1981. The urban areas serviced by the proposed Master Plan surface supply grids during the Intermediate Phase are shown in Figure 14-1.

The average daily water demands from municipal surface supply systems for the Intermediate Phase service area of the HSD include 55 mgd for domestic use and 13 mgd for industry, totaling 68 mgd. The domestic demands are based on per capita allowances of 40 gpd. Industrial demands are based on allowances of 1,300 gpd for those industrial areas within population zone VII and 1,500 gpd for those areas within population zone VIII.

Approximately 37 mgd of the average daily demands of the Intermediate Phase will be met by existing and Interim Phase groundwater supplies; hence, within the Intermediate service area an additional average daily supply of 31 mgd must be provided by the proposed new surface supply system.

The proposed surface water system improvements for the Intermediate Phase service area of the HSD are shown in Figure 14-1. The proposed new Howrah waterworks, located in the vicinity of Paddapukur Jala, has an Intermediate Phase maximum daily capacity of 37 mgd. Although the Intermediate Phase capacity of the Howrah waterworks is only 37 mgd, it is recommended that sufficient land (about 500 acres) be obtained to construct a plant of Ultimate Phase capacity (265 mgd). It is planned that the southwesterly portion of the HSD be serviced by a single supply line extending from the new Howrah waterworks to Uluberia. Because of the length of this supply line two booster stations are planned. In the northeastern portion of the HSD (the Howrah and Bally municipal areas) a fairly extensive primary supply grid is planned. There is to be one ground level storage reservoir with appurtenant pump station, located in the vicinity of the intersection of Benaras Road and Grand Trunk Road.

Ultimate Phase

During the Ultimate Phase it is proposed to extend the primary surface water supply grid to those areas of the HSD in which projected population densities exceed 25 ppa by the year 2001. The Ultimate Phase service area of the HSD surface supply grid is shown in Figure 14-2. In the remainder of the HSD it is planned that groundwater be utilized as the primary source of supply. The existing and Interim Phase groundwater supplies are to be placed on standby status; hence, the entire water demand of the Ultimate Phase service area of the HSD is to be supplied from the new Howrah waterworks.

The average daily water demand of the Ultimate Phase service area of the HSD includes 134 mgd for domestic use plus 47 mgd for industry, totaling 181 mgd. The domestic demand is based on a per capita allowance

of 50 gcd, except for Howrah municipality where the allowance is increased to 60 gcd, and the industrial demand on per acre allowances of 2,400 gad and 3,000 gad for the industrial areas of population zones VII and VIII respectively.

In addition, provisions are made for transporting an average of 40 mgd from the New Howrah waterworks to the Port of Haldia located outside the CMD study area. The 40 mgd demand for Haldia Port will be required by about 1986. The provisions for Haldia Port are limited to 50 mgd capacity (maximum day) at the new Howrah waterworks and the provision of 50 mgd additional capacity in the supply line serving the southwestern portion of the HSD.

The water supply improvements for the Ultimate Phase service area of the HSD are shown in Figure 14-2. The capacity of the new Howrah Waterworks is increased to 265 mgd. A parallel supply line for the southwestern portion of the HSD, which also serves as the transmission line for furnishing the maximum daily flow of 50 mgd to the Port of Haldia, is proposed. Two 2.5-mgd ground-level storage reservoirs with appurtenant pump stations are planned for the southwestern area.

Also the northeastern area (Howrah/Bally) grid is strengthened by the addition of several parallel mains, and the grid is extended to service the Bally nonmunicipal urban area (Figure 14-2). Ultimate Phase proposals in the northeastern portion of the HSD include the provision of three groundlevel storage reservoirs. The details of the reservoirs and appurtenant pump stations are listed below:

<u>Reservoir Location</u>	<u>Storage Capacity (mg)</u>	<u>Pump Capacity and Head</u>	
		<u>Capacity(mgd)</u>	<u>Head(ft)</u>
Intersection of Makarda Rd. and Eastern Railway Line	5.0	8.2	136
Intersection of Banaras Rd. and Dasarath Ghosh Rd.	5.0	3.8	153
Panchanantola Rd., extension Bally Non-Municipal Urban Area	5.0	4.4	146

Estimated Costs

The estimated costs of the Intermediate and Ultimate Phase surface water supply system improvements are tabulated below:

Intermediate Phase Improvements

- (1) Primary grid, reservoirs, and booster stations
- (2) Secondary grid
- (3) Water treatment plants

Millions of Rs.

20.81
115.66
10.20

Ultimate Phase Improvements

- (1) Primary grid, reservoirs, and booster stations
- (2) Secondary grid
- (3) Water treatment plants

57.33
95.62
55.32

Total

354.94

PART III: SEWERAGE AND DRAINAGE

CHAPTER 15 - GENERAL CONSIDERATIONS

Investigations have been made into the adequacy of existing sewerage and drainage facilities, and methods have been devised whereby deficiencies can be eliminated. Because combined sewers are used in some portions of the CMD, and because of the close relationship between sewerage and drainage throughout the CMD, both subjects are presented in Part III of the report.

Description of Existing Facilities

Within the CMD, sewerage systems are in operation in Kalyani, Serampore, Bhatpara, Titagarh, and Calcutta, and works are under construction in Dum Dum and Maniktala. The Kalyani system is designed to collect, treat, and dispose of sewage from a population of 200,000 persons and to drain limited quantities of stormwater. The Serampore, Bhatpara, and Titagarh systems are relatively small. Parts of the Calcutta Corporation area are served by the Town System and the Suburban System where sewage and stormwater are drained to Palmersbridge and Ballygunge pumping stations, respectively, and then pumped to open channels leading to the Kulti River.

With minor exceptions, municipal sewerage systems do not exist in other areas, disposal being by means of cesspits and septic tanks. Generally, raw sewage is discharged to drainage ditches.

Except within areas served by the Calcutta combined systems, drainage is by means of ditches and canals, generally in an easterly direction to the Kulti River on the east Bank and directly or indirectly to the Hooghly River on the west Bank. Except for Kalyani, and under dry-weather conditions in parts of Calcutta, there is a widespread and urgent need for sewerage and drainage improvements throughout most of the CMD.

Comparison of Separate and Combined Systems

With the exception of the Calcutta system, all other existing systems are partly combined (i.e., they are designed to receive limited quantities of storm runoff). For reasons of economy and ease in the construction phasing, it is recommended that new systems be built on a separate basis. It is intended that the Town and Suburban Systems remain combined with the addition of suitable drainage relief measures, and that in general all partly combined systems be converted to separate systems. Partly combined systems are regarded as unsatisfactory under prevailing conditions in the CMD.

CHAPTER 16 - DESIGN CRITERIA AND ZONING

Sewerage Design

Design of facilities for the collection, treatment, and disposal of wastes is dictated primarily by the estimated loadings to be imposed upon them. In developing such estimates, it is necessary to determine on a unit basis both the flow or volume of waste and its strength and composition.

Waste Water Volumes: Waste water flows are made up of essentially three components, namely sanitary sewage, industrial waste, and infiltration consisting of subsurface water which enters a sewer system through joints and other openings and of storm water which enters through manhole openings and illicit drain connections. Because the major portion of infiltration or storm water inflow occurs during periods of prolonged precipitation, it is necessary to consider sewage volumes in terms of both dry weather and wet weather flows. Dry weather flow usually determines the normal loading to be imposed on treatment plants, whereas wet weather flow dictates the hydraulic capacity required for sewers, pumping stations, and force mains.

Data on unit sewage flows obtained from various sources indicate that per capita sewage quantities within India are between 70 and 90 per cent of per capita water supply. The quantity of sewage obtained from residential areas within the CMD is estimated to be 80 per cent of the per capita water allowances, which corresponds to conventional practice for metropolitan areas of this size.

Because of the varied nature (type and size) of the existing and anticipated future industries within the CMD, industrial waste flows are difficult to predict with any degree of accuracy and only general estimates of industrial contribution were made. It is desirable, for promotion of the metropolitan economy and welfare, that the public sewer system be capable of receiving all liquid industrial wastes which would otherwise create a health hazard or public nuisance. Certain types of industrial wastes, however, will require pre-treatment prior to being discharged to the public sewers, in order to provide proper protection to the sewerage system. The extent of such pre-treatment is indicated in the suggested Control Ordinance presented in Appendix 16-1.

In areas to be provided with separate sanitary sewers, it is neither necessary nor desirable that hydraulic capacity be provided in the sanitary sewers for all of the water consumed and wasted by industries. Sizable quantities of industrial water consumption are for cooling purposes and steam generation, and because the waste water from such processes is generally nonobjectionable, it can be discharged to ditches, storm drains, etc. Under such circumstances, it is expected that 50 per cent of the industrial water consumption will be discharged to the sewerage system. This value has been found in general to be a reasonable allowance for large industrial areas where suitable regulatory controls are applied. In areas served by combined sewers, it is expected that 80 per cent of the industrial water consumption will be discharged to the public sewers.

For areas with separate sewers, an infiltration allowance of 1,700 gad (gallons per acre per day) has been adopted. This figure was determined from a study of 16 sewered areas of Calcutta varying in size from 10 to 700 acres, where the total length of each size of sewer and house connection was determined and an infiltration allowance of 2,000

gallons per inch diameter of sewer per mile per day was assumed (corresponding to general practice elsewhere where groundwater is prevalent and sewers reasonably well constructed). It is recognized that, under existing conditions in the CMD, infiltration no doubt exceeds 1,700 gad, but it is anticipated that with time there will be improvements in sewer jointing practices, in regulatory control of illegal connections, etc., so that the 1,700 gad figure represents a sound basis for design. In certain cases (for example, where there are no lateral connections to a major sewer for a considerable distance along its length), an infiltration allowance based on gallons per acre cannot be appropriately applied. In such cases the infiltration allowance adopted was 2,000 gallons per inch of sewer diameter per mile per day.

The design of sewers is based on maximum rather than average flow, and the ratio of maximum to average flow varies according to location within the sewerage system, that is, on the extent of the tributary area from which sewage is being collected. For design purposes estimates were made of this "peaking factor" (rate of maximums to average flow), which varies in accordance with the tributary population, and this relationship is presented in Figure 16-1.

Studies of industrial plant operations within the CMD show that major industries operate on a three shift, 24-hour basis. For this reason it is not likely that the industrial peak and the domestic peak will coincide. The peaking factors presented in Figure 16-1 are therefore to be applied only to the domestic sewerage quantities. Thus, design flow equals peak domestic flow plus average industrial flow plus infiltration.

Waste Water Characteristics: The waste water of the CMD area will be derived from domestic sewage and industrial discharges. Thus, to estimate the future BOD and suspended solids loadings it is necessary to allow for contributions from new industries and from domestic users with higher living standards. Inasmuch as industries of various types will be located throughout the CMD, it is hardly possible to estimate the exact magnitude and nature of the industrial loadings. For purposes of this report loading factors were established on the basis of BOD and suspended solids concentrations reportedly used in actual designs throughout India, and on the basis of the recommendations by the CPHERI's headquarters in Nagpur. The design factors adopted for various stages of development are presented in Table 16-1.

The design concentrations of BOD and suspended solids adopted for the years 1981 and 2001 were taken at higher than existing values to allow for the expected increases in living standard and increased industrial loads on the municipal system. It is assumed that the concentration of BOD and suspended solids in industrial wastes is equal to that of domestic sewage.

Design Criteria: The Manning formula has been used for the solution of problems involving open-channel flow in sewers. The following values

of "n" (roughness coefficient) have been adopted for use with this formula, corresponding to field observations of existing sewers and anticipated future conditions: 0.012 for design of new concrete sewers over 60 inches diameter; 0.013 for design of new brick sewers, all sizes; 0.013 for design of new concrete sewers, 24 inch through 60 inch diameter; 0.015 for design of all new sewers under 24 inch diameter; 0.015 for analysis of existing sewers in average conditions; and 0.017 for analysis of existing sewers in poor condition.

All sewers have been designed on the basis of 100 per cent full-flow capacity (approximately 80 per cent of diameter for circular sewers). Smaller sewers were designed using the following minimum slopes:

<u>Diameter of Sewer</u> (inches)	<u>Minimum Slope</u>
8	0.004
10	0.0028
12	0.0022
15	0.0015
18	0.0012
21	0.0010
24	0.0008

For larger sewers, minimum slopes are such as to provide a velocity of 2 fps (feet per second) with a sewer flowing full, except that higher minimum velocities are used where necessary to inhibit the formation of hydrogen sulfide. Where sulfide problems are significant, good practice attempts to realize average velocities not less than 3 fps and preferably as high as 4 fps.

Storm Drainage Design

Rational Method: The rational method has been adopted as the basis for estimating storm water runoff for the urban areas of the CMD. The rational method translates rainfall into runoff by the formula $Q = CiA$, in which A is the drainage area in acres tributary to the point under design; i is the average rainfall intensity, in inches per hour, for the period of maximum rainfall of the design storm frequency having a duration equal to the time of concentration; C is a runoff coefficient which expresses the ratio between the maximum rate of rainfall and average rainfall intensity; and Q is the maximum rate of runoff in cubic feet per second.

The two-month storm frequency has been adopted as the basis for estimating maximum runoff rates for the design of separate drainage and combined sewerage facilities for the urban areas of the CMD. The degree of protection for urban areas is based on reducing the present frequent serious flooding conditions (about 15 serious floods per year) to a level of perhaps one-fourth as much, and also, so that when floods do occur, the residual effects will be of brief duration rather than prolonged as at present. A family of curves, which show the relationship between maximum runoff from the design two-month

frequency storm, and the time of concentration, for different percentages of roofs and pavements, is presented in Figure 16-2.

