THE BASIC DESIGN REPORT
ON
THE ESTABLISHMENT PROJECT FOR WATER SUPPLY FACILITIES
IN
THE PEOPLE'S REPUBLIC OF BANGLADESH

(7 Towns)

DECEMBER, 1984

Japan International Cooperation Agency

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P R E F A C E

In response to the request of the Government of the People's Republic of Bangladesh, the Government of Japan decided to conduct Basic Design Study on the Establishment Project for Water Supply Facilities and entrusted the study to the Japan International Cooperation Agency (JICA). The JICA sent to Bangladesh a study team headed by Mr. Yutaka Hosono, Deputy Director of Grant Aid Dept., JICA, from March 31st to June 13th, 1984.

The team had discussions with the officials concerned of the Government of Bangladesh and conducted a field survey in Narayanganj, Narsingdi, Jenidah, Chuadanga, Gaibandha, Kurigram, Feni and Sunamganj.

After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that his report will serve for the development of Project and contribute to the promotion of friendly relations between our two conntries.

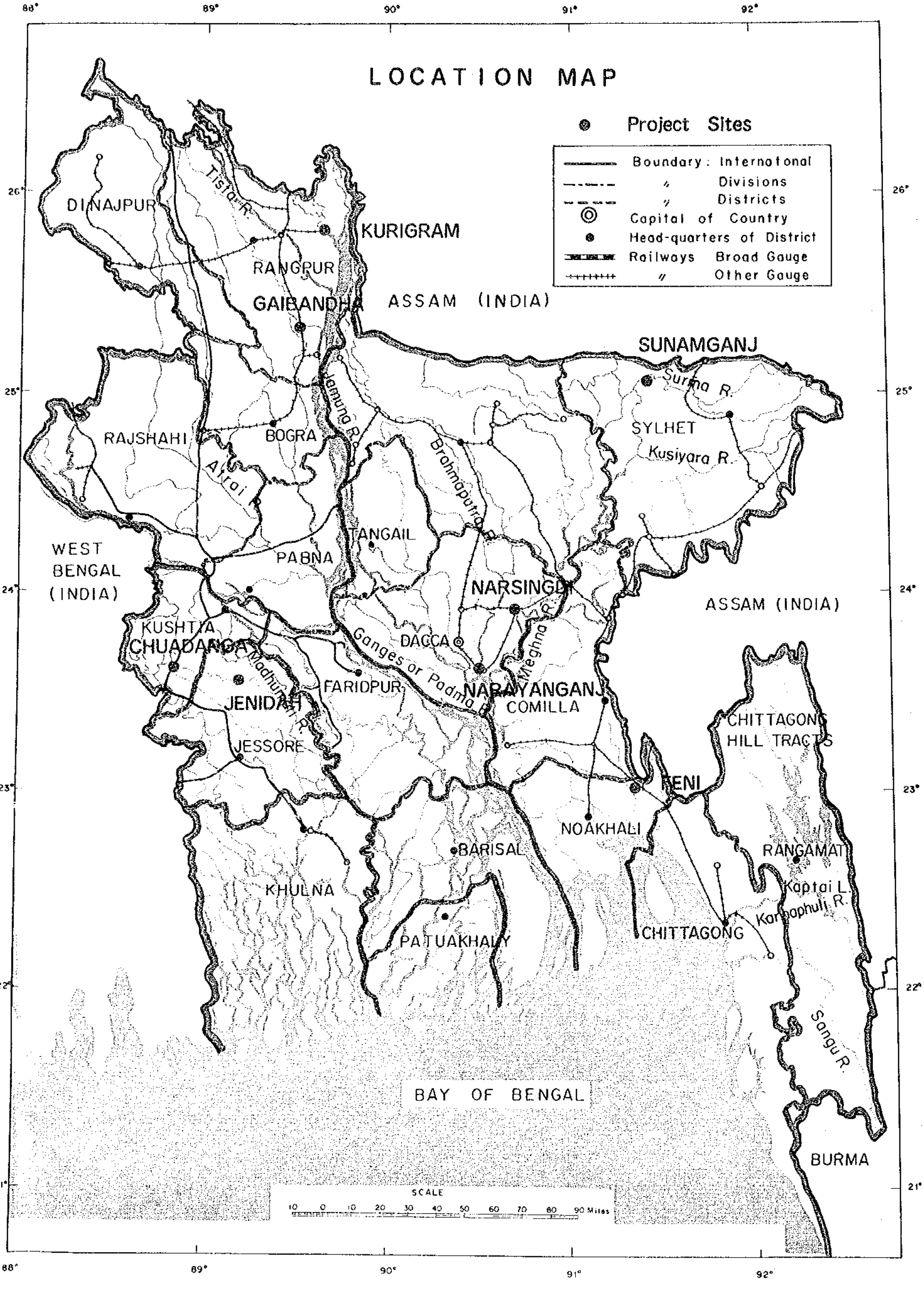
I wish to express my deep appreciation to the officials concerned of the Government of the People's Republic of Bangladesh for their close cooperation extended to the team.

December, 1984

Keisuke Arita

President

Japan International Cooperation Agency


LOCATION MAP
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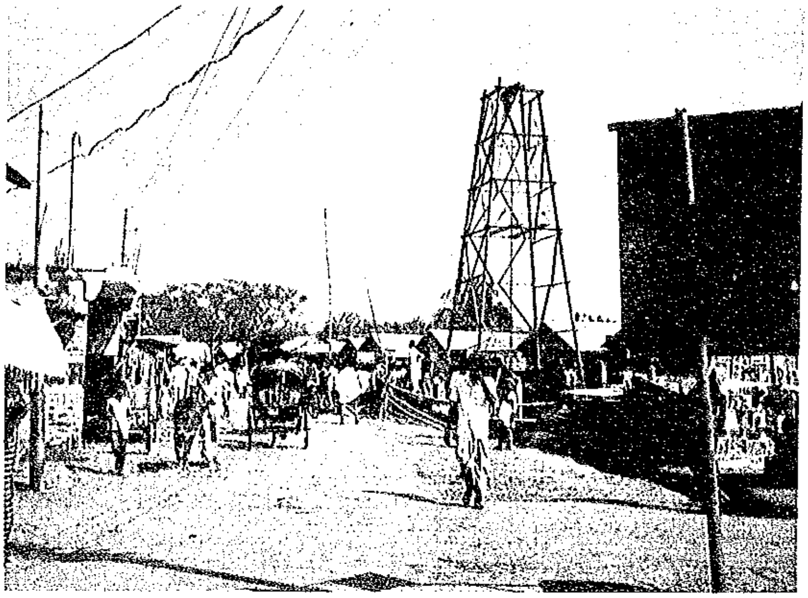
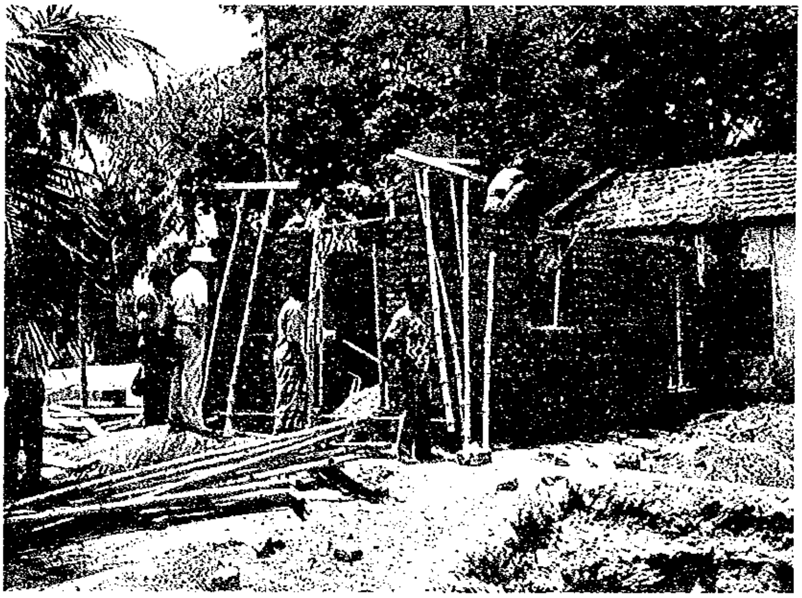
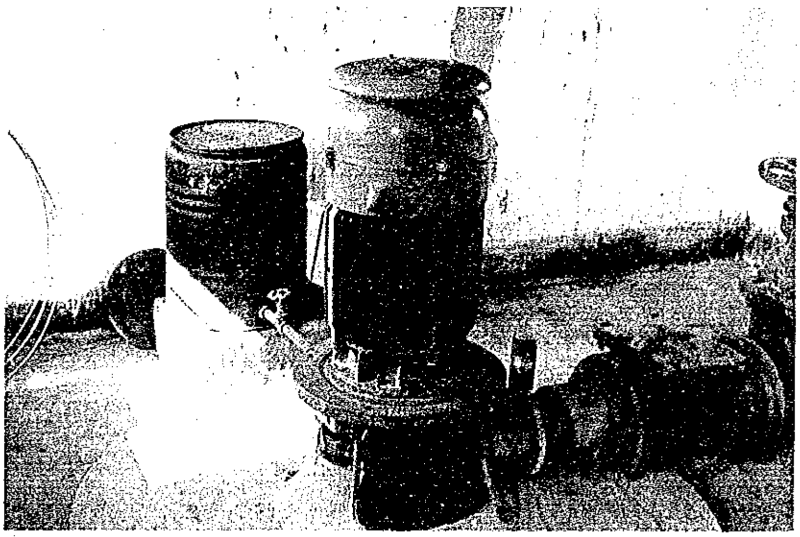


A Production well under construction by DPHE (Narsingdi)



A pump house under construction by DPHE (Chuadanga)



A pumping-up motor at a production well constructed by DPHE (Narsingdi)

A public post on service
constructed by DPHE (Jenidah)

A street scene in
Gaibandha Town

A street scene in
Feni Town

S U M M A R Y

The great majority of the people in Bangladesh are using shallow wells, rivers, ponds or the standing water as the water for their living. Tose water sources are polluted with human waste. It is said that 80% of diseases in Bangladesh are related with the water, with 30% of children's deaths are associated with diarrhea caused by the water. The amount of water supply from those sources is also short, and the insurance of adequate water supply for lives of the people is difficult.

In order to improve living environments for the people, the government of Bangladesh is striving for the construction of water supply facilities to ensure safe and hygienic drinking water and improvement of sanitary facilities. As for the drinking water, the construction and improvement of the piped water supply system are being promoted for urban areas and the construction of hand pump tube wells for rural areas.

The drinking water supply operation is done by two organizations namely department of Public Health Engineering of Ministry of Local Government, Rural Development & Cooperatives and Water and Sewage Authorities (WASA) in Bangladesh. The WASA covers two major cities of Dhaka and Chittagong only, while the DPHE covers the whole nation.

The WASA, with aids from the World Bank, is carrying out the operation of piped water supply system, while the DPHE is doing the same with aids from the Asian Development Bank (ADB), UNICEF, Netherland, etc. For the district town and the sub-divisional town (currently included in the district town) consisting of 64 towns, the DPHE is planning 10 water supply schemes, of which nine schemes

are currently at the implementation stage. Of such nine schemes, six schemes (for 30 towns) are being implemented by aids of Netherland and ADB, and remaining three schemes (for 32 towns) are being implemented by the national funds of the Bangladesh Government alone. The UNICEF is giving the aid for the construction of hand pump tube wells in rural Area.

While the progress of schemes under foreign nations' aids is said to be 60% or more of the target, the progress of schemes by the Bangladesh national funds is within the range of 24 to 35% due to inadequate provision of GOB Fund. An adquate budgeting cannot be expected from the Bangladesh Government in coming years, so that substantial delays are anticipated in the completion of projects. The improvement of water supply facilities would not be sufficient enough to cope with the rise in demand for drinking water due to the increase in population, and the gap between supply and demand would tend to widen rather than narrow each year.

The Bangladesh Government, placed under such a dielemma, requested the Japanese Government to provide them with funds without compensation for the water supply shceme to cover 27 sub-divisional towns (now included in the district town) out of three schemes being implemented by the national funds.

In response to the request, the Japanese Government decided to carry out a preliminary study , that was done by the Japan International Cooperation Agency.

In this preliminary study , the Bangladesh Government made additional requests for following two projects.

(1) Narayanganj Town Water Supply Project (one of projects being implemented by the national funds); and

(2) Sanitary Facility Improvement Project

As a result of the preliminary study , the Japanese Government recognized the necessity and appropriateness of a basic design study , and decided to carry it out for following eight towns.

(1)	Narayanganj Town	(5)	Gaibandha Town
(2)	Narsingdi Town	(6)	Kurigram Town
(3)	Jenidah Town	(7)	Feni Town
(4)	Chuadanga Town	(8)	Sunamganj Town

In line with the decision, the Japan International Cooperation Agency sent the "Basic Design Study Team on the Establishment Project for Water Supply Facilities" to Bangladesh from March 31, 1984, to June 13, 1984, in order to have the study team consulted with the concerned Ministry and Agency in Bangladesh and to collect data and to carry out the investigation.

The Basic Design Study Team prepared the Drinking Water Supply Facility Improvement Project documents for the eight towns. Of the eight projects, the project document for Narayanganj Town had been prepared separately from the rest. The project documents for the remaining seven towns had been prepared in this Report.

The design conditions for the preparation of the drinking water supply project are as follows;

(1) Planned target fiscal year: 1990

(2) Planned water supply quantities:

(a) 50% of the population subject to water supply is assumed to be done by means of house connection: 90 liters per person/day (20 gpcd)

(b) Remaining 50% of the population subject to water supply is assumed to be done by means of public post: 34 liters per person/day (7.5 gpcd)

(c) 30% of the sum of the (a) and (b) above is estimated as the loss.

(3) The underground water is to be used, as a rule, as the water source, that will be taken from deep wells. For Sunamganj Town, where the underground water is not appropriate as the water source, the river water will be used as the water source. Therefore, water purification plants are planned. If groundwater is required to be treated, water purification plant will be incorporated.

(4) For the water distribution piping, PCV pipes produced in Bangladesh will be used. Layout of pipeline networks and location of overhead tanks, etc. were determined based on the results of hydraulic studies. The PVC pipes produced in Bangladesh is 200 mm or less in caliber. Therefore, cast iron pipes will be used where pipes of 250 mm or greater in caliber are requred for distributing water.

(5) Overhead tanks will be made of reinforced-concrete, with the capacity of 20% of the daily water supply quantity. The height will be based

on the hydraulic calculation, with the average height of 17.0 m. The height of No.1 Water Tower in Kurigram, however, will be 22.0 m.

(6) As for the pumping facilities, the multi-stage turbine pumps will be used, and motors will be used as prime movers, both of which are procurable in Bangladesh.

The contents of the proposed drinking water supply projects on the basis of the above design conditions and the present status of drinking water supply facilities already completed by DPHE are as shown on Table 1.

The part of the project cost to be borne by the Bangladesh Government will be 105.2 million TK, and the operation and maintenance cost of them will be 13.1 million TK per year.

The project will be implemented by the Department of Public Health Engineering in association with Japanese Consultant and Construction Firm. The counterpart staff of the Department of Public Health Engineering required for implementation, operation and maintenance of water supply project of the proposed towns should be provided.

It was recognized according to findings obtained by the investigation and studies that stable, safe and clean water supply could be ensured for residents of the towns concerned under the project. The living level of the residents will be also stabilized and improved, with significant improvements in health and hygienic living environments. Moreover, the development and progress of each local city are expected to be promoted, with sufficient appropriateness of this project recognized.

As regards the additional requests placed by the Bangladesh Government at the time of preliminary survey, however, the sanitary facility/improvement project was found to have following shortcomings.

(1) The basic plan of hygienic treatment of human waste does not exist in the district towns except Dhaka.

(2) The water seal latrine is done by penetrating human wastes in the soil. Therefore adequate investigation and studies will be required in relation to shallow wells, relative locations of water seal latrines and washing/bathing ponds, etc. as well as their elevations, possible occurrence of floods, etc.

(3) Comparative studies with other human waste treatment methods are also required.

Due to the reasons mentioned above, it would be proper to eliminate the additional projects from the current cooperation project in the form of grants in aid.

In conclusion, prompt solutions of pending matters on the part of the Bangladesh Government are strongly desired upon implementation of this project.

