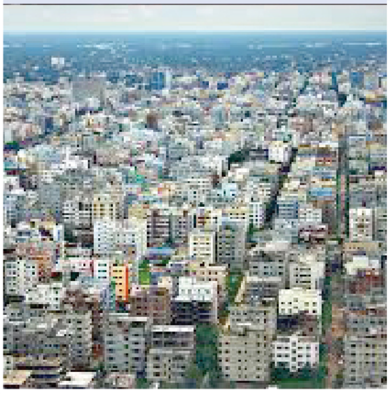


Ministry of Local Government
Rural Development and
Co-operatives

Dhaka Water Supply and Sewerage Authority

Water Supply MASTER PLAN for Dhaka City

Final Report

Volume 1of 5 **Main Report**

September 2014

Prepared by : IWM DevCon
Joint venture of IWM-DevCon

Managing Director
Dhaka Water Supply and Sewerage Authority (DWASA)

Foreword

Dhaka Water Supply and Sewerage Authority (DWASA) is a service oriented autonomous commercial organization in the Public sector, entrusted with the responsibility of providing water supply, sewerage, and storm water drainage services to the urban dwellers of Dhaka, the capital of Bangladesh. It covers more than 401sq km service area with around 12.5 million people. Dhaka WASA faces a number of challenges. These include unplanned city development and informal settlements, transition to using surface water instead of groundwater, and management of large investments. But Dhaka WASA has a number of notable achievements including significant increase in water production and productivity, improved service quality, increased revenue, reduction of non-revenue water, and provision of water supply at an affordable cost.

While the rate of development and achievement on different fronts of Dhaka WASA over the years had not been observably uniform, some pragmatically designed programs have been initiated by the present management since 2010 that brought in encouraging results in some key areas. Such efforts have been topped up by a well-thought-out "**Dhaka WASA Turn Around**" program that specifically identified areas of improvement, followed by appropriate action programs for their realization. The program of DWASA focused on institutional reform for capacity building, promoting transparency, establishing a new chain of command for accountability, and improving its operating ratio. The program also fosters excellence in customer service.

DWASA has made an outline of programs and projects for the decades to come. It has already developed the sewerage master plan of Dhaka city up to 2035 earmarking an investment of around US$ 2.3 billion. The drainage master plan has been prepared for the next 30 years with a budget plan of US$ 2 billion. Now we have completed the water supply master plan for the Dhaka city. The total firm investment estimate for implementation of this plan up to 2035 is around US$ 4 billion. The water supply master plan also gives a perspective plan for the period from 2036 to 2060. Major guiding principles of this plan are:

1) access to safe and sufficient water are recognized as human right
2) ensure equitable water distribution to all sections of the population
3) ensure safe, sufficient, affordable and reliable water supply
4) ensure 24 hours pressurized water supply to all consumers including Low Income Communities (LICs)
5) reducing dependency on GW sources for water supply
6) Establish block tariffs – protect consumers and maintaining financial viability of water utilities; lifeline rates for the poor
7) community based water facilities, ownership and management
8) reduce non revenue water
9) plan and policies to become financially sustainable
10) horizontal and vertical relation within and outside institutes
11) organizational reform for good water utility governance
12) institutional setup considering future jurisdiction and service requirements (capacity building, monitoring, enforcement)

I am sure this plan will guide us to provide better service to the DWASA customers. This will also help us to present our case to the Government of Bangladesh and also to the development partners in a more transparent and technically sound basis. The plan has taken into consideration the challenges and opportunities of DWASA for improved service delivery for the present and the future.

I extend my thanks to the consultant's team and the project office of DWASA for their extensive effort in preparing this document. I also thank experts, academicians, and stakeholders from different sections of the society for providing their useful and very important support and for sharing their experience and knowledge with the master plan team.

Engr. Taqsem A Khan
Managing Director, DWASA

Summary

Background

This project has been undertaken by Dhaka Water Supply and Sewerage Authority (DWASA) to prepare the Water Supply Master Plan for Dhaka City. The project was awarded to the Joint Venture of Institute of Water Modelling (IWM) and DevConsultants Limited (DevCon). The goal of the project according to the ToR is to prepare a Master Plan, to indentify priority investment projects and to recommend an appropriate institutional framework.

Socio-Economic Situation of the Master Plan Area

The last national census was undertaken in 2011 and includes data on a number of socio-economic characteristics of Dhaka City. In order to obtain a more up-to-date assessment of the socio-economic situation, a sampling programme was implemented covering a range of issues. In total 907 households were surveyed in December 2012. The questionnaire covered different points of investigation, including basic information about households (education, occupation, income, *etc*), water supply status, attitudes and perceptions.

In the Master Plan survey, it was found that average family size was 4.9 and a typical building has about 7 families. The most common household income bracket was 10,001 to 20,000 Tk/month/HH bracket with 31% respondents. About 23% of respondents had household incomes less than or equal to 10,000 Tk/month/HH. Approximately 4% of respondents reported monthly household income in excess of 1 lac Tk/month/HH. The distribution of education levels of household heads were: illiterate (11%), Class 1-5 completion (12%), Class 6-10 completion (18%), SSC completion (10%), HSC completion (11%), university graduates (32%) and others (6%)**.** The distribution of structure types surveyed were 42% paka (including 1-storied, 2-6 storied and high rise); 39% semi-paka and 19% kacha/jhupri (tin shed). The most common occupations of household heads were occupational worker/technician (24%) and others (26%). A significant proportion of household heads were retirees (13%). Also, a significant proportion of respondents stated that the household head occupation was in business (11%). 64% of respondents lived in their own homes. The most common house size was less than or equal to 600 sqft (32% of respondents). House sizes of 601-1,000 sqft and 1,001-1,500 sqft were also quite common (22% and 21%, respectively). House sizes of 1,501-2,000 sqft was also significant (11%).

Overall, there is good public support for DWASA as almost 80% of respondents stated that they would accept water supplied by DWASA through alternative means. Approximately 90% of households surveyed had a metered DWASA connection. About 30% of respondents stated that they receive insufficient water supply. The proportion of households facing water supply problems varied from 38% (in Nov to Apr period), to 25% (in May to Jun period) to 14% in (Jul to Oct period). Overall, 32% of respondents use suction pumps and 45% have underground storage reservoirs. About 56% of respondents stated at least one water quality problem.

Existing Water Services Situation

Water Sources

The existing water services heavily relies on groundwater with about 78% of water produced by DWASA currently sourced from aquifers. However, this needs to be further reduced to stop the continuous decline of the water table. Over the years, the number of DWASA deep tube-wells (DTW) has increased to nearly 633 across the city. The upper well casing length of DTWs is increasing to keep pace with the lowering static water table. Furthermore, due to disturbances in the aquifer and clogging of DTWs due to over extraction, the DTWs yields are decreasing resulting in short operational life of about two to three years. As a result, about 40 to 60 DTWs are replaced each year. The recurring maintenance and replacement costs add up to a significant number. In addition, synchronizing the operation of so many DTWs is a significant management challenge. On an average, at least 15 to 20 DTWs are out of operation on a daily basis due to mechanical and electrical failures. Considering the existing groundwater situation, DWASA is making a strategic effort to build more surface water treatment plants (SWTPs). Currently, there are 4 SWTPs in operation. Sonakanda SWTP is currently being rehabilitated and the new plant will have 12 MLD capacity. Godnail SWTP is currently producing 18 MLD but after renovation works it will have 45 MLD treatment capacity. Chandnighat SWTP has a capacity of 39 MLD after renovation works but produces 13 MLD on an average during dry seasons due to low water levels in Buriganga River. Even the treated water at the plant cannot meet the WHO and Bangladesh standards due to poor intake water quality. In fact, all four SWTPs suffer this problem from time to time. Of the existing 4 plants, Saidabad SWTP Phase-I plant is the largest and it has been operating since late 1990s, while Phase-II plant became operational in December 2012. Currently Saidabad SWTP Phase-I and Phase-II is providing 450 MLD. Due to the deteriorating raw water quality of Sitalakhya River, DWASA is also working on supplying water from the major rivers: Padma and Meghna.

Transmission Mains

The existing Saidabad Phase-I transmission main is operating at desired performance level without any major disruption. The additional 225 MLD water from Saidabad Phase-II SWTP unit is transmitted through the Phase-I mains and also through 9.6 km of new mains. Godnail and Sonakanda SWTP Transmission Main is currently undergoing rehabilitation (35 km) and 60 km new mains of diameter 150 mm to 800 mm are being constructed. New primary and secondary distribution mains for the proposed SWTPs will also be required.

Distribution System

The distribution network suffers from lack of proper planning, ageing fixtures, poor materials and poor workmanship. The system also suffers from illegal connections and pilferage. The District Metered Area (DMA) program plans to rehabilitate and replace the existing distribution network. DMA is designed to be a 24 hr pressurized system that will source water from local DTWs and SWTPs i.e. conjunctive usage. However, given the uncertainty associated with DTW supply due to mechanical and electrical failure of DTWs; the 24 hr continuous pressure condition in the network will be a challenging proposition to realize in a conjunctive usage scenario. DWASA should be mindful that unless and until the DTWs are sustainable and network is pressurized, previous practices of suction pump usage, illegal connections will reappear and plague the network. The risk of DMAs failing is being reduced by increasing SWTP supply to the distribution network.

Laboratory Facilities

Analyses of the existing situation at DWASA's two laboratories (at Asad Gate and at Saidabad SWTP) have identified some issues. Both labs require an inventory management system. Laboratory activities like water quality test, quality control, research, etc. should be performed efficiently with proper equipments. The entire premises of Asad Gate laboratory should be put to use for laboratory purpose only. It is recommended that simple Laboratory Information Management System (LIMS) software be used, whereby all data will be documented properly for present and future actions of good water management.

Non-revenue Water

The DMA initiative by DWASA will replace and rehabilitate the existing distribution network and aims at reducing NRW from 30% to 15%.As per its definition, the DMA will be extensively metered to monitor the network status. However, if leakage monitoring and control is not properly implemented, the 24 hr pressurized system may incur significant NRW through new leakages.

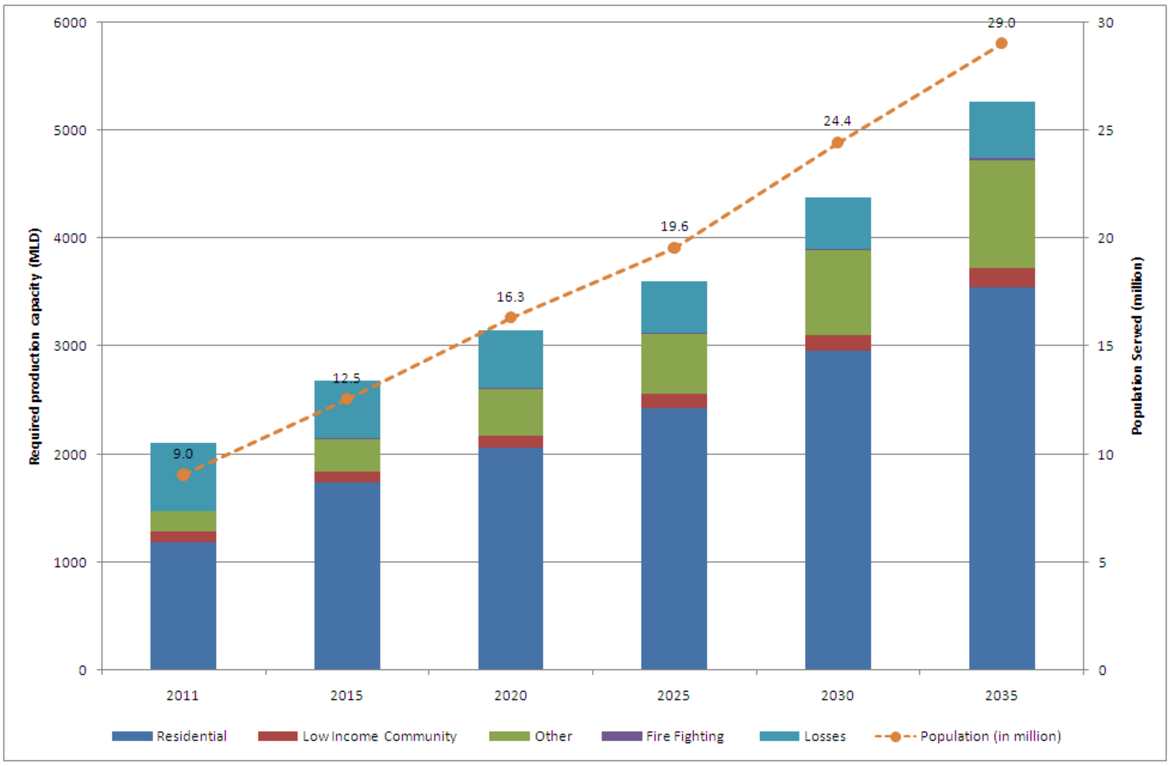
Institutional Analyses

The institutional analyses covered departmental setup; internal functions; links with external organizations; role of unions; regulatory framework; outsourcing; and other important considerations. DWASA was created by gazette Notification in 1963. Currently, it is an autonomous body according to DWASA Act 1996 with its own board and Managing Director (MD). DWASA organizational structure is vertical in nature. This is a common organizational culture of public establishments in Bangladesh. This creates communication difficulties.

DWASA is obviously understaffed with 29% vacancy of approved positions. Vacancies in Class III and Class IV grades causes overtime payments at double the hourly pay. Overtime payments constitute at least 29-34% of the total administrative expenses. Contractual hire or secondment to fill the permanent positions has also contributed to high administrative costs. Recruitment for most posts is conducted through public announcement. Promotion to chief positions or management posts other than the four top posts is generally handled through in-house promotion. Investment in training and development division is limited. Officers appointed to the post of Chief Training Officer (CTO) and lower posts should be encouraged and motivated with additional benefits. DWASA should invest in developing a comprehensive training and development program.

Demand Assessment and Required Production Capacity

Water demand for the future has been estimated for domestic, low income community, fire fighting and other uses. The main basis of estimating the demand is population projection for the time under consideration. Figure 1 gives an overview of demand projection for various uses. The total production capacity, however, considers physical losses (leakage) from the transmission and distribution pipelines and appurtenances. The demand scenario presented considers implementation of an effective demand management strategy. The strategy consists of introduction of a 3-tier increasing block tariff (IBT) structure as soon as possible and an advocacy of the adoption of water efficient gadgets.



DWASA Service Coverage (sq km)	401	401	496	496	617	617
Year	2011	2015	2020	2025	2030	2035
Demand (MLD)						
Residential	1,186	1,737	2,055	2,429	2,954	3,546
Low Income Community	98	102	114	125	154	174
Other	192	294	434	562	777	1,004
Fire Fighting	0	11	13	14	16	17
Total demand (MLD)	1,476	2,144	2,616	3,130	3,901	4,741
Losses	632	536	536	468	482	527
Total required production capacity (MLD)	2,108	2,680	3,152	3,598	4,383	5,268

Figure 1: Water Demand and Required Production Capacity for Dhaka Master Plan Area

It has been planned that DWASA will expand its service area from the present 401 sqkm to 617 sqkm in 2035, covering its entire jurisdiction and some additional areas. As a result of increase in domestic, industrial, commercial and other uses in the expanded service area of DWASA, the total demand will rise from 1,476 MLD in 2011 to 4,741 MLD in 2035. If we consider that leakage from the system will be reduced from the present level of 30% to 10% of the total supply in 2035, the total required production capacity will increase from the 2,108 MLD in 2011 to 5,268 MLD in 2035. This is an increase of 2.5 times. However, during the same period, population increase will be 3.2 times and service area increase will be 1.5 times.

For the period 2035 to 2060, the likely scenario is that there will be approximately 50% growth in demand. As a result, an additional 2,650 MLD production capacity will be required by 2060. It is expected that in future reviews and updates of the Water Supply Master Plan the long-term demand will be considered in more detail in light of the development of Dhaka City.

Resource Assessment

There are around 650 DTWs withdrawing water from the upper and lower aquifers of Dhaka city. Every year the groundwater level is depleting at a rate of 2-3m in the upper dupitila aquifer. Therefore, water supply from the groundwater aquifers is not sustainable in the long-term. Identification and utilization of alternative groundwater sources is very important to meet the water demand of Dhaka City. A project is being carried out by DWASA which will bring 300 MLD of groundwater in two phases from a well field in Savar and Singair Upazilla.

The most critical period of the year is March in terms of water availability and water quality for the surface water sources. Therefore assessment of water availability was made based on historical simulated data from March. It was found that withdrawal for water supply from the peripheral rivers would not result in any major change in water depth. But the water quality is progressively declining due to increase in pollution load from various domestic and industrial sources. The situation would further deteriorate if no pollution control measures are implemented. Therefore, the peripheral rivers of Dhaka city are considered vulnerable as water supply sources .

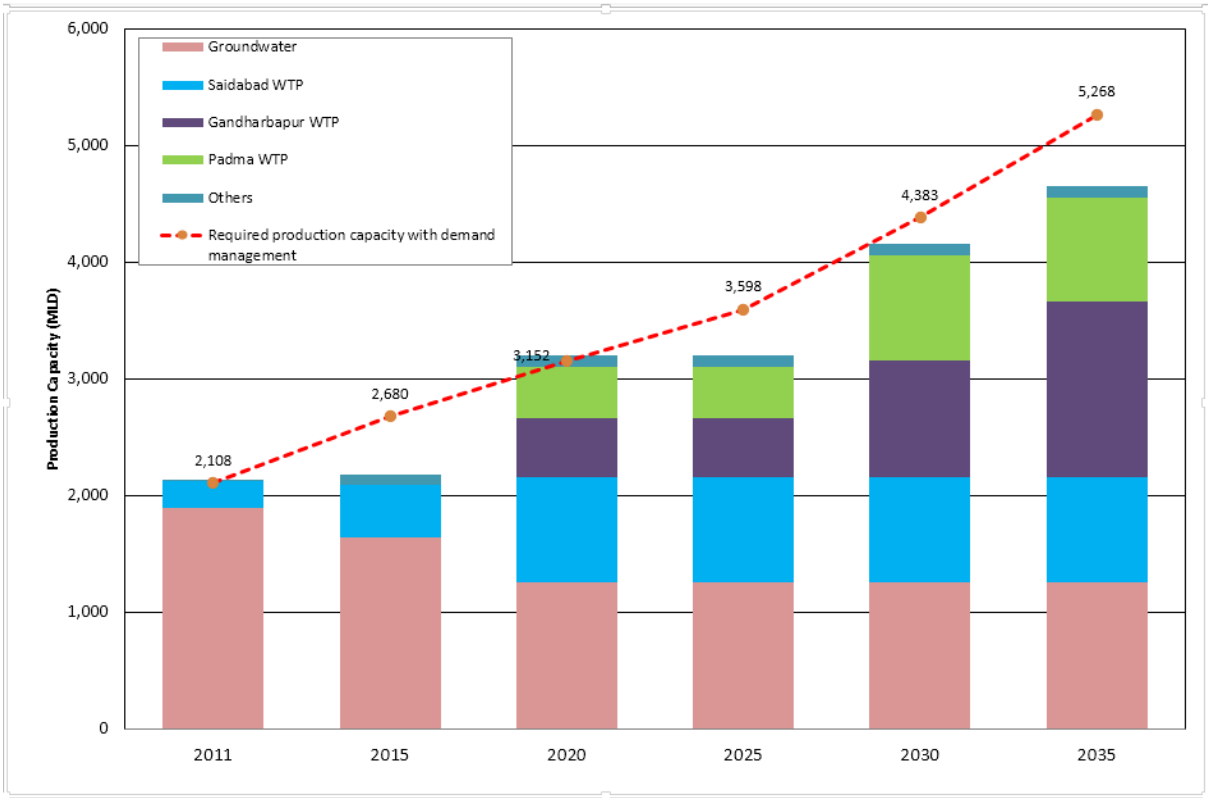
Water availability analysis in the major rivers of the country show that they have significant flow available. The water quality of these rivers is also acceptable. The feasibility studies of the Gandharbapur SWTP and Saidabad Phase-III found abstraction of 2,525 MLD water is viable from Meghna River. The feasibility studies of Jashaldia SWTP found abstraction of 900 MLD is viable from Padma River. These sources have been found to be technically and economically feasible in the long-term for Dhaka City. Additional analysis has been done for resource assessment periods 2035 to 2060. It is recommended that the Padma River should be utilized as a long-term source. Protection from pollution is required if peripheral rivers are to be considered for future supply.

Strategy for Water Supply Master Plan

A set of guiding principles were discussed with stakeholders to get their feedback. The strategic priorities included several items. For institutional framework it is proposed that the capacity of the organization be increased in order to manage future requirements of DWASA. Strategy regarding planning focuses on improving coordination between stakeholders, efficient management of assets and human resources. Strategy for infrastructure development proposes reduction of groundwater use; protection of water supply sources; ensure pressurized water supply distribution and identification of future urban expansion areas. In addition to improving overall efficiency of O&M, the strategy proposes steps to reduce non-revenue water and power consumption. Implementing the recommended strategy for efficient water utilization and promotion of water use conservation is important for demand management in Dhaka City. To increase the revenue needs, revenue opportunities need to be expanded and collection efforts need to be improved.

Future Sources of Supply

Assessment of demand shows that the required production capacity by the year 2035 the total demand is expected to rise to 5,268 MLD in the 617 sqkm of DWASA jurisdiction area. To meet the demand, options for DWASA are limited to harnessing the water resources of Meghna and Padma rivers. Resource assessment study (IWM, 2006) showed that sufficient water of adequate quality is available in these two rivers. The two feasibility studies conducted for the Padma (Jashaldia) and Meghna (Gandharbapur) WTP also shows that these two plants are technically, socially and economically viable. Preliminary assessment made in the feasibility study of Saidabad WTP Phase III shows that, Meghna River could also be a source for the three phases of the Saidabad WTP planned to produce 900 MLD in total. Therefore, total supply from the Padma and Meghna could be planned for 900 MLD and 2,400 MLD respectively by the year 2035. Figure 2 shows different levels of deficit through the planning horizon up to 2035, except for the year 2020.



Year	2011	2015	2020	2025	2030	2035
Required Production (MLD)	**2,108**	**2,680**	**3,152**	**3,598**	**4,383**	**5,268**
From GW sources (MLD)	**1,900**	**1,640**	**1,260**	**1,260**	**1,260**	**1,260**
Godnail, Sonakanda & Chandnighat	10	96	96	96	96	96
Saidabad I	225	225	225	225	225	225
Saidabad II		225	225	225	225	225
Saidabad III			450	450	450	450
Gandharbapur I			500	500	500	500
Gandharbapur II					500	500
Padma (Jashaldia) I			450	450	450	450
Padma (Jashaldia) II					450	450
Gandharbapur III						500
From SW sources (MLD)	**235**	**546**	**1,946**	**1,946**	**2,896**	**3,396**
Total Production (SW + GW) (MLD)	**2,135**	**2,186**	**3,206**	**3,206**	**4,156**	**4,656**
Surplus or Deficit (MLD)	**27**	**-494**	**54**	**-392**	**-227**	**-612**

Figure 2: Future Sources of Supply for Short-term and Medium-term Plan

The allowable limit of groundwater abstraction from the upper dupitila aquifer is around 1,640 MLD, which also includes Singair and Tetuljhara-Bhakurta groundwater well fields. The lower dupitila aquifer is considered not dependable. Therefore, DWASA will have to rely only on the groundwater resource of upper dupitila aquifer only. It is recommended that around 75% of the resource in the upper dupitila aquifer is harnessed for water supply to Dhaka Master Plan Area. Rest of the extractable groundwater resource should be reserved for any future uncertainties, which might arise due to increase of demand or delay in commissioning of large bulk surface water supply sources. Around 96 MLD will be available by rehabilitation and expansion of the Chandighat WW, Godnail WTP and Sonakanda WTP.

For the period 2035 to 2060, the possible cost effective sources of water could be the Lakhya and Buriganga Rivers (if their conditions improve). However, the Padma River is also a reliable source. It is expected that in future reviews and updates of the Water Supply Master Plan the identified supply sources will be considered in more detail. Though identifying projects this far into the future is difficult, it helps in the identification of potential land purchases, right of way and integration with other sectoral plans.

Sectorization

One of the key components of the water supply strategy is dividing the service area into sectors based on main sources of supply and connected primary mains. Each sector will have a dedicated and independent major source and primary main to transmit treated water to localities within the sector. The criteria that were used to delineate a sector are as follows:

a) The maximum contiguous area where the incident demand can be adequately served by production capacity of the source.
b) The area up to which the primary main can provide water to secondary mains, distribution systems at a minimum 1 bar pressure (based on preliminary hydraulic modeling).
c) Existing and proposed DMA boundaries.

Water supply production scenario and sectorization in 2035

Source	*Distribution Sector*	*Production Capacity. (MLD*
Singair Well Field Phase-I	Singair	150
Singair Well Field Phase-II	Singair	150
Padma Phase-I	Padma North-West	450
Padma Phase-II	Padma South	450
Saidabad Phase-I, II, III	Saidabad West-East	900
Char Gandharbapur Phase-I	Khilkhet	500
Char Gandharbapur Phase-II	Khilkhet	500
Char Gandharbapur Phase-III	Bandar Rupganj Tongi & Gachcha	500

Each of the sectors will be supplemented by local GW

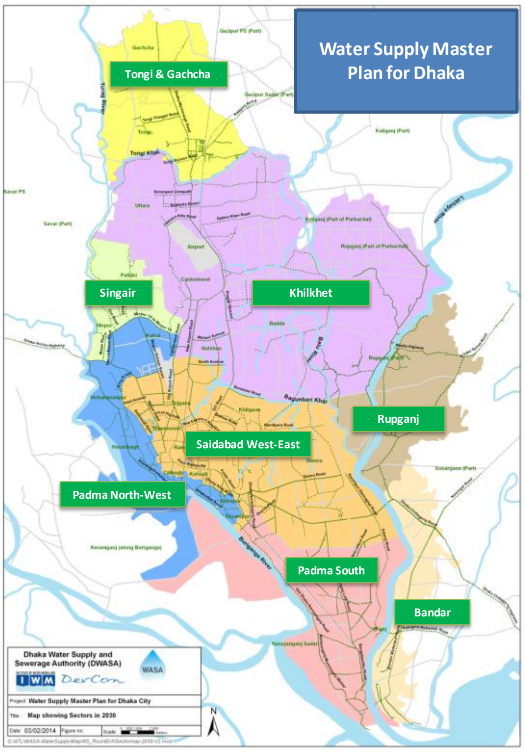


Figure 3: DWASA Sectorization of Service Area by 2035

Based on the available major sources of supply, the ongoing and proposed projects in near future, the entire DWASA service area is divided into eight sectors. Figure 3 describes them in elaborate detail.

Future Transmission and Distribution

The surface water distribution system is based on water from the 650 DTWs of the City. Only major source of supply is the Saidabad SWTP. As result, the distribution system lacks larger pipes to transmit water from one part of the City to another. As new plants will be constructed to meet the future demand, primary distribution lines will be required to transmit the water from the different sources. Each sector has a plant which will be built in phases. The primary transmission main will have to be built in each sector to transmit the water from the plants. Secondary and tertiary distribution lines will be required to distribute water to the customer end. DWASA has taken up DWSSDP project which is establishing DMAs for the distribution system. DMA is essential to ensure a minimum amount of NRW and minimize the loss of precious water through system leakage. In each sector, DMAs will be established to transmit water from the primary distribution. The current network is not designed to implement DMAs, so gradually the current system has to be changed in to DMAs. Using hydraulic models, the primary distribution lines have been designed according to the supply requirements in different parts of the sector to the DMAs. The primary and DMA distribution line that will be required in each sector in addition to the construction of treatment plants is shown in Table 1. Khilkhet sector will require the highest length of primary transmission as the SWTP is located in Char Gandharbapur, some distance from the City and it also supplies distant areas in different directions.

Table 1: Primary and DMA Distribution for Sectors up to 2035

Year	Primary Distribution (km)	DMA Distribution (km)	Sector Name
2020	41.54	606	Padma North-West
2030	57.42	384	Padma South
2020	98.35	685	Khilkhet
2030	81.44	293	
2035	18.59	60	
2015	46.22	824	Saidabad East-West
2020	57.53	381	
2015	52.86	354	Singair
2025	41.00	82	
2035	21.29	37	Rupganj
2035	23.66	113	Bandar
2035	31.13	96	Tongi & Gachcha

Action Plan

The action plan for works and services of the Master Plan are outlined below.

Action Plan and Targeted Dates for Works

Sl. No.	Activity	Time Frame	Costs (million USD)	Remarks
1	DTW performance Assessment and future recommendations for sectors	2014 - 2025	0.6	Availability of surface water source need to ensured
2	Construction of intake for Godnail WTP	Ongoing	5	Timely completion, successful operation and improvement in intake water quality are important
3	Renovation of Sonakanda WTP & primary and secondary mains	Ongoing	20	Timely completion, successful operation and improvement in intake water quality are important
4	Implementation of Singair Well Field Phase-I & primary and secondary mains; expansion of distribution network	2013-2017	105.1	Funding arrangements have to be ensured
5	Shifting of intake for Chandnighat WTP from Buriganga to Dhaleshwari	2015-2017	10.4	Water quality of Buriganga river is very low. Therefore, intake of Chadnighat needs to shift to Dhaleshwari river to operate WTP at full capacity
6	Implementation of Padma WTP I & primary and secondary mains; expansion of distribution network	2015-2018	554	Finance has been ensured for SWTP and DMA (part);Funding arrangements have to be ensured for primary & secondary mains and DMA (remaining)
7	Implementation of Saidabad WTP III & primary and secondary mains; expansion of distribution network	2016-2018	652	Finance has been ensured for SWTP and DMA (part); Funding arrangements have to be ensured for primary & secondary mains and DMA (remaining)
8	Implementation of Gandharbapur WTP I & primary and secondary mains; expansion of distribution network & establish DMA	2016-2019	729	Finance has been ensured for SWTP and DMA (part); Funding arrangements have to be ensured for primary & secondary mains and DMA (remaining)

Sl. No.	Activity	Time Frame	Costs (million USD)	Remarks
9	Implementation of Singair Well Field Phase-II & primary and secondary mains; expansion of distribution network	2023-2025	75.9	Funding arrangements have to be ensured
10	Implementation of Gandharbapur WTP II & primary and secondary mains; expansion of distribution network	2027-2030	719	Funding arrangements have to be ensured
11	Implementation of Padma WTP II & primary and secondary mains; expansion of distribution network	2027-2030	533	Funding arrangements have to be ensured
12	Implementation of Gandharbapur WTP III & primary and secondary mains; expansion of distribution network	2032-2035	720	Funding arrangements have to be ensured
13	Implementation of DMA in Dhaka City phase 2	2016-2020	300	Funding arrangements have to be ensured
14	Replacement, rehabilitation and optimization of production tube wells	2016-2020	150	Funding arrangements have to be ensured

Action Plan and Targeted Dates for Services

Sl. No.	Activity	Time Frame	Costs (million USD)	Remarks
1	Implementation of revised tariff structure	2014-2016	0.63	Political challenge exists, public awareness has to be raised.
2	Organizational structure for future operation of DWASA		0.75	Organizational restructuring is needed. If private sector is involved then regulatory reform is also required.
3	Institutional reform & regulatory framework for private sector participation	2014-2016	1.25	Have to be in line with DWASA mandate. Sufficient policies to enable partnerships have to be ensured. Regulatory framework is under preparation at Govt. level.

Sl. No.	Activity	Time Frame	Costs (million USD)	Remarks
4	Policy & regulatory reforms	2014-2016	0.63	Have to be in line with national policies and regulations. DWASA jurisdiction should be increased in relation with the DMDP boundary and planning & policy should be reformed accordingly.
5	Human resource development and training programmes	2015-2035	5	Human resources development programme should be prepared in line with restructuring of the organization. Local & international training and higher study programmes should be undertaken to improve capacity of the DWASA staffs
6	Development of Enterprise Resource Planning (ERP) System	2014-2017	2	Updating of GIS system. Development Asset management system.
7	Implementation of performance monitoring system (KPI)	Continuous process	-	Adequate organizational setup and accountability are required to ensure proper monitoring
8	DMA operation	Continuous process	-	Capacity building, organizational setup and resources required for DMA operations
9	Ground water monitoring and recharge	Continuous process	-	Ground water should continuous monitored.
10	Strategy for protection of the raw water sources and establishment of pollution control zone	2015-2016	0.75	Enforcement of government regulations and awareness will be required
11	Study for development of drinking water sources by rain water harvesting	2015-2017	0.5	Govt. policy and regulation will be required for implementation.
12	Improvement of Communication system	Continuous process		Internal & external communication must be improved for the improvement of DWASA performance
13	Water for Urban Poor	2014-2017	0.5	Co-ordination with NGOs will be required.
14	Strengthening of the Water Quality Lab	2014-2017	1.5	Capacity building of staff, equipment, budget and Laboratory Information Management System (LIMS) software will be required.

Sl. No.	Activity	Time Frame	Costs (million USD)	Remarks
15	Pilot study to develop a good monitoring programme using SCADA	2016-2017	2	Establishment of DMA
16	Water Safety Plan for DWASA	2016-2017	0.5	Govt. policy will encourage adoption within DWASA
17	Update Water Supply Master Plan	2022-2024	2	The Master Plan to be updated based on BBS survey and DWASA consumer survey in 2021
18	Establishment of groundwater monitoring system	2015-2017	0.5	Required for optimizing groundwater abstraction according to the Water Supply Master Plan

Financial Assessment

Table 2 presents investments that will be required in the future years for water supply by DWASA. Some of these investments are already in progress as a part of ongoing development. As of 2014 DWSSDP, Singair Well Field and Padma SWTP projects are on implementation stage, Gandharbapur SWTP which is in DPP stage and Saidabad Ph-III is in feasibility stage. Investment plans are already in advanced stage for these projects. The amount of all the major investments are calculated in present value and the total amount required up to 2035 is *325 billion BDT or 4.17 billion USD*. Investment requirement envisaged for projects in 2025 and onwards can be updated through a revisit of the Master Plan in 2022-24.

Table 2: Year-wise Capital Investment Requirement in Million BDT

Year	2015	2020	2025	2030	2035
Saidabad I & II DMA Distribution	6,760				
Singair I WF & Primary Dist	5,300				
Singair I DMA Distribution	2,906				
Saidabad III SWTP		43,408			
Saidabad III Primary Dist		3,892			
Saidabad III DMA Distribution		3,126			
Gandharbapur I SWTP		41,367			
Gandharbapur I Primary Dist		9,909			
Gandharbapur I DMA Distribution		5,614			
Gandharbapur II SWTP				42,400	
Gandharbapur II Primary Dist				11,253	
Gandharbapur II DMA Distribution				2,401	
Padma NW SWTP		33,390			
Padma NW Primary Distribution		4,828			

Year	2015	2020	2025	2030	2035
Padma NW DMA Distribution		4,971			
Singair II Wellfield			4,160		
Singair II Primary Dist			1,368		
Singair II DMA Distribution			344		
Padma South SWTP				33,390	
Padma South Primary Distribution				5,037	
Padma South DMA Distribution				3,146	
Gandharbapur III SWTP					42,400
Gandharbapur III Primary Dist					11,253
Gandharbapur III DMA Distribution					2,513
Total Cost	**14,967**	**150,505**	**5,694**	**97,627**	**56,166**

Proposed Tariffs

About 35% of respondents in the Master Plan survey expressed willingness to pay higher than the 2012-3 tariff (6.99 Tk/kL) if 24hrs drinking water supply can be ensured. The main reasons for agreeing to pay included: reliability of supply (65%), no complications (41%), clean water (36%), reasonable price (21%). Main reasons for not agreeing to pay higher price included: price is too high (78%), government's duty (27%) and DWASA will not be able to ensure reliable supply (12%). 56% of respondents stated that the water bill should be 2% or less of household income. 70% of respondents stated that it should be less than 5%.

During the analysis of tariff two pricing structures were considered: flat rate and 3-slab increasing block tariff structure. In the financial analysis block tariff structure was assessed and the main factors considered were:

- Start year of IBT strategy – is 2015
- Change in the tariff rate on annual basis

The recommended IBT structure is shown in Figure 4. The first slab's price is the current 7.34 Tk/KL which will be incremented by 5% in 2015. Thus the basic flat rate expected in 2015 is 8.09 Tk/KL. The third slab's price is three times the first slab's price and is also the expected starting water tariff for commercial and industrial users in 2015 (based on annual 5% increases as per DWASA rule). Based on the expected population proportion falling into each slab, the weighted average price will be 12.94 Tk/KL. However, the slab prices in the IBT should increase over time to take into account of inflation.

Table 3 presents the annual increase rate required for different interest rates on loan. It was found that for an interest on loans of 2% the required annual tariff increase rate has to be 6% per year, and for an interest of 5% the required tariff increase rate is 7.5% per year. Based on these findings, it can be recommended that the current interest rate of 5% by GoB needs to be lowered in order to keep the tariff rate within an acceptable range of the consumers.

Table 3: Impact of Changes in the Annual Increase in Price of Water

	Tariff Growth 6%, Interest on Loan 2%			Tariff Growth 7.5%, Interest on Loan 5%		
Project	FIRR	NPV (mBDT)	FBCR	FIRR	NPV (mBDT)	FBCR
Padma Ph-I	3.80%	2,030	1.03	3.55%	359	1.00
Singair Ph-I	6.31%	2,924	1.31	6.02%	2,747	1.24
Gandharbapur Ph-I	3.43%	(629)	0.99	3.11%	(3,640)	0.96
Saidabad Ph-III	3.77%	2,001	1.03	3.59%	698	1.01
All		6,326	1.03		164	1.01

Note: Discount rate for financial analysis is 3.5%, Cost growth 3%, NRW 15%

It can be recommended from the financial analysis that the tariff may be raised every year by 6% for all users. Figure 4 shows the weighted average tariff proposed for the future. This increase is an important strategy to ensure the feasibility of the projects that will be undertaken by DWASA. This also implies that as long as the rate of inflation is above 6%, the real price of water is in fact reducing over time from that of the initial year of 2015.

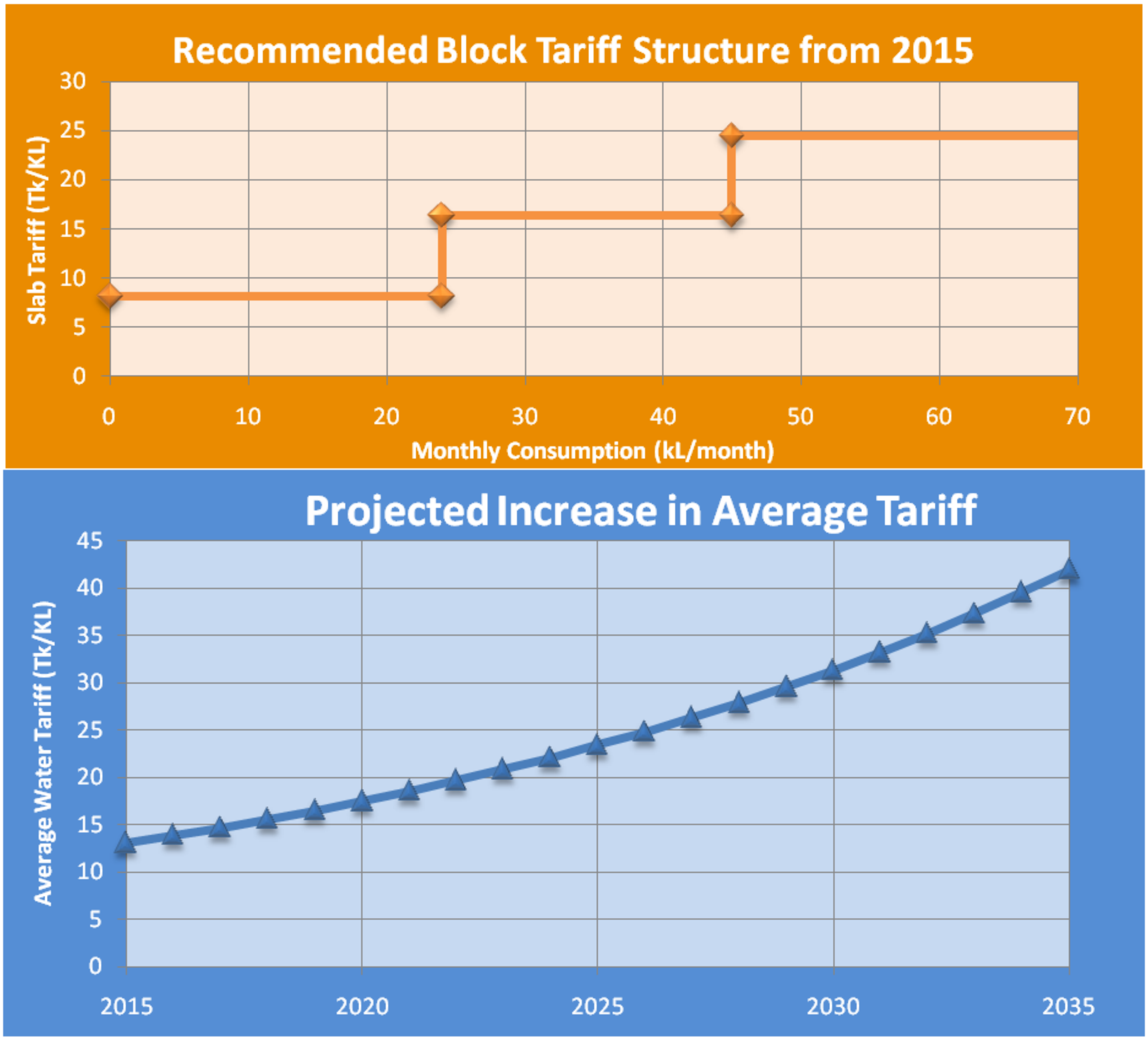


Figure 4: Recommended Tariff Structure and Increases in Average Tariff in Future Years

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Abbreviation & Acronyms

ADB	Asian Development Bank
AFD	French Development Agency
AMR	Automatic Meter Reading
B2B	Business to Business
BBS	Bangladesh Bureau of Statistics
BDT	Bangladesh Taka
BIBM	Bangladesh Institute of Bank Management
BMRE	Balancing, Modernization, Rehabilitation and Expansion
BNBC	Bangladesh National Building Code
BOD	Biochemical Oxygen Demand
BSTI	Bangladesh Standards and Testing Institution
BUET	Bangladesh University of Engineering and Technology
BWDB	Bangladesh Water Development Board
CBO	Community Based Organization
COD	Chemical Oxygen Demand
CUS	Centre for Urban Studies
DAP	Detailed Area Plan
DCC	Dhaka City Corporation
DEPC	Department of Environment Pollution Control
DESCO	Dhaka Electric Supply Company Limited
DESWSP	Dhaka Environmentally Sustainable Water Supply Project
DHI	Danish Hydraulic Institute
DIEWRMP	Dhaka Integrated Environment and Water Resource Management Project
DMA	District Metered Area
DMD	Deputy Managing Director
DMDP	Dhaka Metropolitan Development Plan
DMP	Dhaka Metropolitan Police
DNCC	Dhaka North City Corporation
DND	Dhaka-Narayanganj-Demra
DO	Dissolved Oxygen
DOE	Department of Environment
DPDC	Dhaka Power Distribution Company Limited
DPHE	Department of Public Health Engineering
DPP	Development Project Proposal
DSCC	Dhaka South City Corporation
DSK	Dustha Shasthya Kendra
DSL	Depth Sevices Loan
DSMA	Dhaka Statistical Metropolitan Area
DSS	Dissolved Suspended Solids
DWASA	Dhaka Water Supply and Sewerage Authority
DWRMP	Dhaka Water Resource Management Programme
DWSSDP	Dhaka Water Supply Sector Development Project

DWSSP	Dhaka Water Supply and Sanitation Project
ECSCSL	Employees Consumers Supplies Cooperative Society Limited
EDCF	Economic Development Cooperation Fund, Korea
EIA	Environmental Impact Assessment
EIB	European Investment Bank
EM	Electro-Mechanical
EQS	Environmental Quality Standards
ERP	Enterprise Resource Planning
ERWSSNT	Expansion and Rehabilitation of Water Supply System at Narayangonj Town
ETP	Effluent Treatment Plant
FAR	Floor Area Ratio
FBCR	Financial Benefit Cost Ratio
FCBC	Financial Capacity Building Consultant
FM	Field Maintenance
FS	Feasibility Study
GDP	Gross Domestic Product
GMDK	Grontmij Denmark A/S
GNP	Gross National Product
GoB	Government of Bangladesh
GRP	Glass fibre Reinforced Plastic
GW	Groundwater
HRD	Human Resources Department
IBT	increasing block tariff
IDA	International Development Association
IEC	Information, Education and Communication
IEE	Initial Environmental Investigation
IWM	Institute of Water Modelling
JICA	Japanese International Cooperation Agency
LGED	Local Government Engineering Department
LIC	Low income Communities
LPCD	Liters per Capital per Day
LS	Lift Station
MES	Military Engineering Services
MIS	Management Information System
MLD	Million Litres per Day
MODS	Maintenance, Operation, Distribution and Service
MoEF	Ministry of Environment and Forestry
MoF	Ministry of Finance
MoLGRDC	Ministry of Local Government, Rural Development and Cooperatives
MoP	Ministry of Planning
NCRM	North Central Regional Model
NGO	Non-Governmental Organization
NRW	Non-Revenue Water
NWRD	Natural Water Resources Database
O&M	Operation and Maintenance
p.e.	Population Equivalent

PLM	One Pipe line Mechanic
PP	Project Proposal
PPP	Public Private Partnership
PPTA	Project Preparatory Technical Assistance
PRV	Pressure Reducing Valve
PS	Pump Station
PTS	Pagla Trunk Sewer
RAJUK	Rajdhani Unnayan Kartripakhhya
REB	Rural Electrification Board
RoI	Return on Investment
RP&D	Resource Planning and Development Division
RPE&M	Resource Planning Equipment & Machineries
SCADA	Supervisory Control And Data Acquisition
SDG	Sustainable Development Goal
SDP	Sector Development Plan
SEA	Strategic Environmental Assessment
SIDA	Swedish International Development Agency
SMA	Statistical Metropolitan Area
SMEP-GD	Survey and Mapping of Environmental Pollution in Greater Dhaka
SOC	Systems Operations and Control
SP	Structure Plan
SPZ	Strategic Planning Zone
SRO	Statutory Regulatory Order
SS	Suspended Solids
STP	Sewage Treatment Plant
SW	Surface Water
SWTP	Surface Water Treatment Plant
TA	Technical Assistance
ToR	Terms of Reference
TSS	Total Suspended Solids
UAP	Urban Area Plan
UN	United Nations
UNDP	United Nations Development Program
WACC	Weighted Average Cost of Capital
WARPO	Water Resource Planning Organization
WASA	Water Supply and Sewerage Authority
WB	World Bank
WELS	Water Efficient Labelling and Standards
WHO	World Health Organization
WSMP	Water Supply Master Plan
WSS	Water Supply and Sanitation
WSUP	Water and Sanitation for the Urban Poor
WWTP	Wastewater Treatment Plant

1 Introduction

1.1 Objective of the Master Plan

The overall environmental condition of Dhaka is increasingly reaching a critical situation which is mainly due to a very dense population with high growth rates, and limited water distribution coverage for the city. On the other hand, Bangladesh is already committed to improving the water and sanitation scenario of its urban settlements. This commitment is further reinforced due to its policy of achieving Sustainable Development Goals (SDG) for 2030. Accordingly the guiding principles of the Water Supply Master Plan were formed.

The Master Plan aims at a phased implementation plan identifying the resources required to provide adequate water supply for Dhaka City. The Master Plan documents the existing legal, institutional, financial and operational weaknesses and recommend strengthening measures. Overall objectives of the Master Plan include:

1. Prepare water supply plan for Dhaka City for a planning horizon of 50 years
2. Prepare priority investment projects for the next 10 years
3. Recommend appropriate institutional and financial framework for sustainable O&M.

1.2 Planning Area of the Project

The TOR has defined the study area as the area within the jurisdiction of DWASA as per the DWASA Act 1996 and the Narayanganj MODS zone. Accordingly, the study area, as shown in Figure 1-1, is approximately 500 sqkm covering main Dhaka City area (303 sqkm), Tongi and Gachcha (61 sqkm), part of Rupganj (97 sqkm) and part of Narayanganj Sadar (36 sqkm). Dhaka City and major part of Narayanganj Sadar is surrounded by Turag River, Buriganga River, Tongi Khal, Dhaleswari River, Lakhya River and Balu River. Tongi lies on the north of Tongi Khal while Rupganj extends on both sides of Lakhya River. Bandar Thana, which falls within the Narayanganj MODS zone, lies on the left bank of Lakhya River. The general terrain of the study area and its surrounds is shown in Figure 1-2.

The existing DWASA service area covers approximately 401 sqkm and includes some localities that are not mentioned in DWASA 1996 Act (parts of Narayanganj Sadar and Bandar Thana). Over the planning horizon, the service area will expand to cover not only all of the existing jurisdiction area but also some neighbouring locations in Keraniganj and Sonargaon Upazillas.

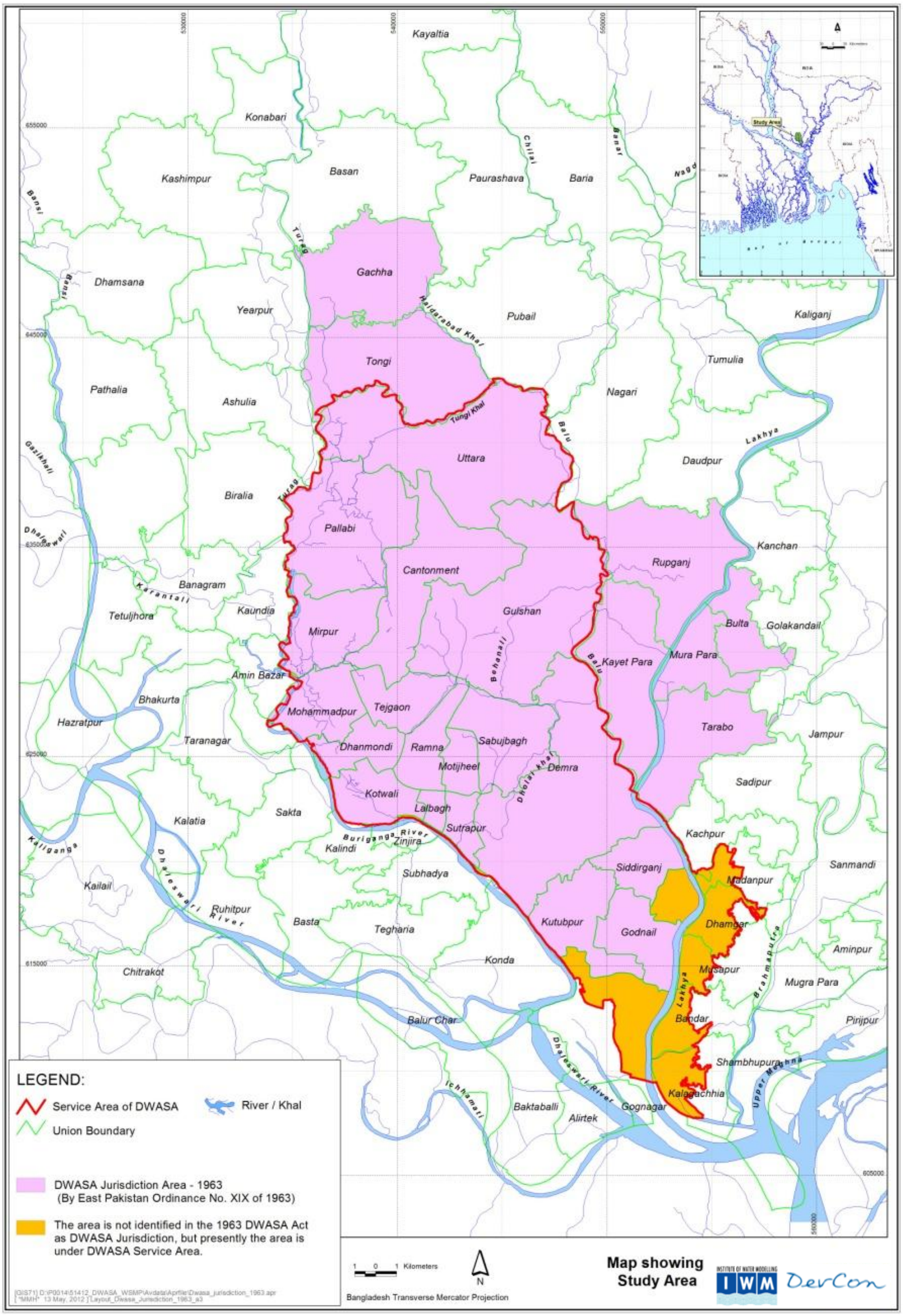


Figure 1-1: Map of Study Area (pink and orange shaded areas)

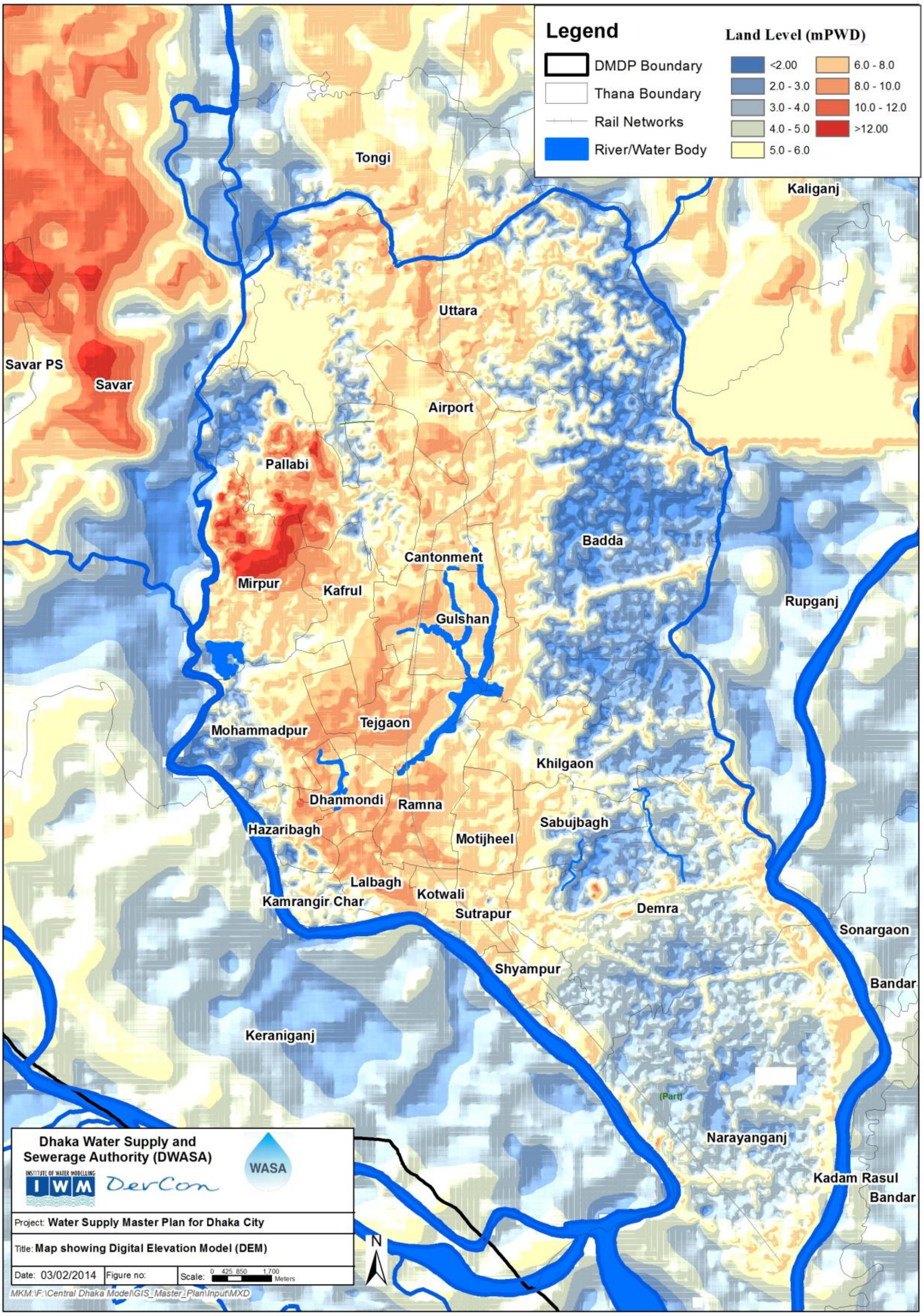


Figure 1-2: Map of Topography of the Study Area

1.3 Master Plan Preparation Process

The overall approach for this project is outlined in Figure 1-3. First, a review and assessment of water sources and infrastructure (supply side) was conducted. At the same time, water demand issues were reviewed and assessed. After that, various water supply strategies were identified and evaluated in a participatory approach. Finally, the Master Plan has been developed by prioritizing selected projects over different time horizons. More details about the methodology used for each of these steps are provided in the relevant chapters.

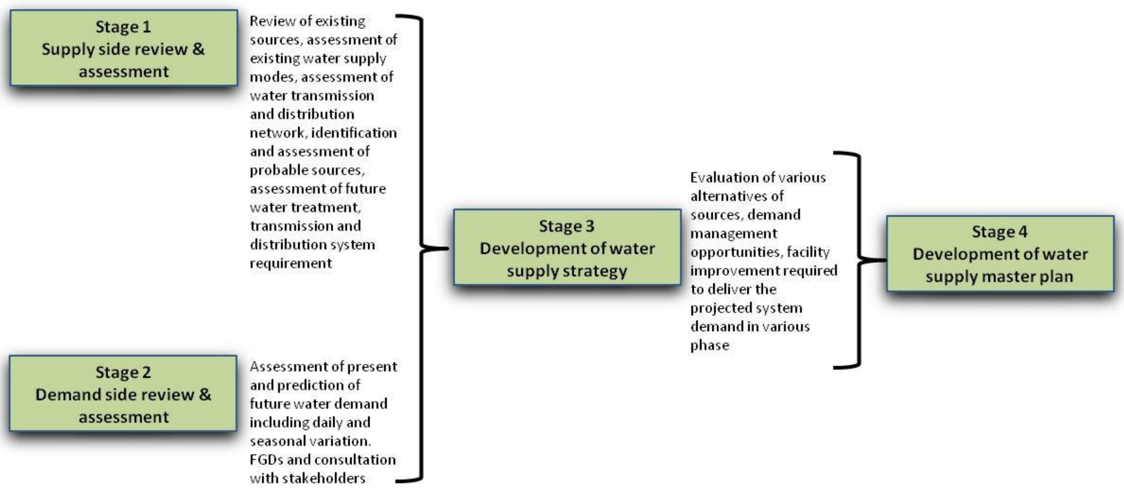


Figure 1-3: Overall Approach for the Project

1.4 Organization of the Master Plan Report

Volume 1 – Main Report

The Master plan Main Report is organized as follows:

Chapter 02: Existing Water Supply Infrastructure –This chapter describes current state of the most crucial water distribution infrastructure components of DWASA; the treatment plants; distribution mains; transmission mains; groundwater production wells and overhead tanks. It highlights key recommendations associated with these facilities.

Chapter 03: Existing Institutional Setup – This chapter describes the current organizational structure of DWASA. It also elaborates external organizational environment, peripheral entities in the industry and the legal setup within the sector. The chapter also articulates a revised organizational structure along with some key recommendations for the future.

Chapter 04: Existing Water Supply Situation – This chapter summarizes the survey findings in relation to key water supply issues, which includes: source of water supply; water supply condition; actions taken during shortages; and water quality issues.

Chapter 05: Existing Revenue, Financial and Investment Situation – This chapter describes current budget, tariff plan and financial management of DWASA. It also describes recent investment of DWASA and existing billing & accounting of DWASA.

Chapter 06: Demand Assessment – This chapter illustrates present and future water demands in DWASA service area. Future demand has been projected based on different scenarios for the time horizon up to 2060.

Chapter 07: Water Resource Assessment – This chapter describes quality and availability of surface water in nearby rivers. It also illustrates aquifer system and available groundwater in Dhaka City along with rain water harvesting.

Chapter 08: Strategy for the Master Plan – This chapter describes strategy for the Master Plan which includes strategy for demand, improvement of system and financial performance. This chapter also describes demand verses supply in Master Plan time horizon, institutional capacity and legal aspects.

Chapter 09: Water Supply Master Plan – This chapter illustrates sectorization of DWASA service area and corresponding future water demands. It also describes require improvements (SWTP, transmission line, distribution line) in different time horizon.

Chapter 10: Financial Assessment of Master Plan – This chapter describes the required capital investments for DWASA up to 2035 and the financial feasibility of major projects. It describes analyse of the important parameters for future financial performance of DWASA. Based on the analyse a tariff structure and interest rate for capital investment financing arrangements is proposed.

Chapter 11: Strategic Environmental Assessment – This chapter provides assessment of significant environmental and social impacts of the Water Supply Master Plan. It identifies and recommends mitigation measures and institutional adjustments for the interventions of the master plan and measures needed to build the capacity of the DWASA for mainstreaming environmental and social considerations.

Chapter 12: Feasibility of Priority Investment Projects– This chapter describes technical feasibility studies of three primary and secondary transmission mains from surface water treatment plants, which are supposed to be implemented by 2020. These plants are Jashalida SWTP, Gandharbapur SWTP and Siadabad Ph-III SWTP. The reports also contain future developments that will be required in the proposed Sectors of DWASA.

Volume 2 – Existing Situation Report

The volume contains details of socio-economic characteristic of the Master Plan area, existing water supply infrastructure, institutional analysis, existing water services situation, surface water treatment plants in Dhaka, water quality of treatment plants, transmission and distribution system assessment, and assessment of existing wastewater facilities.

Volume 3 – Demand Assessment Report

This volume provides a detailed assessment of water demands and required production capacity for the DWASA service area. An assessment of demands for 2011 is provided and a detailed projection up to 2035 is provided. An estimate of total required production capacity for the service area in 2060 is also provided.

Volume 4 – Support Assessment Reports

Three separate assessment reports are provided in this volume. The Resource Assessment Report provides details of surface water resources, groundwater resources and rain water harvesting in the context of Dhaka City. The Financial Assessment Report provides details of financial analysis done for the Master Plan. The details of Strategic Environmental Assessment are provided in this volume.

Volume 5 – Feasibility Studies

Technical Feasibility studies done for primary and secondary distribution main for Jashalida SWTP, Gandharbapur SWTP and Saidabad Phase-III SWTP are included in this report. It contains design considerations, cost estimates, IEE and design drawings for the primary and secondary distribution mains. It also contains detailed descriptions of the sectors and their future developments for water supply.

1.5 Land Use Transition and Urban Growth

Dhaka's land use pattern has changed based on the land development over time. Approximately 50 years ago, lowlands, cultivated areas and water bodies were the dominant land use types, and the direction of urban expansion was northward. Afterwards, the built-up areas replaced most of the water bodies and depressions within the city as well as the cultivated land along the peripheral zone. The depressions and water bodies within the city disappeared relatively quickly after independence in 1971 as areas were developed for residential, commercial, academic and business purposes. Between 1975 and 1992, when road transportation from Dhaka to the vicinity was improved by the construction of bridges over the rivers, urban expansion extended further to the north, northwest and to the west. Consequently, the area of cultivated land and water bodies declined markedly during the period 1975-1992. In last decade, the land use patterns started to expand in all directions, primarily at the expense of vegetated and wetland/lowland areas. The rate of urban encroachment on other land uses increased significantly following the preparation of a new Master Plan in 1995 and the development of infrastructure. The construction of a bridge over the Buriganga River accelerated urban expansion in the southerly and north-westerly directions.