Design Criteria: As with separate sewers, the Manning formula has been utilized for the solution of problems involving open channel flow in storm drains. The "n" (roughness coefficient) values selected for use with this formula, for the design and analysis of pipes or other closed type storm drain conduits, are the same as for separate sewers. The "n" values selected for use for design and analysis of open channels (for clean channels) are as follows: 0.025 for unlined open channels; 0.015 for channels with brick sides and concrete bottom; and 0.017 for brick lined channels.

All pipe storm drains are designed on the basis of 100 per cent full-flow capacity (approximately 80 per cent of the diameter for circular sewers). Box conduits are designed with the maximum water surface elevation 12 inches below the top slab. Insofar as possible underground storm drains are designed with invert slopes resulting in a flow velocity at full depth of not less than about 2.5 feet per second (fps). Because it is comparatively inexpensive to remove silt deposits from open channels, these may be installed at flatter slopes. In general, open channels of earth are designed with slopes which will result in velocities not exceeding about 2.5 fps.

Design Periods

The following criteria are considered generally applicable in the CMD with respect to useful life of facilities:

Land requirements for treatment plants, pumping stations, etc.	40 years
Outfall structures containing subaqueous features	40 years
Structures such as major pumping stations	40 years
Mechanical and electrical equipment within pumping stations	15 years
Major elements of sewage treatment plants	15 years
Trunk sewers and drains	40 years
Secondary sewers and drains	40 years

Proposed Sewerage of CMD

Within the CMD the salient factors which govern the number of feasible independent sewerage systems, or the service zones, are population concentrations, topography, location of existing facilities or existing service zones (such as the Calcutta Corporation area), location of suitable points for final effluent disposal, and requirements for treatment. Upon consideration of these factors, the CMD has been divided into sewerage zones as follows (Figure 16-3):

Calcutta	Kalyani
Tollygunge	Bansberia
Dum Dum	Konnagar
Howrah	Garden Reach
Chandernagore	Budge Budge
Barasat	Rajpur
Khardah	Maniktala
Barrackpore	Northern Salt Lake
Bhatpara	Serampore

In addition, future zones are indicated in the extreme southwest of the CMD.

Delineation of sewerage zones has been limited to the urban areas of CMD because these areas are more highly and densely developed, have fairly well established road and street patterns, and also, represent those areas where sufficient topographical data is available to establish zonal limits. However, where applicable, service zones have been set up so that as new areas develop in proximity to an original service zone, the zone can be expanded into a larger unit.

Master Plan sewerage proposals are presented in varying degrees of detail according to the estimated urgency of need for improvement, and where the physical layout of urban development is such that rational systems can be planned. Subsequently presented proposals cover the following zones:

Calcutta	Tollygunge
Dum Dum	Howrah
Chandernagore	Khardah
Konnagar	Garden Reach
Maniktala	Northern Salt Lake

The above zones contain more than 75 per cent of the present population of the CMD and nearly 70 per cent of the estimated population by the year 2001.

Proposed Drainage of CMD

Master plan drainage proposals for the CMD are based upon recommendations presented in the Greater Calcutta Master Drainage Plan of 1953 for East Bank areas, and upon proposals by the Hooghly Division of the Irrigation & Waterways Department for the West Bank. As revised by the EC, the CMD is divided into separate drainage basins as follows (Figure 16-4):

Tollygunge-Panchannagram	Maniktala
Northern Salt Lake	Calcutta
Howrah	Bagjola
Konnagar	Khardah
Manikhali	Tolly's Nullah
Churial	Kaorapukur
Magrahat	Sonarpur Arapanch
Southern Salt Lake	Boinchita
Sunti	Ichapur
Nawi	Bager Khal
Rajapur	Barajala
Northwest Riparian	

Because in most metropolitan areas provision of waterworks and sanitary sewerage provide a large measure of over-all health protection, drainage works are generally assigned a lower priority. For certain areas in Metropolitan Calcutta, however, because the natural drainage is poor, the close relationship between drainage and public health is clearly evident in that, during the monsoon, frequent flooding results in promiscuous spreading of fecal matter. In a number of instances, therefore, specific drainage projects have in effect the same level of importance as sewerage projects. In those basins in which such conditions

are judged to apply, detailed Master Plan studies have been undertaken and are described subsequently. The basins so selected are listed as follows:

Tollygunge	Maniktala
Northern Salt Lake	Calcutta
Howrah	Bagjola
Konnagar	Khardah
Manikhali	Tolly's Nullah

CHAPTER 17 - TREATMENT AND DISPOSAL CRITERIA

One of the basic requirements in the planning of any sewerage system is that of providing safe, effective, and innocuous methods for disposal of the wastes collected. This chapter assesses the various factors governing the disposal of waste effluents in the CMD; establishes reasonable effluent quality criteria for the various waste discharges; and determines the degrees of treatment and necessary to meet these criteria.

Presently the Kulti River and, to a lesser extent, the Hooghly River, serve as the receiving bodies for the water-borne wastes of the CMD and it is anticipated that in the future both the Hooghly and the Kulti Rivers will continue to serve as the primary means for dispersion and assimilation of the CMD wastes. The primary factors considered in the disposal of wastes by dilution in these surface waters are as follows:

- (1) The quality levels which must be maintained to protect the various beneficial uses of the receiving waters, such as drinking water supply, industrial water supply, and agricultural uses.
- (2) The volume and strength of the wastes to be discharged.
- (3) The capacity of the receiving waters to handle the wastes, which in turn is based on the quality and quantity of the receiving water available for diluting and absorbing the waste effluents.

A breakdown of the quantities of waste water effluents to be discharged to the Hooghly River (including its tributaries) and to the Kulti River is presented in Table 17-1, based on the assumption that the entire population of the CMD is to be sewered (both at present and for ultimate conditions).

A summary of characteristics of sanitary sewage in the CMD is presented in Table 24-2, which are comparable to the characteristics of sewage of essentially domestic origin. In addition to adding organic waste materials, domestic use of water adds dissolved mineral salts, the increment being about 300 ppm. Thus, the concentration of salts in the sewage will be somewhat greater than in the water supply, but the salt additions derived from domestic use are not normally enough to significantly impair the water for domestic reuse. In general, experience has shown that significant concentrations of toxic materials of a type hazardous to public water supplies, e.g., heavy metals and radioactive materials, are not found in sewage from domestic sources. Domestic sewages, however, may contain biological pathogens including bacteria and viruses. The strength of industrial waste waters varies widely from industry to

to industry and with changing manufacturing procedures within the same industry. Hence, it is not feasible to attempt to assign definite values to the characteristics of industrial wastes to be produced in the CMD.

As previously noted, the industrial waste problem is best handled by control of discharges on an industry-by-industry basis, and a recommended ordinance is presented in Appendix 16-1. Control of industrial discharges to the CMD sewers is essential for the following reasons: (1) To protect the system pipelines from damage which might be caused by acid corrosion, explosions of volatile substances, or deposits of solids and grease; (2) to prevent disturbance of treatment processes which might be caused by shock loads or substances toxic to biological treatment units; and (3) to prevent the deterioration of the receiving waters for reuse through the addition of undesirable substances such as brines, boron, or heavy metals.

Dry weather flows in the Hooghly now average from 1,000 to 2,000 cfs and for purposes of treatment and disposal considerations the present dry weather flow was assumed to be 1,000 cfs. The dry weather flow period extends for about five months from mid-January to mid-June. After completion of the Farakka Barrage minimum flows in the river will average 20,000 cfs, and the dry weather period will last two months from mid-March to Mid-May. At present, because of the salinization problem, the quality of the Hooghly River during the dry weather period varies with geographic location along the river. Pertinent quality data at two locations, Garden Reach (brackish water zone) and Bhatpara (fresh water zone), are presented in Table 17-4. After completion of the Farakka Barrage the quantity of the Hooghly River will stabilize throughout the CMD area reach. Anticipated future water characteristics of the river are presented in Table 17-5. Because the primary use of the Kulti River sewage outfall channel is compatible with a wide range of water quality with few restrictions, detailed data on characteristics of this river have not been presented.

In establishing waste disposal criteria consideration must be given to the effects of waste effluents on the receiving waters, taking into account all the various public health and economic values associated with the receiving waters. The more usual criteria may be summarized according to the types of effects, such as effects on public health, on conservation of wildlife and of natural resources, on aesthetics, and on economic resources. Of the many and varied beneficial uses of the Hooghly River, three are of major economic importance to the CMD area, namely, domestic water supply, industrial water supply, and navigational uses. Domestic use is generally conceded to be the highest and most essential use and therefore afforded the highest sanitary protection; thus, disposal criteria fixed for the Hooghly River will be based on the requirement to protect this river as a source of raw water for domestic purposes.

Recognizing the fact that the waters of the Hooghly River will require filtration and chlorination before use for domestic purposes, the following

water quality objectives were established as a guide to waste disposal to the Hooghly River:

- (1) Floating, Suspended, and Settleable Solids: None attributable to sewage, industrial wastes or other wastes or which after reasonable dilution and mixing with the river water will not impair its waters as a domestic raw water source.
- (2) Taste and Odor Producing Substances: None attributable to sewage, industrial wastes, or other wastes.
- (3) Dissolved Non-toxic Mineral Substances: None alone or in combination with other substances in sufficient amounts or of such nature as to make the water unsuitable as a domestic source.
- (4) Dissolved Oxygen: Greater than or equal to 4.0 ppm.
- (5) Hydrogen Ion Concentration: Hydrogen ion concentration expressed as pH should be maintained between 6.5 and 8.5.
- (6) Toxic or Other Deleterious Substances: None alone or in combination with other substances or wastes in sufficient amounts to make the river waters unsafe for human consumption (WHO International Standards).
- (7) Phenolic Compounds: Less than five parts per billion.
- (8) High Temperature Wastes: Not in sufficient quantities alone or in combination with other wastes to impair the river water for domestic use.

The Kulti River outfall channel was built with the expressed objective of protecting the waters of the Hooghly River from contamination, and has already proven its value as a waste outfall channel. Present arrangements for disposal of untreated wastes in the Kulti River are considered satisfactory and should be continued. Inasmuch as the Kulti River outfall system flows through relatively undeveloped rural areas, there is little probability in the foreseeable future that significant health hazards or nuisance conditions will develop. If, in the future, increased activity in the area surrounding the waste discharge channels results in the formation of health hazards or nuisances, or should deposits of sewage solids prove uneconomical to remove during routine channel maintenance, the quality of the waste discharges can then be upgraded through primary treatment.

Data obtained from tests during the study period and from recorded information show the MPN of coliforms in the Hooghly River range from 43,000 to 1,500,000 organisms per 100 ml. The MPN of raw sewage varies from 15,000,000 to 20,000,000 organisms per 100 ml, which is only about 10 times greater than that of the Hooghly. This difference, of only one order of magnitude, does not represent a significant increase in health hazard; hence, in general elaborate waste disinfection procedures do not appear to be warranted. However in certain cases, for example where a waste discharge point is relatively close to waterworks intake, e.g., the Howrah area, chlorination may be necessary. Situations of this type must be evaluated on a "case" basis.

Under ultimate conditions it is estimated that the raw waste organic load collected by the CMD sewerage systems will total 1,650,000 lb of oxygen per day, of which 324,000 lb can be absorbed by the river.

The remaining 1,331,000 lb, or 80 per cent of the total load, must be removed by appropriate treatment processes. Thus waste effluent discharged into the river should have BOD's not in excess of 60 ppm. Under present conditions, assuming the entire population is sewered, the total organic load discharged into the Hooghly is equivalent to 146,000 lb of oxygen per day. Assuming reasonable reaeration values the Hooghly River should have about 115,000 lb of dissolved oxygen available to absorb organic loadings during periods of minimum flow. The remaining 41,000 lb or about 30 per cent of the total must be removed by appropriate treatment. It is obvious that for the ultimate situation (period ending 2001) complete treatment would have to be provided in order to produce an effluent suitable for discharge into the Hooghly River or its tributaries. In the present stage, sewage treatment can be limited to primary sedimentation.

Despite the importance of the watercourses within the CMD area, particularly the Hooghly River, to the area's growth and economy, it should be noted that the CMD area is last among the many users of the water resources of these rivers; hence unless some basin-wide regulations are established, the CMD may find it increasingly more difficult and costly to use the Hooghly River as a water source and for disposal of wastes. In addition to controlling waste discharges within the CMD, the CMD officials should promote the establishment of a regional authority for focusing on problems of basin wide pollution control.

To control the various factors which may affect the river's ability to function effectively as a source of water supply, as a place of disposal, and as a port facility will necessitate the continuous surveillance of river characteristics. A comprehensive undertaking of this sort will require a coordinated program of sampling, testing, and analysis, which will involve setting up and operating a series of sampling stations up and down the river, the formulation of sampling procedures and frequencies, the determination of the qualitative and quantitative data required, establishment of standard analytical procedures, and finally the analysis, preparation, and dissemination of the test results. Two agencies in the CMD area, the AIHPH and the CPHERI, are particularly qualified to assist in implementing such a program.

CHAPTER 18 - CALCUTTA COMBINED SYSTEM

The Calcutta Combined System serves the only area within the CMD containing a truly combined sewerage system, which is located within the westerly portions of the Calcutta Corporation. This system, shown in Figure 18-2, consists essentially of two subsystems, namely, the Town System serving densely populated and highly developed residential and commercial areas in northwest Calcutta, and the Suburban System serving developed residential areas containing some commercial sections in southwest Calcutta.