Table 1 Present Status, Contents of Water Supply Facilities completed by DPHE and Contents of Proposed Water Supply Project For Seven Towns

Item		Town	Narsingdi	Jenidah	Chuadanga	Kurigrm	Gaibandha	Feni	Sunamganj
Present Status of Towns		Location	It belongs to the Dhaka Division, located about 40 km northeast of Dhaka, at the right bank of Magna River.	It belongs to the Khulna Division, located 50 km north of Jensore City.	It belongs to the Khulna Division, located 40 km west of Jenidha, near the boarderline to India.	It belongs to the Rajshahi Division, located 40 km east of Ramgpur, being adjacent to India across the Jamna River.	It belongs to the Rajshahi Division located 60 km south-east of Ramgpur, near the Jamna River.	It belongs to the Chittagong Division, located 70 km south of Comila.	It belongs to the Chittagong Division, located 70 km north-west of the Northern East Region of Sylhet, near the boarderline with India.
		Population (1984)				55,000	45,000	27,000	25,000
		Area of Town				20.7	6.0	6.5	2.6
		Major industries	Textile industry is active, accounting for the vital portion of the businesses. In-house industry is also active. A number of brick factories are located in the vicinity.	No large plant available, but it is located at a vital point along the Khulna Path. Busy commercial activities.	No large factories/plants. Busy commercial activities.	Agriculture produce collecting/distribution site, including jute, etc. Busy commercial activities.	An old site for the collection/distribution of agricultural produce. Busy commercial activities.	Located along the trunk road of Dhaka-Chittagong. There are 20 small biscuit factories, etc. though no big factories/plants are available. Busy commercial activities.	A big fish processing factory is under construction. About 25 small rice mills, wood mills, brick factories, etc. are present.
	Status quo of drinking water supply	Operating Conditions of DPHE water supply facilities	No water supply service at present.	water is supplied at the daily rate of 45,000 galons by the operation of 3 hours. 85 house connections; 5 public posts.	No large factories/ at present.	No water supply service at present.	No water supply facilities at present.	6 hour water supply per day. 200 house connections & 10 public posts.	No water supply service at present.
		Hand pump	764 pumps (399 pumps for the DPHE & 365 pumps at the site) Average depth 120 feet (36 m)	397 pumps for the DPHE, Average depth 140 feet (42 m)	160 pumps for the DPHE, Average depth 125 feet (37.5 m)	330 pumps for the DPHE, Average depth 50 feet (15 m)	150 pumps for the DPHE, Average depth 46 feet (13.8 m)	368 pumps for the DPHE, Average depth 67 feet (20 m)	170 pumps (100 pumps for the DPHE & 70 pumps for individual) Average depth 500 feet (150 m)
		Deep tube well	2 wells at the plant, 1 well each for the C & B and the railroad	Total 3 wells at the WDB, hospital & college	Total 3 wells, at the WDB, railroad & hospital	I well at the C & B.	Total 2 at the PWD & NDTI	No well in the town	ø4", aver. depth 500ft (150m), Wells? 7(Hospital, public official residence, etc.)
		Water sources for washing & bathing	Same as left.	Same as left.	Same as left.	Same as left	Same as left	Same as left.	Same as left
Contents of Water Supply Facilities Completed by DPHE as of June, 1984	Production Well	Dia.(mm) x Depth(m)	ø150 x 130(average)	ø150 x 125(average)	ø150 x 103(average)	ø200 x 43	Non	ø150 x 168 (average)	ø150 x 210
		No.	2	2	2	1		2	1
		Daily Supply Water(m^3)	No water supply	200m^3/day	No water supply	No mater supply		m^3/day	No mater supply
		Pump Facilities (No.)	1	1	1	1 (Diesel engine)	Non	2	1
	Distributing Pipes	Kind of Pipe	AC and PVC Pipe	PVC Pipe	PVC Pipe	AC and PVC Pipe	Non	AC and PVC Pipe	PVC Pipe
		Dia.(mm)	ø100 - 200	ø100 - 200	ø100 - 200	ø100 - 200		ø100 - 200	ø150
		Total Length(m)	2,993	6,637	6,204	3,830		8,945	1,806
		House Connection (No.)	0	85	0	0	0	200	0
		Public Post (No.)	6	5	0	20	0	10	0
		Overhead Tank	0	0	0	0	0	0	0
Contents of Proposed Water Supply Project		Town Population at 1990	165,000	116,000	81,000	78,000	64,800	40,000	37,000
		Population supplied at 1990	152,700	69,000	68,000	48,000	54,000	40,000	37,000
		Service Area (ha)	810	470	350	310	290	360	360
		Proposed Daily Supply ater(m^3)	12,369	5,589	5,508	3,888	4,374	3,240	2,997
	Production Well	Dia. of Well(mm)	ø150	ø150 - 200	ø150 - 200	ø200	ø200	ø150	Water Purification Plant
		Depth (m)	115 - 169	125 - 132	102 - 123	43 - 73	105	144 - 219	5,300 m^3/day
		Yield per one well (m^3/hr)	45 - 90	110 - 180	130 - 180	180	150	85	
		No. of Well	14	3	3	2	3	4	
	Pump Facilities	Kind of Pump	Turbine Pump	Turbine Pump	Turvine Pump	Turbine Pump	Turbine Pump	Turbine Pump	
		Output of Motor (kw)	15 kw x 8 Nos. 19 kw x 6 Nos.	30 kw x 3	30 kw x 3	30 kw x 2	30 kw x 3	15 x 3 19 x 1	
		No. of Pump	14	3	3	2	3	4	
	Transmission Pipes	Kind of Pipe	DCIP	DCIP	DCIP	DCIP	DCIP	DCIP	DCIP
		Dia. (mm)	ø150 - 250	ø200 - 250	ø200	ø200	o150 - 300	ø150 - 250	ø150 - 250
		Total Length (m)	4,930	1,260	390	80	1,270	1,150	1,390
	Overhead Tank	Total Capacity (m^3)	2,500	1,200	1,200	800	900	700	600
		Capacity x No.	500 x 5	400 x 3	400 x 3	400 x 2	400 x 1 500 x 1	200 x 2 300 x 1	400 x 1 200 x 1
		Height (m)	17	17	17	17 and 21	17	17	
	Distributing Pipes	Kind of Pipe	DCIP and PVC Pipe	PVC PIPE	PVC Pipe	PVC Pipe	PVC Pipe	PVC Pipe	PVC Pipe
		Dia. (mm)	ø100 - 250	ø100 - 200	ø100 - 200	ø100 - 200	ø100 - 200	ø100 - 200	ø100 - 200
		Total Length (m)	44,453	26,757	24,064	27,220	24,470	25,715	23,396
		House Connection	0	0	0	0	0	0	0
		Public Post	10	10	10	10	10	10	10

THE BASIC DESIGN REPORT ON THE

ESTABLISHMENT PROJECT

FOR

WATER SUPPLY FACILITIES IN THE PEOPLE's

REPUBLIC OF BANGLADESH

(7 TOWNS)

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LIST OF DRAWINGS

Abbreviations

GOB	:	Government of Bangladesh
GOJ	:	Government of Japan
M.L.G.R.D.C. & R.A.	:	Ministry of Local Government, Rural Development, Cooperatives and Religious Affairs
L.G. Div.	:	Local Government Division
DPHE	:	Department of Public Health Engineering
WASA	:	Water and Sewage Authorities
EPCB	:	Environment Pollution Control Board
CE	:	Chief Engineer
SE	:	Superintending Engineer
EE	:	Executive Engineer
SDE	:	Sub-Divisional Engineer
SAE	:	Sub-Assistant Engineer
G.W. & E.	:	Ground Water & Exploration
SIR	:	Survey, Investigation & Research
P&C	:	Programme & coordination
V.S.	:	Village Sanitation
ADB	:	Asian Development Bank
UNICEF	:	United Nations Children's Fund (former United Nations INternational Children's Emergency Fund)
WHO	:	World Health Organization
W/S Scheme	:	Water Supply Scheme

Exchange Table

1 in = 25.4 mm

1 ft = 12 in = 30.48 cm

1 yd = 3 ft = 91.44 cm

1 mile = 1,760 yd = 5,280 ft = 1.60934 km = 1,609.34 m

1 acre = 43,560 ft^2 = 4,046.86 m^2 = 40,4686 a = 0.00405 km^2

1 $mile^2$ = 640 acre = 25,899.9 a = 2.58999 km^2

1 ft^2 = 144 in^2 = 0.09290 m^2

1 in^2 = 6.4516 cm^2

1 yd^2 = 9 ft^2 = 0.83613 m^2

1 gal (1 mp. British) = 4.54596 liters = 0.00455 m^3

1 oz (ounce) = 28.3495 g

1 lb (pound) = 16 oz = 453.592 g = 0.45359 kg

1 long ton (British ton) = 1.01605 t

1 short ton (American ton) = 0.90718 t

gpcd : gallons per capita (per) day

gpd : gallons per day

lakh : 100,000 (one hundred thousand)

crore : 10,000,000 (ten million)

lac : lakh

CHAPTER 1 INTRODUCTION

The Government of Bangladesh is exerting efforts to improve and promote social welfare and public health so that its people might enjoy a healthy and civilized life. A part of its efforts as a result is being directed to implementing water supply improvement projects with the objective of supplying safe and clean potable water to the urban dwellers. In the two major cities of Dhaka and Chittagong, Water and Sewage Authorities (WASA) is in charge of implementing the water supply projects with the assistance of the World Bank while in the other district towns and sub-divisional towns (which are now district towns, too), Department of Public Health Engineering (DPHE) is undertaking those projects. There are altogether 66 district towns and sub-divisional towns combined, excluding Dhaka and Chittagong, and for these towns, DPHE has formulated 10 projects which it is now implementing. For six of these projects, the Netherlands and the Asian Development Bank (ADB) have promised to give their assistance while on one other project, DPHE is sounding out Denmark and Sweden in the hope of gaining their assistance. As for the other three projects, the Government of Bangladesh started out to execute them by its own funds, but because of financial difficulties it has become difficult to implement them according to plan. As a matter of fact, there is no prospect whatsoever that any of them would be completed by the initially scheduled target years. Because of this, the Government of Bangladesh has requested the Government of Japan for its cooperation in the form of grants in aid for the 27 Sub-Divisional Towns Water Supply Project which is one of the three projects which the Government of Bangladesh began implementing by its own funds.

In response to this request, the Government of Japan has decided to conduct a preliminary study, and the Japan International Cooperation Agency dispatch a Preliminary Study Mission to Bangladesh to confirm the contents of this request as well as conduct a survey and study of the project background, and the appropriateness of taking it up as a grant in aid program. The Mission has discussed the project with the concerned authorities of the Government of Bangladesh and has also collected relevant data and conducted field reconnaissance at four of the towns which had been selected from those covered by this project during the period from January 10 through January 27, 1984.

During this preliminary study, the Government of Bangladesh has requested Japan's cooperation on two additional projects, namely:

(1) Narayanganj Town Water Supply Project (which is one of the three projects which the Government of Bangladesh is implementing by its own funds)

(2) Sanitary Facilities Improvement Project

The water supply scheme for Rangamati town is politically a high priority project in terms of its being a countermeasure for the minority races and other reasons, but as of now, the Government of Bangladesh seems to have determined to implement it by it by its own funds instead of counting on any foreign aid.

Upon comiling the results of the series of discussions held with the concerned authorities of the Government of Bangladesh and selecting eight towns to be taken up for basic design study, the Mission has signed the minutes of the meeting.

The Government of Japan has had the Japan International Cooperation Agency conduct a basic design study of the eight towns based on the results of the preliminary study. The Basic Design Study Team was in Bangladesh from April 1, 1984, through June 12, 1984, and during this time it has collected data, carried out observations and conducted field reconnaissance which were necessary for developing the basic design for the eight towns selected in the preliminary study. It has also held consultations with the concerned authorities of the Government of Bangladesh. After returning to Japan, the team has made an analytical study of the hydrologic, geographic hydrographic data collected and put together its basic design study report as hereunder.

The eight towns for which the basic design was developed this time are as follows:

(1) Narayanganj
(2) Narsingdi
(3) Jenidah
(4) Chuadanga
(5) Gaibandha
(6) Kurigram
(7) Feni
(8) Sunamganj

The report on Narayanganj town has been compiled in a separate volume. This report therefore summarizes the water supply plan for the remaining seven towns.

CHAPTER 2 PROJECT BACKGROUND

2-1 Current Status of Potable Water Supply

The country of Bangladesh lies at the eastern tip of the Indian Sub-Continent. The country faces the Bay of Bengal in the south, is encircled by India on the west, north and east while a part of its southeastern tip borders on Burma.

Its territory is 144 thousand km² and its total population 92 million as of June, 1982. The country's population density is 639 people/km², which is the highest in the world. Approximately 90% of its territory consists of flat deltas formed by such big rivers as the Ganges, Jamuna, Meguna and Brahmaputra. The difference in elevation within 600 km in the south-north direction across its territorial land is about 40 m, and big rivers and their tributaries are reticulately interwoven over such a topography.

The type of soil may be classified into new alluvium composed of sand, clay and mud deposited by rivers in the delta plains, old alluvium in the western region where there is little rainfall, and laterite in the eastern and northern hilly zones.

The country has three seasons: the summer season (March through May), the monsoon rainy season (June through October) and the dry season or winter season (November through February). The annual average mean precipitation for the country as a whole is 2,300 mm, but the seasonal difference is violent as 90% of the rainfall is concentrated during the six months from May to October while only around

4% of it is during the dry season when the soil as a result becomes extremely dry.

The poor living conditions in the rural areas where most of the 90 million people of the nation live under severe natural conditions are causing many epidemics to break out.

As far as water use during the dry season is concerned, the shallow wells, the pools of water formed on the ground and the meager flow of river water are the only sources of household water supply for the local inhabitants. In regard to sanitation, human excrement is disposed of in latrines which are only shallow pots or simply disposed of out in the fields, while household water is allowed to soak into the ground about the houses to eventually find its way into the shallow wells, the pools on the ground and the rivers. It is the common use of such insanitary water that is causing the spread of epidemics. This is evident from the fact that 80% of diseases are relevant to water and that 30% of child deaths are caused by diarrhea.

By taking advantage of the fact that ground water is easily obtainable in Bangladesh because most of its territory lies over deltas wherein numerous rivers of varying sizes are interwined, the Government of Bangladesh is in the process of converting from the use of insanitary surface water as drinking water to the use of clean underground water as a measure to improve the nation's poor sanitary environment. It is along with this basic idea that the Government of Bangladesh is improving its piped water supply system in the urban areas where the population density is particularly high (district towns and sub-divisional towns) and building hand pumps for tube wells in the rural areas where the population density is relatively low. WASA in the two big cities of Dhaka and Chittagong among the urban areas is proceeding with its waterworks improvement projects under the assistance of the World Bank. In the district towns and sub-divisional towns (which are also district towns now) other than Dhaka and Chittagong, DPHE is pushing its waterworks improvement projects under the assistance of the Netherlands and ADB.

Although water is being supplied through piped water supply system in all of the district towns, the water supply pervasion rates range between 5 and 37%, the average being around 21.6%. Also in 25 out of 48 sub-divisional towns (which are now district towns, too), water supply is being carried out through piped water supply system, but the water supply pervasion rates range between 6 and 39% with the average being only 16%. (The state of piped water supply system in the district towns and sub-divisional towns are as shown in Tables 2-1 and 2-2.)

As above, the piped water supply system pervasion rates in the district towns and sub-divisional towns (which are also district towns now) are low, and the reality is that most of the inhabitants obtain their drinking water from hand-driven pumps of tube wells. The actual situation is that the sanitary environment centering around the household living water has hardly been improved that even today the rivers, ponds and pools on the ground are being used for washing and bathing.

As of July, 1983, a total of about 550 thousand hand pumps which pump up water from tube wells have been constructed by DPHE in the urban areas and rural areas combined. Of these, only 496 thousand pumps are in operation as about 10% (or 54,000 pumps) are already choked up. The number of hand pumps which pump up water from tube wells in various districts are as per Table 2-3.

Table 2-1 Status of Urban Water Supply as of June, 1983

(District towns)

Sl. No.	Name of Towns (District towns)	Total daily supply (lac gal.)	Ground water tube-wells (Nos.)	Surface water (Daily supply in lac gal.)	Overhead tank (capacity in (lac gal.)	Distribution line (Miles)	House connection (Nos.)	Street hydrant (Nos.)	Yard faucets (Nos.)	Estimated population in June'83 (lac Nos.)	Road (Miles)	Population served (%)
1	2	3	4	5	6	7	8	9	10	11	12	13
1.	Khulna	45	25	2.00	4.10	95.00	12,000	480	-	7.40	185	37%
2.	Rajshahi	18	12	-	4.50	40.00	2,210	266	-	3.34	70	27%
3.	Comilla	11	6	-	5.00	39.00	1,850	384	10	2.97	35	22%
4.	Mymensingh	13	8	-	5.10	21.00	1,450	255	100	3.28	45	17%
5.	Bogra	13	9	-	2.00	13.00	1,250	-	-	1.24	27	20%
6.	Jessore	9	9	-	-	23.50	1,800	40	300	2.84	48	19%
7.	Barisal	10	8	0.50	4.50	31.00	2,100	300	-	2.42	66	24%
8.	Sylhet	5	5	1.00	2.00	12.50	2,000	75	-	2.59	35	15%
9.	Maijdee	2	6	0.56	0.10	8.50	150	42	-	1.64	46	5%
10.	Tangail	4.50	5	-	1.00	9.00	1,000	15	4	1.19	44	24%
11.	Jamalpur	5.50	7	-	1.50	9.00	700	50	-	1.41	19	18%
12.	Dinajpur	4.50	5	-	2.50	16.75	525	28	40	1.52	36	30%
13.	Rangpur	4.50	4	-	1.50	25.50	808	4	200	1.33	44	18%
14.	Pabna	11	7	-	2.50	12.50	1,100	27	323	3.20	58	20%
15.	Kushtia	5	5	-	2.00	16.25	1,025	45	202	1.89	29	18%
16.	Faridpur	5	8	-	1.50	20.50	730	115	-	1.84	53	26%
17.	Patuakhali	4	5	-	1.00	12.50	525	38	84	0.62	18	29%
18.	Rangamati	3	2	2.00	10.00	7.60	700	32	-	0.57	10	20%

(Data acquired from DPHE)

Table 2-2 Status of Urban Water Supply as of June, 1983

[Sub-divisional towns (currently district towns, too)]

