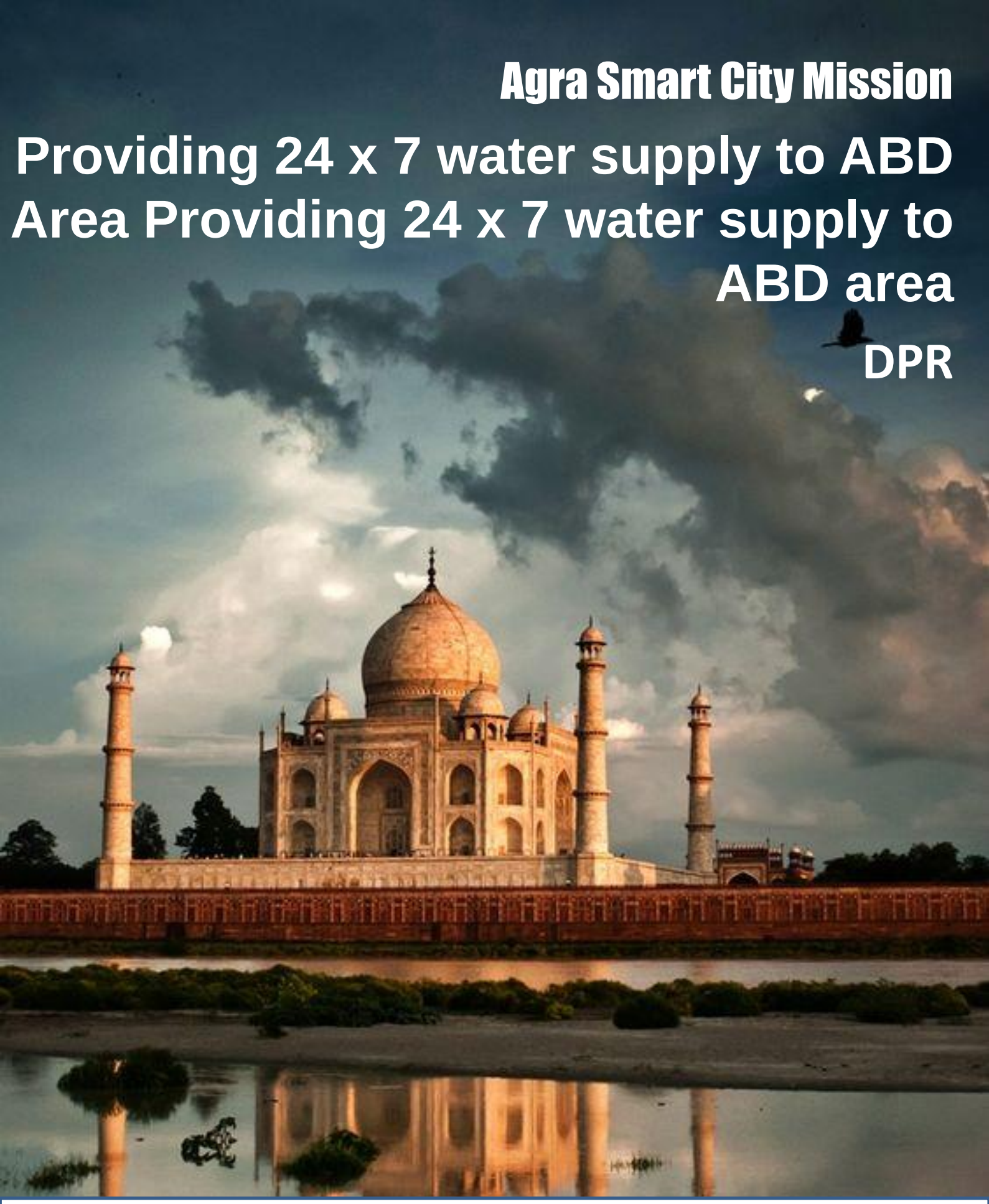
Agra Smart City Mission

Providing 24 x 7 water supply to ABD Area Providing 24 x 7 water supply to ABD area

DPR



Submitted by:

DARASHAW 1925 ALL ABOUT TRUST gaia smart cities STC

Submitted to:

Agra Smart City Limited

CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ADB	:	Asian Development Bank
AWWA	:	American Water Works Association
bar	:	Pressure unit: 1 bar ~ 10 metres of water column
BIS	:	Bureau of Indian Standards
BHP		Brake Horse Power
BL		Bed Level
cm	:	Centimetre
BOD5	:	Biochemical Oxygen Demand at 5 days
CDP	:	City Development Plan
CPHEEO	:	Central Public Health and Environmental Engineering Organisation
d	:	Day
DBO	:	Design Build Operate
DI	:	Ductile Iron (material for pipelines and fittings)
DIN	:	Deutsches Institut für Normung (German Institute forNorms)
DMA	:	District Metered Area
DPR	:	Detailed Project Report
DRA	:	DRA Consultants Pvt. Ltd.
EIA	:	Environmental Impact Assessment
EMP	:	Environment Management Plan
ESR	:	Elevated Service Reservoir
GL	:	Ground Level
GoR	:	Government ofRajasthan
GoI	:	Government of India
Grontmij	:	Grontmij A/S, Denmark
hr	:	Hour
ha or Ha	:	Hectare
HDPE	:	High Density Poly Ethylene (material for pipelines)
HP	:	Horse Power; 1HP = 0.745699872 kW = 745.699872 Nm/s (Newton metre / second)
ISO	:	International Organisation for Standardisation
kg	:	Kilogramme
kg/h	:	Kilogramme per hour
KPI	:	Key Performance Indicator
km	:	Kilometre
kV		Kilovolt
kVA		Kilovolt Ampere
kW	:	Kilowatt
kWh	:	Kilowatt hour
l	:	Litre
L	:	Length
LEAP	:	Local Environmental Plan
LOS	:	Levels of Service
LSGD	:	Local Self Government Department – Govt. of Rajasthan
l/d or lpd	:	Litres per day
l/h or lph	:	Litres per hour
l/m or lpm	:	Litres per minute
lpcd or l/c/d	:	Litres per capita per day (referring to the consumption of water)
l/s or lps	:	Litres per second
m above MSL.	:	Metres Above Mean Sea Level
m	:	metre
m^2	:	square metre
m^3/d	:	cubic metres per day
m^3/hr	:	cubic metres per hour
MDDL	:	MinimumDraw Down Level
mld or MLD	:	Million Litres per day

mm	:	Milimetre
MWL	:	Maximum Water Level
NRW	:	Non-Revenue Water
NSLB	:	National Service Level Benchmark
NTU	:	Nephelometric Turbidity Unit
OD	:	Outer Diameter (refers to non-metallic pipelines)
RW	:	Raw Water
RWPS		Raw Water Pumping Station
OJT	:	On the Job Training
OHSR	:	Over Head Service Reservoir
OHT	:	Overhead Tank
OHASAS	:	Occupational Health and Safety Standard
O&M	:	Operation and Maintenance
PE	:	Poly Ethylene (material for pipelines and fittings)
PI	:	Performance Indicator
PIU	:	Project Implementation Unit
PMDSC	:	Project Management, Design and Supervision Consultant
PMU	:	Programme Management Unit
PN	:	Nominal Pressure (normally followed by a number that represents bar)
PPTA	:	Project Preparatory Technical Assistance
PRV	:	Pressure-Reducing Valve
PSP	:	Public Stand post
ppm	:	parts per million = milligrams per litre
PVC	:	Poly Vinyl Chloride (material for pipelines and fittings)
RCC	:	Reinforced Cement Concrete
RF	:	Resettlement Framework
RP	:	Resettlement Plan
RWR	:	Raw Water Reservoir
SCADA	:	Supervisory Control and Data Acquisition
SDR	:	Standard Dimension Ratio for [HDPE pipes] (outer diameter / pipe wall thickness)
SEIAA	:	State Environment Impact Assessment Authority
SS	:	Suspended Solids
STC	:	Shah Technical Consultants
STP	:	Sewerage Treatment Plant (or WWTP)
TA	:	Technical Assistance
LAC	:	Local Administrative Committee
ToR	:	Terms of Reference
TM	:	Transmission Main
TSS	:	Total Suspended Solids
TW	:	Treated Water
TWPS	:	Treated Water Pumping Station
UFW	:	Unaccounted for Water
ULB	:	Urban Local Body
VAT	:	Value Added Tax
WDS	:	Water Distribution Station
WHO	:	World Health Organization
WTP	:	Water Treatment Plant(or) Willingness to Pay

EXECUTIVE SUMMARY

The Smart Cities Mission of the Government is a bold, new initiative. It is meant to set examples that can be replicated both within and outside the Smart City. Agra is one of 13 smart cities selected in Utharpradesh under "Smart City Mission". The ABD area is earmarked for about 2250 Acres comprising wards of 7, 71, 72, 74, 80, 81, 85, & 86. Along with Mayapur and KalalKheria villages.