Existing Facilities

Suburban System: The general arrangement of the Suburban System consists of combined trunk sewers discharging in an easterly or south-easterly direction to a major pumping station at Ballygunge. From this point, sewage is lifted to two high-level gravity sewers leading to Topsia Point A and thence to the Kulti River. Stormwater is pumped at this station to the Calcutta Corporation stormwater channel which connects to other such channels leading to the Kulti River. It is reported that this system was designed to accommodate 1/6 inch per hour of rainfall at 100 per cent runoff. Field inspections disclosed that existing combined trunk sewers are generally in a satisfactory physical condition, although routine maintenance and minor repair work is required. The Ballygunge pumping station is in need of a major overhaul including replacement of existing pumping equipment.

The major deficiency of the system is its inability to prevent sustained flooding during the monsoon season. In view of the pattern of rainfall intensities prevailing in the area, and the present and future extent of urbanization, design criteria used to develop this system are grossly inadequate with the consequence that substantial stormwater relief measures are urgently required. Flooding results primarily because of an insufficient number of street inlets, gross hydraulic inadequacy of lateral sewers, and substantial hydraulic inadequacy of trunk sewers.

Town System: The Calcutta Town System is a combined sewerage and drainage system of which the principal elements are trunk sewers discharging by gravity in an easterly direction from relatively high ground in the immediate vicinity of the Hooghly River to a system of intercepting trunk sewers located east of Upper and Lower Circular Roads. These intercepting sewers discharge to Palmersbridge pumping station, whence sewage is pumped to two high-level sewers discharging at Topsia Point A. Stormwater is lifted at Palmersbridge pumping station to the Calcutta Corporation stormwater channel. It is reported that stormwater capacity for the Town System is based on a design criteria of 1/4 inch per hour of rainfall at 100 per cent runoff. Subsequent Master Plan investigations show that these criteria are not always met.

The physical condition of the Town System is less satisfactory than that of the Suburban System and extensive renovation is urgently required for the major trunk sewers, together with major reconstruction of minor sewers to provide a substantial increase in hydraulic capacity. The Palmersbridge pumping facility consists of two separate pumping stations, namely, a dry-weather flow station and a stormwater pumping station. The dry-weather flow station is in urgent need of rehabilitation, including replacement of much of the existing equipment.

Deposition of silt from the unfiltered water distribution system constitutes an operating problem in the Town System (and to a lesser extent in the Suburban System), although improved maintenance procedures would go a long way toward solving this problem. Operational deficiencies are

generally as listed for the Suburban System.

Master Plan Proposed Improvements

Detailed analyses of each major trunk sewer shows in general that the system is adequate under dry-weather flow conditions. Proposed improvements (Figure 18-7) consist of a series of stormwater relief measures by means of overflow structures to be built to existing sewers, separate relief drains and pumping stations or a combination of the two. The principal proposed improvements are listed as follows:

- (1) Renovate all existing trunk sewers.
- (2) Reorganize and modernize sewer maintenance procedures.
- (3) Design and construct secondary drainage systems for areas served by proposed trunk drains.
- (4) Design and construct secondary combined sewers for areas to be served by existing and combined trunk sewers.
- (5) Replace existing combined sewer in Tollygunge Road.
- (6) Construct proposed combined sewer in Park Street.
- (7) Construct proposed relief sewer in CIT Road
- (8) Convert Tiljala Road sewer to a separate sewer.
- (9) Design and construct secondary drains for the Diamond Harbour Road trunk drain.
- (10) Construct proposed drains in Bhukailash Road, Alipore Road, Belvedere Road, Chetla Hat Road and Chetla Central Road.
- (11) Construct proposed drains in Dhakuria Lakes area, Manohar Pukur Road, Ramesh Mitter Road, Debendra Ghosh Road, and Gariahat Road.
- (12) Rehabilitate Ballygunge Pumping Station and high-level sewers.
- (13) Construct South Suburban proposed drains in Taratala Road, Gargacha Road, Diamond Harbour Road, Budge Budge Road, Biren Ray Road, Barashivtala Road, A.C. Ray Road, and Nalini Ranjan Avenue.
- (14) Relieve the Lower Circular Road trunk sewer by constructing a 75 cfs relief pumping station at Camac Street and a 30 cfs overflow structure at Elliot Road. Detach Upper Park Street trunk sewer from the Lower Circular Road System.
- (15) Replace existing sewers in Elliot Road, Ripon Street, and European Asylum Lane.
- (16) Divert 60 cfs from Dharamtala Street trunk sewers.
- (17) Divert 100 cfs from Bepin Behary Ganguly trunk sewer. Replace upper reaches.
- (18) Divert 90 cfs at Lower Chitpur Road and 90 cfs at Chittaranjan Avenue from Kolutala trunk sewer.
- (19) Construct relief drains in Chittaranjan Avenue, Kolutala Street, Bepin Behary Ganguly Street, Bentinck Street, S.N. Bannerjee Road, Chowringhee Road, Sudder Street, Ochterlony Road, and Auckland Road. Construct proposed pumping station at Auckland Road with a capacity of 560 cfs.
- (20) Replace existing sewer in Keshab Sen Street, and construct proposed 340 cfs pumping station and acnillary works.
- (21) Replace existing sewer in Kailas Bose Street and connect to the Upper Circular Road System.
- (22) Divert 120 cfs from the Beadon Street trunk sewer.
- (23) Divert 90 cfs from the Grey Street trunk sewer.

- (24) Construct relief drains in Grey Street, Chittaranjan Avenue, and Vivekananda Road. Construct Tagore pumping station with a capacity of 310 cfs.
- (25) Replace existing sewer in Bhupendra Bose Avenue.
- (26) Replace existing sewer in Raja Dinendra Street, construct 72-inch force main, and renovate the Maniktala pumping station to a total capacity of 193 cfs.
- (27) Construct bulkhead in Upper Circular Road sewer.
- (28) Replace existing sewer in Baghbazar Street, construct relief sewer in Upper Circular Road, and construct connection between Upper Circular Road and Canal West Road.
- (29) Rehabilitate Palmersbridge pumping station and high level sewers.
- (30) As conditions become appropriate, improve Tolly's Nullah and construct future Tolly's Nullah outfall pumping station. Or, as a less desirable alternative to the Tolly's Nullah outfall pumping station, construct such future pumping stations along the banks of Tolly's Nullah and the Chetla Boat Canal as may be required.

Construction Costs

The estimated construction costs for the proposed works are Rs. 21.42 million.

CHAPTER 19 - SEPARATE SEWERAGE SYSTEMS

Tollygunge Zone

The Tollygunge Zone (Zone 2) is located to the southeast of Calcutta and consists of nearly 7,000 acres containing a present population (1961 census) of 364,000 persons and an estimated population of about 670,000 persons by the year 2001. For sewerage purposes, the zone is divided into three subdivisions, namely, Tollygunge, South Panchannagram, and North Panchannagram. Tollygunge is a rapidly developing residential suburb and both Panchannagram areas are expected to develop a similar manner at a later date following completion of better roads and drainage facilities. With minor exceptions, the entire zone is presently unsewered and the urgent need for sewerage is widely recognized by local authorities. In Tollygunge, the CMPO has prepared a more detailed sewerage report, based on Master Plan proposals and this report has been approved by appropriate central authorities in New Delhi. Detailed surveys and preparation of design and contract documents are currently in progress.

Master Plan proposals are shown on Figure 19-2. A suitable network of roads exists in Tollygunge such that Master Plan trunk sewer proposals can be developed. These sewers have been located in major roads most of which are scheduled for early improvement by the CIT and it is intended that the sewerage and road works shall be closely coordinated during construction. With the exception of the proposed Netaji Subhas pumping station, serving a low-lying pocket, and the proposed Prince Anwar Shah pumping station which acts as a lift station, the entire Tollygunge area can be seweraged by gravity from high ground in the south and west to the proposed Tollygunge pumping station located near the northerly limits of the subdivision.

From this point, it is intended that sewage be pumped to the Panchannagram Canal which is a drainage channel discharging to the Calcutta Corporation storm water channel and eventually to the Kulti River.

A Master Plan layout of trunk sewers was not developed for the South Panchannagram subdivision because much of the area is presently rural in character, the existing road network is inadequate to serve anticipated needs, and suitable road layout plans have yet to be approved. Master Plan studies were confined to a determination of suitable sewerage boundaries for the area together with initial studies establishing the fact that the area is best served (largely by gravity) by a proposed pumping station at the southeast boundary.

Similar Master Plan procedures were adopted, for similar reasons, in the North Panchannagram subdivision. In this case it would appear desirable to sewer the area by gravity to a proposed centrally located pumping station whence sewage can be pumped initially to the Calcutta Corporation storm water channel, and under possible future conditions to a treatment plant at Topsia Point A. Treatment of sewage from the Tollygunge Zone is considered of secondary importance as compared to the urgent need to remove sewage from densely populated areas. Public health hazards should not occur if raw sewage from Tollygunge and South Panchannagram is pumped directly to the Panchannagram Canal, and from North Panchannagram directly to the Calcutta Corporation storm water channel. At a future date, treatment facilities can be constructed at either or both of the two treatment plant sites, should the need for treatment arise. In discussing the above with the CMPO and other local authorities, the intention was expressed of providing nominal sewage treatment facilities at the Tollygunge site.

Estimated costs are given as follows:

	Rs.
(a) Tollygunge Proposed Master Plan Facilities	5,830,000
(b) Tollygunge Secondary Facilities	<u>37,700,000</u>
Subtotal	43,530,000
(a) South Panchannagram Proposed Master Plan Facilities	3,320,000
(b) South Panchannagram Secondary Facilities	<u>10,030,000</u>
Subtotal	13,350,000
(a) North Panchannagram Proposed Master Plan Facilities	4,200,000
(b) North Panchannagram Secondary Facilities	<u>11,090,000</u>
Subtotal	15,290,000
Tollygunge and South Panchannagram Future Primary Treatment Plant	10,800,000

Maniktala Zone

The Maniktala Zone is located within Sewerage Zone 1 and consists of an industrial suburb containing medium and low value housing. The area is more than 2,000 acres with a population of 255,600 persons (1961 census), which is estimated to increase to 314,000 by the year 2001. Sewerage and drainage is principally by means of an obsolete system of open ditches leading to Ultadanga, Maniktala, Narikeldanga, and Beliaghata pumping stations discharging to adjacent salt marshes, which are now

being filled and developed as a new township. In 1956 the CIT prepared a report for a replacement combined system which is presently under construction. Figure 19-3 shows existing facilities.

CIT trunk sewers discharge sewage and stormwater to a lift station at Dhapa Lock which in turn pumps to the Central Lake Channel leading to the Calcutta Corporation outfall channel. This partly-combined system is presently inadequate to serve the area, with the result that stormwater and sewage remain in ditches and depressions, and flooding is frequent. Furthermore, a detailed Master Plan analysis of the CIT combined system proposals shows that this system, in its completed form, would provide substantially less than the minimum recommended drainage protection. It should also be noted that of the four pumping stations served by open ditch systems, only Narikeldanga is fully operative. From the above, it can be seen that sewerage and drainage of Maniktala is generally unsatisfactory.

After due consideration of various alternatives, it was considered desirable to convert the Maniktala Subzone to a separate system by incorporating recently constructed facilities into a Master Plan sewage layout as shown on Figure 19-8. It is recommended that, upon completion of these facilities, the original four pumping stations and open ditch system be abandoned.

Master Plan proposals include construction of a new lift station at Ultadanga serving North Maniktala, which will pump to a High Level Sewer. This sewer will also receive sewage from part of the proposed Salt Lake Township and will discharge to an existing 13'3" x 14'0" conduit. The southerly area of Maniktala will be served by gravity. All sewage will be pumped into the Central Lake Channel at Dhapa. At such times as discharge of raw sewage to the Central Lake Channel becomes a hazard to public health, Dhapa Lock Pumping Station will pump to a future treatment plant to be located at Topsia Point A.

The estimated costs of facilities, as shown in Figure 19-8, are as follows:

	<u>Rs.</u>
Master Plan Proposed Facilities	2,650,000
Future Force Main or High Level Sewer	660,000
Secondary Facilities	<u>11,500,000</u>
Total	14,810,000

Northern Salt Lake Zone

The zone is located within Sewerage Zone 3 and consists of a presently unpopulated but reclaimed salt marsh scheduled for development primarily as a residential area, but also including areas set aside for institutions and industry in accordance with a town plan prepared by Messrs. Invest-Import. The initial development area is 3.75 sq miles divided into three sectors, to be followed by a similar additional 2 sq mile area at a later date.

Master Plan studies include a detailed analysis of Invest-Import sewerage proposals, which resulted in retaining their proposals in general for Sector I, except for alterations in grade and sizes of trunk sewers (to eliminate lift stations) and treatment of sewage at the Bagjola Sewage Treatment Plant, thereby eliminating a small Sector I proposed plant. Master Plan proposals are shown on Figure 19-13.

Master Plan recommendations for Sectors II and III are also shown on Figure 19-13 and are substantially different from the earlier Invest-Import proposals. Sewage from Sector II (and part of Sector III) will be treated at Bagjola. The remainder of Sector III will be served by trunk sewers to the Maniktala High Level Sewer, thence to Dhapa Lock Pumping Station (See Maniktala Zone) and finally to a system of sewage outfall channels serving the Calcutta Zone. Proposals include eventual treatment of all sewage pumped at Dhapa Lock (see Maniktala Zone). The studies include estimates of population, sewage quantities, and sewage costs for the additional two sq mile area.