Sl No.	Name of town (Sub-Divisional towns)	Total daily supply (lac gal.)	Ground water tube-wells (Nos.)	Surface water (Daily supply in lac gal.)	Overhead tank (capacity in (lac gal.)	Distribution line (Miles)	House connection (Nos.)	Street hydrant (Nos.)	Yard faucets (Nos.)	Estimated population in June'83 (lac Nos.)	Road (Miles)	Population served (%)
1	2	3	4	5	6	7	8	9	10	11	12	13
1.	Narayangonj	25	10	15.10	5.17	71.75	3,200	2,200	-	2.98	140	30%
2.	Moulavibazar	2	2	-	-	5.00	620	20	-	0.17	25	6%
3.	Feni	2	2	-	-	5.50	60	-	-	0.23	20	6%
4.	Khagrachari	2	1	-	0.50	1.50	130	5	-	0.05	41	10%
5.	Jhenaidah	1	1	-	-	2.50	100	-	-	0.49	18	10%
6.	Meherpur	1	1	-	-	4.25	250	-	-	0.23	15	2%
7.	Manikgonj	2	2	-	-	4.90	238	7	-	0.38	22	8%
8.	Noagoan	2	3	-	-	2.50	-	-	-	0.52	23	8%
9.	Thakurgoan	1	2	-	-	5.00	-	-	-	0.25	17	6%
10.	Jhalakati	1	1	-	-	4.00	-	-	-	0.31	19	7%
11.	Nawabgonj	2	2	-	-	5.00	23	-	-	0.65	22	16%
12.	Natore	1	1	-	-	2.75	29	-	-	0.32	18	12%
13.	Sathkir	4	4	-	-	3.25	100	-	-	0.58	26	18%
14.	Bagerhat	2	-	2.00	-	3.50	-	-	-	0.38	30	32%
15.	Gazipur	0.50	1	-	0.50	3.00	191	12	-	0.60	25	6%
16.	Chandpur	6.00	1	4.50	2.25	13.00	1,250	300	-	0.80	80	24%
17.	B. Baria	2.80	3	-	-	6.00	750	50	-	0.89	30	20%
18.	Munshigonj	3.00	2	-	1.50	6.50	540	66	-	0.38	22	9%
19.	Kishoregonj	2.00	2	-	1.50	11.00	517	100	-	0.52	20	32%
20.	Cox's Bazar	2.00	3	-	-	7.00	128	-	-	0.30	26	25%
21.	Hobigonj	2.50	2	-	-	4.00	520	20	-	0.25	26	19%
22.	Sorajgonj	1.75	5	-	3	6.90	300	28	180	1.04	54	39%
23.	Madaripur	0.55	3	-	1.50	7.00	170	25	-	0.59	25	30%
24.	Rajbari	0.60	3	-	1	11.00	230	40	150	0.36	27	23%
25.	Gopalgonj	0.50	5	-	1.50	7.00	50	10	-	0.18	31	12%

Note: Piped water supply is not yet implemented in the sub-divisional towns not listed in this table.
(Data acquired from DPHE)

Table 2-3 Status of Tube Well as of 1st July, 1983 in Various Districts

(under DPHE)

Sl. No.	District	Total Tube Wells	Choked-up Tube Wells	Operable Tube Wells
1.	Dhaka	49,649	3,959	45,690
2.	Tangail	17,004	1,165	15,839
3.	Mymensingh	42,761	4,609	38,152
4.	Jamalpur	14,893	1,361	13,532
5.	Chittagong	29,209	4,421	24,788
6.	Rangamati	3,588	970	3,221
7.	Bandarban	1,277	367	910
8.	Comilla	44,637	3,439	41,198
9.	Noakhali	26,842	3,222	23,620
10.	Sylhet	35,160	4,238	30,922
11.	Rajshahi	38,108	2,677	35,431
12.	Pabna	22,991	1,237	21,754
13.	Bogra	19,510	2,110	17,400
14.	Rangpur	42,021	3,180	3,841
15.	Dinajpur	23,928	2,237	21,691
16.	Khulna	24,635	3,196	21,439
17.	Jessore	30,559	2,106	28,453
18.	Kushtia	16,409	1,053	15,356
19.	Faridpur	34,841	1,741	33,100
20.	Barisal	25,106	3,122	21,984
21.	Patuakhali	6,419	3,072	3,347
	Total	549,547	53,546	496,001

(Data acquired from DPHE)

2-2 Administrative System for Water Supply

Water supply operations in Bangladesh are carried out by the Department of Public Health Engineering (DPHE) which belongs to the Ministry of Local Government, Rural Development and Co-operatives and also by the Water and Sewage Authorities (WASA).

WASA is in charge of waterworks and sewage operations in the two major cities of Dhaka and Chittagong, while DPHE is responsible for such undertakings as water supply and sewage works, public health, flood discharge, etc. for all of Bangladesh with the exception of the aforestated two cities.

(1) DPHE

DPHE commenced its activities with the independence of Pakistan in 1947 and came to assume its current status after several organizational changes. In 1963, the water supply and sewage functions of the two major cities of Dhaka and Chittagong which had been under DPHE became independent and came to be called the Water and Sewage Authorities (WASA). Then in 1977, the water quality conservation function, Water Pollution Control (WPC) of DPHE also became an independent organization and was named Environment Pollution Control Board (EPCB).

The activities of DPHE pertain to water supply, sewage, sanitary facilities and flood discharge, but water supply and sewage in Dhaka and Chittagong are carried out by WASA although flood discharge in these two cities is the duty of DPHE.

The activities of DPHE's sanitary function may be broadly classified into the following two categories.

(1) Rural water supply and sanitation

(2) Urban water supply and sanitation

For rural water supply, DPHE provides water supply facilities such as shallow wells, deep wells, installing hand pumps, developing existing natural spring, installing deep well pumps and ring wells in the rural areas including Thana Headquarters, and these are being constructed mainly under the assistance of UNICEF.

As for urban water supply, it now covers 18 district towns and 48 sub-divisional towns (which are now district towns, too) excluding Dhaka and Chittagong, and in the future, it intends to expand its coverage to include Thana Headquarters. Urban water supply aims at improving the piped water supply facilities including water purification plants, production wells, distribution pipes, overhead tanks and pumping facilities.

In sanitation, DPHE's aim is to improve the sanitary facilities, and is advancing pilot programs to popularize the one-pit water seal latrine in the rural areas and the two-pit water seal latrine in the urban areas.

DPHE is headed by a chief engineer who is assisted by an additional chief engineer, and is organized by eight circles (headed by superintending engineers), 37 divisions (headed by executive engineers), 71 sub-divisions (headed by sub-divisional engineers) and 436 Thana Offices (headed by sub-assistant engineers). Its organization chart is as shown in Fig. 2-1.

The water supply projects in the sub-divisional towns (27 towns and Narayanganj which are now district towns) which are the objects of this study are under the jurisdiction of DPHE.

(2) WASA

WASA has been organized in the two big cities of Dhaka and Chittagong where it is undertaking water supply and sewage operations. WASA had been separated from DPHE in 1963 and, like DPHE, it is a public enterprise (authority) that belongs to the Ministry of Local Government, Rural Development and Cooperatives.

(a) Dhaka WASA

It supplies water to 2,500,000 people or 70 to 80% of Dhaka's total population of 3.5 million. The water sources are the 103 deep wells and one water purification plant from where 85 million gallons (390 thousand m^3) of water is supplied daily.

The sewage dissemination rate is about 40 to 45% now, but WASA aims at raising it to 80% by year 2010.

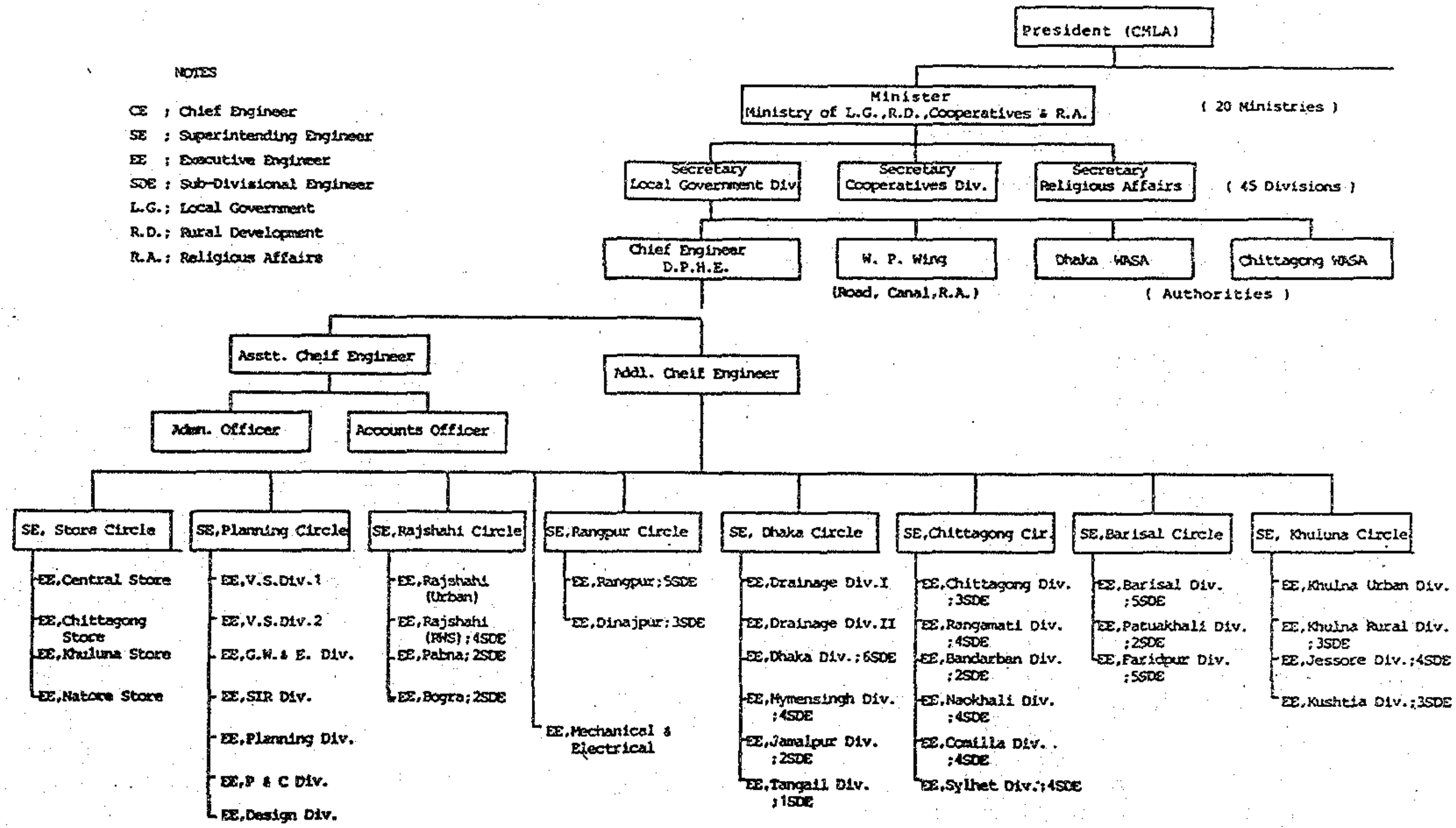
The organization chart of Dhaka WASA is as shown in Fig. 2-2.

(b) Chittagong WASA

Chittagong, with a population of about 700,000, is the second largest city in Bangladesh. It now supplied water to 300,000 persons, or to 40 to 45% of its current population. The water sources are the 35 deep wells and one water purification plant from where 35 million gallons (160 thousand m³) of water is supplied daily.

The organization chart of Chittagong WASA is as shown in Fig. 2-3.

Fig. 2-1 Organization Chart of Department of Public Health Engineering



G.W.& E; Ground Water & Exploration
SIR ; Survey, Investigation & Research
P & C ; Programme & Coordination

V.S. ; Village Sanitation

Fig. 2-2 Organization Chart of Dhaka WASA

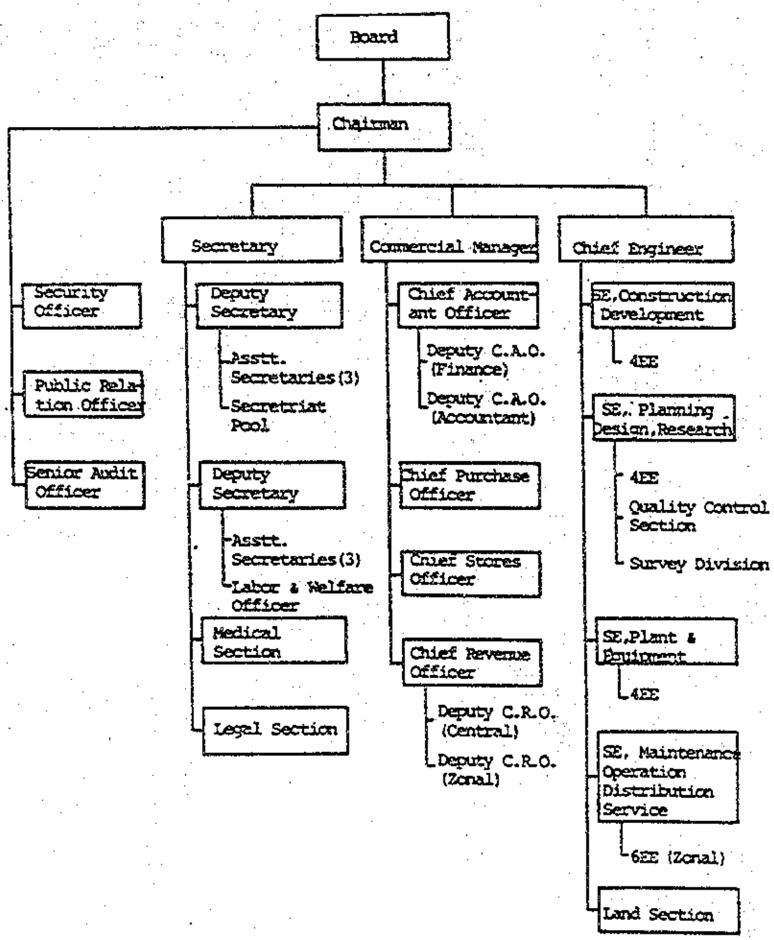
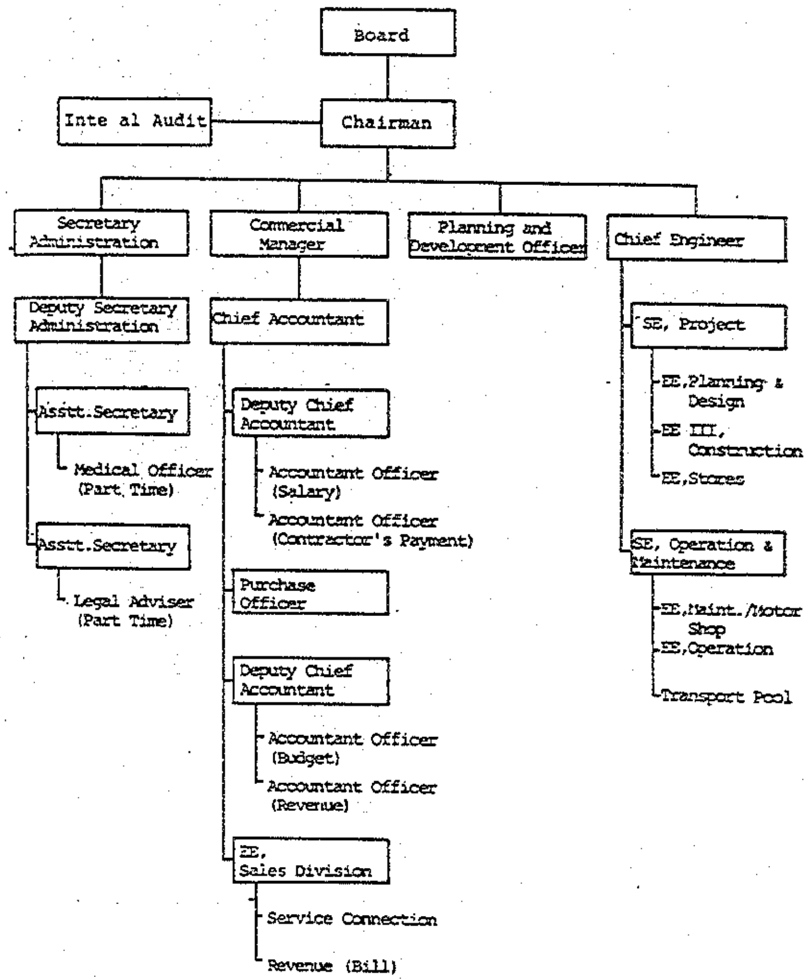


Fig. 2-3 Organization Chart of Chittagong WASA



2-3 Drinking Water Supply Plan

(1) Long-range Target for Improvement of Facilities for Supplying Drinking Water

Because of the difficulty in programming the procurement of its own funds, the water supply improvement schemes in Bangladesh have always been contingent on the availability of foreign aid. As a result, its long-range targets have been compelled to undergo frequent changes.

For the two big cities of Dhaka and Chittagong, WASA establishes long range targets which are to supply water to 70 to 80% of the urban population in Dhaka which it projects to reach 12 million by the year 2010. And to 100% of the population in Chittagong, by the end of 1985.

In the district towns and sub-divisional towns (which are now districts towns, too) which fall under the responsibility of DPHE, the target is to attain the water supply pervasion rate of 100%, 24-hours a day by the year 2,000. In Upozillas (which correspond to Thana Headquarters), the target is to attain 50 to 80% water supply pervasion depending on the size of the towns.

Table National Perspective of Pipes Water Sypply

(1980-2000)

Year		1980	1985	1990	1995	2000
District Town		30%	37	60	85	100% (24hr)
Sub-Divisional Town (now district town)		10	20	50	80	100 (24hr)
Uposilla	0 - 100	5	5	30	50	80
	101 - 200	-	-	-	30	60
	201 - 300	-	-	-	20	50
	301 -	-	-	-	-	50

Note: Coverage by population

(2) Drinking Water Supply Schemes

The water supply schemes being planned or implemented by DPHE are as shown in Table 2-4. Nos. 1 through 6 of the same table are the schemes for the rural areas and Nos. 7 through 19, the schemes for the urban areas.