Three sectors, *viz.* the public, private, and individual household sectors, are responsible for all of the land developments in Dhaka. Most of the previous development projects were undertaken on an ad-hoc basis by the public sector, examples of such developments include Gulshan Model Town, Banani, Uttara Model Town and Dhanmondi. In recent years, property development has proliferated in Dhaka in both wetlands and agricultural areas without any consideration of the concomitant environmental costs. In addition, individual households have started to develop the peripheral areas. Land speculation influenced the development of suburban areas, increasing land prices and growing demand for housing. Lowlands and agricultural areas in the fringe zone are rapidly becoming built-up by the individual and property developers.

The Dhaka-Narayangonj-Demra (DND) area, despite approximately 6000 ha being set aside for agricultural production in the 1960s, has been used by local and migrant people for residential purposes since 1990s without any municipal approval, illustrating the lack of effective coordination among the organizations involved in the planning and development of Dhaka.

Although urbanization is generally related to demographic change and economic growth, the nature of urban expansion may also be associated with other factors such as topography, land use, and transportation. Generally, two factors have been observed to have promoted urban growth: (1) increased economic activity associated with the establishment of economic zones (*e.g.* export processing zone), and (2) redefinition of the metropolitan area. Between 1975 and 1992, reclassification of urban areas as well as infrastructure development played a crucial role in the expansion of urban areas. For instance, the north-westward and southward expansion of the city occurred in response to construction of a flood embankment in 1992 and a bridge on the Buriganga River in 2001. The spatial characteristics of built-up areas have also been shaped by the construction of a number of transportation routes in the same period. The expansion to the east and north-east led to the development of unplanned suburbs in the lowlands and agricultural areas that were previously located in those areas.

GIS analysis has revealed that the area occupied by water bodies decreased by 16.2%, wetlands by 11.5%, cultivated land by 34.1%, and vegetation by 13.6% between 1975 and 1992. Another significant change was the decline in wetlands and vegetation from 1992 to 2003. In 1992, wetlands and vegetation occupied 28% and 13.7% of the total study area, but by 2003, these areas had declined to 21.7% and 5.5%, respectively. Conversely, built-up areas increased in size by 37.9% in the period from 1992 to 2003. The decline of vegetation and wetlands was clearly due to intensification of urban development in the greater Dhaka area, particularly through the process of suburban development.

The direction of urban expansion in Dhaka has been highly influenced by its physical setting, particularly its topography. The four major rivers, swamps and depressions within and around the city have always played a pivotal role in the development of built-up areas in the city. Urbanization initially occurred in the elevated areas that were not affected by flood. Once all the elevated positions had been developed, the rising demand of urban land has been met by the transformation of low-lying areas, vegetated areas and wetlands. The urban development of wetlands, for instance, has led to a substantial loss of natural resources and an increase in habitat degradation. The growth of property developers has accelerated encroachment of urban areas on wetlands and threatens biodiversity.

The development pattern that has already taken place and the pattern likely to continue over the planning horizon will be that of: 1) increased densification; 2) infill development; 3) continual expansion in all directions and accelerated continuous growth especially to the north; and 4) growing importance in the development and implementation of satellite communities.

- **Increased Densification:** Densification, which is already high in some areas, is expected to continue over the already urbanised areas.
- **Increased Infill Development:** Infill development in the low lying areas, particularly in the eastern and western fringes is currently ongoing and expected to continue into the future.
- **Continuous Expansion and Accelerated Growth:** Development and continuous expansion of the city is expected and already happening and accelerated growth is expected in the eastern fringe, DND triangle, western fringe and the airport area.

- **Growing Importance of Satellite Communities:** The possibility of new community development in Tongi, Gazipur, Dhamsona and Savar will arise and may become imminent, as future population absorption peaks.

As a result, urban development in Dhaka city can be categorized into the following types:

Developed areas: Core of the city, mainly older areas where population densities are high and has reached saturation but is also undergoing redevelopment in some locations.

Developing areas: Adjoining core areas of the city under jurisdiction of DCC & Pourashavas which have developed as suburban areas and still has sufficient space available for development.

Fringe areas: Falling under jurisdiction of union parishads, which are still agricultural in nature and within flood plains of the peripheral river systems, have the potential to rapidly develop and are presently witnessing conversion of land from agriculture to other uses.

Slum areas: There are also many slums in Dhaka city. The formation of slums is closely associated with rural-urban migration. Poor people living in the city slums have mostly migrated there from rural areas rather than other cities or towns. Presently, there are over 4 million people living in the slum areas of Dhaka city.

Commercial and industrial areas: The main commercial areas of the city include Motijheel, New Market, Gulshan, Kawran Bazar and Farmgate, while Tejgaon and Hazaribagh are the major industrial areas. Growth has been especially strong in the finance, banking, manufacturing, telecommunications and services sectors, while tourism, hotels and restaurants continue as important elements of the Dhaka economy.

1.6 Demographic Changes

Dhaka has been growing at a very high pace especially over the last three decades. The growth of Dhaka City has been analysed by different agencies resulting in different growth scenarios. The primary government agency engaged in collecting and providing data is the Bangladesh Bureau of Statistics (BBS). Other government agencies use their data for predictions required to serve their purposes.

Dhaka was declared a mega city by the BBS in 1991, when the population was 6.4 million. However, during the previous census (1981), the population was 3.4 million. Two decades back, in 1961, the population of Dhaka City was less than a million. By the beginning of this century, the population stood at 10.7 million although the growth rate slowed down by a half.

Likewise the aerial expansion of Dhaka City (according to BBS statistics) has been tremendous. In 1951, the city occupied a space of only 85.45 sqkm and by year 2001 the greater Dhaka region covered about 1,528 sqkm, denoting a 17.9 times increase. The city spread laterally by more than 2.5 times from 1961 – 1974, especially after the war of independence when it received the status of a capital city. Again in 1991, the Statistical Metropolitan Area (SMA) of Dhaka was increased to a mega city status. It should be noted that while the horizontal expansion of Dhaka City is limited on the one hand by its physical factors, being surrounded by rivers acting like moats on all sides, its vertical expansion is progressing without heed to financial resource constraints and the capability of providing services and utilities where maintenance of existing infrastructures is already a problem.

Table 1-1 illustrates the areal expansion and population growth of Dhaka City during the last five decades:

Table 1-1: Areal Expansion & Growth of Greater Dhaka (1951 – 2011)

Year	Area (km^2)	Area Increase (%)	Population	Population Increase (%)	Annual Growth Rate (%)	Density (people/km^2)
1951	85.45	-	411,279	-	-	4,814
1961	124.45	46	718,766	75	5.7	5,776
1974	335.79	170	2,068,353	188	8.5	6,160
1981	509.62	52	3,440,147	66	7.5	6,751
1991	1,352.87	165	6,487,459	89	6.5	4,796
2001	1,528.00	13	10,712,206	65	5.1	7,011
2011	1,528.00	0	14,543,124	36	3.1	9,518

Source: Bangladesh Census 2001 & 2011

Further discussion on the demographic trend of the city is done in subsequent chapters.

1.7 Recent Initiatives

Asian Development Bank (ADB) in conjunction with an international consultant carried out a study in 2006 to formulate a long term roadmap for DWASA. This included identification of immediate project needs to meet demand of the city by year 2030. During the study, a pilot project at Manikdi, Dhaka Cantonment showed significant water loss between production source and consumer end. This is primarily due to leakages in the pipe networks and service connection lines. Most of the water supply fixtures were aged and had undergone wear and tear. The consultants found similar circumstances across the system and concluded that, the network needed rehabilitation to prevent significant loss of water. The study also conducted a demographic study to assess the water demand projections up to year 2030. The urban growth projected will also require water distribution network expansion. In addition to the primary distribution network rehabilitation and expansion, the study also recommended new surface water sources to meet the elevated demand. This is congruent with DWASA's overall strategic shift from groundwater to surface water sourcing. In sum, the following structural projects are proposed:

- Dhaka Water Supply Sector Development Project (DWSSDP).
- Construction of 225 MLD Saidabad water treatment plant Phase-II
- Construction of 450 MLD Siadabad Water Treatment Plant Phase-III
- Construction of 300 MLD Singair well field project Phase-I & II
- Construction of 500 MLD Gandharbapur water treatment plant Phase-I
- Construction of 500 MLD Gandharbapur water treatment plant Phase-II
- Construction of 450 MLD Padma Water treatment Plant Phase-I
- Construction of 450 MLD Padma Water Treatment plant phase-II

DWASA is actively pursuing the projects. In fact, Saidabad Phase-II is already completed. The Master Plan incorporates these projects and also articulates scope, phasing and coordination. The following sections describe the projects in brief.

Dhaka Water Supply Sector Development Project (DWSSDP)

The project is already in progress. ADB and Government of Bangladesh (GOB) are funding the project. It is formally known as "Dhaka Water Supply Sector Development Project (DWSSDP)".The project not only involves infrastructure installation but also institutional development and project management. The main components of the project are:

I. **Distribution System and Quality Improvement:** Involves physical rehabilitation and strengthening of DWASA's water distribution network to minimize losses and to enable 24 hour pressurized water supply, and provision of water quality assurance and control measures

II. **Capacity Building and Institutional Strengthening:** Aims at institutionalization of sound financial management, efficient billing, and revenue collection and customer record systems. Also includes extensive demand control and awareness campaign for consumers.

III. **Project Management and Implementation Support:** Involves planning, design of structural interventions, project management, tendering, construction supervision and consulting services for capacity building and institutional strengthening.

ADB has sanctioned a loan amounting US$ 200 million for DWSSDP, consisting of US$ 50 million program loan and US$ 150 million project loan.

Construction of 225 MLD Saidabad Water Treatment Plant Phase-II

Construction of the Saidabad Phase-II, capacity 225 MLD; completed in 2012 and the plant was officially commissioned by the Honourable Prime Minister. To distribute the treated water, primary distribution network of Saidabad Phase-I has been extended and production schedule at the DTWs have been revised.

Construction of 450 MLD Saidabad Water Treatment Plant Phase-III

After successful completion of Saidabad Phase-I and II, Government of France has commissioned a feasibility study for further expansion of the plant. A grant of 500,000 Euro has been allocated for the study. The proposed 450 MLD will serve the expanding urban areas of Khilgaon, Sabujbag and Demra Thanas. The plant is expected to be operational by year 2018.

Construction of 300 MLD Singair Well Field Project Phase-I & II

The feasibility study for the project is complete. The project localities are Tetuljhara –Bhakurta & Dhalla-Jamirta under Savar and Singair upazilla respectively. The groundwater aquifer in these localities will be tapped by sinking deep tubewells. Water produced at the well fields will be treated for iron removal. Upon treatment, the water will be pumped and transmitted to the city. The transmission main will connect to the existing network at Gabtoli point. The project is being implemented in two phases. Each phase will sink enough deep tubewells to produce 150 MLD water. The first phase of the project has already been initiated with EDCF funds and will come online by 2017. The second phase is expected to be completed by 2025.

Construction of Gandharbapur Surface Water Treatment Plant (SWTP) Phase-I, Phase-II & Phase-III

Feasibility study of Gandharbapur SWTP has been completed earlier. Construction of the first phase will initiate in 2016 and the unit will become online by 2019. Construction of second and third phase production capacity of 500 MLD, the plant will eventually have a total production capacity of 1500 MLD. The intake structure at Meghna River will have a total capacity of 2525 MLD, which includes provision for future extension. The treatment plant will be located at DWASA owned land in Char Gandharbapur locality. Several raw water transmission mains will be built in phases along with the phasing of the treatment plant units.

ADB, EIB and AFD are interested in financing the first phase of the project. The crucial components of the project are elaborated in brief in the following sections.

The treatment plant units will be developed in three phases. Gandharbapur I, Gandharbapur II and Gandharbapur III and each unit will have a production capacity of 500 MLD. The treatment process will comprise of traditional treatment of water: pre-chlorination, coagulation, flocculation sedimentation, filtration and post chlorination. Allowance for recirculation of backwash water is made. The plant will incorporate full automation of operation.

Construction of Padma (Jashaldia) Surface Water Treatment Plant (SWTP) Phase-I and Phase-II

The feasibility study of the project was completed in early 2011. Padma River will be the source of raw water. The location of the treatment plant will be at Jashaldia near the left bank of Padma River. Raw water quality sampling was taken and analyzed at the intake point. On the basis of the outcome, process design for the plant was devised. Similar to other ongoing DWASA projects, this facility will be built in phases as well. Capacity of the first phase will be 450 MLD. The second phase with an equal capacity is projected to be completed by year 2030. Therefore, the plant will eventually have a total production capacity of 900 MLD. From the treatment plant, two transmission mains will convey the pumped water towards Dhaka City and there will be a booster pump at Abdullahpur before crossing the Buriganga River. Trenchless method will be used to cross the river along the river bed and the mains will connect to the DWASA water distribution network at two locations. The Phase-I transmission main will cross the river along Buriganga Friendship Bridge-II and connect to the network at Mitford Hospital locality. The other transmission main will connect to the network at Postagola locality upon crossing the Buriganga channel along Buriganga Friendship Bridge-I.

The first phase will be constructed with assistance from EXIM Bank, People’s Republic of China. The contractors are conducting initial survey and the plant is scheduled to become operational by year 2018.

Dhaka Environmentally Sustainable Water Supply Project (DESWSP)

This project will continue DWASA’s infrastructure development past the DWSSDP project. The project with its different components will conduct distribution network improvement (DNI) across different MODS zones within the service area. This will include rehabilitation of distribution network, water connection and installation of new meters. The project and its resultant DNI will facilitate supply of water to new and existing service areas from upcoming Gandharbapur SWTP.

Dhaka WASA Turnaround Programme 2010 – 2012

The programme aimed for institutional reform for capacity building, promoting transparency in all activities, establishing a new chain of command for accountability, and improving its operating ratio. It also fosters customer service excellence.

The objectives included (a) full implementation of Dhaka WASA Act 1996; (b) Sustainability of Dhaka WASA (c) Manage the incoming investments (d) shifting to surface water source from groundwater source and (e) making Dhaka WASA profitable.

Due to the initiative, the current NRW stands at around 29% and is projected to be brought further down to 25%. Collection of water supply and sewerage charges climbed from Taka 4 billion to current Taka 5 billion, an observable 25% rise and operational ratio is brought down to 0.79.

For these achievements, the organization received Water Leader’s Award – 2013 at the Global Water Summit.

Ashulia reservoir and Turag Surface Water Treatment Plant

The RAJUK master plan outlined 26 Specialized Planning Zones (SPZ) for the Greater Dhaka city area. In this regard, Ashulia was categorized as a ‘Flood Flow Zone’. Such zones are supposed to be preserved as wetlands and no land development activity will be allowed within the area. With a land mass of about 6200 acres, Ashulia is considered the main flood flow zone of Turag river.

Three reservoirs with a total area of more than 3000 acres will be developed within the floodplain by designating the boundary through road development. The roads will also act as dykes and there will be regulator structures along the road alignment. During the wet season i.e. 01 July to 01 October; the regulators will stay open and flood flow from Turag River will be allowed to pass through the reservoirs without any restriction. The water quality of Turag River during that period improves significantly due to dilution. When the flood water will recede to a level of 6.46 mPWD, the regulators will be closed and the reservoirs will store a total volume of 55 million m^3 water. The stored water will be treated and supplied to DWASA service area through transmission mains. The source will be able to supply 150 MLD water to localities in Tongi and Gachcha. Though the Gandharbapur SWTP source is supposed to serve these localities, availability of water from Ashulia reservoir will allow redundancy and water security. Also, treated water from Gandharbapur may be diverted to other localities.

Under the proposed plan, the reservoirs will be developed not only for water retention but also for waterfront recreation. Dhaka is a burgeoning megapolis with very few amusement outlets. Since the project site is close to the city with high accessibility, it is commercially viable to build a convention center in the peripheral area of the reservoirs. Along with the convention center; hotels, provisions for fine dining, eco-tourism facilities such as bird observation decks, boating facilities, museum, landscaped parks, gardens, etc. will be developed for the visitors. To ensure ease of access, there will be a commuter train station, parking space, etc.

2 Existing Water Supply Infrastructure

2.1 Water Source

2.1.1 Groundwater Deep TubeWells

The water supply system of Dhaka City is dependent mainly on groundwater source. As of November 2013, DWASA has more than 650 production wells. From these production wells, DWASA is providing about 78% of the city water supply. Before introduction of Saidabad Phase-II unit (225 MLD), the DTWs used to provide about 88% of supply. Such unusual abstractions may endanger the aquifer environment and also create a threat to sustainability of the city. The level of the water table is reported to be sharply depleting, resulting in declining yield from existing tube wells. Due to mining, the groundwater level is falling by about 2-3 meters per year (IWM 2008). The groundwater is estimated to be 80 meters below the surface compared 10m in 1970 in the upper dupitila aquifer (IWM 2007a). The ever increasing water demand in the city and decreasing water table is leading to introduction of more DTWs along with replacement of underperforming ones.

Analysis of recent DTW data (January, 2010 to May, 2013) from DWASA MIS shows that, the DTW network is growing at a median rate of 3 DTWs every month and at times, there were 6 new DTWs introduced in one month. However, this account does not factor in DTW replacement.

Table 2-1: DTW Capacity and Production by MODS Zones in May, 2013

Zone	No. of DTWs in Operation	Capacity as of October, 2012 (MLD)	Average Daily Water Production during January, 2013		Average Hours Operated Per DTWs	
			Total MLD	Avg./DTW(MLD)	Daily	Monthly
Zone I	64	188	187.9	2.94	22.72	704
Zone II	49	211	158.7	3.24	21.16	656
Zone III	89	310	270.0	3.03	22.48	697
Zone IV	81	234	202.8	2.5	20.39	632
Zone V	51	130	125.5	2.46	23.24	720
Zone VI	93	245	220.2	2.37	22.76	706
Zone VII	34	120	110.0	3.24	21.97	681
zone-VIII	46	108	108.0	2.35	20.94	649
Zone-IX	43	160	143.8	3.34	21.96	681
Zone-X	58	186	162.9	2.81	21.09	654
N. Ganj	25	68	56.92	2.28	16.46	510
Total	**633**	**1960**	**1746.9**			

Source: DWASA MIS, 2013

The DTW operation along with maintenance of civil structures is carried out by pumping station operators under control of the MODS Zone offices, i.e. MODS Circle. For every two DTW pump stations there are seven operators. The DTWs and Pumping Stations are operated in three 8 hour long shifts within 24 hours.

Most of the DTWs are equipped with diesel generators to maintain uninterrupted production during power outages. The electro-mechanical equipments are maintained by technical foremen and mechanics. The complaints received from customers mainly include: lack of water in supply line, leakages and contamination.

Situation Analysis:

The upper well casing length of DTWs is increasing to keep pace with the lowering static water table. The DTWs yields are not sustainable and most of them have a short operational life, about two to three years. This low shelf life of DTWs is causing 40 to 60 DTW replacements every year. Though from capital cost perspective, DTWs are relatively low cost solutions compared to a surface water treatment plant; the recurring maintenance and replacement costs add up to a significant number. In addition, synchronizing the operation of over 650 DTWs is a tall order. On an average, at least 15 to 20 DTWs are out of operation on a daily basis due to mechanical and electrical failure. Given this level of uncertainty, it is highly improbable to realize the 24/7 pressurized network proposed in the DMA scheme unless surface water supply is ensured to maintain the pressure.

DWASA is also trying to increase the efficiency of the DTW resources. In this regard, it has established a water operator's partnership (WOP) with Vitens Evides International, a subsiding of the largest water companies in the Netherlands. The WOP will modify existing DTW design template for better performance and longevity, develop a tubewell regeneration methodology, select less energy intensive pumps etc.

It has been established that the current groundwater management practice is unpractical. DWASA recognizes this reality and is gradually shifting bulk source of water from groundwater to surface water with the goal to limit the supply from DTWs to 1260 MLD.

2.1.2 Surface Water Treatment Plants

DWASA has a zonal approach of water supply to its consumers by conjunctive use of groundwater and surface water sources. Among the existing 11 zones only 8 nos. zones have conjunctive sources water, i.e. the supply consist of groundwater and surface water sources. The surface water treatment plants are constructed at Zone-2, Zone-1 and Narayanganj area but their service command areas are covered over Zones 1 to 7 and Narayanganj. Water from the existing 4nos. surface water treatment plants mixed with the DTW's water in the distribution network and increases both quantity and pressure in the network. Table 2-2 shows the service coverage areas of each water treatment plant.

Table 2-2: Surface Water Treatment Plant Details

Sl.	Name DWTP	Capacity (MLD)	Coverage area	Remarks
1.	Saidabad Water Treatment Plant (Ph-1 and 2)	450	MODS Zone-1,2,3,4,5,6,7	Zone 4 achieved after completion of 2nd phase
2.	Chandnighat (Dhaka) Water Works	39	MODS Zone- 2,3	
3.	N.ganj (Godnail) Water Works	34	Narayanganj west	
4.	Sonakanda Water Works	1	Narayanganj east	Currently undergoing rehabilitation works to increase capacity to 12 MLD

Saidabad Surface Water Treatment Plant (SWTP):

Saidabad water treatment plant (Phase-1, capacity 225 MLD) was built in 2002 under 4th Dhaka Water Supply Project. The total project cost under Phase-I investment was BDT 584 core financed by the WB, French Government and GoB.

The plant has been built on an area of about 22 acres. The present capacity of the treatment plant is 450MLD, after the second phase was commissioned in December 2012. Eventually the total plant capacity will be 900MLD when the third phase is completed.

Raw water is drawn from the River Sitalakhya through an intake pumping station constructed in the river at Sarulia point. From the intake, raw water is transmitted through a 40 m wide, 4.6 km long canal known as DND canal. At the tail end of the canal, water is transmitted through gravity to twin 2.0 m x 1.5 m culvert. The culvert itself is 1.6 km long. The culvert extends up to the sump of the pumping station, at the entrance point of the treatment plant.

At the beginning, biological pre-treatment aerates the raw water to convert ammonia to insoluble nitrate and nitrite. This ensures, ammonia in raw water is not reacting with chlorine in pre-chlorination and post chlorination cycles. At the flash mixing chamber, chlorine is added for raw water pre-chlorination. Aluminium sulphate is added for coagulation and lime for flocculation. In the pre-treatment clarification unit, four pulsator type clarifiers facilitate particle separation mechanism by both flocculation and sedimentation. The sludge blanket removes colloids and planktons. Water from the clarifiers is filtered in a set of 12 dual chamber sand filters. Finally, at the two chamber clear water reservoir, 30 minute chlorine contact is facilitated to ensure final disinfection of water. Lime is added for pH adjustment and filtered water neutralization.

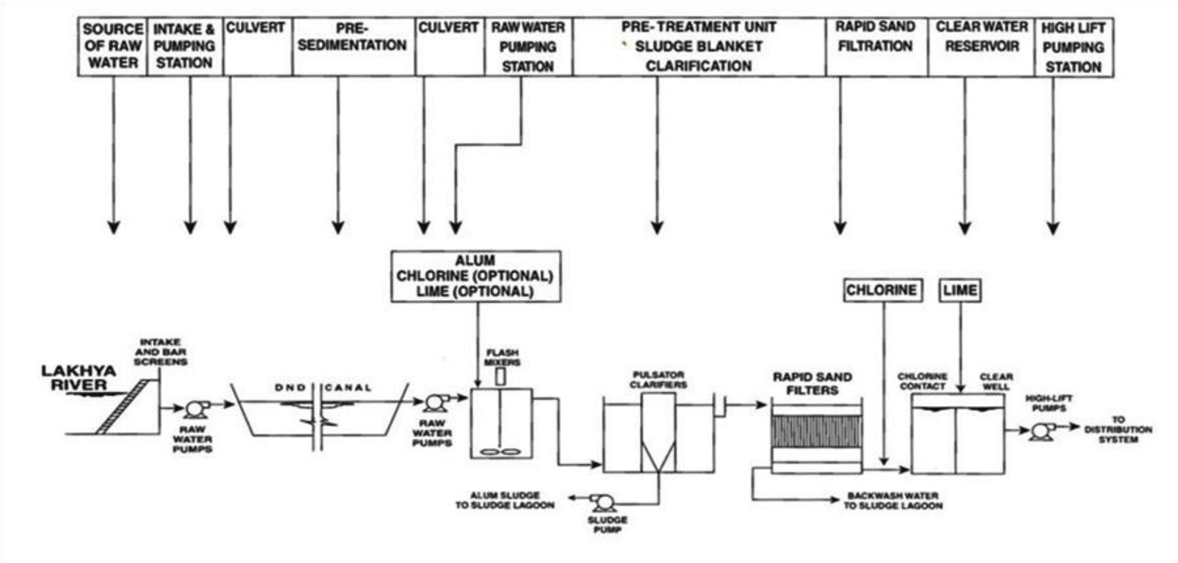


Figure 2-1: Process Flow Diagram at Saidabad SWTP

The day to day operation and maintenance activities in Saidabad SWTP is carried out by more than 100 personnel. O&M staffs are being trained by contractors. Eventually, DWASA staffs will take over the entire O&M activities within the plant. Emergency electro-mechanical repair works are conducted by the Maintenance Team headed by a Foreman, as and when required. In addition, the electro-mechanical schedule maintenance work is also carried out by a field maintenance team headed by a foreman. Large volume and/or complicated maintenance work is conducted by the contractor. Detailed record keeping of disinfectant usage such as chlorine, alum (aluminum sulfate) is kept to monitor temporal variation. The laboratory is part of the quality control unit. Daily and weekly internal water quality controls have been performed for 25 different parameters.

Situation Analysis:

Saidabad SWTP Phase-I plant is operating efficiently while Phase-II plant just became operational. To accommodate the additional amount of water, the system pressure head had been adjusted and DTW production schedule will be revised. The accompanying transmission main has been extended to reach more customers as well. The Phase-III plant with a capacity of 450 MLD will become available tentatively by 2018.

The raw water quality of Sitalakhya River is deteriorating continuously. This is mainly due to upstream pollution from the drainage canals, industrial effluents, etc. The dissolved oxygen (DO) in raw water is not within acceptable range. One of the solutions is to shift the source of raw water from Lakhya River to Meghna River.

Installation of a new biological treatment step for removal of ammonia has improved treated water quality in dry season. The alum consumption at the plant has decreased significantly due to introduction of the pre-treatment plant. However, additional de-nitrification units may be introduced to reduce chlorine dosage requirement since the existing dosage equipment has reached its highest capacity.

Chandnighat Surface Water Treatment Plant (SWTP):

Constructed in 1874, this is the 1st surface water treatment plant in the country. This water treatment plant covers almost all of the old city of Dhaka, which is one of the most vital business areas having lots of small scale industries and commercial enterprises. Buriganga River is the source of raw water for the plant.

Rehabilitation works of this treatment plant had been carried out in 1947, 1970 and in 1996 by Shimizu Corporation of Tokyo under JICA financial cooperation this plant BMRE (Balancing, Modernization, Rehabilitation and Expansion) has been implemented. After BMRE, the production capacity of this plant has been raised from 17 MLD to 39 MLD.

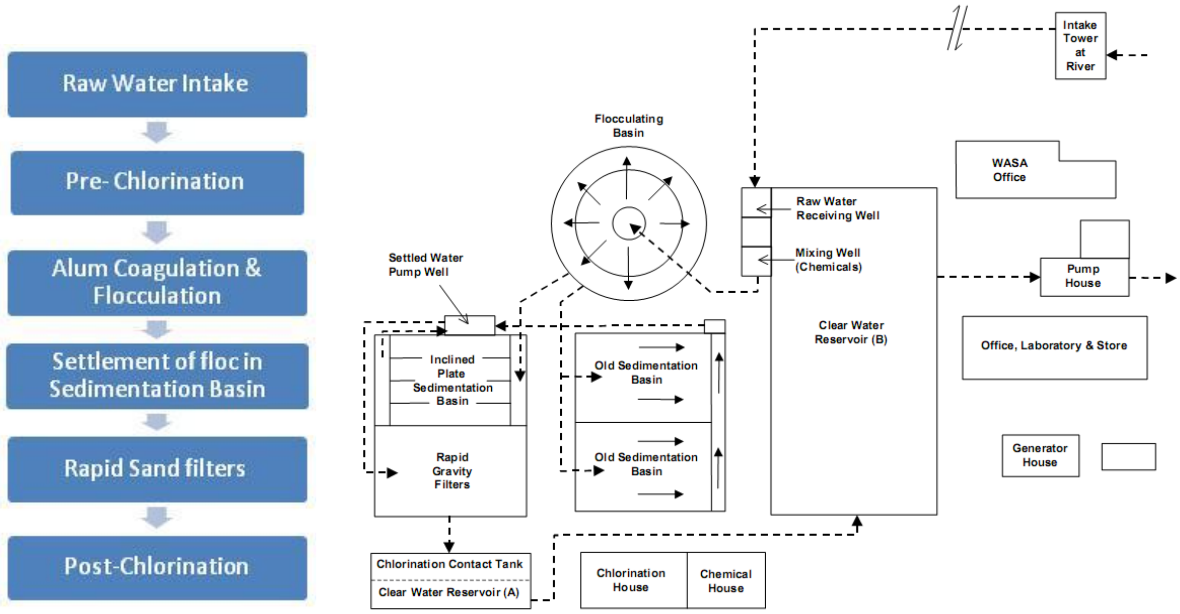


Figure 2-2: Chandnighat SWTP Process Diagram and Plant Layout

Water from Buriganga River is mixed with aluminium sulphate to generate flock and is settled out from the water in the flocculation basin. After the flocculation, water is pumped to rapid sand filters for turbidity removal through filtration.

The plant is under the jurisdiction of MODS Zone 02. There are 55 staffs dedicated for operation and maintenance of the water works. The staffs include pump operators, generator operators, filter operators, etc. A foreman is assigned for electrical repair works and another foreman for mechanical repair works. There is also a small scale laboratory with three lab assistants at the plant. In addition, DWASA microbiologist at Asad Gate Lab conducts monthly water quality control measurement.

Situation Analysis:

The treatment plant is fraught with issues stemming from its intake point. First and foremost, the water quality of Buriganga is too poor to be treated. The quality is exacerbated due to discharge of untreated sewer wastewater in the vicinity of the intake. The situation only worsens during dry season.

During the dry season, elevated concentration of pollutants in the raw water hampers floc generation. As a result, desired turbidity and colour of water cannot be achieved. Because of high turbidity during dry season, the rapid sand filters get clogged and their operation is hampered.

Though the intake point was extended further into the river, neither quality nor quantity of water improved. Moreover, though the capacity of the plant has been raised to 39 MLD through renovation; the plant produces 13 MLD on an average during dry season. This is because of the drop in water level in Buriganga River.

Chemical application and dosing is not conducted through any automated electro-mechanical means. The entire process is manual.

Godnail Surface Water Treatment Plant (SWTP):
The plant is also known as Narayanganj Water Works. The plant was originally designed for 45 Million Liter per Day (MLD) capacity, but current production level has reduced to 10 – 12 MLD. The source of water for the treatment plant is Sitalakhya River. It draws water from the west bank of the river.

The raw water contains organic matter, micro-organisms and other pollutants. At the intake, water flows to a grit chamber under gravity and then, delivered to the mixing chamber of the treatment plant by submersible pumping equipment. Upon pre-chlorination, Max Floc Tee is used to remove oil and grease substance from raw water and alum is used for coagulation. Water is passed through baffled wall type flocculator with over & under flow. The half hour retention at the flocculation basin facilitates suspended particles to combine into large masses. From there, water is passed through rapid sand filters for removal of turbidity. The filtrated water is post-chlorinated at the inlet of the clear water reservoir and from there, is pumped to an overhead tank (OHT). Water is distributed from the OHT.

The plant is part of Narayanganj MODS Zone and has a total workforce of about 60 staffs. The staffs include pump operators, generator operators, filter operators, etc. There are six foremen assigned, three foremen each for electrical and mechanical repair works. The laboratory at the plant location conducts jar Test, chemical dosing, pH, turbidity and residual chlorine tests. In addition to the three lab assistants at the plant location, DWASA microbiologist at Asad Gate lab measures water quality parameters for this plant.

Situation Analysis:
The plant lacks any electro-mechanical mixer for coagulant and chemical dosage. The lift pumps have inadequate capacity and subject to wear and tear. The rapid sand filter bed’s backwashing mechanism is not properly operating due to lack of flow velocity. The ongoing project of “Expansion and Rehabilitation of Water Supply System at Narayangonj Town” (ERWSSNT) intends to restore the plant to its original capacity by redesigning the intake structure. The raw water quality issue at this part of Lakhya River stems from increased ammonia concentration during dry season. The current treatment process deals exclusively with removal of suspended solids (turbidity) and disinfection. However, given the growth of industrial and manufacturing facilities upstream of the intake, namely the Adamjee export processing zone (EPZ), DND area; the raw water quality should be analyzed for industrial and chemical effluents.

Sonakanda Surface Water Treatment Plant (SWTP):

This SWTP facility is located on the east bank of the Sitalakhya River at Sonakanda. It takes raw water from the Sitalakhya River. It had a production capacity of 2 MLD of potable water. There is no standard coagulation and flocculation arrangement in the plant. Flocculation is supposed to be facilitated in an open surface drain. However, the channel size and shape is not suitable for producing sufficient flock. Only the sedimentation unit is operating properly.

Situation Analysis:

The ongoing project of "Expansion and Rehabilitation of Water Supply System at Narayangonj Town" (ERWSSNT) will construct a new plant of 12 MLD capacity.

The treatment plants should run at design capacity. Operation and Maintenance manuals for each plant should be developed and followed rigorously. Any reduction in production capacity will require action from DWASA management.

2.2 Water Transmission and Distribution Mains

2.2.1 Transmission Mains

According to conventional definition, a Transmission main is larger diameter pipe that is designed to transport large quantities of water. Water services for small individual customers are normally not placed on trunk lines. Usually, such mains transmit water from raw water source to the treatment plant. However, in DWASA context; mains that transmit water from production source to large consumption areas are designated as transmission mains. Water sourced from transmission mains are distributed to the households through smaller diameter distribution mains. The pipe diameter of transmission mains typically range from 400 mm to 1800 mm. Table 2-3 illustrates the zone wise length of distribution line.

The transmission mains may be broadly categorized into two types, a) Mains originating at surface water treatment plants and b) Intra Zone transmission mains among production DTWs.

Table 2-3: Length (km) of Existing Water Distribution Lines in Different MODS Zones

MODS Zone	Total Length (km)
Zone-01	504
Zone-02	176
Zone-03	317
Zone-04	501
Zone-05	280
Zone-06	168
Zone-07	137
Zone-08	188
Zone-09	263
Zone-10	230
Narayanganj	78
Total	**2842**

Source: DWASA Facilities Survey, 2012

Saidabad SWTP Transmission Main:
The main transmits water from the two SWTP units at Saidabad to different localities within central Dhaka; the densest parts of the city. The localities served by the transmission main are Mugdapara, Bashabo, Khilgaon, Malibag, Rampura, Mouchak, Rajarbag, Mogbazar, Tejgaon, Green Road, part of Dhanmondi, Elephant Rd., Lalbag, Azimpur, Gulistan, Tikatuli, Noyabazar, Sadarghat, Jatrabari, Postagola, Motijheel and Bijoynangar. The pressure in the transmission system required at recently upgraded Saidabad SWTP is 5.8 bar and minimum observed is around 1.5 bar at the most distant node from SWTP. For the Phase – I SWTP (225 MLD) unit, 36.6 km long Transmission Main was constructed. The transmission main provides water to distribution networks through 42 nodes. The nodes are equipped with Pressure Reducing Valves (PRV), Gate valves and water meters to control and measure flow of water. The diameter of the transmission system varies from 400-1800mm.

The construction of Phase-II SWTP unit completed in 2012 and another 10 km main has been added to the existing transmission main with additional 17 distribution nodes. The new areas to be served are Gulshan, Rampura, Dhanmondi, Mohammadpur, Shyamoli, Kallyanpur and Darussalam. Water produced at the Phase-II unit is also supplementing areas supplied by the Phase-I unit.

Chandnighat SWTP Transmission Main:
Chandnighat SWTP, built in 1874, was the first water works in Dhaka. The plant, along with the transmission system still serves the historical parts of Dhaka city such as Armanitola, Ashek Lane, Victoria Park, Tipu sultan Rd, Gendaria and Nawabganj. The plant was originally connected to 7 overhead tanks through 300 mm to 350 mm rising mains. Those tanks are no longer operational but the localities are still served by the rising mains as distribution mains. A new transmission main about 3.5 km long and with pipe diameter 500 mm has been constructed. The new main transmits treated water from the SWTP to the said distribution mains.

Godnail SWTP Transmission Main:
Water from Godnail SWTP is transmitted through a 700mm diameter main. The 2.5 km long transmission main transmits treated water to an overhead tank located in Khanpur, Narayanganj. Water is distributed across the City from the overhead tank in combination with supply from DTWs located in various part of Narayanganj City.

Sonakanda SWTP Transmission Main:
Sonakanda SWTP was built during the same time when Chandnighat SWTP was constructed. Currently, it is undergoing renovation to increase its capacity up to 12 MLD. A new, 6 km long transmission main with a diameter of 450 mm is also designed to supply water to the Kadamrasul locality on the east bank of Lakhya River.

Each SWTP has its own plumbing group for maintenance and upkeep of associated transmission mains. Their responsibilities include maintenance of air pressure valves, washout chambers, valves etc.

Situation Analysis

- **Saidabad SWTP Transmission Main:** The transmission main is operating at desired performance level without any major disruption. The additional 225 MLD water from Saidabad Phase-II SWTP unit is transmitted through the same main. It was supposed to be accommodated by increasing the pump head at plant from 2.9 bar to 5.8 bar. This will result in elevated water pressure at localities adjacent to the plant. The head increase is necessary to provide water at the farthest points of the main particularly, the localities around the additional 10 km main. The objective is to attain a minimum of 1 bar pressure at the farthest point. However, the objective is yet to be realized.

- **Godnail and Sonakanda SWTP Transmission Main:** The ongoing project of "Expansion and Rehabilitation of Water Supply System at Narayanganj Town" (ERWSSNT) will rehabilitate 35 km of transmission and distribution network and about 60 km new mains of diameter 150 mm to 800 mm will be constructed.
- **Intra Zone Transmission Mains among production DTWs:** The 650 deep tube wells spread across the DWASA service area form the bulk of water supply source in Dhaka city. The DTWs pump water to surrounding localities. The mains transmit water from one DTW source area to another need area. Maximum diameter of these Asbestos Cement pipes is 450 mm. These particular types of mains are spread out across the city along with 300 mm distribution pipes. They were constructed on an ad hoc basis and often integrated with new sources of water as they became available. For example, parts of these transmission mains are used as secondary transmission mains for Saidabad SWTP.

As more SWTP sources will become operational around the city and District Metered Areas (DMA) becomes the norm, these quasi Transmission Mains will formulate the primary distribution mains of the DMAs. The Intra zonal transmission mains are maintained by respective MODS zone offices.

Situation Analysis

DWASA is replacing the Asbestos Cement pipes with ductile iron pipes. Within the DMA structure, the mains will collect water from SWTP transmission mains through Pressure Reducing Valves (PRV). The lines will also act as conveyance conduits among DMAs.

In addition to the existing mains, several new transmission mains will transmit water from surface water treatment plants that are being developed. These mains will transmit treated water from the plants to different parts of the city. Design criteria for the mains should consider pipes with diameter between 400 mm and 2000 mm.

The Master Plan proposes dividing the DWASA service area into independent water distribution sectors each having an SWTP, supplementary DTW sources and associated transmission main. To ensure reliability of the system, provision may be left to transmit water from one sector to another sector. This will require designing a transmission main as such that it can provide large volume of water to a different main without compromising the flow and pressure requirements of its own sector. Further recommendations are provided in the strategy section of the report.

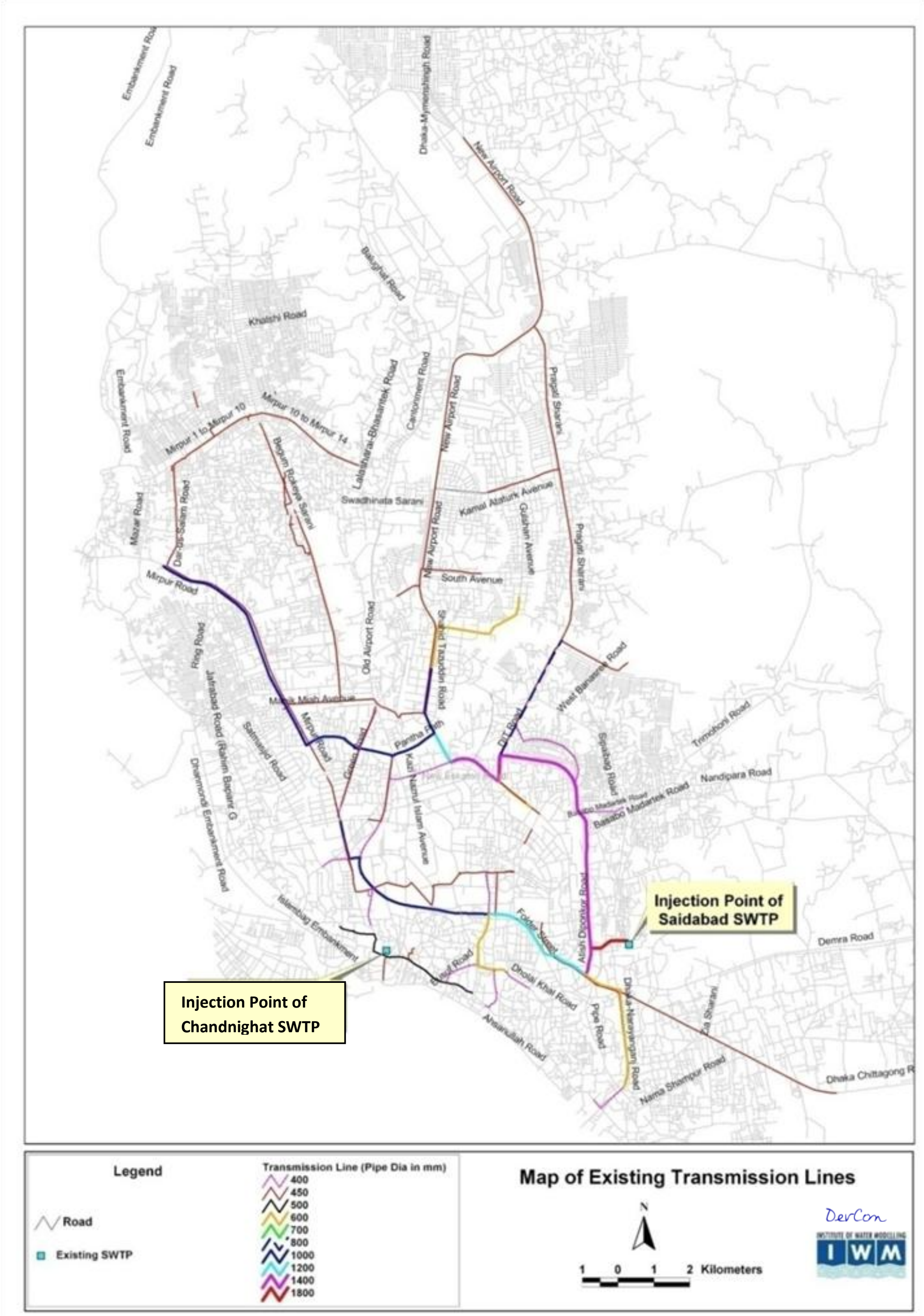


Figure 2-3: Existing Transmission System of Dhaka

2.2.2 Distribution Main

The distribution system primarily comprises of PVC pipes of diameter up to 300 mm. The network serves water sourced from local DTWs or transmission mains.

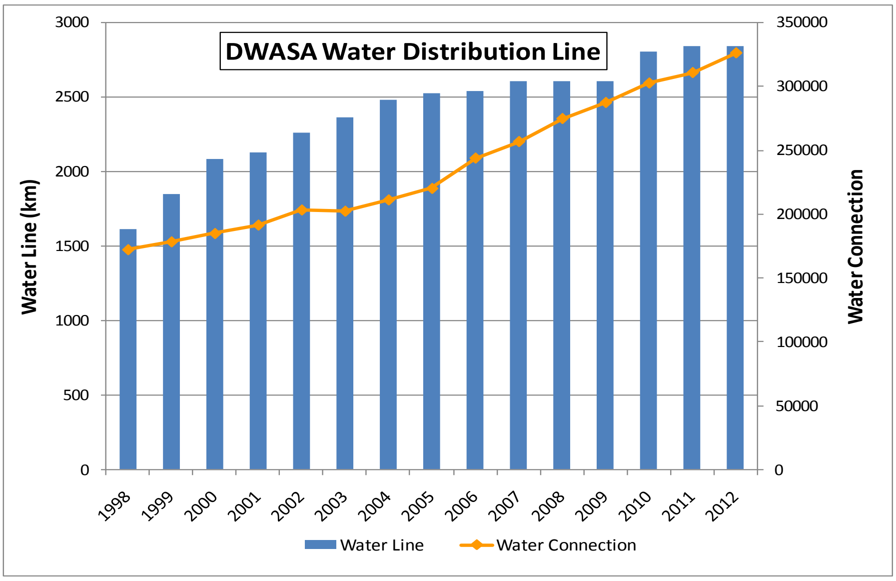
The distribution main is laid along roadways and serves water at household level through water connections. Table 2-4 provides the year wise total number of consumers.

Table 2-4: No. of Consumers over the Period 2006 to 2012

Years	No. of Consumers
2006-2007	244,097
2007-2008	256,375
2008-2009	279,338
2009-2010	286,915
2010-2011	295,516
2011-2012	311,064

Source: DWASA MIS

Historically, the distribution system grew with increase in DTW wells. However, between 1999 and 2000, the network grew by about 440 km. In recent time, between 2004 and 2010; the growth was almost stagnant. The number of water connections kept on increasing (Figure 2-4). In year 2011 and 2012, the system grew by 200 km each year. This may be the outcome of Dhaka Water Supply Sector Development Project (DWSSDP).



Source: DWASA Annual Reports

Figure 2-4: Timeline of DWASA Distribution System Expansion

DWASA network suffers from poor oversight. Low pressure supply and frequent deficiency due to pump or DTW failure leads to unauthorized tampering of the network and illegal connections. Ageing fixtures, subpar materials and poor workmanship causes leakage at service connection points and across the system. Earlier, non revenue water (NRW) was about 40%. A major portion of the

NRW is through physical losses at the distribution mains. However, recent turnaround initiatives along with network rehabilitation activities reduced NRW up to 22%.

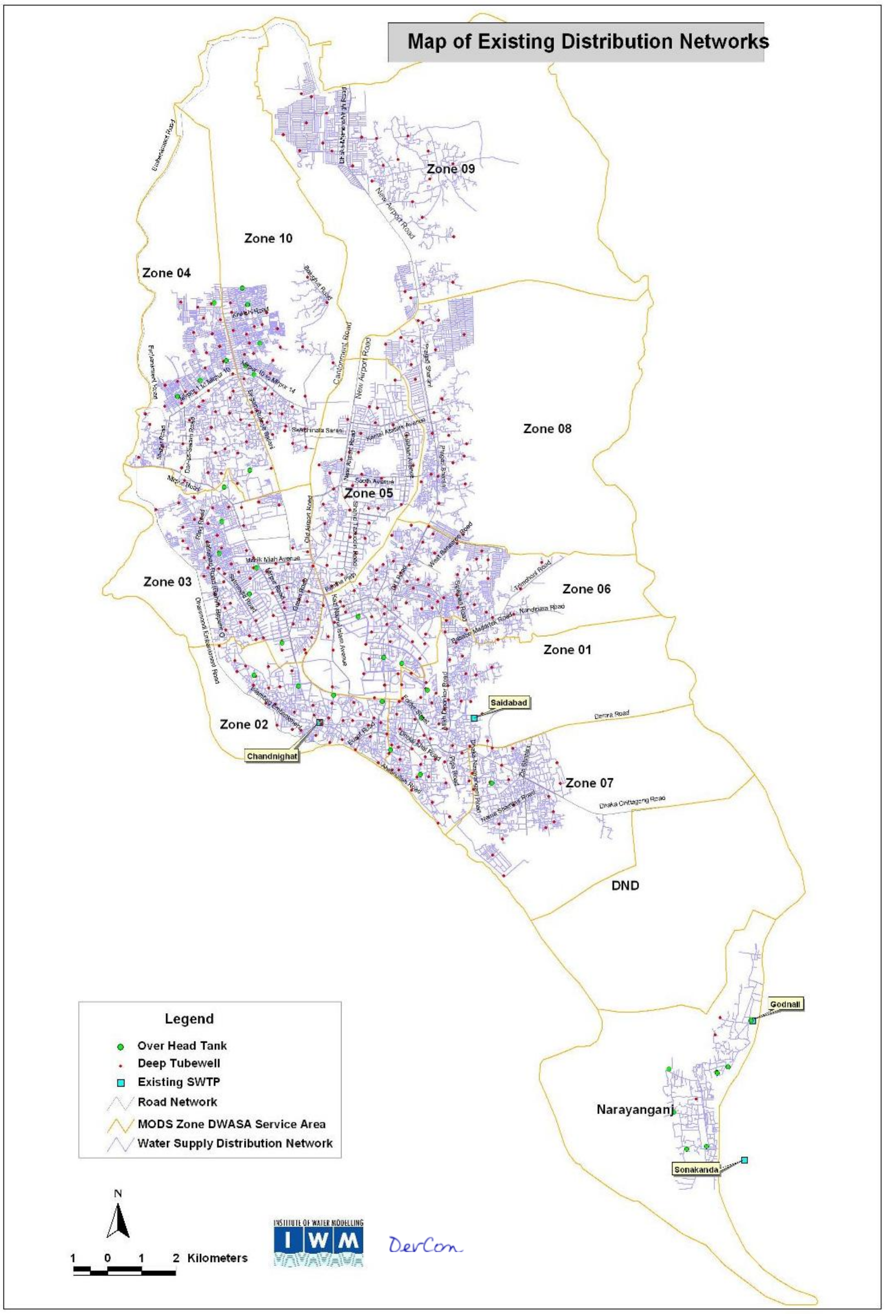


Figure 2-5: DWASA Distribution System

Source: DWASA GIS MIS 2004

The distribution network maintenance within a MODS zone is the responsibility of the associated zonal office. Each zone has 3 or 4 maintenance squads for network upkeep. Each squad is headed by a pipeline inspector. The squad consists of one pipe line inspector, One Pipe line Mechanic (PLM) and two Assistant Pipe line Mechanics (APLM). The plumbing groups work on receipt of complaint from the zonal complaint center. Each squad is supervised by 1 sub assistant engineer. DWASA organogram proposes at least one such squad for every 40 km pipeline.

Situation Analysis:

The distribution system expanded on an ad hoc basis as the city expanded. As a result, the unplanned growth of the city is also reflected in the network pattern. The distribution lines followed the road network to gain easy access. Since it is not possible to redesign and realign the network in built part of the city, the network will remain dendrite. However, in the recent planned sections of the city, the network exhibits grid patterns with loops.

Since the current system is not pressurized, consumers have adopted suction pumps to draw water from the network. But operation of such pump leaves downstream connections with even lower pressure. Therefore, the pressure issue exacerbates. Moreover, usage of such devices draw debris and pollutants into the network through the leakage points, which deteriorates the quality of water in the network.

Since there is little oversight upon network integrity, illegal/unconventional activities take place with regards to the connection. For example, whenever water deficiency takes place, the service connections are often shifted and enlarged to draw more water without consulting DWASA. Due to low pressure condition, connections are made at the bottom of the distribution line to draw water through gravity. In such circumstances, connection holes are not often properly clamped and solvent cement is used at pipe joints. These practices lead to further leakage i.e. Non-Revenue Water (NRW).

In its bid to reduce non revenue water, DWASA is rehabilitating the distribution network and introducing a new asset management concept, 'District Metered Area' (DMA). Each DMA distribution network will be sufficiently metered to monitor and account for water flow. Any anomaly in the system due to leakage, pilferage, etc. will be quickly identified and remedied.

A DMA will be managed by a DMA manager and he or she will be responsible for network management and revenue collection.

2.3 Overhead Tanks

DWASA water supply system includes 43 overhead tanks (OHT). However, only 17 of them are currently in operation. The overhead tanks were constructed at different times as the system expanded. There were a multitude of reasons for their construction. The tanks can be categorized into two basic types on the basis of their purpose:

i. Local Storage: Water extracted from deep tube wells is pumped to these tanks for storage. The tank water is supplied to surrounding localities during peak hours of demand.
ii. Balancing Reservoir: The primary function of these tanks is to maintain system-wide pressure of 3.4 bar. There are 3 such reservoirs in Lalmatia, Fakirapool and Mohakhali. However, the reservoirs remained unutilized as balancing reservoirs from the year of their construction due to insufficient system pressure. The Fakirapool OHT is used to store water, that is used to fill DWASA water tankers.

Table 2-5: Summary of Overhead Tanks

MODS Zone	Location	Ground Elevation (m)	Elevation Base (m)	Elevation Maximum (m)	Storage Capacity (Litre)	Present Status
1	Victoria Park	6.53	21.34	29.84	562,500	Inactive
1	S.K Das Road	6.27	21.34	29.84	450,000	Inactive
1	Bangladesh Bank	7.28	21.34	29.84	450,000	Inactive
1	Haat Khola	7.39	21.34	29.84	450,000	Inactive
2	Azimpur-7	6.87	21.34	29.84	909,200	Active
2	Hazaribag-4, (Badda Nagar)	7.78	21.34	29.84	909,200	Inactive
2	Bakshi Bazar	6.93	21.34	27.23	450,000	Inactive
2	Dhaka Water Works	6.45	21.34	27.23	562,500	Inactive
3	Babar Road,	5.01	21.34	29.84	909,200	Inactive
3	Dhanmondi-8,Road-13/A	6.06	21.34	25.84	454,600	Inactive
3	Dhanmondi-9, Road-1,	7.75	21.34	25.84	454,600	Inactive
3	Lalmatia Steel Tank,	7.67	34.89	45.39	4,546,000	Inactive
3	Salimullah Road,	7.18	27.91	34.41	681,900	Inactive
3	Shamoli Barabo,	7.46	28.38	34.88	681,900	Inactive
4	Agargaon-1	5.18	20.73	27.23	681,900	Active
4	Mirpur Pallabi-21, Pump	14.54	31.5	36.50	454,600	Inactive
4	Mirpur Section-1	12	30.00	35.00	454,600	Active
4	Mirpur-6/16	10	31.00	36.85	681,900	Inactive
4	Mirpur-2/9	8.5	29.5	35.65	909,200	Active
5	Mohakhali T.B. Gate (Steel Tank)	6.25	27.64	36.64	909,200	Inactive
5	Gulshan-4	6.77	21.77	26.77	454,600	Inactive
5	Tejgaon-8	7.6	22.66	27.66	454,600	Inactive
5	Tejgaon Thana Health Complex	6	33.43	44.43	4,546,000	Inactive
5	DOHS, Mohakhali	7	25.39	30.39	454,600	Inactive
6	Bijoy Nagar	6.3	28.64	33.64	454,600	Active
6	Fakirapool (Steel Tank)	5.8	34.23	45.23	4,546,000	Active
6	Kakrail (S.O.C. Office)	8.1	24.24	29.24	454,600	Active
7	Donia-1	7.9	28.38	34.88	450,000	Inactive
8	Uttara 9/A Pump, Sector-9	8.2	28.38	34.88	450,000	Inactive
9	Mirpur 10/28, (Bottle Jaat Plant)	8	28.73	35.43	681,900	Active
9	Mirpur-10/18	9.2	29.93	36.63	681,900	Active
9	Mirpur-12/D, (Ceramic)	10	30.73	37.43	681,900	Active
9	Mirpur, Eveniew-5, Sectn-11	9.5	30.23	36.93	681,900	Active
9	Mirpur-12/D-24	6.87	21.34	29.84	909,200	Active
NRNGNJ	Nitaiganj	7.95	21.34	29.11	2,000,000	Active
NRNGNJ	Deobhog	7.75	21.34	26.77	500,000	Inactive
NRNGNJ	Maajdair	8.13	21.34	26.77	500,000	Inactive
NRNGNJ	Khanpur-1	8.53	27.64	34.67	2,000,000	Active
NRNGNJ	Khanpur-2	7.87	27.64	34.67	2,000,000	Active
NRNGNJ	Godnail	7.64	21.34	29.11	1,000,000	Active
NRNGNJ	DC Bunglow	7.96	21.34	26.77	500,000	Inactive
NRNGNJ	Paik Para	8.43	21.34	26.77	500,000	Active
NRNGNJ	Ekrampur	8.15	21.34	26.77	500,000	Inactive

The tanks are maintained by respective MODS zone offices. All overhead tanks are accompanied by a DTW. The DTW is usually the primary source of water of the tank. Therefore, concerned DTW operators control the tank filling and delivery schedule. They are also responsible for its maintenance.

Situation Analysis:

The OHTs are gradually becoming less effective not due to fault of their own but due to the city's growth dynamics. Dhaka is arguably the fastest growing megacity in the world. To cope with this massive influx, the city is growing vertically. This phenomenon is resulting in densification of the existing localities within the city. Originally, the OHT's were constructed to meet the elevated demand of peak hour usage. The tanks were supposed to store water during off-peak hours to meet the demand of peak hours. However, due to densification, the incident peak demand today is too high compared to the storage capacity of overhead tanks. As a result, the tanks cannot supply the demand long enough to cover the entire duration of peak hours.

Due to the history of uncertainty in water supply availability; one of the adaptive measures the city residents took is constructing underground reservoirs at the building footprint level. The underground reservoir stores water from the supply line when water is available at the supply main; usually, during off-peak hours. The reservoir gets replenished from the main when storage drops to a certain level. This provision of localized storage ensured continuous supply of water at the user end regardless of availability along the water mains. Since the system no longer abides by the 24 hour pressurized constraint, OHTs are no longer required for pressure maintenance. Availability of water in such localized storage process made overhead tanks in Bijoy Nagar, Gulshan 4, Tejgaon Health Complex and Tejgaon-8 redundant and out of operation. Kakrail overhead tank is in operation and is used as water filling station of the DWASA water carrier truck fleet.

However, Dhaka is adopting 24 hrs. pressurized supply approach in near future. The new system is designed following the district metered area (DMA) concept. The distribution system will receive water from both local deep tubewell sources and SWTP sources through transmission mains. Another feature of the system is, it will supply water at a minimum pressure of 1 bar. However, the system pressure is inadequate to lift water to existing overhead reservoirs.

The localities where DWASA can maintain 1 bar pressure in transmission line overhead works will not require any additional infrastructure to maintain system pressure. However, the utility balancing reservoirs require at least 3.5 bar system pressure to get replenished. Therefore, due to the system pressure constraint of 1 bar pressure; it is not possible to make the balancing reservoirs functionable.

Overhead tank located at Khanpur, Narayanganj is necessary to operate Godnail water treatment plant at full capacity. For areas where intermittent supply is still continuing, overhead tanks will be required.

3 Existing Institutional Setup

3.1 Introduction

DWASA currently operates under, and is legislated by, the Water Supply and Sewerage Authority Act of 1996. DWASA established under the Water Supply and Sewerage Ordinance of 1963 wherein its basic responsibilities were defined as the construction, expansion, operation and maintenance of water supply, sanitary sewerage works and drainage system for Dhaka City. The 1963 Ordinance also surmised that DWASA would assume responsibility for solid waste collection and disposal, but the Authority has never performed these activities. These functions were excluded in the amended Act of 1996, and this activity is now the responsibility of the City Corporation. In 1989, storm water drainage was transferred from the Department of Public Health Engineering to DWASA by a Government order. The responsibility for water supply of Narayanganj Pourashava was given to DWASA in 1990. DWASA's responsibilities under the multi-donor funded Flood Control Program now include the management and operation of canals and flood control pumps.

3.2 DWASA Organizational Structure

The major responsibilities and functions currently undertaken by DWASA are (from DWASA website):

- construction, operation, improvement and maintenance of the necessary infrastructures for collecting, treating, preserving and supplying potable water to the public, industries and commercial concerns
- construction, operation, improvement and maintenance of the necessary infrastructures for collecting, treating and disposing domestic sewerage and industrial wastes
- construction, operation, improvement and maintenance of the necessary infrastructures for drainage facilities of the city.

To facilitate more autonomy in operations, the WASA Act 1996 established the WASA Board consisting of members representing different stakeholders. The functions of DWASA are governed by the DWASA Board. The chairperson and 13 members of the Board are high level government officials or chief of professional institutes. Managing Director is the Chief Executive Officer (CEO) of DWASA. The organizational structure is oriented around four major wings (Figure 3-1). Each wing is headed by a Deputy Managing Director (DMD). All DMDs report to the Managing Director. The subsequent sections elaborate DWASA's organizational structure in further detail.

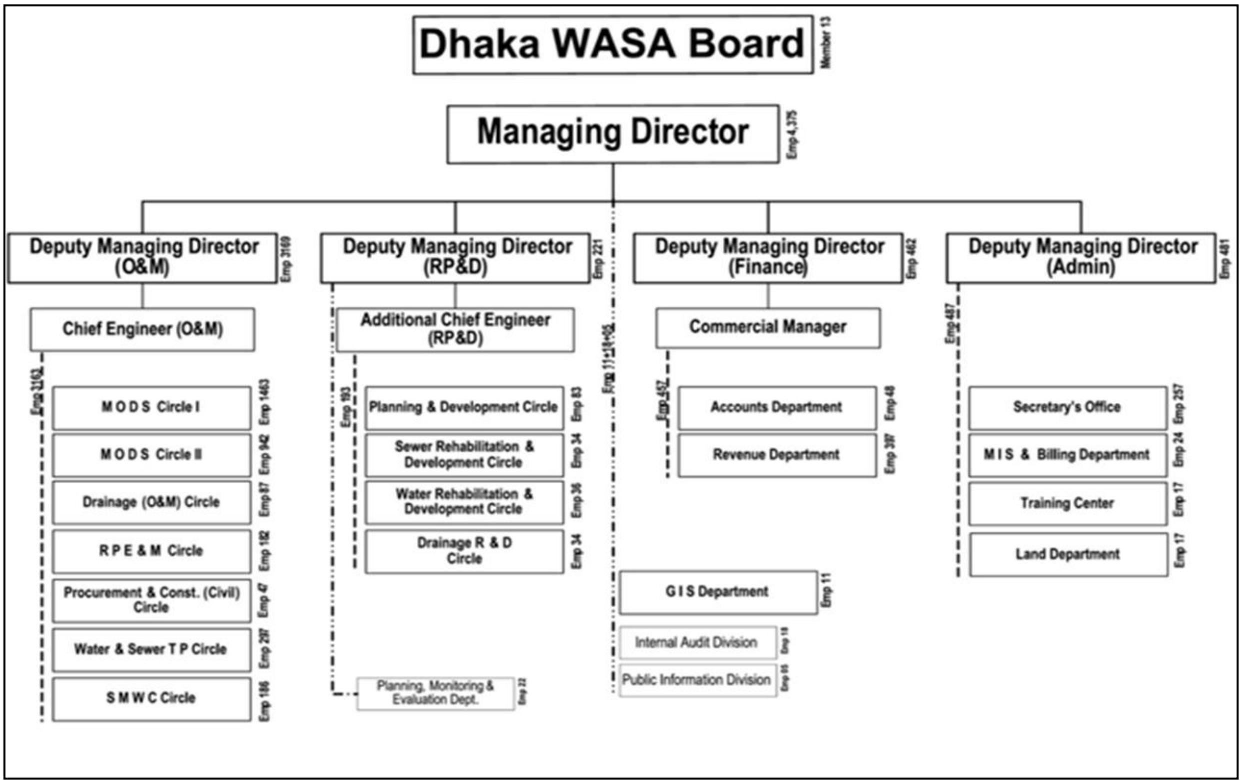


Figure 3-1: Current Organogram of DWASA

3.3 Planning and Development

This wing is responsible for research, design, planning and implementation of DWASA's capital improvement works for water supply, sewerage and drainage networks. There are independent circles for rehabilitation and development circles of water supply and sewerage. DMD (RP&D) leads one (1) additional Chief Engineer, four (4) Superintending Engineers, one (1) Deputy Chief Planning and twelve (12) Executive Engineers for design, planning and execution of project works. In the organogram there is provision of 221 officers and staffs under this wing.