The Proposals

Additional components are to be developed in order to ensure that the water supply system would function in efficient manner fully meeting the needs of the town population and fully meeting the water demand. Following describes components which will be executed in next three years in the water system of the town and bringing down the NRW within acceptable limits.

Proposed pumping station at GeoniMandi water works

A separate pump house at GeoniMandi water works is proposed to pump treated water for ABD area and TajGanj Zone. The pumping station is designed to accommodate the following pumps with 100% standby and power backup arrangements

- Direct pumping system for Zone-7 covering wards of 81 (p), 85 (p) & 86 (p) as it is nearby water works and being a small isolated pocket in ABD area.
- To pump treated water requirement of 40.33 MLD to zone-1, zone-2, zone-3, zone-4, zone-5 & zone-6
- To accommodate additional pumps for pumping 65 MLD for Taj Ganj Zone to be installed by Jal Nigham

Treated water transmission main

The treated water requirement for ABD area will be available at CWR at GeoniMandi WTP location. The scope of work starts with proposed pumping station at GeoniMandi water works. The treated water will be transmitted through a new transmission main from GeoniMandi WTP to ZPS at TajGanj. The transmission main is designed to accommodate the water requirements of Wards contributing to ABD area 7, 71, 72, 74, 80, 81, 85 & 86 and for wards outside ABD area of 70,73& 89.

The transmission main is capable of carrying 105.23 MLD of treated water out of which 40.33 MLD will be drawn at CWR at TajGanj ZPS. About 65 MLD will be tapped by JalKal for rest of TajGanj area water demand as bulk supply.

Clear water reservoir

A RCC clear water reservoir of 10 LL capacity is proposed at TajGanj ZPS to balance serve as balancing tank to pump to OHTs. The CWR is capable of accommodating half an hour of average pumping demand.

Clear water pumping stations

It is proposed to construct a new pump house to accommodate pumps to pump from CWR to zonal OHTs with 50% standby and power backup arrangements

Feedermains

It is proposed to lay feedermains from TajGanj ZPS to zonal OHTs directly with DI-K9 pipes of diameter varying from 150mm to 500mm to a total length of 5.55 Kms

Overhead service reservoirs (OHTs)

It is proposed to construct 5 Nos of zonal OHTs across the project area to envisage 24 x 7 water supply for ABD area. The capacity of OHTs and staging height are as follows

- Zone-1 25 Lakh litres 25m staging
- Zone-2A& 2C 20 Lakh litres 25m staging
- Zone-2B 20 Lakh litres 25m staging
- Zone-3 15 Lakh litres 15m staging
- Zone-4 27 Lakh litres 15m staging
- Zone-5 25 Lakh litres 25m staging
- Zone-6 3 Lakh litres 25m staging

For Zone-7 it is proposed to supply by direct pumping by using VFD pumping arrangements

Distribution system

The entire ABD area is divided into 7 zones considering the topography and natural boundaries to serve the water supply system efficiently with equitable water supply with adequate pressure. The from 110mm to upto 225mm OD HDPE pipe of PE 100 PN 10. Above that DI pipe of K7 is proposed. The zone wise distribution pipe length is listed below

- Zone-1 57 Kms
- Zone-2 36 Kms
- Zone-3 6 Kms
- Zone-4 12 Kms
- Zone-5 20 Kms
- Zone-6 11 Kms
- Zone-7 2.5 Kms

Consumer Connections

A provision has been made for providing about 16,000 consumer connections which includes replacement of existing connections. Each consumer connection will be in HDPEPN6 pipeswith electro fusion joints, will be metered with ultrasonic AMR water meters and will generally Existing consumer connections will be shifted on the new communication pipes in HDPE PN6 to be laid for this purpose.