Among the schemes for the urban areas, interim W/S for five district towns (No. 10), establishment of four zonal laboratories (No. 13) and removing water logging from Dhaka City (No. 14) have already been completed. Also, the feasibility study on six district towns (No. 19) is a study of a part of W/S scheme for 10 district towns (No. 11). Accordingly, nine projects on water supply schemes are now being planned or implemented. Although it is not listed in Table 2-4, there is a project being planned for four district towns of Panchagar, Ramgarh, Kaptai and Lawa, for which countries who might render assistance are being sounded out now. Therefore, when this project is included, it means that there are altogether 10 project.

WASA is responsible for the planning of the projects in the two big cities of Dhaka and Chittagong, and they are being implemented as the Dhaka Waterworks Improvement Project and the Chittagong Waterworks Project.

For the rural areas, five projects have been planned and are being implemented. They are projects to build hand pumps to pump up water from tube wells and to replace the choked up wells.

Table 2-4 Water Supply Schemes Executed by DPHE

Area	No.	Scheme	Target	Cost (in ¥ million) GOB/F.A.	Period of Execution	Progress as of Jun./'83 %
Rural Area	1.	Sinking 10,000 Deep Tube Well	10,000	893.25/331.00	1976 - 85	70%
	2.	Replacement of 50,000 Chocked-up Tube Well	50,000	544.80/1,337.50	1979 - 83	45.3
	3.	Sinking 250,000 Shallow Tube Well	250,000	3,640.00/7,160.00	1980 - 87	33
	4.	Sinking 8,000 Deepset P.T.W.	8,000	310.40/707.00	1980 - 87	17
	5.	Sinking 2,000 Deepset P.T.W. and 150 Ring Well in CHT	2,000 DST 150 RW	438.29/Nil	1980 - 83	113
	6.	V.S. Scheme Phase II	225,000 Cent. 476	667.00/556.00	1982 - 85	23
Urban Area	7.	Interim W/S Scheme for Rajshahi Town	100%	110.00/140.00	1980 - 84	63
	8.	W/S Scheme for Rangamati Town	"	150.00/Nil	1980 - 85	25
	9.	W/S Scheme for Narayanganj Town	"	150.00	1980 - 85	36
	10.	Interim W/S for 5 District Towns	"	158.50	1980 - 83	112
	11.	W/S for 10 District Towns	"	795.00	1980 - 85	44
	12.	W/S for 27 Subdivisional Towns	"	2,250.00	1978 - 87	24
	13.	Establishment of 4 Zonal Laboratory	"	70.80/79.00	1981 - 83	100
	14.	Removing Water Logging from Dhaka City	"	190.00	198 - 83	100
	15.	W/S for 4 Sub-divisional Towns	"	110/140	1981 - 84	62
	16.	Rehabilitation and Expantion of Khulua W/S Scheme	"	48.3/168	1981 - 84	69
	17.	W/S for 5 District Towns	"	1,833/3,467	1983 - 88	-
	18.	W/S for 12 Sub-divisional Towns	"	252/551	1983 - 87	-
	19.	Feasibility Study for 6 District Towns (A part of No.11, W/S for 10 District Towns)	"	9/229	1983 - 85	-

Note: V.S.; Village Sanitation

2-4 Implementation Status of Drinking Water Supply Schemes

Table 2-5 shows the contents and the state of how the water supply schemes which DPHE is undertaking are being implemented in the district towns and sub-divisional towns (which are now district towns, too). Nine projects are being implemented now and for one other project, the countries that might render assistance to it are still being sounded out. Of the nine projects, assistance has already been committed or finalized by the Netherlands on four projects and by ADB on two projects.

Accordingly, three projects are being financed and implemented by Bangladesh's own government funds.

The state of progress of each of these projects is shown in Table 2-4. Leaving aside, those projects which have yet to make their start, the projects aided by foreign countries are already 62 to 69% completed, but the projects financed by the Government of Bangladesh are way behind and are only 24 to 36% completed. The water supply schemes for the 27 sub-divisional towns and for Narayanganj town for which Japan's assistance has been sought are now 24% and 36% completed, respectively.

The Government of Bangladesh is in such poor financial condition today that a further delay is feared in the implementation of the projects being financed solely by its own funds.

The water supply scheme for Rangamati town is politically a high priority project in terms of its being a countermeasure for the minority races and other reasons, but as of now, the Government of Bangladesh seems determined to implement it by its own funds instead of counting on foreign aid.

The waterworks projects in Dhaka and Chittagong, for which WASA is responsible, are being carried out on loans extended by the World Bank.

The status of foreign aid for the water supply schemes in the district towns and sub-divisional towns (which are now district towns, too) is entered in the column on source of fund in Table 2-5. For some district towns, aid or loan by the Netherlands and ADB, and for some sub-divisional towns (which are now district towns, too), aid by the Netherlands, have already been committed.

For development of tube wells in the rural areas, assistance is being rendered by UNICEF.

Table 2-5 Contents and Implementation Status of Water Supply Schemes in District Towns and Sub-Divisional Towns

No.	Name of Project	Towns Covered	Major Contents of Work: No. of Test Borings	No. of Production Wells	Pipe-line Length (miles)	Pumping Facilities	Over-head Tank	House Connection, etc.	Adm. Facilities, etc.	Execution Period	Project Cost: Total	LC	FC	Fund Sources GOB. F.A	Appropriations: Expenditures up to June, 1983	Budget for 1983/1984	Remarks
1	Khulna W/S Rehabilitation & Expansion Scheme	Khulna 1	(8)	(8)	(5.0)	(6)	(-)	(4,090)	(-)	1981 -'86.6	5,550.0	350.0	200.0	GOG Dutch 155.0	115.52	70.65	Under Construction
2	Interim W/S Rajshahi Town	Rajshahi 1	6	4	12.5	4	3	150	8	1980-'85	250.0	182.0	68.0	GOB 110.0 Dutch 140.0	130.55	102.05	Under construction
3	W/S Scheme for Rangamati Town	Rangamati 1	6	3	10.0	3	-	1	4	1980-'87	150.0	150.0	-	GOB 150.0	30.87	15.10	D/D completed; Measures for minority race
4	W/S Scheme for 5 District Towns	Comilla, Mymensingh, Bogra, Jessore, Barisal 5	-	13	150.0	23	16	26,250	-	1984-'89	5,300.0	2,650.0	2,650.0	GOB 1,833.0 ADB 3,467.0	-	-	F/S completed; D/D scheduled to commence within a few months
5	W/S Scheme for 10 District Towns	Noakhali, Sylhet, Tangail, Jamalpur, Faridpur, Kushtia, Pabna, Rangpur, Dinajpur, Patuakhali 10	40	24	60.0	24	4	300	60	1980-'87	795.0	-	-	GOB 795.0	226.86	160.17	Under construction; ADB study on 6 towns under way
6	W/S Scheme for Narayanganj Town	Narayanganj 1	6	6	9.0	6	1	200	8	1980-'85	150.0	125.0	25.0	GOB 150.0	53.69	25.00	B/D conducted by Japan. Under construction by own funds.
7	W/S Scheme for 4 Sub-divisional Towns	Natore, Nawabganj, Satkhira, Bagerhat 4	4	4	19.3	5	3	600	5	1981-'84	250.0	186.8	63.2	GOB 110.0 Dutch 140.0	108.16	136.12	Under construction
8	Improvement & Expansion of W/S Scheme for 12 Sub-Divisional Towns	Cox's Bazar, Habiganj, B-Baria, Chandpur, Munshiganj, Kishorganj, Serajganj, Madaripur, Rajbari, Gopalganj, Pirojpur, Jaydebpur 12	31	23	53.0	22	9	1,000	25	1981-'86 (Phase I) -'88 (Phase II)	820 (400)	? (150)	? (250)	GOB 150.0 Dutch 250.0	-	167.61	Phase I: B/D completed Phase II: yet to commence
9	W/S Scheme for 27 Sub-divisional Towns	27	108	81	162.0	81	27	27,000	135	1998-'85	2,250.0	1,794.5	455.5	GOB 2,250.0	623.64	296.10	B/D con-ducted by Japan.
10	4 Towns	Kaptai, Panchagar, Rangarh, Lama 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	Pending

2-5 Drinking Water Supply Status and Progress of Water Supply Schemes in 27 Sub-Divisional Towns

(1) Status of Water Supply

In the sub-divisional towns (which are now district towns), the hand pumps which supply water from tube wells built by DPHE so far are used as the major drinking water supply facilities. Besides those which were constructed by DPHE, the privately built hand pumps are also seen fairly widely diffused.

The ponds, rivers and pools on the ground even today are used for washing and bathing.

The team was able to conduct hearing surveys this time on the number of hand pumps in 11 out of 27 towns, according to which hand-driven pumps are arranged at an average interval of 150 m to 300 m with each pump being utilized by 100 to 300 inhabitants.

In some cases, however, the hand pumps are arranged at an interval of 600 m with each pump being utilized by as many as 500 inhabitants.

In general, the areas which are suffering from a shortage of drinking water are mostly the hilly zones and the coastal zones. Particularly in the hilly zones, a considerable number of the wells have been abandoned because of having become dry. In the other zones, water intake by means of a well is relatively easy because of the many interwining rivers of various size and because of being on deltas formed by the Ganges and the Brahmaputra Rivers.

In some towns where the piped water supply systems have been partly completed, water is being supplied on a time-restricted basis. In such towns, public water posts which are utilized free of charge are provided along roads in addition to the facilities that supply water to each household. For water service to each household, water charges are collected. There is no meter for measuring, and water charges are determined according to the caliber of the service pipe. The water charges of a 1/2" caliber pipe are 20TK/month (¥200/month) for household use and 40TK/month (¥400/month) for business use (shops and offices), and the beneficiaries must share the cost of construction of the facilities for supplying water to each household. The burden which the beneficiary must share in the case of a 1/2" caliber pipe is 300TK (¥3,000) for household use and 600TK (¥6,000) for business use.

Maintenance, operation and management of the piped water supply systems in these towns will eventually be transferred to each town in the future, but while construction is under way, DPHE will be responsible for these duties.

(2) Progress of Water Supply Schemes

The water supply schemes in these 27 towns about 20% completed as shown in Table 2-6.

Table 2-6 Conditions in 27 Towns and Progress of Construction of the Drinking Water Supply Facilities

No.	Town	District Division	Population (1981)	Location & Traffic Means	Existing Tube Wells: No. of Hand Pumps & No. of Persons Served per Pump	Existing Tube Wells: Town Area & Interval Between Adjacent Pumps*	Test Boring Data: Water Quality: pH	Water Quality: Fe	Water Quality: Cl	Water Quality: Hardness	Test Boring Data: Position of Screen	Progress**: Production Well	Progress**: Pump	Progress**: Pipe-line	Progress**: Over-head Tank	Progress**: House Connections	Progress**: % Population Served	Use of Project Cost: Expended by June, 1983/budget for 1983/1984	Use of Project Cost: Total
1	Narsingdi	Dhaka/ Dhaka	(persons) 70,006	R.R. Narsingdi Staion, abt. 40 km from Dhaka, ferry unneccessary	227 (sets) 308 (persons)	2.0 sm 150 m	7.5	ppm 0.6	ppm 3.0	ppm 33	ft 193 -205	1/2	place 1/2	miles 2.2/ 2.0	capa-city -/-	houses -/200	% -	L.TK 220/21.4	L.TK 43.4
2	Manikaganj	" / "	37,996	Abt. 60 km from Dhaka, ferry unnecessary			7.4	1.0	11	60	364 -388	2/-	2/1	4.9/	-/-	209/ 100	(8%)	38.05/5.40	43.45
3	Sherpur	Jamalpur/ "	51,854	15 km from R.R. Jamalpur Station, abt. 220 km from Dhaka, ferry unnecessary	322 (sets) 161 (persons)	9.5 sm 275 m	7.2	3.9	4.0	404	300 -325	1/1	1/1	1/1.6	-/-	-/100	-	19.0/13.85	33.75
4	Netrokona	Mymensingh/ "	39,116	R.R. Netrokona Station, abt. 250 km from Dhaka, ferry unnecessary			7.46	1.0	0	100	546 -566	1/1	1/1	1.25/ 2.0	-/-	-/100	-	19.9/14.25	34.15
5	Naria (Shariatpur)	Faridpur/ "	7,000	Accessible only by boat from Dhaka, no connecting road			7.8	1.5	180	-	620 -650	-/1	-/1	-/-	-/-	-/-	-	3.49/6.90	10.39
6	Naogaon	Rajshahi/ Rajshahi	51,791	R.R. Naogaon Station, 45 km from Bogra			7.6	0.7	35	140	190 -210	3/-	2/1	2.45/ 2.0	-/-	-/200	(8%)	34.06/8.00	42.06
7	Kurigram	Rangpur/ "	46,132	R.R. Kurigram Station, 40 km from Rangpur			6.7	21.0	3.0	76	190 -210	1/1	1/1	1.5/ 1.5	-/-	-/50	-	23.89/7.15	31.04
8	Gaibanda	" / "	38,342	R.R. Gaibanda Station, 60 km from Rangpur	200 (sets) 192 (persons)	31.4 sm 200 m	7.0	12.5	4.8	84	160 -180	-/2	-/2	-/-	-/-	-/-	-	19.50/6.60	26.10
9	Lalmonirha	" / "	36.118	R.R. Lalmonirhat Station, 30 km from Rangpur via local road			7.4	0.3	20	410	230 -250	-/1	-/1	-/1.2	-/-	-/-	-	2.10/13.55	15.65

* In sq. miles and meter

** Completed by June 1983/scheduled for 1983/84

Table 2-6 (Cont.)

No.	Town	District Division	Population (1981)	Location & Traffic Means	Existing Tube Wells: No. of Hand Pumps & No. of Persons Served per Pump	Existing Tube Wells: Town Area & Interval Between Adjacent Pumps*	Test Boring Data: Water Quality: pH	Water Quality: Fe	Water Quality: Cℓ	Water Quality: Hardness	Test Boring Data: Position of Screen	Progress**: Production Well	Progress**: Pump	Progress**: Pipeline	Progress**: Overhead Tank	Progress**: House Connections	Progress**: % Population Served	Use of Project Cost: Expended by June, 1983/budget for 1983/1984	Use of Project Cost: Total
			(persons)					ppm	ppm	ppm	ft		place	miles	capacity	houses	%	L.TK	L.TK
10	Nilphamari	Rangpur/ Rajshahi	29,443	R.R. Nilphaman Station, 70 km from Rangpur			7.6	0.2	0.4	71	595 -619	-/2	-/1	-/1.2	-/-	-/-	-	5.70/12.80	18.30
11	Joypurhat	Bogra/ "	39,167	R.R. Joypurhat Station, 50 km from Bogra			6.6	0.7	8.2	120	100 -120	2/-	1/1	1.88/ 1.5	-/-	-/100	-	21.05/12.35	33.40
12	Thakurgaon	Dinajpur/ "	25,190	60 km from R.R. Dianajpur Station, 120 km from Rangpur			6.9	1.7	0.5	30	350 -370	2/-	1/1	5.8/ 0.5	-/-	-/200	(6%)	37.22/8.50	43.72
13	Jenidah	Jessore/ Khulna	49,355	20 km from R.R. Kaligahj Station, 50 km from Jessore	332 (sets) 149 (persons)	6.0 sm 215 m	7.3	1.4	10.5	310	280 -300	1/1	1/1	2.5/ 2.00	-/-	44/160	(25%)	36.76/8.7	45.46
14	Magura	" / "	29,294	50 km from Jessore	300 (sets) 98 (persons)	7.5 sm 253 m	7.6	0.7	10	364	363 -387	1/1	1/1	2.2/ 1.5	-/-	50/150	(20%)	27.05/14.25	41.30
15	Narail	" / "	20,329	35 km from Jessore			7.0	1.4	390	310	175 -200	1/1	-/2	-/1.5	-/-	-/-	-	8.19/15.40	23.59
16	Chuadanga	Kushtia/ "	47,815	R.R. Chuadanga Station, 80 km from Jessore	262 (sets) 183 (persons)	12.0 sm 350 m	7.2	1.7	6.0	382	320 -340	1/1	1/1	0.9/ 1.5	-/-	-/100	-	26.15/12.45	38.60
17	Mecherpur	" / "	23,147	30 km from R.R. Chudanga Station	155 (sets) 149 (persons)	5.25 sm 295 m	7.5	3.2	3.0	464	390 -410	1/1	1/1	4.25/ 1.6	-/-	44/100	(8%)	41.21/12.00	53.21
18	Jhalakhati	Barisal/ "	31,381	No connecting road, accessible only by boat			7.8	1.5	260	26	968 -992	1/1	1/1	4.0/ 1.75	-/-	144/200	(7%)	48.34/15.15	63.49

* In sq. miles and meter

** Completed by June 1983/scheduled for 1983/84

Table 2-6 (Cont.)