This wing is more closely associated with design and planning of DWASA's structural assets. A Superintendent Engineer is in charge of each circle while each zonal office and division is headed by an Executive Engineer.

Water Rehabilitation and Development Circle:
This circle is responsible for installation of DTWs, new water supply networks and rehabilitation of existing networks. There are two divisions within the Circle. The Superintendent Engineer (SE) devises potential projects and executes them upon receipt of funding from the Government.

Sewer Rehabilitation and Development Circle:
This circle is responsible for installation of new sewer pipes and rehabilitation of existing network. The organizational structure and project execution framework of the Circle is similar to Water Rehabilitation and Development Circle.

Drainage Rehabilitation and Development Circle:
This circle is responsible for installation of new drainage pipe and rehabilitation of existing network. The organizational structure and project execution framework of the Circle is similar to Water Rehabilitation and Development Circle.

Planning and Design Circle:
The primary responsibilities of the circle include design of infrastructures planned by Rehabilitation and Development Circles, preparation of drawings for contractors, review as-built drawing upon project execution, record keeping of existing networks and infrastructures, etc.

P&D Water and Hydrology division also assist the MODS Circles (upon request) in preparing designs and drawings of projects associated with operation and maintenance. The division supports Water R&D circle in preparation of fixture design during construction of DTWs. P&D Sewer division and P&D Drainage division also provide such assistance beyond their respective assignments.

P&D Electrical and Mechanical division supports all three R&D circles with electro-mechanical project components such as specification, design, etc. They also assist Field Maintenance divisions (within Resource Planning Equipment & Machineries Circle) to troubleshoot electromechanical issues at DTWs and generators.

Environmental Monitoring division is responsible for private DTWs. They evaluate applications and upon justification, provide permit. The division maintains the list of private DTWs across the city and monitors them. Furthermore, the division also controls pollution of groundwater (GW) and surface water (SW) pollution in coordination with Department of Environment (DOE).

Central Laboratory at Asad Gate is also within the circle. The laboratory itself represents two divisions: Microbiology division and Chemical division. Together, these two divisions monitor water quality of DTWs at different locations in the network and recommend improvement works when needed. They also respond to customer complaints of water contamination by testing samples taken from site. In addition to DTW water quality monitoring and customer complaint investigation, they also conduct regular water quality testing of raw and treated water at the smaller SWTPs of DWASA at Chandnighat, Godnail and Sonakanda.

Planning, Evaluation and Monitoring Division:
The division reports directly to the DMD's office. It evaluates proposed projects and provides their opinion, prepares Development Project Proposals (DPP) on behalf of project directors and submits them to DMD (R&D). They are also responsible for submission of monthly progress report to the Government for all ongoing projects. These reports assist monthly project evaluation meeting at LGD, facilitates coordination between Government and project directors. The division also assists project directors in fund disbursement from Government. Upon completion of project, the division prepares Project Completion Report (PCR) for Government review. If development agencies provide funds for the project, they also receive the PCR.

3.4 Operation and Maintenance

For operation and maintenance purposes, DWASA service area has been divided into 11 MODS Zones (Maintenance, Operations, Development and Services). Operation and maintenance of water supply, sewerage and drainage are controlled by one (1) Chief Engineer along with seven (7)

Superintending Engineers and twenty eight (28) Executive Engineers under the leadership of DMD (O&M). There is provision of 3,163 officers and staffs for operation and maintenance in the Organogram. The Organogram also allows increase in number of operational staffs with increase of work volume.

MODS Circle is responsible for the operation of the deep tubewells but can call on Field Maintenance Division for assistance in emergency situations. System Monitoring Waste Control Circle provides a specialist service for water chlorination maintenance to the MODS group.

RPE&M Circle manages the Field Maintenance Division which is responsible for the rehabilitation and installation of pumping plant and the Mechanical & Electrical (M&E) maintenance of all the deep tubewell installations including pumps, motor starters, etc. M&E plant maintenance can be simply described as a breakdown policy with repairs only carried out on some essential pieces of equipment. Ancillary equipment, such as flow meters, chemical dosing systems, spare pumping plant, and so on fail occasionally and repairing works take long time because of inadequate maintenance budgets. Supply failures and substandard quality water entering the network occur due to the same. There was no evidence of any meaningful, planned maintenance being undertaken. All repairs on pumping motors are contracted out and are generally of poor quality, resulting in the waste of scarce maintenance funds.

MODS Circle 01:
Responsible for O&M of six MODS Zones, MODS 01 through MODS 06. Each Zone has one executive engineer and supporting workforce with independent office.

MODS Circle 02:
The circle deals with O&M of the remaining five MODS Zones, MODS 07 through MODS 10 and Narayanganj. It follows the same structure as MODS Circle 01.

Drainage (Operation and Maintenance) Circle:
Responsible for O&M of drainage system along with pumping stations dedicated for drainage. There are three divisions within the circle. Two of the divisions are responsible for O&M of drainage system and electro-mechanical division is responsible for upkeep of permanent and temporary pump stations.

Resource Planning Equipment & Machineries (RPE&M) Circle:
This circle is responsible for O&M of mechanical and electrical issues of DTW pumping stations (FM Divisions) and generators. They are also charged with the responsibility of procurement of necessary equipment and materials for proper maintenance of the electro-mechanical assets (Procurement Divisions). Each of the five divisions within the circle is headed by an Executive Engineer.

Water and Sewage Treatment plant Circle:
This circle is responsible for O&M and security of DWASA’s two most important infrastructures: Saidabad Surface Water Treatment Plant (SWTP) and Pagla Wastewater Treatment Plant (WWTP). Two divisions are assigned with Saidabad SWTP along with a quality control laboratory unit and security outfit. The division assigned with Pagla also operates the Sewage Lift Station at Narinda. Each division is headed by an Executive Engineer also procure additives, chemicals and other materials required for daily operation of the plants.

There will be new SWTPs at Char Gandharbapur (Gandharbapur SWTP) and Jashaldia (Padma SWTP) along with further expansion of Saidabad SWTP; expansion of Pagla WWTP treatment units at different phases up to 2035 as per Sewerage Masterplan, a new WWTP at Dasherkandi, etc. Considering all these infrastructure developments, their growing importance in service delivery; DWASA may consider revising its organizational structure and elevate the plant manager's rank from Executive Engineer to Superintendent Engineer.

System Monitoring & Waste Control (SMWC) Circle:
There are several divisions within the circle with varied responsibilities. The objectives can be broadly described as system monitoring and optimization, civil works of DWASA facilities and inventory management.

Waste prevention division is primarily responsible for reducing system loss in all shape and form. Metering and monitoring the network is a proven means to achieve such a goal. The meter division provides the support through meter installation at households. The meter workshop branch responds to customer complaints and repair meters if necessary.

The SOC (System, Operation and Control) division manages and keeps track of all complaints received within the O&M wing. Before 10 PM every day, the division collects complaint and response information from different zones, number of water tanker requested and supplied at different zonal offices. SOC also collects DTW production data at every zone. The monitoring data is communicated to DWASA management and concerned government agencies. In addition to monitoring, SOC also provides water tanker service when MODS zone resources are already committed or unavailable, during public events, fairs, etc. and DTW failure. Therefore, this division is DWASA's first response whenever temporary deficiency takes place within the system. The division also installs chlorination equipments at all DTW pump stations and is also responsible for supply and maintenance of chlorine gas/ bleaching powder.

Civil (construction) division is responsible for construction of all civil structures such as office buildings, staff quarters, etc. The projects are funded from capital head of the revenue budget. Civil Maintenance division is in charge of maintenance of existing civil assets.

Store division is in charge of inventory management. The inventory includes all materials and equipment procured by all other divisions. The division keeps track of material issued and annual inventory audits are performed.

Unlike other O&M circles, the divisions within the circle do not necessarily share a common goal or specialization. Even the SOC division is responsible for tasks that have minimal correlation. A streamlining of the organization to associate more concerned divisions within same organizational platform such as a wing may increase efficiency and communication.

3.5 Finance and Community Programme

This wing is responsible for billing and collection for the services and preparation of annual revenue budget and maintenance of DWASA accounts. One (1) Commercial Manager, one (1) Chief Revenue Officer, one (1) Chief Accounts Officer, five (5) Deputy Chief Revenue Officers and three (3) Deputy Chief Account Officers are working under the leadership of DMD (Finance). There is provision of 462 officers and staffs in the Organogram under this wing.

Revenue Department:
Chief Revenue Officer is in charge of the department. All 11 revenue zone offices that are at the MODS zones are under his/her authority. These revenue offices are responsible for billing and collection of revenue. In addition to them, there is a Central function and PDR (case) division that is charged with DWASA's government clients and pursuit of arrear bills, violation prevention, etc.

Accounts Department:
The department is headed by one (1) Chief Accounts Officer. There are two accounts division, a finance division and a budget division. The finance and budget divisions are actively involved in managing project and revenue accounts.

Community Program and Consumer Relations division:
The division is in charge of DWASA's relationship with informal settlement residents. DWASA's original institutional arrangement had no mechanism to provide water to the urban poor. Eventually, DWASA amended the rules to serve the slum areas provided there is a representative Non-Government Organization (NGO) who is accountable for revenue collection and other relevant interactions. The NGO formulates Community Based Organizations (CBO) comprising of slum residents. DWASA provides connections to CBOs that are certified by the NGO.

In sum, the O&M and RP&D wings formulate the primary components of DWASA's value chain while Administration and Finance wing are the supporting components.

3.6 Other Authorities & Entities

City Corporations:
Groundwater based water supply system has been developed in the Gazipur City Corporation area and constructed by DPHE under a development project. After construction, the water supply network/facilities was handed over by DPHE to the City Corporation for operation and maintenance. The present water supply system consists of 10 production wells, 2 overhead tanks, 29 km pipe network and 11 street hydrants. This City Corporation can meet about 62.63% of its water demand. They can supply 9.47MLD of water against demand of 15.12MLD. The area where the main pipe network does not exist, the households have to arrange their own water procurement system. The usual method is hand tube well, as the groundwater is easily available by sinking a tubewell. At present there are 415 hand tubewells in this area.

The surface drains are constructed and maintained by Dhaka City Corporation (DCC) in Dhaka Metropolitan area as per its own mandate. Piped, brick and box culvert drainage sewers are constructed and maintained by DWASA. Hence there is a question of enormous co-ordination between DWASA and the DCC. However, in Narayanganj, the total drainage function is a Narayanganj City Corporation (NCC) mandate.

Tongi Municipality:
Tongi Pourashava, presently under the jurisdiction of Gazipur City Corporation, was established in 1974 as an industrial town in the north part of DMDP area (RAJUK area), at a distance about 15 km to the north of Dhaka city. Total area of Tongi Pourashava is 32.36 sq. km.

There is an existing water supply network which serves only the central part of the Pourashava. About 22 nos. of DTWs and 1 no. of overhead water tank (450 m^3 capacity) is located in the Pourashava area for household water supply. In addition to this there are also 475 nos. deep-set hand tubewells rendering water supply facilities to the people who do not have connection to the water supply network. Besides this, industrial, commercial, educational and other private organizations have their own arrangement for water supply through DTWs installed at their own premises. But water supply is inadequate and does not fulfil the requirements. People of those areas use natural surface water from ponds, khals and rivers for bathing, washing and agricultural purposes.

Other Institutional Entities:
Within the DWASA service area there are places which have their own water supply system. The source of supply is groundwater and the distribution system is maintained by the individual organizations. In many of these areas DWASA has provision to supply water if required. Description of these individual independent areas within the City is described below.

Cantonment Board:
Dhaka Cantonment is located in the northern part of Dhaka. The headquarters of Bangladesh Army, Navy and Air Force are situated within this cantonment. The total area is about 9 sq. km, which is maintained by two engineering divisions named Garrison EngMaint North and Garrison EngMaint South. They are responsible for civil works as well as electric and water supply of this autonomous jurisdiction.

The water is supplied in this area through groundwater extraction by 41 DTWs. Daily 29MLD of water is extracted whereas existing demand is 36 MLD. GE (Army) Maint North has a present demand of 24 MLD and GE (Army) Maint South has 12 MLD. This has been estimated considering per head daily water consumption of 227 liter for an 8 member family and additional 91 liter per head requirement in officers' quarter for gardening and car wash.

The average housing depth of tubewells is 150m. But in the last few years 5 pumps at 60-90m level went out of service and some new pumps had to be placed at 215m depth. It is assumed that the rest of the tubewells which are at 90m depth will be out of service within 2025. The average capacity of these pumps is 1 cusec and they are operated up to 14 hours per day.

There are 20 to 25 small/large ponds available in this area among which Dhamalkote, AFMC and Mohakhali DOHS wetlands are significant. To cope up with continually increasing demand in future and rapidly decreasing groundwater level, cantonment board has taken an initiative to construct a surface water treatment plant and reservoir in Dhamalkote wetland which is about 2.3m deep and extended up to 0.12 sqkm area. The proposed water reservoir would be 9.1m deep within 0.12 sqkm area and will have the capacity to store 40 days water demand of the whole cantonment area. This plant will not only solve the future water scarcity but also the existing water logging problem in northeast and southwest part of Dhaka Cantonment by an interconnecting canal system. Three existing overhead tanks of 682,000 liter capacity which are currently not in use can be also revived.

Water is supplied through 152 mm main diameter GI pipe and distributor pipe diameter varies from 152 mm to 25 mm. There are 14 chlorination plants to treat the supplied water. There is 440/11 KV substation and 38 generators to cope with power shortage.

BUET:

BUET is a public university in Bangladesh and the oldest engineering institution in the region. Every year, about 1000 students get enrolled in undergraduate and postgraduate programs to study engineering, architecture, planning and science in this institution. The total number of teachers is about 500. The main profession in this area is to provide education and residential facilities for students and teachers. Major infrastructures include 11 academic buildings, 8 academic halls, 2 teachers quarters and 1 staff quarter which comprises of 0.31 sq. km area. Excluding the students coming outside of the university every day, there are about 10,000 residents in this area. There is one commercial place named BUET market under its jurisdiction. To maintain water supply in such huge area BUET engineering and maintenance division is working constantly.

The area is fed by 100% groundwater extracted through 2 DTWs. The average housing depth of tubewells is 100 m. Previously the rate of extraction was 1.5 cusec for 20 hours to meet the demand of 6 MLD. But due to decrease of water level, another 2 tubewells have come into service and pump operation is continued for 14 hours. There is no surface water treatment plant or overhead tank. The extracted water is treated by post chlorination before supply. The water distribution system is maintained through 152 mm main line. Distribution pipe comprises of 38 mm, 50 mm, 76 mm and 101 mm dia.

To support the pumping operation and supplying 24 hours electricity in the area, BUET has 11KV substation and 9 transformers. There are 3 gas generators of 1MW, 1MW & 2 MW and 1 diesel generator of capacity 1.2 MW to support the power supply.

Dhaka University:

Dhaka University was known as “Oxford of the East” in its earlier days. It is the oldest and largest public university of Bangladesh. Every year about 7500 students enroll for undergraduate and post-graduate studies in 13 faculties of the university. About 1800 teachers educate these students. The university area is about 1.4 sq. km comprises of academic building, 17 student halls, teachers quarter, staff quarter, auditorium, cafeteria, stadium, mosque, etc.

Responsible authority to maintain proper water supply in this area is the Engineering Division of the university. Main component of the system are 10 groundwater DTWs (boring depth of 300 m) each of size 700/200 mm and two (2) overhead tanks of total capacity 900 m^3. In addition to this system, DWASA provides water supply in Kuwait Moitri Hall located near BGB gate no. 3 and also in Shahnewaz Hall. To maintain supply in this two halls, one DTW was installed by DWASA in Kuwait Moitri Hall premises. Apart from this whole system there is provision to supply water from DWASA sources in emergency cases.

Railway:

Department of Railway provides water supply to Komlapur Central rail station and railway colony near station by DTWs. DWASA also contributes to the supply in railway colony maintaining one DTW. In emergency or during failure of the DTWs, DWASA provides additional supply to these locations.

Public Works Department:

The Public Works Department (PWD) provides water supply to the house of parliament and the staff quarters within the premises of National Parliament house. Currently 13 nos. of DTWs of sizes varying from 100 mm to 150 mm is facilitating this supply. These tubewells are operated and maintained by the staffs of PWD. In addition two (2) nos. of DTWs were installed by DWASA and presently are in operation, assisting water supply in this area. These two tube wells were installed to provide additional supply to the buildings constructed for Non Alliance Movement (NAM) conference.

Civil Defence:
As per government decision, DWASA has installed deep tube wells (with coupling connection) in the premises of almost every fire fighting station of the city. These tubewells ensure sufficient water for the fire fighting stations and at the same time provide water supply in nearby areas. DWASA provides this facility free of cost to the fire fighting stations. Besides this, all fire fighting trucks with capacity of 4000 gallons each are allowed to fill their tanks from any water filling station of DWASA.

Airport:
Department of Civil Aviation maintains water supply in Shahjalal International Airport and also in the Administrative zone (located at Kawla), which comprises of administrative office and residence of the staffs. Source of water supply is groundwater and the supply system is driven by DTWs and overhead tanks. In case of system failure or any emergency, DWASA also assists Civil Aviation Department for maintaining adequate supply in this area.

Non-Government Organizations:
The Community Program and Consumer Relations division of DWASA works along with several Non-Governmental Organizations (NGO) in its outreach initiatives to urban poor in informal settlements. The most notable of these NGOs are: DusthaShasthya Kendra (DSK), Water and Sanitation for the Urban Poor (WSUP), WaterAid Bangladesh, etc. DWASA values the organizations' activities and is actively considering their role in future planning. Case in point, in the Management and Supervision consultant (MSC) terms of reference for DESWSP, the consultants are going to monitor NGO activities and coordinate with DWASA Low Income Community (LIC) cell. Activities the NGOs are assigned with include Gender Action Plan (GAP), improve service access to low income communities (LIC), etc.

3.7 Relationship with Other Organizations

Local Government Division (LGD) of the Ministry of Local Government, Rural Development and Co-operatives (MLGRDC) is the administrative arm by which the GOB administers DWASA. Besides LGD, Dhaka City Corporations (DCC) and Narayanganj City Corporation (NCC) have significant interaction with DWASA since the corporation areas form DWASA's operation area. DNCC & DSCC are also involved with DWASA with regards to Drainage O&M. The surface drains of Dhaka city are being developed, operated and maintained by the DNCC & DSCC.

It is noteworthy that DWASA has established protocol of interaction with other relevant organizations. However, there is no formal procedure articulated to describe transition of responsibilities. The legal framework needs to be modified to explain how DWASA should establish its authority when expansion, annexation takes place.

3.8 Legal Issues

With respect to water distribution sector, the laws and policies which have an impact include:

- Building Construction Act, 1952
- Town Improvement Act, 1953
- Water Supply and Sewerage Authority Ordinance, 1963
- Environmental Pollution Control Ordinance, 1977
- Dhaka City Corporation Ordinance, 1983

- Environmental Quality Standards of Bangladesh, 1991
- National Environment Policy, 1992
- National Conservation Strategy, 1992
- Environment Conservation Act, 1995, *incl.* the latest 2010 amendment
- National Environmental Management Action Plan, 1995
- Water Supply and Sewerage Act, 1996
- Environment Conservation Rules, 1997 and subsequent amendments
- National Policy for Safe Water Supply and Sanitation, 1998
- National Water Policy, 1999
- Environment Court Act, 2000 and subsequent amendments
- National Water Management Plan, 2004
- Pro-Poor Strategy for Water and Sanitation Sector (PPSWSS), 2005
- Local Government Acts 2009
- Sector Development Plan (FY 2011-2025)
- Water Act, 2013

3.9 Situation Analysis

The key institutional weaknesses associated with DWASA include the following:

- There is no water sector regulator for setting standards, monitoring service provision and tariff approval.
- DWASA has limited control on key policy decisions, including investment planning and tariff setting. Although the DWASA Board is empowered to adjust tariffs, water tariffs are insufficient to fund extension works or operations and maintenance, possibly due to tariff setting being a political issue.
- MODS Zone offices lack skills in financial and infrastructure planning, and asset management for operations and maintenance. The lack of funding provides limited opportunity for financial planning.
- Wage packages and incentive structures are limited, especially for key staff positions. In absence of suitable financial packages for such positions, other incentives may be required to attract staff, e.g. use of new systems in planning, design and operations.
- There is a lack of application of advanced systems for asset management and GIS.
- The DWASA Training Institute for Water and Sewerage Management and Technical Training has a lack of training courses in water sector planning, operations and maintenance. This does not make key positions attractive when recruiting new staff.
- To support implementation of priority investments in the water sector, construction management expertise should be appointed within the Project Management Unit to support the construction phase. This has already begun with Dhaka Environmentally Sustainable Water Supply Project (DESWSP).

DWASA may consider a re-structured organogram (Figure 3-2) for separating the water, sewerage and drainage services which may facilitate planning and transparent financing. This will also enable easy operation and maintenance for the proposed implementations to address water supply, sewerage and drainage with DWASA jurisdiction area.

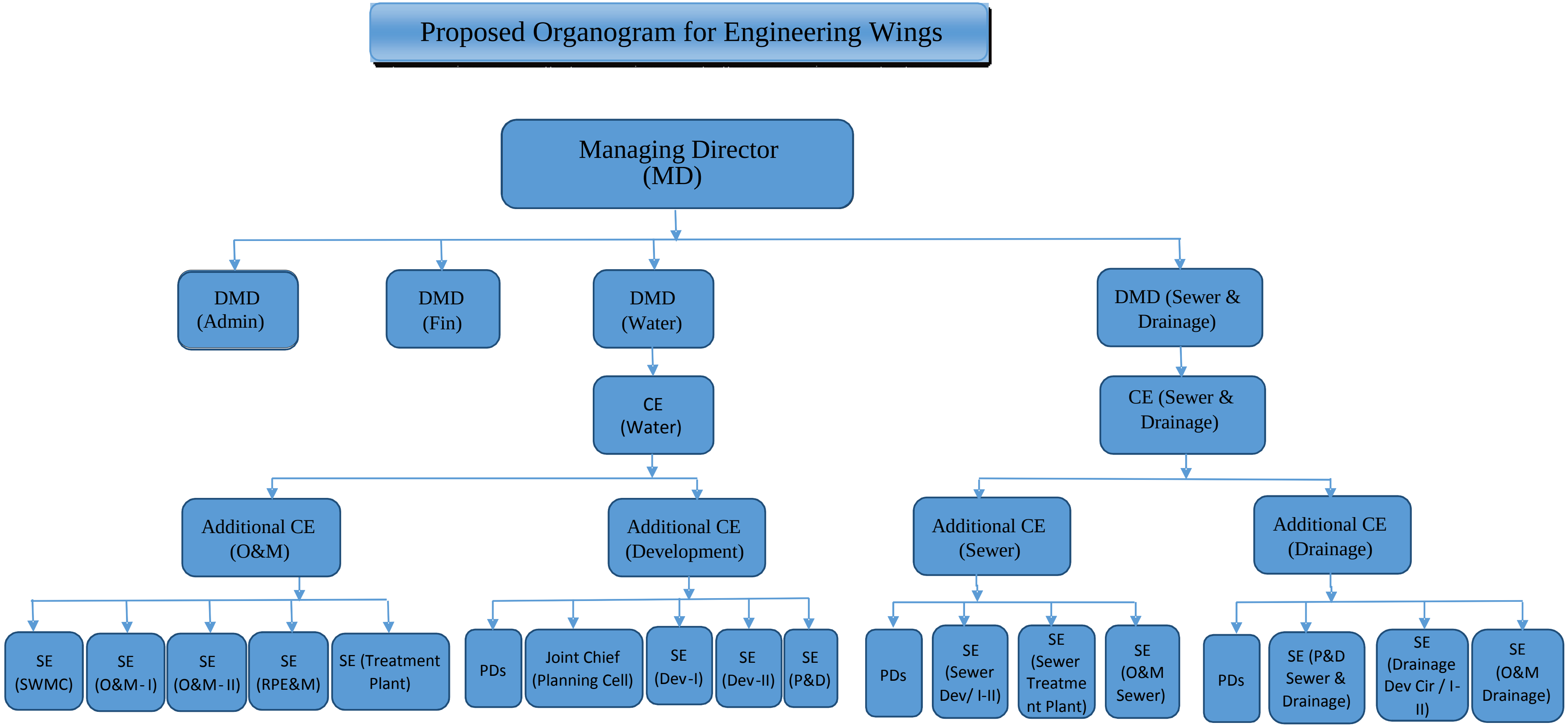


Figure 3-2: Proposed Organogram for Water & Sewer Services of DWASA

Master Plan Recommendations Concerning DWASA Institutional Issues:

1. An independent regulator should be introduced at ministerial level to manage and monitor setting of standards of water supply services and associated tariffs

2. DWASA should prepare a water policy to ensure transparency in the allocation of capital investments and recurrent expenditures as well as tariff income.

3. In order to improve sanitation planning and operations, DWASA should consider: i) Application of advanced systems for planning, asset management, GIS; ii) Create a Superintendent Engineer position responsible for all surface water treatment plants; iii) consider separating the water and sanitation departments in a separate governance structure.

4. Infrastructure plans should be prepared for each sector which will become the basis for request for allocation of State funds. These should be updated on a regular basis, nominally every 5-10 years, depending on development growth in each sector.

5. A range of management, planning, design and operations skills should be updated for DWASA staff to be managed by the DWASA Training Institute.

6. The planning process is the main opportunity for DWASA to influence future development, in particular, water supply facilities associated with private and public development. DWASA may consider being more actively involved in providing strategy advice at the DMDP level to RAJUK and more detailed service provision advice at the Detailed Area Planning level concerning water supply planning.

7. During the building permitting process, DWASA may consider presenting minimum demands for developers concerning provision of water supply services for each building permit. This may include private developers providing water distribution infrastructure as well as operations and maintenance services for developments not within the reach of DWASA services.

8. The DMDP, associated Structure Plan and local Detailed Area Plans (2010) have limited planning advice on water distribution systems. Although included on the DMDP Committee, DWASA has not been successful in incorporating water supply and sanitation planning issues. DWASA should consider preparing a policy document for RAJUK to define the options for water and sanitation management, especially concerning the land requirements for treatment sites. DWASA may also consider undertaking common training courses on water conservation with RAJUK staff in order to improve skills and nurture relationships.

9. The Building Construction Rules (1996) administered by RAJUK provide the minimum criteria for construction of buildings, including houses and apartments. It represents a key opportunity for DWASA to influence water conservation at the household level. DWASA may consider preparing a water conservation and recycling check-list to support RAJUK staff approving building plans for residential properties.

10. Dhaka City Corporation Ordinance should be revised in order to clarify the roles concerning potable water provision, including supply to formal and informal settlements. Tenure issues should be decoupled from service delivery for slum areas. Recent initiatives by DWASA to provide water supply service to informal settlements through NGOs will bring these communities within the metered and authorized consumer's fold. The DESWSP project acknowledges such concerns. DNCC & DSCC should communicate with DWASA to form a broad consensus in this regard.

11. The Water Supply and Sewerage Act (1996) authorizes DWASA to provide water distribution services, however private sector participation may contribute to improved service delivery, esp. operations and maintenance. In the case of new developments which are not currently covered by the water distribution system, private sector participation may include requiring private developers to provide water distribution infrastructure as well as providing operations and maintenance services.

12. Tariff rates for water supply should reflect the total cost of providing potable water services throughout the city, including capital investment as well as recurrent costs, and should be set in order to avoid water wastage.

13. A formal approach is required to co-ordinate inputs from various stakeholders associated with the water supply sector. DWASA should consider developing an electronic data archiving system which may allow access from other agencies involved in infrastructure development.

4 Existing Water Supply Situation

This section summarizes the survey findings in relation to key water supply issues, which includes: source of water supply; water supply condition; actions taken during shortages; and water quality issues.

4.1 Source of Water Supply

Around 84% of respondents stated that DWASA was their main source of water (see Figure 4-1). About 9% stated that their primary water source was by deep tubewells (DTW).

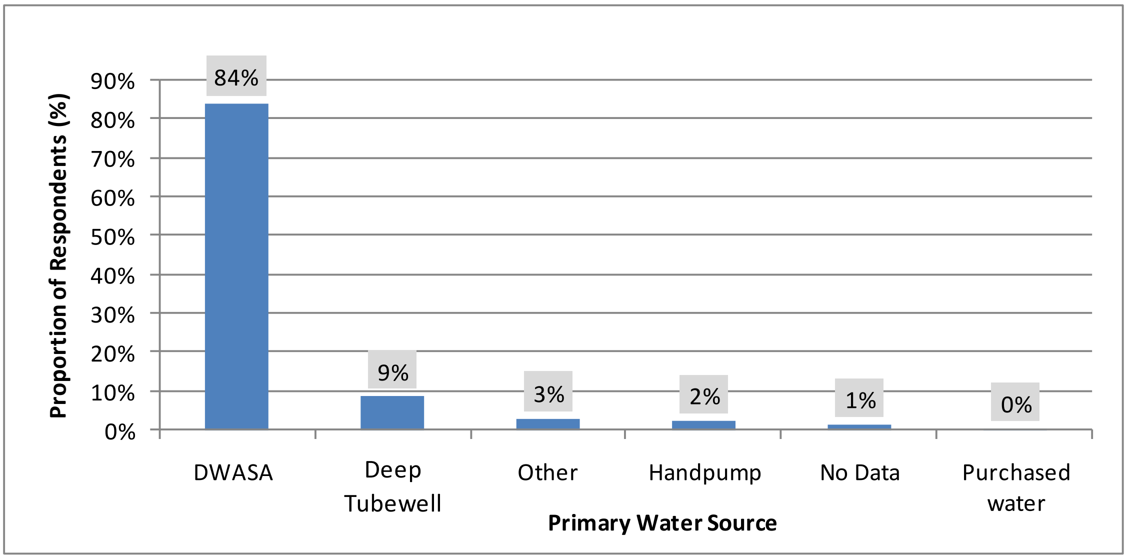


Figure 4-1: Distribution of Primary Water Sources

In the survey for the Sewerage Master Plan, about 90% houses had a DWASA connection (Grontmij 2011). Of the 10% of people not using DWASA water, 40% had HTW, 55% sourced water from DTWs, 5% were using public taps (Grontmij 2011). In the 2012 IWM survey, overall 84% of respondents stated that their main water supply source was DWASA. This has important implications in terms of service coverage. As this approaches 100% of the population, there will be non-incremental demand as people switch to DWASA water supply.

As shown in Figure 4-2, the proportion varies for different structure types. As expected, a lower proportion of respondents (55%) living in tin shed buildings rely on DWASA as the main water supply source. Their other sources included deep tube wells (DTW) (24%), hand pumps (7%), purchasing water (2%) and other sources (11%). 87% of respondents in semi-paka structures have DWASA as their main water supply source, with alternative sources identified as deep tube wells (DTW) (7%), hand pumps (3%) and other sources (2%). For 1-storey and 2-6 storied buildings, 99% and 95% of respondents stated DWASA as their main water supply source. 4% of respondents in 2-6 storied building stated that their main water source was a private well. Around 86% of respondents living in multi-storied buildings stated DWASA as their main source of water supply. Another 11% stated private wells as their main source and 4% of respondents did not give any data.

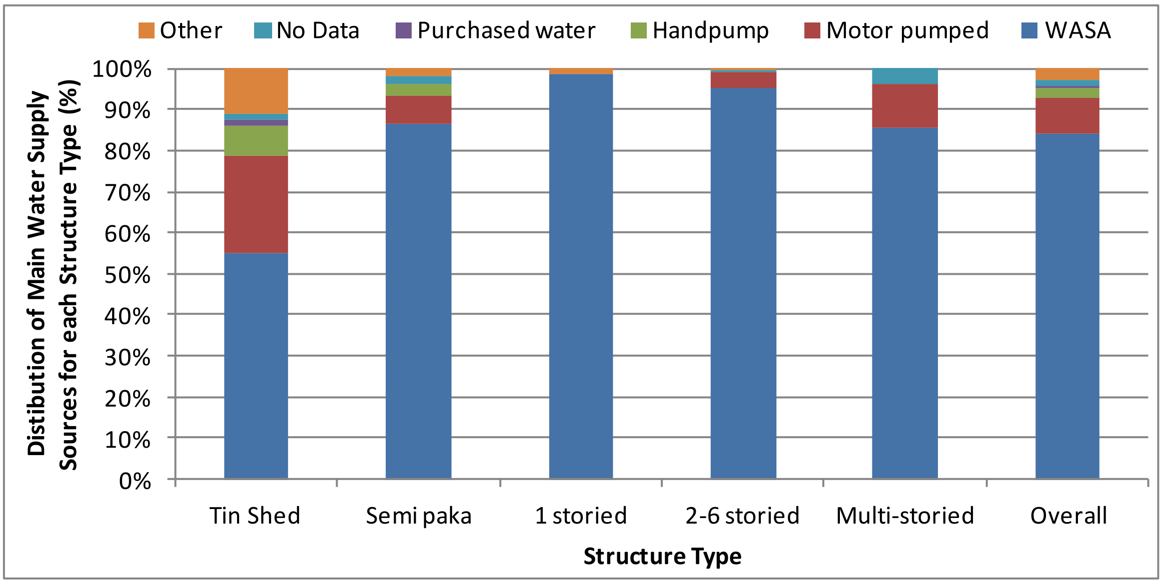


Figure 4-2: Distribution of Main Water Supply Sources by Structure Type

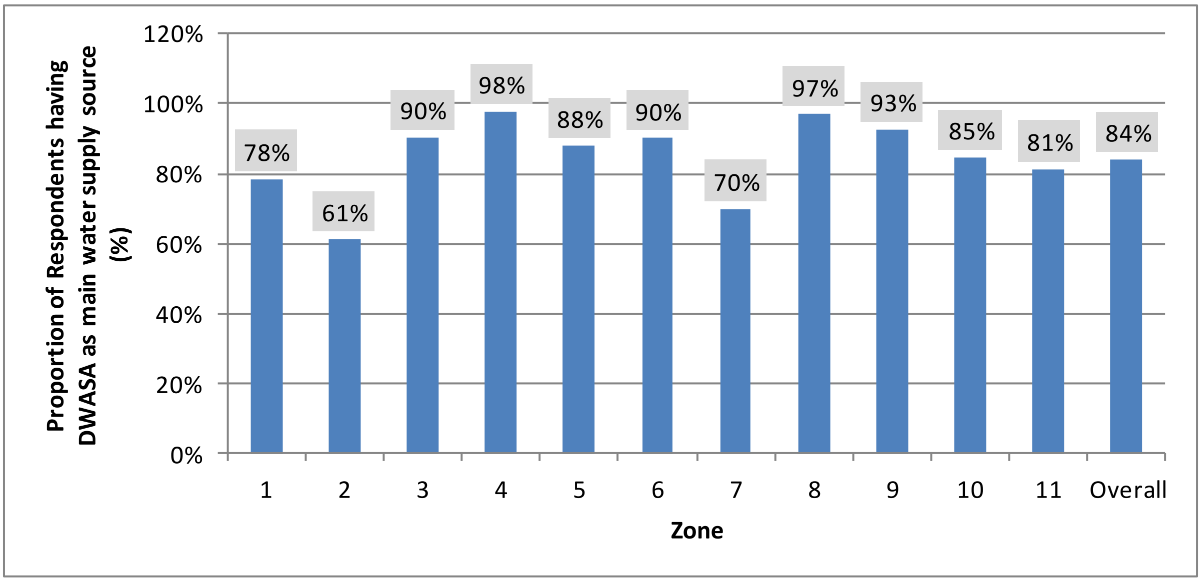


Figure 4-3: Zonal Distribution of DWASA as Main Water Supply Source

The proportion of respondents identifying DWASA as the main water supply source for each MODS Zone is shown in Figure 4-3. The proportions in Zones 1, 2, and 7 (78%, 61% and 70%) were particularly lower than the overall response rate of 84%. These three zones had relatively higher usage of private wells as the main water supply source compared to the other zones.

4.2 Water Supply Condition

The responses to seasonal water supply condition are shown in Figure 4-4. This question was addressed to the building manager or person who is knowledgeable about the water supply condition from the main source (DWASA line, private wells, etc.). In the dry season (Nov to Apr), 62% of respondents stated that they had no water supply problems, 34% stated some supply problems and 4% had no water supply. In the pre-monsoon season (May and Jun), the supply condition improved and the response rates were 75%, 24% and 1% for no problem, some problem and no supply conditions. In the monsoon season (Jul to Oct), 86% of respondents had no supply problems, 13% had some problems and only 1% had no water supply.

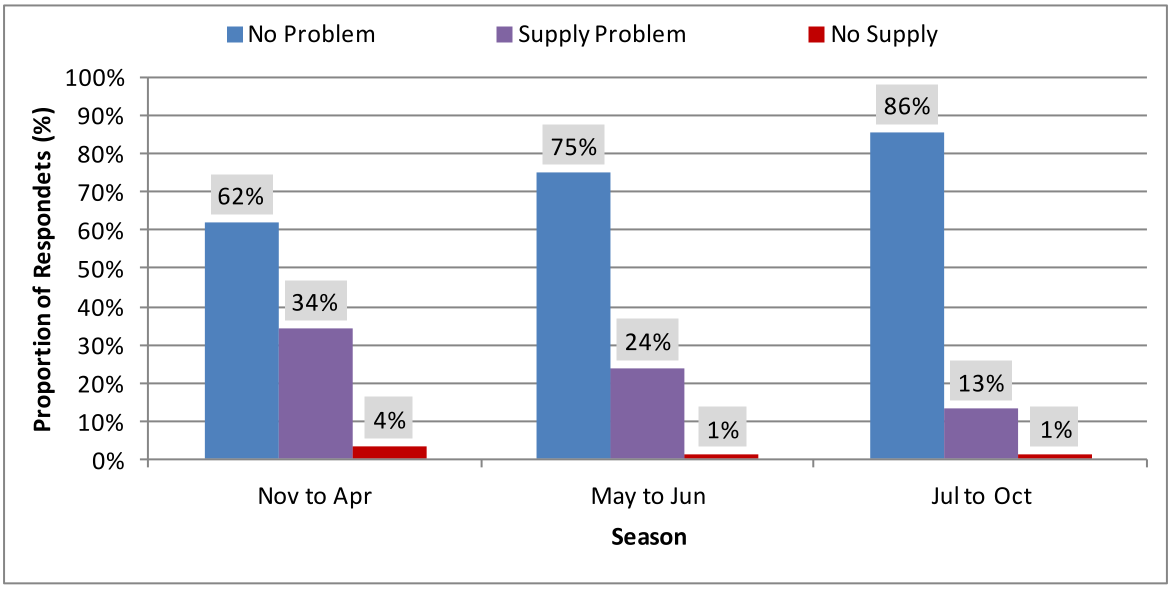


Figure 4-4: Seasonal Water Supply Condition

The responses to seasonal supply conditions for the three different seasons in each MODS Zones are shown in Figure 4-5. In the dry season (Nov to Apr), Zones 1, 2, 3, 4, 6 and 8 performed relatively better compared to the other Zones. Zones 10 and 11 have the highest response rates for supply problems (50% and 54%, respectively). All the zones had "no supply" respondents except for Zones 4 and 8.

In the pre-monsoon season (May and Jun), the water supply condition improves in all Zones except for Zone 8 where 73% of respondents had no problems in the dry season but this reduced to 63% in the pre-monsoon season. The reason for this could be due to temporary problems with DTW production in the area. The situation in Zones 9, 10 and 11 improve more significantly in the pre-monsoon season compared to the other Zones. "No Supply" problems still persist in some Zones, particularly in Zone 1, where 4% of respondents still complained of no water supply.

As expected, the water supply condition across all the Zones is best in the monsoon season (Jul to Oct). Only Zones 5, 8 and 10 had 20% or more respondents stating that they had some water supply problems. Only 5 Zones had respondents stating "no supply": Zones 1, 5, 6, 7, and 10. Of these, Zone 1 had the highest response rate of 6%, which is odd as in the pre-monsoon season this was lower (4%).

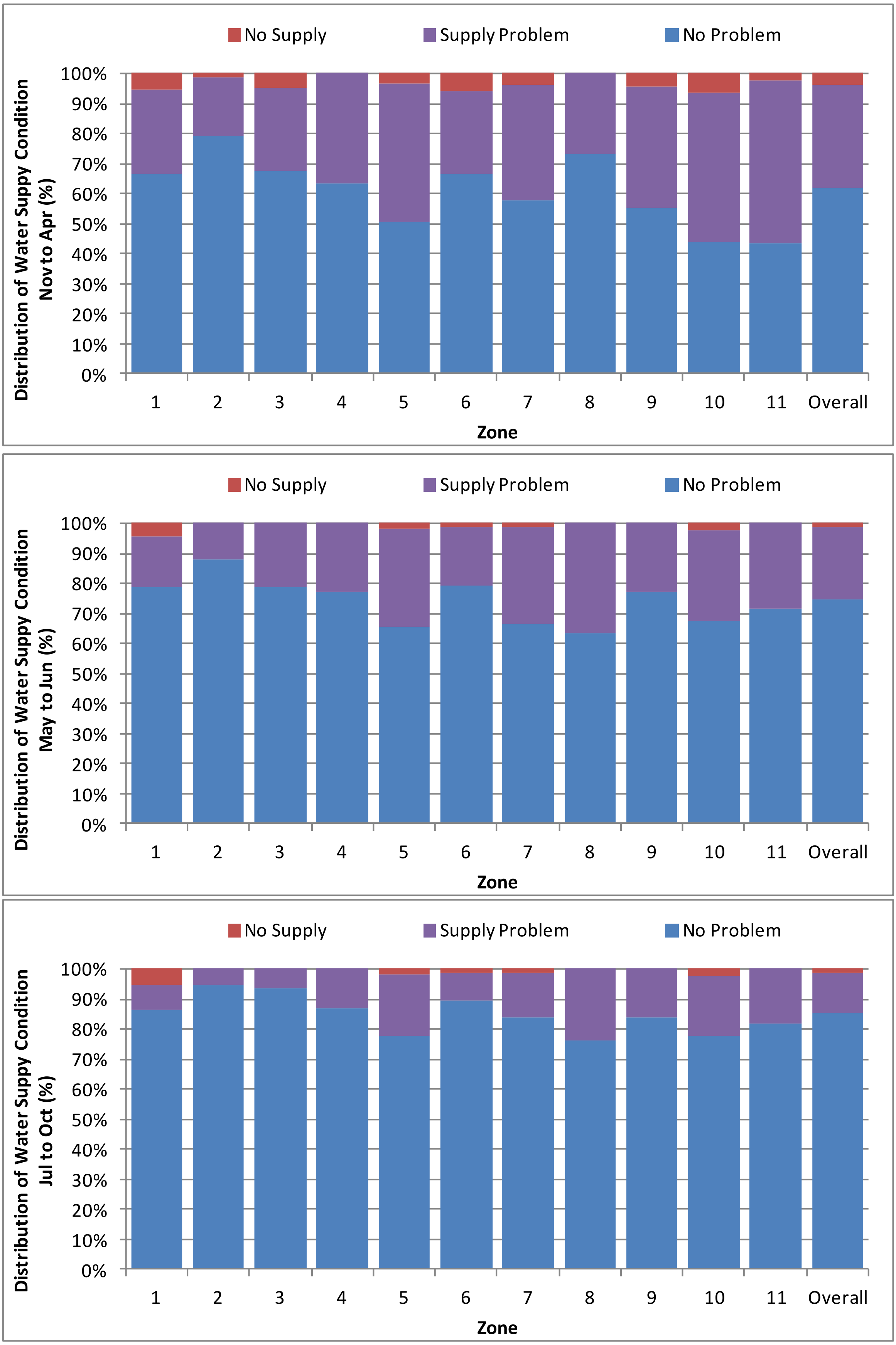


Figure 4-5: Seasonal Water Supply Condition by DWASA MODS Zones

The response rates for insufficient water supply are shown in Figure 4-6 for each MODS Zone. Overall, only 30% of respondents stated that the water supplied/available to their building was insufficient. Zone 2 had the lowest proportion of respondents (19%) stating that they had insufficient supply to their building. Zone 3 had the maximum proportion (35%), although that was only marginally higher than many other Zones.

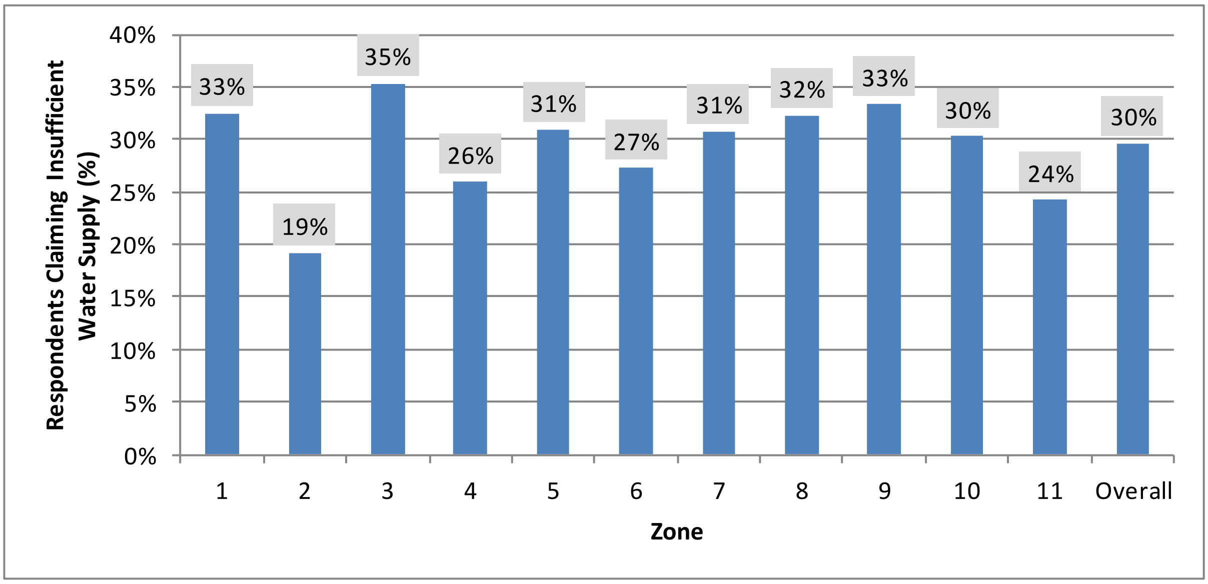


Figure 4-6: Response Rates for Insufficient Supply by DWASA MODS Zones

In the survey for the Sewerage Master Plan, among the DWASA connected households, 6% were getting water for 24 hours/day and 23% for a period of 12-24 hours a day; the rest were getting water for less than 12 hours (Grontmij 2011). Therefore, it is not surprising that in that survey, 43% of DWASA connected people stated that they were not getting sufficient water from the supply lines. This proportion is higher than that found in the IWM 2012 survey because the 2011 survey was conducted in May (when supply shortfalls occur the most) and the 2012 survey was conducted in September. Another reason could be that in 2012, DWASA installed more production wells which improved the water supply condition. With the commissioning of Saidabad SWTP Phae II in Dec 2012, the water supply condition is expected to have improved even more.

The water supply condition is expected to improve further into the future as DWASA is currently preparing three more water supply projects which include: Padma (Jashaldia) water treatment plant, Gandharbapur water treatment plant, and Saidabad III water treatment plant. Furthermore, ADB's DWSSDP project is currently rehabilitating water supply pipelines which will ensure 24 hours full pressure water supply with lower water loss. All these factors will combine to lead to incremental demand (increased consumption in existing connections) and non-incremental demand (switching to DWASA connection from alternative sources).

4.3 Actions Taken during Shortage of Supply

The respondents experiencing water supply shortages were asked from where they source water as alternatives. As shown in Figure 4-7, about 41% of respondents stated that during water shortages they tried to get water from DWASA and only 8% from DTWs. Around 51% stated that they availed other alternatives such as taking water from neighbouring house, purchasing from stores, etc.

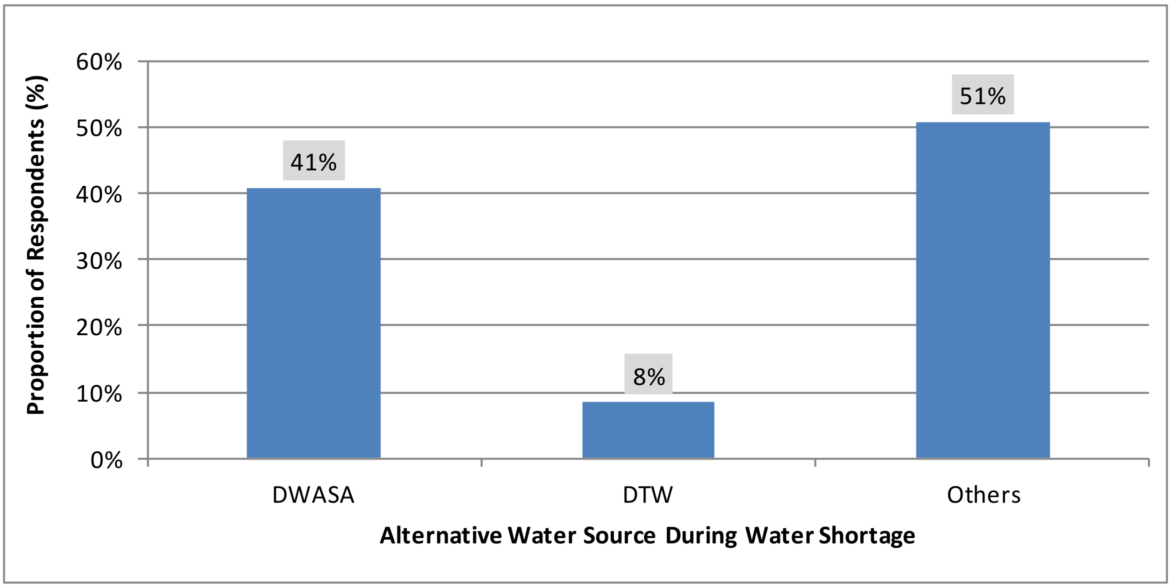


Figure 4-7: Alternative Water Sources during Water Shortage

When purchasing water during water shortages, the first choice is from DWASA, followed by purchasing from stores or other vendors (see Figure 4-8).

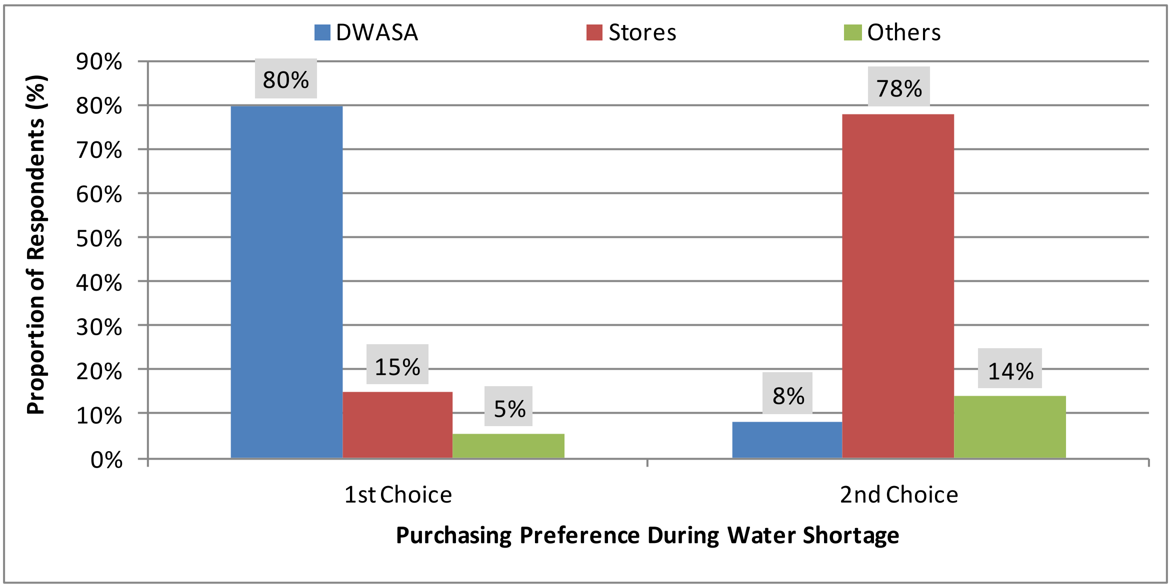


Figure 4-8: Purchasing Preferences during Water Shortages

Based on the 2012 IWM survey, the usage of suction (pull) pumps across different structure types is shown in Figure 4-9. Overall, 32% of buildings used suction pumps with higher proportion used in paka buildings (about 49%) compared to tin shed (5%) and semi paka buildings (25%). This correlates well with the supply condition situation discussed above.

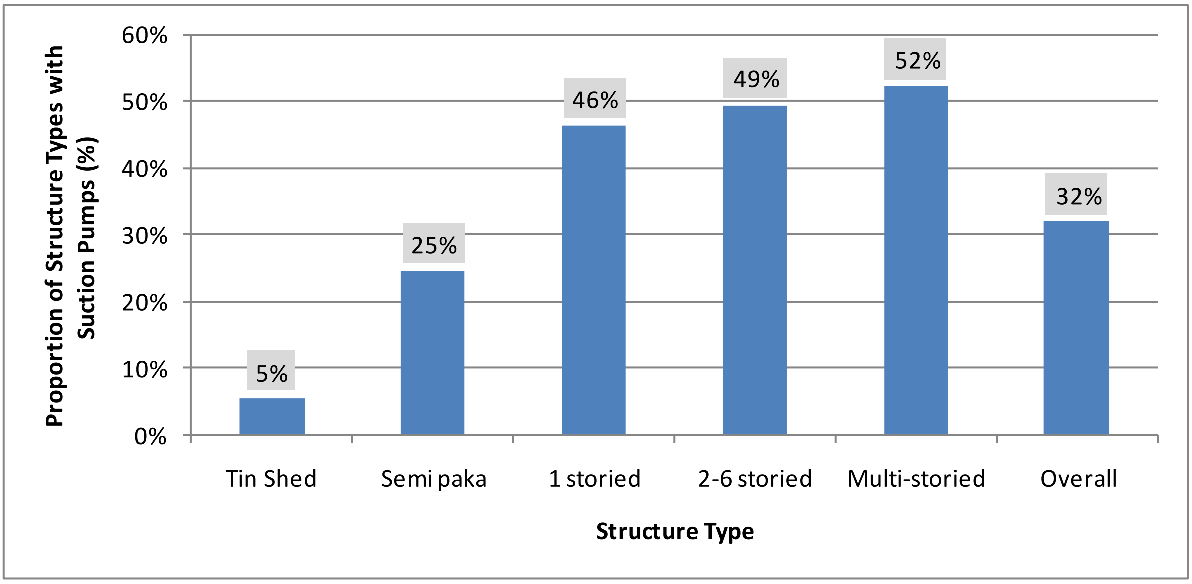


Figure 4-9: Use of Suction Pumps by Structure Type

The 2012 IWM survey also looked into the prevalence of water supply reserve (underground storage) tanks across Dhaka. As shown in Figure 4-10, overall 45% of buildings had an underground reservoir. The proportion is higher for multi-storied (100%) and 2-6 storied buildings (92%) compared to 1-storied (57%) and semi paka (20%) and tin shed (6%) structures.

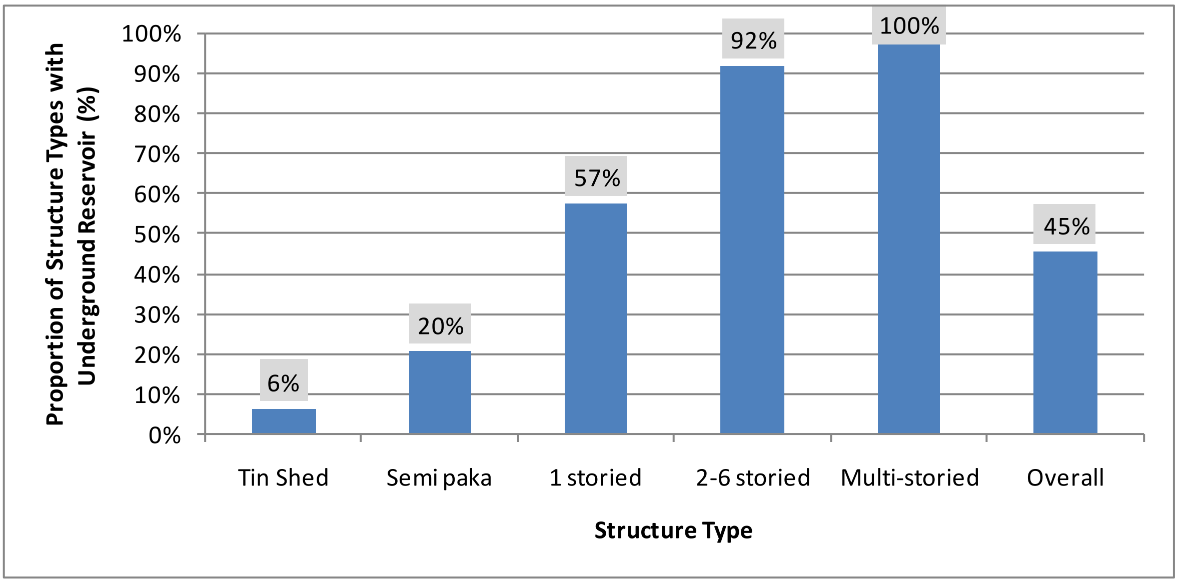


Figure 4-10: Use of Underground Reservoirs by Structure Type

4.4 Water Quality Issues

Indoor water quality issues were also surveyed at each household. Overall, 43% of respondents stated that they had no water quality issues, 20% stated one issue, 19% mentioned 2 issues, 10% listed 3 issues, 6% identified 4 issues and 1% gave 5 issues (see Figure 4-11). In the 2011 Sewerage Master Plan Survey (Grontmij 2011), it was found that about 38% connected people were happy with the quality of supply water. The slight increase in satisfaction (5%) could be due to the commissioning of an ammonia removal plant at Saidabad in Dec 2011.

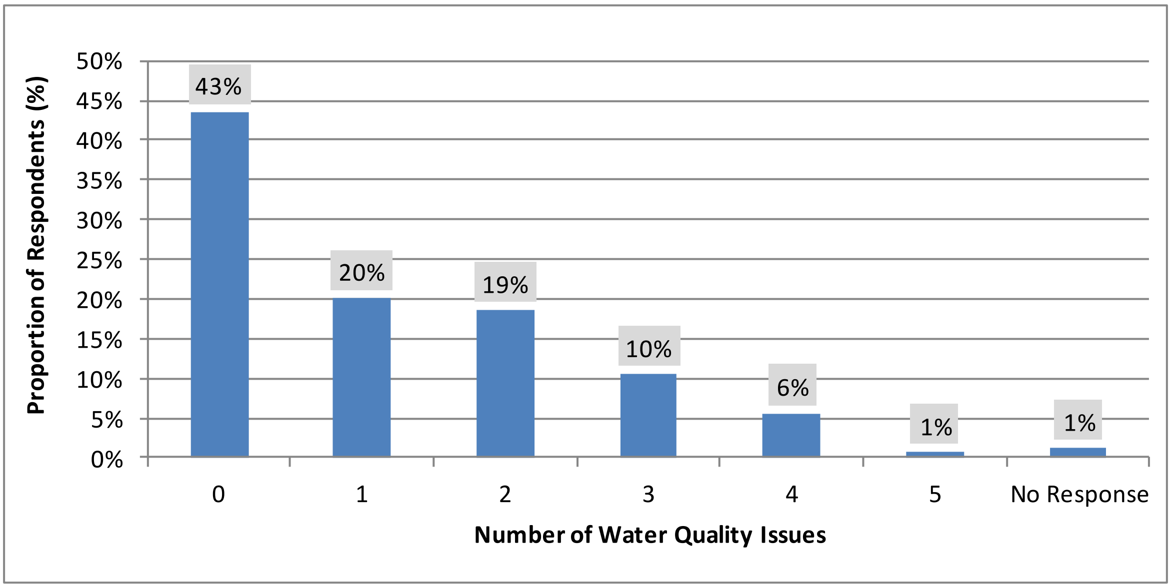


Figure 4-11: Proportion of Respondents with Water Quality Issues

The frequency of different water quality issues are show in Figure 4-12. Out of the 56% of respondents that stated water quality issues, the most common issue was smell (76%), followed by sediments (57%), then colour (44%), taste (20%) and other issues (9%).

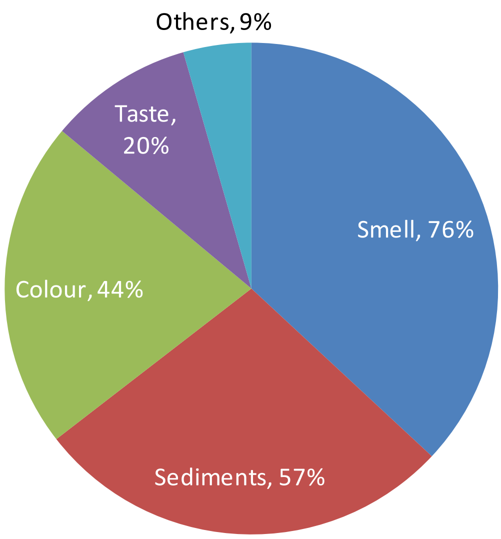


Figure 4-12: Frequencies of Different Water Quality Issues

Water quality issues may arise from several different sources in the supply system: DWASA pipeline condition, service connections, water reservoirs at individual houses, overhead tanks, etc. Thus, insufficient maintenance of water tanks at the household level can cause water quality issues for which the customer mistakenly blames DWASA.

4.5 Water for Urban Poor

DWASA had procedural limitations for water supply to slums as they lack the tenancy right which is required by DWASA rules for getting a water connection. In 2010 slum water supply and sewerage has been incorporated in the service rule. Over the past two decades, DSK and other NGOs have been working to improve water supply for low income communities. They started working by a model – social intermediation model (SIM) – through which a NGO, on behalf of the community people, remain guarantor for the bills to be paid. Usually the communities take a connection via a bulk meter to a ground reservoir from where water is drawn by hand pump tubewells. The communities collect money from the users and pay the water bills. This model was subsequently used by several NGOs and is recognized as a success by DWASA and NGOs. Based on this experience, and to sustain such initiatives, DWASA now allow community based organizations (CBO) to get water connections directly without any legal tenureship.