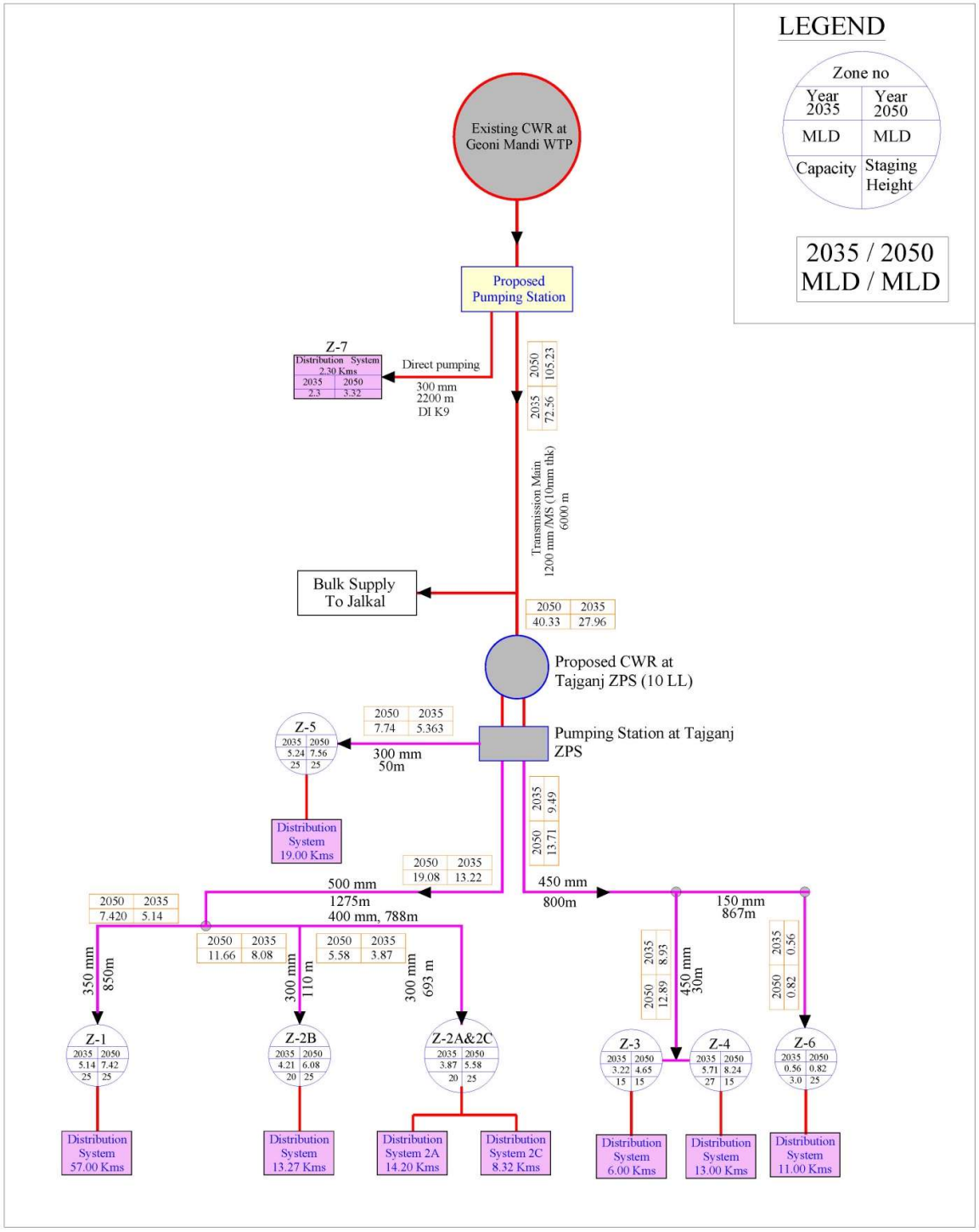
Operation and Maintenance

The entire water supply system will be monitored by full SCADA system compatible to link to master control centre. A period of 24 months shall be provided to the contractor to construct the water supply system. Thereafter the Contractor shall operate and maintain the water supply system thus constructed for a period of next 5 years. All the functions of operations, repair & maintenance, providing new connections and disconnections, if any, metering billing and collection of revenue etc will be carried out by the contractor on behalf of the Agra Smart City Limited.

Summary of project cost

General Abstract for Providing 24 x 7 water supply system to ABD area with water meters and SCADA system		
Sl No	**Description**	**Amount in Lakhs**
1	**Construction of pumping station at Geoni Mandi Headworks**	**60.12**
	Geoni mandi Mechanical Estimate	151.90
	Geoni mandi Electrical Estimate	160.61
	Sub total at Geoni Mandi Headworks	**372.63**
2	**Laying of transmission main from Geoni Mandi headworks to Taj Ganj ZPS (1200mm M.S pipe for 6 Km)**	**1862.06**
3	**Construction of CWR at Taj Ganj ZPS (10 LL capacity)**	**49.50**
4	**Construction of pumping station at Taj Ganj ZPS**	65.85
	Taj Ganj ZPS Mechnical estimate	124.69
	Taj Ganj ZPS Electrical estimate	98.81
	Sub total at Taj Ganj ZPS	**289.35**