Construction costs are estimated as follows:

	<u>Rs.</u>
Sector I Master Plan Proposals	1,475,400
Sector II and Sector III (part only) Master Plan Proposals	749,700
Sector III (remainder) Master Plan Proposals	<u>692,900</u>
Sector I, II and III Total Master Plan	2,918,000
Sector I, II and III Secondary Facilities	<u>14,500,000</u>
Sector I, II, and III Total Facilities	17,418,000

For the additional two sq mile development area construction costs are estimated as follows:

	<u>Rs.</u>
Estimated Master Plan Proposals	1,547,000
Secondary Facilities	<u>7,680,000</u>
Total	9,227,000

Howrah Zone

The Howrah study area forms a part of the Howrah Sewerage Zone, as indicated on Figure 19-1, and consists of the Howrah and Bally municipal areas, the Bally non-municipal urban area, and portions of the rural area in the Jagacha Thana. The Howrah study area comprises about 10,400 acres located on the west bank of the Hooghly River due west of Calcutta. The Howrah area is the most important metropolitan unit on the West Bank of the Hooghly River and stands second in the CMD, being subordinate only to the dominance of Calcutta. The area is industrially oriented and is the most important rail and road transport terminus within the CMD. The present population of the Howrah study area is about 649,000. By 1981 this population is expected to grow to 891,000 and the predicted population in the year 2001 for the Howrah area is 1,200,000.

At present there are no underground sewers in the Howrah area and waste water flows are carried to various discharge points by open drains.

In 1962, the HIT (Howrah Improvement Trust) prepared a comprehensive sewerage plan for the Howrah Municipal Area. The general features, sewer alignments, sewer sizes, and service areas of the HIT proposals are shown in Figure 19-16. Sewers were designed on the basis of a partially separate (combined) system using the following data.

- (a) 50 gallons per capita per day average sewage contribution.
- (b) Maximum sewage flow of 6 times dry weather flow which includes allowance for future increase in flow, infiltration, and runoff from streets in the central areas.

The HIT proposals included provisions for secondary treatment (high rate trickling filters) for an average dry weather flow of 10 mgd. Flows up to three times dry weather flow would receive primary treatment and flows in excess of three times would be diverted to the Howrah drainage channel (which drains into the Hooghly River) during the monsoon.

After detailed review of the HIT proposals the following conclusions were developed:

- (a) Because the Howrah Zone (Figure 16-3), which has been designated as the new Howrah Corporation by the CMPO's Land Planning Section, is a more comprehensive planning unit than the Howrah Municipality, certain of the basic design concepts and design features adopted in the HIT scheme are no longer applicable.
- (b) Because of the change in concept from a partially separate to a completely separate sewerage system for Howrah, certain of the basic design criteria adopted by HIT are no longer valid and must be modified.
- (c) Considering the original scope and design concepts used by HIT, the Howrah sewerage scheme was basically sound and well engineered. To satisfy criteria and concepts presented herein, certain changes to the original HIT proposals are necessary. The location of the sewerage treatment plant and of the majority of main trunk sewers can remain as proposed by HIT. However, changes in project scope and up-dating of design criteria will require certain adjustments in sewer location, pipe size, slopes, and elevations.

The quantities of domestic sewage and industrial waste flow have been estimated to be 80 per cent and 50 per cent of their respective water supply allowances. Estimates of total (industrial plus domestic) average daily waste flow, at 10 year intervals from the year 1961 to 2001, for the Howrah Study Area are presented in Table 19-7.

Two alternative sewerage plans were prepared for the Howrah study area, designated A and B, shown in Figures 19-20 and 19-21 respectively. The estimated cost of facilities proposed in Alternate A is approximately Rs. 15,700,000 and for Alternate B about Rs. 16,400,000. Thus, on the basis of the first costs, Alternate A appears to be the better of the two alternatives. However, the total difference in cost amounts to less than five per cent, which is beyond the limit of accuracy for the estimates; hence, for all practical purposes the two plans are equal as far as costs for the two plans are nearly equal; thus, with no significant difference in either the construction or operation and maintenance costs, either Alternate A or B could be recommended for

acceptance. However, the Alternate B proposals possess one intangible advantage in that independent trunk sewer facilities are provided for Subzones 3 and 4. Thus immediate service for the densely populated areas of Subzone 3 (Bally Municipality and Aalkia) can more readily be provided in the early stages of construction without typing up large amounts of capital in joint Subzone 3/Subzone 4 facilities, i.e., in trunk line D (Figure 19-21), which may not be fully utilized for a relatively long period of time. Therefore Alternate B is considered to be the more acceptable and is recommended.

It is proposed that waste waters from the Howrah area be discharged into the existing Howrah drainage channel for ultimate disposal into the Hooghly River. To protect the Hooghly River as a water supply source and to prevent the development of objectionable conditions in the lower reaches of the Howrah drainage channel, the long range sewerage plan for Howrah must include provisions for complete sewage treatment including chlorination of the treated effluent. The ultimate phase treatment plant would be comprised of the following main process units:

- Grit Chambers.
- Primary Sedimentation Tanks
- High Rate Biological Treatment Units
- Secondary Sedimentation Tanks
- Effluent Chlorination Units
- Sludge Digesters
- Sludge Drying Facilities

Based on ultimate conditions in the Howrah Zone (study area plus zonal extensions), the treatment plant's average capacity would be about 85 mgd. Therefore, provision for sufficient land (about 90 acres) to construct a 85 mgd facility should be made at the Howrah plant site.

At present, complete sewage treatment in the Howrah area is not considered of primary importance and should await the construction of sewers, sewage pump stations, and other sewerage appurtenances. In the initial stage, sewage treatment in the Howrah Zone can be limited to primary sedimentation with provisions for disinfection of the primary effluent. This type of facility would produce, during the initial low flow period, an effluent of suitable quality for discharge in the drainage channel and subsequent disposal in the river. However, it is essential that provision of complete treatment in Howrah be coordinated with the construction of the waterworks at Garden Reach and Howrah so that secondary sewage treatment units are in operation before withdrawals for drinking water purposes are made from the Hooghly River.

In the Howrah area construction of the treatment plant in four stages is considered. As a part of first stage construction in primary facility having a 10 mgd capacity is recommended. Second stage construction (about 1975) would require the addition of secondary treatment units and an increase in plant capacity to 25 mgd. In the third stage (about 1985) the plant capacity increases to 50 mgd and in the fourth stage to the ultimate capacity, 85 mgd.

Estimated cost of the Master Plan sewerage improvements are as follows:

<u>Unit Description</u>	<u>Millions of Rs.</u>
Sub-zone 1	
(a) Master Plan Sewerage Facilities	2.84
(b) Secondary Sewers	31.50
Sub-zone 2	
(a) Master Plan Sewerage Facilities	3.41
(b) Secondary Sewers	22.40
Sub-zone 3	
(a) Master Plan Sewerage Facilities	3.80
(b) Secondary Sewers	21.00
Sub-zone 4	
(a) Master Plan Sewerage Facilities	3.26
(b) Secondary Sewers	34.30
Sewage Treatment Plant	54.68
Total	177.19

Konnagar Zone

The general location of the Konnagar Zone is shown on Figure 16-3. The area is located on the west bank of the Hooghly River due north of the Howrah/Bally urban complex. The present Konnagar Zone (study area) has a total area of about 3,200 acres and with future extensions will comprise an urbanized area of over 10,800 acres. The present zone includes within its boundaries the Uttarpara, Kotrung, Konnagar, and Rishra municipalities. The present population is about 119,000 and it is anticipated that the population will increase to 165,000 by the year 1985, and 339,000 in the year 2001. There are no existing underground sewers or other sewerage facilities in the Konnagar zone and sullage flows are carried to various low lying areas by a network of open drains.

The average quantity of domestic and industrial wastes has been estimated to be 80 per cent and 50 per cent of respective water supply allowances. Estimates of total (domestic plus industrial) average daily waste flow, at 10 year intervals, from the present to the year 2001 for the Konnagar Study Area are presented in Table 19-10. For purposes of sewerage planning the Konnagar study area was divided into two sub-zones (Figure 19-24). The detailed Master Plan proposals for separate sewage facilities are shown in Figure 19-25.

It is recommended that the waste water effluents of the Konnagar study area be discharged into the Hooghly River for final disposal. To meet the established quality criteria, the treatment plant will be comprised of the following main process units:

- Grit Chambers
- Primary Sedimentation Tanks
- High Rate Biological Treatment Units
- Secondary Sedimentation Tanks
- Sludge Digesters
- Sludge Drying Facilities
- Effluent Chlorinators

Based on the ultimate requirements of the Konnagar Zone with future zonal extensions, the treatment plant's average capacity will be about 30 mgd. Therefore, provisions for sufficient land (approximately 30 acres) to construct a 30 mgd facility should now be made at the Konnagar plant site.

It is proposed that the Konnagar Zone treatment plant serving the present Konnagar Zone be constructed in two stages. In the initial stage, a plant with a 5.0 mgd capacity is recommended. Second stage construction (about 1981) would require an increase in plant capacity to 15 mgd. These treatment plant capacities will serve only that area falling within the present Konnagar Zone. The provisions for trunk sewers, pump stations, and treatment plant capacity for the Future zonal extension are described later.

Effluent disposal facilities will consist of an effluent pump station located at the treatment plant site and an effluent force main running from the site to the Hooghly River. It is recommended that both the effluent pump station and effluent force main be constructed in two stages. In the initial stage the proposed effluent pump station will have a capacity of about 30 cfs with a TDH of 20 ft and one 42-inch effluent force main will be provided. The second phase (about 1981) will require an effluent pump station with a capacity of 60 cfs and a TDH of 20 ft and the addition of a second parallel 42-inch effluent force main. It is recommended that the effluent pump station be equipped with 20 per cent standby pumping capacity. The general route of the parallel effluent lines is shown on Figure 19-25.

Because of the relatively large size of the future zonal extension (over 6,000 acres with a projected population of 228,000 in the year 2001), the Master Plan studies for the Konnagar Zone include preliminary cost estimates of the major facilities necessary to provide sewerage in this area. It is anticipated that extensive development will not take place in the area of zonal extension until after 1985. Integration of the area of future zonal extension into the Konnagar Zone sewerage system will require the provision of the following facilities.

- (1) Construction of major trunk sewers.
- (2) Construction of a raw sewage pump station with 36 cfs pumping capacity
- (3) Construction of additional 15 mgd in secondary treatment plant capacity.
- (4) Installation of additional 36 cfs pumping capacity at effluent pump station.
- (5) Construction of third parallel 42-inch effluent force main.

The estimated costs of the proposed separate sewerage facilities for the Konnagar Zone with future extensions are tabulated below:

<u>Unit Description</u>	<u>Millions of Rs.</u>
Sub-zone 1	
(a) Master Plan Sewerage Facilities	1.20
(b) Secondary Sewers	13.79
Sub-zone 2	
(a) Master Plan Sewerage Facilities	1.34
(b) Secondary Sewers	8.48
Sewage Treatment Plant	14.84
Future Zonal Extensions	27.72
	<hr/>
Total	67.37

Khardah Zone

The general location of the Khardah Zone is shown in Figure 16-3. The Khardah Zone is located on the east bank of the Hooghly River approximately 10 miles north of Calcutta. The present Khardah Zone has a total area of about 9,350 acres and includes the Khardah, Titagarh, and Panihati municipalities; a portion of Barrackpore municipality and a small portion of the rural area in the Khardah, Titagarh, and Barasat Thanas. When the future zonal extensions are added the Khardah Zone will service an area of about 22,300 acres. The portion of the present Khardah Zone (study area) located between the Eastern Railway line on the east and the Hooghly River on the west is extensively developed. The eastern portion of the Khardah Zone is in general relatively low lying and undeveloped. The present (1961) population of the zone is about 268,000, and its population is expected to increase to 468,000 by 1981 and to 1,051,000 by the year 2001.

Presently there are no existing underground sewers within the Khardah Zone and sullage flows are carried to the existing treatment plant by open drains. The existing Titagarh Municipality treatment plant was constructed during 1925 and put in operation in 1926. The plant was originally designed to handle an average flow of 1.05 mgd. Presently, flows at the plant average about 1.8 mgd; of this total 1.0 mgd is treated by the plant and the remaining 0.8 mgd is bypassed into two large storm water tanks which act as oxidation ponds. Because of its age, relatively small size, poor working condition and unsuitable location near the central urban area, no detailed analysis of the Titagarh plant was carried out. It is recommended that the plant be abandoned upon implementation of the Master Plan proposals.

The average quantity of domestic sewage has been estimated to be 80 per cent of the established water supply allowance, and the quantity of industrial waste water has been estimated to be 50 per cent of the industrial water allowance. The estimated total average waste water flows (including both industrial and domestic flows) for the Khardah study area and future zonal additions at 10 year intervals, from the year 1961 to 2001, are presented in Table 19-13.

For the purposes of sewerage planning the Khardah Zone was divided into two subzones (Figure 19-28). Details of the recommended Master Plan sewerage plan are shown in Figure 19-29. It is proposed that waste waters from

the Khardah Zone be discharged into the Nawi River for final disposal. The Nawi River runs through fairly open country flowing in a southeasterly direction and emptying into the Kulti Gong (a tidal river flowing into the Bay of Bengal). The Kulti Gong presently receives about 90 mgd of untreated waste discharges from the Calcutta Corporation's outfall system. Sewage treatment should not be necessary during the initial stages. Because of these factors, provision for sewage treatment for the Khardah Zone discharge in the Nawi River is not considered a high priority item and should await the construction of sewers, pump stations, and other sewerage facilities. Initially sewage treatment can be limited to the provision of open earthen sedimentation tanks. However, provisions should be made now for enough land in the vicinity of Khebla Bil to construct a 72 mgd primary treatment facility (about 70 acres). Effluent disposal facilities will consist of an effluent pump station located at the treatment plant site and an effluent force main for delivery of the treated wastes to the Nawi River for disposal (Figure 19-29).