No.	Town	District Division	Population (1981)	Location & Traffic Means	Existing Tube Wells: No. of Hand Pumps & No. of Persons Served per Pump	Existing Tube Wells: Town Area & Interval Between Adjacent Pumps*	Test Boring Data: Water Quality: pH	Fe	Cℓ	Hardness	Position of Screen	Progress**: Production Well	Pump	Pipe-line	Over-head Tank	House Connections	% Population Served	Use of Project Cost: Expended by June, 1983/budget for 1983/1984	Total
			(persons)					ppm	ppm	ppm	ft		place	miles	capa-city	houses	%	L.TK	L.TK
19	Bhola	Barisal/ Khulna	18,025	Boat service, 15 km from Gazipura via local road			7.4	0.8	153	76	820 -840	1/1	-/1	0.7/ 1.5	-/-	-/200	-	22.81/10.45	33.26
20	Barguna	Patuakhali/ "	16,430	Boat service only	33 (sets) 498 (persons)	5 sm 623 m	7.7	0.4	-	116	905 -929	1/1	-/1	-/-	-/-	-/-	-	5.44/5.50	10.94
21	Laxmipur	Noakhali/ Chittagong	35,095	30 km from R.R. Begamganj Station, 170 km from Chittagong			9.5	1.3	3.5	286	120 -132	-/1	-/1	-/1.5	-/-	-/-	-	3.84/16.50	20.30
22	Feni	" / "	23,199	R.R. Feni Station, 100 km from Chittagong	243 (sets) 96 (persons)	25. sm 162 m	7.0	1.5	1.8	94	603 -627	/	1/1	5.5/ 0.7	-/-	110/ 100	(6%)	49.21/8.70	57.91
23	Sunamganj	Sylhet/ "	21,565	80 km from Sylhet			6.9	2.8	1.3	148	464 -494	1/1	1/1	1/1.5	-/-	-/100	(5%)	21.85/10.20	32.05
24	Maul-vibazar	" / "	16,697	25 km from R.R. Srimangal Station, 60 km from Sylhet			6.16	6.0	0	24	310 -330	2/-	2/-	5/1	-/-	185/ 100	(6%)	40.61/2.00	42.61
25	Patiya	Chittagong/ "	15,500	R.R. Patiya Station, 25 km from Chittagong			7.0	2.9	13	76	762 -782	-/1	-/-	-/-	-/-	-/-	-	12.50/3.3	15.80
26	Bandarban	Chittagong Hill Tlacts/ "	10,000	80 km from Chittagong via local road across hilly zone	46 (sets) 218 (persons)	2.5 sm 373 m	7.1	2.7	10	80	79 -97	-/2	-/2	1/1.5	-/-	-/50	-	12.48/19.30	31.70
27	Khag-rachari	" / "	5,000	180 km from Chittagong via local road across hilly zone	200 (sets) 25 (persons)	1.5 sm 139 m	6.1	1.1	1.0	28	201 -297	1/1	1/1	1.5/ 1.0	-/-	-/50	(10%)	20.38/11.95	32.33

* In sq. miles and meter

** Completed by June 1983/scheduled for 1983/84

2-6 Sanitary Facilities Improvement Plan

Eighty percent of the diseases in Bangladesh are said to be related to "water". Thirty to thirty-two percent of child deaths (between the ages of 1 and 9) are said to be caused by diarrhea, and also because of malnutrition, the situation seems to be getting worse.

In view of the situation, the Government of Bangladesh is promoting a sanitary facilities improvement program in order to improve the nation's health environment. The water seal latrine was first introduced into Bangladesh in around 1962 and has been installed at about 200,000 places to date, but only about 60% of them are being used properly.

DPHE is planning to include a sanitary facilities improvement scheme in its water supply scheme for each of the district towns and sub-divisional towns (which are district towns now). For the rural areas, DPHE has established a village sanitation scheme which it is now implementing. Under Village Sanitation Scheme (Phase I), sanitary facilities at 137,000 places have been improved between 1976 and 1982 with a total working expense of 809.0 Lakh Taka. The Village Sanitation Scheme (Phase II) which is being implemented since 1983 plans to improve the sanitary facilities at 225,000 places.

The sanitary facilities being planned by DPHE are of the one-pit and the two-pit systems, and it is recommending the two-pit system in the urban areas such as district towns and sub-divisional towns, and the one-pit system in the rural areas.

Since the objects of this project are the sub-divisional towns (which are now district towns, too), DPHE hopes to include the construction of the two-pit system sanitary facilities in the water supply scheme. The cost of building a two-pit system sanitary facility is estimated to be 2,537 Taka (about $100) per place.

2-7 General Socio-Economic Conditions

(1) Territorial Land

Bangladesh is located at the eastern tip of the Indian subcontinent between 22° and 26° of north latitude and 89° and 92° of east longitude. It extends over deltas of the Ganges and Brahmaputra and covers a land area of 144,000 km^2, most of which is below 100 feet (30 m) in elevation.

The country's population is estimated to have been 92 million as of June, 1982 and the population density, 639 persons/ km^2.

The annual mean precipitation is 2,300 mm, and the country has a tropical monsoon climate. The winter season lasts from November to February, the summer season from March to May and the rainy season from June to October.

(2) Local administrative units

Administrative units in Bangladesh haven been changed since February 1984 as follows:

Before change	New administrative unit
Division (4)	Divisions (4)
Districts (22)	Districts (64)
Sub-divisions (46)	
Thanas (493)	Upazilas (Thana Parished)

Unions (4,472)	Unions (Unions Parished)
Mouzas (60,315)	Mouzas
Villages (85,650)	Villages

* Statistical Year Book of Bangladesh 1982

The seven towns, the objects of the project had each been classified as a Sub-division, but under the new system have been as a District each.

(3) GNP (for 1981/82 per data compiled by the World Bank in 1983) GNP: 11,261 million dollars

GNP per capita: 120 dollars

(4) Real Growth of GNP in Recent Years (per data compiled in 1983 by the World Bank)

1977/78	7.3(%)
1978/79	3.6
1979/80	3.8
1980/81	4.9
1981/82	1.1 (provisional)
1982/83	2.4 (provisional)

(5) Price Trends (Rate of rise in consumer prices, per data compiled by the World Bank in 1983)

1977/78	13.3(%)
1978/79	9.4
1979/80	13.5
1980/81	10.7
1981/82	11.4

(6) Balance of International Payments

	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82
Exports	411	490	610	727	711	627
Imports	865	1,349	1,556	2,372	2,524	2,587
Balance of trade	-454	-859	-946	-1,645	-1,813	-1,960
Balance on current account	-402	-778	-830	-1,432	-1,425	-1,618
Overall balance	81	-25	124	-119	-24	-128

Unit: in million dollars

(7) Recent Trends in the Amount of Economic Assistance Received (Based on expenditures, per data compiled by the World Bank in 1983)

	1976/77	1977/78	1978/79	1979/80	1980/81	1981/82
Assistance in Food	121.6	177.9	179.1	374.6	194.1	230.5
Assistance in Com-modities	252.9	374.3	482.5	377.8	393.1	421.4
Assistance in Projects	158.6	275.7	368.4	469.8	560.2	584.3
Total	533.1	827.9	1,030.0	1,222.2	1,147.4	1,236.2

Unit: in million dollars

(8) Major Economic and Technical Assistance from Foreign Countries (ODA net expenditure basis, per OECD data)

(a) Bilateral

Country	1978	1979	1980	1981
Japan	119.6	206.3	215.1	150.0
U.S.A.	165.0	157.0	174.0	118.0
West Germany	49.6	86.6	114.6	101.2
U.K.	84.4	71.7	99.2	67.6
Canada	77.6	59.2	57.1	58.0
The Netherlands	63.6	45.9	53.2	54.7
Sweden	26.4	39.3	27.6	24.7

Unit: in million dollars

(b) International Organizations

Organization	1978	1979	1980	1981
IDA	103.1	162.6	155.7	159.0
ADB	36.3	40.5	57.4	44.8
IMF	48.1	49.0	41.7	0.6
EC	29.8	22.3	33.2	53.8
UNDP	13.3	13.4	18.8	23.1
UNICEF	14.6	22.2	17.8	12.2
WFP	41.6	36.7	13.3	28.0
UNHCR	3.2	5.2	0.7	0.7
Arab·OPEC Agencies	1.1	10.5	4.2	32.7

Unit: in million dollars

Note: Excerpt from "Recent Situations in Bangladesh and the Bangladesh-Japan Relation" compiled by the south-West Asian Division, Asian Bureau, Ministry of Foreign Affairs, Japan.

CHAPTER 3 OUTLINE OF THE PROJECT AREA AND CONTENTS OF THE PROJECT

3-1 Purposes and Design Conditions of the Project

(1) Purposes of the Project

As a mentioned in the section "Background", this Project is part of the 27 Sub-Divisional Towns (currently Distric Towns) Water Supply Project, which is one of the potable water supply projects (shown in Table 2-5) that are being implemented with the purpose of supplying safe and clean potable water to the population of Bangladesh, and comprises seven of the said towns.

The seven towns in questions are scattered throughout the country and belong to the following Divisions.

(1)	Narsingdi	: Dhaka Division
(2)	Jenidah	} Khulna Division
(3)	Chuadanga	
(4)	Gaibandha	} Rajshahi Division
(5)	Kurigram	
(6)	Feni	} Chittagong Division
(7)	Sunamgarj	

The target year of this Project is 1990, and it is aimed at equipping the water supply systems in order to supply 50% of the urban population with running water by means of house connection and the remaining 50% by means of public posts.

(2) Design Conditions

The potable water supply schemes of the seven towns are drawn up on the undermentioned design conditions. In defining the said design conditions, attention was paid to prevent the occurrence of conspicuous discrepancies compared with the design conditions adopted in the water supply projects already implemented with aid from the Netherlands and the ADB, and the final version of the said design conditions was decided after consultations with the Government of Bangladesh (DPHE).

(i) Area and population to be served by the water supply project

The areas to be served by the potable water supply project consist principally of the municipal area of each town, and are determined by taking such factors as the current demographic distribution state, the future trend of development of housing sites, etc.

The population to be served by the potable water supply project in 1990 is estimated by forecasting the demographic growth rate through the examination of data of the census carried out in 1974 and 1981, as well as the trend of demographic growth rate in the last two or three years.

The annual average demographic growth rate of Bangladesh as a whole is or the order of 2.3%, but the demographic concentration in local cities has been conspicuous of late, with Narsingdi Town growing at an annual average rate of 18%, Jenidah 23% and other cities reaching average growth rates of the order to 7% to 10%.

This Project takes into consideration the demographic growth rate of the 1974-1981 period and assumes furthermore that the growth rate of the last two or three years will remain unchanged until 1990. Such being the case, an annual growth rate of 10% is assumed in the Towns of Narsingdi and Jenidah, while a growth rate of 6% is assumed in the other five towns.

(ii) Volume of water to be supplied

The volumes of water to be supplied by the potable water supply projects that are being implemented with aid provided by the Netherlands and the ADB are shown in the following table.

Household water to be supplied by the Five District Towns Water Supply Project financed by the ADB is as follows.

	Volume of Water to be Supplied	Percentage of Population
(1) Multi Tap User	27 gpcd (21.7)	80% (50)
(2) Single Tap User	18.9 gpcd (15.1)	9% (25)
(3) Stand Pipe	5 gpcd (5.0)	11% (25)
(4) Wastage	10% of (1) and (2) 20% of (3)	

Note: 1) The table above refer to the target year 2000. The figures enclosed with parenthesis refer to the target year 1990.

2) In addition to water for household use, running water to be consumed by hotels, commercial establishments, restaurants, hospitals, public schools, public institutions, factories, etc., are also calculated and tabulated separately.

The volume of water to be supplied by the 12 Sub-Divisional Towns (currently District Towns) Water Supply Project financed by the Netherlands is as follows. (Target year 1990).

		Volume of Water to be Supplied	Percentage of Population
(1)	House Connection	21 gpcp (95 liters/man-day)	20%
(2)	Yard Connection	17 gpcp (75 liters/man-day)	30%
(3)	Public Standposts	5.5 gpcp (25 liters/man-day)	50%
(4)	Wastage	25% of (1), (2) and (3)	

The volume of water to be supplied in this Project was decided by taking into consideration the results of consultations with the DPHE as well as the volumes of water to be supplied in the aforementioned projects financed by the ADB and the Netherlands. The following volumes of water will be supplied in this Project.

		Volume of Water to be Supplied	Percentage of Population
(1)	House Connection	20 gpcd (90 liters/man-day)	50% (80)
(2)	Public Post	7.5 gpcd (34 liters/man-day)	50% (20)
(3)	Wastage	30% of (1) and (2)	

Note: The figures enclosed with parenthesis of the column "Percentage of Population" refer to the target year 2000.

Note: (1) The figures enclosed with parenthesis of the column "Percentage of Population" refer to the target year 2000.

(2) The volume of water to be supplied includes the water for non-domestic consumption (restaurants, hospitals, schools, offices, household industries etc.).

According to the table, the volume of water to be supplied per capital will be as follows.

- House connection:	90 liters/man-day x 0.5 = 45 liters/day
- Public post:	34 liters/man-day x 0.5 = 17 liters/day
- Wastage:	(45 + 17) x 0.3 = 18.6 liters/day
Total	80.6 ≑ 81 liters/day

The volume of water to be supplied in each town is calculated by assuming 81 liters/man-day.

(iii) Water supply project

In principle, the water source of this Project will be ground water that will be pumped up from deep wells. Water drawn up from the deep wells will be stored in overhead tanks and will be supplied to the inhabitants of the towns via distributing pipe network. As a result of consultations with the DPHE, it was decided that the operation time of the pumps and other equipment of the water supply system will be 12 hours a day, by taking into consideration the maintenance, administration, labour conditions and other relevant factors. The pumps will operate 12 hours during the daytime to supply water via water towers.

(iv) Water source

As for water source, either ground water or surface water may be considered. As can be seen from the comparison in Table 3-1-1, ground water offers more advantage. Therefore, in respect of water quality, selection of construction site, construction cost and operation/maintenance as long as the quality of water does not pose any problem, the water source to be used in this Project will be ground water in principal. The use of water of rivers will be considered when there is not so much possibility for development of ground water. In Sunamganj Town the possibility for development of ground water is not so favourable, the aquifer to be exploited is thin in view of the stratigraphy, the object of exploitation is the same layer as the aquifer that is being used currently to draw water with hand pumps, and furthermore the water itself has high content of iron (4.0 ppm). Such being water source for drinking purpose. Therefore, construction of purification plant is planned for this town, by considerating the utilization of water of the Surma River. As for the other six towns, there is no problem in using ground water as water source.

(v) Water quality

In Bangladesh, the potable water quality standards for urban areas are in conformity with the WHO standards. However, the permissible content of iron in the project is to be 2.0 ppm according to the agreement between the study team and DPHE.

Table 3-1-1 Comparison among Different Water Sources

Item	Ground Water (deep well)	Surface Water (river water)
Use as drinking water (Quality of Water)	If the quality of water does not pose any problem, it is often supplied for drinking without treatment. If iron and other substances are dissolved, a system to remove them are necessary Highly saline water may not be suitable for drinking.	Generally unsuitable for drinking without treatment at a purification plant, as the water is often polluted with pathogenic bacteria and mixed with impurities.
Available quantity of water	Quantity of water which can be drawn from one well is limited, so that if the required quantity of water is large, it may be difficult to rely solely on wells. Seasonal fluctuations are small.	Save for rivers that run dry during the dry season, quantity of water poses no problem since rivers of large discharge are normally selected. Seasonal fluctuations are substantial.
Method of intake	Necessary to construct deep well and install water pump.	If large quantity of water must be intaken, weir for coffering river is necessary. Structures like intake tower, intake slice way are also necessary.
Construction Site	Can be selected near the water supply district with relative ease.	As for construction site, the spot for water intake is restricted by the conditions of gut and levee of the river concerned. Water conveyance facilities from the water intake point to the target water supply district become necessary.
Maintenance and control	Not difficult to control as it is operated by water pump. Proper pumping rate must be observed as excessive pumping results in lowering water level and drying up the well. Operation of pump costs money.	Purification plant requires technical skill in operating mixing basin, coagulation basin and filter basin. Chemicals and electrical power cost money.
Construction cost	Inexpensive and easily constructed if the quantity of water needed is small.	Costs less if the quantity of water supply is large but more expensive if the quantity is small.

Note: Lakes and lagoons, water pools and ponds are also surface water but they are outside of the objects of this project. Water running on the ground surface (river water) only was taken up for comparison.

Table 3-1-2 Drinking Water Standard

Items	EPCB 1/ (ppm)	WHO 2/ (mg/1)	Japan (ppm)
Physical		Min. - Max.	
Turbidity	25 units	5 - 25 units	2°
Color	30 units	5 - 20 units	5°
Odor	Unobjectionable	Unobjectionable	Unobjectionable
Total Dissolved Solids	1,500	500 - 1,500	500
Chemical			
Chloride (Cl)	600 (1,000 max.)	200 - 600	200
Iron (Fe)	1.5 (5 max.)	0.1 - 1.0	0.3
Manganese (Mn)	0.5	0.05 - 0.5	0.3
Zinc (Zn)	15	5.0 - 15	1.0
Copper (Cu)	1.50	0.05 - 15	1.0
Sulfate (S)	400	200 - 400	-
pH	6.5 - 9.2	n.a.	5.8 - 8.6
Total Hardness (as $CaCO_3$)	250 (450 max.)	100 - 500	300
Fluoride (F)	1.0 (2)	1.0	0.8
Nitrate (NO_3)	45 (50 max.)	45	10
Phenols	0.002	0.001	0.005
Cyanide (CN)	0.2	n.a.	0
Hexavalent Chromium (Cr)	0.05	n.a.	0.05
Lead (Pb)	0.05	0.1	0.1
Cadmium (Cd)	-	0.01	(0.01)
Bacteriological	90% of Samples: Coliform undetected or MPN index equal nil.	Raw water: containing less than 3 coliforms for 100 ml Treated water: zero coliforms per 100 ml	

1/ Environment Pollution Control Board, Bangladesh, by which the present standard is recommended.

2/ World Health Organisation.

3/ ( ) shows maximum value to be allowed for specific water sources.

(vi) Production well

The estimation of the state of things of the aquifers, depth, diameter and screen position of the production wells, and volume of water to be pumped from each well is carried out through the examination of the water resources of each town from the hydrological and geological standpoints, based on data obtained from the existing productive wells and test boring.

Screens made of stainless steel will be used in the wells. The periphery of the screen will be filled with gravel, and the upper part of the well will be filled with earth and cement mortar.

The wells will have distinct diameters depending on the town, but there will be two types of housing pipes, i.e., ∅380 mm and ∅300 mm and two types of casings, i.e., ∅200 mm and ∅150 mm.