5	**Laying of feedermain from Taj Ganj ZPS to Zonal OHTs rannging dia 150mm to 500mm DI-K9 pipe (5025m)**	**393.55**
6	**Design, plan and construct OHT of required capacity and staging height**	
	Zone 1(2500 KL)	367.50
	Zone 2 (2 X 2000 KL)	588.00
	Zone 3(1500 KL)	220.50
	Zone 4(2700 KL)	396.90
	Zone 5(2500 KL)	367.50
	Zone 6(250 KL)	51.00
	Sub total OHTs	**1991.40**
7	**Laying of distribution mains using HDPE pipe and DI-K7 pipe**	**1750.36**
8	**Providing House Service Connections using HDPE PN 6 pipe and AMR water meters (17225 Nos.)**	**2210.21**
9	**SCADA system for entire water supply system**	**344.41**
10	**Operation & Maintanance cost for 5 years**	**3294.80**
	Base cost of project	**12558.26**
	Labour cess @ 1%	**125.58**
	GST @ 12%	**1506.99**
	Shifting of Utilities 0.5 %	**62.79**
	Grand Total	**14253.63**
		142.52 Crores


LEGEND
Zone no
Year 2035
Year 2050
MLD
MLD
Capacity
Staging Height
2035 / 2050
MLD / MLD
Existing CWR at Geoni Mandi WTP
Proposed Pumping Station
Z-7
Distribution System
2.30 Kms
2035 2050
2.3 3.32
Direct pumping
300 mm
2200 m
DI K9
2050 105.23
2035 72.56
Transmission Main
1200 mm /MS (10mm thk)
6000 m
Bulk Supply To Jalkal
2050 2035
40.33 27.96
Proposed CWR at Tajganj ZPS (10 LL)
Pumping Station at Tajganj ZPS
2050 2035
7.74 5.363
Z-5
2035 2050
5.24 7.56
25 25
300 mm
50m
Distribution System
19.00 Kms
2035 9.49
2050 13.71
2050 2035
19.08 13.22
500 mm
1275m
400 mm, 788m
450 mm
800m
150 mm
867m
2050 2035
7.420 5.14
2050 2035
11.66 8.08
2050 2035
5.58 3.87
350 mm
850m
300 mm
110 m
300 mm
693 m
2035 8.93
2050 12.89
450 mm
30m
2035 0.56
2050 0.82
Z-1
2035 2050
5.14 7.42
25 25
Z-2B
2035 2050
4.21 6.08
20 25
Z-2A&2C
2035 2050
3.87 5.58
20 25
Z-3
2035 2050
3.22 4.65
15 15
Z-4
2035 2050
5.71 8.24
27 15
Z-6
2035 2050
0.56 0.82
3.0 25
Distribution System 57.00 Kms
Distribution System 13.27 Kms
Distribution System 2A 14.20 Kms
Distribution System 2C 8.32 Kms
Distribution System 6.00 Kms
Distribution System 13.00 Kms
Distribution System 11.00 Kms

1. Introduction

Agra is one of 13 cities selected for smart city mission by Govt. of India,ABD area is earmarked based on selection criteria as follows

- The city profile
- Citizen opinion and engagement
- Opinion of the elected representatives
- Discussion with the urban planners and sector experts
- Discussion with the suppliers/ partners

The ABD area covers about 2.40 % of total Municipal corporation area. Two villages KalalKheria and Mayapurais located adjacent to the Municipal limit is also added to ABD area. The details of ward wise coverage is tabulated below

1.1 Location and Area

Agra city is located on the southern bank of river Yamuna. It is a northern part of Uttar Pradesh, India. The state capital Lucknow is about 378 Km on east. Agra is near national capital New Delhi about 206 Kms northwest direction. The city is also well connected with National highways, rail networks to other major cities and district headquarters.

Agra is a major tourist destination because of its many Mughal-era buildings, most notably the TājMahal, Agra Fort and FatehpurSikri, all three of which are UNESCO World Heritage Sites. Agra is included on the Golden Triangle tourist circuit, along with Delhi and Jaipur; and the Uttar Pradesh Heritage Arc, tourist circuit of UP state.

The climate of Agra experiences mild winters, hot and dry summers and a monsoon season. Agra has a reputation of being one of the hottest towns in India. In summers the city witnesses a sudden surge in temperature and at times, mercury goes beyond the 46°C mark in addition to a very high level of humidity. During summer, the daytime temperature hovers around 46-50°C. Nights are relatively cooler and temperature lowers to a comfortable 30°C. Winters are bit chilly but are the best time to visit Agra. The minimum temperature sometimes goes as low as 2 or 3°C but usually hovers in the range of 6 to 8°C.