Presently DWASA partners with 13 NGOs that finance the infrastructure in the slum areas mostly with external funding sources, of which the most important are: Water Aid, UNICEF, World Bank, Plan International and UPPR-LGED.

Historically DWASA did not have any institutional structure and human resources designated for the services of LICs. At that time, the Commercial Manager played an informal but catalytic role to provide water to the slums. Recently a new division called "Community Programme & Consumer Relation Division" has been created in its new organogram to cater to the particular needs of the LICs. The organizational structure of the Community Programme and Consumer Relation Division is shown in Figure 4-13.

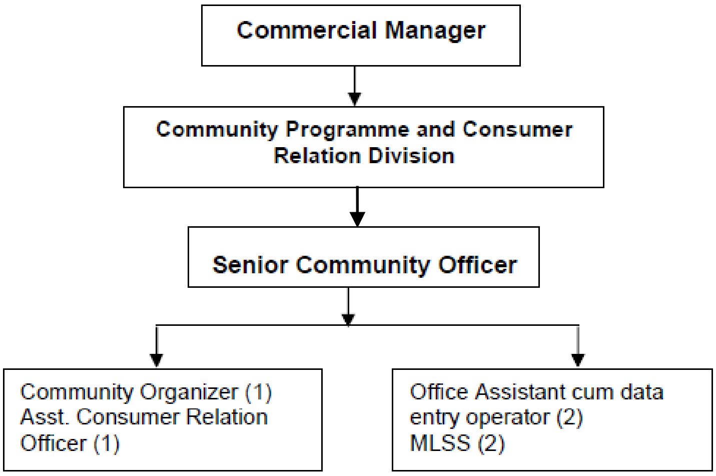


Figure 4-13: Organizational structure of Community Programme and Consumer Relation Division

4.6 Communication

A utility organization of DWASA's breadth and depth requires an extensive communication apparatus. The status quo internal communication is within the organization, to communicate and educate all employees along the chain of command about upper management's expressed decisions. External communication deals more with DWASA's stakeholders: Consumers, Government, media, other utility agencies, development partners, NGOs, etc.

DWASA emphasizes the organization to be viewed as a public sector enterprise with adequate autonomy so that it can make quickest of decisions regarding its service delivery and to meet emergency conditions. Importantly, DWASA has put in place an effective grievance redress mechanism and complaints/queries by the customers are met with extreme urgency. In 2010 DWASA has set up a “*Help-Desk*” and “*Complaint Cell*” in the head office and zonal offices.

Figure 4-14: Dhaka WASA Water Conservation Promotion Pamphlets

The Public Information Division is assigned with external communication while Internal Survey Division conducts a component of internal communication. Internal communication across the organization is done through publications of newsletters; annual reports; presentation by consultants; meetings; etc. External communication is conducted using multiple mediums. For Business to Business (B2B) exchanges, formal meetings, workshops, information presentation sessions, relationship management by senior management, etc. are conducted.

Non-structural best management practises at consumer end can impart significant improvement of services. To educate the consumer, DWASA needs to reach out to them. Awareness campaigns are done using mass media (Newspaper, broadcast media, etc.), door to door interpersonal communication and survey, school and religious establishment communication, distribution of pamphlets, flyers, miking, etc. Collaboration with NGO’s is another method of external communicati0on.

DWASA has launched a 24/7 help line ‘WASA Link’-16162 set up in November 2012. It is available round the year to receive complaints. Complaints about water supply and sewer system will be recorded from customers and will be forwarded to responsible divisions.

DWASA website (www.dwasa.org.bd) is an effective instrument for both internal and external communication. The website is routinely updated with consumer sensitive information, directives, etc. It also showcases DWASA’s annual reports and Management Information System (MIS) data. The website is also an avenue for DWASA to register consumer concerns. Consumer feedback and complaints can be lodged through it. DSWASA also maintains dedicated customer service telephone lines to receive complaints. Also, DWASA offices have information and complaint booths.

4.7 Private Wells

There are about 1,570 private DTWs across the city. The wells have a combined permitted production capacity of 68.5 MLD. The private well operators are predominantly academic, medical, industrial, administrative establishments and large apartment complexes. Considering their spatial distribution, private DTWs in MODS Zone 04 extracts the highest amount of water at 13.4 MLD. Zone 04 also has the highest number of private DTWs, about 400 DTWs. The private wells are broadly categorized into four groups, i. Domestic ii. Commercial iii. Industrial and iv. Social. From the available record, it seems Zone 07 has the highest number of private DTWs belonging to industrial facilities. Existence of industrial clusters such as Shyampur and Sutrapur may have contributed to such a high concentration. Zone 04 has the highest number of commercial owned of private DTWs. The zone also has the second highest number of domestic private well users. Zone 03 with residential localities such as Dhanmondi, Mohammedpur, Kalabagan, etc. has the highest number of domestic private DTWs. The wells vary in diameter size as well. The range of diametesr is between 50 mm and 200 mm. More than half of the wells are of 50 mm diameter size.

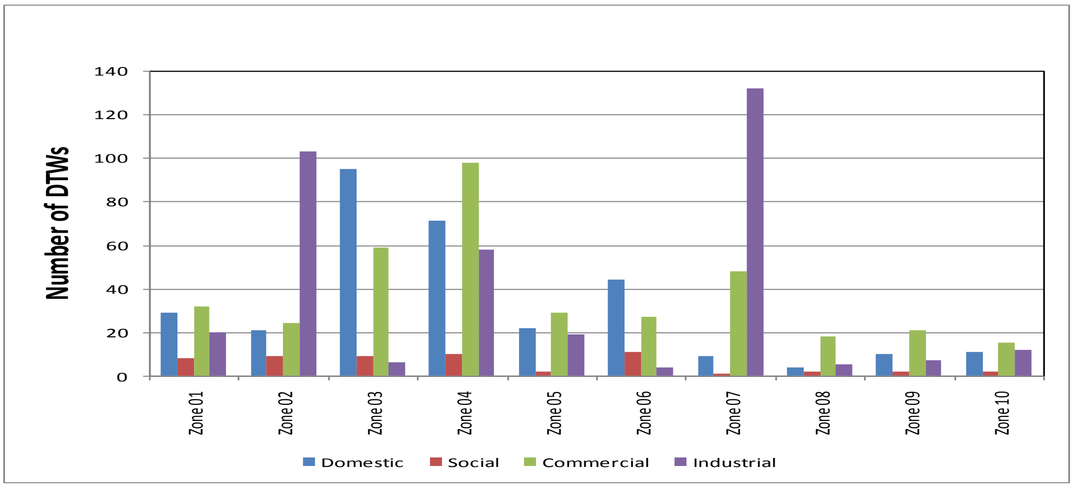


Figure 4-15: Distribution of categorized Private Wells across MODS zones

5 Existing Revenue, Financial and Investment Situation

5.1 Budget System

DWASA prepares the budget once in a year according to financial year (July-June) following an incremental approach in which the new budget figures are based on previous year's values plus a 20-30% increase. As a result, DWASA does not adopt a results oriented budget approach in which physical and financial targets, i.e. Strategic Targets, are defined.

According to the 1996 WASA Act, the Board has the power to approve both the Annual and the Supplementary Budget of DWASA, but in practice the final approval is given by the Ministry of Finance and the budget is then finalized in a tripartite meeting among the Ministry of Finance, the Administrative Ministry LGD and DWASA and approved in the parliament. Upon approval, the accounts department apprises concerned departments of their portion of the total allocation.

Revisions to both development and revenue Budget are made and sent to GOB for approval in the month of April. Actual expenditure is compared with budget twice in a year in December and June. DWASA also publishes monthly financial reports comparing actual against budget figures and monthly progress reports on project execution which provide information about stage of project execution. The monthly Management Information System Report also includes a comparison of actual financial performance against budget.

Operational budget of DWASA is maintained by the Accounting and Finance division. Operation and maintenance activities are not planned ahead but they are executed on a need basis. DWASA has been able to finance its operating expenditures out of its own revenues.

Upon taking Inputs from concerned project directors, the development budget is formulated by the Planning and Monitoring unit under the Resource Planning and Development Division (RP&D). The development budget is entirely financed out of Annual Development Plan (ADP) funds which usually consist of both Government funds and foreign borrowing in the form of multilateral and bilateral financing. Government funds officially take the form of loans, but they are hardly repaid thus representing de facto a grant to the utility. Nonetheless, it is difficult to gauge the extent of Government support to DWASA development budget as domestic and foreign financing are consolidated and DWASA accounting division does not provide separate records for the central government share on ADP funds.

DWASA repays a fraction of its debt as DSL (Debt Service Liability) but never paid as per the schedule that was agreed upon Audits of DWASA's financial statements reveal such delays in repayment of these loans. As a result, arrears in principal repayment lead to a build up in interest liabilities with subsequent increase in debt service. DWASA should be mindful of this fact before incurring any further debt.

5.2 Tariff Plan

DWASA has maintained flat rates for two categories of uses – commercial (and industrial) and domestic (and community). This has grossly under-priced the water, which creates chances for wastage and inequitable water uses. The water tariffs were increased by 5%/yr since July 2011. Commercial and industrial tariffs are higher than domestic and community tariffs. For metered connections, the current tariffs are 7.34 Tk/ and 22.17 Tk/m^3 for domestic (and community) and commercial (and industrial) customers respectively. Un-metered residential water connections were billed 128 Taka (US$1.72) per month. Tariff increase has been permitted within DWASA Act 1996 and has been limited to a nominal 5% year on year (the cap set in the act), this despite allowing electricity price increase above this level at around 11% and staff wages and salaries rising annually by a similar amount.

Other best management practices that have been implemented to support the tariff plan include: increased efforts for timely and correct billing, introduction of on-line bill paying system, expansion of outsourcing of bill collection, raising the production of water, metering, regularization of illegal connections, reduction in NRW, etc.

The major concern faced by DWASA due to low tariffs is that it results in insufficient revenue to cover the costs of supplying water. In 2010, the total revenues were the equivalent of about US$70 million per annum which cover about 25% more than the operating costs of the utility (operating expenses/ operating revenues = operating ratio of 0.79).

According to ADB (2004), "Tariff level should be tied to meeting objectives and two of these objectives should be connecting the urban poor to piped water and providing 24-hour potable piped water in the home to all. The average domestic tariff in Asian water utilities is $0.05-0.15/m^3. Domestic tariffs in South Asian countries are even lower ($0.01-0.05/m^3). At the moment, DWASA provides water at only US$0.09/m^3.

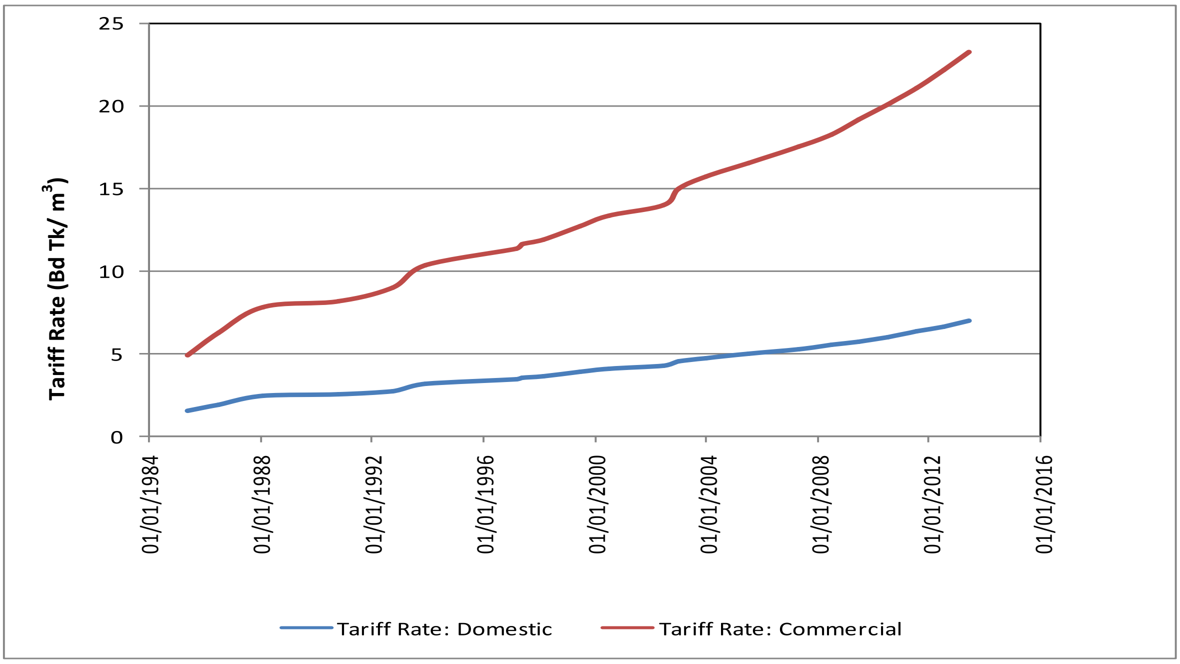


Figure 5-1: Timeline of Tariff Rate Change

To minimize use and wastage of water consumption, Progressive Tariff or Increased Block Tariff (IBT) (being effectively followed by many countries) can be adopted. Highest tariff slab may be reserved for the consumers not having meters, which will reduce the number of meter less consumers and eventually the system loss.

This is a method that is generally considered to be the most socially acceptable and promotes affordability. The lowest tariff rate is based around minimum requirements and the charge is generally subsidized by the higher-level consumers. Moreover, in a city like Dhaka, where household income per annum can vary from Tk. 200,000 to Tk. 20,000,000, a flat rate tariff may be too high for some and too low for others. According to ADB, the best block tariff system might be a three-block system with the lifeline monthly consumption rate of up to 6 m^3 (tariff limited to 5% of household income for the lowest 10^{th} percentile), consumption of monthly 6-20 m^3 charged at a rate to recover all financial costs, and consumption of more than 20 m^3monthly charged at a penalty rate equal to about $1/$m^3$ (to conserve water).

While crafting a Tariff adjustment Plan, all economic costs namely: Operation & Maintenance Cost, existing Debt Service Liability (DSL) (including principal and interest), Capital costs, Income tax and any other cost that may come in the very near future have to be taken into consideration for full cost recovery.

5.3 Financial Management

DWASA financial functions are under the responsibility of the Deputy Managing Director (DMD) Finance. A Commercial Manager reports to the DMD and under him is the finance and accounting section headed by the Chief Accounts Officer supported by two Deputy Chief Accounts Officer. The revenue section (handling billing and collection), headed by a Chief Revenue Officer, also reports to the Commercial Manager.

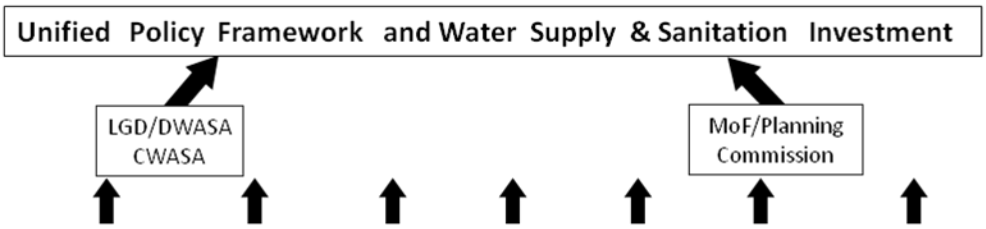
DWASA has the legal status to incur debts in pursuit of its projects subject to limits prescribed under DWASA Act of 1996. It has implemented loan projects with Asian Development Bank (ADB – 3 projects), International Development Association (IDA - 5 projects) and Swedish International Development Agency (SIDA - 1 project).

Funds received from either ADB, World Bank or any other donor agencies are deposited into Bangladesh Bank. From Bangladesh Bank, funds are transferred to a commercial bank through which DWASA can disburse for project expenditures. Counterpart fund or government contribution is included in the Annual Development Program, which are released to the project on a quarterly basis. Separate accounts for projects are maintained. All the project accounts also incorporated in the final account of DWASA.

Development partner funds are lent to GoB which in turn re-lends them to DWASA. Usually re-lending terms include (i) Interest rate 5%, (ii) maturity period of 20-25 years, and (iii) grace period of 5 years.

5.4 Investment Plan

Investment activities are planned by the Planning and Development Division. However, funding for such activities is provided by the Government as part of the Annual Development Fund allocation to LGD. The investment proposals are prioritized among other LGD projects and selected based on their merits and impact. Use of fund is recorded into the Development Budget held by the Planning Division.



Timeline	DANIDA	ADB	Japan	Korea	WB	EDCF	China	GoB
FY08	DWASA Saidabad Water Treatment Plant (Phase II) (US$130 million) Approved <2007-2012>	DWASA DWSSDP (US$200 million ADF loan) <2007-2011> Advisory TA for Capacity Building (US$2.5 million grant) <2007-2011> DWSSDP-2 PPTA (US$800,00 grant) <2009>	DWASA Improvement of Storm Water Drainage System (Yen 600 million Grant) <2007-2008>		DWASA Dhaka Sewerage and Drainage Project (US$100 million IDA credit)			Counterpart funding for ADB loan DWSSDP (BD Taka 62.7 million) Counterpart funding for ADB TA (US$625,000)
FY10		DWSSDP-2 loan (US$25 million) 2010	TA for Capacity Building and Reduction of Non-Revenue Water (Yen 300 million JICA) <2008-2010>					
FY11		Advisory TA for Capacity Building (US$800,00 grant) <2010-2015>						
FY12 and onwards	Saidabad SWTP Ph-III	Chargandharba Pur SWTP Ph-I (US$220 million) DESWSP US$600 million 2013 (Partial)		Singair Ph-I Well field (US$66 million)		Chargandharba Pur SWTP Ph-I (AFD US$100 million, EIB US$ 100 million) Saidabad SWTP Ph-III (AFD) DESWSP US$600 million 2013 (Partial)	Jashaldia SWTP (US$420 million)	Chargandharba Pur SWTP Ph-I (US$168 million)

Figure 5-2: Investment Mechanism with Development Partners

DWASA plans to substitute surface water for groundwater through the construction of four large water treatment plants by 2020 at a cost of US$1.8 billion. They are 'Saidabad Phase II', 'Saidabad Phase III', 'Padma' and 'Gandharbapur'. Saidabad Phase II has already been commissioned. Currently DWASA has six ongoing investment projects, including one to construct boreholes for DTWs, and the Dhaka Water Supply Sector Development Plan to completely replace the water pipelines using Asian Development Bank funding.

Figure 5-3 shows DWASA's performance in repayment of loans in recent times. It is evident in the figure that difference between net cash flow from operating activities and repayment of loan is increasing.

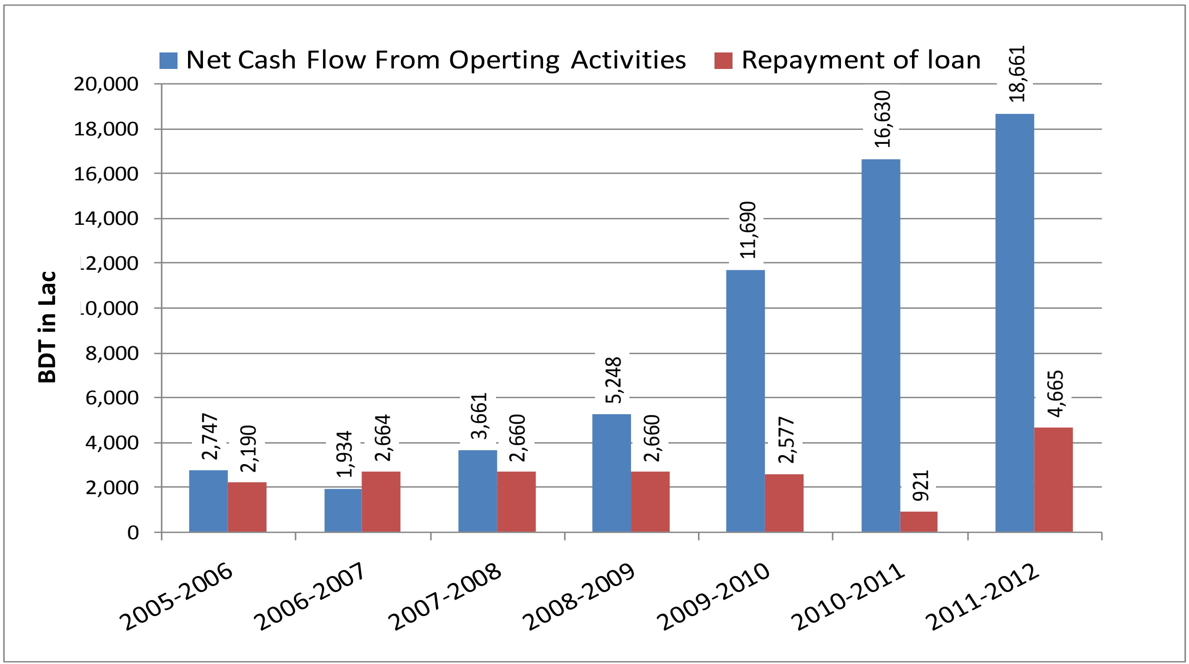


Figure 5-3: Repayment of Loan of DWASA

5.5 Billing and Collection

Revenue recovery has risen up to 92% within DWASA. This success is considered to be the result of introduction of the billing and collection system (BCS), successful outsourcing of the activities to Employees Consumers Supplies Cooperative Society Ltd. (ECSCSL) through the Program for Performance Improvement (PPI), etc. However, revenue budget should be worked out very carefully. In the PPI zones, it is observed that the achievements are over and above the target figure. This indicates, either the budget has not been worked out efficiently or some basic consideration was absent while the target was consolidated.

In spite of the fact that the billing system is computerized, numerous system deficiencies still exist primarily due to the practice of billing based on estimates. The practice is reportedly due to work overload of the Revenue Inspectors who are supposed to read the meters and prepare bills based on such meter readings. In most cases, a single inspector has to cover over a thousand customers. In such situations, the appointed revenue inspector engages his own assistants to assist him in meter reading, bill preparation and bill delivery works. As a result, there is a substantial difference between number of connections, number of total bills, number of computer generated bills, and number of bills collected.

5.6 Accounting

The basis of accounting is accrual following the International Accounting Standard (IAS) and Bangladesh Accounting Standard (BAS) as adapted by the Institute of Chartered Accountants of Bangladesh (ICAB).

The internal audit department under the control of the Managing Director (MD) initiates internal audit procedures that includes pre-audit and post-audit of disbursement. Statutory audit is done by external auditor appointed by management for a period of 3 years. In addition, GOB conducts its own audit for each project and revenue divisions of DWASA. Recently, DWASA has adopted dual entry method of accounting and software package for its implementations.

Financial Statements are prepared in accordance with international accounting standards and Bangladesh accounting standards (BAS). Three main reports are prepared: annual report, Monthly information system report (MIS) and the statutory Audit Report by external auditors. The reports record financial information about operating receipts and expenditures, assets and liabilities.

6 Demand Assessment

6.1 Current Demand

The assessment of current demand has been made based on primary data collection and also analyses of secondary data, e.g. BBS 2011 Population Census. The total demand has been divided into the following components:

- Residential consumption – split into non-low income community (non-LIC) and LIC consumption
- Other consumptions – government/institutional, commercial, industry and community consumption
- Fire fighting requirement

The current required production capacity was also estimated based on total demand plus losses (water lost through the distribution network).

6.1.1 Approach & Methodology

The approach and methodology used for demand assessment and projection was adopted after reviewing the guidelines of the Asian Development Bank (ADB) and other internationally accepted methods and practices. The approach involved collection and analyses of primary and secondary data sources. This involved extensive socio-economic surveys, analyses of census data, review of urban development plans and study of previous demand assessments and projections.

The current demand pattern was assessed by surveying over 900 households, of which 50 also kept a 7-day diary of indoor water consumption at each water usage point (e.g. toilets, sinks, etc.). The survey was designed to cover all MODS Zones and to be representative of the different structure types found in Dhaka: tin shed/kacha, semi-paka, paka 1-storied, 2-6 storied and multi-storied (7 floors and higher). This survey was also used to investigate the current socio-economic situation, including willingness to pay and attitudes and perceptions related to water supply and consumption.

6.1.2 Residential Consumption

The September 2012 household water demand survey provided detailed information about water consumption patterns in and around Dhaka City. The per capita daily consumption (LPCD) was calculated based on DWASA billing data provided by the respondents and number of household members. The variation in LPCD for each structure type is summarised in Table 6-1. For all structure types and the overall average consumption rates were higher than expected. The median values are lower than the average values but still seem relatively high. Another unexpected finding is high variation in consumption rates within each structure type. The largest variation was seen in the 2-6 storied structures. As expected, the consumption rate increased as the structure type improves, which reflects the impact of household incomes on water demands. The consumption rates for 2-6 storied and multi-storied buildings were quite similar.

Table 6-1: LPCD Statistics for Each Building Structure Type for Dhaka (2012 Survey)

LPCD	Tin Shed	Semi paka	1 storied	2-6 storied	Multi-storied	Overall
N	169	352	70	284	28	903
Median	59	141	186	224	239	165
Mean	86	188	218	280	282	211
75th percentile	101	271	312	372	540	307
90th percentile	159	466	590	639	931	523
St. devtn.	75	164	144	197	155	177

The breakdown of indoor household water consumption from the 2012 survey is shown in Table 6-2. For comparison, a recent limited survey (4 households) done by Abedin and Rakib (2013) and a study (of 60 households) by Gunawansa and Hoque (2012) is also provided. There are some distinct differences between the two survey results. First of all, the Abedin and Rakib (2013) study found average indoor water usage of 250 LCD, which seems excessive given the consumption from billing data is around 210 LCD. The amount of water consumed per person for personal washing (showering, ablution and face/hand washing), clothes washing and floor washing seems to be particularly high. Secondly, Gunawansa and Hoque (2012) estimated a very high consumption rate for cooking (58 LPCD). Furthermore, the amounts they have shown for flushing (60 LPCD) and floor washing (39 LPCD) seem excessive too.

Table 6-2: Breakdown of Indoor Household Water Consumption

	IWM Survey for WSMP (2012)		Abedin and Rakib (2013)		Gunawansa and Hoque (2012)	
Feature	**L/C/D**	**%**	**L/C/D**	**%**	**L/C/D**	**%**
Personal Washing	72	45%	90	36%	80	25%
Toilet Flushing	31	20%	42	17%	60	19%
Washing Utensils	27	17%	40	16%	42	13%
Clothes Washing	20	13%	52	21%	40	12%
Drinking	3	2%	2	1%	2	1%
Cooking	3	2%			58	18%
Floor washing	2	1%	24	9%	39	12%
Other Uses	1	0%			0	0%
Total	159	100%	250	100%	321	100%
Sample size	48		4		60	

As shown in Table 6-3, about 44% of total household consumption is unaccounted for. It is suspected that this is due to leaks from underground reservoir, taps, cisterns, etc. Meter error can also be a source for the discrepancy. It is expected that as the water price increases people will be more cautious about leakages and their water consumption in general, as has happened with electricity consumption.

Table 6-3: Breakdown of Indoor and Outdoor Household Water Consumption

Feature	Avge. Daily Consumption (L/C/D)		% of Total	
Indoor usage		159		48.6
Showering and Ablution	72		21.8	
Toilet Flushing	31		9.6	
Washing Utensils	27		8.2	
Clothes Washing	20		6.1	
Drinking	3		1.0	
Cooking	3		1.0	
Floor washing	2		0.6	
Other Uses	1		0.2	
Outdoor usage		26		7.8
Garden Usage	10		2.9	
Car Washing	13		4.1	
Garage/Front Space Washing	3		0.8	
Other (leakages, estimation/meter error)		142		43.5
Total	327			100.0

6.1.3 Other Consumptions

It was not possible to assess other consumptions such as government/institutional, commercial, industrial and community buildings. Therefore, as with other recent studies such as ADB PPTA (2007) and Sewerage Master Plan (2012), other consumptions have been approximated as a percentage of total residential consumption.

6.1.4 Demand Assessment for 2011

A detailed demand assessment for 2011 has been undertaken based on the latest BBS population census data (see Table 6-4). Given a service coverage area of 401 sqkm the population was estimated to be 10.76 million people. Based on the IWM household survey results, it was assumed that 84% of the total population are served by the DWASA supply network. It was also assumed that the proportion of the population living below the (upper) poverty line (low income community LIC) was about 18%[1] with a daily per capita consumption rate of about 60 LPCD (based on median consumption rate of tin shed structures, see Table 6-1). The residential LPCD for the remaining 82% of the population was assumed to be 160 LPCD based on the weighted average of median values for each structure type from the household survey. Given median LPCD values of 59, 141, 186, 224 and 239 LPCD for tin shed, semi-paka, 1-storied paka, 2-6 storied and multi-storied building types (see Table 6-1), which in 2011 had proportions of 18%, 40%, 8%, 31% and 3%, respectively (i.e. 159 = 59x18% + 141x40% + 186x8% + 224x31% + 239x3%). As a result, the total residential (domestic) consumption in 2011 was estimated to be 1,283 MLD.

In line with other studies, other consumptions have been assumed to be about 15% of total residential (domestic) consumption. The resulting total consumption was estimated to be 1,476 MLD (assuming no fire fighting requirement). Assuming 30% of total supply is lost, the required total production capacity in 2011 was estimated to be 2,108 MLD.

[1] Based on BBS HIES 2010 (p.61), reported incidence rate of poverty in urban areas of Dhaka Division.

Table 6-4: Demand Assessment for 2011

Year	Units	2011
Coverage Area	sqkm	401
Total Population Served (84% coverage)	million	9.04
Proportion Above Poverty Line	%	82%
Proportion Below Poverty Line	%	18%
Population Above Poverty Line	million	7.41
Population Below Poverty Line	million	1.63
Residential Consumption Rate	LPCD	160
Low-income Consumption Rate	LPCD	60
Residential Consumption	MLD	1,186
Low-income Consumption	MLD	98
Total Residential Consumption	**MLD**	**1,283**
Other Consumptions (Govt, Ind, Commercial, Community) as % of Residential Consumption	%	15%
Other Consumptions	MLD	192
Total Consumption	**MLD**	**1,476**
Fire Fighting Requirement	MLD	0
Total Demand	**MLD**	**1,476**
Losses (as % of Total Supply)	%	30%
Losses	MLD	632
Required Production Capacity	**MLD**	**2,108**

Notes: Residential consumption rates based on household demand survey results

6.2 Future Demand Assessment

6.2.1 Approach & Methodology

Based on analyses of primary and secondary data a demand projection model has been developed. The model incorporates the key water demand factors: population projection (including proportion below poverty line), per capita daily consumption and proportion of other (non-residential) demands. The model has been used to assess future demand for different scenarios up to 2035. The required production capacity was estimated for each of the scenarios based on different rates of system losses. The population has been projected based on previous inter-census growth rates, growth rates used in related studies and urban development plans. Per capita daily consumption rates are based on the household survey findings for different structure types, possible reductions in poverty levels in the future[2], expected responses to tariff re-structuring and projections of changes in housing structure types. The proportion of other (non-residential) water demands has been based on urban development plans and possible composition of economic activities in Dhaka. The

[2] Based on Perspective Plan of Bangladesh (Planning Commission 2012) and Poverty Reduction Strategy Paper (IMF 2013)

different rates of system losses have been based on expected implementation of DMAs in existing and new service areas and assumptions on improved operation and maintenance of water supply infrastructures. It is expected that the projected water demands will be updated as part of regular reviews of this Water Supply Master Plan.

6.2.2 Demand Projection Model

The structure of the demand projection model is shown in Figure 6-1. The demand projection model consists of three key modules:

1) Building composition module – which provides an estimate of composition of structure types for Dhaka in the future based on different growth rates for tin shed, semi-paka, 1-storied paka, 2-6 storied and multi-storied buildings.
2) Tariff module – contains flat rate and increasing block tariff (IBT) pricing options and price sensitivity in the future.
3) Population projection module – which provides estimates of thana population at 5-year intervals for different scenarios and also the proportion of total population that are in the low income community (i.e. proportion of population below poverty line).

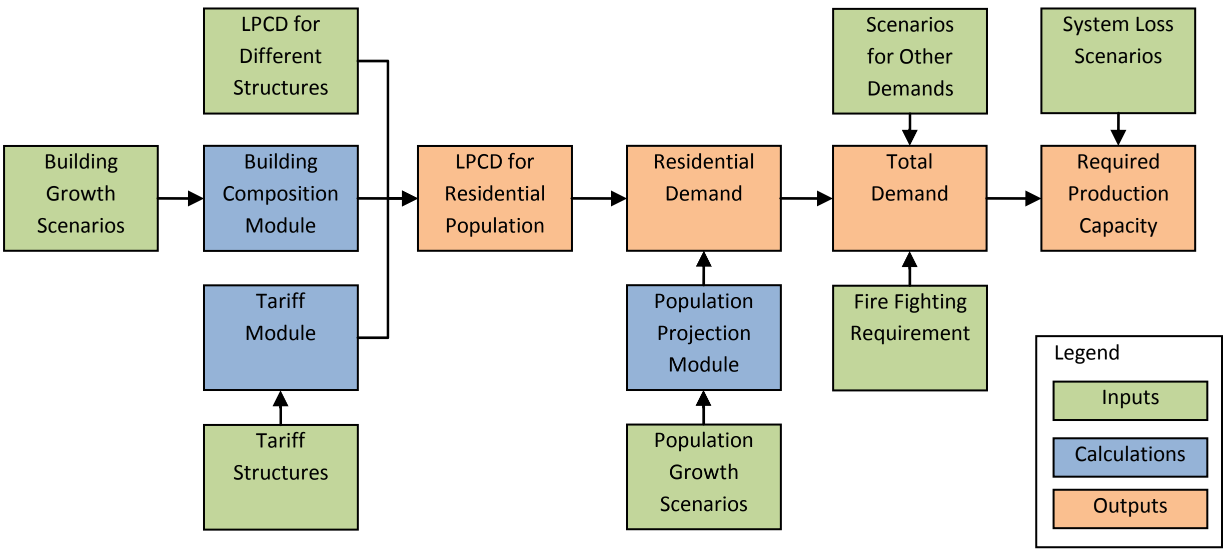


Figure 6-1: Structure of Demand Projection Model

The main inputs required for the demand model are:

- LPCD for different structures – based on household survey data
- Building growth scenarios – based on household survey data and assessment of possible changes in growth rates of each structure type in the future
- Tariff structures – flat rate and number of blocks in IBT structure
- Population growth scenarios – based on urban development plans, scope for horizontal and vertical expansion, broader growth drivers, etc. including proportion of population below poverty line (low-income community)
- Scenarios for other (commercial, industrial, institutional and community) demands as a percentage of total residential consumption - based on type of economic growth, level of service, etc.

- Fire fighting requirement – calculated based on population[3]:

  Fire Demand (MLD) = 100*(Population/1000)/1000
- System loss scenarios – based on likely infrastructure improvements especially at the distribution level (e.g. implementation of DMAs throughout the service area).

The main outputs from the model are:

- Overall daily per capita water consumption (LPCD) for the service area in the future
- Projected residential water demand (low-income and non-low-income populations) by multiplying residential LPCD with population estimate
- Projected total water demand for the service area:

$$\text{Total Demand} = \text{Residential Demand} + \text{Residential Demand} * \text{Percentage of Other Demands}$$

- Projected required production capacity to satisfy total demand by

$$\text{Required Production Capacity} = \text{Total Demand} \; / \; (100 - \text{Percentage Losses})$$

6.2.3 Building Composition Module

The building composition module projects the proportion of tin shed, semi-paka, 1-storied, 2-6 storied and multi-storied structures. This is based on the growth rates for each structure type over recent decades and assessment of likely changes in the growth rates for different scenarios.

6.2.4 Tariff Module

The tariff module includes two pricing structures: flat rate and 3-block increasing block tariff structure. The main inputs for this module are:

- Water demand price sensitivity at 5 year intervals – the 2012 household survey found an overall 3% sensitivity, i.e. 1 Taka increase in price leads to 3% decrease in per capita daily demand. Due to increasing household incomes and fewer opportunities to reduce demand as consumption decreases, it is expected that price sensitivity will tend to decrease over time. Therefore, it has been assumed that the price sensitivity will decrease by 0.5% every 5 years from 2015.
- Annual flat rate increase – currently this is 5%/yr and it has been assumed that this will continue in the future (without IBT structure).
- Start year of IBT strategy – it is assumed to commence from July 2015.
- Consumption limit for each slab and the percentage of population likely to fall in each slab – this has been set based on the IWM 2012 household survey undertaken for the WSMP. The consumption limits for the three slabs are 160, 300 and 500 LPCD which correspond to 50%, 40% and 10% of the population.
- Annual increases in tariffs for each slab – this was set at 6%/yr keeping in mind affordability especially for LIC households and the need for financial viability of upcoming major investments by DWASA.

[3]Manual on Water Supply and Treatment, Central Public Health and Environmental Engineering Organization, Ministry of Urban Development, The Government of India, 1999, p.12.

- Expected savings from water efficient gadgets and advocacy programs – based on empirical assessment of limited number of gadgets and also from published literature values. As more and more of the population adopt water conservation practises, the reduction in non-LIC consumption rates is expected to increase over time, i.e. savings gradually increase over time.

The main outputs from the model are:

- Projected residential LPCD with flat tariff structure
- Projected residential LPCD with IBT structure
- Projected residential LPCD with IBT structure and use of efficient water gadgets & advocacy

6.2.5 Population Projection Module

The population has been projected at the thana level for the whole study area. Different growth rates were used for each thana based on:

- Inter-census growth rate (from 2001 to 2011)
- Growth rates used in other studies, e.g. Dhaka Sewerage Master Plan (Grontmij 2011), ADB PPTA Study (2007), etc.
- Analyses of proposed land uses in Detailed Area Plan (RAJUK).

Three different growth rates have been used to develop three projections scenarios:

- Moderate – overall growth rate gradually decreasing
- High – overall growth rate decreasing relatively slowly
- Low – overall growth rate decreasing relatively quickly

The population projections have been summarised in Figure 6-2. For the main city area of 303 sqkm (21 thanas as per 2001 census) the inter-census growth rate from 2001 to 2011 was 3%/yr. In the moderate scenario, annual growth rate increases initially to about 3.8%/yr (for 2011-15 period due to high growth in Uttara, Badda, and Demra) then decreases to 3.2%/yr by 2035. In the high growth scenario, the growth rate decreases to 3.4%/yr by 2035. The underlying assumption is that in-migration rates do not reduce as expected in the moderate scenario. In the low growth scenario, the growth rate reduces to 2.7%/yr, assuming lower in-migration rates compared to the moderate scenario. The low growth scenario also assumes that density control measures are effectively implemented. The 2011 population of 9.3 million in Dhaka City (303 sqkm) is projected to reach by 2035: 21.6; 20.9 and 19.2 million people for the high, moderate and low scenarios, respectively. The corresponding densities are: 71,000; 69,000 and 63,000 people/sqkm for the high, moderate and low growth scenarios, respectively (compared to 31,000 people/sqkm in 2011). According to the 2011 census, the density of Mohammadpur thana was around 58,000 people/sqkm and about 77,000 people/sqkm for Khilgaon Thana. So in the moderate and high population growth scenarios, the overall city density is expected to reach the existing density of Khilgaon thana.

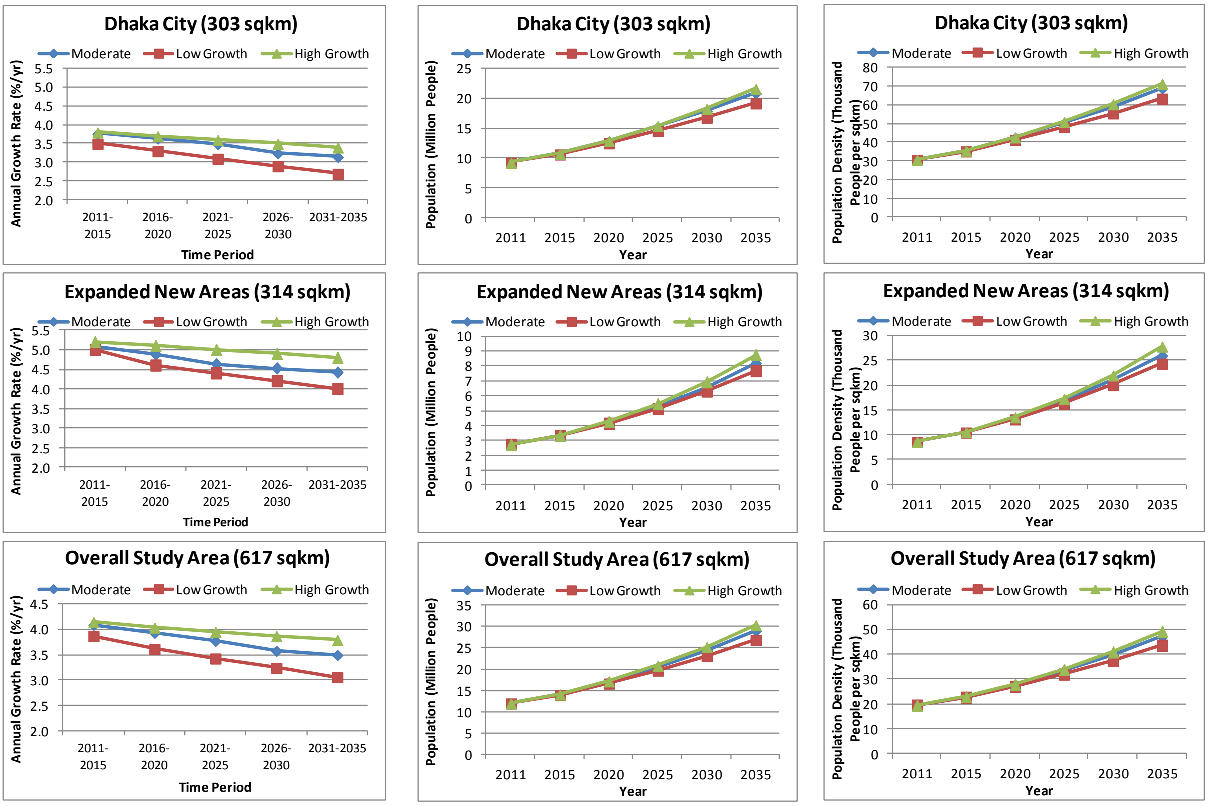


Figure 6-2: Population Projections for Study Area

For the expanded new areas of 314 sqkm (consisting of Purbachal and parts of Gazipur Sadar (Tongi and Gachcha), Keraniganj, Sonargoan and Rupganj), the growth rates are higher compared to the Dhaka City area. The overall growth rate from the 2001 census to the 2011 census for these areas was 6.6%/yr. For the three projection scenarios, growth rate is expected to decrease to: 4.8; 4.2 and 4.0%/yr in the high, moderate and low growth scenario respectively. The corresponding population increase from 2.7 million (in 2011) to 2035 is 8.7; 8.2 and 7.7 million people for the high, moderate and low growth scenarios, respectively. The density is expected to increase from around 9,000 people/sqkm in 2011 to: 28,000; 26,000 and 24,000 respectively. In the 2011 census, the density of Dhaka City was about 31,000 people/sqkm.

For the overall study area, the population growth rate was 3.7%/yr between the two censuses (2001 to 2011). From 2011-15 this is expected to increase slightly then by 2035 decrease to 3.8, 3.5 and 3.1%/yr in the high, moderate and low growth scenarios, respectively. From approximately 12.0 million in 2011, the total population is expected to reach 30.3; 29.0; and 26.8 million people by 2035 in the high, moderate and low growth scenarios, respectively. This equates to an increase by a factor of 2.2 to 2.5 over a period of 24 years.

6.3 Water Demand Scenarios to 2035

6.3.1 Key Considerations

Future water demand scenarios have been developed taking into consideration several key factors:

- Population growth rates – three scenarios were used (as described in previous section) and changes in low-income community as proportion of total population.

- Nature of economic development – high growth rate leading to relatively higher migration rates, higher household incomes and higher water consumption rates and
- Demand management measures – tariff structure, annual price increment rates and use of water efficient gadgets & grassroots level advocacy of water conservation measures.

The demand scenarios are defined in Table 6-5. Each of the scenarios and projected demand figures are provided in the following sub-sections.

Table 6-5: Water Demand Scenarios to 2035

Sl.	Scenario	Population Growth	Economic Development	Demand Management Measures
1.	High Demand	High	High	Flat tariff
2.	Moderate Demand with IBT	Moderate	Moderate	IBT
3.	Moderate Demand with IBT, Gadgets & Advocacy	Moderate	Moderate	IBT, efficient gadgets & advocacy programs
4.	Low Demand	Low	Low	IBT & efficient gadgets& advocacy programs

The change in low-income population (as proportion of total population below the poverty line) was an important consideration in the demand projection. As shown in Table 6-6, three scenarios were used based on poverty reduction strategies[4] and different economic growth expectations. With high economic growth, it is expected that the proportion of LIC will decrease rapidly from approximately 18% of the total population in 2011 to about 5% by 2035. In the moderate scenario it is expected to decrease to around 6% and to 10% in the low economic growth scenario (by 2035).

Table 6-6: Proportion of Population below Poverty Line Scenarios to 2035

Sl.	Scenario	2011	2015	2020	2025	2030	2035
1.	High Economic Growth	18%	12%	8%	7%	6%	5%
2.	Moderate Economic Growth	18%	14%	10%	8%	7%	6%
3.	Low Economic Growth	18%	16%	13%	12%	11%	10%

Based on an assessment of different consumption rates of different structure types around Dhaka in 2012, three scenarios for LIC daily per capita consumption rate (LPCD) have also been used in the demand projection (see Table 6-7). With high economic growth, it is expected that LIC will live in better structures with relatively good standard of living resulting in significant increase to 140 LPCD by 2035. With moderate economic growth the consumption rate is expected to increase to about 100 LPCD by 2035. With low economic growth the consumption rate is expected to reach about 80 LPCD by 2035.

[4] Poverty Reduction Strategy (IMF 2013, p.179) has projected urban poverty level in Dhaka Division to be 13.5% in 2015. The Perspective Plan of Bangladesh (Planning Commission, 2012, p. 73) has set a target for the national poverty level to reduce from 31.5% in 2010 to 15% by 2021, so urban poverty in Dhaka has been assumed to reduce at a similar rate in the moderate scenario.

Table 6-7: LIC Daily per Capita Consumption Rate (LPCD) Scenarios to 2035

Sl.	Scenario	2011	2015	2020	2025	2030	2035
1.	High Economic Growth	60	70	80	100	120	140
2.	Moderate Economic Growth	60	60	70	80	90	100
3.	Low Economic Growth	60	60	65	70	75	80

The projected residential (non-LIC) daily per capita consumption rate for the different tariff and demand management scenarios are shown in Table 6-8. With high economic growth and the existing flat tariff structure (increase at 5%/yr), the L/C/D is expected to reduce from around 170 L/C/D in 2015 to 150 L/C/D in 2020, after which it will remain constant. The increase in L/C/D from 2011 to 2015 is due to expected increases in connections within the existing service area and also due to better supply conditions (24 hours, pressurised water supply network). With moderate economic growth and the proposed IBT structure commencing in 2015 (and tariffs increasing at 6%/yr), the L/C/D is expected to reach 165 L/C/D in 2015 and the decrease to 150 L/C/D in 2015, after which it will remain constant. The same scenario with the adoption of efficient water gadgets and advocacy reducing overall L/C/D by 5% every 10 years from 2015 leads to 160 L/C/D in 2015 reducing to around 130 L/C/D by 2035.

Table 6-8: Non-LIC Daily per Capita Consumption Rate (LPCD) Scenarios to 2035

Sl.	Scenario	2011	2015	2020	2025	2030	2035
1.	Flat tariff, increasing 5%/yr	160	170	150	150	150	150
2.	IBT with avge. price increasing 6%/yr	160	165	150	150	150	150
3.	IBT & 10% savings from efficient gadgets & advocacy	160	160	140	135	130	130

The total residential consumptions for each scenario is shown in Table 6-9. By 2035, the total residential consumption is expected to cross 3,300 MLD (in the low demand scenario) and reach around 4,500 MLD (in the high demand scenario). Compared to 2011 estimated total residential consumption is expected to increase by a factor of 2.6 to 3.5; whereas the population is expected to increase by a factor of 2.2 to 2.5. In the high demand scenario, the factor of increase in total residential consumption is higher than the population increase factor mainly because of lower proportion of LIC.

Table 6-9: Projected Total Residential Consumption to 2035

Scenario		2011	2015	2020	2025	2030	2035
High Economic Growth & Flat tariff, increasing 5%/yr	MLD	1,283	1,986	2,371	2,908	3,730	4,533
Moderate Economic Growth & IBT with avge. price increasing 3.7%/yr	MLD	1, 283	1,893	2,316	2,824	3,562	4,265
Moderate Economic Growth & IBT & 10% savings from efficient gadgets & advocacy	MLD	1, 283	1,839	2,170	2,554	3,108	3,720
Low Economic Growth & IBT & 10% savings from efficient gadgets & advocacy	MLD	1, 283	1,791	2,074	2,387	2,861	3,354

For the demand projection, other consumptions have been estimated as a percentage of total residential (domestic) consumption. Other consumptions include government/institutional, industrial, commercial, and community consumptions. Three scenarios have been developed based on different economic growth considerations. In all scenarios, it is expected that other consumptions will grow due to economic growth and switching from private tubewells to DWASA supply due to improved water supply services. With high economic growth, it is expected that there will be significant increase in other consumptions (as percentage of residential consumption) due to rapid growth in services and manufacturing sectors in and around the study area. Also high economic growth is likely to lead to improved level of services from government, institutional and community sectors, i.e. per thousand people there will be more government officials, educational establishments, religious centres, etc. Therefore, in the high economic growth scenario, other consumptions are expected to reach about 30% of residential consumptions by 2035. With moderate economic growth, other consumptions are expected to increase to about 27% of residential consumption and to 24% in the low economic growth scenario.

Table 6-10: Other Consumptions (as % of Residential Consumption) Scenarios to 2035

Scenario	2011	2015	2020	2025	2030	2035
High Economic Growth	15%	17%	22%	24%	27%	30%
Moderate Economic Growth	15%	16%	20%	22%	25%	27%
Low Economic Growth	15%	15%	18%	20%	22%	24%

Notes:

1. Slightly higher than normal increase in 2020 is due to expansion of service area into highly industrialized areas such as Tongi and Gachcha.
2. Slightly higher than normal increase in 2030 is due to expansion of service area into new development areas which are expected to have high levels of service from institutional, commercial and community sectors.

The total consumption projections for each scenario are provided in Table 6-11. By 2035, the total projected consumption varies from about 4,200 MLD to just under 5,900 MLD. This corresponds to a 2.8 to 4.0 factor of increase compared to total estimated demand in 2011. The higher factor of increase (compared to increase in total residential consumption) is accounted for by relatively high other consumptions (as proportion of residential consumption) in the high demand scenario.

Table 6-11: Projected Total Consumption to 2035

Scenario		2011	2015	2020	2025	2030	2035
High Economic Growth & Flat tariff, increasing 5%/yr	MLD	1,476	2,324	2,893	3,605	4,737	5,892
Moderate Economic Growth & IBT with avge. price increasing 6%/yr	MLD	1,476	2,196	2,780	3,445	4,453	5,417
Moderate Economic Growth & IBT & 10% savings from efficient gadgets & advocacy	MLD	1,476	2,133	2,604	3,116	3,885	4,724
Low Economic Growth & IBT & 10% savings from efficient gadgets & advocacy	MLD	1,476	2,059	2,447	2,864	3,490	4,159

In 2035, the projected fire fighting requirement varies from 17 MLD (for population of 30.32 million) to 16 MLD (for population of 26.83 million).

Three scenarios for system loss (as percentage of total supply) were developed based on expected improvements in the distribution network in the future (see Table 6-12). In the high system losses scenario, it has been assumed that DMA implementation will be slower than expected and therefore the system losses will reduce relatively slowly to 20% by 2020. Then, with expansion into new service areas with relatively new distribution networks, the system losses is expected to reduce to about 12% by 2035. In the moderate system losses scenario, the implementation of DMAs is expected to be timely and relatively successful leading to moderate reductions up to 2020. Then the reductions in losses are expected to continue more steadily to about 10% by 2035. In the low system losses scenario it was assumed that DMA implementation will be quick and very effective throughout most of the service area. However, it is not expected that system losses will be less than 8% in 2035 as this is the normal standard in developed countries.

Table 6-12: System Loss (% of Total Supply) Scenarios to 2035

Scenario	2011	2015	2020	2025	2030	2035
High System Losses	30%	23%	20%	16%	14%	12%
Moderate System Losses	30%	20%	16%	13%	11%	10%
Low System Losses	30%	16%	14%	12%	10%	8%

The required production capacity for each scenario is shown graphically in Figure 6-3. Large increases are seen from 2015 to 2020 and again from 2025 to 2030 due to expansions of service area. By 2035, the total required production capacity is projected to vary from around 4,500 MLD to about 6,700 MLD. This corresponds to a 2.2 to 3.2 factor of increase compared to total estimated production capacity in 2011. In the low demand scenario, the factor of increase in required production capacity is similar to the factor of increase in projected population (2.2) due to the combined effects of decreasing L/C/D and reductions in system losses. In the high demand scenario, the required production capacity does not increase by the same factor as the total demand (4.0) due to the reduction in system losses in all scenarios.

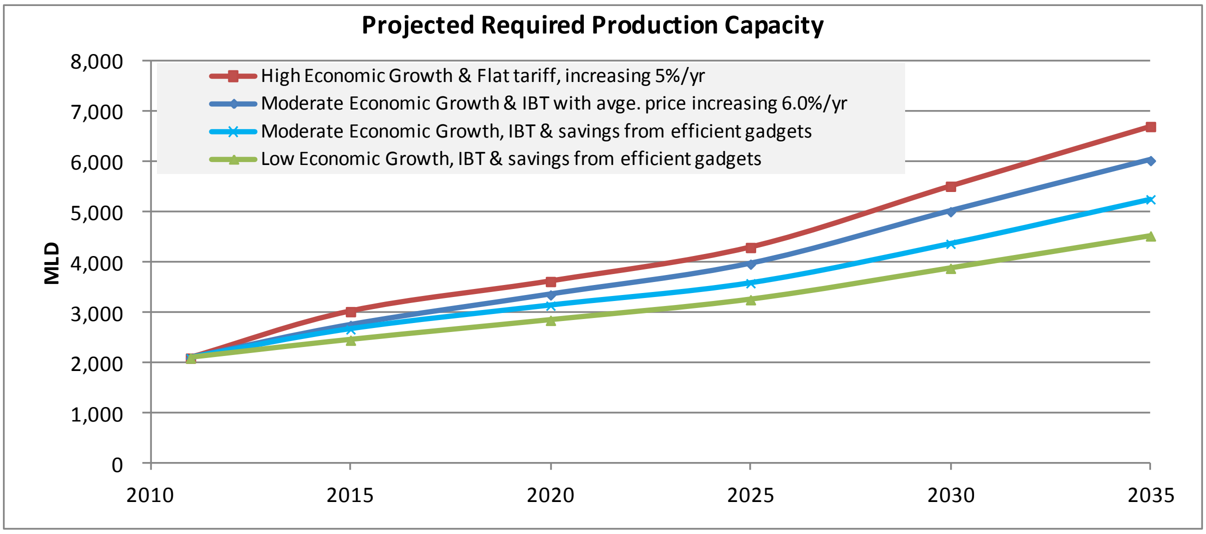


Figure 6-3: Projected Required Production Capacity to 2035 for Study Area

6.3.2 High Demand

The combined effects of high population growth and low poverty levels lead to a high total residential consumption of approximately 4,500 MLD by 2035. Then with a high rate of other consumptions (30% of total residential consumption by 2035) and fire fighting requirement, the total demand is expected to reach about 5,900 MLD by 2035. Finally, combined with relatively high system losses, the required production capacity by 2035 is expected to be about 6,700 MLD by 2035. The detailed breakdown of demand projection for the high demand scenario is provided in the Demand Assessment Report (see Volume 3).

6.3.3 Moderate Demand with IBT

The combined effects of modest economic growth and moderate population growth lead to a total residential consumption of approximately 4,300 MLD by 2035 – that is about 200 MLD less than in the high demand scenario. Then with a moderate rate of other consumptions (27% of total residential consumption by 2035) and fire fighting requirement, the total demand is expected to reach about 5,400 MLD by 2035 – that is about 500 MLD less than in the high demand scenario. Finally, combined with moderate reductions in system losses, the required production capacity by 2035 is expected to be about 6,000 MLD by 2035 – that is about 700 MLD less than in the high demand scenario. The detailed breakdown of demand projection for this scenario is provided in the Demand Assessment Report (see Volume 3).

6.3.4 Moderate Demand with IBT, Water Efficient Gadgets & Advocacy

The detailed breakdown of demand projection for the moderate demand with IBT, water efficient gadgets scenario & advocacy is provided in Table 6-13. The combined effects of modest economic growth and moderate population growth with effective demand management lead to a total residential consumption of approximately 3,700 MLD by 2035 – that is about 600 MLD less than in the scenario without the use of efficient water gadgets & advocacy. Then with a moderate rate of other consumptions (27% of total residential consumption by 2035) and fire fighting requirement, the total demand is expected to reach about 4,700 MLD by 2035 – that is about 700 MLD less than in the scenario without efficient water gadgets & advocacy. Finally, combined with moderate reductions in system losses, the required production capacity by 2035 is expected to be about 5,300 MLD by 2035 – that is about 700 MLD less than in the scenario without water efficient gadgets & advocacy. This difference is greater than the size of a major surface water treatment plant.

6.3.5 Low Demand

The combined effects of low economic growth and low population growth with effective demand management lead to a total residential consumption of approximately 3,400 MLD by 2035 – that is about 300 MLD less than in the similar scenario with moderate growth rates. Then with a low rate of other consumptions (24% of total residential consumption by 2035) and fire fighting requirement, the total demand is expected to reach about 4,200 MLD by 2035 – that is about 500 MLD less than in the similar scenario with moderate growth rates. Finally, combined with relatively high reductions in system losses, the required production capacity by 2035 is expected to be about 4,500 MLD by 2035 – that is about 800 MLD less than in the similar scenario with moderate growth rates. This difference is almost the capacity of two major surface water treatment plants. The detailed breakdown of demand projection for this scenario is provided in the Demand Assessment Report (see Volume 3).

Table 6-13: Moderate Demand with IBT, Water Efficient Gadgets& Advocacy Scenario to 2035

Year	Units	2011	2015	2020	2025	2030	2035
Coverage Area	sqkm	401	401	496	496	617	617
Total Population	million	9.04	12.55	16.31	19.56	24.43	29.02
Proportion above poverty line	%	82%	87%	90%	92%	93%	94%
Proportion below poverty line	%	18%	14%	10%	8%	7%	6%
Population above poverty line	million	7.41	10.86	14.68	17.99	22.72	27.27
Population below poverty line	million	1.63	1.69	1.63	1.56	1.71	1.74
Residential Consumption rate	L/C/D	160	160	140	135	130	130
Low-income consumption rate	L/C/D	60	60	70	80	90	100
Residential Consumption	MLD	1,186	1,737	2,055	2,429	2,954	3,546
Low-income Consumption	MLD	98	102	114	125	154	174
Total Residential Consumption	**MLD**	**1,283**	**1,839**	**2,170**	**2,554**	**3,108**	**3,720**
Other Consumptions (Govt, Ind, Commercial, Community) as % of Residential Consumption	%	15%	16%	20%	22%	25%	27%
Other Consumptions	MLD	192	294	434	562	777	1,004
Total Consumption	**MLD**	**1,476**	**2,133**	**2,604**	**3,116**	**3,885**	**4,724**
Fire Fighting (function of population)	MLD		11	13	14	16	17
Total Demand	**MLD**	**1,476**	**2,144**	**2,616**	**3,130**	**3,901**	**4,741**
Losses (% of Total Supply)	%	30%	20%	17%	13%	11%	10%
Losses	MLD	632	536	536	468	482	527
Required Production Capacity	**MLD**	**2,108**	**2,680**	**3,152**	**3,598**	**4,383**	**5,268**

Notes:
1. Initial residential consumption rate based on household demand survey
2. Area expansion in 2020 includes Purbachal, Tongi, Gachcha and part of Keraniganj and Rupganj
3. Area expansion in 2030 includes parts of Rupganj, Sonargoan and additional parts of Keraniganj.

6.4 Demand Management Strategy

The demand management strategy consists of introducing increasing block tariff (IBT) pricing structure and promoting efficient water gadgets & advocacy through the establishment of a Water Efficient Labelling and Standards (WELS) Scheme with relevant supporting regulatory framework.

6.4.1 Block Tariff Structure

An increasing block tariff (IBT) pricing structure is recommended to help prevent over-consumption and wastage of water at the user end without adversely affecting the LIC. Such a recommendation was made in the 2011 Sector Development Plan (Main Report, p.133), ADB PPTA study (ADB 2007) and is also found in many Asian cities (Gunawansa and Hoque 2012). Recent changes in the electricity pricing structure for Dhaka have also shown how this is an effective demand management strategy for a utility service. However, the pricing structure (slabs) have to be carefully set so that majority of the population is not adversely affected, especially the LIC.

Table 6-14: Recommended Increasing Block Tariff Structure for 2015 onwards

Slab Tariff (Tk/KL)	**8.09**	**16.18**	**24.27**
Slab LPCD	160	300	No Limit
Slab Limit for kL/month/5 peoplehousehold[1]	24	45	No Limit
% of population exceeding slab volume[2]	50%	40%	10%

Notes:

1. Average household size from 2012 survey was 4.9 people/household
2. Based on the distribution of overall LPCD.

The recommended IBT structure is shown in Table 6-14. The first slab's price is the current 7.34 Tk/KL incremented by 5% in 2014 and again in 2015. The first consumption slab of 160 LPCD is based on the 90th percentile LPCD of tin shed structures (159 LPCD), which amounts to 24 kL/month for a 5-person household. Therefore, only 10% of households living in tin shed structures would pay more than the basic flat rate expected in 2015, which is 8.09 Tk/KL. As shown in Table 6-14, the first slab encompasses about 50% of the total population, which means this IBT structure is likely to be socially acceptable to the residents of Dhaka. The second slab price is twice the first slab's price. The second slab's consumption rate of 300 LPCD is based on the 75th percentile LPCD of semi-paka structures (277 LPCD) and it is expected that about 40% of the population will fall in this slab (i.e. all building structure types). The second slab limit is 21 kL/month, giving a total of 45 kL/month. The third slab's price is three times the first slab's price and is also the expected starting water tariff for commercial and industrial users in 2015 (based on annual 5% increases from current price). It is expected that 10% of the population will fall into this third slab.

Based on the expected population proportion falling into each slab, the weighted average price is 12.95 Tk/KL. This is expected to bring the non-LIC L/C/D down to about 153 L/C/D (based on the flat price elasticity of -1.4). Given that the projected structure composition is not significantly affecting future non-LIC L/C/D, the projected L/C/D is expected to remain about 180L/C/D with the recommended IBT structure (without price increases). However, the slab prices in the IBT should increase over time to further reduce the non-LIC L/C/D and to take into account of inflation and also financial sustainability of DWASA. Therefore, in the Tariff Module all three tariffs have been set to increase by 6%/yr. The resulting change in non-LIC consumption rate is shown in Figure 6-4, where a comparison is made with the flat tariff increasing by 5%/yr. By the year 2017, it is expected that for both strategies non-LIC consumption rate is expected to reach the set standard of 150 L/C/D. the figure also shows the expected decrease in non-LIC due to adoption of water conservation measures gradually spread throughout the population.