Consideration was given to abandonment of the Nawi River effluent line and disposal directly into the Khardah drainage channel after construction of the secondary treatment works about 1981. Although abandonment of the long effluent line would reduce effluent pumping costs it is anticipated that discharge requirements for disposal in the Khardah drainage channel (which has its outlet in the Hooghly River) will remain substantially higher than those for the Nawi River thus resulting high treatment costs which would outweigh any advantage gained in reduced pumping costs.

Estimated costs of the separate sewerage improvements for the Khardah Zone, shown in Figure 19-29, are tabulated below:

<u>Unit Description</u>	<u>Millions of Rs.</u>
Sub-zone 1	
(a) Master Plan Sewerage Facilities	10.23
(b) Secondary Sewers	45.50
Sub-zone 2	
(a) Master Plan Sewerage Facilities	7.24
(b) Secondary Sewers	20.30
Sewage Treatment and Disposal	20.40
Total	103.67

Chandernagore Zone

The Chandernagore Zone (Figure 16-3) consists of Chandernagore Corporation, portions of Bhadreswar, Champdani, and Chinsurah municipal areas, and part of the rural area in the Chinsurah, Bhadreswar, and Pobra Thanas. The present Chandernagore Sewerage Zone (the study area) consists of about 6,830 acres located on the west bank of the Hooghly River (Figure 16-3). The study area is bounded by the Eastern Railway Naihati-Bandel branch line on the north, the DVC (Damodar Valley Corporation) canal on the south, the Hooghly River on the east, and by the Eastern Railway Main track on the west (Figure 19-32). The probable

future zonal extension comprises some 4,300 acres located west of the Study Area. Hence the Chandernagore Zone (study area plus extensions) has a total area of about 11,100 acres. The present population of the study area is about 178,000. By 1981 the population is likely to be 253,000 and the projected population for the year 2001 is 335,000.

At present there are no underground sewers in the Chandernagore Zone and waste water flows are carried to various discharge points through open drains. In 1954, the Public Health Engineering Department (PHE) of the Government of West Bengal prepared a preliminary plan for the sewerage of Chandernagore Corporation and subsequently drew up a detailed plan. Because of the more comprehensive nature of the Chandernagore Sewerage Zone and the differences in population and sewerage design criteria, the PHE plan was no longer considered applicable and no attempt was made to incorporate elements of this plan in the Master Plan proposals.

The estimated total average daily waste water flows (including both domestic and industrial flows) at 10 year intervals, from 1961 to 2001, for the Chandernagore Study Area and future zone extensions are tabulated below (where "D" represents domestic flow; "I", industrial wastes; and "T", total flow):

Year	Study Area			Future Additions			Totals		
	D	I	T	D	I	T	D	I	T
1961	2.2	--	2.2	0.1	--	0.1	2.3	--	2.3
1971	4.8	0.2	5.0	0.2	--	0.2	5.0	0.2	5.2
1981	8.1	0.5	8.6	0.4	--	0.4	8.5	0.5	9.0
1991	10.6	0.7	11.3	0.5	--	0.5	11.1	0.7	11.8
2001	13.5	1.0	14.5	0.6	--	0.6	14.1	1.0	15.1

To facilitate sewerage planning the Chandernagore Zone was divided into two subzones (Figure 19-32). The detailed proposals for sewerage facilities are shown on Figure 19-33.

It is planned that waste waters from the Chandernagore area be discharged in the existing Chandernagore Garh (ditch) for ultimate disposal into the Hooghly River. Because the point of discharge of existing Chandernagore Garh into the Hooghly River is only about five miles upstream from the Palta waterworks intake point, to protect the Hooghly River as a water supply source, the Chandernagore Zone sewerage plan must include provisions for complete sewage treatment including chlorination of the treated effluent. Based on the ultimate requirements of the Chandernagore Zone, the treatment plant's average capacity will be about 15 mgd. Provisions for sufficient land (approximately 15 acres) to construct a 15 mgd facility should, therefore, be made at the Chandernagore plant site. The proposed location of the Chandernagore Zone treatment plant is shown in Figure 19-33. The treatment plant is to be constructed in two stages. In the initial stage, a plant with a 5 mgd capacity is recommended. Second stage construction

(after 1981) would require an increase in plant capacity to 15 mgd.

As stated earlier, it is proposed to discharge the Chandernagore Zone effluent in the Chandernagore Garh which ultimately discharges into the Hooghly River. Effluent disposal facilities will consist of an effluent pump station located at the treatment plant site and parallel effluent force mains running from the effluent pump station to the Chandernagore Garh.

Estimated costs of the Master Plan sewerage facilities are as follows:

<u>Unit Description</u>	<u>Millions of Rs.</u>
Subzone 1	
(a) Master Plan Sewerage Facilities	1.88
(b) Secondary Sewers	19.60
Subzone 2	
(a) Master Plan Sewerage Facilities	2.53
(b) Secondary Sewers	24.50
Sewerage Treatment Plant and Effluent Disposal Systems	13.11
Total	61.62

Garden Reach Zone

The general location of the Garden Reach Zone is shown in Figure 16-3. The zone is located on the east bank of the Hooghly River and lies southwest of Calcutta. It is comprised of a portion of the Calcutta Corporation and the Garden Reach and South Suburban municipalities, the Panchur non-municipal urban area, and the Maheshtala, Behala, and Behala police districts. The present zone (study area) includes only the dock area of the Calcutta Corporation, the Garden Reach and South Suburban municipalities, the Panchur non-municipal urban area, and a small portion of the Maheshtala and Behala police districts. The present population is about 434,000. It is anticipated that the population of the study area will increase to 898,000 by the year 1981 and to 1,230,000 by the year 2001. At present there are no existing underground sewer or other related sewerage facilities and a network of open drains carried sullage flows to either the river or low lying pockets for disposal.

Average domestic sewage flows have been estimated to be 80 per cent of the established water supply allowances, and average industrial waste flows have been estimated to be 50 per cent of established industrial water allowances. It is estimated that the present total daily averages (domestic plus industrial) flow of the study area is about 9.0 mgd, and it is expected that this value will increase to about 42 mgd by the year 1981 and to about 76 mgd by the year 2001.

To facilitate sewerage planning, the zone was divided into three sub-zones (Figure 19-38). The sub-zone delineations are as follows:

Subzone 1: Subzone 1 is located in the northwesterly portion of the zone and is comprised of the Garden Reach municipality and the Panchur nonmunicipal area.

Subzone 2: This consists of the South Suburban municipality and small portions of the rural area in the Behala and Maheshtala police districts.

Subzone 3: Subzone 3 is located in the northeast corner of the zone and is comprised of Wards 75 and a portion of Ward 73 of the Calcutta Corporation.

The detailed proposals for sewerage facilities within the zone are shown in Figure 19-39.

It is proposed that waste waters from the Garden Reach Zone be discharged into the existing Manikhali Khal for ultimate disposal into the Hooghly River. To protect the Hooghly River as a water supply source and to prevent objectionable conditions in the lower reaches of Manikhali Khal, the long range sewerage plan for zone must include provisions for sewage treatment including chlorination of the treated effluent. It is proposed that the treatment plant be located at the present low ground under Maheshtala Urban Area lying between Biren Roy Road and Budge Budge Road. Secondary treatment in the form of high rate trickling filters or the high rate activated sludge process, with secondary sedimentation and effluent disinfection, will be required.

Based on ultimate conditions in the Garden Reach Zone (study area plus future additions), the treatment plant's average capacity would be about 85 mgd. Provision for sufficient land (about 90 acres) to construct an 85 mgd facility should be made at the treatment plant site.

At present complete sewage treatment is not considered of primary importance and should await the construction of sewers, sewage pump stations, and other sewerage appurtenances. In the initial stage sewage treatment should be limited to primary sedimentation with provision for disinfection of the effluent. This type of facility will produce, during the initial low flow period, an effluent of suitable quality for discharge in the Manikhali Khal and subsequent disposal in the river. However, it is essential that provision of complete treatment in zone be coordinated with the construction of the waterworks at Garden Reach and Howrah so that secondary sewage treatment units are in operation before withdrawals for drinking water purposes are made from Hooghly River at these locations.

The treatment plant is to be constructed in four stages. As a part of first stage construction a primary treatment facility having a 20 mgd capacity is recommended. Second stage construction (about 1975) would require the addition of secondary treatment units and an increase in plant capacity to 40 mgd. In the third stage (about 1985) the plant capacity increases to 60 mgd and in the fourth stage to the ultimate capacity, 85 mgd.

Estimated costs of the Master Plan improvements are as follows:

<u>Unit Description</u>	<u>Millions of Rs.</u>
Subzone 1	
(a) Master Plan Sewerage Facilities	3.74
(b) Secondary Sewers	31.50
Subzone 2	
(a) Master Plan Sewerage Facilities	6.78
(b) Secondary Sewers	59.50

<u>Unit Description</u>	<u>Millions of Rs.</u>
Subzone 3	
(a) Master Plan Sewerage Facilities	1.14
(b) Secondary Sewers	19.60
Sewage Treatment Plant	52.60
Total	<u>174.86</u>

Dum Dum Zone

The general location of the Dum Dum Sewerage Zone is shown in Figure 16-3. The Dum Dum Zone has an area of about 30 sq miles on the northerly fringes of Calcutta, and is a natural outlet for the urban spread of this city. It is anticipated that the population of the Dum Dum Zone will increase from its present total of 670,000 to 1,465,000 by the year 1981 and to 2,384,000 by the year 2001. Two major sewerage facilities, the Bagjola sewage treatment plant and the Jessore Road trunk sewer system, are presently under construction within the Dum Dum Zone.

The Bagjola treatment plant is designed to provide secondary treatment for an average flow of 6 mgd, and has a peak hydraulic capacity of 18 mgd. The plant is comprised of the following main units.

- Mechanical Bar Screen
- Grit Chamber
- Primary Sedimentation Tank
- High Rate Trickling Filter
- Recirculating Pumps
- Secondary Sedimentation Tank
- Primary and Secondary Digesters
- Sludge Drying Beds

The effluent from the Bagjola treatment plant will be discharged into the Bagjola drainage channel and conveyed to the Kulti River for final disposal.

The Jessore Road scheme, prepared by PHE is designed on the "combined basis" employing a constant 1/4-inch per hour rainfall and a runoff coefficient of 40 per cent, with a design service area of about 1,000 acres. The service area covers the southeasterly portion of Cossipore-Chitpore (700 acres) and a strip of land adjoining Jessore Road in the South Dum Dum Municipality (300 acres). The combined flows from these areas will be collected by two parallel main drains in Jessore Road and delivered to a new pump station located at the junction of Jessore Road and Bagjola drainage channel. From the pump station combined flows up to three times dry weather flow will be pumped to the Bagjola treatment and disposal, and excess storm flow (above three times dry weather flow) will be bypassed directly into the Bagjola drainage channel.

The quantity of domestic sewage has been estimated to be 80 per cent of the established per capita water allowances. Estimates total (industrial plus domestic) average daily waste flow, at 10 year intervals from 1961 to 2001, for the Dum Dum Zone and its various components are presented in Table 19-23.

For purposes of sewerage planning the Dum Dum Zone was divided into the three subzones shown in Figure 19-42. Sewerage of Subzone 1 will be provided by converting the major portion of the combined system of pipelines constructed by PHE in the Jessore Road to a separate sewerage system. The ultimate (year 2001) separate sewerage needs of Subzone 1 can be provided for by use of the 48-inch RCP gravity line, one of the two parallel 60-inch RCP gravity lines proposed to be laid by PHE along Belgachia-Jessore Road, the intermediate lift station, the final pump station, and the 42-inch force main (Figure 19-43).

The principal feature of the Subzone 2 sewerage proposals in the main trunk sewer (Line M) which begins at the intersection of Graham Road and Barrackpore Trunk (BT) Road in Kamarhati and flows south along BT road to the intersection of Gopal Lal Tagore Road in Baranagar. The sewer then turns east along the bank of Bagjola canal and flows south along the Eastern Railway tracks where it again turns east and crosses the Eastern Railway tracks discharging into Pump Station 1. From Pump Station 1 the main trunk sewer runs generally southeasterly parallel to the Bagjola Canal. The Line terminates at the main pump station, which is located at the Bagjola sewage treatment plant site. The Subzone 2 main trunk is serviced by five main branch lines, the Kamarhati branch sewer (Line A), the Baranagar branch sewer (Line B), the Jessore Road branch sewer (Line E), the Cantonment Khal branch sewer (Line H), and the North Dum Dum branch sewer (Line J).

The proposals for separate sewerage facilities in Subzone 3 of the Dum Dum Zone are presented earlier in this chapter in Northern Salt Lake Master Plan sewerage proposals.

It is proposed that the waste flows of the Dum Dum Sewerage Zone be discharged into the Bagjola Canal for conveyance to the Kulti River for final disposal. In view of the fact that the ultimate disposal point is the Kulti River, the provision of sewage treatment facilities within the Dum Dum Zone is not necessary during the initial stages of construction. Should treatment become necessary at some later stage it is anticipated that only primary facilities need be constructed.

Estimated costs of the Master Plan sewerage improvements for the Dum Dum Zone (excluding Subzone 3) area as follows:

<u>Unit Description</u>	<u>Millions of Rs.</u>
Subzone 1	
(a) Master Plan Sewerage Facilities	1.54
(b) Secondary Sewers	10.50
Subzone 2	
(a) Master Plan Sewerage Facilities	8.45
(b) Secondary Sewers	72.10
Sewage Treatment Plant	64.80
Total	<u>157.39</u>

Tollygunge Panchannagram Drainage Basin

The Tollygunge Panchannagram Drainage Basin is located southeast of Calcutta and covers an area of about 7,400 acres (exclusive of certain small fringe areas) being approximately the same area as covered by the Tollygunge Sewerage Zone.