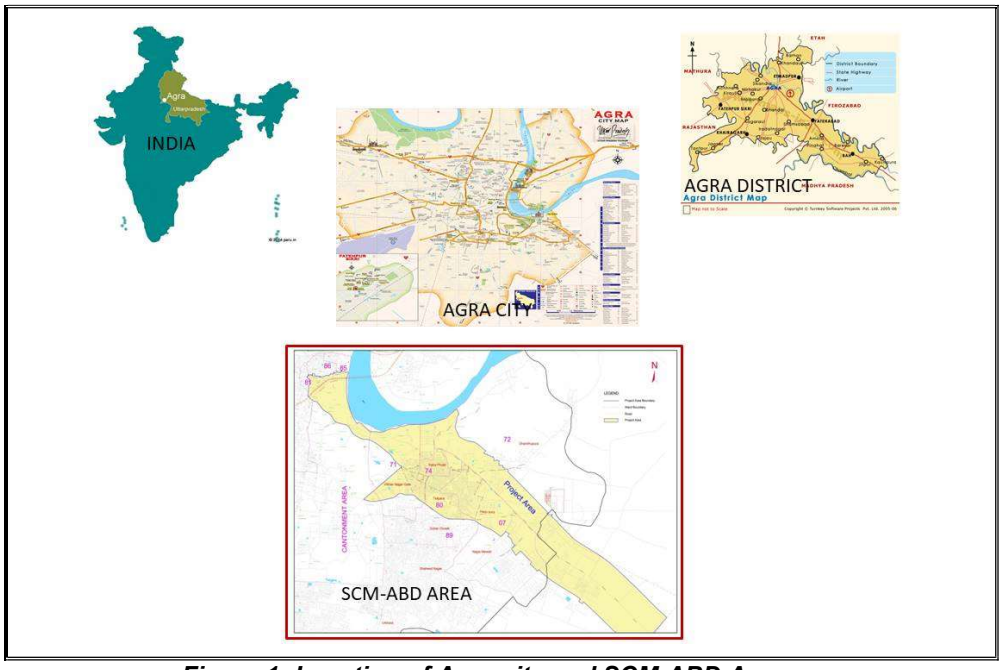


Figure 1: Location of Agra city and SCM-ABD Area

1.2 Demographics

Agra is a major tourist destination because of its historical Mughal-era buildings, three historical monuments are earmarked for UNESCO World Heritage sites.

1. Taj Mahal,
2. Agra Fort
3. Fatehpūr Sikrī,

Agra City with a total land area of 141 km^2 had a population of 2,22,943 in 2011. The growth rate of Agra varies from decade to decade and last three decade the growth rate is increasing. In last six decades the population has grown almost 4.75 folds, with increase in population from 3,33,530 in 1951 to 15,85,704 in year 2011. The growth pattern of the town is illustrated in the Table1:

Table 1:Decadeal Population and Growth Pattern

Sl.No.	Year	Population		Decadal Growth rate Population Variation %
		Population	Variation	
1	1951	333530		
2	1961	462020	128,490	39%
3	1971	591917	129,897	28%
4	1981	694191	102,274	17%
5	1991	891790	197,599	28%
6	2001	1275134	383,344	43%
7	2011	1585704	310,570	24%

Agra recorded an overall literacy rate of 60.10 % with female literacy of 40.96%, Thus Agra compares favourably in terms of literacy and sex ratio compared to state averages on these indicators.

1.3 Objectives of the assignment

The water supply project proposed for Agra has objective to achieve ultimate goals of continuous 24 X 7 water supply system, sustainability, imparting energy efficiency, control on NRW, and Introducing (SCADA) automation for efficient management of water supply system

Deign period is 30 years, taking base year as 2020.

- Projection of population
- To review the existing water supply system in ABD area
- Creation of new raw water storage at the existing headworks
- By abandoning existing infrastructure wherever the same is uneconomical when undertaken for rehabilitation
- Design and Provide transmission main
- Design and provide new raw water and clear water pumping plants
- Design and provide new OHTs of required quantity and staging height
- Replacement of old & inefficient pumping machinery installed at various places serving ABD area with new & energy efficient pumping machinery
- Abandoning the existing old distribution system by a newly designed distribution network
- Reduction in NRW in pilot zones with the objective of attaining continuous water supply with minimum residual pressure of 17m
- system automation (SCADA)

1 EXISTING SYSTEM OVERVIEW

1.1 Source

The primary source of water is from river Yamuna one of the sacred rivers of India. It is also perennial rivers originating from Yamunotri glaciers from Himalayan range. Due to urbanization along the river bank and flowing through national capital the pollution level is increased considerably due to discharge of untreated domestic sewage and effluents from tannery and food processing industries upstream of Agra city.