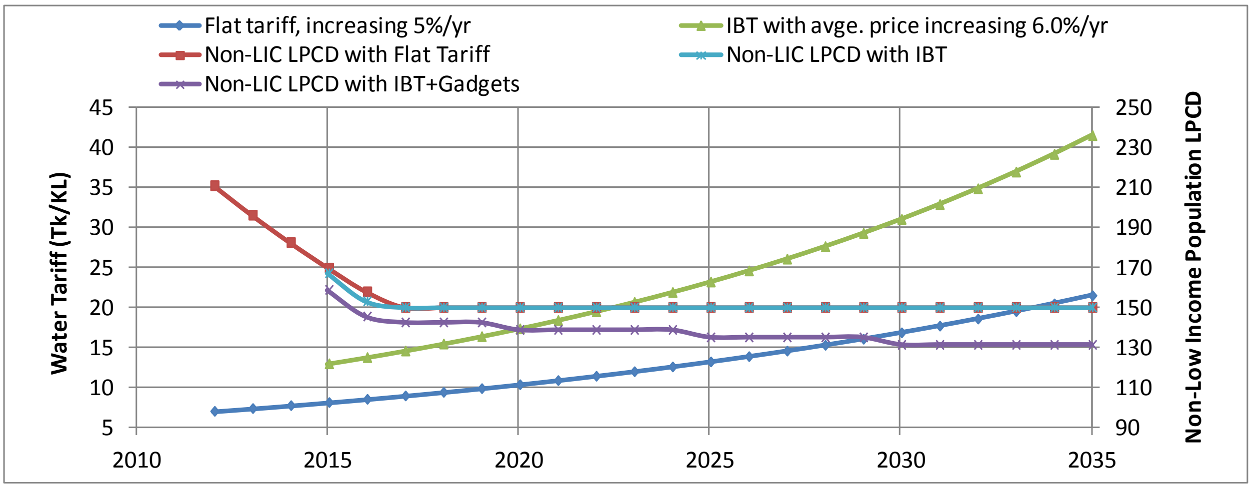


Figure 6-4: Projected Non-LIC L/C/D with Different Strategies

6.4.2 Water Conservation Advocacy

Based on 2012 household diary surveys, the main areas for indoor water conservations identified are: personal washing, toilet flushing and washing utensils. This accounts for about 70-80% of total indoor water consumption. By using more efficient faucet (tap) and shower heads, and dual flush systems, indoor water consumption can be reduced considerably. Simple aerators fitted to existing faucets can reduce the flow rate by about 20-30%, efficient shower heads save around 20-40% and dual flush help conserve about 40-60%. As washing machines become more prevalent in houses in the future, this can also be a major area for water savings. Considerable savings can also be made from fixing leakages.

Table 6-15: Expected Savings in Indoor Household Water Consumption

Feature	2012 Consumption Rate (L/C/D)	Expected Savings (%)		Expected Savings (L/C/D)	
		Lower	Upper	Lower	Upper
Personal Washing	72	20%	30%	14.4	21.6
Toilet Flushing	31	40%	60%	12.5	18.8
Washing Utensils	27	20%	30%	5.4	8.1
Clothes Washing	20				
Drinking	3				
Cooking	3				
Floor washing	2				
Other Uses	1				
Total	159			32.3	48.4

Note: Consumption rates calculated from IWM's survey of 48 households who kept a diary of water usage over 7 days.

As shown in Table 6-15, a conservative estimate of potential water savings is 20 to 30% of total indoor water consumption (i.e. 32 to 49 L/C/D). Similar order of savings from outdoor usages will lead to about 11 to 17% of the total median household consumption from the diary survey (327 L/C/D). When considering the whole population in the service area, it is expected that the overall non-LIC consumption rate for the service area will reduce by about 5% (in 2015). This will then continue to grow by about 5% every 10 years such that by 2030 the standard consumption rate can be reduced by approximately 12.5%. **Therefore, use of water efficient gadgets & advocacy in conjunction with the proposed IBT strategy will help reduce non-LIC population's water consumption to about 140 L/C/D up to 2025 and then down to 130 L/C/D from 2030.**

DWASA and the government need to take some particular steps to increase wider use of such gadgets. These steps include:

1) **Raise public awareness** about availability of water efficient gadgets already available in the local market. Gunawansa and Hoque (2012) reported that almost 60% of the respondents in their survey stated that they did not know water efficient gadgets were available in the local market. About 20% were aware but said the cost was too high. Another 18% said that they are aware of such gadgets but do not give the issue sufficient importance.
2) **Individual metering of residential units** is required. Although this may not be practical in the short-term, this is essential for three reasons. First of all, metering individual households will make the proposed block tariff pricing structure fairer for households with less than 5 people residing in apartment buildings sharing one common meter. Second of all, individual metering of households will send the intended price signals directly to each household, which will help promote adoption of water conservation measures such as purchasing of water efficient gadgets. Gunawansa and Hoque (2012) found that “accurate billing through metering” would be one of the main reasons (25% of respondents) to use water efficient gadgets by households who are aware of their availability but not giving it sufficient priority. The third reason is that households that are already efficient water users will feel demotivated if they share a common meter with other households that do not conserve water, because the former will be subsidising the latter. To make individual metering of individual apartment units practical and feasible Automatic Meter Reading (AMR) system will need to be introduced by DWASA.
3) **Effective regulatory framework** is required to provide incentives for marketing of water efficient gadgets and purchasing by residents. Already dual flush systems are becoming common in new buildings due to availability from companies like RAK (Ras Al Khaimah) Ceramics. The strong emphasis on conservation in the recent Water Act (2013) is also a step in the right direction – however enforcement needs to be ensured. Specific considerations for regulatory framework include:
    a. Introduction of a compulsory or voluntary Water Efficient Labelling and Standards (WELS) Scheme (with supporting Act of Parliament). Through this scheme, the water gadget manufacturer/suppliers will need to provide water consumption information (and star ratings) to enable customers to make informed decisions. The testing and standardization component of the scheme could be administered by Bangladesh Standards and Testing Institution (BSTI).
    b. Restriction on manufacturing and sales of water fixtures that do not comply with the standards specified in the WELS Scheme.
    c. Ensure all gadgets available in the market have proper labelling so that customers make informed choices

An effective regulatory framework will also help reduce non-residential water demands, because water efficient faucets and toilet flushes will also become common in non-residential buildings (offices, businesses, mosques, etc.). This will have major dividends in reducing the overall water demand of Dhaka City. Initiatives to promote wide adoption of water efficient gadgets can be combined with “green building” efforts currently under way.

6.5 Scenarios to 2060

For the period 2035 to 2060, a more qualitative assessment has been undertaken. The approach focused on how much change may occur in the total demand for the study area for different scenarios. Table 6-16 summarizes the possible demand scenarios in 2060, relative to 2035, the key factors underlying each scenario and also possible supply-side strategies.

Table 6-16: Demand Scenarios for 2060

Sl.	2060 Demand relative to 2035	Key Factors	Possible Supply Side Strategies
1.	Less demand	Population decrease (out-migration) Decreasing LPCD due to higher tariffs Higher proportion of LIC with lower LPCD	Delay some investments in 2030
2.	Low (25%) increase	No to low increase in population Slight increase in overall LPCD	Investigate additional supply sources from 2040 Invest in new sources from 2045
3.	Moderate (50%) increase	Low to moderate increase in population Moderate increase in LPCD Some increase in non-residential demand	Investigate additional supply sources from 2025 Invest in new sources from 2030
4.	High (100% or more) increase	Moderate increase in population Moderate increase in LPCD Moderate increase in non-residential demand	Bring forward investments planned for 2030 Investigate additional supply sources from 2020 Invest in new sources from 2035

After 2035, there is a good possibility that the total demand will continue to increase but at a moderate rate. Eventually, by 2060, the total demand could be about 50% higher than the 2035 demand. This situation may occur due to the following reasons:

- Low to moderate increase in population may occur due to continued in-migration and also lower death rates due to higher living standards and medical services. Also, this will be combined with more vertical expansion of residential buildings throughout the study area.
- A moderate increase in per capita daily water consumption can also occur due to higher economic growth leading to increasing household incomes. Alternatively, this can also occur due to demand management measures not working effectively.
- Non-residential water demand (e.g. commercial, industrial, institutional, etc.) may continue to grow after 2035 due to higher economic growth, increasing demand for better services from the public, etc. Therefore, even if the residential water demand does not increase the growth in total demand can be driven by higher non-residential demands.

Depending on the demand scenario, this growth in required production capacity can vary from about 2,400 MLD to 4,000 MLD. For the recommended demand management scenario of the WSMP, by 2060 the additional required production capacity is about 2,650 MLD (see Figure 6-5).

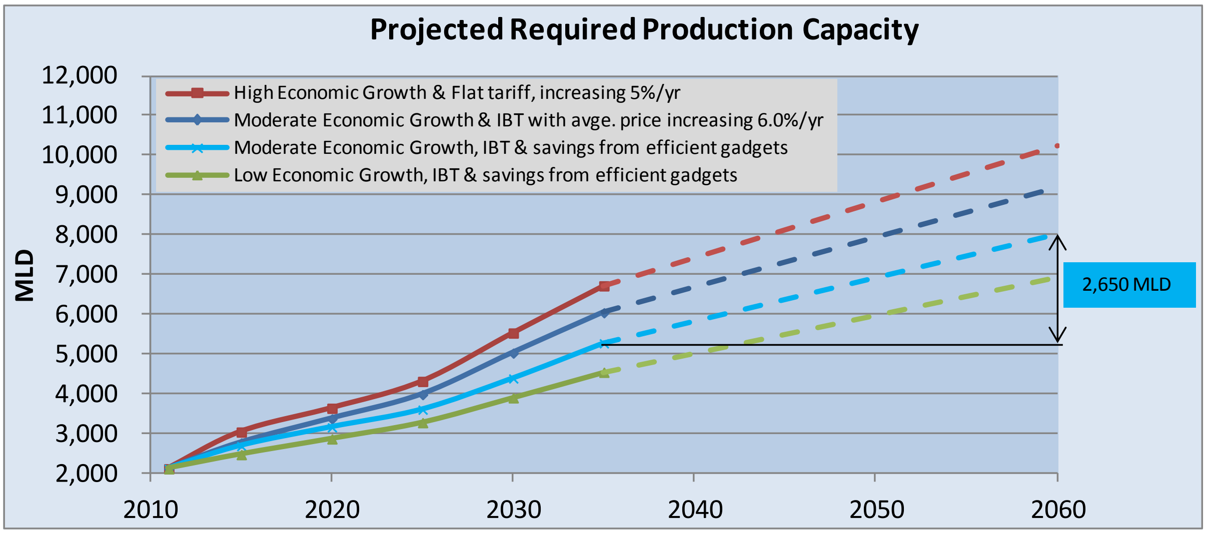


Figure 6-5: Required Production Capacity Scenarios based on 50% Increase from 2035 to 2060

Within the core Dhaka city areas, it is not expected that there will be much growth in demand after 2035. The likely growth areas after 2035 are expected to be: Uttara, Badda, Demra, Narayanganj Sadar, Keraniganj (along Buriganga), Tongi and Gachcha, Purbachal, parts of Kaliganj, Rupganj, Sonargaon and Bandar thanas.

The signs of such a scenario occurring should become apparent by the growth in total water demand up to 2025. By then, studies to identify and quantify additional water supply sources should be undertaken, e.g. recycling of stormwater, greywater re-use, etc. Investments in new supply sources will be required by 2030. Also it is likely that the Master Plan area will need to be expanded to bring in new growth centres into the service area.

7 Water Resource Assessment

7.1 Surface Water

The past studies have investigated various surface water sources for Dhaka city water supply, which includes the following:

- Peripheral Rivers: Lakhya, Buriganga, Kaliganga-Dhaleswari
- Large Rivers: Padma, Meghna

In the current study, data from the studies done in the past and also additional data collected afterwards were used to make an assessment of surface water resources. The surface water resource assessment considered both water availability and also the water quality of the sources. A summary of available flow and water quality of these sources are given below.

7.1.1 Peripheral Rivers

The study found that the most critical period of the year is January to March in terms of water availability and water quality. Therefore assessment of water availability was made based on historical simulated data for this period. Results from the assessment are given in Table 7-1.

Table 7-1: Water Availability in Peripheral Rivers (1999-2004, January to March)

River	50% dependable flow	80% dependable flow	Minimum depth
Buriganga at Chandnighat	48.1 m^3/s	21.0 m^3/s	12.5 m
Lakhya at Majhina	71.1 m^3/s	36.2 m^3/s	12.0 m
Kaliganga at Taraghat*		13.40 m^3/s	1.55 m

*IWM (2006)

The water availability was comprehensively assessed in the Resource Assessment Study (IWM, 2006). Among the locations dependable flows were revaluated in two major locations with recent data. Dependable flows have been computed for Chandnighat at chainage 28250 m using NCRM model results. Water availability of Lakhya River was also computed at Majhina around 7.5 km upstream of the existing intake of the Saidabad Water Treatment Plant at Sarulia. It was computed at chainage 93500 m using NCRM model results. It is evident that considerable volume of water is available in the peripheral rivers of Dhaka even after considering around 40% flow for in-stream demand. Model result shows that the change in water depth at Majhina on Lakhya River is only around 0.02 m after allowing withdrawal of 10 m^3/s which is the planned withdrawal for combined Saidabad WTP Ph-I, II and III. It may thus be concluded that withdrawal for water supply from Lakhya would not result in any major change in water depth.

However, the water quality in Lakhya (downstream of Majhina), Balu, Buriganga and Turag River has deteriorated extensively. Water quality is progressively declining due to increase in pollution load from various domestic and industrial sources. Nine round of samplings were collected between January to June from the following 5 (five) locations, in the “Water Quality and Pollution Monitoring for Greater Dhaka” Study (SWECO, 2011). The locations were:

- Sarulia near the Intake of SWTP at Saidabad, Lakhya River
- Rupganj near Ferryghat, Lakhya River
- Chandnighat near the Intake of SWTP, Buriganga River

– Rekabi Bazaar under Narayanganj District, Dhaleswari River &
– Hemayetpur at Savar, Dhaleswari River

Summary of some parameters of the test results are shown in Table 7-2. It is observed from the results that in some samples pH and DO values exceed the EQS value in all the 5 locations. BOD values is always much higher than EQS value.

Table 7-2: Summary of Some parameters of River Water Quality Test Results

Location	River		pH	DO (mg/l)	BOD (mg/l)	Remarks
Chandnighat	Buriganga	Range	7.4-11.2	0.94-8.3	39-77	In 4 samples pH value exceeded and in 6 samples DO level is below EQS value. In all samples BOD values were much higher than EQS value
		Avg	8.9	3.43	64	
Rekabi Bazaar	Dhaleswari	Range	7.3-10.5	3.6-8.1	33-47	In 3 samples pH value exceed and in 5 samples DO level is below EQS value. In all samples BOD values are much higher than EQS value
		Avg	8.4	5.68	41	
Rupganj	Lakhya	Range	7.7-11.1	0.79-8.4	35-52	In 3 samples pH value exceed and in 6 samples DO level is below EQS value. In all samples BOD values are much higher than EQS value
		Avg	8.7	3.43	42	
Sarulia	Lakhya	Range	7.5-11.1	2.29-7.8	28-58	In 4 samples pH value exceed and DO level is below EQS value. In all samples BOD values are much higher than EQS value
		Avg	9.0	5.18	47	

Source: Water Quality and Industrial Pollution Study-2010 by DWASA

For sampling points at Sarulia near the Intake of SWTP (Rupganj), Chandnighat near Intake of SWTP, Rekabi Bazaar & Hemayetpur it is noted that the BOD level is maximum in the month of March and minimum in the month of June. COD level is maximum during the month of March to April and minimum in the month of June. TSS is maximum during the month of March to April and minimum in the month of June. pH is maximum in the month of April and minimum during the month of May to June. Nitrate and Ammonia is maximum during the month of March to April and minimum in the month of June.

Dissolved Oxygen levels have been analyzed and it is noted that the tested values are within the allowable range (4.5 – 8.0 mg/l) for all Rivers during the 7th, 8th& 9th Round of sampling i.e. during May-June. Based on these results, it is concluded that the Dissolved Oxygen level is worst at Chandnighat during January to April and other places also Dissolved Oxygen level is worst during February-April**.** **Figure 7-1 shows** the water quality of different parameters in Buriganga River for some recent years.

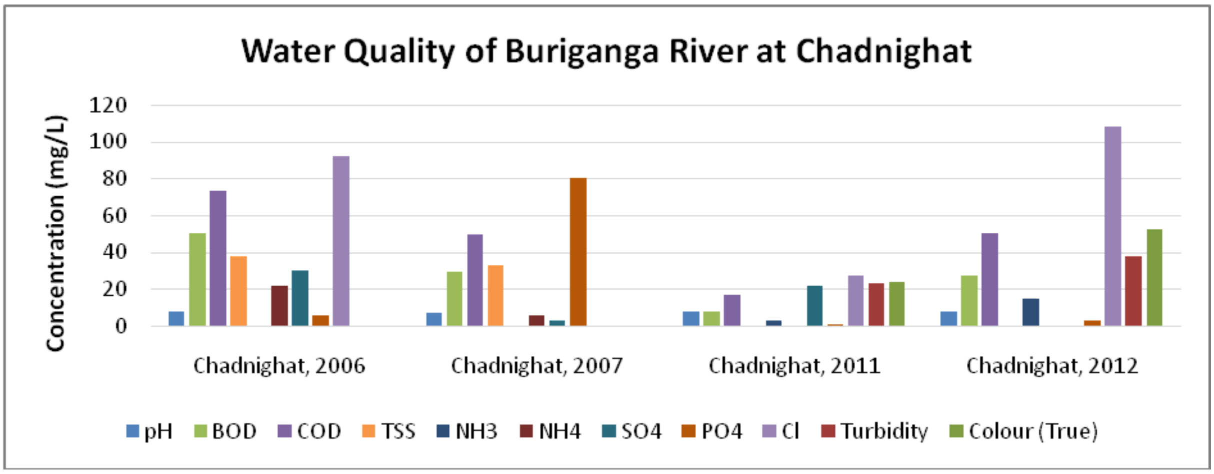


Figure 7-1: Water Quality of Buriganga River

Water samples were collected from Rupganj during the dry season in a study done by SWECO in 2006. 4 samples had ammonia concentrations between 1.5 and 2.5 mg/l. Rupganj Ferry Ghat is about 8 km upstream of Sarulia. It was concluded that shifting of the intake for Saidabad from Sarulia to Rupganj would not be feasible because ammonia up to 2.5 mg/l were detected and that it was likely to deteriorate further with the increased urbanization along Sitalakhya river. In the Gandharbapur WTP feasibility study 10 mg/l ammonia was measured at Khanchon Bridge which is further 8 km upstream along Sitalakhya River. This dramatic deterioration of the water quality of Sitalakhya River is surprising and highly alarming and indicates that urbanization along the Sitalakhya River has dramatically accelerated. It becomes a question whether water abstraction from Sitalakhya would be sustainable if current trend continues in the future. Sitalakhya can only remain as a viable source if measures are taken to prevent pollution in the peripheral rivers. At the Saidabad SWTP, raw water samples have been collected & analysed every day since the inauguration of the plant in 2004. The data shows a highly cyclical pattern in the water quality of Sitalakhya which is shown in Figure 7-2.

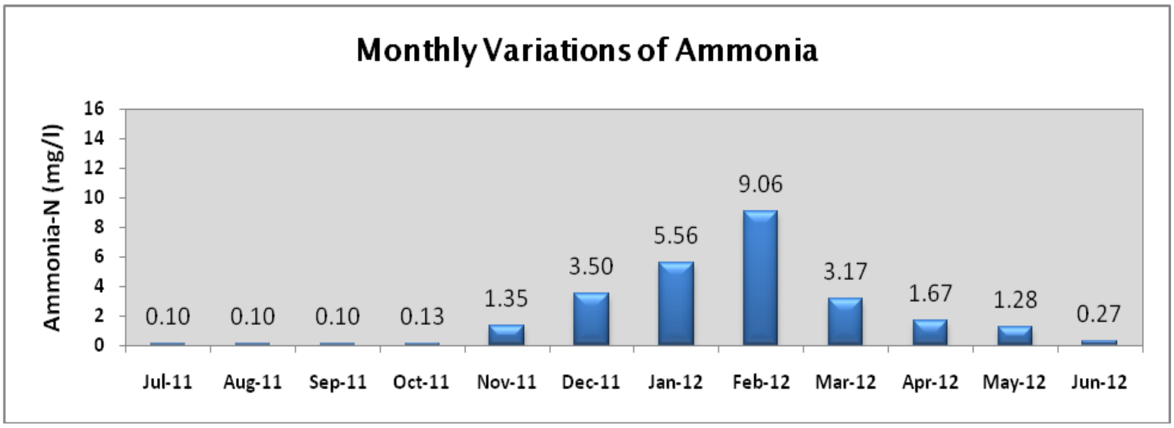


Figure 7-2: Monthly variation of Ammonia at the intake of Saidabad SWTP

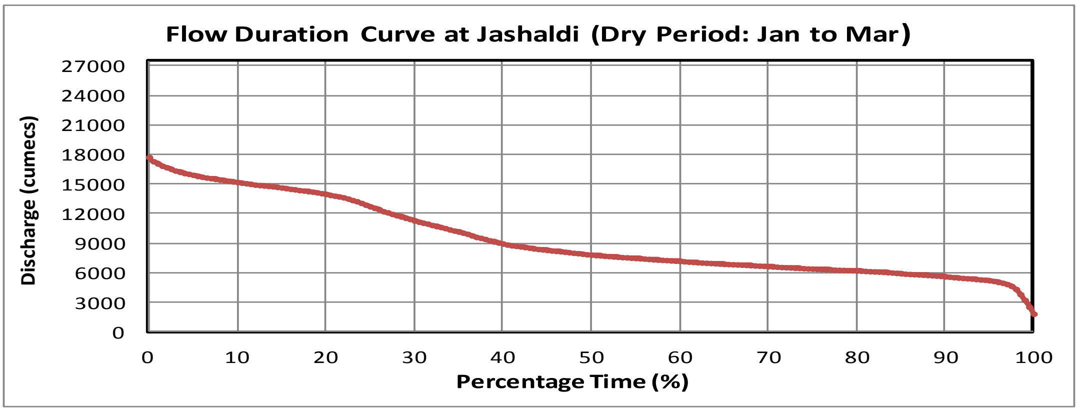
7.1.2 Major Rivers

Water availability in the major rivers is shown in Table 7-3. It is evident from the figures that the major rivers have significant flow available. The water quality of these rivers is also acceptable. Thus DWASA has already taken initiatives to harness the Padma and Meghna Rivers as long-term sustainable raw water sources for Dhaka city. The socio-economic and techno-environmental implications of bringing water from the major rivers werw considered before recommending these locations as sources for Dhaka city water supply.

Table 7-3: Water Availability in Major Rivers

River	80% Dependable Flow	Available Flow after Withdrawal	Environmental Flow
Padma at Jashaldia	6226 m^3/s	6215 m^3/s	2490 m^3/s
Meghna at Bisnondi	210 m^3/s	190 m^3/s	84 m^3/s
Meghna at Haria	176 m^3/s	165 m^3/s	78 m^3/s

Dependable flows have been computed for the dry seasons of January to March for the period of 1966 to 2006 (missing year 1991 to 1998) for Jashaldia at chainage 72000 m using IWM's General Model results. The analysis was done for the period of 1965 to 2007 (missing year 1991-98) for Bisnondi and Baidder Bazar at chainage 72000 m and 82000 m respectively. The flow duration curves are shown in Figure 7-3.



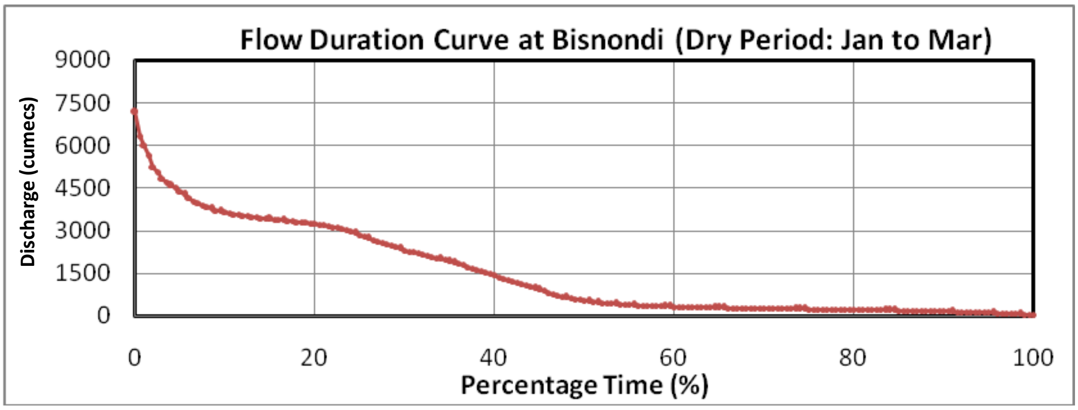


Figure 7-3: Flow duration curves of Padma at Jashaldia and Meghna at Bishnondi

For the selection of treatment units process/operations for Padma SWTP, water quality investigation of field condition and model studies were carried out with three batches of water samples from April to July, 2010. Table 7-4 shows the water quality of Padma in 2006 and 2010. There were no significant variations in water composition except turbidity value, suspended solids and TS count during the sampling period from April, 2010 to August, 2010. The increase in the three parameters was due to increase of flow of water during rainy season, as sediment load in river water also increased significantly. Compared to the peripheral rivers, the water quality is far better in Padma. For example BOD level ranges around 5 mg/l and Ammonia (NH3-N) is 0.01 mg/l in Padma, whereas in the peripheral rivers BOD is 40-60 mg/l and Ammonia is 1-5 mg/l. It can be concluded that treating water from Padma would be cost effective, as the water from Padma will require a lot less treatment than water found in the peripheral rivers.

Table 7-4: Water Quality in Padma and Meghna River in Different Years

Para-meters	Unit	Padma		Meghna		
		Mawa		Haria	Bisnondi	Haria
		(4/4/2006)	(29/4/2010)	(3/4/2006)	(20/03/2010)	(13/7/2013)
DO	mg/l	5.9	-	7.5	7.7	7.6
BOD_5	mg/l	5	-	2.2	-	1
COD	mg/l	8.4	7	3.7	6	8
NO_3-N	mg/l	1	-	0.5	0.8	0.4
NH_3 - N	mg/l	0.01	0.03	0	0.35	0.001
NH_4^+ - N	mg/l	0.29	0.67	0.05	-	0.23
pH	-	7.71	7.12	8.02	7.9	7.03
Temp.	^oC	27.1	-	28.7	29.75	30.2
Cl^-	mg/l	8	8	8	7	10
TDS	mg/l	109	582	85	236	35
TSS	mg/l	19	501	10	9	11
SO_4	mg/l	26.5	-	12.1	9	8.6
PO_4	mg/l	0.45	-	0.75	0.04	0.067
Cd	mg/l	0.001	-	0.002	0.001	0.002
Cr	mg/l	0.008	-	0.01	0.003	0.005
Hg	µg/l	<0.001	-	<0.001	0.0001	<0.0001
Pb	µg/l	1.6	-	1.7	0.01	<0.01
Zn	mg/l	0.0984	-	0.0486	0.059	0.051
Turbidity	NTU	-	320	-	3.95	6.87
EC	µS/cm	-	125	-	141	58

Table 7-4 also shows the water quality in Meghna River for different years. Both water from sampling points, Bisnondi at Araihazar Upazila and Haria, Baidder Bazar at approximately 10 km upstream of Meghna Bridge, seems to be of high quality. For example the turbidity level and TSS are significantly higher during the wet season in nearby Sitalakhya River than similar data from the Meghna River. During dry season the COD is 35 mg/l and Ammonia is 8.5 mg/l in Sitalakhya whereas the COD is 6 mg/l and Ammonia is 0.35 mg/l in Meghna. So it will be easier to treat the water from Meghna to potable water using conventional processes. It is planned that water from Meghna will supply water to Saidabad and Gandharbapur SWTP in the future. Currently Saidabad SWTP gets water from Sitalakhya which is getting more polluted each year. So the intake will be relocated to Meghna in the future. Nearly 2000 MLD of water will be abstracted from Meghna for these plants.

7.2 Groundwater

7.2.1 General

Graphical plots showing changes in water levels over time-using data collected from monitoring wells provide a visual representation of the range in water-level fluctuations, seasonal water-level variations, and cumulative effects of short-term and long-term hydrologic stresses. Groundwater level data of Upper Dupitila aquifer system in Dhaka city demonstrates a steady downward trend. The gradual declining trend of groundwater level implies that the groundwater over abstraction situation has started in the city area long before. Depletion started from or just before the 1990's. Up to 2009 this depletion rate of Upper Dupitila aquifer in the city was about 2.5m to 3.5m per year (Figure-7-4). The over abstraction situation causes the change of upper aquifer characteristics from semi-confined to unconfined nature with increased risk of mining situation.

Under Resource assessment and Groundwater monitoring project of DWASA, IWM installed twin monitoring wells at 10 locations in Dhaka. During the project period groundwater level data was collected regularly. These data were analyzed and hydrographs constructed. From most of the hydrographs it was revealed that both shallow and deep aquifers get annual recharge every year but there was an overall declining trend due to over extraction. The annual replenishment sample plot of Diabari is presented in Figure 7-4. At Diabari and Beraid area hydrograph of Shallow and Deep monitoring wells are reflecting similar pattern of annual recharge and also declining rate.

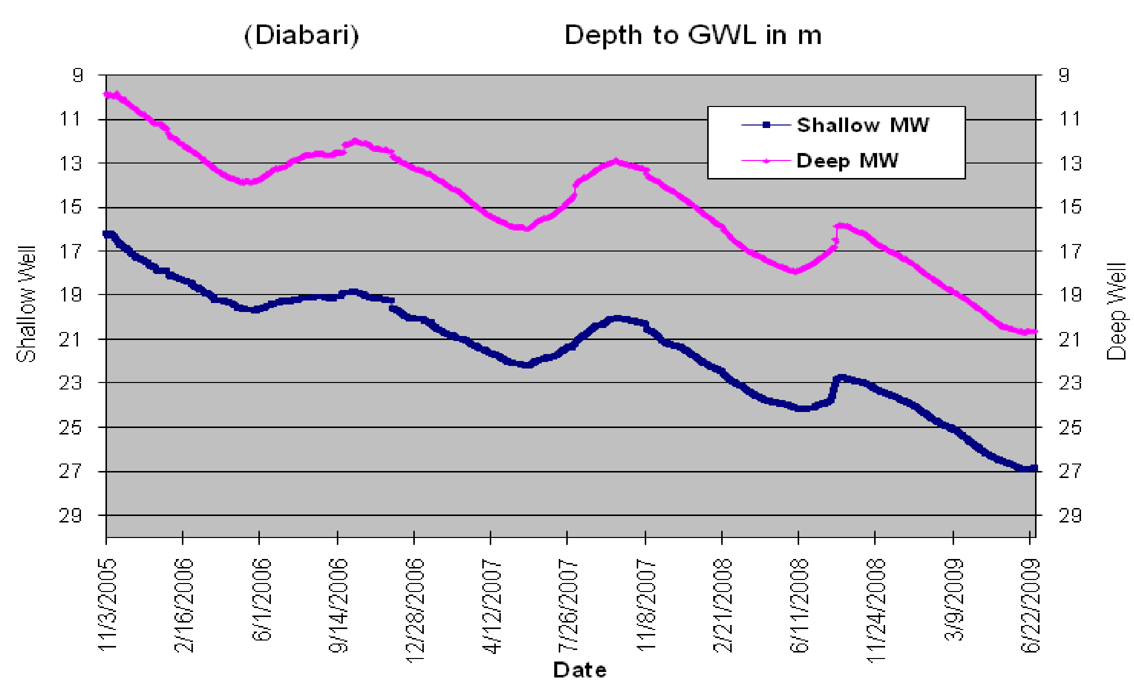


Figure 7-4: Hydrograph of Shallow and Deep monitoring Well at Diabari, Well ID: DMW-2

Regarding similar pattern it may be mentioned here that when aquifer recharge catchments and recharge period of two individual aquifer of different depth are same than pattern of groundwater hydrograph of these aquifer are also be same. However more detail study in this regard is required for making any conclusive remarks.

7.2.2 Upper Dupitila Aquifer System

The computed value for groundwater mining presented in the Resource Assessment study has some approximation, as reliable data on abstraction volume, particularly for the private well's abstraction was hard to obtain. Considering the abstraction volume from aquifer storage in 2004-05, aquifer recharge is about 604 Mm^3. As such, with the present condition, water volume available from Upper

Dupitila Aquifer system without causing further depletion is approximately 600 Mm^3. But this volume is the quantity obtained as maximum potential recharge volume. Out of this quantity the useable recharge could be considered at least 10% less than the potential recharge volume

7.2.3 Lower Dupitila Aquifer System

In DWASA -IWM Resource Assessment report it is proposed to consider 15 m as rated drawdown for abstraction of groundwater from the deeper aquifer system. In case of 15 m rated drawdown the piezometric head in aquifer system would be lowered down to maximum of about 45 m depth uniformly provided uniform distribution of estimated withdrawal is ensured throughout the area.

Based on 15 m rated drawdown level in the city area, the total drainable storage that would be available from Lower Dupitila aquifer system is about 139 Mm^3 or 380 MLD. It has also been suggested that at least 4 hours recovery period should be maintained after every 20 hours of pumping, otherwise pumping from aquifer storage may create a continuous declining situation in the Lower Dupitila aquifer system. It may be mentioned here that due to data limitation about private well abstractions, the impact of abstracting from deeper aquifer is yet to be fully understood. However abstraction from the aquifer is possible in the peripheral area of Dhaka city near the rivers where the piezometric level is at a higher level. In that case careful consideration should be made of aquifer-river interaction, which might result in aquifer contamination from polluted river water.

Presently, there are no monitoring wells and water testing campaign in place to understand the extent of aquifer - river interaction. It is highly recommended that line wells from river bank towards the city centre be installed to understand the phenomenon together with testing of water samples from these wells to establish a timeseries of water quality over the year. This would facilitate forming any recommendation of further abstraction from the aquifers. Considering the above discussion it can be summarized that the total groundwater resource available as safe yield from both Upper Dupitila Aquifer and Lower Dupitila Aquifer systems is as follows:

- Resource available from UDA as sub-surface inflow and vertical recharge
  » 604 Mm^3 or 1650 MLD
- Groundwater resource available from LDA (15m rated Draw down)
  »139 Mm^3 or 380 MLD

7.2.4 Groundwater Quality

A detailed hydro-chemical investigation has been carried out under “Resource Assessment and Monitoring of Water Supply Sources of Dhaka City” project of DWASA. The study reveals that groundwater quality deterioration of shallow aquifer is becoming a threat to safe water supply and affects the baseline water quality of Upper Dupitila aquifer system. Besides the above study, further analyses have been carried out on DWASA groundwater quality monitoring data. DWASA collects random samples from its production wells periodically and analyzes 23 parameters in their laboratory. From these collected time series data electrical conductivity data of the year 2001, 2005 and 2007 has been analysed. Zone (old) wise maximum EC concentration is presented in Figure 7-5. As the electrical conductivity value of groundwater is considered as an indicator of contamination threat and status. Using these EC values, contour maps have been constructed for each year. The constructed contour maps exhibit gradual increase of electrical conductivity value as well as encroachment towards city central area. During the period of 2001 and 2005 higher EC was noticed only in the vicinity of Hazaribag area. But the contour map of 2007 revealed that encroachment extended further towards city area. Importantly it was noticed that higher concentration of EC was formed in the Pallabi and Tongi areas. Such high EC plume reveals the possible contamination of groundwater from the nearby polluted rivers. It is also evident that the pollution level in river Turag is increasing from its past situation, due to increase of industries in the area and similarly industries also increased in the Mirpur area.

Under WSMP project for studying present groundwater situation, DWASA groundwater quality data has been collected for the year 2012. Based on these data a contour map is constructed. But the contour pattern does not indicate any pollution plume along the river side, rather EC concentration is becoming less particularly along the river. Such situation may because of sampling period or sampling location or the river water had less pollution because of higher rainfall.

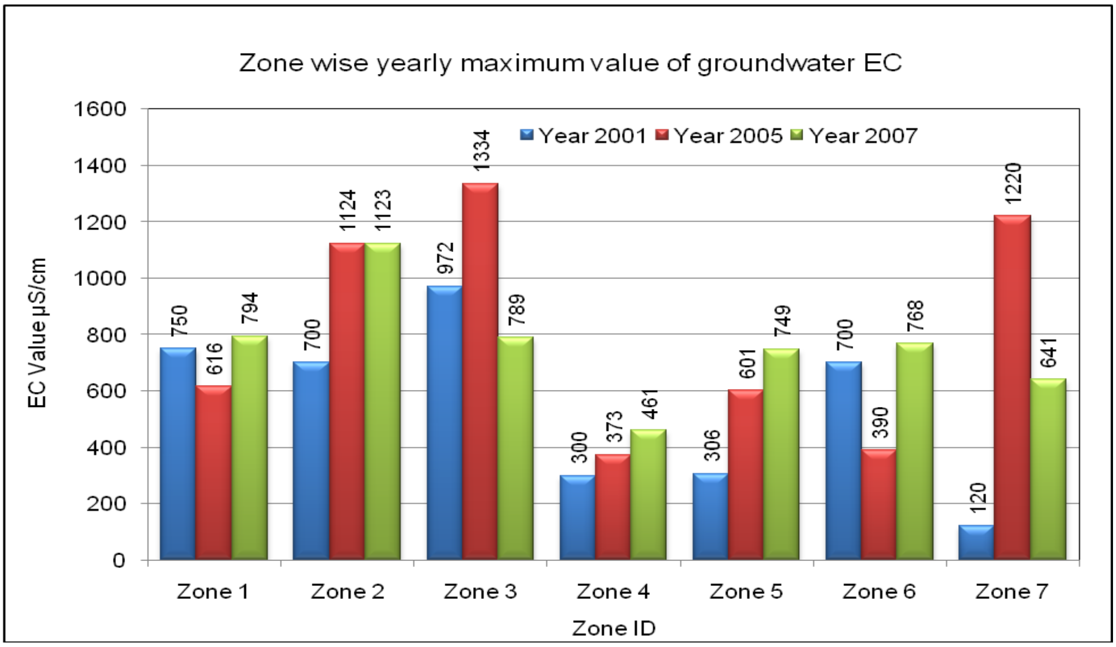


Figure 7-5: Zone wise yearly maximum value of groundwater EC

7.3 Rain Water

Rainwater harvesting is a common and good option as an alternative water source for city water supply. There are two different ways to use harvested water; (a) direct use and (b) through artificial recharge to groundwater. Household level direct use of harvested rainwater is very common practice in Bangladesh, particularly in saline prone coastal area. However, direct use is not commonly practiced in Dhaka city because of limited facility for household level rainwater harvesting and reluctance to incur the extra cost for installing the required plumbing, pumps, etc. Considering the limited scope of rainwater harvesting for direct use in household level, use of harvested rainwater through artificial recharge is the best option for Dhaka city area. Moreover, such artificial recharge will also increase recharge volume to Dhaka aquifer, which will help to keep groundwater balance in respect to huge abstraction in groundwater depleting areas.

Artificial Recharge is the process by which the groundwater reservoir is augmented at a rate exceeding that under natural conditions of replenishment. Any man made scheme or facility that adds water to an aquifer may be considered to be an artificial recharge system. Natural replenishment of groundwater reservoir is slow and is unable to keep pace with the excessive continued exploitation of groundwater resources, particularly in Dhaka city. In order to augment the natural supply of groundwater, artificial recharge of groundwater has become an important management strategy for both DWASA and RAJUK. Artificial recharge techniques are dependent on the hydrogeological situation of the area. Natural recharge to groundwater reservoir is restricted to monsoon period only. Artificial recharge techniques aim at increasing the recharge period during the monsoon season. This results in providing sustainability to groundwater development during the lean season.

7.3.1 Situation Analysis

Groundwater recharge condition of Dhaka city is not similar to other parts of the country. During wet season, unconfined to semi-confined type aquifer layers gain maximum recharge through vertical percolation from precipitation and surface runoff. However, in Dhaka, aquifer layers are covered by a thick Pleistocene clay layer and top surface area is also covered with impervious surfaces such as roads, buildings, etc. The clay layer and impervious surface completely restrict or retard any form of vertical percolation. Therefore, Dhaka aquifer gains most of its recharge volume through underground horizontal inflow. However, the horizontal inflow is not sufficient to maintain groundwater balance considering current rate of abstraction.

Declining groundwater table makes pumping of groundwater more costly and technically difficult. This results in lower water security. Furthermore, such abstraction activity causes groundwater quality hazard due to intrusion from nearby polluted river water. In this regard, the surrounding rivers of Dhaka are severely polluted from discharge of industrial effluent, domestic sewage, untreated drainage runoff, etc. The situation demands recharging of freshwater zones in declining water table areas with artificial means to maintain the groundwater table at optimum levels. The benefits of artificial recharge for aquifer augmentation are: it does not require any expensive storage reservoir; there is no evaporation loss; and little or no contaminant exposure from surface.

7.3.2 Artificial Recharge in Dhaka Context

Artificial recharge practice is a viable solution to reverse the declining groundwater effect. In city areas, precipitation falling on roof tops will turn into storm runoff and can be collected and diverted to injection wells / bore wells. The wells will accompany a filter bed for particulates, debris etc. To encourage adoption of the technology, a systematic implementation plan should be adopted. In this regard, RAJUK has already formulated a SRO under *Building Construction Act 1952 (Act No-II of 1953)*. This SRO is being named as "*Dhaka City Building (Construction, Development, Maintenance and Demolition) Rules 2011"*.

As per the directive, RAJUK is going to enforce rainwater harvesting from building's roof top in city areas. According to this SRO, for roof top space exceeding 300 sq.m and up to 1000 sq.m, arrangement should be made for artificial recharge to aquifer through a single percolation well. When roof top size exceeds 1000 sq.m, an additional percolation well is to be constructed for the remaining space or for every 1000 sq.m space. Rainwater harvesting, use and artificial recharge to aquifer should be carried out as per building code. It should also adhere to approved specification of relevant authority included in BNBC.

In artificial recharge, quantity of recharge varies from place to place depending upon the characteristics of soils, intensity and quantity of precipitation, etc. There are technically simple, cost-effective and sustainable methods of recharge available. Examples of such methods include: spreading, pit, induced recharge and injection well method.

The area requirement of spreading method sometimes limits its use. The recharge / injection well method can directly feed depleted aquifers with fresh water by gravity from ground surface. Recharge through this technique is fast and does not incur any transit loss or evaporation loss. This will ensure timely disposal of excess runoff as well as replenishment of aquifer. The bulk of the recharge well is constructed underground. The only exception is the recharge pit. Since the recharge pit does not require a lot of land surface, this method is not surface area intensive and hence fits well with Dhaka context. Due to the existences of weathered soil and thick Pleistocene Clay layer over the Upper Dupitila aquifer system in Dhaka city, artificial recharge by injection wells through gravity is more practical and appropriate.

The best source of water for recharge pit is the rooftops of the city. Average annual rainfall of Dhaka City is 1700-2200 mm/yr. As such, rainwater collected from various rooftops of buildings can be used as a good recharging source.

If 60 % of the total rainfall only from concrete roof top can be collected; annually, about 89,496 million liters of rain water will be available for recharge of aquifer. This recharge volume, in theory, can facilitate more than 200 MLD for later extraction and supply.

Table 7-5: House with Concrete Roof

City area (sq. km)	Avg annual rainfall (m)	Total rainfall (M litre)	Total concrete house available for rain water collection *	Each roof area (m^2)	Total roof area (km^2)	Yearly total (M litre)
370	2	740,000	6,78,000	110	74.58	149160

Source: Final Report, DWASA –IWM Resource Assessment Study Part-II and Statistical Year Book-2006, BBS

It may be mentioned here that DWASA successfully carried out two pilot projects on artificial recharge from roof top rainwater. Lessons from such pilot projects should be replicated and utilized by DWASA. Such best management practices can partially restore the saturated condition of the upper aquifer.

8 Strategy for the Master Plan

8.1 Guiding Principles

The following guiding principles have been considered for the Master Plan after discussing with DWASA and also with various stakeholder organizations relevant to Dhaka City:

1) access to safe and sufficient water are recognized as human right
2) ensure equitable water distribution to all sections of the population
3) ensure safe, sufficient, affordable and reliable water
4) ensure 24 hours pressurized water supply to all consumers including Low Income Communities (LICs)
5) water supply more from surface water sources and less from groundwater sources; reducing dependency on GW sources
6) alternative supply sources – rainwater harvesting (storage and groundwater recharge)
7) Establish block tariffs – protect consumers and maintaining financial viability of water utilities; lifeline rates for the poor
8) community based water facilities, ownership and management
9) reduce non-revenue water
10) plan and policies to become financially sustainable
11) horizontal and vertical relation within and outside organizations
12) organizational reform for good water utility governance
13) institutional setup considering future jurisdiction and service requirements (capacity building, monitoring and enforcement)

8.2 Water Supply Service Area

It is expected that the present water supply service area of DWASA (401 sqkm) will expand to cover all of its jurisdiction area (approximately 500 sqkm). As urban development continues into the future, it is expected that the service area will expand further to include parts of Keraniganj. Furthermore, some locations will be included in the service area by 2030 as primary transmission lines will pass through these localities. Such areas include parts of Keraniganj and Sonargaon thanas.

8.3 Demand Management Strategy

The strategy for water demand incorporates 100% coverage of the projected population for the existing and future service areas. The strategy takes into account of different population growth rates for different parts of the service area, expansion of service area and improved water supply services to low income communities (LICs). The demand management strategy consists of introducing increasing block tariff (IBT) pricing structure and promoting efficient water gadgets through the establishment of a Water Efficient Labelling and Standards (WELS) Scheme with relevant supporting regulatory framework. The strategy has been discussed in detail in section 6.4 and also in the Demand Assessment Report (Volume 3).

An effective regulatory framework will also help reduce non-residential water demands, because water efficient faucets and toilet flushes will also become common in non-residential buildings (offices, businesses, mosques, etc.). This will have major dividends in reducing the overall water demand of Dhaka city. Initiatives to promote wide adoption of water efficient gadgets can be combined with “green building” efforts currently under way.

8.4 Strategy to Improve System Efficiency

An efficient water supply system has several characteristics. These include less leakage, which results in less NRW, better management resulting in improved service delivery with less resource, more coverage for a given length of pipe, better quality and more. At the same time power is also another issue that dictates the efficiency. An efficient system should also have enough pressure. It should also have adequate storage for emergency supply and fire protection. Lot of these objectives can be met by establishing DMA. Moving from GW and to SW will also help reduce O&M cost, improve operation efficiency and the system will ultimately move towards a sustainable source. Operation and maintenance is very important for improving efficiency. Three major components of efficiency management are non-revenue water, power consumption, and ensuring water quality establishment.

<u>Sectors:</u> The design horizon of the Master Plan is up to year 2060. DWASA has a commitment to provide potable water to all areas within its jurisdiction set by DWASA Act of 1963. It also adopted a strategy to divide its existing distribution network into smaller management units like District Metered Areas (DMA). There are also several SWTP projects that will supply treated water to meet the growing demand. It is very important to determine which areas will be served by these sources. All the new supplies are bringing water from sources outside of the City and the injections from these new SWTP, will enter the City in different locations. Accurate determination of the areas supplied by each of the plants is also required for hydraulic efficiency. The areas that will be covered by each of these sources are named as ‘Sector’ based on the source of supply.

<u>DMA to address NRW:</u> There are several components of Non-Revenue Water (NRW). According to the Asian Development Bank (ADB), causes of NRW in Dhaka are mainly three: leakage from the service connections and distribution lines; faulty metering; and unauthorized consumptions. Establishing a DMA can address these issues. DMA is controlled network where the water balance of the network can be assessed. Using this information the following steps can be taken to reduce system loss:

- Identification of non-metered domestic and commercial connections
- Identification of illegal connections
- Pipeline leakage detection
- Replace poor quality connections
- Optimization of pressure

<u>Operations & Maintenance:</u> Good operation starts with proper planning, management and monitoring of O&M. The integration with MIS department will help them with the required information to provide guidance for better performance. The MIS department can get information using technology like SCADA. Developing a SCADA system for DWASA will provide automated water production and distribution information. This will also pave the way for effective monitoring of DWASA service facilities. SCADA can be used for both monitoring and operation. The current operational plans and manuals need to be reviewed to match the future system. Finally, strengthening the Planning, Monitoring and Evaluation Division is required for overall supervision.

Energy efficiency: Energy accounts for about 30% of total operating cost. It is very important that DWASA develop a comprehensive plan to address its overall energy management. The first step would be to develop a monitoring and evaluation of the power consumption. Institutional setup needs to be arranged between DWASA, DPDC, DESCO and REB. Rehabilitation of poor performing systems and proper maintenance will be useful in the long-term based on monitoring of energy consumption. Finally, the design requirement for pumps and DTWs need to be updated considering energy efficiency.

Sufficient Good Quality Water: The future system would supply adequate water to all citizens in all parts of the service area. The supply water will meet water quality standard of ECR Bangladesh Guideline, 1997. The requirement needs to be maintained at tertiary level of the distribution system. The current sample collection from nearly 70 locations needs to be further improved. The DWASA Central Laboratory is already getting renovated and its improvement needs to be continued to meet future requirements:

- Ensure treated water quality at the Plants: Saidabad, and other future plants.
- Ensure produced quality from the DTWs: well defined program to monitor and maintain water quality from the DTWs of DWASA.
- Ensure quality at customer end- regular monitoring and evaluation at critical locations and also response from complaint centre.

Level of Service: An efficient system will also provide better Level of Service at the customer's end. This will consider the following factors:

- Ensure supply of specific residential demand
- Improve pressure at house connections
- Minimize number and duration of supply interruptions
- Efficient customer care center
- Notification to customers of potential service interruption
- Provide better firefighting capability

SDP (2011) suggests preparing customer satisfaction survey reports and establishment of a One-stop customer service units. The recently created customer service centre of DWASA "WASA Link" can be equipped with management and response systems, adequate staffs and other resources. Overall integration with MODS Zone offices, FM Division and PM&E Division will be required to improve level of service.

Dual Water Supply: Dhaka city is surrounded by rivers and is situated far inland from the Bay of Bengal. Therefore, sea water, brackish water cannot be considered as sources of water for a dual water system. Also, black water is not a socially acceptable option. This leaves storm water and grey water as potential sources. Untreated water from the surrounding rivers may be considered as well. However, given the state of the water quality in surrounding rivers in Dhaka; sourcing a dual water system is infeasible unless and until the water quality is restored in these water bodies.

Due to the saturated state of land use in Dhaka; there is little or no storm water retention ability within the city. Lately, there had been suggestions to incorporate rain water harvesting provisions within the building code. This had been primarily promoted as an adaptation measure for climate change. If properly adopted, this can be a viable source of a dual water system.

The Department of Environment (DOE) through its legislations has mandated Effluent Treatment Plant (ETP) for all kinds of industrial entities. Manufacturing systems also require a lot of water for cooling purposes. Since both source and need coincide, there is potential for dual water system integrated within the production process. However, adopting a dual water system for domestic and commercial use will be a tall order.

There are behavioral barriers to overcome before introducing any such system. Given the relative low cost of readily available potable water in Dhaka city, the need for a dual water system will be difficult to establish. Regardless of how far off the usage of dual water system will be from personal usage, there will be lingering concerns about exposure and hygiene.

If we consider the scale of a potential dual water system, it will be difficult to convince building owners in Dhaka to spend the extra amount of money for the plumbing required for an individual scale dual water system. A district scale system is also infeasible given the constricted nature of the cityscape. Any dual network pipe system must be laid along the existing road networks. There are already existing piped infrastructures sunk along the roadways and the insufficient record of the underground structures whereabouts is another hindrance.

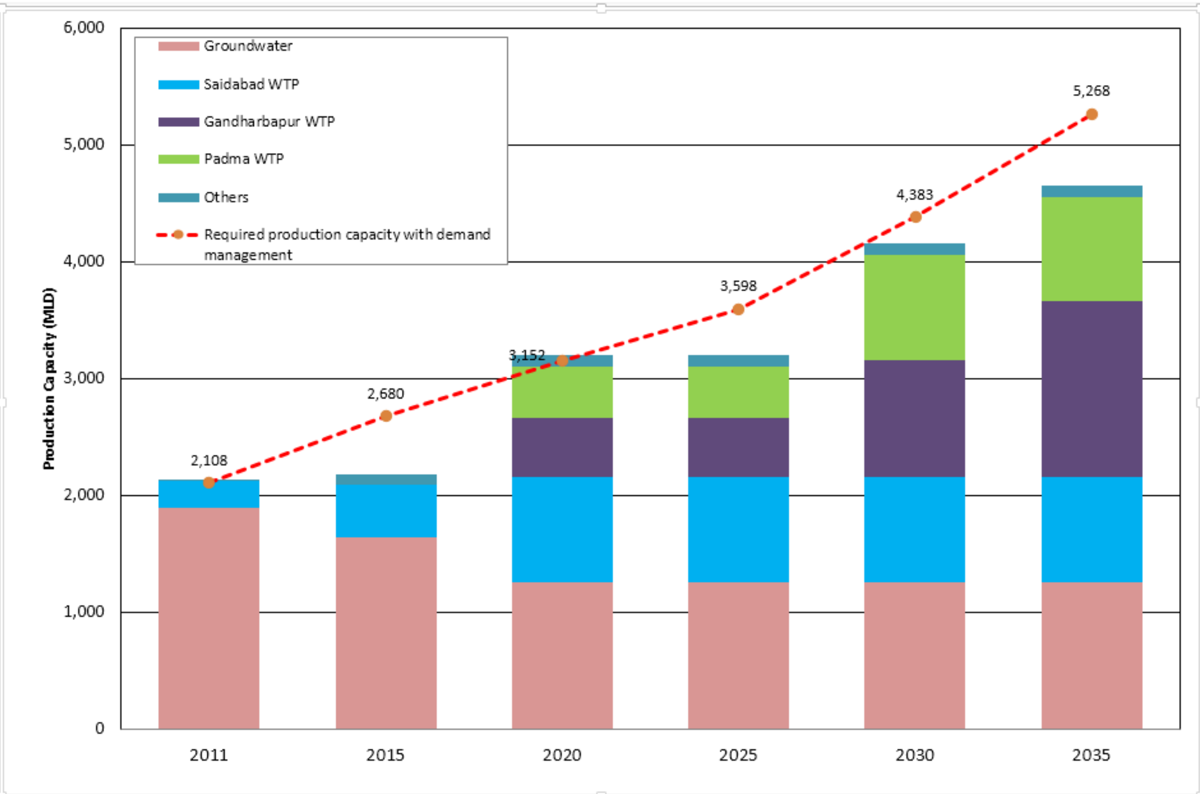
The most important concern with regards to a dual water system is obviously health and safety of the residents of the city. Due to apparent lack of coordination among different agencies within the city, there is potential for cross-connection between potable and non potable water supply systems. Due to the dense nature of the city, any such incidence can lead to mass exposure and subsequent outbreak of diseases.

In sum, before contemplating any dual water system, inter-services coordination, updated and precise infrastructure management system and practices must be guaranteed. Water safety makes a dual water system technically feasible. However, acceptance of such system will be realized only when behavioral change and affordability leads to mass scale adoption. It should also be added that, people tend to exhibit more environmental consciousness as his or her economic condition improves. Considering the long-term economic trajectory of the city, a dual water system may become a preferred technology in the long run.

8.5 Demand Supply Gap Matching

Assessment of demand and required production capacity for meeting the demand shows that by the year 2035 the total demand is expected to rise to 5,268 MLD in the 617 sqkm of DWASA's planned service area. To meet the demand, options for DWASA are limited to harnessing the water resources of Meghna and Padma Rivers. Resource assessment study (IWM, 2006) shows that sufficient water of adequate quality is available in these two rivers. The two feasibility studies conducted for the Padma and Meghna (Gandharbapur) WTP also shows that these two plants are technically, socially and economically viable. Preliminary assessment made in the feasibility study of Saidabad WTP Phase III shows that, Meghna could also be a source for the three phases of the Saidabad WTP planned to be producing 900 MLD in total. Therefore, total supply from the Padma and Meghna could be planned for 900 MLD and 2525 MLD respectively by the year 2035.

As discussed earlier, allowable limit of groundwater abstraction from the upper dupitila aquifer is around 1640 MLD, which also includes Singair and Tetuljhara-Bhakurta groundwater well fields. The lower dupitila aquifer is considered not dependable. Therefore, DWASA will have to rely only on the groundwater resource of the upper dupitila aquifer. It is recommended that around 75% of the resource in the upper dupitila aquifer is harnessed for water supply to Dhaka Master Plan area. Rest of the extractable groundwater resource should be reserved for any future uncertainties which might arise due to increase of demand or delay in commissioning of large bulk surface water supply sources. Around 97 MLD will be available by rehabilitation and expansion of the Chandighat WW, Godnail WTP and Sonakanda WTP.



Year	2011	2015	2020	2025	2030	2035
Required Production (MLD)	**2,108**	**2,680**	**3,152**	**3,598**	**4,383**	**5,268**
From GW sources (MLD)	**1,900**	**1,640**	**1,260**	**1,260**	**1,260**	**1,260**
Godnail, Sonakanda & Chandnighat	10	96	96	96	96	96
Saidabad I	225	225	225	225	225	225
Saidabad II		225	225	225	225	225
Saidabad III			450	450	450	450
Gandharbapur I			500	500	500	500
Gandharbapur II					500	500
Padma (Jashaldia) I			450	450	450	450
Padma (Jashaldia) II					450	450
Gandharbapur III						500
From SW sources (MLD)	**235**	**546**	**1,946**	**1,946**	**2,896**	**3,396**
Total Production (SW + GW) (MLD)	**2,135**	**2,186**	**3,206**	**3,206**	**4,156**	**4,656**
Surplus or Deficit (MLD)	**27**	**-494**	**54**	**-392**	**-227**	**-612**

Figure 8-1: Strategy of Meeting the Supply-Demand Gap

Figure 8-1 shows different levels of deficit all through the planning horizon up to 2035, except for in 2020. It is expected that demand management measures will be in place to reduce the deficit.

8.6 Institutional Capacity

The current institutional arrangement of DWASA needs to be aligned with its future organizational needs. Several aspects will play key roles in the future organizational activities.

Jurisdiction: Though DWASA currently operates in 12 MODS Zones, DND and Narayanganj area, there are areas within the 1963 jurisdiction which are not currently covered by DWASA. Tongi (now under Gazipur City Corporation), Gachcha Union, Rupganj and Kaliganj Upazillas will be supplied by DWASA in the future. The existing facilities and resources of these organizations will have to be taken up by DWASA. The action needs to be coordinated within respective administrative levels through meetings in the ministry and finally through Government Acts.

Groundwater to Surface Water: The DWASA supply system is heavily dependent on GW now. In the future SW will provide major part of the supply. In order to supply from 650 DTWs current institutional setup has to focus on pump operation, pump replacement and well rehabilitation. These activities will be reduced in the future to only sustainable use of GW, which will improve the life and performance of the wells. On the other hand only 500 MLD is produced from SWTP currently. This will increase to nearly 3000 MLD in future and will be supplied from 2 more new treatment plants. These plants will have long raw water lines and also transmission system. DWASA will require skilled professionals to run these new systems.

Integration of Sectors and MODS Zones: MODS zones will be aligned with Sectors that are conceived for SWTP. Transmission system will supply water from the SWTP to different DMAs within a Sector. The future plan is to move towards operation driven by SWTP and DMA. In that regards the role and responsibilities of a lot of the current positions and Division setup have to be redefined. Thus it is crucial to maintain skilled, effective, stable and diverse workforce responsive to changing technology. Unlike MODS Zones, the Sectors will have treatment plants and DMAs to manage, which will be independent of other Sectors. Thus each Sector may need to be administered by an Additional Chief Engineer. The previous mixed administration may have to be changed to separate administration for water, drainage and sewerage.

Revenue collection: The bill collection is done by Employees Consumers Supplies Cooperative Society Limited (ECSCSL) in six Zones. The other Zones where bill collection is done by DWASA needs to be outsourced, so that all the Zones are comparable. This will be affected by the Sector concept that is conceived in the Master Plan. In the future DWASA revenue will be collected based on Sector administration. This will help bring in line revenue collection with the financial planning of the Sector.

Overall Divisions: Some of the Divisions which needs to be rehabilitated are Water Rehabilitation & Development, Field & Maintenance, SOC, and Generator Division in addition to the MODS Zones. The Planning department needs to be strengthened to match with introduction of new technologies. The capacity of GIS department needs to be strengthened and has to be introduced with asset management capabilities. There should be integration between P&D, GIS and also MIS divisions. The newly established Customer Service Center 'WASA Link' should be strengthened to ensure:

1. Increase customer satisfaction with the service provided and customer expectations
2. Implement remedial actions to reduce customer complaints

Awareness raising program should be conducted with more emphasis on minimizing wastage of water, and the issues faced by DWASA to provide water to the City residents.

Human Resource Department: A fully functional HR Department is essential for efficient management of DWASA. Proposed Human Resource Department will plan and provide HRD facilities and strategies which are relevant to DWASA and its staff. The objective of the HRD should include:

- Develop employee skill profile to enable DWASA management to identify skills gaps and plan current and future development programs and trainings.
- All posts will have detailed job descriptions indicating responsibility and accountability along with performance requirement which will be signed off by the post holders.
- Provide development opportunities and succession planning for all staff, related to performance management, so as to meet organizational, occupational and individual needs.
- Train human resource for SWTP management and DMA operation
- Computerization of staff information and its use for HR management

Policy Matrix: SDP (2011) suggests implementing the Policy Matrix as contained in the Partnership Framework Agreement between the GoB and Development Partners. The Policy Matrix addresses three key areas: i) strengthening governance and organization structure, ii) improved financial management capacity, and iii) sustainable service delivery.

8.7 Legal and Policy

Protection of Raw Water Sources: DWASA requires policy support at its water source points. Stronger policy and enforcement is required to ensure water quality in both surface water and groundwater sources. DWASA will be extracting water from Padma and Meghna Rivers in the future. These sources need to be protected from industrial, agricultural and sewage pollution. The problem is more acute in peripheral rivers, where Godnail, Sonakanda and newly proposed Ashulia reservoir are located. One option is to relocate the major industrial zones and also ensure treatment of effluent discharged to these rivers.

Considering 1600 MLD groundwater will be extracted from DWASA, in the future this policy is guided by sustainable use of the resource. The policy should ensure assessing the sustainable yield and allowable draw down for its aquifer system. DWASA already has a groundwater monitoring system. These monitoring results have to be integrated with its operation.

Service Levels: The treated water quality by DWASA has to comply with WHO guidelines as well as Bangladesh standard (ECR 1997). To ensure water quality at users' end, water quality tests will be carried out each month at random piped outlets and the results published in the national newspapers and DWASA web- site. In the event of deterioration of water quality for some reason, the people living in the risk zone must be informed about the possible health risk and protection measures to be adopted.

Coverage with piped water supplies will be increased to 100% of the population subject to willingness to connect and pay. Standpipe water supplies will be phased out and replaced with house connections at the earliest wherever possible. Priority will be given to schools and slums in the provision of piped water supplies and sanitation facilities. At markets, bus stands, and public toilets, 24 hour water supply will be maintained.