For drainage purposes, this Basin is divided into twelve sub-basins, of which I, II, III, VII, VIII, IX, X, and XII are located in Tollygunge and the remainder in the Panchannagram area as shown on Figure 20-1.

The existing degree of urbanization within the basin varies widely. Tollygunge is an intensively developed and rapidly expanding suburban area with most of the older construction in the south and west and more recent expansion in the low-lying areas to the east. The west and southwest portions of the Panchannagram have developed as low-value residential property, the middle areas are semi-rural, and the easterly areas are agricultural lowlands.

Existing drainage facilities consist of the Panchannagram Canal, the Outfall Pumping Station, and associated branch canals currently under construction. These receive storm water from practically the entire basin, with the exception of high ground adjacent to Tolly's Nullah which drains directly to the Nullah by means of open ditches.

With the exception of the above high ground, present drainage throughout almost the entire area is unsatisfactory. Flood waters, mixed with sewage, accumulate in the low-lying easterly areas of Tollygunge where recent urbanization has occurred, and is still occurring. The need for drainage improvements in the Panchannagram is less acute because areas subject to inundation are largely rural. The drainage problem is well recognized by local authorities. Steps are being taken by the CMPO and the Irrigation & Waterways Department to place the Panchannagram drainage canal in operation and provide necessary trunk drains so that storm water runoff can enter the canal from densely populated areas.

Master Plan proposals (Figure 20-1) consist of trunk drains leading to Tolly's Nullah in the immediate vicinity of this creek. Provision is made for future pumping stations in these areas. Elsewhere, proposed trunk drains discharge to the Panchannagram Canal or to its associated branch canals.

The Irrigation & Waterways Department design of the Panchannagram Canal is such that flooding of the rural areas of the Panchannagram will continue under certain design conditions. Whereas this is considered an acceptable arrangement until such time as the majority of the Panchannagram becomes urbanized, eventually the hydraulic gradient in the canal will have to be lowered so as to provide adequate drainage. Master Plan studies of the hydraulics of the canal show that satisfactory future performance can be obtained by re-excavation of earth channels and by an increase in capacity of the Outfall Pumping Station.

Estimated construction costs are presented as follows:

Drainage Sub-Basin Col.1	Proposed		Future	
	Master Plan Col.2	Secondary Col.3	Master Plan Col.4	Secondary Col.5
	Rs.	Rs.	Rs.	Rs.
I	3,234,000	4,830,000	69,000	85,000
II	3,644,400	4,284,000	1,129,000	1,416,000
III	3,787,200	3,871,000	2,449,000	3,072,000
IV			4,585,000	5,748,000
V			3,253,000	4,077,000
VI			4,273,000	5,352,000
VII	2,029,200	2,406,000	738,000	
VIII	2,047,200	2,502,000	577,000	
IX	1,218,000	1,598,000	567,000	
Main Canal			318,000	
Outfall P.S.			1,182,000	
Totals	15,960,000	19,491,000	19,140,000	19,750,000

The estimated cost figures shown in Column 2 were obtained from Master Plan studies of individual trunk drain conduits. The costs of secondary drains shown in Column 3 were determined from a figure of Rs. 4,400 per acre as presented in the CMPO Tollygunge Storm Drainage Report of August 1965, on the assumption that open ditches will be utilized where practicable and pipe drains at other locations.

Future Master Plan costs are shown in Column 4. These figures include the cost of increasing Irrigation & Waterways Department canal capacities to meet future Master Plan recommendations. The cost of future trunk drains discharging to these canals has also been included. Such drains are not shown in Figure 20-1, because no street layout plans are presently available. The estimated cost of the main pumping station does not include the cost of the present 450 cfs installation presently under construction. In drainage Sub-Basins VII, VIII, and IX, the Master Plan costs make provision for three future pumping stations at Tolly's Nullah. Although the future needs of these three stations is by no means certain, it is considered desirable to include their cost for budgetary purposes in the present estimate.

Column 5 shows the estimated cost of secondary drainage facilities in presently undeveloped areas.

Maniktala Drainage Sub-Basin

Although the Maniktala Drainage Sub-basin is located within the general Calcutta area, it forms a distinct entity for drainage purposes, and is consequently treated separately. Reference should be made to a preceding discussion on Maniktala sewerage for a description of the area, existing sewerage, and drainage conditions, and the CIT improvements presently under implementation.

Master Plan proposals (Figure 20-3) include the construction of separate trunk drains flowing from west to east to a proposed intersecting trunk drain to be located along the alignment of the New Canal (now abandoned

and partly filled). The entire storm runoff of the area (plus some runoff from the Salt Lake Township) will be discharged by gravity to the existing Central Lake Channel, and thence via existing open channels to the Kulti River. Provision is also made for a future storm water pumping station, if found to be necessary. A modification proposed by the CMPO to this general layout is also presented in the main text of the report.

The estimated cost of proposed facilities is listed as follows:

<u>Item</u>	<u>Millions of Rs.</u>
Master Plan Facilities	23.38
Secondary Facilities	20.14
Total	<u>43.52</u>

Northern Salt Lake Sub-Basin

The Northern Salt Lake Sub-Basin is located in the northern portion of the North Salt Lake Drainage Basin and covers the same area as described in the Northern Salt Lake Sewerage Zone.

Master Plan studies included a detailed analysis of Invest-Import drainage proposals and cost comparison studies leading to the adoption of a one-year frequency storm with a 15-minute inlet time and an assumed cover of 70 per cent roofs and pavements. The Invest-Import drainage proposals were replaced by Master Plan drainage proposals as shown on Figure 20-6.

It is proposed that all storm water from Sector I and Sector II be drained to the Krishnapur Canal under gravity flow conditions. The present and anticipated future ability of the canal to receive Salt Lake drainage was found to be satisfactory, provided that maintenance, operation, and possible minor improvements to the canal are effected. To provide for the possibility that the canal may deteriorate to an extent that drainage of the Salt Lake Township is adversely affected, the Master Plan layout includes provision of future pumping stations for Sector I and Sector II.

It is intended that the westerly portions of Sector III be drained to the proposed New Canal intercepting drain serving Maniktala, and that the easterly portion be drained to a proposed South Main Drain. Both drains will discharge to the Central Lake Channel which connects with other drainage channels leading to the Kulti River. Under the circumstances, the need to pump this storm flow is not anticipated; however, to cover the possibility of a future increase in elevation of the design water surface in the outfall channels, provision has been made for future pumping facilities at the extreme southerly boundary of Sector III.

Construction costs for the Master Plan proposals are estimated as follows:

<u>Item</u>	Proposed Works	Future Works
	<u>Rs.</u>	<u>Rs.</u>
(a) Sector I, Master Plan Facilities	3,865,000	4,645,000
(b) Sector I, Secondary Facilities	5,600,000	
(a) Sector II, Master Plan Facilities	2,150,000	2,510,000
(b) Sector II, Secondary Facilities	4,128,000	
(a) Sector III, Master Plan Facilities	8,353,000	1,054,000
(b) Sector III, Secondary Facilities	9,720,000	
Totals	33,816,000	8,209,000

Preliminary estimates of costs for drainage of the additional 2 sq mile area proposed to be developed later by Government of West Bengal are presented as follows;

(a) Master Plan Facilities	10,962,000
(b) Secondary Facilities	9,600,000
Totals	20,562,000

Konnagar Basin

The general location of the Konnagar Basin (study area) is shown in Figure 16-4. The area is located on the West Bank of the Hooghly River just north of the Howrah-Bally urban complex. The Konnagar Basin has a total area of about 3,300 acres and includes within its boundaries the Uttarpara, Kotrung, Konnagar, Rishra, and Serampore municipalities. At present urban development is confined to the higher grounds adjacent to the river. The western portion of the area adjoining the railway line is relatively low-lying and in certain places occupied by paddy fields. At present there are no existing underground drainage facilities in the study area. Combined storm water and sullage flows are carried to various low-lying outlet points by a network of open drains.

Master Plan design criteria for estimating storm runoff include the adoption of the two month storm frequency with a 15-minute inlet time and an assumed cover of 70 per cent roofs and pavements. Based on detailed studies of pertinent river level data, the design water levels for gravity discharge in the Hooghly River were set at 12.00 ft GTS datum in the southerly portion of the Basin and 13.00 GTS in the northern half.

For purposes of drainage planning the Konnagar Basin study area was broken down into two major sub-basins. The delineation of the sub-basins is shown in Figure 20-7.

The drainage of Sub-basin 1 will be accomplished by the construction of 31 parallel interceptors running west to east and discharging into the Hooghly River. It is proposed to provide major drainage interceptors in the following locations:

- (1) Ananda Prasto Ghose Road/Pandit N.C. Banerjee Lane, Serampore (Line A).
- (2) Chhetra Bazar Road, Serampore (Line B).
- (3) Jale Para Lane, Serampore (Line C).

- (4) K.M. Saha Street/Convent Garden, Serampore (Line D).
- (5) New Gate Street, Serampore (Line E).
- (6) Panchanan Tola Lane, Serampore (Line F).
- (7) Bhagirathi Lane, Serampore (Line G).
- (8) Satgop Para Lane, Serampore (Line H).
- (9) Ganguli Bagan Lane and Banga Lakshmi Cotton Mill Road, Serampore (Line I).
- (10) Goalpara Road/Satya Chandra Sastree Street, Serampore (Line J).
- (11) Netaji Subhas Road/S.D. Banerjee Street, Rishra (Line K).
- (12) N.K. Banerjee Street/Sastitala Street, Rishra (Line L).
- (13) Ryland Road, Rishra (Line GG).
- (14) Rishra (Line M).
- (15) S.C. Mukherjee Street, Konnagar (Line N).
- (16) C.S. Mukherjee Street, Konnagar (Line O).
- (17) S.C. Chatterjee Street and Shib Chandra Deb Street, Konnagar (Line P).
- (18) N.C. Mitter Lane and Sree Aurobindo Road, Konnagar (Line Q).
- (19) Rishi Bankim Chandra Street and N.C. Mukherjee Lane, Konnagar (Line R).
- (20) Dharamtala Lane, Kotrung (line S).
- (21) Baidikpara Ghat Road, Kotrung (Line T).
- (22) Ananda Ghosh Ghat Lane, Kotrung (Line U).
- (23) Shibtola Ghat Lane and Sastitola Lane, Kotrung (Line V).
- (24) Bishalakshi Ghat Lane/Danpara Lane/Haranathpur Road, Kotrung (Line W).
- (25) Sakher Bazar Lane, Kotrung (Line X).
- (26) Ram Sita Ghat Lane, Kotrung (Line Y).
- (27) Bijoy Kissen Street, Uttarpara (Line Z).
- (28) Dr. Saroj Mukherjee Street, Uttarpara (Line BB).
- (29) Netaji Subhas Road, Uttarpara (Line CC).
- (30) Raj Kissen Street, Uttarpara (Line AA).
- (31) Uttarpara (Line DD).

With the exception of the Satgop Para Lane interceptor in Serampore, which will require a small lift station, all of the major Sub-basin 1 interceptors noted above discharge into the river by gravity. The drainage of Sub-basin 2 will be accomplished by the construction of two major northsouth interceptor drains, the Uttarpara/Kotrung interceptor (line EE) and the Konnagar interceptors (Line FF).

The Uttarpara/Kotrung Interceptor (Line EE), which serves the southerly one half of Sub-basin 2, will begin at approximately the northern boundary of Kotrung municipality, and flow south through the open land paralleling the Eastern Railway tracks, terminating at a lift station located on the north bank of Bally Khal. The proposed Uttarpara/Kotrung drainage pump station (Pump Station 1) will have an ultimate design capacity of 280 cfs with a TDH of 15 ft.

The proposed Konnagar interceptor (Line FF) which serves the northern half of Sub-basin 2, will begin at the southern boundary of Konnagar Municipality and will flow north running along the open land parallel to the Eastern Railway tracks terminating at a lift station located on the south bank of Bagh Khal. The proposed Konnagar drainage pump station (Pump Station 2) will have an ultimate design capacity of 285 cfs with a TDH of 15 ft.

Construction costs of the drainage improvements for the Konnagar Basin are estimated as follows:

<u>Unit Designation</u>	<u>Millions of Rs.</u>
<u>Sub-basin 1</u>	
(a) Master Plan Drainage Facilities	8.59
(b) Secondary Drainage Facilities	20.45
<u>Sub-basir 2</u>	
(a) Master Plan Drainage Facilities	7.80
(b) Secondary Drainage Facilities	12.60
Total	<u>49.44</u>

Manikhali Basin

The general location of the Manikhali Basin is shown in Figure 16-4. Located southwest of Calcutta, the basin includes Garden Reach Municipality, a portion of the South Suburban municipality, Pachur and Nangi non-municipal urban areas, and a portion of the rural area in the Maheshtala police district. The Manikhali Basin has a total area of about 19.0 sq miles. The terrain is generally flat with ground surface elevations varying between about 16.50 ft (GTS Datum) and 5.50 ft (GTS Datum). The ground generally slopes from the periphery towards the center of the basin.

Three existing drainage channels, the New Manikhali Khal, the Old Manikhali Khal, the Hayatpur Khal, serve the Manikhali Basin, and all discharge into the Hooghly River (Figure 20-9). At present there are no underground drainage facilities, and storm water is fed into the existing channels by systems of small open lateral ditches or by direct spill of overland flow. Field inspections revealed that many of these open ditches are of inadequate hydraulic capacity and are poorly maintained. The carrying capacity of the three main outfall channels (New Manikhali Khal, Old Manikhali Khal, and Hayatpur Khal) has been greatly reduced by silt deposits, hence these channels are at present relatively ineffective.