The source of water from river Yamuna by branching canal to the intake structure. There are three intake structures

1. New intake well
2. Old intake well
3. New Jal Nigham intake well

Figure 2: Intake works at GeoniMandi Water Works

As per the earlier report prepared for AMRUT by Agra JalNigham, it was reported that 280 MLD of water is being withdrawn at intake location against present demand (2018) of 445.35 MLD. During summer the flow is considerably reduced and thereby concentration of pollutants also increased. Thus, the quantity and quality of source is unreliable. To cope up to the present deficit and future growing demand alternative source from river Ganga is envisaged through Ganga Jal project. In this project allotment of 345 MLD for Agra city will be treated at JeoniMandi and Sikandra water treatment plants. As per the allocation 200 MLD for JeoniMandi and 145 MLD for Sikandra water works.

The dedicated demand of 45.56 MLD of raw water is part of the total allocation and will be treated in JeoniMandi WTP. The clear water requirement of 30.96 MLD and 44.68 MLD for intermediate and ultimate demand including transmission main loss and firefighting demand is reserved at CWR available at JeoniMandi WTP.

Raw WateRaw Water Pumpsets

There are 3 Nos. (2W+1S) of VT pumpsets installed in the intake well at JeoniMandiheadworks to pump the raw water from the Raw Water canal diverted from river Yamuna to the Water Treatment Plants (WTP), vide Fig.4. Duties of the pumpsets are as follows.

Table 2: Details of the raw water pump at old intake well

Sl.No	Pump No.	HP	Discharge (Cum/Hr.)	Head (m)
1	Pump-5	150	2430	15.38
2	Pump-6	185	3180	15.38
3	Pump-7	93	1215	17

Table 3: Details of the raw water pump at new intake well

Sl.No	Pump No.	HP	Discharge (Cum/Hr.)	Head (m)
1	Pump-1	132	1950	15.80
2	Pump-2	132	1950	15.80
3	Pump-3	132	1950	15.80

Table 4: *Details of the raw water pump at new JalNigham intake well*

Sl.No	Pump No.	HP	Discharge (Cum/Hr.)	Head (m)
1	Pump-1	150	2460	15.5
2	Pump-2	180	3180	15.5
3	Pump-3	185	3180	15.38

1.2 Water Treatment Plants

The surface water from intake canal is treated at Water Treatment Plants (WTPs) of 225 MLD capacity constructed during British period. The treatment plants are periodically rehabilitated. At present the treatment capacity is only 160 MLD against its full capacity of 225 MLD which is 71% efficiency. Under assistance from JICA in Ganga Jal Project the renovation work is on-going and after completion it will run its full capacity.

1.3 Clear water pump sets

1.3.1 For Tajganj ZPS

There are 6 Nos of pumpsets installed in the headworks to pump the clear water from the Clear Water Reservoir to the distribution system of Tajganj Zone Duties of the pumpsets are as shown in Table 5

Table 5: Clear water pumps at TajGanj ZPS

Sl.No	Pump No.	HP	Discharge (Cum/Hr.)	Head (m)
1	Pump-1	50	600	32
2	Pump-2	50	600	32
3	Pump-3	75	600	34
4	Pump-4	75	648	30
5	Pump-5	75	648	30.48
6	Pump-6	37	186	32

1.3.2 Present condition of the Pump

Pump-1 is not in working condition, these existing pumps will serve for TajGanj zone other than ABD area. Hence these pumps are retained for on-going water supply and for ABD area new pumping station with pumping machinery will be installed to deliver water from CWR to OHTs.

1.4 Transmission Mains

The transmission main of 800mm CI for about a length of 8 Kms conveying the water from JioniMandi WTP to zonal pumping station CWR's at TajGanj. The alignment of existing transmission main is shown in the drawing. shown in the Fig.8. Salient details of the existing Transmission Mains are listed Table 2.4 below.

1.5 Service Reservoirs

There are one GLSR, 2 UGR and four OHT located in ABD area. Two UGRs (TajGanj 1a and TajGanj 1b) at GobarChauki having capacity of 2750 KL and 2575 KL respectively. Another CWR of 600 Kl and one OHT of 1200 KL is at NaglaMewati which is not serving at present. Entire TajGanj area is being supplied by direct pumping from this CWRs. The present water supply is intermittent for 2 hours in the mroning and 2 hours in evening. Following illustrates the condition of OHTs

	The OHT is located in ward no.7 at Kolhai. Having Latitude: 27° 9'58.54"N, Longitude: 78° 3'1.21"E. It was constructed during 2000 and yet to be commisioned. It will be serving for Zone-2A The OHT is in good condition. Needs protection works like protection wall handrails etc.. As the staging height is less than the required staging height, the OHT couldn't be utilised in the proposal.