The distance between productive wells will be made as large as possible, in order to prevent mutual interference even when they are used for a long time. As for the number of wells, they will be determined by taking into consideratin the volume of water to be pumped from the wells and the volume of water to be supplied in the project, and the productive wells that have already been constructed by the DPHE will be used as much as possible, after checking their production capacity.

(vii) Pumping facilities

Vertical-shaft type multi-stage turbine pumps are being manufactured in Bangladesh. The said kind of pump will be adopted in this project, with the purpose of facilitating the procurement of parts and components required for maintenance and repair of the pumps after the completion of the facilities. The use of other types of pumps will be examined if vertical-shaft multi-stage turbine pumps are regarded as inadequate in view of requirements related to the volume of water to be pumped and head.

As a result of consultations held with the DPHE, it was decided that the operation time of the pumps will be 12 hours a day, by taking into consideration the maintenance and administration of the facilities, duty conditions of the operators, and other relevant factors.

The pumps will be installed in such a way to make effective use of the housing pipes in order to cope with some lowering of the ground water level, because 30 m (100 ft) housing pipes will be used in the productive wells.

The volume of water to be pumped by each pump (q) is calculated from the volume of water to be supplied from the well in question (Q).

$$q = Q/H$$

where, H : the operation time of the pump (12 hours)

(viii) Transmission pipes

The diameter of the transmission pipes is calculated from the volume of water to be conveyed, and the most economical diameter that minimizes the sum of the construction cost and the maintenance and operation cost of the water conveyance system shall be selected.

The relationship between an economical diameter and an economical velocity of flow is said to be 0.7 to 1.0 m/sec. for a diameter in the range of 75 mm and 150 mm, and 0.8 to 1.0 m/sec. for a diameter in the range of 200 mm and 300 mm, based on empirical performance records. From these, the economical rate of flow for each diameter was calculated and summarized in the table below.

Pipe Diameter (mm)	Sectional Area (m^2)	Economical Velocity of Flow (m/sec.)	Discharge (liter/sec.)
100	0.00785	0.7 - 1.0	5.50 - 7.85
150	0.01766	0.7 - 1.0	12.36 - 17.66
200	0.03140	0.8 - 1.0	25.12 - 31.40
250	0.04906	0.8 - 1.0	39.25 - 49.06
300	0.07065	0.8 - 1.0	56.52 - 70.65

Accordingly, the diameter of the transmission pipe shall be obtained from the relationship between each diameter and flow rate tabulated above. In case where the pipeline length is short and the loss of head is small, however, the motor output and pump capacity may not be affected materially even if the diameter is made smaller. In such a case, the diameter shall be so planned as to minimize the construction cost regardless of the foregoing tabulation.

There are two alternatives in terms of type of transmission pipe, i.e., steel pipe and cast iron pipe. The characteristics of the steel pipe and cast iron pipe are compared in Table 3-1-3. As is clear in the table, steel pipe has inferior workability in terms of the flexibility expanding or contracting and of pipe joints, etc, and is,

Table 3-1-3 Comparative Characteristics of Steel Pipe and Ductile Cast Iron Pipe

<table>
<tr><th></th><th colspan="2">Steel Pipe
(below ø300; JIS G 3452, above ø350; JIS G 3457)</th><th colspan="2">Ductile Cast Iron Pipe
(JIS G 5526)</th></tr>
<tr><td rowspan="5">Safety</td><td>1. Pipe Body Strength</td><td><table><tr><th>Diameter</th><th>Tensile Strength (kgf/mm²)</th><th>Bending Strength (kgf/mm²)</th><th>Elongation (%)</th></tr><tr><td>ø250,ø300</td><td>above 30</td><td>above 30</td><td>above 25</td></tr><tr><td>ø350-ø700</td><td>above 41</td><td>above 41</td><td>above 18</td></tr></table></td><td>1. Pipe Body Strength</td><td><table><tr><th>Diameter</th><th>Tensile Strength (kgf/mm²)</th><th>Bending Strength (kgf/mm²)</th><th>Elongation (%)</th></tr><tr><td>ø250-ø700</td><td>above 42</td><td>above 60</td><td>above 10</td></tr></table></td></tr>
<tr><td>2. Resistance against External Pressure</td><td>Easily deflects due to large ductility and thin wall. Especially in back-filling, fill with sand and tamp the sides of pipe as a rule to prevent deformation of pipe.</td><td>2. Resistance against External Pressure</td><td>Withstands large load due to thicker wall and larger bending rigidity than steel pipe. No particular consideration necessary in back-filling.</td></tr>
<tr><td>3. Resistance against Internal Pressure</td><td>Withstands high water pressure but inferior to ductile pipe.</td><td>3. Resistance against Internal Pressure</td><td>Withstands high water pressure. Bursting water pressure varies depending on caliber and kind of pipe, but generally withstands water pressure of 100 kgf/cm² or more.</td></tr>
<tr><td>4. Water Tightness of Joint</td><td>Below ø300: Normally screwed joint. Both corrosion resistance and water tightness unreliable.
Above ø350: Normally welded joint, demanding highly trained skill and satisfactory welding conditions.</td><td>4. Water Rightness of Joint</td><td>Highly water tight due to self sealing mechanism of the rubber ring. Leakage does not occur until pipe body ruptures.</td></tr>
<tr><td>5. Flexibility against Expansion and Contraction</td><td>Both screwed joint and welded joint lack flexibility against expansion and contraction, and generate excessive stress in the pipe body at the time of temperature change or change in foundation on soft ground. To moderate these stresses, expensive flexible expansion pipe must be used at every turn.</td><td>5. Flexibility against Expansion and Contraction</td><td>The joint of ductile pipe has excellent flexibility against expansion and contraction and can smoothly accommodate itself to changes in the ground foundation and temperature without generating stress in the pipe body.</td></tr>
<tr><td rowspan="2">Workability</td><td>1. Excavated Ditch and Foundation</td><td>(1) Use of sand bed and adequate tamping around the pipe are necessary to prevent deformation of pipe.
(2) To secure proper position of weld, adequate space must be excavated around the joint intersection.</td><td>1. Excavated Ditch and Foundation</td><td>(1) In general, a flat bottom ditch is sufficient without requiring any special bed or work.
(2) In the case of a T shape, extra space by excavating around the joint intersection is hardly needed.</td></tr>
<tr><td>2. Pipe Jointing</td><td>(1) Welding work will take a long time. (centering, welding, inspection, painting, etc.)
(2) Licensed welder with sophisticated skill and experience is needed.
(3) Welding work is influenced by natural and climatic conditions and underground laying conditions. (rain, moisture, ground water, etc.)
(4) As jointing work by welding and coating or covering require long time, traffic may be disturbed.</td><td>2. Pipe Jointing</td><td>(1) Jointing work possible in a short time by simply setting rubber rings and inserting the spigot into the receptacle.
(2) Jointing possible with only simple tools and without requiring advanced skill.
(3) Workable under varied conditions.
(4) Back-filling possible immediately after jointing.</td></tr>
<tr><td rowspan="3">Maintenance and Upkeep</td><td>1. Anti-Corrosiveness (inner surface)</td><td>When the caliber is below ø600, coating of inner pipe surface is almost impossible and the pipe could be easily corroded.</td><td>1. Anti-Corrosiveness (inner surface)</td><td>Inner surface has an excellent anti-corrosive property by the alkaline anti-corrosive effect of cement mortar lining</td></tr>
<tr><td>2. Anti-Corrosiveness (outer surface)</td><td>Heavy anti-corrosive coating must be applied on the external surface of pipe. If handling flaws are buried as they are, pitting corrosion might result. Also, covering or coating of joint is done manually at the construction site which requires skill and experience and makes quality control difficult. To prevent these trouble, electrical corrosion protection becomes necessary. In the screwed joint, possible corrosion of the screwed portion poses a problem.
Repair work cannot be performed unless water has been completely drained.</td><td>2. Anti-Corrosiveness (outer surface)</td><td>Anti-corrosive property peculiar to cast iron is available (has the empirical proof of more than 300 years) Tar epoxy coating is applied in general.
Repair and extension work can be easily done.</td></tr>
<tr><td>3. Depreciable Life</td><td>25 years</td><td>3. Depreciable Life</td><td>40 years</td></tr>
</table>

in the cases of it with smaller diameters, impossible to paint inside after joints are welded, thus entailing problems in view of corrosion resistance besides its general anti-corrosion problem with its outside surface. Thus, from an overall viewpoint, cost iron pipe seems to be better. Therefore, transmission pipes made of cast iron will be used in this Project.

(ix) Overhead tanks

The seven towns in question have flat topography, and the roads where the service pipelines will be laid have no undulations and are practically horizontal. Overhead tanks with the purpose of adjusting the pressure and controlling the volume of water will be constructed in this Project, because there are no adequate hills for construction of distributing reservoirs in the vicinity of the municipal areas of the towns in question. The location of the overhead tanks will be decided through hydraulic studies taking into consideration its relationship with the productive wells, in such a way as to require pipe diameters not exceeding 200 mm, in order to make possible the use of PVC pipes manufactured in Bangladesh.

The capacity of the overhead tank is of the order of 15% to 20% of the volume of water supplied each day in the projects by the aid of the Netherlands, while in the projects financed by the ADB it is of the order of six hours of supply. According to the Japanese standards, the capacity of overhead tank is of the order of eight to 12 hours of estimated maximum daily supply in principle, and overhead tanks constructed for the purpose of controlling the distribution volume and pressure of water and protecting pipeline have the capacity of one to three hour supply at the maximum supply rate and are constructed together with service reservoir, for structural and economical reasons.

In this Project the daily operation time of the pumps will be 12 hours (during the daytime). The change of the volume of water to be supplied with time has distinct characteristics in urban and rural areas according to the circumstances therein. In Japan the running water consumption pattern has morning and evening peaks and a relatively large consumption during the first half of the night hours in urban areas, but in rural areas the consumption rate becomes low during night. We have no data about the change of running water consumption rate with time in Bangladesh, and it is difficult to make a simple comparison with Japan. However, assuming that local cities of Bangladesh correspond to rural areas of Japan, it is presumed that the consumption of water during the night time becomes extremely low in the provincial cities of Bangladesh, by taking into consideration the differences between the customs of the two countries (use of bath, shower, etc.).

In this project, the capacity of overhead tank was determined to be around 20% of daily water consumption by using as a reference the results of water balance calculations conducted with respect to the relationship between the capacity of overhead tank and the operating hours of pump based on an assumed hourly water consumption pattern in Bangladesh. (See 3-10-4)

The height of the overhead tank shall be determined by taking into consideration the results of hydraulic calculations. In the Project implemented with aid of the Netherlands the minimum water level of the water tower is 18 m to 21 m above the ground. In this Project the overhead tanks will be designed with the minimum water level 17.0 m above the ground level, by taking into consideration the results of the hydraulic calculations.

Table 3-1-4 Comparison of the Structures of Water Tower

Item	Steel Tower	Reinforced Concrete Tower
Construction material	Steel must be imported from Japan.	Can be constructed with locally available materials like cement, gravel, sand and steel bar.
Water tightness of storage tank	Leakage unlikely as water tank is jointed by welding.	Waterproofing work with mortar or resin is necessary.
Maintenance and upkeep	Periodical coating of inside and outside of the water tank and struts is necessary to prevent corrosion.	Coating unnecessary.
Retention of water temperature	More susceptible to atmospheric temperature and exposure to direct heat than reinforced concrete tower.	Less susceptible to atmospheric temperature and exposure to direct heat than steel tower.
Foundation work	No. of foundation piles is less than reinforced concrete tower due to lighter weight to support.	No. of foundation piles is more than steel tower.
Construction period	Construction period is short as it can be constructed by assembling and welding steel materials.	Construction period is long as assembling of molds and timbering, placing and curing of concrete, etc. take time.
Construction cost	Generally inexpensive, but if tariff, etc. on imported materials are included as in Bangladesh, it may not necessarily be inexpensive.	Construction cost is high due to larger scale foundation works and other reasons.

As for structure of water tower, the steel tower and the reinforced concrete tower have advantages over the others as compared in Table 3-1-4. However, it was considered advaisable to use reinforced concrete in view of the policy to use materials and equipment which can be locally procured to the maximum extent possible in planning facilities and also because protective coating after completion involves a sizable money.

In connection with the water quality, as a general rule there is no risk of contamination with microbes because it is pumped from deep wells (ground water), but the overhead tanks will be equipped with simple sterilization equipment in order to cope with the occurrence of infectious diseases and other unexpected situations. Furthermore, the water towers will be equipped with lightning arresters as well.

(x) Distributing pipeline

The design flow is the maximum hourly water supply rate. The maximum hourly water supply rate is twice the design hourly water supply rate.

$$q_D = q_{max} = 2 \times q_{av} = 2 \times Q/24$$

where;

q_D : Design flow (m^3/hr)
q_{max} : Maximum hourly water supply rate (m^3/hr)
q_{av} : Design hourly water supply rate (m^3/hr)
Q : Design daily water supply volume (m^3/day)

As for the pipes, PVC pipes (Class B) manufactured in Bangladesh will be used when the required caliber is less than 200 mm. Cast iron pipes imported will be used when the required caliber is 250 mm or more.

In principle, the pipe diameter is determined by carrying out hydraulic calculations referring to the design flow, internal pressure in the pipes, etc., but future expansion plans are also taken into consideration in this connection.

It is assumed that an internal pressure of 9 m (30 ft, 0.9 kg/cm²) will be kept at the extremity of the distributing pipe.

Gate valves, blow-off, etc., will be provided at places regarded as necessary from the standpoints of maintenance and operation.

The configuration of the distributing pipe network will be determined by taking into consideration such factors as the current demographic distribution, areas where the population is expected to grow in the future, conditions of the exiting road network, etc.

The hydraulic calculations of the distributing pipes are carried out by means of the Hesen-Williams formula, by assuming an uniform water velocity coefficient C = 110 (including bend loss), irrespective of the type of pipe.

(xi) Water purification plant

In principle, this Project is considering the use of ground water as water source. However, if ground water is regarded as inadequate as water source in view of such characteristics as depth, volume of water, water quality, etc., it will be necessary to consider the use of river water, and in that case it is necessary to consider the construction of water purification plant.

In six of the seven towns it is possible to use ground water as water source, notwithstanding the necessity of examining the iron content in some cities.

In the Sunamganj Town however, it is necessary to consider the construction of the water purification plant and to supply treated river water for potable use by the population, because ground water is regarded as inadequate as water source, in view of such factors as volume of water, water quality, depth and relation with the water source of the exiting water pumps.

(xii) House Connection

In principle, the cost for construction of the house connection should be borne by the beneficiary. The Government of Bangladesh will construct the house connections.

Therefore, the construction of house connections is excluded from this Project.

(xiii) Public post

The water supply project will provide 50% of the population with potable water by means of public posts. The only source of income of the water supply project is the water charge of the house connections. Immediately after the completion of this Project there will be very few house connections, and the water charge income is expected to be insufficient to realize a satisfactory operation of the water supply system. It is very difficult to collect water charge from public posts, and as a general rule they are used free of charge. Such being the case, it is desirable to construct public posts concurrently with the diffusion of house connection. Therefore, this Project assumes the construction of approximately 10 public posts in each town.

The public posts of this Project will be constructed with 13 mm (ø1/2") caliber PVC pipes, and will be located at distances of the order of 5 m from the mains. One 13 mm-caliber hydrant will be provided in each public post.

(xiv) Policy for procurement of materials and equipment

The water supply systems of this Project will be constructed by using as much as possible materials and equipment manufactured or available in Bangladesh, in order to facilitate the maintenance, repair and expansion after the completion of the work.

The structure of the facilities in question will be made as simple as possible in order to facilitate their maintenance with the technical level available in Bangladesh, and the use of complicated structures and many machines will be avoided as much as possible. In reality, however, it would be impossible to manufacture or procure all of the required materials and equipment in Bangladesh. Because of the limited production capacity of factories and limited sotck on hand of dealers, procurement of large quantities of materials at a time may be difficult. In such an event, materials imported from Japan will be used.

(xv) Foundation treatment method

The foundation treatment for various facilities including water tower, pump house and purification plant are considered to be as follows.

Since investigation of the foundation beds at the proposed construction sites of these structures has not been carried out yet, no data is available. However, the following data which were obtained from the grants-in-aid projects of Japan implemented in Bangladesh are available.

(1) Ground bearing power test results (food warehouse construction project)

at Khulna	: Allowable bearing power q_a = 6.4 t/m²
at Bogra	: Allowable bearing power q_a = 6.1 - 6.9 t/m²
at Chittagong	: Allowable bearing power q_a = 7.9 - 8.1 t/m²
at Mymensingh	: Allowable bearing power q_a = 6.8 - 8.5 t/m²

(2) Loading test results of piles (Narayanganj: hospital construction project)

According to the results of loading test on ø400 mm cast-in-place concrete piles driven to the depth of 16 m, the bearing power was 80 t/pile. This bearing power is not the ultimate bearing capacity since the test was discontinued within the allowable load of the pile itself.
Since it was reported that hardly any sinking occurred at the load of 80 tons during the test, the ultimate bearing capacity is considered to have been more than 80 tons.
Normally, 1/3 of the ultimate bearing capacity is adopted as the allowable bearing power of pile, but in this Project, it is judged safe enough to use 1/2 of the observed value of 80 t/pile as the allowable bearing power in consideration of the aforementioned test conditions.

Since the ground in all of the seven towns is Quaternary alluvium, the results of other projects are considered applicable to the study of the foundation treatment method for this Project.

Accordingly, of the structures to be constructed under this Project, those subject to small load, for instance pump house, will be designed to have the direct foundation work with an allowable ground bearing power of 6 t/m^2.

For foundation of structures subject to large load like the water tower, steel pipe pile or reinforced concrete pile may be considered. In Bangladesh, cast-in-place reinforced concrete pile seems appropriate, because an ordinary well drilling machinery can be used for this work and all of the required materials can be locally procured.

q_a = 40 t/pile will be used as the allowable bearing power of cast-in-place pile in designing the foundation work.