Recognizing the need for drainage improvements in the Manikhali Basin, the Irrigation and Waterways Department of the Government of West Bengal (IWWD) prepared a drainage scheme for this area. For the following reasons, the IWWD proposals for the Manikhali Basin proved inadequate and no detailed analysis of these proposals was necessary:

- (1) The IWWD estimates of design storm water run-off for the basin area were based on runoff rates varying from 1/32 inch per hour to 1/6 inch per hour. The Master Plan proposals are based on the rational method employing a two-month storm frequency and runoff rates vary from about 1/2 inch per hr to 1/6 inch per hour, or are about three to five times as large as those used by the IWWD.
- (2) Based on a design discharge level of 9.00 ft above GTS Datum in the Hooghly River, it is impossible employing the IWWD design to efficiently drain, without pumping or provision of a large storage reservoir, those basin areas below 9.00 ft GTS;

Master Plan design criteria for estimating storm runoff include the adoption of the two-month storm frequency with a 15-minute inlet time and an assumed cover of 70 per cent roofs and pavements in densely populated areas of the Basin and 40 per cent in sparsely populated area.

For the purpose of drainage planning, the Manikhali basin was broken down into four sub-basins (Figure 20-10). Sub-basin 1 is that portion of the Manikhali Basin which can be drained by gravity to the Hooghly River; Sub-basin 2 is that portion tributary to New Manikhali Khal; Sub-basin 3 is that portion tributary to Old Manikhali Khal; and Sub-basin 4 is that portion tributary to Hayatpur Khal. The Master Plan for the separate drainage facilities in the Manikhali Basin is shown in Figure 20-11.

No detailed proposals for the drainage of Sub-basin 1 were considered. This area can be drained into the Hooghly River by gravity, employing a series of parallel interceptors similar in design to those proposed in either drainage basins, e.g., the Konnagar Basin.

Master Plan drainage proposals for Sub-basin 2 include the following improvements:

- (1) Construction of a major interceptor drain in Naskar/U.N. Banerjee Road (Line A).
- (2) Construction of a major interceptor drain in Biren Roy Road (Line C).
- (3) Resectioning of the existing New Manikhali Khal (Line M) and its major branch channel (Line D).

The Master Plan proposals for drainage improvements in Sub-basin 3 are limited to the resectioning and improvement of Old Manikhali Khal. The Old Manikhali Khal (Line E) serves an area of about 1,830 acres and has been redesigned as a lined trapezoidal section (Side slopes 1.5:1).

Master Plan drainage proposals for Sub-basin 4 (Hayatpur Khal) include the following improvements:

- (1) Construction of a major drainage interceptor in Budge Budge Road (Line F).
- (2) Resectioning and improvement of the existing Hayatpur Khal (Line G).

The proposed outfall channels, namely, the new Manikhali Khal (Line M), the Old Manikhali Khal (Line E), and the Hayatpur Khal (Line G), are designed as brick-lined trapezoidal sections ($n = 0.017$). However, it is recommended that the first stage construction can be limited to the provision of unlined sections for the following reasons:

- (1) Estimates of ultimate case peak storm runoff were made employing a composite runoff coefficient calculated using a weighted average of 70 per cent and 40 per cent roofs and pavements values. At present there are fairly large portions in the basin area where the roofs and pavements are substantially less than the composite value used. Thus at present and in the near future peak runoff rates will be somewhat less than the ultimate case estimates.
- (2) The full impact of the ultimate case of peak runoff rates will not be felt until such time as the majority of the basin area is fully connected to the proposed channels, i.e., until the major interceptor drains and branch and lateral drains are constructed. Initially the new channel will probably be fed by suitable tie-ins with the existing network of surface drains and the conversion from surface to pipe drains and other up-dating of the drainage system will have to be phased over many years. This condition will, in effect, amount to a reduction in effective catchment area and thus reduced peak discharges.

Construction costs for the Master Plan improvements are estimated as follows:

<u>Unit Designation</u>	<u>Millions of Rs.</u>
<u>Sub-basin 2</u>	
(a) Master Plan Drainage Facilities	15.36
(b) Secondary Drainage Facilities	75.60
<u>Sub-basin 3</u>	
(a) Master Plan Drainage Facilities	2.60
(b) Secondary Drainage Facilities	18.30
<u>Sub-basin 4</u>	
(a) Master Plan Drainage Facilities	3.37
(b) Secondary Drainage Facilities	14.50
Total	<u>129.73</u>

Howrah Basin

The general location of the Howrah Basin (study area) is shown in Figure 16-4. The Study Area consists of the Howrah and Bally municipal areas, the Bally non-municipal urban area, and portions of the rural area in the Jagacha police district. The Howrah area is the most important metropolitan unit on the West Bank of the Hooghly River and second in importance in the CMD, being dominated only by Calcutta. The area is industrially oriented and is the most important rail and road terminus in the CMD.

With the exception of the Naskarpara Road interceptor (Figure 20-13), there are no underground drains of any significance in the Howrah study area. Storm water runoff is carried away to various outfall points by a complex network of open ditches. One major open channel, the Howrah drainage canal (hereinafter referred to as the existing Howrah drainage canal) services the Howrah Basin.

Master Plan design criteria include the adoption of the two-month storm frequency with 15-minute inlet time and an assumed cover of 70 per cent roofs and pavements for estimating stormwater runoff quantities. Based on studies of pertinent river levels, the design levels for gravity discharge were set at 10.0 ft GTS for Howrah municipality and 11.0 ft GTS for Bally municipality.

For purposes of drainage planning the Howrah area was broken down into three major sub-basins (Figure 20-12). The Master Plan drainage proposals for Sub-basin 1 of the Howrah study area are shown in Figure 20-13. The Sub-basin 1 drainage facilities consist of 14 parallel major interceptors which flow generally from west to east discharging by gravity into the Hooghly River. It is proposed to provide major underground storm drains in the following locations:

- (1) Bengal Engineering College Area, Howrah (Line C).
- (2) Duke Road/Jagat Banerjee Road, Howrah (Line D).
- (3) GT Road/Dr. G. Mukherjee Road, Howrah (Line E).
- (4) Wityadhan Mukherjee Road, Howrah (Line F).

- (5) GT Road/Dr. Abani Dutta Road, Howrah (Line G).
- (6) GT Road/Rishi Arabinda Road, Howrah (Line H).
- (7) Naskarpara Road, Howrah (existing).
- (8) Wallace Road/Mohan Lal Surkhal Road, Bally (Line J).
- (9) Rajen Sett Lane, Bally (Line K).
- (10) Lal Babus Sair Street, Bally (Line L)
- (11) R.N. Bhattacharjee Street, Bally (Line M).
- (12) Daws Temple Road, Bally (Line N).
- (13) GT Road/Aukhoy Kr. Dutt Road, Bally (Line O).
- (14) Goswami Para Street/Dingsai Para Lane, Bally (Line P).

With the exception of the GT Road/Dr. Abani Dutta Road, Daws Temple Road, and Goswami Para Street/Dingsai Para Road interceptors, which require lift stations, all of the above listed major drains can discharge to the Hooghly River by gravity.

In general, the drainage of Sub-basin 2 will be accomplished by the construction of a major outfall channel in the HDCL right of way. Line B, the new channel (hereinafter) referred to as the new Howrah drainage canal, will flow from north to south and discharge into the existing Howrah drainage canal (which has its outlet in the Hooghly River).

The new channel serves a tributary area of approximately 3,435 acres, and to handle ultimate condition storm water quantities was designed as a bricklined ($n = 0.017$) trapezoidal section with 1.5:1 side slopes and a 5.5 ft water depth. A profile and a typical cross section of the proposed channel are shown in Figure 20-14. The water level of the new Howrah drainage canal at its entrance to Padmapukur Jala is too low to permit direct gravity discharge into the existing Howrah drainage canal. In lieu of installing a large capacity pump station to lift the Sub-basin 2 storm flows into the existing Howrah drainage canal, it is proposed to convert the low lying Padmapukur Jala into a storm water reservoir. The reservoir will store flood waters during the high tide periods and release the stored water during periods of low tide.

It is estimated that the total volume of storm runoff from the Sub-basin 2 catchment area a two-month frequency storm is about 315 acre ft. Employing a 3 ft operating level difference (GTS 6.00 to GTS 9.00), the storage reservoir requires 105 acres of land area. The existing Jala site is more than adequate to handle a reservoir of this size. The outlet channel from the reservoir to the existing Howrah drainage canal runs along the existing Government of West Bengal Public Works Department channel right-of-way (approximately 4,400 ft) and was designed with a capacity of 800 cfs. A sluice has been provided at the downstream end of the outfall channel to prevent back flow of the existing Howrah drainage canal into the reservoir.

Detailed information with regard to design and operating water levels in the existing Howrah drainage canal were not available at the time this study was prepared. Proper integration of the existing Howrah drainage canal with the newly proposed outfall channel and reservoir are necessary to insure that the reservoir system functions properly. Thus the final selection of the reservoir size and operating levels and the final outlet channel design will require detailed field and office studies of the hydraulic

conditions which prevail in the existing Howrah drainage canal.

As pointed out earlier, the proposed Howrah drainage canal is designed as a brick-lined section; however, the first stage construction can be limited to the provision of an unlined section for the following reasons:

- (1) Estimates of ultimate case peak storm runoff were made employing a 70 per cent roofs and pavements value. At present there are fairly large portions of Sub-basin 2 where the percentage roofs and pavements is substantially less than 70 per cent. Thus, in the present and near future peak runoff rates will be somewhat less than the ultimate case estimates.
- (2) The full impact of the ultimate case peak runoff rates will not be felt until such time as the majority of the Sub-basin 2 catchment area is fully connected to the proposed new channel, i.e., until the major interceptor drains and branch and lateral drains are constructed. Initially the new channel will probably be fed by suitable tie-ins with the existing network of surface drains and the conversion from surface to pipe drains and other up-dating of the drainage system will have to be phased over many years. This condition will, in effect, amount to a reduction in effective catchment area and thus reduced peak discharges.

Because of the more undeveloped nature of Sub-basin 3, no detailed Master Plan proposals were made for this area.

Construction costs of the proposed drainage improvements for the Howrah Basin are estimated as follows:

<u>Unit Designation</u>	<u>Millions of Rs.</u>
<u>Sub-basin 1</u>	
(a) Master Plan Drainage Facilities	11.08
(b) Secondary Drains	62.00
<u>Sub-basin 2</u>	
(a) Master Plan Drainage Facilities	9.78
(b) Secondary Drains	34.00
Total	<u>116.86</u>

Bagjola Basin

The Bagjola Basin is located due north of Calcutta and includes within its boundaries the Panihati, Kamarhati, Baranagar, Dum Dum, North Dum Dum, and South Dum Dum municipal areas, the Cossipore-Chitpore area of the Calcutta Corporation, and portions of the rural area in the Dum Dum Thana.

The Bagjola Basin has a total area of about 21.5 sq miles. The terrain is generally flat with ground surface elevations varying between about 18 ft and 3 ft GTS. The higher ground is generally located along the north and east boundaries of the basin, with the ground sloping to the southeast. Presently the Baranagar and Kamarhati Municipal areas, the Cossipore-Chitpore area of Calcutta, and the southern portion (generally south of Jessore Road) of South Dum Dum are extensively developed. The basin area located between the two branches of the Eastern Railway and north of the Bagjola Khal is at present relatively undeveloped.

The principal existing drainage facility within the Bagjola Basin is Bagjola Khal (Figure 20-15) constructed by the Irrigation and Waterways Department of the Government of West Bengal (IWWD). The channel design was based on the recommendations of the Greater Calcutta Master Drainage Plan of 1953. In the design of the Bagjola Canal the IWWD adopted a drainage index of 3 inches per day less 25 per cent retention for urban drainage, and 3/4-inches per day less 25 per cent retention for rural drainage. The channel was designed as an unlined trapezoidal section, with an "n" of 0.025, and using side slopes of 1.5:1. The hydraulic elements of the Bagjola Canal are presented in Table 20-8, and a profile of the existing channel is shown in Figure 20-19.

The Bagjola canal has capacity to carry only about one-half to one-quarter of the estimated runoff from the IWWD-designated catchment areas; hence substantial additional channel capacity will be required to meet Master Plan design criteria.

A system of underground drains, pump stations, and force mains (originally planned by the CMPO) is presently being constructed in the Belgachia-Jessore Road under the authority of the Government of West Bengal Public Health Engineering Directorate (PHE). The details of this system are discussed in Chapter 19 of this report. Prior to the start of construction of the above works a detailed review was made of the PHE proposals and various changes recommended. The majority of the Jessore Road facilities will be converted to separate sanitary sewers and integrated into the Master Sewerage Plan for the Dum Dum Zone. The only facility converted to drainage will be one of the two parallel 60-inch RCP gravity lines.

Master Plan design criteria for estimating storm runoff include the adoption of the two-month storm frequency with a 15-minute inlet time and an assumed cover of 70 per cent roofs and pavements, in the densely populated areas of the basin. A roofs and pavements value of 30 per cent was used in the relatively unpopulated areas. Because of the relatively large size of the Bagjola Basin, a rainfall distribution factor of 80 per cent has been applied to the estimates of runoff for the lower channel reaches (tributary areas greater than 2,000 acres). In addition to the Bagjola Canal, the Bagjola Basin is served by two other major drainage outlets, the Hooghly River and the Krishnapur Canal. Based on a detailed study of river elevations a design water level of 11.00 GTS was set for gravity discharges into the Hooghly River. A design level of GTS 6.50 was set for the Krishnapur Canal.

For purposes of drainage planning the Bagjola Basin was divided into two major sub-basins (Figure 20-16). Sub-basin 1 is that portion of the Bagjola Basin discharging to the Hooghly River, and Sub-basin 2 is the portion tributary to the Bagjola Canal. The Master Plan proposals for Sub-basin 1 are shown in Figure 20-17.