Water for Urban Poor: The current policy mandates that to serve a slum area there is a representative Non-Government Organization (NGO) who will be also involved for coordination. The future policy should have the following objective:

- An equitable approach to water service provision for all inhabitants of DWASA service area. Recognizing that all inhabitants of DWASA service area have a right to water service connection with the same level of service and ensuring a single tier service with clear processes for requesting connections for consumers irrespective of economic status.
- Introduce a Low Income & Slum Community Services Support Cell at the Head Office
- Empower the Zonal/MODS Managers to support connection provision to low income and slum communities through proven mechanisms. Open a community wing in each MODS Zone office.
- Incentivize the performance of the Zonal/MODS Organizations
- Promote initiatives for private participation in the distribution of water to low income and slums communities.

Jurisdiction and additional municipalities: The extent of service of DWASA will expand to parts of Tongi and Gazipur in the northwest, Kaliganj in the northeast, Rupganj in the west, Keraniganj in the southwest and Bandar in the southeast. The water supply systems in these areas are run by the local administration. In the future, government initiatives and policies will have to be taken by respective Ministries i.e. LGD to transfer the water supply responsibility to DWASA. The political and local stakeholders will also have to be involved in the process.

Sector approach for overall service improvement: Sector approach shall be adopted for overall improvement of water supply. Within a Sector, "District Metered Area" will be established where adequate water supply of acceptable quality will be ensured for 100% of the population for 24 hours and almost 100% collection of DWASA revenue can also be ensured. The operation, maintenance and financial activities will be independent for each Sector. The current MODS system will be gradually aligned to the Sectors.

Demand management: Demand management will play a very important role to minimize the gap between demand and supply and make the future plan sustainable for DWASA. Tariff has to be increased in order to meet the demand management requirements and cover the O&M costs. Individual meter installation policy for households is required to implement block tariffs. Also for demand management, use of water efficient gadgets (faucets, flushes, etc.) will be required, which has to be encouraged by DWASA. Awareness program will be carried out to promote DWASA policies, plans, conservations through community involvement which will have representation from NGOs, academia, media and LIC.

Policy for private land development: In order to generate adequate funds to meet the cost of building water supply, sewerage and storm water drainage infrastructure in the housing areas, the respective Private/Public organization(s) will build-in the cost of providing water supply, sewerage and storm water drainage services with the cost of the housing plots.

Water Services Act: SDP (2011) mentions that a regulatory framework is required to meet the WSS sector challenges. In order to establish the framework WSS sector would require a Water Services Act, which would be drafted by the LGD. The Act would also facilitate creation of a Water Supply Regulatory Commission. This will encourage private sector participation and investment, ensure affordable and sustainable service provision, improve performance and cost effectiveness of service providers (both Private sector and Government), help set rational tariff, and strengthen the overall transparency and accountability of DWASA.

Private Sector Partnership: To enhance the efficiency of operation and maintenance of water supply systems, the private sector will be involved in the utility services. DWASA has already privatized its revenue collection services which have been found to be cost effective. As such, private sector participation will be expanded to all future Sectors of DWASA. Private sector participation will also be encouraged in infrastructure development including source augmentation along with operation and maintenance of water supply and sewerage systems. In this connection specific set of rules have to be formulated by DWASA for commercially operating public utilities. SDP (2011) suggests following a transition path to PPP by first starting with simple types like service contracts and management contracts. DWASA will prepare contract guidelines and initiate service contracts and some management contracts on pilot basis.

Water Safety Plan:DWASA will gradually introduce Water Safety Plan as recommended by World Health Organization in the Guidelines for Drinking Water Quality, (2004) for consistently ensuring the safety of a water supply. The Plan will guide assessment of the system, effective operational monitoring and development of management plans for appropriate actions including system upgrading and improvement. Information, Education and Communication (IEC) Guideline will be prepared and mainstreamed in existing and new projects.

8.8 Financial Strategy

The national policy and principles recognize the economic value of water and the need for eventual full cost recovery of water and sanitation services. However, since DWASA believes that water is a social good, it will shift to full cost-recovery gradually and with safety-nets to maintain affordable price among Low income communities (LIC). The focus should be to become a commercially orientated organisation that can generate a healthy balance sheet sufficient to provide the means for required growth and investment. The current operating surplus will be increased to reduce the burden of capital expenditure.

Basis for Financial Assessment: Section 35 of the 1963 Ordinance and Section 36 of the WASA Act (1996) require that separate accounts be maintained for all the individual services. This separation will enable DWASA to properly define the financial strategies and accurately determine the return on investments. With introduction of Sectors and DMAs, DWASA needs to aim for targets which will match the physical investment required and relevant financial return. The Sectors will operate independently which will provide clear targets for financial planning. The aim will be to assess the operating expense, investment and revenue for each Sector separately.

Revenue and Expenditure: The operation and maintenance cost has to be clearly articulated in respect of groundwater, surface water and pipe line. This will provide the basis for identifying improvement areas. The reduction of staff cost, improvement of bill collection by exploring outsourcing all the Zones, increased metering by having meters for all customers, automatic metering setting up AMR system, automation of billing system, less delays in the billing system to improve the average collection period, etc. are all required. Computerized accounting system, linking current MIS with billing and existing asset by creating an asset registry will provide a comprehensive assessment. Automation of financial management (billing, accounting, all payments and procurement) will help revenue and expenditure reconciliation.

Tariff: SDP (2011) emphasizes the current provision in WASA Act (1996) to increase the water tariff to meet the increasing costs and make their operations financially viable. The plan proposes to establish progressive water tariffs that reflect the true costs of services, while providing a safety net for the poor. Revenues from tariffs must be sufficient to cover O&M costs and generate funds to meet a portion of the capital costs. The amount of NRW will have to be lowered through the participation of the private sector, CBOs and NGOs. These groups can also be involved in preventing unauthorized connections and reducing non-revenue water (NRW) and enhancing revenue collection.

Investment Plan: The Master Plan will be the basis for future investment requirements up to 2035. The tariff plan, non-revenue water target and collection efficiency should be set at a level so that DWASA can accumulate annual savings with revenues in excess of requirements for operation and maintenance. The Partnership Framework with the Donor agencies will be a key to investment sources for capital improvement. Private sector funding can be an option for DWASA, especially for projects with robust cash flow. Land developers can also be considered to bear the expense of infrastructure development, which can substantially reduce the burden of capital development required by DWASA. However, some grants from the government would be required to ensure adequate water supply for a City like Dhaka.

Partnership Framework: The Partnership Framework signed by the Government and major Development Partners will be followed to support the development plan of DWASA. It is expected that the individual Development Partners' project investments would be coordinated with each other, and would be consistent with the agreed policies and actions outlined in the Partnership Framework.

9 Water Supply Master Plan

9.1 Sectors

The major water supply sources (SWTP plants and well fields) are located in consideration of proximity to available sources, availability of land, etc. As a result, they happen to be located in different parts in and around the city. The Transmission Mains originating from these sources will enter the city from different locations. Each source will operate in a region of the city on the basis of the following criteria:

- The maximum contiguous area where the incident demand can be adequately served by production capacity of the source.
- The area up to which the transmission main can provide water to the distribution systems at a minimum 1 bar pressure (based on preliminary hydraulic modelling).
- Existing and proposed DMA boundaries.

Delineation of such areas is referred to as sectorization. The areas that will be covered by each of these major sources are named as 'Sector'. Considering the population density, strategy of city development, nearby available sources of ground and surface water, socioeconomic condition of the locality and the corresponding water demand, the service area has been divided into eight Sectors. Projected populations and water requirement for each sector have been calculated up to the year 2035. The source of water for each sector has been established. The sectors are:

- Saidabad West-East Sector
- Padma North-West Sector
- Padma South Sector
- Singair Sector
- Khilkhet Sector
- Tongi & Gachcha Sector
- Bandar Sector
- Rupganj Sector

Figure 9-1 depicts the service area in 2015 to 2019, Figure 9-2 shows the service area in 2020 and Figure 9-3 shows the service area in 2030.

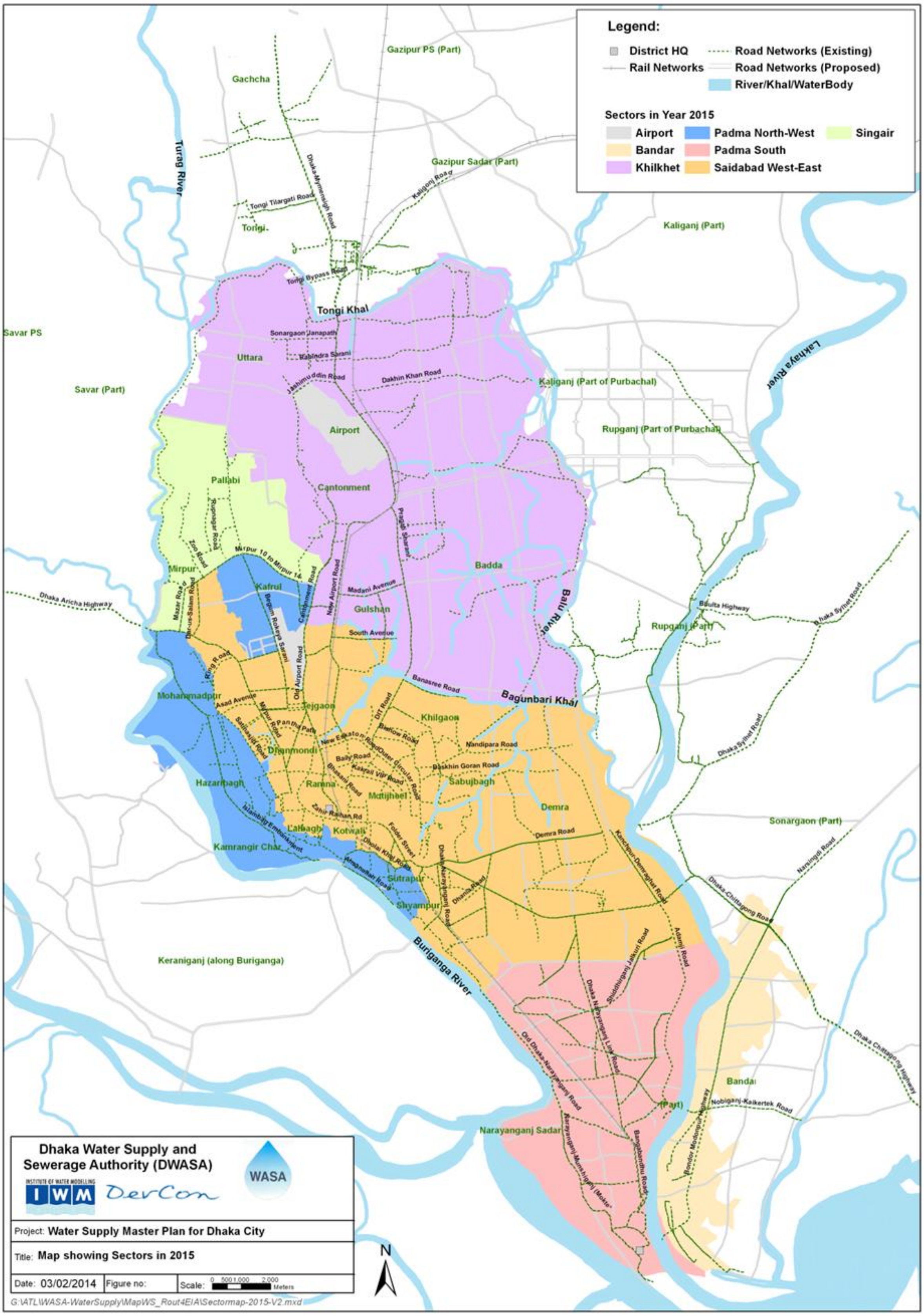


Figure 9-1: Proposed Sectors in 2015 to 2019

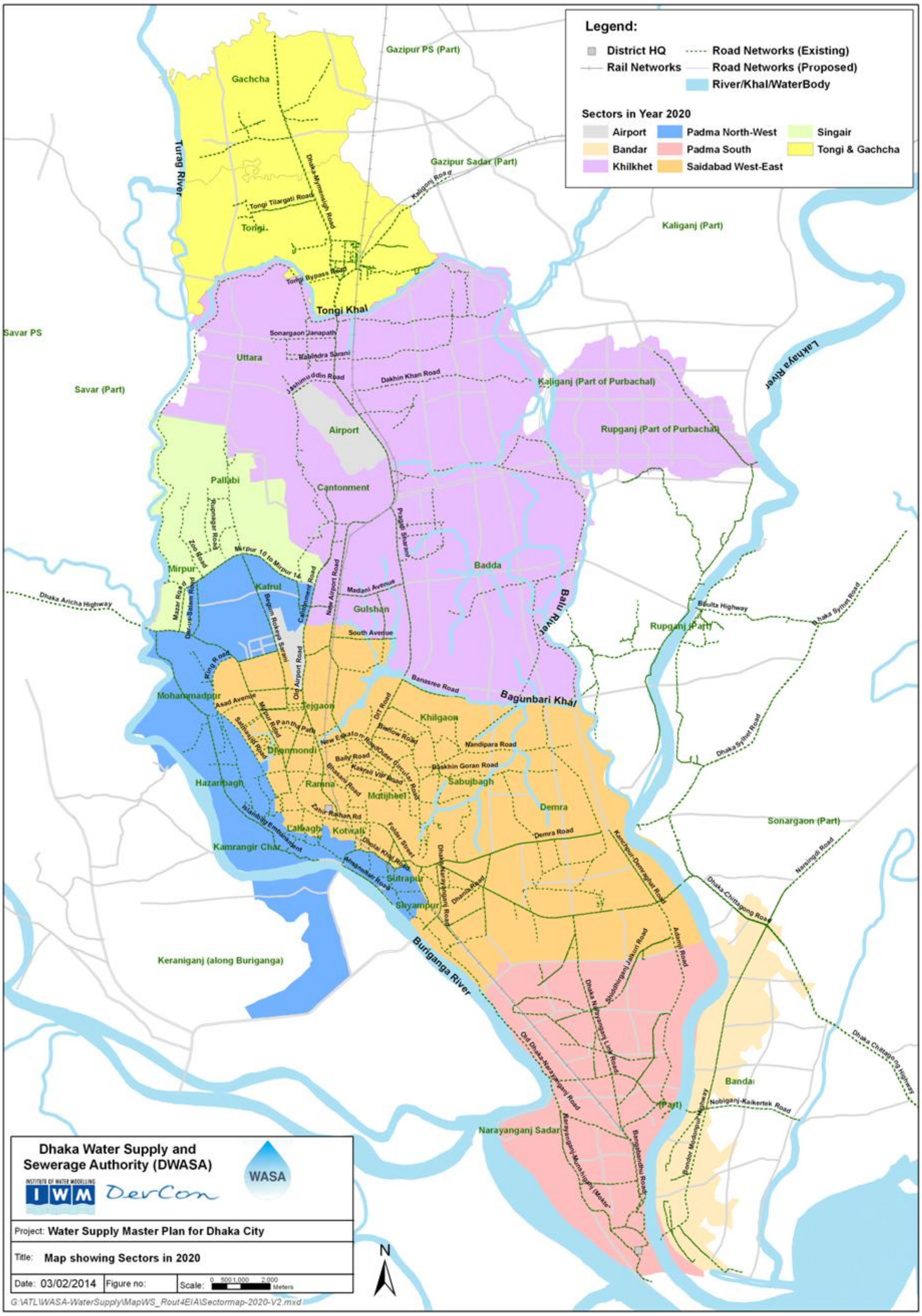


Figure 9-2: Proposed Sectors in 2020

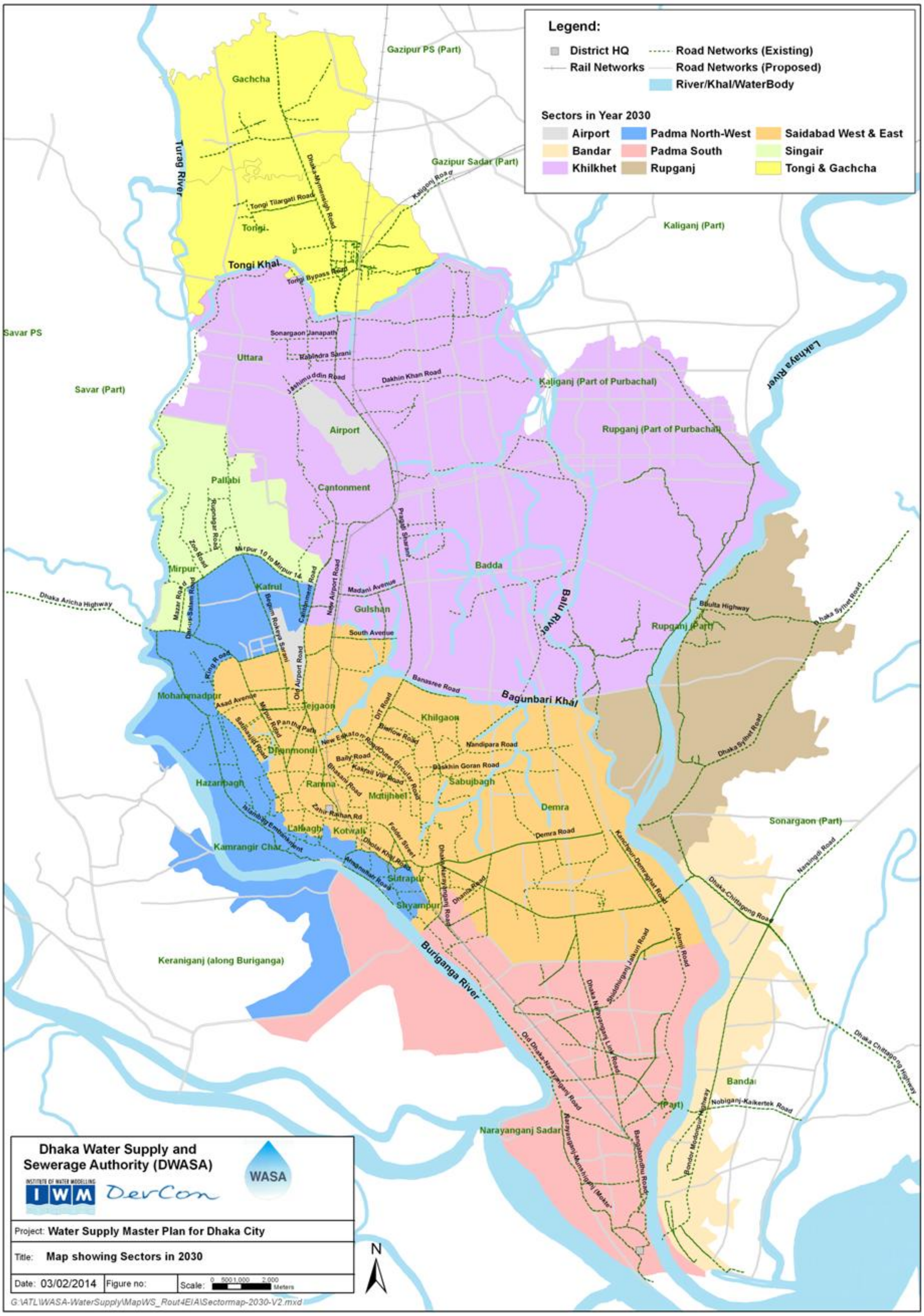


Figure 9-3: Proposed Sectors in 2030

9.2 Future Sources of Supply

The design horizon of the Master Plan is up to year 2060. Given the trend of economic growth, land development spurred by in-migration to Dhaka; the city is projected to experience robust growth within the design horizon. DWASA has a commitment to provide potable water to all areas within its jurisdiction set by DWASA Act of 1996. It also adopted a strategy to divide its existing distribution network into smaller management units called District Metered Areas (DMA). Water supply infrastructure development should commensurate the urban growth for it to be sustainable. There are several SWTP projects that will facilitate treated water to meet the growing demand. Also the future sources of supply will move away from current dependence on groundwater to a surface water based system. Within the framework of the sector concept the demand and supply has to match. As more the surface water becomes available the use of 650 or so DTWs to produce groundwater will be reduced. Table 9-1 shows the demand and supply for each sector. It shows the necessity for the introduction of new sources in order to meet the growing demand and reduce the already over exploited groundwater.

Table 9-1: Sources of Supply Sectors up to 2035

Sector Name	Year	Surface Water Treatment Plant†	Area (sqkm)	Total Demand (MLD)	Surface Water (MLD)*	Ground water (MLD) †
Padma North-West	2015		32.9	456	0	290
	2020	Padma Phase-I	47.3	535	462	100
	2035	Padma Phase-I	50.9	700	489	80
Padma South	2015		62	264	0	200
	2030	Padma Phase-II	87.4	561	495	120
	2035	Padma Phase-II	87.4	681	495	120
Khilkhet	2015		137.3	571	0	400
	2020	Char Gandharbapur Phase-I	162	714	500	230
	2030	Char Gandharbapur Phase-I&II	199	1217	1000	200
	2035	Char Gandharbapur Phase-I,II&III	199	1610	1080	200
Saidabad West-East	2015	Saidabad Phase-I&II	115.8	1064	450	500
	2020	Saidabad Phase-I,II&III	111.3	1065	900	280
	2035	Saidabad Phase-I,II&III	106.5	1284	900	260
Singair	2017	Singair Well Field Phase-I	23.4	254	0	200
	2025	Singair Well Field Phase-I&II	23.4	302	0	350
	2035	Singair Well Field Phase-I&II	23.4	394	0	350
Rupganj	2035	Char Gandharbapur Phase-III	51.4	77	60	0
Bandar	2015		23.2	72	0	50
	2020		23.2	86	12	100
	2035	Char Gandharbapur Phase-III	32	192	202	100
Tongi & Gachcha	2020		60.1	190	0	150
	2035	Char Gandharbapur Phase-III	60.1	330	170	150

† Groundwater abstraction has been calculated based on the assumption that in 2015 total groundwater abstraction will be 1640 MLD and in 2020 & onward total abstraction will be 1260 MLD. However, for some cases more groundwater might be required to makeup temporary deficiencies.

** Including small surface water treatment plants.*

In 2015 the demand in Padma North-West sector is 456 MLD, which has to be met by groundwater. The amount, nearly 290 MLD from the DTWs, is beyond the capacity of the aquifer and hence over abstraction will occur. The demand will rise to 535 MLD in 2020, majority of which can be supplied from the new Padma Phase-1 treatment plant with a capacity of 450 MLD. The new plant reduces the dependence on groundwater to about 100 MLD. Similar development is also observed in other sectors. Addition of new sources in each sector caters to the increase in demand due to future development and at the same time reduces the dependence on groundwater. Rupganj, Bandar, Tongi and Gachcha Sectors are not currently served by DWASA. The demand for these areas will be met as DWASA expands its service area in these peripherals areas of the City.

In addition to the plants mentioned above the existing Sonakanda, Godnail and Chandnighat Treatment plants also need rehabilitation.

9.3 Future Distribution System

The current distribution system is based on supplying water from the 650 DTWs of the City. Only major source of surface water supply is the Saidabad SWTP. As result the distribution system lacks larger pipes to transmit water from one part of the City to another. As new plants will be constructed to meet the future demand, primary distribution lines will be required to transmit the water from the sources. Each sector has a plant which will be built in phases. The primary transmission main will have to be built in each sector to transmit the water from the plants. Secondary and tertiary distribution lines will be required to distribute water to the customer end. DWASA has taken up DWSSDP project which is establishing DMA for the distribution system. DMA is essential to ensure a minimum amount of NRW and minimize the loss of precious water through system leakage. In each sector, DMAs will be established to transmit water from the primary distribution. The current network is not designed to implement DMAs, so gradually the current system has to be changed in to DMAs. Using hydraulic models the primary distribution lines were designed according to supplied water in different parts of the sector to the DMAs. The Primary and DMA distribution line that will be required in each sector in addition to the construction of treatment plants is shown in Table 9-2. Khilkhet sector will require the highest length of primary transmission as the SWTP is located in Char Gandharbapur, some distance from the City and it also supplies distant areas in different directions.

Table 9-2: Primary and DMA Distribution for Sectors up to 2035

Year	Primary Distribution (km)	DMA Distribution (km)	Sector Name
2020	41.54	606	Padma North-West
2030	57.42	384	Padma South
2020	98.35	685	Khilkhet
2030	81.44	293	
2035	18.59	60	
2017	46.22	824	Saidabad West-East
2020	57.53	381	
2015	52.86	354	Singair
2025	41.00	82	
2035	21.29	37	Rupganj
2035	23.66	113	Bandar
2035	31.13	96	Tongi & Gachcha

9.4 Institutional Improvements

In order to build the capacity of DWASA and improve effectiveness of the development works several other measures need to be taken. The importance of these programmes are discussed in the situation analysis and strategy section and listed below.

- Implementation of revised tariff structure
- Institutional reform to address 'Sectorization'
- Policy and regulatory reform
- Development of Enterprise Resource Planning (ERP) System
    - Development of GIS system
    - Development of Asset management system
- Human Resource Development
- Water for Urban Poor
- Community & private sector partnership
- Communication system establishment
- Strengthening the Water Quality Lab
- Development of good monitoring program including SCADA

9.5 Short-term Plan

This period is from 2014 to 2020, which is in line with the Bangladesh Sector Development Plan - Water Supply and Sanitation (2011-25). In this period, water demand will be expected to high in Padma North-West, Saidabad West-East and Khilkhet sectors (Table 9-3). In addition, water demand will also be significant in Singair sector with respect to its commanding area. Though 450MLD surface water is currently available for Saidabad West-East, but still this will not be sufficient to meet demand.Therefore, stable source of supply will be necessary for all these sectors.

Table 9-3: Expected Demand in different Sectors in the Short Term Plan

Sector	Area (sq.km.)		Demand (MLD)		Existing Available SW Source (MLD)
	2015	2020	2015	2020	
Padma North-West	32.9	47.3	456	535	
Padma South	62	62	264	291	
Singair	23.4	23.4	254	271	
Saidabad West-East	115.8	111.3	1,064	1,065	450
Khilkhet	137.3	162	571	714	
Bandar	23.2	23.2	72	86	
Tongi & Gachcha	0	60.1	0	190	
Airport*	6.3	6.3	-	-	
Total	**401**	**496**	**2,680**	**3,152**	

**Note: Demand for this area will be met by Civil Aviation Authority*

However, it is expected that the projects in this period would have approved financing or have a good chance of being approved very soon. Feasibility studies have been already completed or being carried out for these projects. The Singair Well field Phase–I project is already in Tendering Phase. The financing of Padma SWTP Phase-I project has been finalized and currently land acquisition resettlement program has started. The financing of the Gandharbapur SWTP Phase-I project has been confirmed. Feasibility study is on-going for the Saidabad SWTP Phase-III project. Table 9-4 shows the sources of supply that will be added within 2020.

Table 9-4: Sources of Surface Water Supply in the Short-Term Plan

Year	Source of Supply	Amount of Supply (MLD)	Sector Name
2017	Singair Well Field Phase-I	150	Singair
2020	Padma SWTP Phase-I	450	Padma North-West
2020	Char Gandharbapur SWTP Phase-I	500	Khilkhet
2020	Saidabad SWTP Phase-III	450	Saidabad West-East

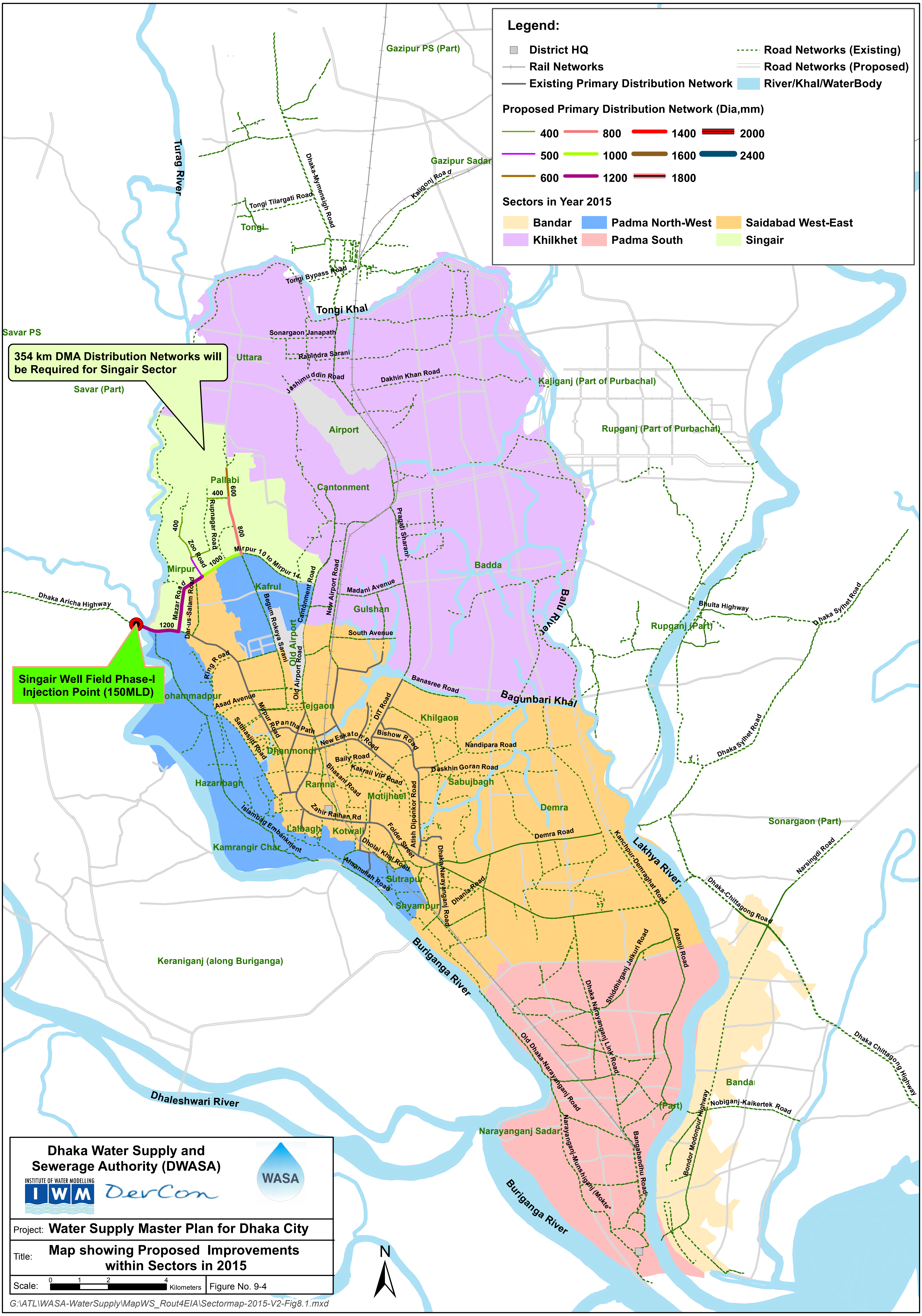
In order to transmit the water from the SWTP primary distribution mains will be required. Under the current Master Plan feasibility study has been conducted for Padma North-West primary distribution, Khilkhet primary distribution and the Saidbad Phase-III primary distribution. The transmission system for Singair has been done under the Singair Well Field Phase-I study. The primary distributions that will be required by 2020 are shown in Table 9-5. DMA distribution will also be required in the sectors that will be served by the new sources. Under the DWSSDP already work is in progress for some areas of the City. The establishment of DMA has to be completed in tandem with primary distribution implementation. Table 9-5 shows that Saidabad West-East sector has the highest length of DMA distribution pipelines. The sector is currently served by Saidabad SWTP and serves the central part of the City. Figure 9-4 & Figure 9-5 shows proposed improvements in the short- term plan.

Table 9-5: Primary and DMA Distribution in the Short-Term Plan

Year	Primary Distribution (km)	DMA Distribution (km)	Sector Name
2015	46.22	824	Saidabad West-East
2020	57.53	381	
2015	52.86	354	Singair
2020	41.54	606	Padma North-West
2020	98.35	685	Khilkhet

Following is the list of institutional measures that will be required within this period.

- Implementation of revised tariff structure
- Institutional Reform to address 'Sectorization'
- Policy and regulatory reform:
- Development of Enterprise Resource Planning (ERP) System
    - Development of GIS system
    - Development of Asset management system
- Human Resource Development
- Communication system establishment
- Water for Urban Poor
- Private Sector Partnership
- Strengthening the Water Quality Lab - It is recommended that simple Laboratory Information Management System (LIMS) software is used, whereby all data will be documented properly for reporting, interpreting data to the authority, policymaker, scientist, etc. for present and future actions of good water management.
- Development of good monitoring program including SCADA


Legend:
District HQ
Rail Networks
Existing Primary Distribution Network
Road Networks (Existing)
Road Networks (Proposed)
River/Khal/WaterBody
Proposed Primary Distribution Network (Dia,mm)
400
500
600
800
1000
1200
1400
1600
1800
2000
2400
Sectors in Year 2015
Bandar
Khilkhet
Padma North-West
Padma South
Saidabad West-East
Singair
354 km DMA Distribution Networks will be Required for Singair Sector
Singair Well Field Phase-I Injection Point (150MLD)
Gazipur PS (Part)
Gazipur Sadar
Turag River
Tongi Tilargati Road
Dhaka-Mymensigh Road
Kaligonj Road
Tongi
Tongi Bypass Road
Tongi Khal
Savar PS
Savar (Part)
Uttara
Sonargaon Janapath
Rabindra Sarani
Jashimuddin Road
Dakhin Khan Road
Kaliganj (Part of Purbachal)
Rupganj (Part of Purbachal)
Airport
Cantonment
Pallabi
Rupnagar Road
Zoo Road
Mirpur
Mirpur 10 to Mirpur 14
Pragati Sharani
Badda
Balu River
Dhaka Aricha Highway
Mazar Road
Dar-us-Salam Road
Kafrul
Begum Rokeya Sarani
Cantonment Road
New Airport Road
Madani Avenue
Gulshan
Old Airport
Old Airport Road
South Avenue
Bhulta Highway
Dhaka Sylhet Road
Rupganj (Part)
Ring Road
Mohammadpur
Asad Avenue
Tejgaon
Banasree Road
Bagunbari Khal
Mirpur Road
Pantha Path
Satmasjid Road
Dhanmondi
New Eskaton Road
DIT Road
Khilgaon
Bishow Road
Nandipara Road
Baily Road
Kakrail VIP Road
Daskhin Goran Road
Sabujbagh
Hazaribagh
Bhasani Road
Ramna
Motijheel
Zahir Raihan Rd
Atish Diponkor Road
Demra
Demra Road
Sonargaon (Part)
Narsingdi Road
Islambag Embankment
Lalbagh
Kotwali
Kamrangir Char
Dholai Khal Road
Folder Street
Kanchpur-Demraghat Road
Lakhya River
Dhaka-Chittagong Road
Ahsanullah Road
Sutrapur
Dhaka-Narayanganj Road
Dhania Road
Shyampur
Buriganga River
Keraniganj (along Buriganga)
Shiddhirganj Jalkuri Road
Adamji Road
Dhaka Narayanganj Link Road
Old Dhaka-Narayanganj Road
Dhaka Chittagong Highway
Bandar
(Part)
Nobiganj-Kaikertek Road
Dhaleshwari River
Narayanganj Sadar
Narayanganj-Munshiganj (Mokte
Bangabandhu Road
Bondor Modonpur Highway
Dhaka Water Supply and Sewerage Authority (DWASA)
INSTITUTE OF WATER MODELLING
IWM
DevCon
WASA
Project: Water Supply Master Plan for Dhaka City
Title: Map showing Proposed Improvements within Sectors in 2015
Scale: 0 1 2 4 Kilometers
Figure No. 9-4
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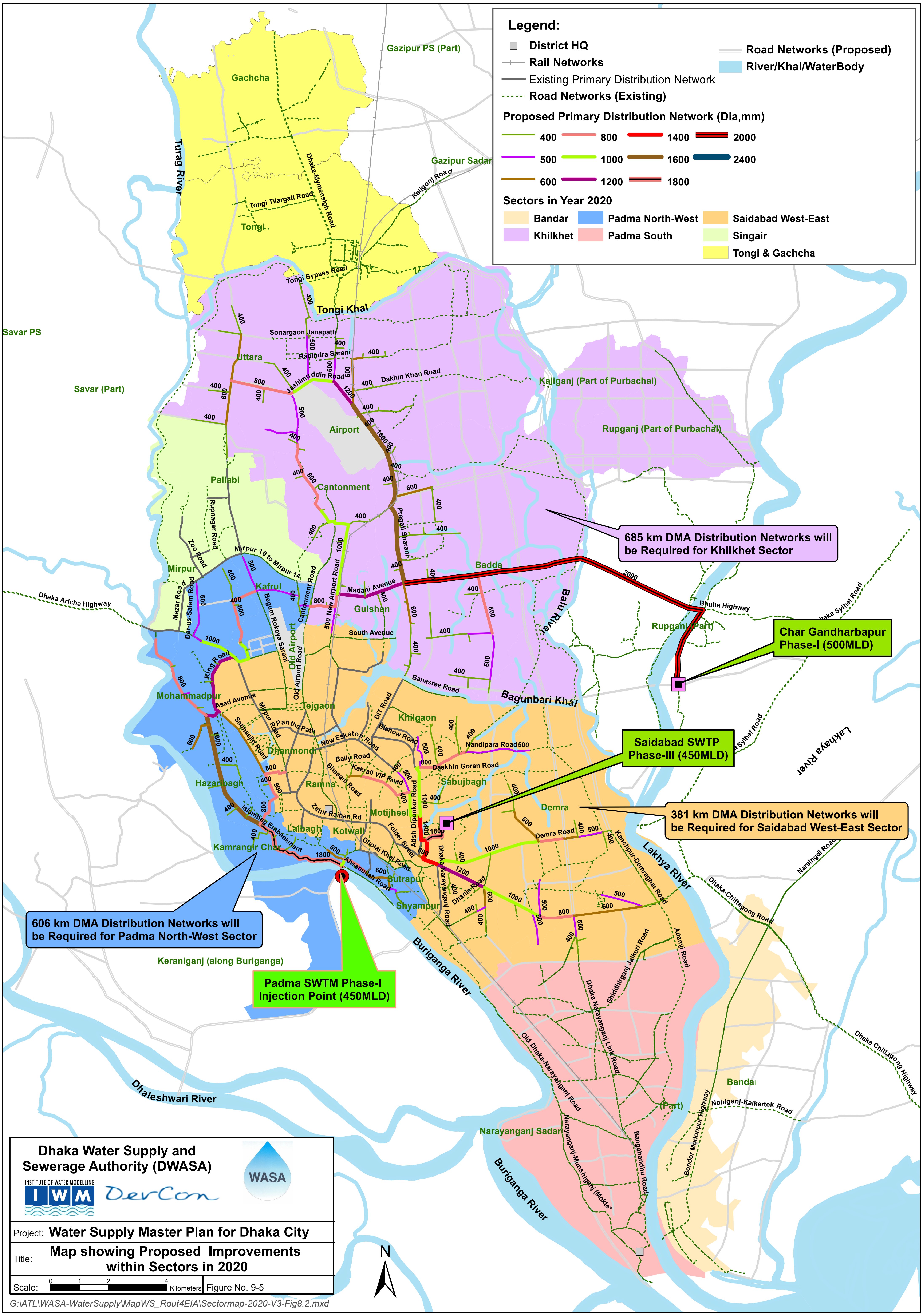

Legend:
District HQ
Rail Networks
Existing Primary Distribution Network
Road Networks (Existing)
Road Networks (Proposed)
River/Khal/WaterBody
Proposed Primary Distribution Network (Dia,mm)
400 800 1400 2000
500 1000 1600 2400
600 1200 1800
Sectors in Year 2020
Bandar
Padma North-West
Saidabad West-East
Khilkhet
Padma South
Singair
Tongi & Gachcha
685 km DMA Distribution Networks will be Required for Khilkhet Sector
Char Gandharbapur Phase-I (500MLD)
Saidabad SWTP Phase-III (450MLD)
381 km DMA Distribution Networks will be Required for Saidabad West-East Sector
606 km DMA Distribution Networks will be Required for Padma North-West Sector
Padma SWTM Phase-I Injection Point (450MLD)
Gazipur PS (Part)
Gachcha
Gazipur Sadar
Turag River
Tongi
Tongi Khal
Savar PS
Savar (Part)
Uttara
Airport
Cantonment
Pallabi
Mirpur
Kafrul
Gulshan
Badda
Kaliganj (Part of Purbachal)
Rupganj (Part of Purbachal)
Rupganj (Part)
Balu River
Bagunbari Khal
Mohammadpur
Tejgaon
Khilgaon
Dhanmondi
Hazaribagh
Ramna
Sabujbagh
Motijheel
Demra
Lalbagh
Kotwali
Kamrangir Char
Sutrapur
Shyampur
Lakhya River
Lakhaya River
Buriganga River
Keraniganj (along Buriganga)
Dhaleshwari River
Narayanganj Sadar
Bandar
Dhaka Aricha Highway
Dhaka-Chittagong Road
Dhaka Chittagong Highway
Dhaka Water Supply and Sewerage Authority (DWASA)
INSTITUTE OF WATER MODELLING
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DevCon
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Title: Map showing Proposed Improvements within Sectors in 2020
Scale: 0 1 2 4 Kilometers
Figure No. 9-5
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9.6 Medium-term Plan

The Medium-term period starts from 2021 and in order to be consistent with Dhaka Sewerage Master Plan (2011-2035) it is considered up to 2035. All the projects are extension of projects considered in the short term period. So preliminary assessment of these projects have been carried out, but the projects will require further study few years before implementation. However, it is expected that water demand in Padma sector will be high by 2030. In Singair sector water demand will also increase significantly. Moreover, large volumes of water will required for Khilkhet sector after year 2030. Tongi & Gachcha and Bandar sectors' water demands will also rise considerably. Hence, a number of stable sources of water supply will be required in this time period.

Table 9-6: Expected Demand in different Sectors in the Medium-term Plan

Sector	Area (sq.km.)			Demand (MLD)			Available SW Source (MLD) till 2020
	2025	2030	2035	2025	2030	2035	
Padma North-West	47.3	50.9	50.9	567	625	700	450
Padma South	62.0	87.4	87.4	331	561	681	-
Singair	23.4	23.4	23.4	302	341	394	-
Saidabad West-East	111.3	106.5	106.5	1,159	1,161	1,284	900
Khilkhet	162.0	199.0	199.0	906	1,217	1,610	500
Bandar	23.2	32.0	32.0	110	144	192	-
Rupganj	0.0	51.4	51.4	0	64	77	-
Tongi & Gachcha	60.1	60.1	60.1	224	270	330	-
Airport*	6.3	6.3	6.3	-	-	-	-
Total	**496**	**617**	**617**	**3,598**	**4,383**	**5,268**	

**Note: Demand for this area will be met by Civil Aviation Authority*

Singair Phase-II Project is considered the earliest to be implemented by 2025 in order to meet supply-demand gap in the Sector. In 2030 two additional sources with a combined capacity of 950 MLD will be required to the meet the growing demand of the Padma South and Khilkhet sectors. It is anticipated that by 2035 DWASA service area will increase to peripheral regions of the City and to serve these additional areas new plants will be constructed (Char Gandharbapur Phase-III). Planned projects for the Mid-term period I (2021-2035) are shown in Table 9-7.

Table 9-7: Sources of Supply in the Mid Term Plan

Year	Source of Supply	Amount of Supply (MLD)	Sector Name
2025	Singair Well Field Phase-II	150	Singair
2030	Padma SWTP Phase-II	450	Padma South
2030	Char Gandharbapur SWTP Phase-II	500	Khilkhet
2035	Char Gandharbapur Phase-III	500	Khilkhet, Rupganj, Bandar, Tongi & Gachcha

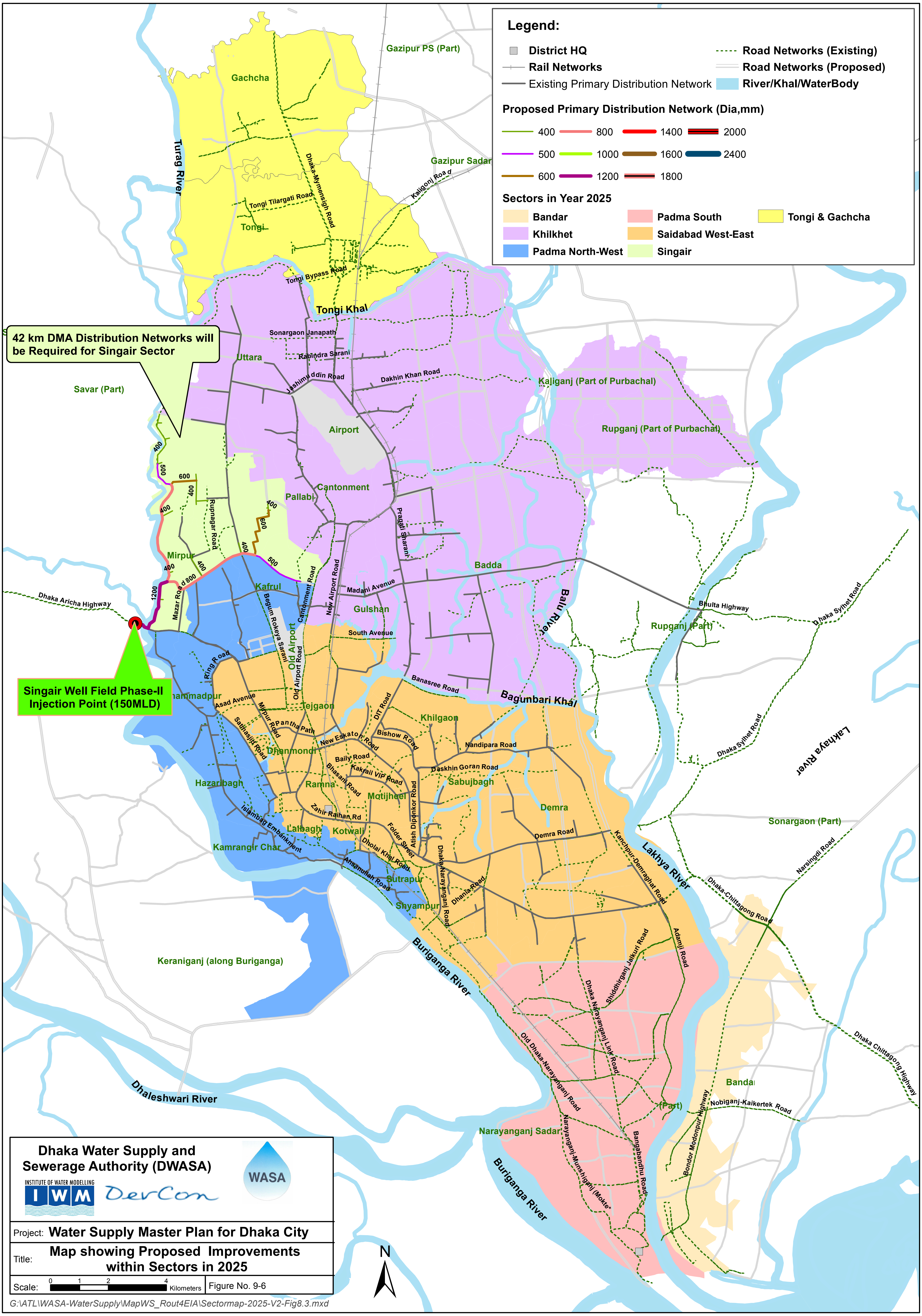
The transmission for Padma SWTP Phase-II will serve the southern part of the City, i.e. Demra, Narayanganj, etc. which requires significant distribution system to be developed. Highest amount of primary distribution will be required during the implementation of Gandharbapur Phase-III as it will have to serve Tongi and Gachcha area from Gandharbapur SWTP Phase-III. Table 9-8 shows the primary and DMA distribution pipelines that will be required within the mid-term period and their respective sectors. Figure 9-6, Figure 9-7 & Figure 9-8 show proposed improvements in the mid-term plan. Figure 9-9 shows proposed improvements for all sectors between 2015 and 2035.

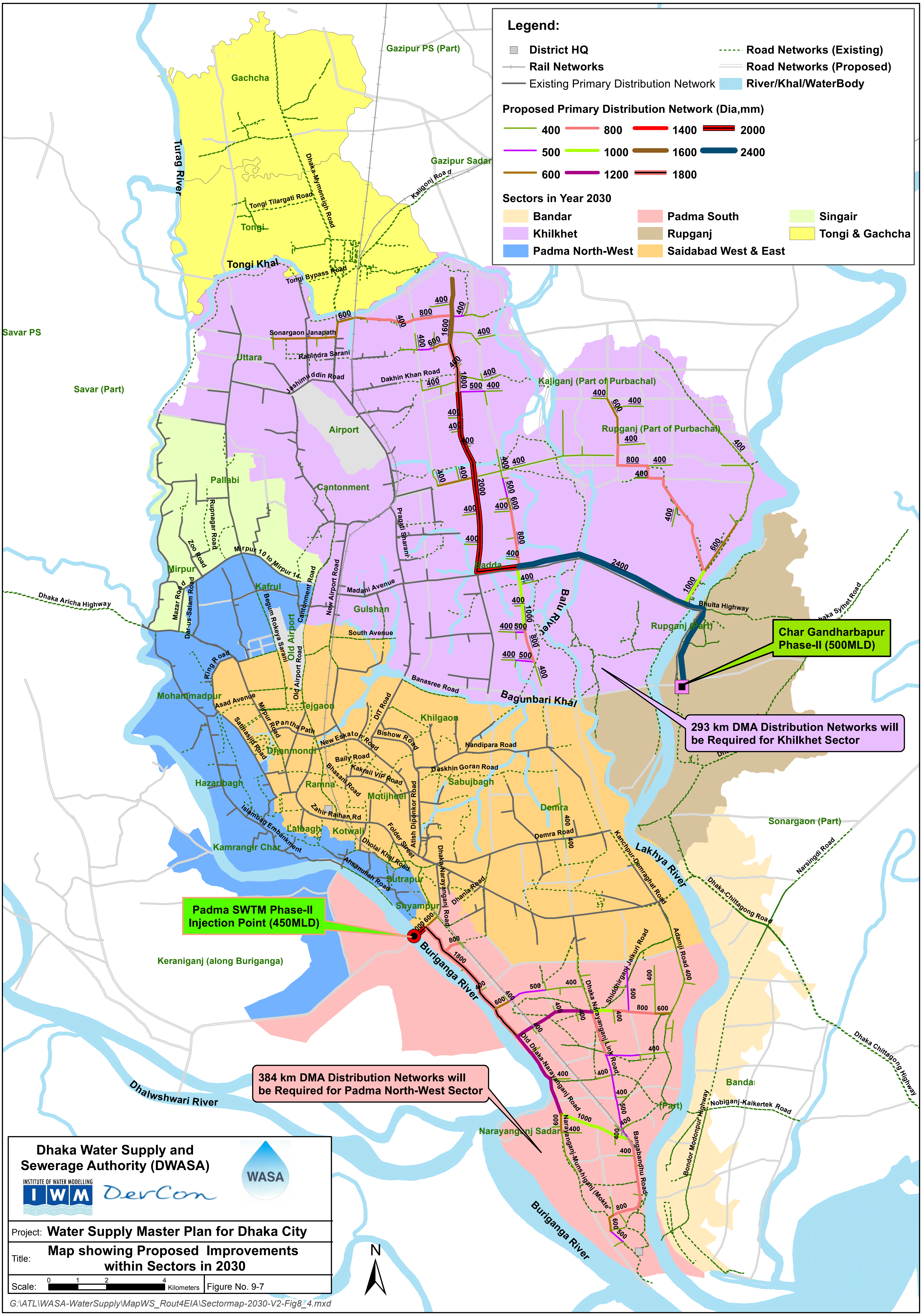
Table 9-8: Primary and DMA Distribution the Mid-Term Plan

Year	Primary Distribution (km)	DMA Distribution (km)	Sector Name
2025	41.00	42	Singair
2030	57.42	384	Padma South
2030	81.44	293	Khilkhet
2035	94.63	306	Khilkhet, Rupganj, Bandar, Tongi & Gachcha

Following is the list of institutional measures that will be required within this period.

- Upgrading the Enterprise Resource Planning (ERP) System
- Improve communication system for better customer support
- Establishing periodic water quality monitoring system in the distribution system
- Development of good monitoring program including SCADA for better operations


Legend:
District HQ
Rail Networks
Existing Primary Distribution Network
Road Networks (Existing)
Road Networks (Proposed)
River/Khal/WaterBody
Proposed Primary Distribution Network (Dia,mm)
400
800
1400
2000
500
1000
1600
2400
600
1200
1800
Sectors in Year 2025
Bandar
Padma South
Tongi & Gachcha
Khilkhet
Saidabad West-East
Padma North-West
Singair
42 km DMA Distribution Networks will be Required for Singair Sector
Singair Well Field Phase-II Injection Point (150MLD)
Gachcha
Gazipur PS (Part)
Gazipur Sadar
Turag River
Tongi Tilargati Road
Dhaka-Mymensingh Road
Kaligonj Road
Tongi
Tongi Bypass Road
Tongi Khal
Sonargaon Janapath
Rabindra Sarani
Uttara
Jashimuddin Road
Dakhin Khan Road
Kaliganj (Part of Purbachal)
Rupganj (Part of Purbachal)
Savar (Part)
Airport
Cantonment
Pallabi
Rupnagar Road
Pragati Sharani
Mirpur
Badda
Kafrul
Begum Rokeya Sarani
Cantonment Road
New Airport Road
Madani Avenue
Gulshan
Bali River
Dhaka Aricha Highway
Mazar Road
Bhulta Highway
Dhaka Sylhet Road
Rupganj (Part)
South Avenue
Old Airport
Old Airport Road
Ring Road
Banasree Road
Bagunbari Khal
Mohammadpur
Asad Avenue
Tejgaon
Mirpur Road
Satmasjid Road
Pantha Path
DIT Road
Khilgaon
New Eskaton Road
Bishow Road
Nandipara Road
Dhanmondi
Baily Road
Kakrail VIP Road
Daskhin Goran Road
Sabujbagh
Lakhya River
Hazaribagh
Ramna
Bhasani Road
Motijheel
Demra
Sonargaon (Part)
Zahir Raihan Rd
Atish Diponkor Road
Islambag Embankment
Lalbagh
Kotwali
Folder Street
Demra Road
Kanchpur-Demraghat Road
Lakhya River
Narsingdi Road
Kamrangir Char
Dholai Khal Road
Ahsanullah Road
Sutrapur
Dhaka-Narayanganj Road
Dhania Road
Dhaka-Chittagong Road
Shyampur
Buriganga River
Shiddhirganj Jalkuri Road
Adamji Road
Keraniganj (along Buriganga)
Dhaka Narayanganj Link Road
Old Dhaka-Narayanganj Road
Dhaka Chittagong Highway
Bandar
Dhaleshwari River
(Part)
Nobiganj-Kaikertek Road
Narayanganj Sadar
Narayanganj-Munshiganj (Mokte
Bangabandhu Road
Bondor Modonpur Highway
Buriganga River
Dhaka Water Supply and Sewerage Authority (DWASA)
INSTITUTE OF WATER MODELLING
IWM
DevCon
WASA
Project: Water Supply Master Plan for Dhaka City
Title: Map showing Proposed Improvements within Sectors in 2025
Scale: 0 1 2 4 Kilometers
Figure No. 9-6
N
G:\ATL\WASA-WaterSupply\MapWS_Rout4EIA\Sectormap-2025-V2-Fig8.3.mxd



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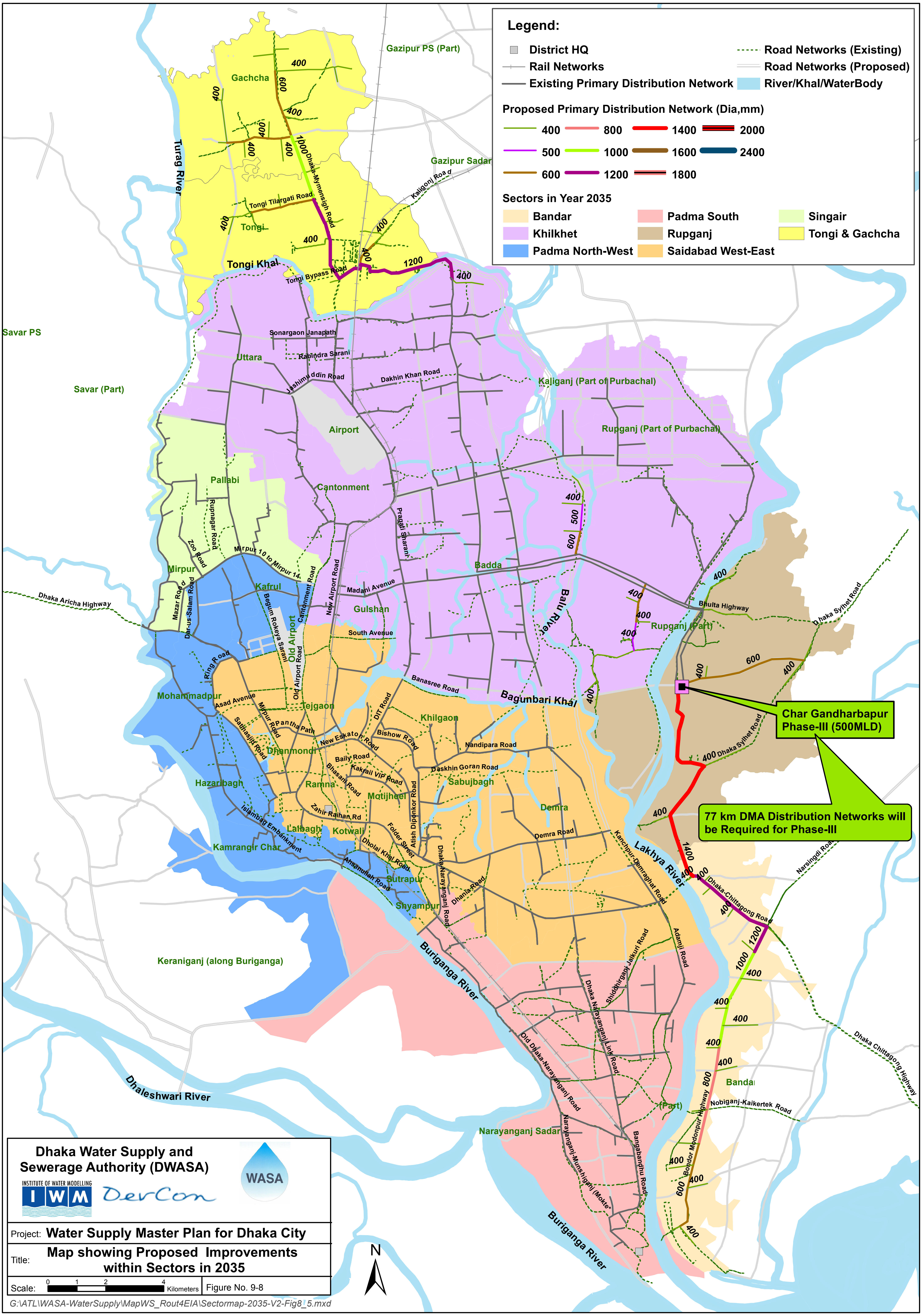

Dhaka Water Supply and Sewerage Authority (DWASA)

INSTITUTE OF WATER MODELLING IWM DevCon WASA

Project: **Water Supply Master Plan for Dhaka City**

Title: **Map showing Proposed Improvements within Sectors in 2035**

Scale: 0 1 2 4 Kilometers | Figure No. 9-8

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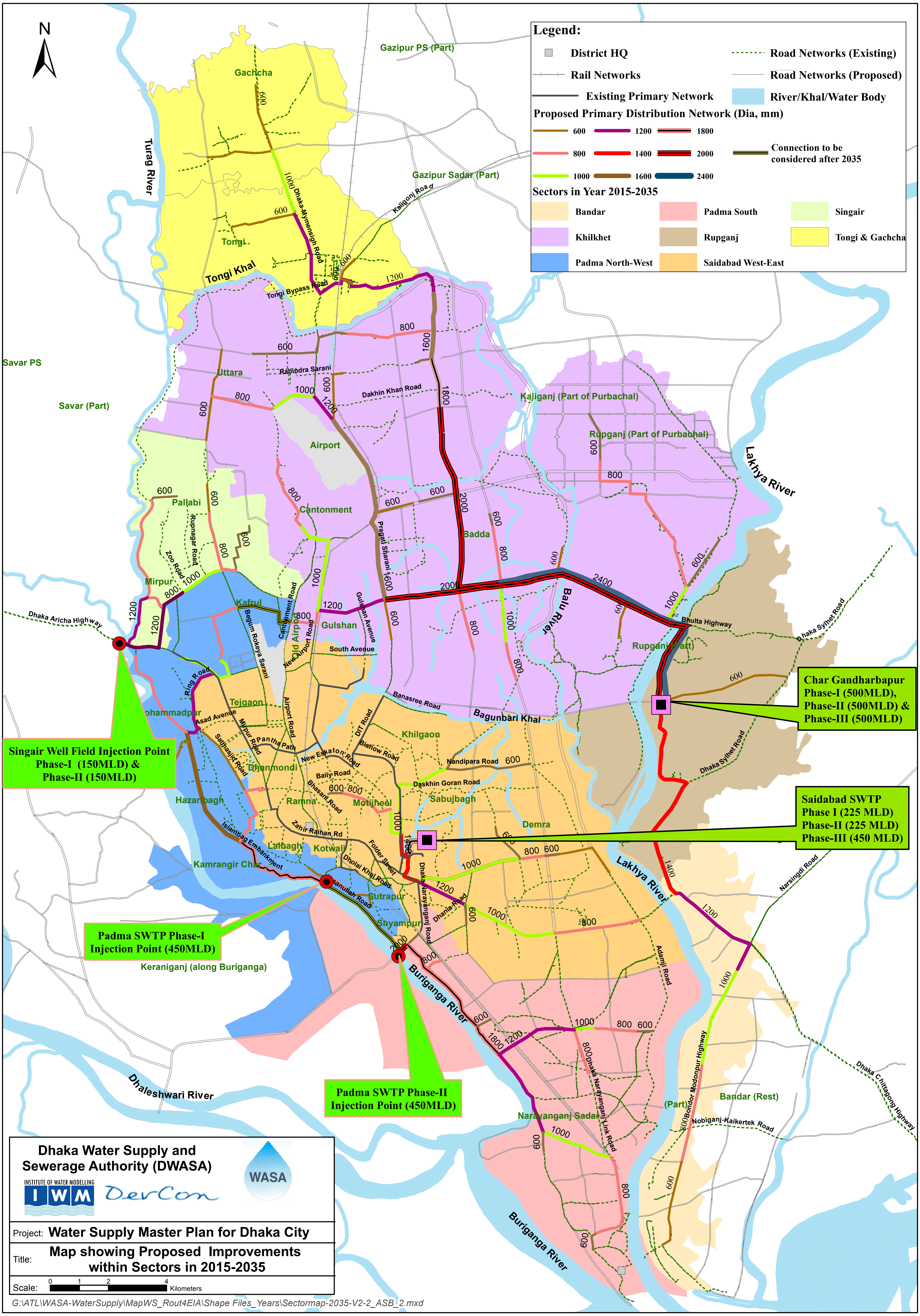

Legend:
District HQ
Rail Networks
Existing Primary Network
Road Networks (Existing)
Road Networks (Proposed)
River/Khal/Water Body
Proposed Primary Distribution Network (Dia, mm)
600
1200
1800
800
1400
2000
1000
1600
2400
Connection to be considered after 2035
Sectors in Year 2015-2035
Bandar
Padma South
Singair
Khilkhet
Rupganj
Tongi & Gachcha
Padma North-West
Saidabad West-East
Char Gandharbapur Phase-I (500MLD), Phase-II (500MLD) & Phase-III (500MLD)
Saidabad SWTP Phase I (225 MLD) Phase-II (225 MLD) Phase-III (450 MLD)
Singair Well Field Injection Point Phase-I (150MLD) & Phase-II (150MLD)
Padma SWTP Phase-I Injection Point (450MLD)
Padma SWTP Phase-II Injection Point (450MLD)
Gachcha
Tongi
Tongi Khal
Turag River
Gazipur PS (Part)
Gazipur Sadar (Part)
Savar PS
Savar (Part)
Uttara
Airport
Pallabi
Mirpur
Cantonment
Badda
Gulshan
Kafrul
Tejgaon
Mohammadpur
Dhanmondi
Hazaribagh
Ramna
Motijheel
Sabujbagh
Khilgaon
Demra
Lalbagh
Kotwali
Kamrangir Char
Sutrapur
Shyampur
Keraniganj (along Buriganga)
Kaliganj (Part of Purbachal)
Rupganj (Part of Purbachal)
Rupganj (Part)
Lakhya River
Balu River
Bagunbari Khal
Buriganga River
Dhaleshwari River
Narayanganj Sadar
Bandar (Rest)
Dhaka Aricha Highway
Dhaka Sylhet Road
Bhulta Highway
Narsingdi Road
Dhaka Chittagong Highway
Dhaka-Mymensigh Road
Tongi Bypass Road
Kaligonj Road
Dhaka Water Supply and Sewerage Authority (DWASA)
INSTITUTE OF WATER MODELLING
IWM
DevCon
WASA
Project: Water Supply Master Plan for Dhaka City
Title: Map showing Proposed Improvements within Sectors in 2015-2035
Scale: 0 1 2 4 Kilometers
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9.7 Long-term Plan

For the period 2035 to 2060, a more qualitative assessment has been undertaken. The approach focused on how much change may occur in the total demand (and required production capacity) for the service area in different scenarios. As discussed in the Demand Assessment section, the likely scenario is that there will be approximately 50% growth in demand. As a result, an additional 2,650 MLD production capacity will be required by 2060. The possible sources of water, along with estimated costs are provided in Table 9-9. If the future conditions of the peripheral rivers improve then the Lakhya and Buriganga Rivers could be cost effective sources. It is recommended that the Padma River should be utilized as a long-term source. Therefore, DWASA should seek to purchase suitable land areas near the Lakhya, Buriganga and Padma Rivers that can be used for locating future surface water treatment plants and transmission mains, if necessary.