The proposed number of pile for type of overhed tank is as follows;

Capacity of overhed tank	Nos. of pile
200 m^3	21 Nos.
300 m^3	27
400 m^3	32
500 m^3	38

3-2 Narsingdi Town

3-2-1 Outline of the Town

(1) Location and General Conditions

This town belongs to the Dhaka Division, Narsingdi District, and is located at the right bank of the Meghna River approximately 35 km to the north-east of Dhaka. The town has a municipal area of 4 square miles.

As for the means of transportation, the railway connecting Dhaka with Bhairab Bazar crosses the town, and the road connecting Dhaka with Sylhet crosses the said railway and passes through the west side of the town. To the south of the town is located a tributary of the Meghna River, and there is a fluvial traffic of boats using this river since old times. This town has a prosperous industry, consisting principally of textile factories that use the aforementioned traffic system. The population of the town grew from 39,140 in 1974 to 70,006 in 1981 and 97,726 in 1984. As things now stand the town has 12 primary schools, six high schools, two colleges, six Madrasha, two kindergartens and one hospital.

(2) Topography and Geology

a. Topography

This town has flat topography because the its ground consists of thick sedimentation of flood deposits formed by the Meghna River which has its source in India, and its altitude is 6.6 m.

The northern side and eastern side of the town is surrounded by the Canal River which flows into the Meghna River, the southern side is bordered by the Meghna River and the western side is surrounded by the road connecting Sylhet with Dhaka. As for the land use of the town, the zone located between the right of way that extends in the E-W direction and the right of way that extends to the south is the central street area, the zone located to the north of the right of way that extends in the E-W direction composes the new street area, and the zone located to the west of the right of way that extends to the south composes the rural area.

b. Geology

The geology of this town consists of a thick deposit of Quaternary fluvial sediments. These sediments consist of alternate layers of clayey matter and sandy matters, and according to the existing data these layers are presumed to be dipped to the south.

The existence of clayey matter has been confirmed in three distinct layers, i.e., one layer distributed from GL 0 m to approximately GL -45 m, the second layer with approximately 10 m thickness located at the vicinity of GL -130 m and the third layer located at the vicinity of GL -170 m. The sandy matter consists of fine sand layer and medium sand layer, with the former one distributed from GL -60 m to GL -100 m and the latter one distributed from GL -100 m to GL -130 m and from GL -140 m to GL -170 m.

(3) River System

This town belongs to the river system of the Meghna River which has its source in India. It is presumed that the Old Meghna River (located to the south of the town), which flows into the Meghna River, was dammed up during the process of change of the river course and eventually acquired the current form. The Canal River, which is a small river flowing into the Meghna River, is located to the north and to the east of the town.

The wharf of the town is located at the vicinity of the confluence of the Old Meghna River and the Canal River, and is used as landing place by the boats that compose the fluvial traffic system of this area. The water level of the Old Meghna River reaches its peak in September, which corresponds to the end of the rain season, with H.W.L. of 5.9 m and L.W.L. of 5.6 m as shown in Table 3-2-1. On the other hand, the minimum water level occurs during the dry season (January and February), with H.W.L. of 1.7 m and L.W.L. of 0.7 m. According to the available data, the maximum value of the H.W.L. recorded so far is 6.9 m (August 31, 1984) and the minimum value of the L.W.L. is 0.6 m (January 27, 1951).

Table 3-2-1 Change of Water Level of the Meghna River

(m)

Year \ Month		1	2	3	4	5	6	7	8	9	10	11	12
1980	H.W.L.	1.7	1.8	2.4	2.8	3.1	4.1	5.0	5.7	5.9	5.8	4.3	1.5
	L.W.L.	0.9	0.7	1.0	1.5	2.4	3.0	4.1	5.0	5.6	4.0	2.0	1.4

* Record H.W.L. 6.9 m (Aug. 31, 1954)
L.W.L. 0.6 m (Jan. 27, 1951)

(4) Climate

a. Rainfall

Generally speaking, Bangladesh has three distinct seasons, i.e., summer (March to May), monsoon season (June to October) and dry season (November to February). Rainfall occurs from midsummer (April) to the monsoon season, with remarkable concentration during the monsoon period.

The annual average rainfall in the town is approximately 2,100 mm, which coincides with the national average. The rainfall record of 1983 is shown in Table 3-2-2.

Table 3-2-2 Monthly Rainfall in Dhaka

(mm)

Month / Year	1	2	3	4	5	6	7	8	9	10	11	12	Total
1983*	10	28	126	192	504	353	376	710	232	320	0	41	2,891
1980*	3	31	52	145	412	325	386	259	292	298	0	0	2,203
1981*	10	42	112	274	411	325	356	187	320	82	9	35	2,163
1982*	0	15	81	104	154	514	-	-	-	-	-	-	

* Dhaka

Rainfall data of Table 3-2-2 show that as a general rule the monthly rainfall exceeds 100 mm from March to October, with particularly high concentration from May to October. This heavy rainfall season corresponds to the monsoon period, which accounts for approximately 90% of the annual rainfall.

b. Temperature

The temperature record of Dhaka is used for the sake of reference in this project, because there is no temperature measurement data of the town itself. During the monsoon period (July) the average temperature is 28°C and during the dry season it is 19°C, with a relative temperature difference of 9°C. The change of temperature in the 1980-1982 period is shown in Table 3-2-3.

Table 3-2-2 Maximum and Minimum Temperature in Dhaka by Month (°C)

Year	Month	1	2	3	4	5	6	7	8	9	10	11	12
1980	Max.	24.8	27.2	31.9	35.7	29.7	31.3	30.5	32.5	29.3	30.7	29.0	26.5
	Min.	12.2	15.1	20.6	25.1	25.3	26.3	26.1	27.3	26.2	23.6	17.0	15.0
1981	Max.	26.3	27.4	30.8	35.7	31.9	32.7	35.3	33.4	31.7	33.3	30.0	25.4
	Min.	12.3	25.7	19.9	22.2	24.5	25.9	26.0	26.4	25.3	23.5	18.1	13.8
1982	Max.	26.3	27.3	30.6	32.6	-	31.6						
	Min.	12.3	14.8	18.9	22.6	-	26.0						

As can be seen from Table 3-2-3, the months with higher temperature are from March to November, with a maximum exceeding 30°C and a minimum exceeding 20°C. On the other hand, the lower temperatures occur in January, with a maximum of approximately 25°C and a minimum of 12°C.

3-2-2 Hydrogeological Outline and Possibility of Developing Groundwater

(1) Hydrogeological Outline

As a general rule, the grain size distribution exerts decisive influence on the acquifiability of layers of soil that have not been consolidated yet. Soils with coarse grain size have superior acquifiability, but the finer the grain size the poorer the acquifiability.

As mentioned in the section on geology, the geology distributed in the town consists of clayey, fine sandy and medium sandy layers. In terms of acquifiability, the fine sand and medium sand layers have good properties, and the clayey soil layer has poor properties.

As for the state of affairs of utilization of groundwater in the town, expressed in terms of number of deep wells, there are three wells of DPHE (two under construction), two of factories, one of C&B and one of the railway, totaling seven deep wells. As for hand pumps, DPHE has 399 and others have 365, totaling 764 wells of this kind. The characteristics of the wells related to DPHE are shown in Table 3-2-4.

Table 3-2-4

T/W No.	Total Depth	Soil of Aquifer	Screen		Pumpage	Static Water Level	Pumping Water Level	Time of Steady State Condition	Recovery Period	Water Quality			
			Length	dia.						pH	Fe	cl	T. Hard
	ft.		ft.	inch	IGPH	ft.	ft.	min	min				
1	400'	MS	80'	6"	15,900	14'4"	67'11"	90	420	6.5	1.0	45.45	
2	450'0"	FMS & MS	100'	6"	9,900	15'4"	82'5"	(720)	(300)	6.8	1.0	30.30	154
3	282'0"	MS & CS	100'	6"	20,000	10'9"	59'7"	-	-	-	-	-	-
Hand Pump	120'	FS & FMS	12'	1.5"	DPHE 399, Public 365 } Total 764								

Of the wells of Table 3-2-4, the hand pumps draw water from the fine sandy layer, while the deep wells pump water from the medium sandy layer.

As for the groundwater level, in the existing well T.W. No.1 it was GL -4.3 m on the occasion of its construction (May 15, 1981) and GL -6.2 m on the occasion of the survey carried out this time, while in the T.W. No.2 it was GL -4.1 m on the occasion of the pumping test (1983).

The well T.W. No.3 is under construction at the present time and the groundwater level was GL -3.2 m on the occasion of the pumping test. From the aforementioned results it is estimated that the groundwater level is of the order of GL -6 m during the dry season.

As for the water quality, it is concluded that there is no problem at all from the existing data.

(2) Possibility of Developing Groundwater

The following conclusions about the possibility of development of groundwater are drawn from the existing data of the Paragraph (1).

a. Hydraulic constants

i. Coefficient of infiltration — T in m^2/min

T.W. No.1 : T = 0.18 to 0.37 m^2/min

ii. Coefficient of permeability — K in cm/sec

From $K = \frac{T}{m}$ where m is the strainer length,

T.W. No.1 : K = 1.2 to 2.6 x 10^{-2} cm/sec

iii. Specific yield of well — S in $m^3/day/m$

T.W. No.1 : S = 108 $m^3/day/m$

The aforementioned parameters indicate indirectly the capacity of the aquifer, and judging from the values calculated above, S is rather small but T and K is large and therefore it is concluded that the medium sandy layer which water is being drawn from has satisfactory characteristics as object of development of groundwater.

b. Influence area of the wells

As a general rule the influence area of one well is examined by constructing an observation well when the well in question is being submitted to pumping test, and by observing the lowering of the water level in correspondence to the pumping. In reality however, the existing data were collected by carrying out the tests without constructing the observation well, and under the circumstances the following conclusions are drawn by using the values of Table 3-2-5 as a reference. It is presumed that adjacent wells must be separated by 300 m or more, because the layers object of exploitation of groundwater consist of fine sandy and medium sandy soil.

Table 3-2-5 Influence Area of Pumping Well
(From the "Soil Test Method")

Soil Quality		Radius of Influence
Classification	Grain Size (mm)	R(m)
Coarse gravel pebble	>10	> 1,500
Gravel pebble	2 to 10	500 to 1,500
Coarse sand	1 to 2	400 to 500
Coarse sand	0.5 to 1	200 to 400
Coarse sand	0.25 to 0.5	100 to 200
Fine sand	0.10 to 0.25	50 to 100
Fine sand	0.05 to 0.10	10 to 50
Silt	0.025 to 0.05	5 to 10

Judging from a. and b., it is concluded that the development of groundwater has no problem at all if the adjacent wells are separated by 300 m or more and the water pumping volume is restricted at $Q = 1.2\ m^3/min$ in the old street area and $Q = 1.5\ m^3/min$ in the new street area.

3-2-3 Water Source

As things now stand potable water is being supplied by one deep well (pumping rate 72 m^3/h) and 764 hand pumps (300 of DPHE and 365 Public ones which are constructed by town), and no river water is being used at all.

Such being the case, the following conclusions are drawn from the studies about the source of potable water of the projects to be implemented hereafter.

a. Groundwater

According to the available data referring to wells, it is concluded that the aquifers containing the largest volumes of water are the sandy soil layers located under GL -45m, particularly the medium grain size layers located from GL -100 m to GL -130 m and from GL -140 m to GL -170 m. According to the existing data, the volumes of water available for pumping contained in the said aquifers is of the order of $45 m^3/h$ to $90 m^3/h$, and as a matter of fact pumping rates of $90 m^3/h$ have been realized in the new street areas. Such being the case, it is concluded that the development of groundwater in this town is possible, as mentioned in the Section 3-3-2.

b. River water

As mentioned in the Section 4-1-2 (3) a. "Water system", the upstream side of the Old Meghna River located to the south of the town was dammed up in the process of displacement of the river course, and the volume of water coming from its upper course is negligible. Such being the case, it is expected to become a crescent lake in the future, because its lower course will be dammed up as a consequence of the gravel flowing in.

Furthermore, the water level of this river becomes low during the dry season, as shown in Table 3-2-1.

Under the circumstances, we come to the conclusion that the old river is not so favorable as a source of water, and therefore we judge that the main stream of the Meghna River is more favorable as water source of this project.

From the considerations of a. and b. above, we come to the conclusion that groundwater is the best alternative as water source for this project.

No.1 OH
No.2 OH
No.3 OH
No.4 OH
No.5 OH
P
LEGEND
; Existing Production Well
; Proposed Production Well
OH ; Proposed Overhead Tank
; Proposed PVC Pipe ø100mm
; Existing Pipe ø100mm
; Proposed PVC Pipe ø150mm
; Existing Pipe ø150mm
; Proposed PVC Pipe ø200mm
; Existing Pipe ø200mm
; Proposed DCIP ø250mm
NARSINGDI
GENERAL PLAN

Fig. 3-2-1

3-2-4 Water Supply Plan

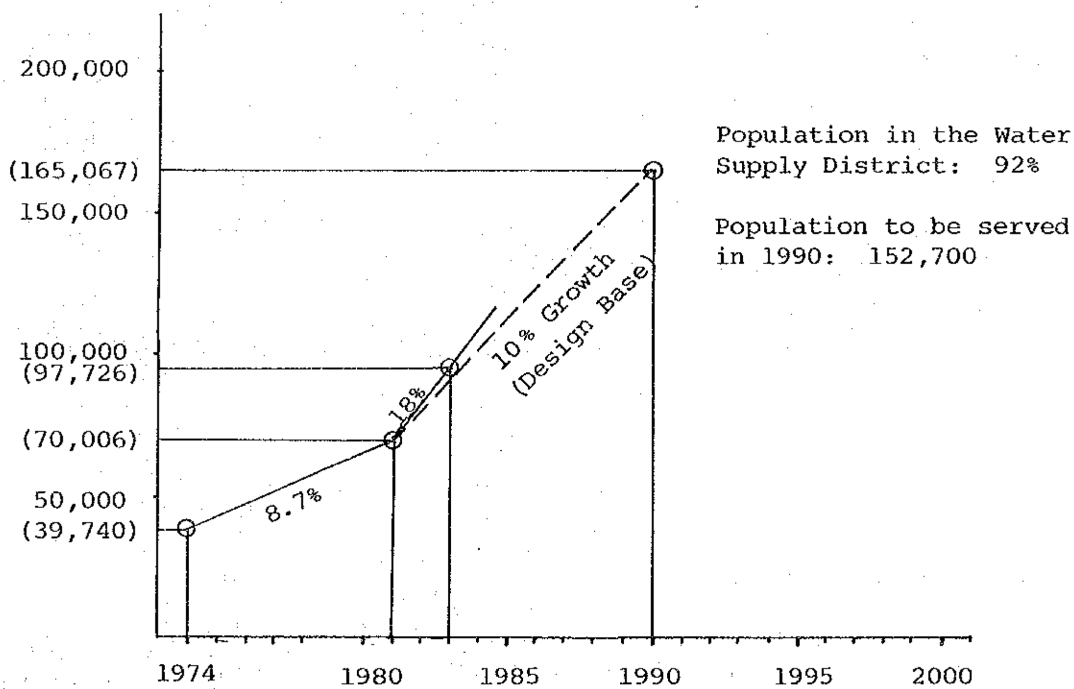
(1) Water Supply District and Population Supplied

The population data at the time of censuses in 1974, 1981 and today (May 1984) are as follows.

Population at the 1974 census	:	39,140
Population at the 1981 census	:	70,006
Population as of May 1984	:	97,726

These data may be plotted as follows.

Population Growth in Narsingdi Town



The average demographic growth rate from 1974 to 1981 was 8.7%, and the average growth rate from 1981 to the present increased to 18%. A remarkable demographic influx has been observed of late, but in reality the recent demographic growth rate of the town is not expected to last for a very long time. In the 1974-1981 period the growth rate averaged 8.7%, which is higher than other areas, and the studies of this project are conducted on the premise of an average growth rate of 10% from 1981 to 1990 (target year of the Project). It is assumed that the population of the town will reach 165,000 in 1990.

The water supply district are defined by taking into consideration the current demographic distribution, the state of formation of the villages, and the future tendency of development of housing areas. The water supply are will account for 92% of the town population. The population to be served by the water supply system will be 152,700.

(2) Water Consumption

The volume of water to be supplied to the 152,700 population is calculated as follows:

$$Q = 81 \text{ liters/man-day} \times 152,700 = 12,369 \text{ m}^3\text{/day}$$

(3) Water Supply Facilities Plan

(i) Production wells

a. Diameter of the well and volume of water to be pumped

As a general rule the larger the volume of water to be pumped the larger the diameter of the well, and when it is necessary to pump further volumes of water the well is made deeper in order to collect water from many aquifers.

In the present case the reference data of Table 3-2-4 indicate that the drawdown becomes 16 to 20 m when water is pumped from a 6" diameter well. The aforementioned data suggest that a larger drawdown many exert influence on the life of the well, and therefore 6" well will be used in this project.