In the design of drainage facilities in Sub-basin 1 first consideration was given to those areas with sufficient elevation and sufficiently close to the Hooghly River to be drained into the Hooghly River by gravity. Drainage in these areas was accomplished by a number of parallel major interceptors which run from east to west starting at Cossipore Trunk Road and terminating at the river. It is proposed that underground pipe drains be provided in the following locations.

- (1) Paramanik Ghat Road (Line A).
- (2) Ratan Babu Ghat Road (Line B).
- (3) Rustamji Parsi Road (Line C).
- (4) Jhil Road (Line D).
- (5) Dilarjung Road (Line E).

The remainder of the Sub-basin 1 area is serviced by three pump stations, one located in Gun Foundry Road (Pump Station 1), a second in the vicinity of Vivekananda Bridge (Pump Station 2), and the third in the vicinity of Nanda Banerjee Road (Pump Station 3). The details of the pumping facilities and appurtenant intercepting drains are shown in Figure 20-17.

The Master Plan proposals for facilities in Sub-basin 2 are shown in Figure 20-18. The principal feature of the Sub-basin 2 drainage improvements is the proposed new Bagjola Canal (Line J). A profile of the proposed canal is shown in Figure 20-19 and a typical cross-section of the proposed channel is shown in Figure 20-20. The proposed Bagjola Canal is a rectangular section with brick retaining walls and an unlined bottom ($n = 0.025$). Using this type of cross-section all reaches of the proposed channel can be fit into the existing Bagjola Canal right-of-way (Figure 20-19); hence no additional land will be required. A pump station is proposed at the lowermost reach of the canal, and downstream of the main pump station (Pump Station 1) it is proposed that the flow from the Bagjola Canal be split into two parts. A discharge equal to its design capacity (665 cfs, i.e., 485 cfs drainage plus 180 cfs sewage) will be pumped into the Bagjola Ghunijatragachi Canal and the remaining flow 865 cfs (1,530 minus 665) will be bypassed into the Krishnapur Canal. Studies of the Krishnapur Canal made in conjunction with Salt Lake Area drainage designs indicate that the Krishnapur Canal has the capacity to handle this additional flow.

Presently the westerly portion of Sub-basin 2 (Figure 20-16) is extensively developed and it is anticipated that development in this area will continue at a high rate. Because of this factor, drainage studies in the westerly portion of Sub-basin 2 were carried out in considerable detail. Major drainage interceptors have been proposed in the following locations (Figure 20-18):

- (1) Nilgunge Road, Kamarhati (Line A).
- (2) Bon Hooghly Scheme Road, Baranagar (Line B).
- (3) Nawpara Road, Baranagar (Line C).
- (4) Following the alignment of the 7 ft x 3 ft existing drain in Baranagar (Line D).
- (5) Dum Dum Road/J.K. Mitter Road, Chitpore area (Line E).
- (6) Urakanta Sen Lane, Chitpore area (Line F).
- (7) Belgachia Road/J.K. Mitter Road, Chitpore area (Line H).
- (8) Outfall channel for interceptors E, F, and H above (Line G).

Because of the more open nature of the easterly portion of Sub-basin 2, Master Plan proposals in this area will be limited to the preliminary design of lead channels connecting to the Bagjola Canal. Based on a preliminary reconnaissance of the area and a study of the IWWD's recommendations, the easterly side of Sub-basin 2 has been divided into three sub-drainage areas. The locations and design details of the three lead channels (Channels, K, L, and M) serving the easterly side are shown in Figure 20-18.

Construction costs of the drainage improvements for the Bagjola Basin are estimated as follows:

<u>Unit Designation</u>	<u>Millions of Rs.</u>
<u>Sub-basin 1</u>	
(a) Master Plan Drainage Facilities	13.72
(b) Secondary Drainage Facilities	28.00
<u>Sub-basin 2</u>	
(a) Master Plan Drainage Facilities	21.30
(b) Secondary Drainage Facilities	110.00
Total	<u>173.02</u>

Khardah Basin

The general location of the Khardah Basin is shown in Figure 16-4. The Khardah Basin is located on the east bank of the Hooghly River about four to six miles north of Calcutta. The Khardah Basin has a total area of about 8,800 acres and includes the Khardah and Titagarh municipalities, portions of the Barrackpore and Panihati municipalities, and a portion of the rural area in the Khardah and Titagarh Thanas. The western portion of the basin, particularly that area located between the Eastern Railway tracks and the Hooghly River, is extensively developed. The eastern portion of the basin is generally low lying and relatively undeveloped.

Two relatively small existing drainage channels, the Khardah Khal and the Titagarh Khal, are located within the Khardah Basin. Both of these drain into the Hooghly River and are tidal. The IWWD has developed schemes for the resectioning and improvement of both channels based on the recommendations of the Greater Calcutta Drainage Plan of 1953. For the following reasons, the IWWD proposals for the Khardah Basin proved inadequate:

- (1) The IWWD estimates of design stormwater runoff for the majority of the basin area were based on a fixed runoff rate of $3/32$ inch per hour ($1/8$ inch per hour less 25 per cent). In the Master Plan proposals, based on the rational method employing a two-month storm frequency, runoff rates vary from $1/2$ inch per hour to about $1/6$ in per hour, or are about two to four times as large as those used by the IWWD.
- (2) The storage capacity of the IWWD-designed channels is not sufficient to store the quantity of water which would runoff during the period the channel is tide-locked. Thus unless additional reservoir capacity or a pumping station is provided, the system will fail under design conditions resulting in indiscriminate flooding of low areas.

Master Plan design criteria for estimating storm runoff include the adoption of the two-month storm frequency with a 15-minute inlet time, and

an assumed cover of 70 per cent roofs and pavements in the densely populated portions of the basin (located west of the Eastern Railway line) and 40 per cent of the remainder of the basin area (Figure 20-22).

For purposes of drainage planning the Khardah Basin was broken down into three sub-basins. Sub-basin 1 is that portion of the basin which is tributary by gravity to the Hooghly River, Sub-basin 2 is that portion which is tributary to the Khardah Khal, and Sub-basin 3 is that portion which is tributary to Titagarh Khal. The location and boundaries of the three sub-basins are shown on Figure 20-23.

The Sub-basin 1 drainage facilities consist of a network of 14 parallel interceptors running east to west and discharging by gravity into the Hooghly River. It is proposed that major underground drains be provided in the following locations (Figure 20-24):

- (1) Peary Bostom Ghat Road (Line P).
- (2) Elias Road (Line O).
- (3) Haladhar Chatterjee Road (Line N).
- (4) Joy Pal Roy Chowdhury Road (Line M).
- (5) Western Extension of Sodepur Station Road (Line L).
- (6) Harish Chandra Dutta Road (Line K).
- (7) Gopal Chandra Chatterjee Road (Line J).
- (8) Panchanan Tola Road (Line I).
- (9) Nathu Pal Ghat Road (Line H).
- (10) Bhattacharjee Para Road (Line G).
- (11) Sham Sundar Ghat Road (Line F).
- (12) Biswas Ghat Road (Line E).
- (13) Bishalakshi Ghat Road (Line D).
- (14) Annapurna Devi Road (Line C).

The drainage of Sub-basin 2 will be accomplished by construction of a major outfall channel along the alignment of the existing Khardah Khal. The proposed channel will begin at Khebla Bil and flow from east to west discharging into the Hooghly River. The proposed Khardah drainage channel (Line A) will serve a tributary area of about 6,300 acres. A profile and typical cross section of the proposed channel are presented in Figure 20-25.

The drainage of Sub-basin 3 will be accomplished by construction of a major outfall drain along the alignment of the existing Titagarh Khal. The proposed Titagarh Drainage Channel (Line B) will begin at Dankuni Bil and flow east to west discharging into the Hooghly River. The Titagarh drainage channel will serve a tributary area of about 1730 acres, with a profile as shown in Figure 20-25.

Construction costs of the drainage improvements for the Khardah Basin are estimated as follows:

<u>Unit Designation</u>	<u>Millions of Rs.</u>
<u>Sub-basin 1</u>	
(a) Master Plan Drainage Facilities	2.51
(b) Secondary Drainage Facilities	8.00
<u>Sub-basin 2</u>	
(a) Master Plan Drainage Facilities	10.66
(b) Secondary Drainage Facilities	63.00

<u>Unit Designation</u>	<u>Millions of Rs.</u>
<u>Sub-basin 3</u>	
(a) Master Plan Drainage Facilities	2.75
(b) Secondary Drainage Facilities	17.00
	<hr/>
Total	103.92

CHAPTER 21 - OUTFALL CHANNEL

Existing Facilities

Storm waters from Palmersbridge and Ballygunge pumping stations and combined flow from the Maniktala area are presently pumped into a series of open channels which meet at Bantala, a point some six miles east of the Calcutta urban areas. Dry weather flow from the Town and Suburban Systems is pumped into a separate dry weather flow channel which connects with the other channels in the general vicinity of Bantala. From this point, the combined discharges (together with storm runoff from other adjacent rural areas) flow some 17 miles in an easterly direction to the Kulti River, and thence to the Bay of Bengal.

No treatment of sewage is provided, although a semi-abandoned primary sewage treatment plant exists at Bantala. Because the Kulti River is tidal, sluices have been constructed at the channel outfall point to prevent the entry of river waters into the channel system. The channel is designed with sufficient storage capacity to act as a reservoir when river stage elevations are too high to permit discharge.

Proposed Improvements

It is recommended that the existing general arrangement for disposal of sewage and storm runoff from Calcutta, Maniktala, and adjacent areas be continued. It is further recommended that the system be enlarged to include similar flows from the Tollygunge-Panchannagram area and from parts of the Salt Lake Township. Such recommendations will involve a continuation and enlargement of earlier proposals to improve the channel system.

Inasmuch as existing system constitutes an acceptable means of disposing of sewage, treatment is not recommended in the foreseeable future. Nevertheless, it is considered desirable to acquire a sewage treatment plant site on presently undeveloped land at Topsia Point A, to cover the eventuality that treatment may be required at some future date.

More specifically, Master Plan recommendations are listed as follows:

- (a) Renovate the Kulti outfall sluice structures.
- (b) Complete a dredging program for the storm water channels.
- (c) Abandon the Bantala sewage treatment plant.
- (d) Acquire a site for a possible sewage treatment plant at Topsia Point A.
- (e) Obtain accurate records of river elevations at the Kulti outfall.
- (f) Obtain accurate records at all points where substantial quantities of runoff will enter the outfall channel system.
- (g) Undertake engineering studies to be used as a basis for subsequent redesign of the outfall channel system.

(h) Redesign and reconstruct outfall channel system.

Costs for these works, including engineering studies, design, and construction are estimated at Rs. 20.0 million.

RECOMMENDATIONS

It is recommended that the conclusions outlined in Chapter 23, entitled "Summary and Conclusions", and described in greater detail under appropriate headings elsewhere in the report, be accepted and that the proposed works be undertaken. Because this program of reconstruction and development is large, and substantial improvements are urgently required in many areas, a detailed selection of project priorities is of necessity a matter for appropriate authorities to decide. With the above in mind, recommendations are presented as a guide for the Fourth and Fifth Plan periods only, with recognition that selection of priorities will be the responsibility of the Government of India. It is recommended that local engineering, construction, and manufacturing resources be effectively expanded to design and construct the vast mass of secondary facilities without which adequate water supply, sewerage, and drainage facilities cannot be effectively improved.

The recommended works for the Fourth Plan period are as follows:

- (a) Completion of the Interim Groundwater Program.
- (b) Improvements to the Calcutta secondary distribution system.
- (c) Improvements to secondary sewerage and drainage facilities of the Town and Suburban Systems.
- (d) Design and construction of secondary sewerage and drainage facilities in Tollygunge, Maniktala, Salt Lake Township, and Howrah.
- (e) Design and construction of secondary sewerage facilities in Dum Dum.
- (f) Interim Phase improvements at Palta Waterworks.
- (g) Renovation of the Calcutta water transmission facilities.
- (h) Interim Phase improvements to the Calcutta distribution system.
- (i) Improvements to major facilities in the Town and Suburban Systems.
- (j) Trunk systems and other major sewerage and drainage facilities in Tollygunge, Maniktala, Salt Lake Township, Howrah, and Dum Dum (sewerage only).
- (k) Calcutta outfall channels.

A similar program, suitably expanded, is recommended for the Fifth Plan period as follows:

- (a) Design and construction of secondary water distribution facilities in all Water Service Districts.
- (b) Further improvements to secondary sewerage and drainage facilities in the Town and Suburban Systems (including drainage in parts of South Suburban).
- (c) Further additions to secondary sewerage and drainage facilities in Tollygunge, Maniktala, Salt Lake Township, and Howrah.
- (d) Secondary facilities in Topsia, Dum Dum, and Garden Reach.
- (e) Secondary drainage facilities in the Bagjola and Manikhali basins.

- (f) Waterworks expansions at Palta, Baranagar-Kamarhati, Garden Reach, Serampore, and New Howrah.
- (g) Primary distribution grids and related facilities in Palta, Calcutta, Garden Reach, Serampore, and Howrah Service Districts.
- (h) Improvements and additions to major facilities in the Calcutta Town and Suburban Systems (including drainage in parts of South Suburban).
- (i) Trunk systems and related sewerage and drainage facilities in Tollygunge, Maniktala, Salt Lake Township, Topsia, and Howrah.
- (j) Trunk sewers and related facilities in Dum Dum and Garden Reach.
- (k) Trunk drains and related facilities in the Bagjola and Manikhali basins.
- (l) Calcutta outfall channels, etc.