Table 9-9: Long-term Supply Sources up to 2060

Sl.	Long-term Water Supply Option	Capacity (MLD)	Estimated Cost (Million USD)	Estimated Cost (Million Taka)	Basis of Cost
1.	Padma Phase-III	900	1,073	85,841	Padma Phase I and II
2.	Padma Phase-IV	450	537	42,921	Padma Phase I and II
3.	Lakhya Phase-I	500	719	57,540	Gandharbapur Phase I
4.	Lakhya Phase-II	500	719	57,540	Gandharbapur Phase I
5.	Buriganga Phase-I	300	432	34,524	Gandharbapur Phase I
	Total	**2,650**	**3,480**	**278,366**	

It is expected that in future reviews and updates of the Water Supply Master Plan the identified supply sources will be considered in more detail. The main aim of identifying projects this far into the future is to assist in the identification of potential land purchases, right of way and integration with other sectoral plans.

9.8 Water Safety Plan

9.8.1 Introduction

The “Water Supply Master Plan of Dhaka City” is not only focused on the provision of sufficient water to the city inhabitants but also this Master Plan is devised to provide safe water to ensure better health of the city population. To ensure safe water supply to the consumers, developing an effective safety management plan is a must. Therefore, a water safety plan (in brief) is prepared for the water supply system of Dhaka city.

The concept of comprising water safety plan in water supply projects has become a regular practice in Bangladesh since 2004 when WHO issued the 3rd edition of their guidelines for drinking water quality, illustrating that water safety plan should be introduced in all water supplies as a key component of water safety management. So far, Department of Public Health Engineering (DPHE) along with NGOs have prepared several water safety plans in different projects. Those safety plans were focused on rural water supply or small urban systems. In continuation of these previous plans “Water Supply Master Plan of Dhaka City” introduces water safety plan for a dedicated urban system like Dhaka.

9.8.2 Identification of Risks & Control Measures

Water safety plan is basically the principle that aims to secure safe drinking water from source to the consumer. The water safety plan under the scope of this Master Plan accounts for all the risks of contamination from source level to the house connection level and provides means of controlling the risks identified. In addition to that, a proper action plan with effective monitoring has been proposed to make the control measures feasible.

Developing a water safety plan includes identification and control of all the potential risks that can take place in every stage of the system and interruptions to the proper and safe water supply to the consumer. In a city like Dhaka risks can arise at four stages:

- At source
    - Surface water
    - Groundwater
- During treatment process
- Within distribution network
- At customer level

In the following tables potential risks and their control measures are discussed in detail.

Risks & control measures at source level

Risk/Interruption	**Control measure**
A. Surface water source	
Microbiological contamination of raw water as a result of no restriction in access to source	Intake of raw water sources need to declared as pollution control zone by DoE & DWASA.
Contamination of raw water with sewage	Sewerage system should be improved within service area and both domestic and industrial sewage should be disposed after proper treatment
Contamination as a result of waste disposal site within watershed.	Waste disposal should be restricted, otherwise intake point needs to be shifted.
Chemical contamination of raw water as a result of proximity to transport corridor and recreational activity.	River traffic should be limited in the vicinity of raw water sources.
Contamination of water with nutrients, pathogens and pesticides due to agricultural activity.	Treatment process at treatment plants should be adjusted considering these pathogens and pesticides.
Insufficient raw water quantity	Intake should be shifted to new place having adequate raw water supply.
B. Groundwater source	
Contamination due to insecure covering of tubewells	Tubewells should be properly covered by some means to prevent entry of solid wastes or animal excreta.
Deterioration of raw water quality as a result of flooding or heavy rain	Upper well casing pipe should be raised above high flood level.
Insufficient water available for abstraction	Alternate source should be explored.
Contamination of well during construction	Drillers should operate according to the water regulations and circulation should be done with pure water.
Contaminated water entering well from upper levels and surface	Sanitary sealing with puddle clay and cement concrete should be done surrounding the well casing.
Deterioration of water quality due to over extraction from aquifer	Over extraction should be prohibited.
Partial contamination of aquifer	Source should be shifted to alternate location. Regular water quality testing should be maintained.

Risk/Interruption	Control measure
Failure of pumps at Pump Station or loss of power to pumps as a result of electrical fault.	Pumps or control panels should be replaced or repaired as soon as possible.
Failure of electricity	Provision of standby generator should be ensured.
Oil contaminating water due to use of unacceptable pump lubricants.	All pumps should use lubricants as specified by manufacturer. Regular checking required by Head Office engineers.
Failure of pumps due to flooding	Pumps and electrical equipments should be installed above high flood level.

Risks & control measures at treatment level

Risk/Interruption	Control measure
Inadequate dosing of alum and other chemicals	Mixing of chemicals should be monitored properly and if possible, installation of automation system for chemical mixing.
Failure to maintain recommended filtration rate	Proper filter wash and backwash should be done depending on the condition.
Irregular maintenance of mechanical electrical installation	Regular maintenance according to O & M manual is needed.
Deterioration in water quality due to disturbance of sediment in reservoir	Reservoirs should be cleaned and inspected on a regular basis.
Loss of supply due to inadequate storage	Reservoirs of sufficient storage capacity should be constructed.

Risks & control measures at network level

Risk/Interruption	Control measure
Loss of pressure as a result of leakage and other losses	If system leakage rates are high, a leakage control program is recommended. DMA should be developed throughout the service area.
Buildup of deposits in network as a result of inadequate flushing frequency and/or velocity	Regular cleaning of the network via washout valves is necessary
Broken main as a result of PRV failure	PRVs should be serviced as soon as possible
Loss of supply and/or deterioration of water quality as a result of broken main	Need to be repaired as soon as possible. After repairing works, flushing and disinfection of that particular portion is necessary.
Contamination of water due to leaking air valves	Air valves should be checked periodically.
Contamination of water in supply as a result of the use of non-approved or inappropriate materials in the network	Any materials used in the network should comply with the appropriate standard.
Contamination of water due to failure to follow proper hygiene practice when carrying out repairs	Plumbers should be fully trained in proper hygiene practice.
Contamination of water in supply as a result of connection to mothballed or abandoned assets.	All abandoned assets should be cut and plugged off.
Deterioration of water quality as a result of incorrect sequence of valve operations	Valves should be maintained and records of their location and operation should be kept.
Deterioration of water quality in supply as a result of unauthorized connection to the network	Unauthorized connections should be minimized. In this respect proper monitoring and awareness campaign is necessary.
Failure to meet demand as a result of failure of pipe bridge	Pipe bridge structures should be checked regularly.
Failure to meet demand as a result of breaks caused by age-related deterioration.	Planned maintenance and rehabilitation of old pipes are necessary.
Iron discoloration in water as a result of metal pick-up	Pipes of appropriate material e.g. PVC should be

Risk/Interruption	Control measure
from the mains material	used.
Loss of supply as a result of failure of critical main due to lack of alternative supply	Damaged main should be replaced at the earliest. Alternative supply needs to provided by water carriers.
Microbiological growth in distribution system as a result of oversized mains and low disinfectant residual	Post-chlorination is necessary during supplying water to the network and oversized mains should be replaced with appropriate size.
Contamination of water during flooding due low pressure in the network.	Sufficient pressure should be maintained in the portion of the network affected by flood.
Contamination of water as a result of sediment deposition in reservoirs	Reservoirs should be emptied, inspected and cleaned on a regular basis.
Contamination of water due to poor hygiene practice when doing planned inspection or maintenance	Operators should be fully trained in proper hygiene practice

Risks & control measures at customer level

Risk/Interruption	Control measure
Contamination of water due to reduction in disinfectant levels resulting from long residence time of water in reservoirs	Reservoirs at house level should be emptied regularly.
Contamination of water in supply or pressure problems as a result of leaking service pipe	Leakage repairing activity should be done immediately with appropriate materials.
Contamination of water in supply as a result of unsatisfactory or damaged new connections caused by inadequate installation procedures	Service connections should be provided as per standard process and by trained plumbers.
Contamination of water in supply as a result of back siphonage caused by the lack of appropriate backflow protection	Non-return valve should be installed in every house connection
Pressure problems as a result of leakage caused by corrosion	Pipes should be replaced and flushed with pure water.
Contamination of water in supply as a result of inappropriate plumbing and installation of inappropriate appliances	Plumbers should only use materials and other appliances specified for potable water supply.
Contamination of water as a result of open storage cistern with no lid.	Storage must be leak proof, covered and located at a safe distance from septic tank.
Contamination of water as a result of the poor situation of the storage tank or lack of maintenance	Periodic maintenance should be assured by monitoring cell.
Contamination of water due to damaged or unworkable in-house appliances.	Failed appliances should be replaced with specified appliances.
Contamination of water as a result of inadequate hygiene practice at bulk water filling stations	Water carriers, trolleys and tanks should be cleaned before filling with water. Awareness program needs to be arranged for vendors.

9.8.3 Action Plan

a) DWASA may take some firm actions with the assistance of DOE to deal with the risks than can occur at surface water sources. To prevent the hazards in case of groundwater sources an effective operation and maintenance manual may be prepared. Respective personnel associated with the operation and maintenance of groundwater sources should be trained to follow the manual precisely. In this respect training programs may be arranged. Similarly, to prevent the risks related with water treatment and distribution network maintenance, specific guidelines should be prepared and steps need to be taken for ensuring appropriate implementation of the guidelines.

b) In order to minimize unauthorized connections, DWASA needs to revise the procedure for having water supply connection, considering the convenience of the customers. In the Short-term DWASA should take some initiative to provide more yard connections (stand pipes) in low income communities to minimize illegal connection in those areas. Also frequent awareness campaigns may be arranged to discourage illegal connections.

c) Massive awareness campaign should be arranged through electronic and print media to counteract the risks involved with improper hygiene practice at consumer level. Besides this, trained and expert plumbers should be engaged to provide service connections. Existing water quality monitoring system at consumer level needs to be upgraded by engaging more trained personnel with advanced equipments. Also, frequency of monitoring in every households need to be increased.

9.8.4 Monitoring of Control Measures

For successful implementation of the control measures effective monitoring is essential. DWASA presently have some monitoring body such as system control cell, zonal control cell, wastewater control cell, etc. but most of them are nearly inactive and inefficient in their operation. DWASA needs to reorganize these monitoring bodies with more manpower and advanced technologies to enhance customization and micro level monitoring. Formation of a strong administrative body to look after the activities of different monitoring cells is also necessary. Formation of local body monitoring by active participation of consumers in different communities, in association with an effective DWASA helpline can play a key role to implement control measures effectively.

9.9 Action Plan and Targeted Dates

The action plan, with target dates, under this Master Plan are provided in Table 9-10 and Table 9-11.

Table 9-10: Action Plan and Targeted Dates for Works

Sl. No.	Activity	Time Frame	Costs (million USD)	Remarks
1	DTW performance Assessment and future recommendations for sectors	2014 - 2025	0.6	Availability of surface water source need to ensured
2	Construction of intake for Godnail WTP	Ongoing	5	Timely completion, successful operation and improvement in intake water quality are important
3	Renovation of Sonakanda WTP & primary and secondary mains	Ongoing	20	Timely completion, successful operation and improvement in intake water quality are important
4	Implementation of Singair Well Field Phase-I & primary and secondary mains; expansion of distribution network	2013-2017	105.1	Funding arrangements have to be ensured

Sl. No.	Activity	Time Frame	Costs (million USD)	Remarks
5	Shifting of intake for of Chandnighat WTP from Buriganga to Dhaleshwari	2015-2017	10.4	Water quality of Buriganga river is very low. Therefore, intake of Chadnighat need to shift to Dhaleshwari river to operate WTP at full capacity
6	Implementation of Padma WTP I & primary and secondary mains; expansion of distribution network	2015-2018	554	Finance has been ensured for SWTP and DMA (part);Funding arrangements have to be ensured for primary & secondary mains and DMA (remaining)
7	Implementation of Saidabad WTP III & primary and secondary mains; expansion of distribution network	2016-2018	652	Finance has been ensured for SWTP and DMA (part); Funding arrangements have to be ensured for primary & secondary mains and DMA (remaining)
8	Implementation of Gandharbapur WTP I & primary and secondary mains; expansion of distribution network & establish DMA	2016-2019	729	Finance has been ensured for SWTP and DMA (part); Funding arrangements have to be ensured for primary & secondary mains and DMA (remaining)
9	Implementation of Singair Well Field Phase-II & primary and secondary mains; expansion of distribution network	2023-2025	75.9	Funding arrangements have to be ensured
10	Implementation of Gandharbapur WTP II & primary and secondary mains; expansion of distribution network	2027-2030	719	Funding arrangements have to be ensured
11	Implementation of Padma WTP II & primary and secondary mains; expansion of distribution network	2027-2030	533	Funding arrangements have to be ensured
12	Implementation of Gandharbapur WTP III & primary and secondary mains; expansion of distribution network	2032-2035	720	Funding arrangements have to be ensured
13	Implementation of DMA in Dhaka City phase 2	2016-2020	300	Funding arrangements have to be ensured

Sl. No.	Activity	Time Frame	Costs (million USD)	Remarks
14	Replacement, rehabilitation and optimization of production tube wells	2016-2020	150	Funding arrangements have to be ensured

Table 9-11: Action Plan and Targeted Dates for Services

Sl. No.	Activity	Time frame	Costs (million USD)	Remarks
1	Implementation of revised tariff structure	2014-2016	0.63	Political challenge exists, public awareness has to be raised.
2	Organizational structure for future operation of DWASA		0.75	Organizational restructuring is needed. If private sector is involved then regulatory reform is also required.
3	Institutional reform & regulatory framework for private sector participation	2014-2016	1.25	Have to be in line with DWASA mandate. Sufficient policies to enable partnerships have to be ensured. Regulatory framework is under preparation at Govt. level.
4	Policy & regulatory reforms	2014-2016	0.63	Have to be in line with national policies and regulations. DWASA jurisdiction should be increased in relation with the DMDP boundary and planning & policy should be reformed accordingly.
5	Human resource development and training programmes	2015-2035	5	Human resources development programme should be prepared in line with restructuring of the organization. Local & international training and higher study programmes should be undertaken to improve capacity of the DWASA staffs
6	Development of Enterprise Resource Planning (ERP) System	2014-2017	2	Updating of GIS system. Development Asset management system.
7	Implementation of performance monitoring system (KPI)	Continuous process	-	Adequate organizational setup and accountability are required to ensure proper monitoring
8	DMA operation	Continuous process	-	Capacity building, organizational setup and resources required for DMA operations

Sl. No.	Activity	Time frame	Costs (million USD)	Remarks
9	Ground water monitoring and recharge	Continuous process	-	Ground water should continuous monitored.
10	Strategy for protection of the raw water sources and establishment of pollution control zone	2015-2016	0.75	Enforcement of government regulations and awareness will be required
11	Study for development of drinking water sources by rain water harvesting	2015-2017	0.5	Govt. policy and regulation will be required for implementation.
12	Improvement of Communication system	Continuous process		Internal & external communication must be improved for the improvement of DWASA performance
13	Water for Urban Poor	2014-2017	0.5	Co-ordination with NGOs will be required.
14	Strengthening of the Water Quality Lab	2014-2017	1.5	Capacity building of staff, equipment, budget and Laboratory Information Management System (LIMS) software will be required.
15	Pilot study to develop a good monitoring programme using SCADA	2016-2017	2	Establishment of DMA
16	Water Safety Plan for DWASA	2016-2017	0.5	Govt. policy will encourage adoption within DWASA
17	Update Water Supply Master Plan	2022-2024	2	The Master Plan to be updated based on BBS survey and DWASA consumer survey in 2021
18	Establishment of groundwater monitoring system	2015-2017	0.5	Required for optimizing groundwater abstraction according to the Water Supply Master Plan

9.10 Implementation Plan of Major Projects

The programme shown in Figure 9-10 indicates the implementation plan for the major projects, taking into consideration the prioritisation of works, realistic opportunities for accessing capital funds, capacity of DWASA to absorb the funds, and construction programme constraints.

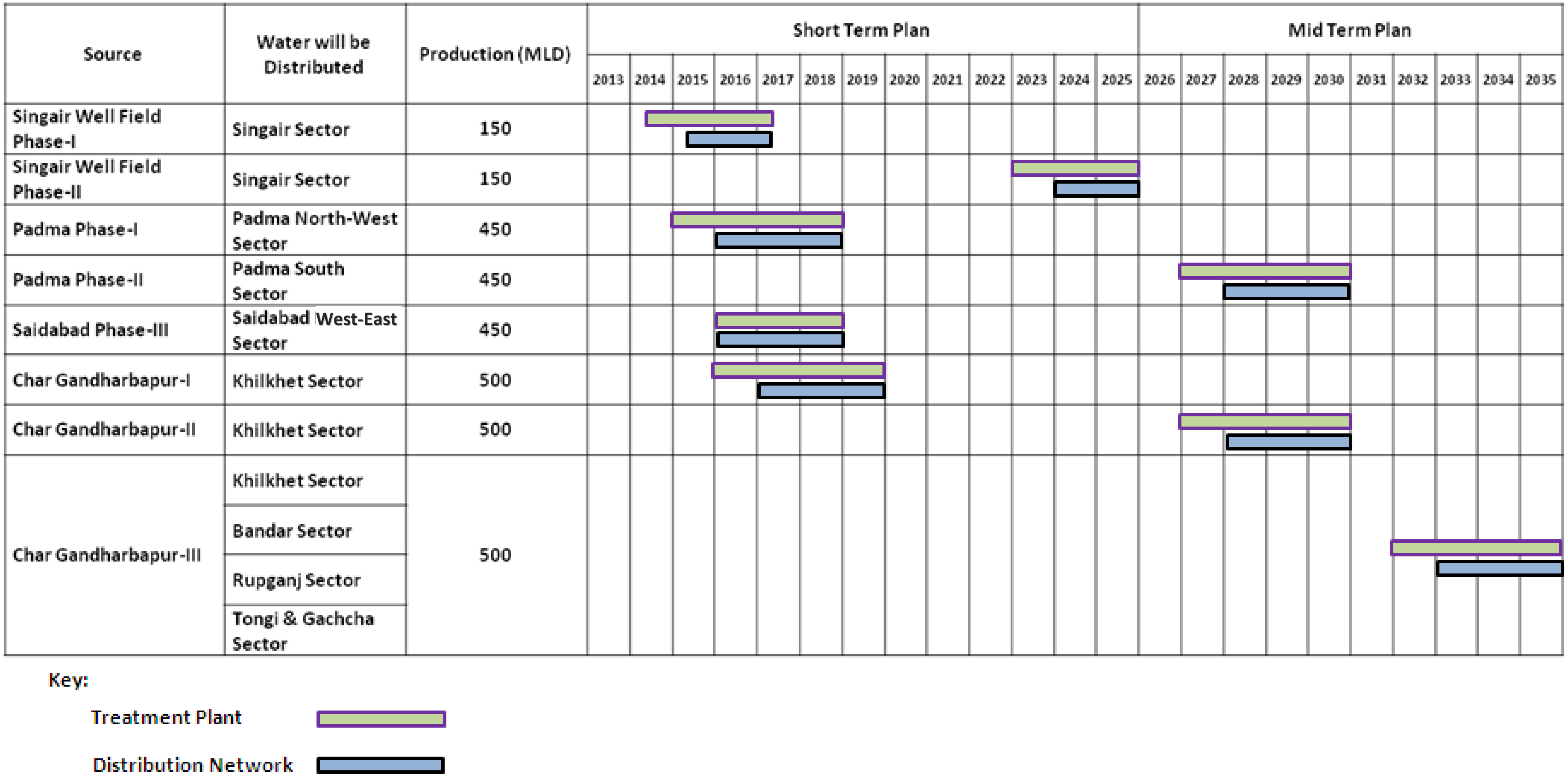


Figure 9-10: Master Plan Implementation Programme of Major Projects

10 Financial Assessment of Master Plan

10.1 Capital Investments Required

The Master Plan has identified projects that will be required to supply water to the City. The major projects that will be required were broadly categorized in the following groups.

- Investment for SWTP
- Investment for primary distribution
- Investment for secondary distribution

For a fully functional and optimized water supply system, some of the proposed projects are interdependent. The Sectors were conceived based on major sources of water. The water from the sources need to be transmitted through primary distribution from the plant to different parts of the City and then distributed to the citizens through DMA distribution.

On the basis of future strategy of DWASA, discussed in the previous section, dependency on groundwater would be reduced. So no major investment was considered for groundwater development in the main city area. The groundwater requirement for future years in different sectors would be met through rehabilitation and maintenance which is described in the following sections.

Table 10-1 provides investments that will be required in the future years for water supply by DWASA. Some of these investments are already in progress as a part of ongoing development. These are DWSSDP which is in implementation phase, Singair Well Field is in tendering phase, Padma SWTP and Gandharbapur SWTP which are in DPP stage and Saidabad Ph-III which is in feasibility stage. Investment plan is already in advanced stage for these projects. The amount of all the investments are calculated in present value and the total amount required up to 2035 is *325 billion BDT or 4.17 billion USD*. Investment requirement envisaged for projects in 2025 and onwards can be updated through a revisit of the Master Plan sometime in the future.

Table 10-1: Year-wise Capital Investment Requirement in Million BDT

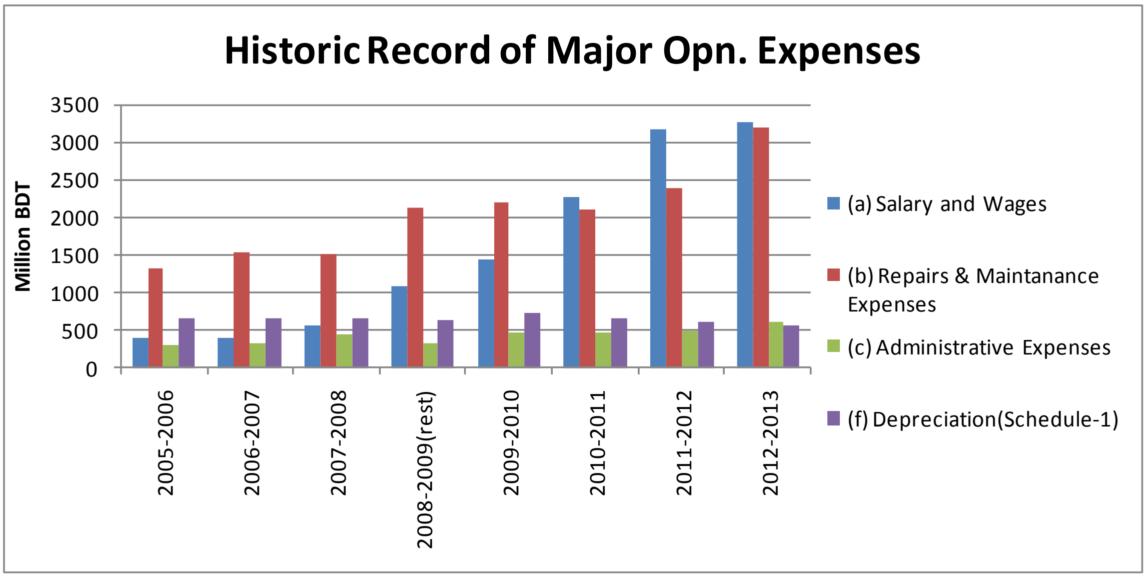
Year	2015	2020	2025	2030	2035
Saidabad I & II DMA Distribution	6,760				
Singair I WF & Primary Dist	5,300				
Singair I DMA Distribution	2,906				
Saidabad III SWTP		43,408			
Saidabad III Primary Dist		3,892			
Saidabad III DMA Distribution		3,126			
Gandharbapur I SWTP		41,367			
Gandharbapur I Primary Dist		9,909			
Gandharbapur I DMA Distribution		5,614			
Gandharbapur II SWTP				42,400	
Gandharbapur II Primary Dist				11,253	
Gandharbapur II DMA Distribution				2,401	
Padma NW SWTP		33,390			
Padma NW Primary Distribution		4,828			
Padma NW DMA Distribution		4,971			
Singair II Wellfield			4,160		
Singair II Primary Dist			1,368		
Singair II DMA Distribution			344		
Padma South SWTP				33,390	
Padma South Primary Distribution				5,037	
Padma South DMA Distribution				3,146	
Gandharbapur III SWTP					42,400
Gandharbapur III Primary Dist					11,253
Gandharbapur III DMA Distribution					2,513
Total Cost	**14,967**	**150,505**	**5,694**	**97,627**	**56,166**

10.2 Cost of Production and Distribution

Cost of production was calculated in previous studies by DWASA. Though it has been termed as cost of production, the calculations included cost associated with both production and distribution. The current study reviewed those reports, which included Performance Improvement Programme (PIP) (2007), Dhaka Water Supply Project (2007) and most recently the ongoing Dhaka Water Supply Sector Development Project (DWSSDP). The methods and assumptions that were considered in the recent study by FCBC as a part of DWSSDP formed the basis of the calculation and were further detailed out where required.

In order to determine the cost of production and distribution it was important understand the historic expenditure. The cost of production is basically the operating expenses to produce the yearly volume of water. The major categories under operating expenses are (i) salary, (ii) repair and maintenance, (iii) administrative and (iv) depreciation. Among these categories, salary is 43%, repair is 42%, administrative is 8% and depreciation is 7% of overall operating expenses according to 2012-13 financial year record.

Figure 10-1 shows the operating expenses and their breakdown from previous years. The salary and wages related expense have several sub-categories which includes basic salary and wages, various allowances, pension and overtime. In the past, overtime was part of administrative expense. This was changed and included under salary and wages in 2008-09 financial year. Under repair and maintenance there are three major categories which are power, chemical and repair maintenance. Among these categories power is 72%, chemical is 5% and repair works is 23% of total repair and maintenance related expense.



Source: DWASA Annual Reports

Figure 10-1: Historic Record of Operating Expenses and their Breakdown

The operating expenses increased over the years and it can be seen that the total expense increased from 2.8 billion BDT in 2005-2006 to 7.7 billion BDT in 2012-13. This indicates the operating expense of DWASA increased almost 3 folds in 7 years time. A comparison can be drawn about the extent operating activities by looking at the number of DTW in operation, which was 440 in 2006 and 644 in 2013.

The above stated figures were total operating expense for DWASA. This includes expenses related to all the three types of services provided by DWASA, which are water, sewer and drainage. In order to determine the cost of production, further breakdown of cost was collected from DWASA to determine the cost of operation for water services. The breakdown was particularly helpful to identify costs associated with repair and maintenance. The breakdown for salary and wages and administrative expenses was not clearly found. The estimation for water related expense by FCBC was also taken into consideration and adjustments were made based on the detailed breakdown. In 2012-13 audit report the total operating expense was found to be 7.7 billion BDT. The operation expense related to water was considered to be 6.6 billion BDT. It has to be mentioned that the expense also included 320 million BDT contributions to DSL and payments to the national exchequer. Table 10-2 shows the cost of production and distribution calculated from 2012-13 audit report and MIS information.

Table 10-2: Cost of Water Production and Distribution

Description	Unit	Quantity
Operation Expense from Audit Report	Lac BDT	76714
Operation Expense related to Water	Lac BDT	65995.9
Average Daily Production	MLD	2267
Total Yearly Production	ML	827455
System Loss	%	23
Distribution after system loss	ML	637140
Cost per unit of Water (1000 Litre)	**BDT**	**10.36**

Source: 2012-2013 audit report and MIS information

As DWASA is planning to shift from GW based water supply system to more SW based system, it is important to understand the cost associated with production from these different sources. Till now, DWASA does not have any separate assessment to determine the cost separately. The financial analysis looked into individual cost of departments and projects of DWASA in order to determine these costs. Based on this individual cost estimation it was be possible to determine and evaluate the cost of production from groundwater, cost production from surface water and the cost to maintain the distribution system. The annual budgets of 2011-12 and 2013-14 were used to do the analysis. There are 74 divisions, major departments and projects within DWASA. These were broadly categorized in 4 groups: water, sewer, drainage and general. The cost of water was then divided in to 3 sub-groups: Groundwater, Saidabad water and distribution line. The costs associated with different departments were distributed among these three groups. The distribution of cost to groundwater, Saidabad water and distribution line is shown in Figure 10-2.

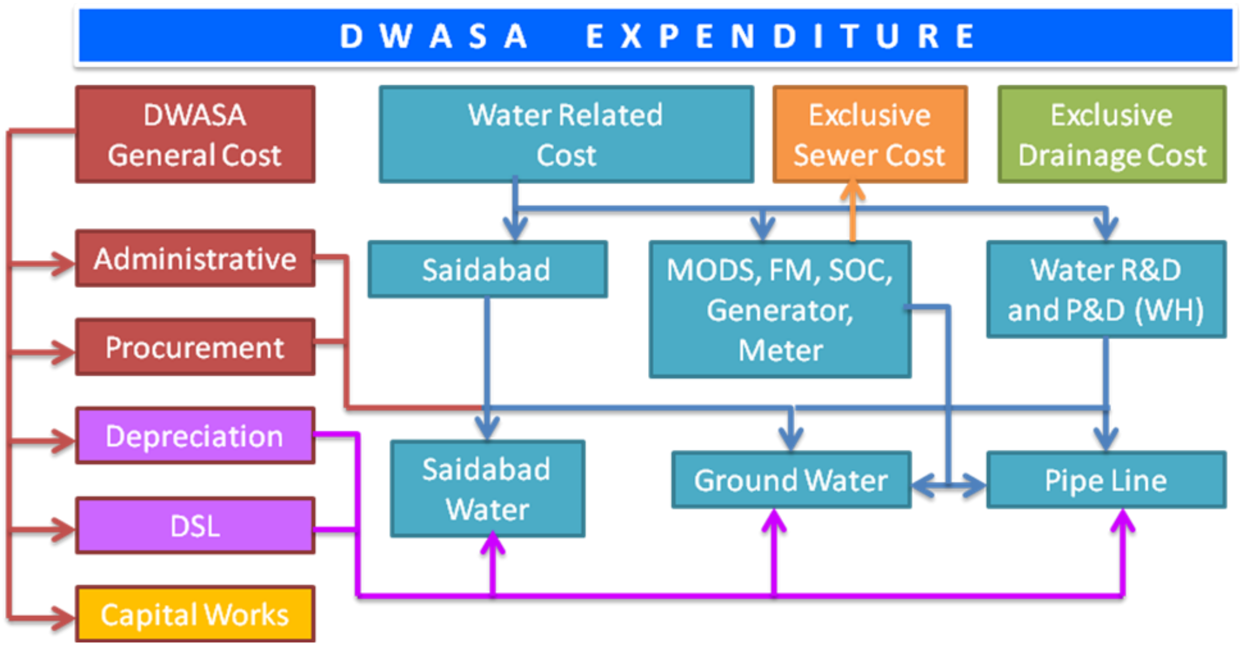


Figure 10-2: Diagram Showing Methodology to Determine Cost of Production

During estimation of cost of water production several important factors were also considered. The detail breakdown of expenses showed items purchased which included pumps, meters, spare parts, generators, etc. These items are used in repair and maintenance can be included as a part of operation expenses. The addition of these relevant procurement items makes the cost of production 11.00 BDT/KL. It was mentioned that the repair works currently done especially for pipe line maintenance is not adequate. If an increased budget of 150 million BDT is considered to improve maintenance, the cost of production becomes 11.23 BDT/KL. In utility organizations around the world it is common practice to include different kind of funds as a part of annual expenditure. These funds can be depreciation equalization fund or reserve funds for emergencies or disasters. There is also example of future generation funds to compensate for the unsustainable use resources. If the cost of production is 12.34 BDT/KL, we can create a reserve fund of 1.4 billion BDT annually to accommodate different kinds of expenses. Figure 10-3 shows the cost of production if these additional factors are considered.

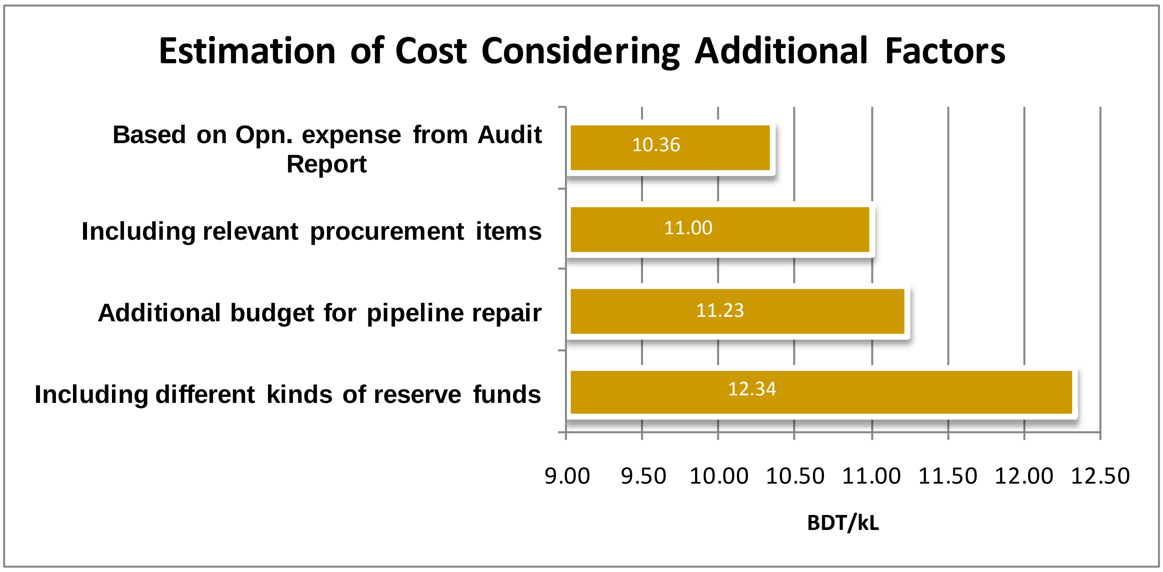


Figure 10-3: Estimated Cost of Water Production and Distribution with Additional Factors

The cost of groundwater production in fact can be taken as O&M cost for groundwater production. It was found that the major part of the cost is associated with the power to run the pumps (66%), followed by repair and maintenance (11%). The cost was directly estimated from MODS Zone information and then percentage of admin cost was included. The depreciation was considered from DWASA combined asset depreciation amount from the audit report. However it was also pointed out by DWASA officials that the actual depreciation related to groundwater may be quite high as the deep tubewells fail prematurely for various reasons.

The cost for Saidabad water production was based on expenses specific for the Division. This cost may not be considered as the O&M cost for the future SWTP. It is likely that power supply to those plants will be electricity whereas Saidabad is run by gas. Also the use of chemicals can be also different in those plants based on source of water. The cost was estimated for per kL volume similar to ground water production.

Separate cost was calculated for pipe line maintenance. The cost was estimated as required expense per meter. Figure 10-4 shows the cost associated with groundwater production, Saidabad water production and pipe line maintenance. These costs were later used during future expense and revenue calculation for water services of DWASA.

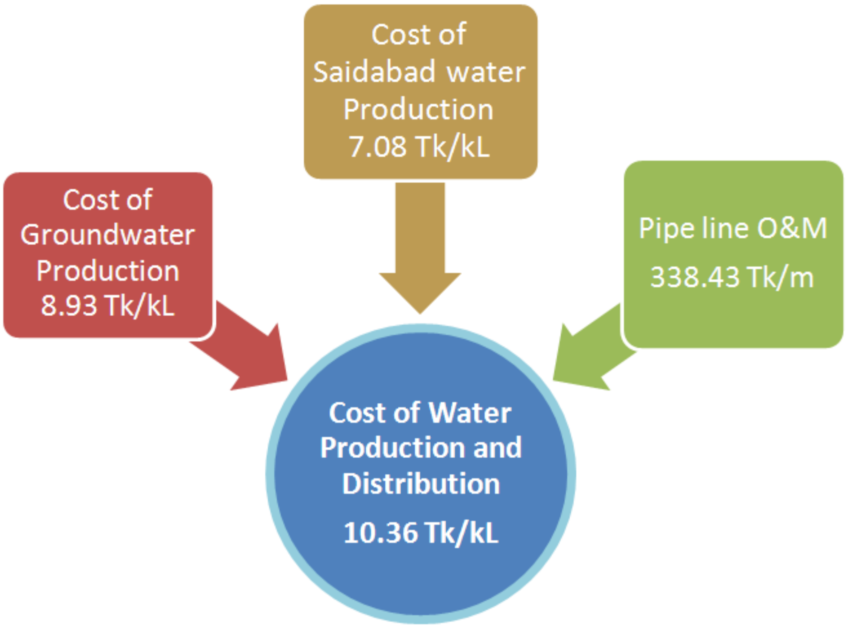


Figure 10-4: Cost of water production and distribution

10.3 Sensitivity Analysis of Cost

After determining the cost of production for groundwater, surface water and pipe line maintenance, it was important to evaluate the major considerations that will influence the future financial condition of DWASA. These considerations are:

- Non-Revenue Water
- Rate of increase in O&M cost
- Interest rate of capital investment

During initial assessment it was considered that a 3-slab block tariff would be considered with an average of 12.94 Tk/kL. As mentioned in the demand management section, the commercial and industrial rates would be the 3rd slab that is 3 times the rate of the 1st slab. Further analysis is provided in the Tariff Requirement Section 10.4. The initial tariff rate increase was considered to be 5% (average of the increase rates for the three blocks). Non revenue water was considered to be reduced to 15%, the O&M cost increase would be 5% per year, interest on capital investment would be 1% and depreciation of assets was considered 4%. Based on these assumptions the financial return on investment and benefit was calculated for the major projects that are required to be implemented within the short term period (Year 2020). These projects are Singair Well field Phase-I, Padma Jashaldia SWTP Phase-I, Gandharbapur SWTP Phase-I and Saidabad Ph-III SWTP. The financial assessment for these projects based on the above assumptions is given in Table 10-3. It can be seen that the projects are not financially feasible for the parameters discussed above.

Table 10-3: Financial Assessment of Projects Based on Initial Assumptions

Project	FIRR	NPV (mBDT)	FBCR
Padma Ph-I	2.83%	(4,071)	0.93
Singair Ph-I	5.35%	1,804	1.21
Gandharbapur Ph-I	2.58%	(7,324)	0.89
Saidabad Ph-III	2.78%	(4,800)	0.92
All		(14,391)	0.93

Note: Discount rate for financial analysis is 3.5%, NRW 15%, Cost growth 5%, Tariff increase 5%, Interest 1%

10.3.1 Impact of Changes in the Growth of Cost

Based on the initial results a sensitivity of the parameters were done to find a feasible choice. The operation cost was analyzed as it will not remain the same in the future and may be subject to price shocks and wage shocks. The rate of cost increase will influence the overall cost. In some of the previous projects it was considered to be 5%. Assessment was done to evaluate influence of operating cost increase on the recent projects that are undertaken by DWASA. Table 10-4 presents the impact on the feasibility of selected projects due to changes in the annual increase rate. For drop in the growth rate of cost from 5% to 4% leads to nearly 50% increase in NPV.

Our initial assumption of cost growth of 5% is based on current practice. It is possible to reduce the growth of cost per annum to 3% using measures through improving the efficiency of O&M. Therefore the analysis was done for both 4% and 3% growth rates. Table 10-4 shows even with 3% growth in O&M cost will not make the project financially feasible.

Table 10-4: Impact of Changes in Annual Increase in Operating Costs

	Cost Growth 4%/yr			Cost Growth 3%/yr		
Project	FIRR	NPV (mBDT)	FBCR	FIRR	NPV (mBDT)	FBCR
Padma Ph-I	3.16%	(2,139)	0.96	3.43%	(442)	0.99
Singair Ph-I	5.67%	2,139	1.25	5.94%	2,440	1.28
Gandharbapur Ph-I	2.86%	(5,218)	0.92	3.09%	(3,378)	0.95
Saidabad Ph-III	3.10%	(2,741)	0.95	3.36%	(942)	0.98
All		(7,960)	0.96		(2,323)	0.99

Note: Discount rate for financial analysis is 3.5%, NRW 15%, Tariff increase 5%, Interest 1%

10.3.2 Impact of Changes in Proportion of Non Revenue Water

Our initial analysis was based on 15% Non Revenue Water (NRW). NRW is also an important parameter in terms of its impact on the viability of the projects. Table 10-5 presents impacts of changes in NRW to 12% and 10%. It shows that FBCR of the projects will increase to 0.99 at 10% NRW. So most of the projects still remain infeasible.

Table 10-5: Impact of Changes Due to Non Revenue Water in the System

Project	NRW reduced to 12%			NRW reduced to 10%		
	FIRR	NPV (mBDT)	FBCR	FIRR	NPV (mBDT)	FBCR
Padma Ph-I	3.18%	(1,995)	0.96	3.40%	(611)	0.99
Singair Ph-I	5.89%	2,342	1.26	6.24%	2,701	1.29
Gandharbapur Ph-I	2.89%	(4,931)	0.93	3.09%	(3,336)	0.95
Saidabad Ph-III	3.11%	(2,647)	0.96	3.32%	(1,211)	0.98
All		(7,231)	0.97		(2,457)	0.99

Note: Discount rate for financial analysis is 3.5%, Cost growth 5%, Tariff increase 5%, Interest 1%

10.3.3 Impact of Changes in the Rate of Interest

DWASA is not a direct recipient of foreign funds. The fund is provided to the government and then the government channels this fund to DWASA. As a result, the government may charge an appropriate rate of interest to DWASA for keeping up the supply of water.

Since water supplied by DWASA benefit the society and not all the benefits were valued in this study, the IRR estimated here is a lower bound. Considering this, it might be argued that DWASA is provided the fund at a reduced rate. In this analysis, an interest rate of 1% is assumed as the base line. Impact of changes of this rate is shown in Table 10-6. It shows that the overall NPV changes from -14000 to -33,000 mBDT for 1% increase in interest rate (comparing Table 10-3 and Table 10-6).

Table 10-6: Impact of Changes in the Rate of Interest on Initial Capital

Project	Interest on Loan 2%			Interest on Loan 5%		
	FIRR	NPV (mBDT)	FBCR	FIRR	NPV (mBDT)	FBCR
Padma Ph-I	1.94%	(9,311)	0.85	-1.01%	(25,031)	0.68
Singair Ph-I	4.56%	1,008	1.12	1.97%	(1,379)	0.93
Gandharbapur Ph-I	1.67%	(14,276)	0.81	-1.34%	(35,131)	0.64
Saidabad Ph-III	1.88%	(10,588)	0.84	-1.08%	(27,951)	0.66
All		(33,167)	0.85		(89,492)	0.67

Note: Discount rate for financial analysis is 3.5%, NRW 15%, Cost growth 5%, Tariff increase 5%

Since the projects were not found to be feasible with changes in cost parameter, the following section examines the feasibility of projects from the revenue side.

10.4 Sensitivity Analysis of Revenue and Tariff Requirement

10.4.1 Impact of Changes in Tariff Growth Rate

During the analysis of tariff two pricing structures were considered: flat rate and 3-slab increasing block tariff structure. In the financial analysis block tariff structure was assessed and the main factors considered were:

- Start year of IBT strategy is 2015.
- Change in the tariff rate on annual basis

The sensitivity is based on discussion on provided in Chapter 6. The recommended IBT structure is shown in Figure 10-3. The first slab's price is the current 7.34 Tk/KL which will be incremented by 5%

in 2015. Thus the basic flat rate expected in 2015 is 8.09 Tk/KL. The third slab's price is three times the first slab's price and is also the expected starting water tariff for commercial and industrial users in 2015 (based on annual 5% increases as per WASA rule). Based on the expected population proportion falling into each slab, the weighted average price will be 12.94 Tk/KL. However, the slab prices in the IBT should increase over time to take into account of inflation. In order to develop an understanding of the annual rise of tariff different rates were considered and their impact was assessed on major projects. The required annual increase was determined for different interest rates in order to make the projects feasible. Table shows that for a 6% growth in tariff rate all the projects are feasible.

Table 10-7: Impact of Changes in Tariff Growth Rate

Project	Tariff Growth 5.5%/yr			Tariff Growth 6%/yr		
	FIRR	NPV (mBDT)	FBCR	FIRR	NPV (mBDT)	FBCR
Padma Ph-I	3.44%	(363)	0.99	4.05%	3,642	1.06
Singair Ph-I	5.92%	2,425	1.26	6.50%	3,083	1.33
Gandharbapur Ph-I	3.18%	(2,669)	0.96	3.78%	2,377	1.03
Saidabad Ph-III	3.41%	(611)	0.99	4.04%	3,931	1.07
All		(1,217)	1.00		13,033	1.07

Note: Discount rate for financial analysis is 3.5%, NRW 15%, Cost growth 5%, Interest 1%

10.4.2 Required Tariff Growth Rate based on Rate of Interest

Table 10-8 presents the annual increase rate required for different interest rates on loan. It was found out that for an interest on loans of 2% the required annual tariff increase rate has to be 6% per year, and for an interest of 5% the required tariff increase rate is 7.5% per year. Based on these findings it can be recommended that the current interest rate of 5% by GoB needs to be lowered in order to keep the tariff rate within an acceptable range of the consumers.

Table 10-8: Impact of Changes in the Annual Increase in Price of Water

Project	Tariff Growth 6%, Int on Loan 2%			Tariff Growth 7.5%, Int on Loan 5%		
	FIRR	NPV (mBDT)	FBCR	FIRR	NPV (mBDT)	FBCR
Padma Ph-I	3.80%	2,030	1.03	3.55%	359	1.00
Singair Ph-I	6.31%	2,924	1.31	6.02%	2,747	1.24
Gandharbapur Ph-I	3.43%	(629)	0.99	3.11%	(3,640)	0.96
Saidabad Ph-III	3.77%	2,001	1.03	3.59%	698	1.01
All		6,326	1.03		164	1.00

Note: Discount rate for financial analysis is 3.5%, Cost growth 3%, NRW 15%

It can be recommended from the financial analysis that the tariff may be raised every year by 6% for all users. Figure 10-5 shows the weighted average tariff proposed for the future. This increase is an important strategy to ensure the feasibility of the projects that will be undertaken by DWASA. This also implies that as long as the rate of inflation is above 6%, the real price of water is in fact reducing over time from that of the initial year of 2015.

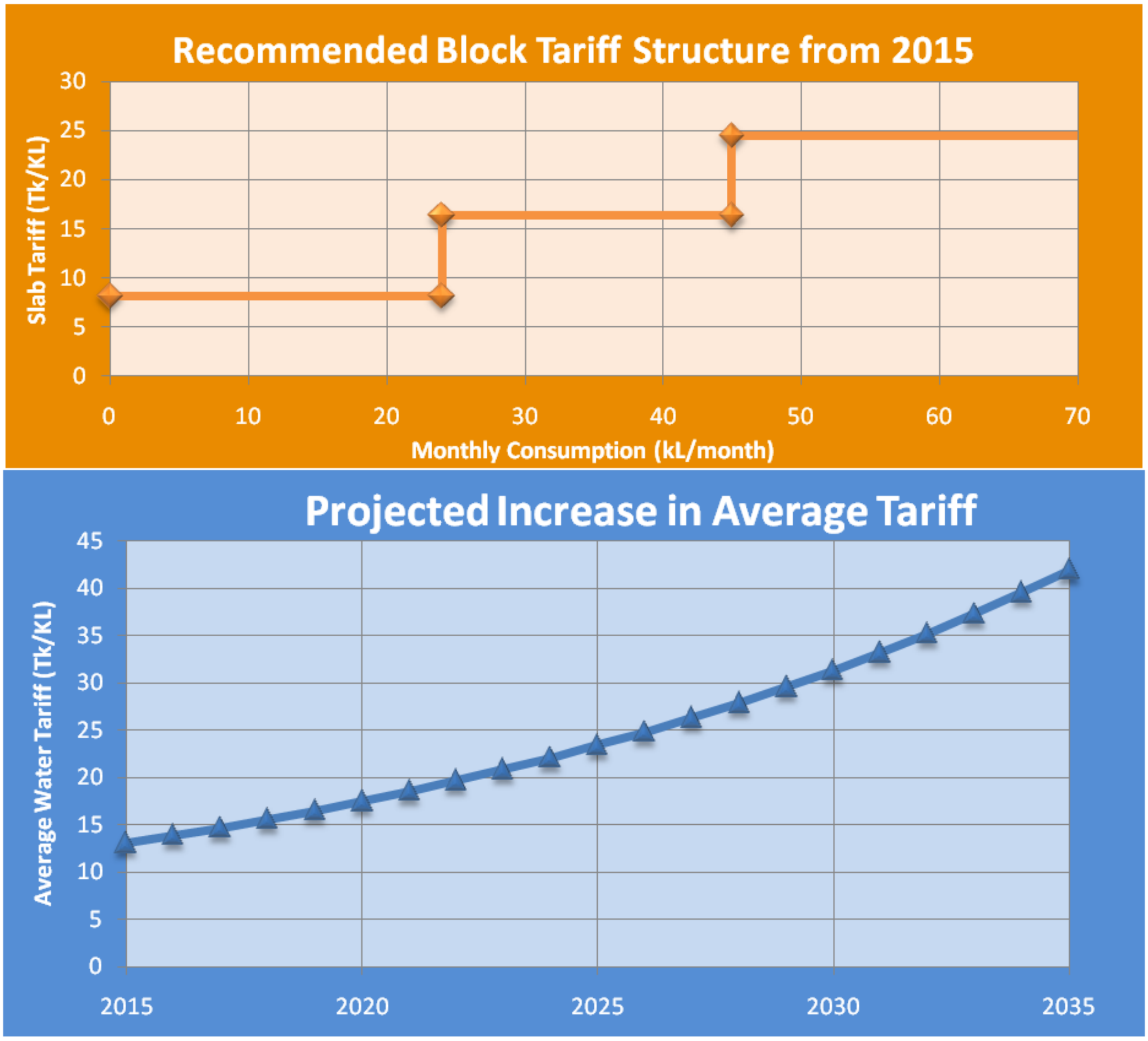


Figure 10-5: Recommended Tariff Structure and Increases in Average Tariff in Future Years

Another major consideration in the tariff analysis was the separation of tariff between sewer and water that was considered in the financial analysis of the projects. In the past many water projects considered revenue from sewer and sewer projects considered revenue from water. This created a double accounting of the revenues. Also the financial performance of sewer services influences the performance of water services. Under the current Master Plan only revenue from water was considered. In this way if there is a possibility that sewer tariff may be less than water it can be utilized. This will create the opportunity to increase water tariff more.

10.5 Projection of Revenue and Expenditure

Analysis was done to assess the revenue and expenditure in the future. Projection was made for 2015, 2020, 2025, 2030 and 2035 which focused on sector wise development. For each sector revenue was calculated from the combined production of GW and SW sources that can be generated from the proposed investments of the Master Plan. The entire volume of water produced does not generate revenue for various reasons, so a target was set for the percentage of NRW that can be achieved. Tariff rate will also change progressively in the future. Revenue for each Sector was calculated based on these assumptions. Revenue calculation for Saidabad Sector can be found in Table 10-9.

The expense was divided in two major sections, operating expenses and capital expenses. Operating expense accounted for cost from three sources. The groundwater cost was determined from the total volume of groundwater produced and was based on the calculated cost of production determined in the previous section. The cost of surface water production considered operation cost estimated from respective projects which includes mainly salary, power and chemical requirements. The cost of water production for Saidabad was calculated from the estimates found in the 2013-2014 budget. Operating cost was also considered for pipe line maintenance. This was calculated based on the length of pipe that will be in place in each sector and the cost of maintenance calculated from the budget. All the costs were assumed to increase at the rate of 5% per year.

Capital cost has two major components. One is the depreciation and the other one is debt services liability (DSL). Depreciation was calculated separately for GW, SW and pipe line. The GW and pipe line depreciation was calculated analysing DWASA budget. Depreciation for the SWTPs was calculated based on proposed investments except for Saidabad SWTP. Depreciation of Saidabad was calculated from historic data. Interest or DSL rate was based on investment amount and was set at 3%. Financing of major investments can differ from each other, which can be explored during individual projects financing. Calculation of expenditure for Saidabad Sector can be found in Table 10-9.

Table 10-9: Projection of Revenue and Expenditure for Saidabad Sector

Item	**2015**	**2020**	**2025**	**2030**	**2035**
Revenue					
Total Demand (MLD)	997	1100	1260	1227	1270
Other Demands (%)	16%	20%	22%	25%	25%
Production (MLD)	950	1200	1200	1180	1150
Yearly Production (ML/yr)	346,750	438,000	438,000	430,700	419,750
NRW (%)	23%	18%	17%	16%	15%
Residential Tariff (Tk/KL)	13.07	17.49	23.41	31.32	41.92
Commercial Tariff (Tk/KL)	24.51	32.80	43.89	58.73	78.60
Total Rev (Tk m)	3,978	7,381	10,147	13,811	18,227
Expense					
Operating expenses (Tk m)					
SW (includes admin)	698	1,604	1,859	2,155	2,498
GW (includes admin)	1,057	736	853	923	955
Pipeline (includes admin)	242	422	489	568	659
Capital Cost					
Depreciation (Tk m)	681	2,389	2,389	2,384	2,377
Interest Expenses / DSL	*395*	*1,362*	*1,362*	*1,362*	*1,362*
Total Costs (excl int)	2,678	5,149	5,589	6,030	6,489
Total Costs (incl int)	3,073	6,512	6,952	7,392	7,851
Net Revenue (incl int) (Tk m)	905	870	3,196	6,419	10,376
Net Revenue per KL (incl int) (Tk/KL)	2.61	1.99	7.30	14.90	24.72
Net Revenue (excl int) (Tk m)	1,301	2,232	4,558	7,781	11,738
Net Revenue per KL (excl int) (Tk/KL)	3.75	5.10	10.41	18.07	27.97

The net revenue for each sector was calculated including and excluding interest rate. Then the revenue was converted to net revenue per volume so that sector-wise net revenue can be compared. Figure 10-6 shows the comparison of revenue among Sectors in 2035 and Figure 10-7 shows year wise total net revenue for DWASA. It can be seen that if interest or DSL is considered (a simple rate was considered) the net revenue stays below Taka 10/kL until 2025, but increases significantly in the next 10 years (2026 to 2035). So calculation was also done to determine net revenue excluding interest so that an assessment can be made independent of financing opportunities. The figures indicate that DWASA will require some level of grants and subsidy from the Govt. This is important as DWASA is still a service oriented organization and given the socio-economic condition of the City as well as the country as whole, a fully commercial operating utility may take some time to be established. The financing options can be explored in the sensitivity section.

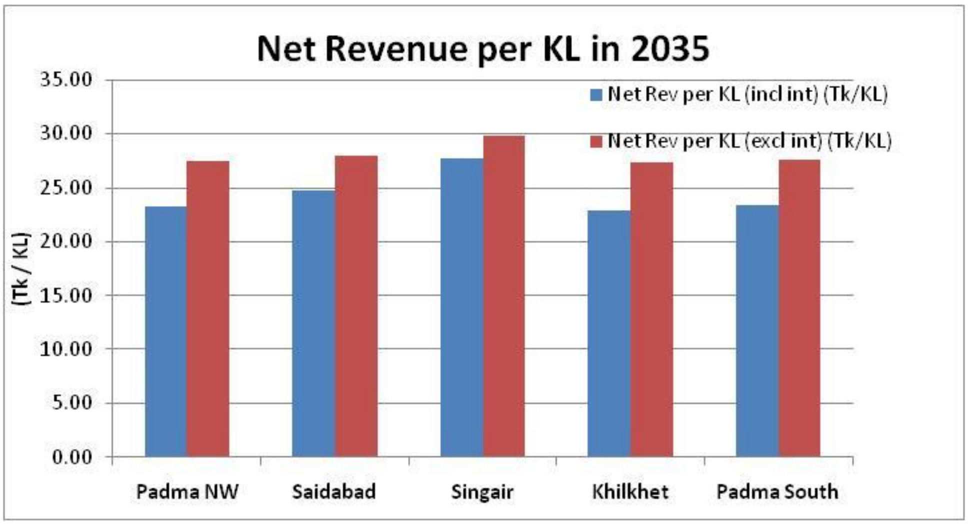


Figure 10-6: Net Revenue for Unit Volume of Production in 2035 for all the Sectors

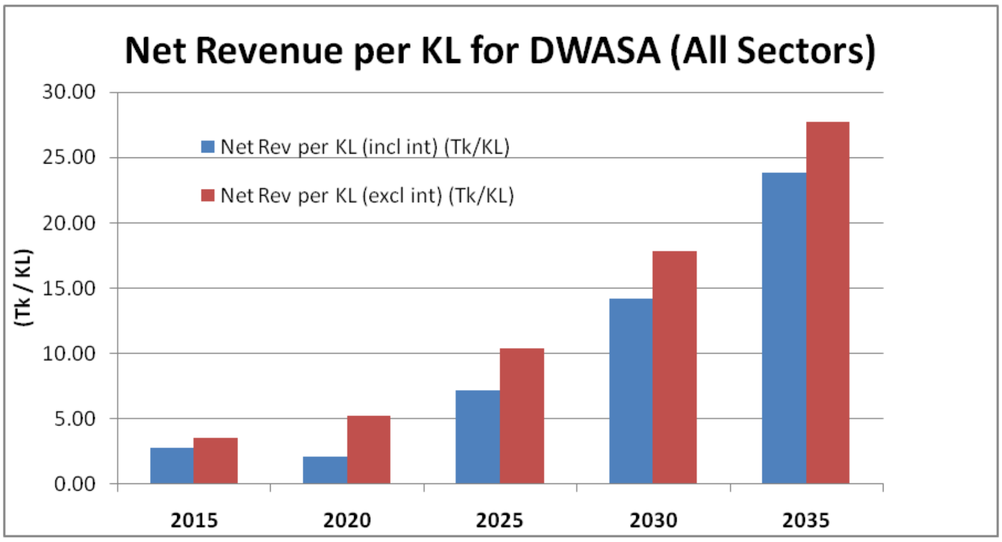


Figure 10-7: Projection of Net Revenue for Unit Volume of Production for DWASA

10.6 Important Financial Policy Considerations for Future Investments

The projections discussed in the previous sections show detailed revenue and expenditure and also the sensitivity analysis provides the key factors in the financial planning and related outcome in the future. For the projects envisaged in the Master Plan, DWASA was has to make major investments. Funding for these huge investments requires special attention. As described earlier, currently GoB provides loans at 5% interest rate for the capital investments to DWASA. In order to recover the cost associated with these investments DWASA needs to increase the tariff. But due to political and social reasons it has been very difficult to increase tariff 5% annually. If DWASA does not get adequate support from the Govt. i.e. very low interest rate on loans or grants for the investments and at the same time the proposed tariff structure is not implemented, it will create a huge burden on overall financial situation of DWASA in the future. Figure 10-8 shows the annual accumulation in the future years if either one of these two considerations are not addressed. The cost recovery only included 5% interest or repayment of the total amount borrowed from the Govt. So it is very important that the Govt. lending rate to DWASA and also the proposed tariff structure is implemented to avoid the financial crisis that may occur, if current practice is continued.

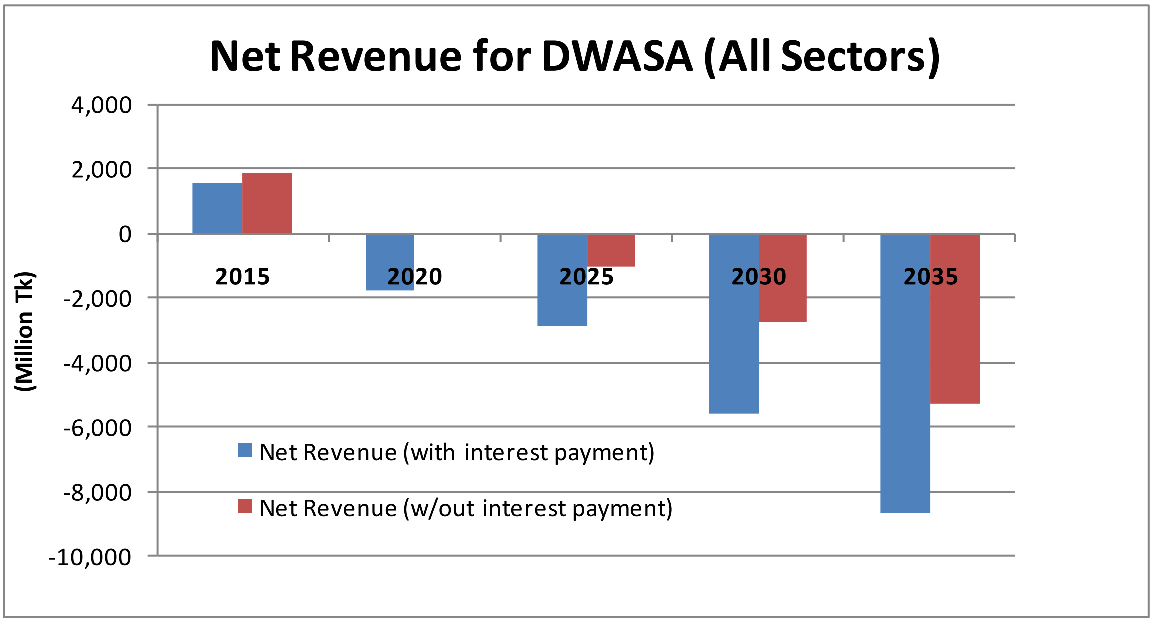


Figure 10-8: Projection of Net Revenue without implementation of the Proposed Tariff

10.7 Cost Recovery of SWTP

Separate analysis was done for the major investments of DWASA that will take place within the short-term period of the Master Plan. These major investments are the construction and implementation of three SWTPs and a Well field to supply groundwater from Singair. Return on investments (RoI) for these projects are important to assess their financial feasibility. Return on investment analyses have been already done for some of these projects namely Padma SWTP, Saingair Well field and Gandharbapur SWTP.