The existing data are not sufficient to determine a definitive value of the volume of water to be pumped, but it is presumed that the values shown in Table 3-2-4 are the most convenient values in view of the drawdown. Therefore, the design pumping flow is Q = 1.2 t/min in the old street area and Q = 1.5 t/min in the new street area.

b. Drawing depth

In view of the estimated geological profile shown in Figs. 3-10-11 and 3-10-12, it presumed that in the old street area water will be drawn from the medium grain size sandy layer located from GL -100 m to GL -130 m, and in the new street area it will be draw from the medium sandy layer located under GL -60 m.

c. Number of wells

The number of wells is calculated as follows, in view of the volume of water to be pumped and volume of water to be supplied.

$$x = \frac{Q}{Qy}$$

where: Q = volume of water to be supplied (m^3/min)

Qy = volume of water to be pumped from each well (m^3/min)

i. Old street area

$Q = 8.97\ m^3/min$

The existing wells are T.W. No.1 = $1.2\ m^3/min$ and T.W. No.2 = $0.8\ m^3/min$.

$$Q = 8.97 - (1.2 + 0.8) = 6.97$$

$$x = \frac{6.97}{1.2} = 5.8 = 6 \text{ wells}$$

As can be seen, six wells will be constructed anew in this project, which summed with the two existing ones will total eight wells.

ii. New street area

$Q = 8.21\ m^3/min$

$$x = \frac{8.21}{1.5} = 5.5 = 6 \text{ wells}$$

The well under construction at the present time will have capacity $Q = 1.5\ m^3/min$, and therefore five wells will be constructed anew in this project.

As can be seen, 14 wells will be required in total, including the three already finished or under construction. Therefore, 11 wells will be constructed anew in this project.

d. Location of the wells

The wells to be constructed in this project will be located at the positions shown in Fig. 3-2-1, which are determined by taking into consideration the existing wells in order to prevent them from interfering with each other.

(ii) Pump facilities

The actual head of the pump facilities will be 45 m, by assuming that the suction level inside the well is (-) 25 m from the ground level (GL) and that the discharge level is 20 m above the ground level (high water level of the overhead tank). In reality the suction water level depends on such factors as the volume of water to be pumped, location of the well and geological conditions of the well, but in this project it is assumed that all wells will have the same suction level.

The head loss of the transmission pipes of each well is calculated in the first place from the volume of water to be pumped, as well as the diameter and length of the transmission pipes, and then it is used to calculate the total head. These data are used to determine the type of pump, number of stages, motor power and other relevant characteristics, and the obtained results are shown in Table 3-2-6.

(iii) Overhead tank

The design supply flow of Narsingdi Town is 12,369 m^3/day, and therefore the required capacity of the overhead tank is 2,473 m^3 which corresponds to 20% of the design supply flow. The number and location of the overhead tanks is determined through hydraulic calculations carried out on the premise of using as much as possible distributing piles sized under 200 mm. It is concluded that five overhead tanks will be constructed in accordance to the locations shown in the plans.

The height of the overhead tanks will be 17 m above the ground level (GL), by adding some spare height to the results of the hydraulic calculations. The five overhead tanks to be constructed in this project will have 500 m^3 capacity each.

(iv) Distributing pipes

The location of the distributing pipes is determined by taking into consideration the demographic distribution conditions, the location of the existing wells and distributing pipes, the road network distribution conditions and the trends of future development of housing areas.

Cast iron pipes sized 250 mm are used in part of the distributing network, but the rest consists of PVC pipes.

The hydraulic calculations are carried out in terms of pipe network, based on the design conditions. The results of the said calculations indicate that water pressure of 9.0 m (0.9 kg/cm^2) will be available at the extremity of the mains and branch pipes.

(v) Public posts

If the minimum water pressure at the extremity of the mains and branch pipes is 9.1 m, the flow from a hydrant sized ø13 mm will be 20 liters/min (14.4 m^3/12 h).

This project assumes that 50% of the population will be supplied with potable water by means of public posts, and the design supply flow is calculated as follows.

$$Q = 152{,}700 \text{ persons} \times 0.5 \times 34 \text{ liters/man-day}$$
$$= 2{,}595.9 \text{ m}^3\text{/day}$$

Therefore, 180 public posts will be required in order to supply the planned volume of water. The number of public posts will be determined by taking into consideration the water supply area, the distribution of the population to be served by the public posts and the forecast of the frequency of use.

The collection of water charge is difficult in the case of water supplied by means of public posts, and as a general rule they are used free. We consider it indispensable to keep the balance between the diffusion of house connection and the construction of public posts, in order to make the water supply system financially feasible.

10 public posts will be constructed in this project for the time being, and the remaining ones will be constructed by the Government of Bangladesh, concurrently with the diffusion of house connections.

Table 3-2-6 Principal Particulars of Pump Facilities

Description / Well No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Actual head, m	45.0	45.0	45.0	45.0 (exist-ing)	45.0	45.0	45.0 (exist-ing)	45.0	45.0	45.0 (exist-ing)	45.0	45.0	45.0	45.0
2. Pumping rate, ℓ/sec	23.95 (47.9)	23.95 (47.9)	16.43 (32.86)	16.43 (32.86)	16.44	17.43 (34.86)	17.43 (34.86)	17.44	22.07 (44.13)	22.07	22.06 (44.13)	23.60	23.60 (47.20)	23.60 (47.20)
3. Transmission pipe														
Kind of pipe	Cast iron pipe	"	"	"	"	"	"	"	"	"	"	"	"	"
Diameter, mm	200,200	150,200	150,200	150,200	150,000	150,200	150,200	150,000	200,250	200,000	200,250	200,000	200,200	200,200
Length, m	440.40	30.40	630.70	30.70	490	440.310	180.310	40	220.130	230	360.130	860	30.40	360.40
4. Loss of head in the transmission pipe, m	3.16	1.43	7.57	1.01	5.37	8.73	5.55	0.48	1.76	1.07	2.41	4.53	0.92	2.65
5. Total head, m	48.16	46.43	52.57	46.01	50.87	53.73	50.55	45.48	46.76	46.07	47.41	49.53	45.92	47.65
6. Type of pump	Turbine	"	"	"	"	"	"	"	"	"	"	"	"	"
7. No. of stages	12	12	14	12	13	14	13	12	11	11	12	13	12	12
8. Motor output, kW	19	19	15	15	15	15	15	15	15	15	19	19	19	19

3-2-5 Contents of the Project

(1) Water Supply Facilities Already Completed by DPHE

The contents of water supply facilities already constructed by DPHE's own funds are shown in Table 3-2-7.

(2) Water Supply Facilities to be Constructed under this Project

The contents of water supply facilities to be constructed under this project, which were determined on the basis of the contents of water supply facilities of this project as a whole and the contents of facilities already completed by DPHE, are as shown in Table 3-2-7, and the proposed plan for them is as shown in Fig. 3-2-1.

Table 3-2-7(1) Outline of the Water-Supply Systems to be Constructed in This Project

Narsingdi

Facilities	Specification	Project as a Whole	Existing Facilities Constructed by DPHE	Facilities to be Constructed Anew
1. Production Well	As per attached sheet	14 Nos.	3 Nos.	11 Nos.
2. Pumping Facilities	As per attached sheet	14 units	0	14 units
3. Pumping House	Brick-and-mortar, pump room: 12.3 m²	14 Nos.	1 No.	13 Nos.
	Driver's room: 8.8 m²			
4. Transmission pipes	As per attached sheet	-	-	-
5. Overhead Tank	Capacity: 500 m³ x 5 Nos	5 units	0	5 units
	Height: 17 m			
	Reinforced concrete structure			
6. Distributing Pipes	CIP: ∅250 mm	780 m		780 m
	PVC Pipe: ∅200 mm	9,192 m	962 m	8,230 m
	∅150 mm	10,536 m	1,206 m	9,330 m
	∅100 mm	23,945 m	825 m	23,120 m
	Total	44,453 m	2,993 m	41,460 m
	Breakdown by paving as per attached sheet			
7. Related Structures of Distributing Pipes	Sluice valve (box): ∅250 mm	3 units	-	3 units
	∅200 mm	40 "	2 units	38 "
	∅150 mm	74 "	6 "	68 "
	∅100 mm	184 "	4 "	180 "
	Blow-off: ∅200 mm	5 "	Wash-out 1 unit	5 "
	∅150 mm	10 "		10 "
	∅100 mm	2 "		2 "
	Pipe and work: ∅100 mm	35 units		35 units
	∅150 mm	3 "		3 "
	∅200 mm	-		-
8. Public Post		16 places	6 places	10 places

Table 3-2-7(2) Specification for Wells, Pumps and Water Distribution Piping for Narsingdi Town

Facility	No.1	No.2	No.3	No.4	No.5	No.6	No.7	No.8	No.9	No.10	No.11	No.12	No.13	No.14
1. Production Well				No.2 (Existing)			No.1 (Existing)			No.3 (Existing)				
Dia. (mm)	ø300x150	ø300x150	ø300x150	ø300x150	ø300x150	ø300x150	ø300x150	ø300x150	ø300x150	ø300x150	ø300x150	ø300x150	ø300x150	ø300x150
Depth (m)	169	169	169	169	169	169	169	169	115	115	115	115	115	115
Strainer Length	24	24	24	30	24	24	24	24	24	30	24	24	24	24
2. Pump Facilities														
Model	B8D	B8D	B8D	B8D	B8D	B8D	B8D	B8D	B8D	B8D	B8D	B8D	B8D	B8D
Nos. of Steps	12	12	14	12	13	14	13	12	11	11	12	13	12	12
Required Output (kW)	19	19	15	15	15	15	15	15	15	15	19	19	19	19
3. Transmission Pipes														
Dia. (mm)	200,200	150,(200)	150,200	150,(200)	150	150,200	150,(200)	150	200,250	200	200,(250)	200	200,200	200,(200)
Length (m)	440, 40	30,(40)	630, 70	30,(70)	490	440,310	180,(310)	40	230,130	230	360,(130)	860	30, 40	360,(40)
4. Nos. of Overhead Tank to which Water is Transmitted (m³)	No.1 (500)	No.1	No.2 (500)	No.2	No.2	No.3 (500)	No.3	No.3	No.4 (500)	No.4	No.4	No.5 (500)	No.5	No.5

Table 3-2-7 (3)

Breakdown of Transmission Pipes and Distributing Pipes by Pavement
(Only Water-Supply Systems to be Constructed Anew)

Narsingdi

Item / Type	By Type of Pavement					Remarks
	As	R.C	Bricks	Kutcha	Total	
1. Transmission Pipes						No.1 - 14
ø6" (Parallel to the road)	1,240m	180m	280m	140m	1,830m	Well - 14 Nos.
ø6" (Crossing the road)						
ø8" (Parallel to the road)	1,270		1,250	420	2,940	
ø8" (Crossing the road)	20				20	
ø10" (Parallel to the road)	130				130	
Total	2,660	180	1,530	560	4,930	
2. Distributing Pipes						
ø4" (Parallel to the road)	3,060m	5,460m	12,760m	1,520m	22,800m	
ø4" (Crossing the road)	130	130	60		320	
Sub-Total	3,190	5,590	12,820	1,520	23,120	
ø6" (Parallel to the road)	1,560	2,800	4,920		9,280	
ø6" (Crossing the road)	30	10	10		50	
Sub-Total	1,590	2,810	4,930		9,330	
ø8" (Parallel to the road)	2,510	1,430	3,860	370	8,170	
ø8" (Crossing the road)	40	10	10		60	
Sub-Total	2,550	1,440	3,870	370	8,230	
ø10" (Parallel to the road)	780				780	
Sub-Total	780				780	
Total	8,110	9,840	21,620	1,890	41,460	

3-3 Jenidah Town

3-3-1 Outline of the Town

(1) Location and General Conditions

The town belongs to Jenidah District of Khulna Division and is located about 43 km to the north of Jessore. The town has a total area of 182 square miles, of which 6 square miles is its municipal area.

As for traffic, the road connecting Khulna and Kushitia crosses the town in the longitudinal direction, and the road connecting Magura and Mehepur crosses the town in the transversal direction. Commercial activities that take advantage of these roads are therefore brisk.

The population of the town grew from 18,130 in 1961 to 34,020 in 1974, 49,355 in 1981 and to 74,959 in 1984. The town has 10 primary schools, six high schools, two colleges, two Madrashas and three hospitals.

(2) Topography and Geology

a. Topography

The town, being located on the delta formed by the Ganges River, has a flat surface and is 10.5 m above sea level.

The town is divided into four sections by the road that traverses it from south to north and another from east to west. The urban area extends along these roads with the center being where the two roads meet. The suburbs are rural areas mostly comprising rice paddies and dry fields.

b. Geology

The soils of this town geologically consists of a thick deposit of Quaternary fluvial sediments. The sediments consist of clayey soil, sandy soil and gravel layers distributed as follows.

Clayey soil is found distributed on the surface, forming a layer about 15 m thick and mixed with sand overall. Sandy soil, which is distributed underneath this clayey soil, forms a fine sand layer about 60 m thick, intercalating clayey soil and medium grain sand here and there. The gravel layer is observed starting from around GL -75 m and is seen to contain a lot of medium and coarse grain sand.

(3) River System

The Nabaganga River which flows from north to east of the town and then south, and past Magura and Narail, merges at Khulna with the Madhumati River, a tributary of the Gandes that originates in the Himalayas.

The Nabaganga River displays a river width of around 80 m, but during the dry season its flow is reduced to a trickle.

(4) Climate

a. Rainfall

The town's annual mean rainfall is around 1,700 mm, which is lower than the national average. The amount of rainfall of the last three years is as shown in Table 3-3-1.

Table 3-3-1

(mm)

Month / Year	1	2	3	4	5	6	7	8	9	10	11	12	Total
1981	-	-	-	244	303	90	393	204	184	18	0	102	
1982	0	24	155	147	152	238	188	185	179	10	76	0	1,354
1983	0	15	64	61	253	243	224	513	147	128	3	19	1,670

The figures in Table 3-3-1 show that the rainy months are from March to October, with a particularly high concentration of rain during April to September. The period of little rainfall, which is the dry season, lasts from November to February. Particularly in January, there is hardly any rain at all.

b. Temperature

Since the temperature has not been regularly measured in this town, the records of Jessor have been used as a reference. The mean temperature during the monsoon season is 28.5°C, and during the dry season, 19°C, with the relative temperature range of 9.5°C. Temperature changes during the 1980-1982 period are shown in Table 3-3-2.

Table 3-3-2 Maximum and Minimum Temperature in Jessore by Month (°C)

Year	Month	1	2	3	4	5	6	7	8	9	10	11	12
1980	Max.	25.3	28.6	32.4	38.1	35.2	32.4	31.8	32.1	33.7	31.4	29.7	26.4
	Min.	11.9	14.9	20.3	25.2	24.2	26.1	26.2	26.2	26.1	23.1	15.2	13.2
1981	Max.	24.9	27.4	31.4	31.7	33.0	33.4	32.0	32.5	32.3	33.1	30.6	25.0
	Min.	11.9	15.2	19.1	22.4	24.4	26.4	25.8	26.0	25.7	22.7	16.3	12.6
1982	Max.	27.1	28.1	31.1	34.9	36.6	33.4						
	Min.	12.4	15.2	18.2	21.7	24.7	25.5						

As seen from the record in Table 3-3-2, the high temperature months are March to November, with the maximum temperature being above 30°C and the minimum temperature above 15°C. The low temperature month is January, with the maximum temperature being around 25°C and the minimum temperature around 12°C.

3-3-2 Hydrogeological Outline and Possibility of Developing Groundwater

(1) Hydrogeological Outline

As described in the section on geology, clayey soil, sandy soil and gravel layers are found distributed in this town. When these layers are evaluated for aquiferous capacity, the gravel layer is quite excellent, the sandy soil good, and the clayey soil poor.

As for use of groundwater in the town, DPHE has two deep wells (of which one is under construction), while there are three others, one well built by WDB, one by a hospital and another by a college. DPHE also 397 hand pumps.

The well related to DPHE are shown in Table 3-3-3.

Table 3-3-3

T/W No.	Total Depth	Soil of Aquifer	Screen		Pumpage	Static Water Level	Pumping Water Level	Time of Steady State Condi-tion	Recov-ery Period	Water Quality			
			Length	dia.						pH	Fe	cl	T. Hard
1	415'4"	CS & G	80'	6"	28,560	13'	22'3"	240	5		0.6	90	342
2	416'8"	CS & G	80'	6"	36,240	8'3"	22'3"	240	22	6.7	1.4	7	261
Hand Pump	140'	FS & MS	-	1.5"	397								

Aquifers from which groundwater is intaken, as shown in Table 3-3-3, are the fine sand to medium grain sand layers in the case of hand pumps and coarse sand to gravel layers in the case of deep wells.

As for groundwater level, it was GL -3.9 m in T.W. No.1 when the well was constructed (on May 10, 1982) and GL -4.1 m when checked this time (in April, 1984); GL -2.5 m in T.W. No.2 at the time of pumping test (on September 13, 1983) and GL -3.8 m when checked this time (in April, 1984). Judging from these results, the groundwater level in the dry season is inferred to be GL -4 m.

As for water quality, it is judged from existing data that there is no problem to use the water for drinking.

(2) Possibility of Developing Groundwater

The possibility of developing groundwater was systematically analyzed as follows based on the existing data given in Paragraph (1).

a. Hydraulic constants

i. Coefficient of infiltration T in m^2/min

T.W. No.1 : T = 1.9 to 2.6 m^2/min

T.W. No.2 : T = 6.2 to 8.2 m^2/min

ii. Coefficient of permeability K in cm/sec

From $K = \frac{T}{m}$ where m is the strainer length,

T.W. No.1 : K = 1.3 to 1.8 x 10^{-1} cm/sec

T.W. No.2 : K = 4.3 to 5.7 x 10^{-1} cm/sec

iii. Specific yield of well S in $m^3/day/m$

T.W. No.1 : S = 1,122 $m^3/day/m$

T.W. No.2 : S = 942 $m^3/day/m$

Judging from the values calculated as above, in which all of T, K, and S indicate large values, the gravel layer from which groundwater is intaken is considered satisfactory for developing groundwater.

b. Influence area of wells

As for the influence area of wells, intervals of 1,000 m or more between wells is presumed satisfactory judging from the data shown in Table 3-2-5 applicable to the layers subject to exploitation of groundwater, which are the coarse sand to gravel layers.