In the Master Plan study the ROI analyses for these projects were done based on the assumptions that have been considered in the Master Plan. The assumptions covered the calculation method for revenue, yearly increasing factor in O&M rate, discount rate, etc. In the feasibility studies of these projects the assumptions were different for different projects. However, for consistency these assumptions were kept similar for the different projects in the Master Plan. One of the important factors in ROI analysis is the increase in revenue due to the project. Future tariff was analysed in the previous section, which was used for revenue calculation. The proposed tariff from the Master Plan was used for ROI analysis of the projects. Sensitivity analysis was also done based on the other assumption factors to evaluate their significance. Table 10-10 presents the RoI analysis for the Padma Phase-I project. The investment cost included not only the cost of SWTP, it also included the cost for primary distribution and distribution within DMA. The O&M cost was calculated during the feasibility study and yearly increase in O&M cost was considered as 5%/yr. The salvage value after 25 years was considered to be half of original value. NPV was calculated based on discount rate of 3.5%.

Table 10-10: Return on Investment Analysis for Padma Phase-I Project

			Incremental Costs				
	Year	Incremental Revenue (Tk m)	Invest-ment Cost (Tk m)	Incremen-tal O&M (Tk m)	Interest Expense / DSL	Total Costs (Tk m)	Net Cash Flow (Tk m)
Year 1	2014	-	14,596	-		14,596	(14,596)
2	2015	-	14,596	-		14,596	(14,596)
3	2016	-	14,596	-		14,596	(14,596)
4	2017	2,172	-	872		872	1,301
5	2018	2,332	-	898		898	1,434
6	2019	2,503	-	925	876	1,801	702
7	2020	2,768	-	953	876	1,828	940
8	2021	2,934	-	981	876	1,857	1,077
9	2022	3,110	-	1,011	876	1,886	1,224
10	2023	3,337	-	1,041	876	1,917	1,420
11	2024	3,537	-	1,072	876	1,948	1,589
12	2025	3,805	-	1,104	876	1,980	1,825
13	2026	4,034	-	1,138	876	2,013	2,020
14	2027	4,327	-	1,172	876	2,047	2,280
15	2028	4,587	-	1,207	876	2,083	2,504
16	2029	4,862	-	1,243	876	2,119	2,743
17	2030	5,267	-	1,280	876	2,156	3,111
18	2031	5,583	-	1,319	876	2,195	3,389
19	2032	5,918	-	1,358	876	2,234	3,684
20	2033	6,348	-	1,399	876	2,275	4,073
21	2034	6,729	-	1,441	876	2,317	4,412
22	2035	7,132	-	1,484	876	2,360	4,772
23	2036	7,560	-	1,529	876	2,405	5,156
24	2037	8,014	-	1,575	876	2,450	5,564
25	2038	8,495	(21,894)	1,622	876	(19,397)	27,892
						FIRR	3.80%
						NPV	2,030
						WACC	3.50%
						FBCR	1.03

In order to supply water and generate revenue the transmission and distribution system is required in addition to the construction of the water supply sources. So in the ROI calculation these two major components were also considered and inclusion of capital cost for transmission and distribution and also the O&M of transmission and distribution influenced the NPV. The ROI analysis in the feasibility study was done based on separate assumptions. Also ROI analysis of some feasibility projects was done based on combined analysis of both water and sewer. Another important factor for deviation from the ROI calculation of the feasibility studies is the Non-revenue water, which was not analyzed in detail in those studies. Under this Master Plan, the ROI calculation of these four feasibility projects were done based on similar assumptions and the results are presented in Table 10-11. It can be seen that though the NPV of the Gandharbapur Ph-I project is negative but in an overall assessment for DWASA the NPV becomes positive, making the short-term financially feasible.

Table 10-11: Financial Feasibility of 4 Major Projects

Project	FIRR	NPV	FBCR
Padma Ph-I	3.80%	2,030	1.03
Singair Ph-I	6.31%	2,924	1.31
Gandharbapur Ph-I	3.43%	(629)	0.99
Saidabad Ph-III	3.77%	2,001	1.03
All		6,326	1.03

Note: Discount rate for financial analysis is 3.5%, Cost growth 3%, NRW 15%, Interest 2%, tariff increase 6%

11 Strategic Environmental Assessment

11.1 Introduction

This project has been undertaken by DWASA to prepare the Water Supply Master Plan for Dhaka City. The goal of the project according to the TOR is to prepare a Master Plan, to identify priority investment projects and to recommend an appropriate institutional framework.

This chapter presents the findings of a Strategic Environmental Assessment (SEA) of the Water Supply Master Plan (WSMP) for Dhaka City. The SEA ensured that environmental considerations have been taken into account throughout the development of the WSMP.

The objectives of the SEA were to:

1. Assess significant environmental and social impacts of the Water Supply Master plan;
2. Identify and recommend mitigation measures and institutional adjustments for the interventions of WSMP for Dhaka City needed to address these significant environmental and social impacts; and
3. Identify and recommend measures needed to build the capacity of DWASA for mainstreaming environmental and social considerations into interventions of Master Plans and programs, and facilitate inter-institutional coordination among agencies relevant to water supply development.

Typically, an SEA seeks to influence the development of a policy, plan or programme prior to its finalisation and approval. The SEA study focused on social and environmental priorities associated with implementing the plan, and strengthening institutional capacities in DWASA for managing social and environmental risks.

11.2 Impact Assessment of the WSMP

Identification of social / environmental impacts and analyses of the alternatives for the perceived impacts forms an important component of the study. The SEA Team began by preparing an overview of the environmental and socioeconomic challenges in Dhaka city. The key effects of WSMP then were narrowed down through a scoping process involving key stakeholders. The overview and scoping exercise were then used as the basis for a strategic assessment of the priority social and environmental issues that are likely to arise during the implementation of the WSMP.

Sub-projects undertaken for water supply development purposes may have negative social fallout on families and individuals in the form of loss of land, loss of structures, loss of livelihood/income, loss of crops/trees and loss of community infrastructure and public utility lines. Further, issues related to vulnerable groups such as the urban poor, women, socially and historically disadvantaged groups from another component of potential social impacts.

At the same time, environmental impacts may be observed on various environmental components such as air, water and land and on surrounding eco-systems (flora and fauna). Since the stakeholders are directly dependent on these components, a sub-project may affect these components both positively and negatively, directly and indirectly. The possible generic impacts due to infrastructure investments on various environmental components are like change in land use, adverse effects on flora and fauna, change in air quality, change in water quality, etc.

The majority of potential negative effects will be short-term and temporary associated with and construction of the schemes where additional infrastructure is required and include:

- Temporary habitat loss and species disturbance along pipeline routes and areas associated with new infrastructure developments
- Temporary landscape and visual impacts associated with ground disturbance, construction activities and machinery/plant associated with laying of pipelines and construction of infrastructure e.g. SWTP
- Permanent landscape and visual impacts due to presence of new SWTPs; however with appropriate design and screening where necessary this impact could be minimised
- Potential loss or disturbance of archaeological features along pipeline routes and in areas associated with new infrastructure developments; however this impact can be avoided through appropriate routing studies
- Temporary air quality impacts associated with dust generated during construction
- Temporary impacts from noise and vibration generated from construction activities (pipeline laying and borehole drilling)
- Temporary community disturbance during construction, e.g. traffic and footpath diversions
- Land sterilization along pipeline easement
- Energy consumption and CO_2 emissions associated with piping water and treating increased volumes of water

There are significant synergistic (positive) cumulative effects between surface water bodies and groundwater aquifers with population and health; surface water bodies and cultural heritage; soil and land resources with groundwater aquifers and urban development; urban development with population and health. These should be enhanced during project design and development stages. No significant negative (conflicting) cumulative effects were identified within the WSMP.

11.3 Plan and Strategies

Clear strategies and plans are needed for better management of social and environmental issues during the implementation of sub-projects under Master Plan intervention areas. In view of this, two plans have been suggested for better implementation of projects considering their sustainability, both socially and environmentally.

Management and Monitoring Plan: An important component of the project management system is monitoring and management of the social and environmental dimensions of the project.

The Environmental Management Plan, as part of overall project management strategy, includes the management of environmental issues incorporated in the project cycle that covers all the stages of a sub-project investment from identification of an investment till the completion of the sub-project and post completion/monitoring/ operational phases of the investment.

Monitoring is important for identifying whether the WSMP is having an adverse effect on the environment. In the event that adverse effects are identified then these need to be addressed. It is also important to monitor the predicted positive effects to check whether the predicted effect is actually occurring. Future reviews of the WSMP and other related plans will also need to take into account of any adverse effects or trends identified during monitoring so that future policies, proposals or strategies can either be rejected or modified accordingly.

The Social Management Plan (provided in Volume 4) proposes various mitigation and other measures to overcome adverse social impacts. The mitigation or other measures are proposed in detail to each and every identified social issue along with the monitoring strategy and the possible contingency measures that can be taken up.

Institutional Capacity Assessment: An analysis of DWASA‘s strengths and weaknesses in environmental management (EM) of WSMP projects was an important part of the SEA. The inter-institutional linkages between DWASA and other relevant organizations were also assessed.

i) Results from the assessment

The SEA team analyzed the institutional strengths and weaknesses of environmental management in DWASA, with the aim of preparing an Action Plan to strengthen DWASA's capacity in this field. The results from the assessment are as follows:

- In terms of preparing environmental assessment reports (i.e., IEEs, EIAs, EMPs, etc.) and conformance to DoE requirements, the experience of DWASA is limited.
- As per approved Organogram (dated November 2007), there is no existence of the Environmental Cell within DWASA. Presently, there is an Environmental Monitoring Division headed by an Executive Engineer who cannot monitor the environmental parameters due to limited number of staffs and inadequate resources and funds
- As per prevailing legislation of the country, DoE is responsible, with limited delegation of power, to take action against the defaulters for the environmental degradations of natural canals, water bodies (both surface and groundwater), peripheral rivers, etc. Unless and until power has been delegated, DWASA cannot take any action against the defaulters who is responsible for the environmental degradation of source water bodies (both surface and groundwater), river pollution, discharging industrial wastes directly to the river without any treatment, etc.
- While several DWASA engineers may be trained in environmental issues associated with public health engineering, there has been no formal training in assessment of environment impacts, compliance to DoE clearance requirements and donor requirements.
- Mechanism for collecting environmental data and Environmental Management information in the water sector are not established. Moreover, there is little systematic monitoring of environmental performance of plans or projects. There are gaps between the monitoring plan in EIA Report and its implementation
- Cooperation between DWASA and relevant institutions during the whole planning process is limited.

ii) Institutional Action Plan

In the institutional action plan several actions to start a long-term process to overcome these institutional shortcomings and strengthen DWASA‘s environmental capacity and performance are proposed. These are grouped into three categories:

- ***Improve the regulatory and institutional framework:*** a precondition to strengthen EM capacity in DWASA is to set up the institutional arrangement for EM through a regulatory framework for EM and the establishment of an Environmental Cell with sufficient budget and manpower.

- ***Improve staff's competence:*** enhance the environmental awareness of management and staff in DWASA by compiling new training materials, adding more training programs, and learning from international and domestic experiences in environmental training.
- ***Improve monitoring & evaluation programs:*** improve the environmental performance of Master Plans and projects by increasing the monitoring activities within DWASA and DoE, improving the quality of environmental data, and constructing an environmental information system for the water supply network. Monitoring should occur through all stages of the process—planning, construction and operation.

11.4 Follow Up

The SEA proposes several actions to strengthen the environmental management capacity in DWASA and the cooperation between DWASA, other sector authorities and stakeholders in Master Plan development. These proposals are the most important outcomes of the SEA process. They should be followed up closely in cooperation with affected institutions. An excellent opportunity to follow up some of the most urgent recommendations would be during the implementation of the priority projects under short-term plan of WSMP (implementation period – 2011 to 2025). Some of the most urgent recommendations (Padma north-west and Khilkhet Sector) could be financed and implemented in cooperation with the Donors (ADB/WB) and tested through the implementation of these projects.

The SEA also proposes several mitigation measures to reduce or eliminate negative environmental and socio-economic impacts from the WSMP. Since the plan has already been finalized and submitted, the follow up will have to be through the detailed planning and implementation of each sub-project. This would require that an EIA is carried out for each sub-project in the plan, taking into account the results of this SEA and how the design and routing of the pipeline could contribute to minimizing the negative impacts. This should work in parallel with the implementation of the institutional action plan.

11.5 Consultations

Several consultations have been held for the Water Supply Mater Plan:

- Consultation with group of key individuals and visionaries regarding the future development of Dhaka City
- Consultations with school children about their experiences, visions and thoughts about Dhaka City, including discussions about water supply and its management
- Consultation with stakeholder organizations of Dhaka City to get their plans and views for future Dhaka

The list of key stakeholders who have been consultated is given in Table 11-1.

Table 11-1: Meetings with Stakeholders

No.	Organization
1	Rajdhani Unnoyon Kartripokkho (RAJUK)
2	Bangladesh Water Development Board
3	Bangladesh Fire Service and Civil Defense Dept.
4	Cantonment Board
5	Naryanganj City Corporation
6	Dhaka University
7	Bangladesh University Engineering Technology
8	WaterAid

Some of the highlights from the comments provided by the stakeholders were:

RAJUK:

- RAJUK has guidelines regarding population density of any area which is known as FAR (Floor Area Ratio). From this guideline they will limit the number of storeys (floor levels) in new buildings
- 'Private Residential Land Development Rules' was enacted in 2004 and amended in 2012. This created a provision so that developers are also responsible to construct utility infrastructures so that utility service providers can take over afterwards
- RAJUK is running a project with ADB for structural plan upto 2035
- Planning to work on DAP again
- Any building with more than 300 sqm roof area should have rainwater harvesting
- A flyover between Paltan and Keraniganj has been proposed
- WSMP should be integrated with Sewerage Master Plan
- Keraniganj and Jhilmil project should be included in WSMP
- To reduce water demand any recommendation from WSMP, RAJUK could be implemented trough BNBC
- Service area and service connection policy by different utility agencies should be coordinated


Figure 11-1: Consultation with BWDB and RAJUK

Bangladesh Water Development Board:

- BWDB mentioned that Buriganga River Augmentation project might not be able supplement water supply, but can contribute to reducing pollution of the River.
- It was mentioned that tanneries will be relocated & BWDB assisted in this initiative. ETP should be enforced & policy should be also taken by DWASA.
- BWDB mentioned that though a study has been done on the Eastern By-Pass project, no decision has been made yet on the implementation of the project.
- The future wastewater treatment plant of DWASA will require around 45 acres land in Uttara Abdullahpur Area. Some BWDB land is available there. DWASA can coordinate to know the specifics.
- DWASA mentioned that an 1800 mm diameter pipe would be required to distribute water from Padma SWTP, which will inject water at Buriganga Bridge No.2 close to Mitford Hospital. BWDB officials suggested that it would be better if this primary distribution main is constructed outside the slope of the embankment. It was also mentioned that BWDB land can be used for the construction of the primary distribution system.
- An intake channel of 0.5 km has been recommended to collect water for the treatment plant in Jashaldia. During construction of intake a lining of 100m is proposed upstream and downstream of the intake. The officials also suggested heavy bank protection needs to be constructed at the intake of the SWTP.
- BWDB suggested the Water Supply Master Plan should be in line with National and Sector Planning. The initiative by DWASA on rain water harvesting was applauded and BWDB suggested to develop specific policies to facilitate the program.

WaterAid:

- Study should address how DWASA can address slum requirement
- All stakeholders should be considered as part of Water Supply Master Plan
- Impact of Climate Change should be incorporated
- Pricing of water could be divided using different slabs for tariff
- WaterAid is studying water supply and billing in slum areas
- Demand of floating people should be considered in demand calculation
- Customer voice should be included in WSMP
- Presently some slums have illegal access to water which should be turn into legal connections so that DWASA could earn some revenue but need to keep in mind that the price of water should be lower compared to other communities

Cantonment Board:

- 30% area of cantonment area is under Cantonment Board
- Water supply to cantonment area currently from DWASA pump/SWTP
- Major portions (70%) of cantonment area operates under MES (Military Engineering Services)
- Population growth rate in cantonment area is similar to overall growth rate of Dhaka City
- Around 50% water use in cantonment area is for non-drinking purposes
- Presently cantonment board is operating four deep tube-well in Dhaka cantonment area
- There are 6-7 water bodies around Dhaka cantonment area which could be use as reservoirs
- Assessment by cantonment authority showed that if all reservoirs could be inter-connected then, supply for about 7-10 days demand might be possible

12 Feasibility of Priority Investment Projects

12.1 Introduction

The major water supply sources (SWTPs and well-fields, both existing and planned) are located in consideration of proximity to available sources, availability of land, etc. As a result, they happen to be located in different parts in and around Dhaka city. Since the primary mains will originate from different major sources, they will enter the city from different locations. Each Primary Main and secondary main(s) stemming from it will serve a region of the city on the basis of the following criteria:

a) The maximum contiguous area where the incident demand can be adequately served by production capacity of the source (SWTP).
b) The area up to which the mains can provide water to the distribution systems at a minimum 1 bar pressure (based on preliminary hydraulic modeling).
c) Existing and proposed DMA boundaries.

Delineation of such areas is referred to as sectorization. The areas that will be covered by each of these major sources are named as 'Sector'.

Present DWASA service area is 401 sqkm including Narayanganj. According to DWASA Act 1996 the jurisdiction of DWASA is around 500 sqkm. As per terms of reference of the study, it has been considered that the DWASA will extend its services to its areas of jurisdiction in accordance with the Act. Considering the earlier stated criteria, population density, strategy of city development, nearby available sources of ground and surface water, socio economic condition of the locality and the corresponding water demand, the services area has been divided into eight Sectors. Projected populations and water requirement for each sector have been calculated up to the year 2035. The source of water for each sector has been established. The sectors are:

- Saidabad West-East Sector
- Padma North-West Sector
- Padma South Sector
- Singair Sector
- Khilkhet Sector
- Rupganj Sector
- Bandar Sector
- Tongi & Gachcha Sector

In this chapter, a brief summary of the design and routing considerations behind the mains are elaborated for three sectors: Padma North-West, Khilkhet, and Saidabad Wes-East Sectors. The initial sections will discuss the general considerations applicable to all sectors and later sections will describe unique attributes of each sector. Further detailed descriptions are provided in the corresponding annexes (Volume 5). The Initial Environmental Investigation (IEE) for Padma North-West, also Khilket and Saidabad West-East Sectors are included in the annex section as an independent report (Volume 5). There are additional annexes with plan drawings of the primary and secondary mains for these sectors (Volume 6). Since the technical drawings reflect generic design of a typical fixture, the drawings included in the Padma Noth-West Sector apply to Khilkhet and Saidabad West-East sectors as well.

12.2 Major Objectives and Considerations

The lay-out for a distribution system will:

- Guarantee continuous delivery of a sufficient quantity of safe drinking water to the consumers
- Be economically and financially viable, ensuring sufficient income for the upkeep and extension of the system

These aims are top priorities for the design of the system.

The system should also have sufficient:

- spare capacity to operate in an emergency situation (power failure, pipe bursts, fires)
- degree of “flexibility”

The capacity of the major components of a distribution system is generally such that the component will perform satisfactory for at least up to 2035.

The construction of primary and secondary network has been designed in a manner that will provide a fully functional pipe line that:

- Upon completion alleviate the consequences of the present system’s short comings
- Effectively transmit water from the Surface water treatment Plants (SWTP) at capabilities that will address as minimum the current needs but will also consider the development of the system up to the design horizon year 2035

Design should carefully consider the significant constructions difficulties and provide tangible solutions, taking due consideration of the limited funds.

12.2.1 Design Considerations

The main design considerations are summarized below.

Design Criteria:

- Design Horizon: 2020/2035
- Total connected population with combination of GW & SW sources: 100%
- Average domestic water demand: 150lpcd to 130 lpcd[5]
- Non-residential demand: 15 to 27% of Total residential demand
- Hazen-William Co-efficient: 120
- Maximum velocity: 1.5 m/s
- Maximum head loss: 2m/km

[5] According to growth and demand forecast about 6% population of the city will be below the poverty line by 2035. This population will be served by pipe water. The water demand for this population has been calculated considering 100 lpcd.

Design Philosophy:

While designing the water supply system following considerations has been adopted for the project:

Design Approach:

- To distribute safe potable water produced from SWTPs
- Ensure efficient distribution of water to the different DMAs under this sector
- Ensure minimum head in the distribution networks to maintain minimum pressure at consumers' end
- Easy operation and maintenance of primary and secondary distribution networks
- Minimize imported operation and maintenance items
- Maximize local labour during construction and operation
- Use local materials wherever possible and provide adequate flexibility

Reliability:

- The network must distribute water continuously with required head and subsequently must ensure smooth production of water from the treatment plant and as well as to ensure the effective operation of Booster Pumping Stations
- The staff must understand the process and equipment
- The mechanical and electrical equipment must be durable
- Spare parts and ability of local personnel to make repair must be readily available
- Process of distribution networks must be designed to perform under varying water pressures and handle occasional oversights of operation personnel
- Reliable local suppliers of equipment with dependable local agents must be available

Simplicity:

- A less complex primary and secondary distribution system will be better to understand and easier to operate
- When labour costs are high automation is a positive factor, but automation means complex equipment and costly maintenance. If less expensive labour is available, primary and secondary distribution system operation can be handled manually and with minimum automation. Instrumentation and remote control will be proposed to measure the flow of different distribution nodes. This will help in the maintaining of DMAs.

Imports and Mechanization:

- Imported items will be limited and local materials will be specified where possible
- All the equipment used in primary and secondary distribution system must be imported into Bangladesh
- Selection of equipment will be made so that there is less dependency on mechanical and electrical requirements for O&M purposes

Use of local materials and labour:

- Local Materials will be used to the greatest extent possible
- Cement and Re-bar, Bricks, Stone, etc. will not be allowed for import
- Local skilled labour must be given preference in construction works

- Local labours should be employed in operation and maintenance works

12.2.2 Criteria of Selection for Primary and Secondary Mains

Route of primary and secondary distribution network of each sector has been selected based on following consideration:

- Avoiding areas which are presently supplied by existing surface water treatment plant and areas which will be supplied by other sources that are under construction or proposed
- Avoid land acquisition
- Minimum under and above ground obstruction
- Minimum disturbance of traffic movement
- Straightness of pipe line to minimize head loss
- Distribution of water with minimum number of sub-distribution nodes
- To bring the area under this network which are presently suffering acute shortage of water
- Follow wider roads so that the line can be laid by not disturbing other existing utilities network

The pipe materials considered for primary and secondary mains in the projects are as follows:

- Ductile iron (DI)
- Steel
- Glass fibre reinforced plastic (GRP)

Considering the following criteria, ductile pipe is considered most suitable for local condition:

a) Ductile pipes are considered semi rigid pipes and are characteristically strong and tough
b) These materials are able to withstand earth and live loads with little support from soils
c) Ductile pipe do not rely on support from soil
d) GRP and steel pipes are both flexible pipes that rely heavily on soil support and are therefore not recommended for the projects
e) Steel pipes will only be used in case of cannel/culvert crossings.

12.3 Padma North-West Primary Distribution

12.3.1 General Description

The implementation of the Padma (Jashaldia) SWTP Phase-I is expected to start soon and completed by end of 2017. According to the water supply strategy of this Master Plan, water produced from the Padma (Jashaldia) SWTP Phase-I (450 MLD) will be distributed in the west and north-west part of the city covering an area of 50.9 sq km. Hence, this area is named as Padma North-West Sector. A feasibility study for the primary and secondary distribution network of this sector is required urgently by DWASA to facilitate project preparation so that the water distribution system is in place when the Padma (Jashaldia) WTP is commissioned in 2017, as planned.

This sector covers most of the areas of Hazaribagh, Kamrangir Char and Mohammadpur Thanas; parts of Kafrul, Keranigan, Kotwali, Lalbagh, Sutrapur, Dhanmondi, Shyampur and Cantonment Thana areas.

It has been learnt that construction phase of Padma Water Treatment Plant is going to be started with the assistance of the Exim Bank of China. The Exim Bank has already engaged a contractor who will complete the treatment plant construction work on the basis of design-build contract. The contractor has negotiated with DWASA as well as with the Local Government Division for finalizing, operational facilities of the treatment plant and other related works. To distribute water produced from the treatment plant, it has become urgent to go for a feasibility study for primary and secondary distribution networks of Padma North-West sector.

12.3.2 Design Objectives for Primary and Secondary Network

In order to determine the most suitable system for primary and secondary distribution network, the water demand for the sector for the period 2015 to 2035 has been considered as the basis of the water supply system design. The feasibility level outline design for primary and secondary distribution networks of the project has been made with provision of 450 MLD of water to be supplied to the Padma North-West sector by the year 2017.

12.3.3 Conceptual Design of the Network

Based on the earlier stated design criteria and routing considerations, the conceptual network design has been formulated. Treated water from Padma SWTP will be supplied to the Padma North-West sector. To distribute water just after injection point, the main primary distribution line will follow the western flood protection embankment. The water will be distributed at different points on the way to Mirpur area. Another primary main will start from Babu Bazar and proceed further south. This main will distribute water to the existing transmission and distribution main of Chadnighat Water Treatment Plant. The line will follow Islampur, Patuatuly, Sadarghat, Banglabazar, Rupla-Dash Lane to Gandaria. The nodal distribution quantity has been calculated based on the present and future population of year 2035. The distribution nodes of Padma North-West sector has been show in Figure 12-1. Total length of primary and secondary distribution lines along with the quantity of water supplied to different nodes are provided in the Volume 5.

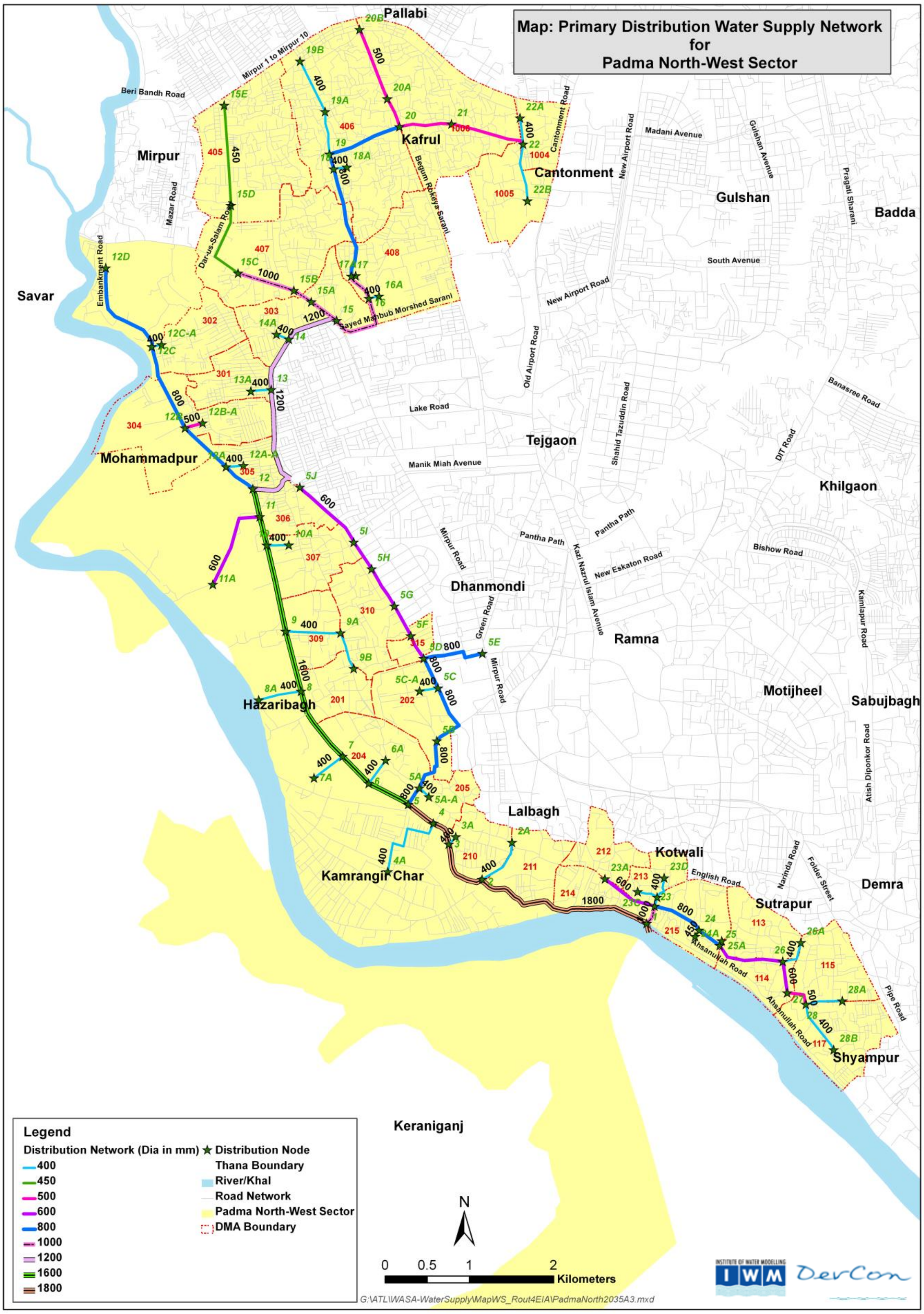


Figure 12-1: Distribution Nodes of Padma North-West Sector

12.3.4 Design of Primary and Secondary Main Networks

Treated water from the Padma SWTP will be injected at Mitford point. From Mitford water will be distributed to the different points of the Padma North-West sector. The existing roads and lanes of the sector are narrow, particularly in the old part of the city. Moreover the roads and lanes remain busy throughout the day and night. In the day time, roads are basically busy with rickshaws and light vehicles. In the night time, trucks are used for transportations of the goods as this part of the city is a key trade centre. Total length of distribution network of Padma North-West sector will be about 42 km (Table 12-1).

Table 12-1: Summary of Primary and Secondary Distribution Network

Diameter (mm)	Length (m)
400	8,360
450	2,183
500	3,082
600	5,534
800	9,503
1,000	2,767
1,200	2,951
1,600	4,389
1,800	3,589
Total	**42,358**

Considering the problems stated above the route of the primary distribution mains has been selected. The details of the proposed routes are described below:

1. From the injection point, water line will follow the Western Flood protection embankment up to Gabtoli point. On the way to Gabtoli, water will be distributed at 16 points. The pipe diameter will be 1,800 mm at injection point and will be reduced depending on the distribution of water on its way to Gabtoli.
2. In addition, two numbers of distribution lines will be laid Badda Nagar and the other one at Bashbari. The 1st one will distribute water to Dhanmondi R/A, Lalmatia, Mohammadpur and adjacent areas. The 2nd one will distribute water to Mohammadpur, Shaymoli, Agargaon, Pirerbag, Monipur, Kafrul, Ibrahimpur and their adjacent areas.
3. The route of the 1st distribution main as stated above will follow the route from Badda Nagar-Peelkhana and SatMosjid Road up to Mohammadpur Bus Stand. The diameter of the pipe has been designed as 800 mm, which will reduce to 600 mm at the end of this line.
4. The 2nd distribution main will start from the embankment near Nabodoy Housing and follow the route of Bashbari, Ring Road, Shaymoli and Agargaon Road. Water will be distributed to the adjacent areas along this route. From Agargaon Road, a new road has been developed up to BIBM (Mirpur-2). This distribution main will follow this road up to Monipur. On the way to Monipur, a branch will be laid from Pirarebag to Rokeya Sarani and then the branch line will be divided in to two lines. One will follow Rokeya Sarani and continue up to Mirpur section 10 Circle. On its way to Mirpur Circle 10, the water will be distributed to Kazipara,

Part of Pirerebag, part of Monipur and their adjacent areas. The 2nd branch will enter in to the Ibrahimpur area to supply water to Ibrahimpur and Kafrul areas.

5. An 800 mm diameter water main will continue from Nabodoy and follow the western embankment up to Gabtoli. On its way to Gabtoli water will be distributed to nearby localities through some distribution nodes.
6. From the injection point at Mitford, a 1000 mm diameter pipe will be laid up to Mitford road and a part of the water will be distributed to the primary main of Chadnighat SWTP for the improvement of water supply condition of Armanitola, Begum Bazar, Moulavi Bazar, Nazira Bazar and their adjoining areas.
7. From Mitford road, a 800 mm diameter water line will be laid and will follow the Islampur-Patoatoly- Bangla Bazar- Ruplal Dash Lane and continue up to KB road at Gandaria. After that, the line will be divided in to two branches. The 1st one will follow Satis Sarkar Road and the 2nd one will follow Hori Charan Ray road. These distribution mains will distribute water to the adjacent areas of Patopatoly, Islampur, Farashganj, Luxmi Bazaar, Gandaria, Postagola and their adjoining areas.
8. One 800 mm pipe has been proposed from node 5C to connect with Saidabad main at node 26 (Saidabad main, Science lab junction). It should be noted that as distribution arrangement has already been provided at node 26 of Saidabad main. Therefore, without disturbing the network, this connection can be used. This will help to transfer water from one system to another if necessary.
9. Saidabad Primary main from Mirpur-Agargaon point to Dar-us-Salam road has been proposed to include in the Padma North-West network. To isolate this part of the network from Saidabad, a butterfly valve in Mirpur road at the south of the junction point of Agargaon and Mirpur road need to be installed.
10. Four numbers distribution nodes have been provided for distributing water to western part of the embankment for the areas like Kamrangir Char, Shikdar Housing area, Dhaka Housing area and Bosila areas. It was assumed that this embankment will be treated as a main road and distribution system will have to be extended to those areas.

The locations of the distribution nodes to the areas stated above have been selected based on the DMA established by the DMC consultants working under DWSSDP project.

Furthermore, in the near future, Keraniganj will be developed as the part of the city. DWASA will have to include this area under its jurisdiction. Water supply to the development projects such as Jhilmil, Basundhara River View, Priangan and South Town will be of prime importance for DWASA. Moreover, Keraniganj Upazila town also needs planned water supply and sanitation. Under the circumstances stated above, 4 (Four) numbers of distribution nodes for Keraniganj area have been provided during preparation of the feasibility study of the Padma (Jashaldia) WTP network. Approximately 20 MLD of water will be distributed to those areas and this distribution will be made before injecting the water at Mitford point.

Saidabad West sector is a very large area with high population density. Presently some areas still have not been connected with distribution nodes. It was found that without disturbing the network of Saidabad at least 5 new nodes can be added. It is known that there are provisions for creation of new distribution nodes in Saidabad network. For example, a distribution node at Bangla Motor was kept but this node has not been connected with the existing distribution system. Furthermore, there are also provisions for six washout valves at different parts of the Saidabad network, in which only one washout system at Begunbari Khal is in use. Other washout valves cannot be used because of limitation of draining out of wastewater. Therefore, these five washout valves can also be connected as distribution nodes.

12.3.5 Project Cost Estimate

The estimated construction and operation costs for primary and secondary water distribution mains and related costs to distribute water produced from Padma SWTP are presented as present day cost (Table 12-2). The cost itself is based on Saidabad Phase-II costs of 2009 and DWASA present cost of procurement of materials and installation.

Three major categories of costs were estimated. They are: i) Cost of Materials ii) CD & VAT for Materials and iii) Cost of Construction.

The cost of procurement of the pipe line materials and its appurtenances have been prepared by estimating the quantities of the different diameter pipes and appurtenances required for distribution of the water to the Padma North West Sector.

Table 12-2: Cost Summary for Padma North-West Sector Primary and Secondary Mains

Serial No	Pipe Materials	Estimated Value (Million USD)	Estimated Value (Million Taka)
1	Cost of Materials	28.5	2,277.7
2	CD & VAT for the Materials	16.8	1,347.9
3	Cost of Construction	9.4	728.9
	Sub-Total	**54.7**	**4,354.5**
	Overhead for General Items (15% of materials & construction costs)	**5.7**	**453.9**
	Grand Total	**60.3**	**4,827.6**

The main duties are customs duty, value added tax (VAT) and development surcharge. Customs duty has been estimated considering HS code: 7307 ductile pipe and fittings, valves, flow meter, etc. as 25% and value added tax have been calculated as 15% of total cost. Total cost for CD, VAT including other taxes has come to 59.98%.

Annual operating costs have been estimated separately for labour, maintenance materials and equipment and miscellaneous costs. Labour costs have been estimated from the staff list of proposed (O&M) organogram of Padma Water Treatment Plant included in the feasibility report. Only costs related to O&M of network and spare parts for the maintenance of the distribution network have been estimated.

A more detailed definition and estimate of each category of cost is listed in the feasibility report (Volume 5).

12.4 Gandharbapur Primary Distribution

12.4.1 General Description

The implementation of the Char Gandharbapur SWTP Phase-I is expected to start soon and completed by end of 2019. According to water supply strategy of this Master Plan,, water produced from Char Gandharbapur SWTP Phase-I (500 MLD) will be distributed in the east and north east part of the city. Hence, this area is named as Khilkhet Sector. A feasibility study for the primary and secondary distribution network of this sector is required urgently by DWASA to facilitate project preparation so that the water distribution system is in place when the Char Gandharbapur WTP is commissioned in 2019, as planned.

This sector comprises 199 sq.km encompassing the whole or parts of 10 nos. thanas namely: Badda, Cantonment, Demra, Gulshan, Kafrul, Pallabi, Uttara, Rupganj, Khilgaon and Purbachal (satellite town of RAJUK). Gulshan and Uttara are the planned residential areas located within this sector with a good road network. The diplomatic zone Baridhara, the restricted part of the cantonment areas are also located in this sector. Average land level is around 1.8 mPWD.

12.4.2 Conceptual Design of Network

The implementation of the Char Gandharbapur SWTP Phase-I is expected to start soon and completed by end of 2019 and will distribute water within Khilkhet sector. Char Gandharbapur SWTP Phase-II supposed to come online on 2030 and Phase-III will be online by 2035. According to water supply strategy of the present study, water produced from the Char Gandharbapur SWTP Phase-I (500 MLD) will be distributed mainly in Uttara (west part), Badda (west part), Cantonment and Gulshan Thana (Figure 12-2). Total length of primary and secondary distribution line for both Phase-I alone and Phase-I & Phase-II combined scenarios have been shown in Volume 5. The details also include quantity of water supplied to different distribution nodes.

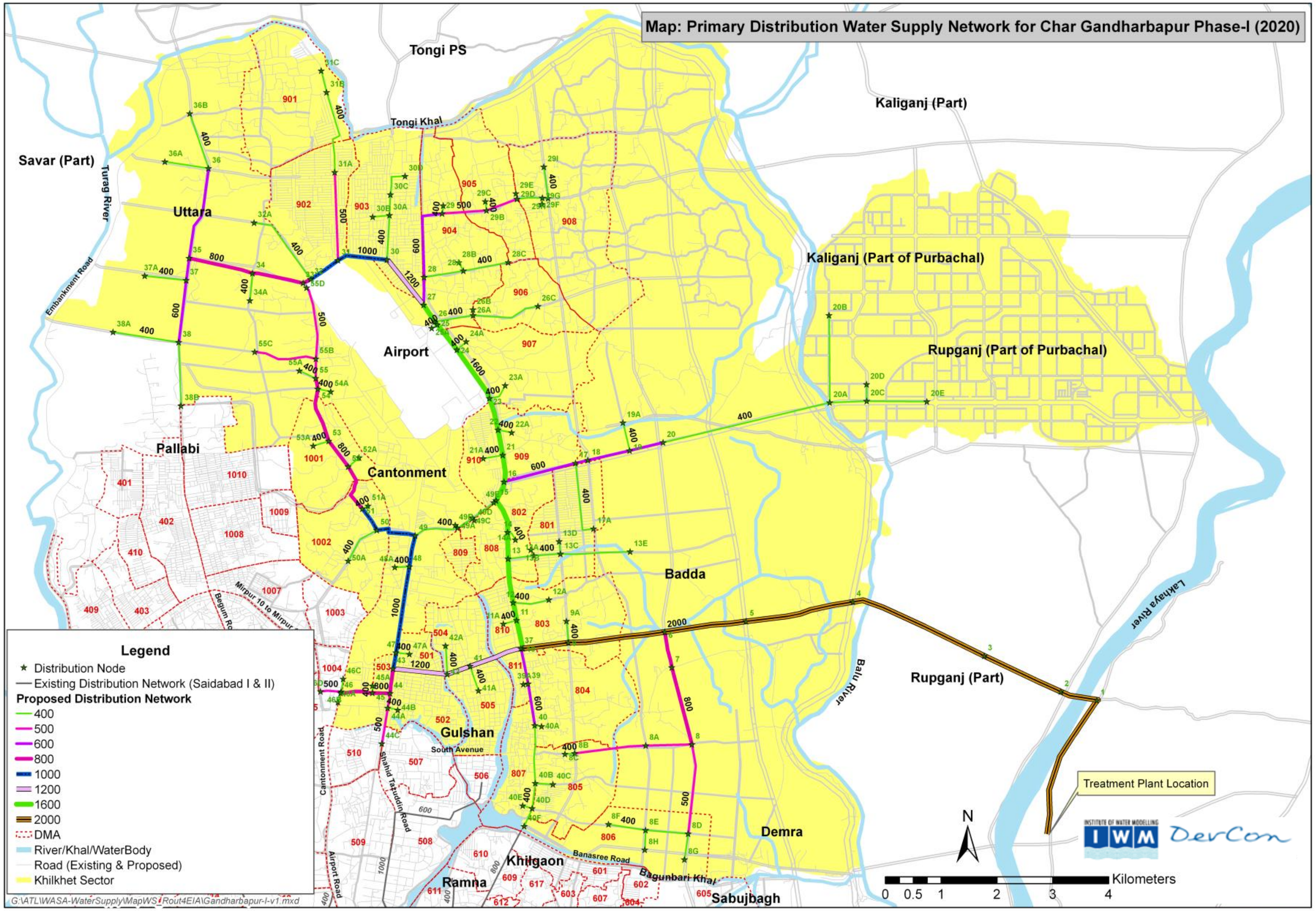


Figure 12-2: Distribution Nodes in Khilkhet Sector for Char Gandharbapur SWTP Phase

12.4.3 Description of Primary and Secondary Distribution Network

The main water supply source for the Khilkhet sector is currently from aquifers. Therefore, it is proposed a new surface water treatment plant (SWTP), located in Gandharbapur (Rupganj Thana, Narayanganj District), will treat water from the Meghna River and supply it to this area in two phases. The first phase of 500 MLD is expected to be completed by 2019 and the second phase of another 500 MLD expected to be completed by 2030 and the third phase of another 500 MLD (total 1,500 MLD for the three phases), expected to be completed by 2035. Primary distribution network of Phase-I would be around 57 km (Table 12-3).

Table 12-3: Summary of Primary and Secondary Distribution Network for Khilkhet sector

Diameter (mm)	Length (m)
500	10,745
600	9,476
800	8,320
1000	5,147
1200	3,453
1600	6,685
2000	13,405
Total	**57,230**

The following is a description of the primary and secondary distribution mains of the treated water from the SWTP.

- From the SWTP, 2000 mm dia pipe will go north in a reserve along the road to the Lakhya River crossing at the end of Bhulta Highway. The crossing will be through tunneling under the river. The pipe will then follow the alignment of a proposed RAJUK road between Lakhya and Balu Rivers. The crossing will be under Balu River near Beraid. The 2000 mm dia pipe continues to Pragati Sharani (Bir Uttam Rafique Islam Avenue) along Madani Avenue, which is currently under construction through Notun Bazar. On the way to Pragati Sharani, a pipe with 800 mm will go south and will distribute water mainly in DMA 805 & 806.
- At the junction of Madani Avenue and Pragati Sharani, from the 2000 mm dia pipe a 1600 mm dia pipe will go north along Pragati Sharani, a 600 mm dia pipe will go south along Progati Sarani and a 1200 mm dia pipe will continue along Madani Avenue towards Kemal Ataturk Road (Gulshan 2 junction).
- The 600 mm dia pipe will continue south along Pragati Sharani to Banasree Road near Rampura Bridge. A branch of the existing Saidabad distribution network ends at this point. On the way to Rampura bridge water will be distributed on both sides of the road.
- The 1200 mm diameter pipe will continue westwards to junction between Kemal Ataturk Avenue and New Airport Road (Dhaka- Mymensingh Highway at Kakoli). From there, an 800 mm diameter pipe will go southwards to the junction of Gulshan South Avenue and New Airport Road near Mohakhali Flyover. A branch of the existing Saidabad distribution network ends at this point. The 1200 mm diameter pipe will continue northwards along the New Airport Road up to the newly constructed railway bridge (Banani Overpass). From there, it will become a 1000 mm dia pipe that will go along Zia Colony Road and Matikata Road, where the diameter will drop to 800mm near Manikdi Kazi Office. The 800mm dia pipe will continue towards Manikdi Graveyard and follow the road northwards along Manikdi Bazar, past Balughat Bazar, Goltek, Aziz Bazar, Hazi Bazar and Dali Bazar. From Dali Bazar, the pipe

becomes 500 mm diameter up to Kali Bari. From Kali Bari this 500 mm diameter pipe will continues northwards to Bawnia Bazar Bus Stand. The pipe then goes westward for about 1km through vacant land. Along this whole route there are several 400 mm dia pipelines branching out to give connections to the local distribution networks.

- The 1600 mm dia pipe will be laid along the Pragati Sharani Avenue, in Badda. It will continue northwards along New Airport Road (Dhaka-Mymensingh Highway). Some 400 mm dia pipes will be used to distribute water to the neighboring areas of Airport and Badda Thana. From 1600 mm pipe, a 600 mm diameter pipe will follow Purbachal road to distribute water locations around Purbachal road as well as in Purbachal. The 1600 mm pipe line will reduce to a 1200 mm dia pipe near the main intersection in front of the Airport entrance. Again at this point a 400 mm dia branch will connect to the local distribution network along Airport-Dakshinkhan Road. The 1200 mm dia pipe will continue along the highway up to Jasimuddin Avenue in Uttara. Along the way, a 600 mm secondary pipe go along Shayesta Khan Avenue and supply water to the local network in Uttara Sector 4 via 400mm dia pipes. A 1000 mm dia pipe will go along Jashimuddin Avenue, at the end of which it will branch to a 500 mm dia pipe going into Uttara Sectors 5, 14, and 13 then reducing to 400mm dia through Sectors 11 and 10. The other branch of the 1000 mm dia pipe at the western end of Jashimuddin Avenue will be a 800 mm dia pipe going along Beri Badh Road and into Uttara Phase 3 area. The conduit line will be carried within the road of Dholipara (near Kadoi Tola) and extend as a 600 mm dia pipe toward the north along Dholiapara road. Finally some 400 mm dia pipes will supply water to local networks in areas of Uttara Phase 3.

12.4.4 Project Cost Estimate

The cost estimation procedure is the same as applied for Padma North-West Sector. Three major cost categories are considered (Table 12-4).

Table 12-4: Cost Summary for Gandharbapur SWTP Phase-I Primary and Secondary Mains

Serial No	Pipe Materials	Estimated Value (Million USD)	Estimated Value (Million Taka)
1	Cost of Materials	58.3	4,662.7
2	CD & VAT for the Materials	34.5	2,759.4
3	Cost of Construction	19.4	1,554.2
	Sub-Total	**112.2**	**8,976.3**
Overhead for General Items (15% of materials and construction costs)		**11.7**	**932.5**
	Grand Total	**123.9**	**9,908.8**

12.5 Saidabad West East Primary Distribution

12.5.1 General Description

The short-term horizon for the Master Plan is from 2014 to 2020, which is in line with the Bangladesh Sector Development Plan - Water Supply and Sanitation (2011-25). Among the several projects identified the Saidabad Surface Water Treatment Plant (SWTP, Phase III) project is a very important project and needs to come online by 2019.

The proposed treatment plant will supply water to the Saidabad West-East sector. The main water supply source for this sector is currently from aquifers and Saidabad SWTP Phase-I (225 MLD) &

SWTP Phase-II (225 MLD). The feasibility study for the Saidabad Phase-III Surface Water Treatment Plant started on 15th May, 2013 by EGIS eau and was completed on April-2014. The proposed new SWTP (Phase-III) will be located next to existing Saidabad Treatment Plant (Phase-II). It will treat water from the Meghna River. The Plant has a proposed supply capacity of 450 MLD.

This sector comprises of 106.5 sq.km area covering most of the area of Demra, Khilgaon, Motijheel, Ramna, Sabujbagh and Tejgaon Thanas; considerable part of Dhanmondi, Kotwali, Lalbagh, Shyampur and Sutrapur Thanas and portions of Cantonment, Gulshan, Kafrul, Mohammadpur, and Narayanganj Sadar Thanas. Till year 2030, all area of Shyampur Thana will be within this sector. However, it is assumed that Padma Phase-II will be in operation by 2030 when 42% area of Shyampur Thana will be in Saidabad West-East sector and rest of Shyampur will be in Padma South Sector.

12.5.2 Existing Situation Saidabad Phase-I & II

Existing primary and secondary distribution network is designed for distribution of treated water, produce from Saidabad WTP Phase- I & II. Key portion of the network was built during execution of Saidabad WTP Phase-I. The total length of the network built was 36 km including 23 PRV's and 42 distribution nodes. Saidabad WTP Phase-II has been constructed recently along with additional 10 km distribution network including 17 distribution nodes and 17 PRV's, leading to a total length of distribution network of 46 km. The numbers of PRV's and distribution nodes have also increased to 40 and 59, respectively. The diameter of the network varies from 300 mm to 1800 mm.

According to DWASA, at the time of commencement of Phase-I, minimum head at the WTP was fixed to 2.9 bar and a head of 1 bar was available at the furthest distribution node (node no. 11). However, after commencement of Phase-II the mathematical model was not updated. Thus sufficient information about the distribution mechanism in respect of PRV adjustment and actual distribution through different nodes is not available with DWASA. Several field visits have been conducted to know the updated information in respect of available pressure head at the WTP. It was seen that pressure head has been readjusted and increased to 4.2 bar to convey water to the distribution network. Therefore water supply is adequate at all distribution nodes.

A mathematical model has been developed by distributing the flow through PRV's based on the diameter of PRV's and maximum velocity of 1-1.5 m/sec. Hazen William coefficient for 12 years old pipe has been selected as 105. Resistance due to the special fixtures and appurtenances has not been added to the head losses. It has been observed that the head available at Saidabad WTP Phase- I & II is sufficient to convey water to the furthest nodes with minimum pressure.

The existing network is designed to distribute 450 MLD water. From the model it was observed that with this quantity, velocity from WTP to node 1 rises to 2.1 m/sec. From node 1 to node 7a velocity in the pipe is higher than the acceptable limit. Velocity in the pipe will further rise if additional flow from Phase- III is injected to the existing network.

The facts stated above shows there is no scope to inject additional flow from Phase – III to the existing network. Therefore a new primary and secondary distribution network has been developed for Saidabad Phase-III.

Figure 12-3 represents the existing primary distribution network of Saidabad Phase-I & II. Detailed calculations of flow and velocity within the network have been shown in Volume-5.

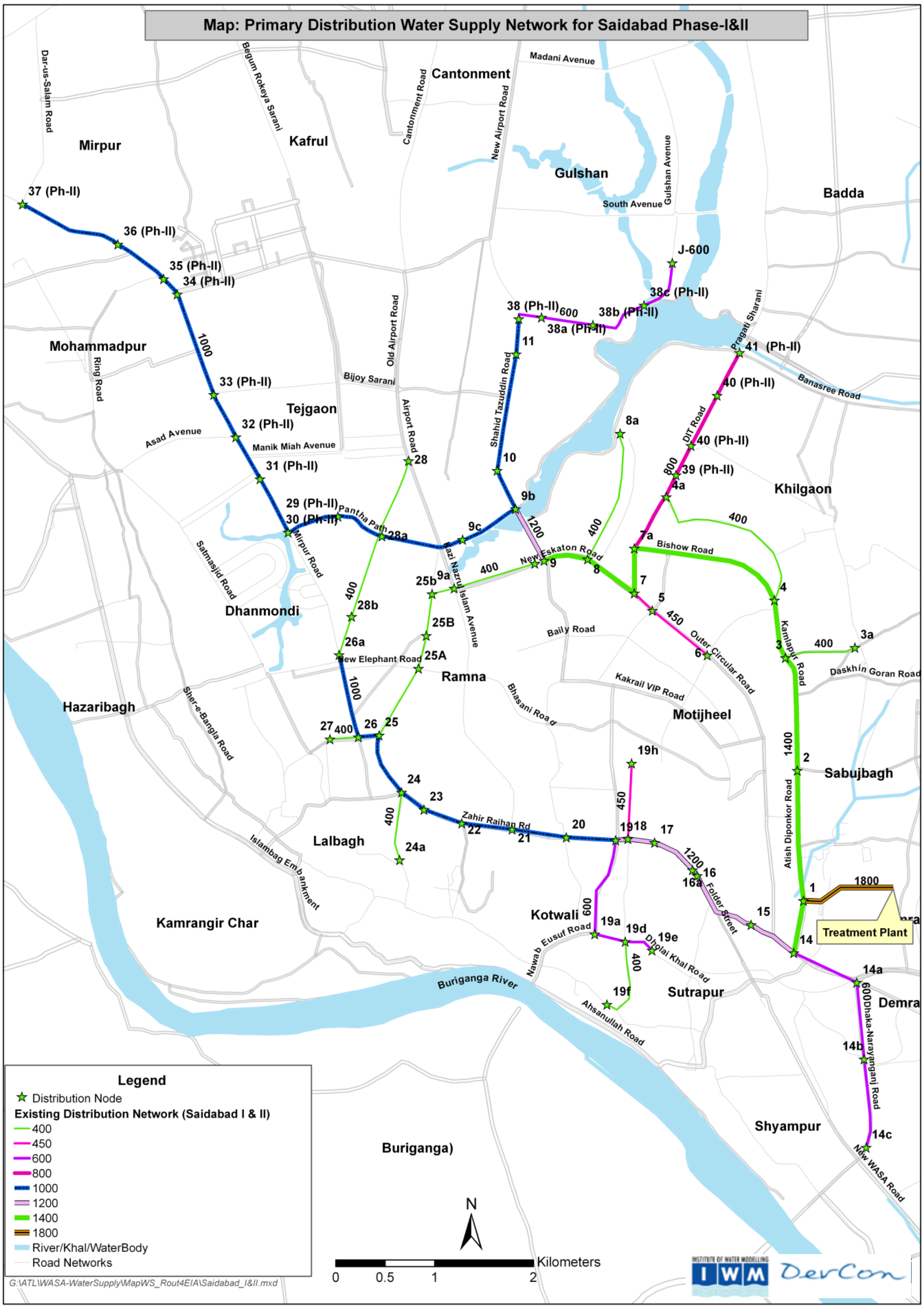


Figure 12-3: Primary Distribution Networks for Saidabad Phase-I & II

12.5.3 Conceptual Design of Network

Treated water from Saidabad Phase-III will be supplied mainly to eastern part of this sector in addition with some western part. In western part, water will distribute nearby location of Outer Circular road (up to Shahjahanpur Circle), Kamalapur road and Kakrail VIP road (up to Kakrail Mosque). In eastern part, water will be distributed to Khilgaon, Goran, Madartek, Banasree, Demra and DND areas. The nodal distribution quantity has been calculated based on the present and future population of year 2035. Till year 2030, all area of Shyampur Thana will be within this sector (Figure 12-4). However, it is assumed that Padma Phase-II will be in operation in 2030 when 42% area of Shyampur Thana will be in this sector and rest of Shyampur will be in Padma South Sector. Total length of primary and secondary distribution lines for Phase-III has been shown in the Volume 5. The details also include quantity of water distribution to different distribution nodes.

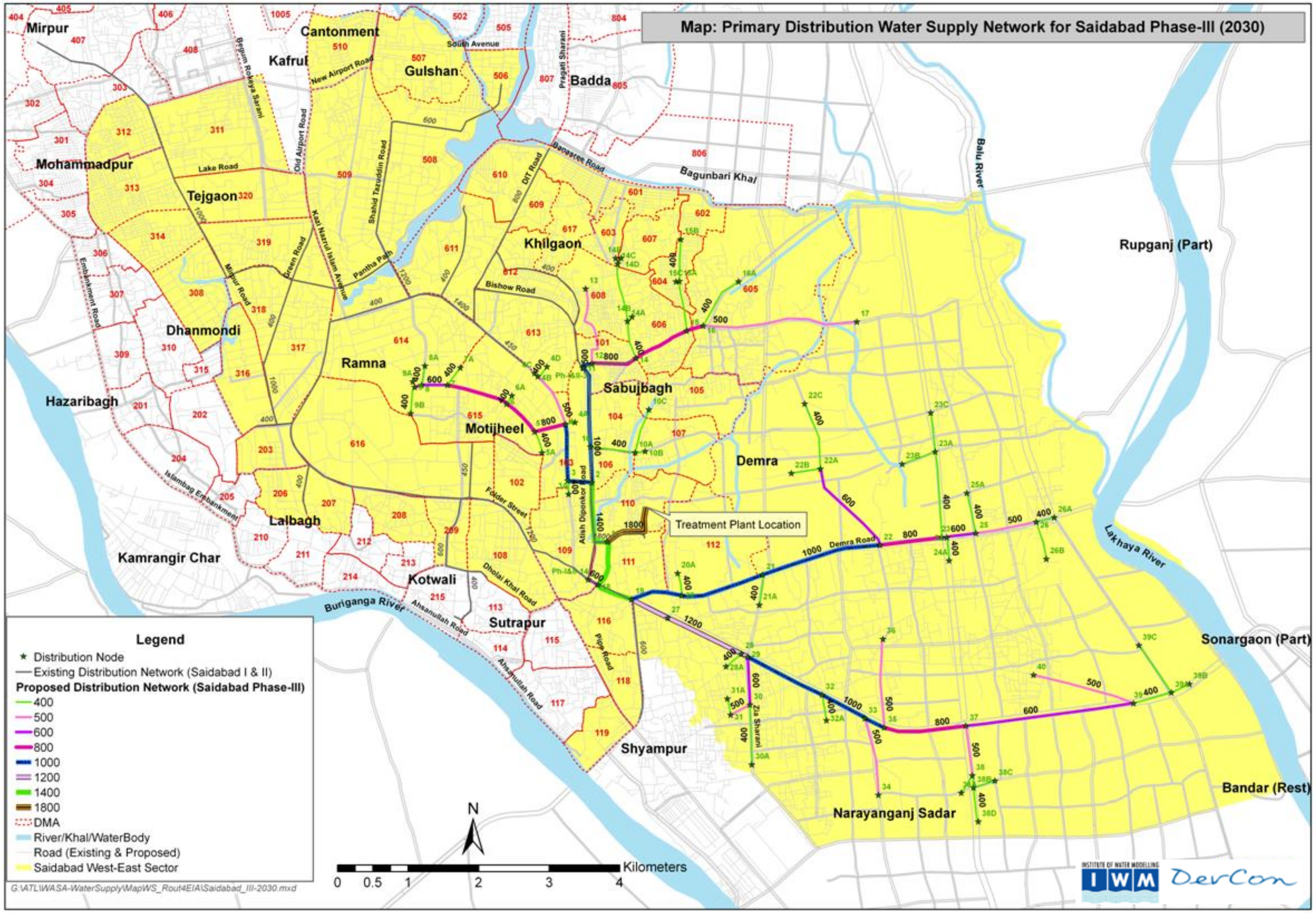


Figure 12-4: Distribution Nodes in Saidabad West-East Sector for Saidabad Phase-III

12.5.4 Description of Primary and Secondary Distribution Network

It is proposed that Saidabad Phase-III will be in operation by 2019. As mentioned earlier, the whole of Shyampur Thana will be within saidabad West-East sector till 2030 and from 2030 42% area of Shyampur Thana will be in this sector. Therefore, there will be some surplus water which will be distributed in Demra and DND area through node 23, 24 and 27 and rest of Shyampur will be in Padma South Sector. Total length of distribution network for Saidabad Phase-III is 54,427 m (Table 12-5), which include extension of networks (400 mm pipe) in 2030.

Table 12-5: Summary of Primary and Secondary Distribution Network for Saidabad Phase-III

Diameter (mm)	Length (m)
400	19,396
500	9,960
600	5,618
800	5,671
1,000	8,824
1,200	1,836
1,400	2,209
1,800	913
Total	**54,427**

The details of the proposed routes are described below.

- From Saidabad Phase-III, an 1800mm diameter pipe will follow the road next to Maniknagar Government Primary School and will continue along the Maniknagar Link Road. The primary main will then be divided into two mains of 1400 mm diameter before crossing point of Saidabad WASA road next to Golapbagh play ground.
- First one of diameter 1400 mm pipe will follow the road next to Golapbagh play ground and will meet Atish Diponkar Raod near CNG station. From the CNG station this line will follow Atish Diponkar Raod and will divide into two 1000 mm pipes near Kamlapur Stadium. The first pipe of 1000 mm will cross Kamlapur Railway track and divide in to two pipes of diameter 800 mm and 600 mm. The pipe of 800 mm diameter will follow outer circular road and will continue up to Kakrail Mosque. At Kakrail Mosque, the diameter of the main will be reduced to 600 mm. All these lines will distribute water to several distribution nodes. The pipe of 600 mm diameter will connect to existing 600 mm diameter pipe at Shahjahanpur Circle, near Eastern boundary of Rajarbagh Police line.
- Another main of diameter 1000mm from Kamlapur Stadium will follow Atish Diponkar Road and continue up to Basabo and then the line will follow Basabo-Madartek-Nandipara road. On the way to Nandipara, water will be distributed to Khilgaon, Goran, Madartek, Banasree and other adjacent areas.
- Second 1400 mm diameter pipe will follow new Dholpur road and will continue up to Jatrabari Circle, where it will be divided into two submains. One submain of dia 1000 mm pipe will be laid along the Demra road and continue up to Demra Circle near Lakhya river. Near Demra circle the diameter of the pipe will be of 400 mm. The other submain

of dia 1200 mm will follow Dhaka-Chittagong Highway and will continue up to Dhaka-Narayanganj Link road crossing. The diameter of the pipe at Dhaka-Narayanganj crossing will be reduced to 800 mm. This 800 mm pipe will continue up DND embankment. This line will supply water to the adjacent areas through several distribution nodes.

12.5.5 Project Cost Estimate

The cost estimation procedure is the same as applied for Padma North-West Sector. Three major cost categories are considered (Table 12-6).

Table 12-6: Cost Summary for Saidabad Phase-III Primary and Secondary Mains

Serial No	Pipe Materials	Estimated Value (Million USD)	Estimated Value (Million Taka)
1	Cost of Materials	22.9	1,831.6
2	CD & VAT for the Materials	13.5	1,083.9
3	Cost of Construction	7.6	610.5
	Sub-Total	**44.1**	**3526.1**
	Overhead for General Items (15% of materials and construction costs)	**4.6**	**366.3**
	Grand Total	**48.7**	**3,892**

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