	The OHT is located in ward no.7 at Paniki Tanki park at Shilpgram. Having Latitude: 27° 9'40.69"N, Longitude: 78° 3'16.63"E. It was constructed during 1998 and 20 years old. At present it is not being used due to deficiency in source. As the staging height is less than the required staging height, the OHT couldn't be utilised in the proposal.
	The OHT is located in ward no.71 at Police Academy colony. Having Latitude: 27° 9'53.28"N, Longitude: 78° 2'8.56"E. It was constructed during 1990 and 28 years old. As it is served its lifetime it will not be considered to utilise. The structure condtion is also not favourable as many cracks in columns, beams and staircase are observed

	The OHT is located in ward no.7 at Pushpanjali road Having Latitude: 27° 8'56.36"N, Longitude: 78° 3'54.55"E. It was constructed by ADA The OHT is located at border of ABD area. As majority of the command area is outside ABD area this OHT is not considered to be utilised in this project

1.6 Distribution system

The existing distribution system is age old and developed in various period of time. Initially AC pipes were laid during 1978 and subsequently PVC pipes were replaced part and piece meal based on the requirements of operation and maintenance. The existing distribution system is experiencing huge water loss due to leakages.

As per NRW reports about 40% of water loss is reported. There is not discrete boundary of command area, zones are interlinked and thereby energy distribution in the distribution mains are uneven resulting loss of pressure and uneven supply of water.

2 NEED FOR THE PROJECT

2.1 Need for the project

The water supply system of ABD area needs improvement in water supply system for ABD area. Following are the deficiencies observed in existing system

- The source of water is inadequate at present. As Ganga Jal project nearing completion it will provide adequate source for entire Agra city
- The existing transmission main from Geoni Mandi WTP to Taj Ganj ZPS is inadequate in size and has direct tapping for consumers. The main also experiencing leakages at many places and not functioning efficiently
- At present the water is being supplied by direct pumping from Taj Ganj ZPS. Due to hourly variation in consumption and deficit source availability, water supply is less than the standards
- OHTs are needed to ensure equitable supply with adequate pressure to consumers. At present existing OHTs are inadequate and not utilised
- The existing distribution system is age old and served its lifetime. There is no descrete boundary for zones. The material is of AC & PVC. These pipes are very poor in strength and experiencing huge loss of water and easily contaminated by drainage or sewage by negative pressure created in the distribution mains during non sullpy hours
- The house service connections are crossing road side drains and age old. There is no water meters available in the project area. Due to this there is huge loss, contamination from drains and exact water usage by consumers are unaccounted

All the deficiencies need to be addressed in this project. So, by implementing this project the entire water supply system of ABD area will be revamped and can be a pilot project to replicate for entire city. This project will give roadmap for revamping the water supply system for entire city.

2.2 Scope of the project

The source for entire city from Ganga Jal is already nearing completion and will be commissioned in a month or two. So, the scope starts from clear water at Geonimandi WTP to connecting to consumers with water meters. Following are the scope identified in this project

- Providing independent pumping arrangment to transmit water from Geoni Mandi WTP to CWR at Taj gand ZPS
- Laying of transmission main to cater entire Taj Ganj demand inclusinve of ABD area demand
- Balancing reservoir to receive water from transmission main and to deliver to OHTs
- Pumping arrangement to pump disinfected water from CWR to OHTs
- Creating zonal service reservoirs with adequate staging height to create necessary head of water column (OHTs)
- Replacing the existing distribution mains with new & suitable pipe material with new water connections for consumers to reduce loss of water and save from contamination
- To measure the quantity of water utilised by the consumers, water meters with AMR technology is needs to be provided. Volumetric tarrif of water will create the consumer awareness to conserve water. So, volumetric tarrif pattern to be implemented

3 POPULATION, WATER DEMAND & WATER ALLOCATION

3.1 Introduction

Agra Smart City Limited being part of this project have considered up-gradation of the entire water supply system including the Pumping stations, transmission system, distribution system and reduction of Non-Revenue Water (NRW) within the ABD area and therefore, the water supply system of the smart city project area. The population contribution of the project area is from ward no.7,71,72,74,80,81,85&86. Apart from the area under municipal limit, nearby two villages KalalKheria and Mayapura villages are also incorporated in ABD area. Hence to arrive at the demand of water for the design years, population projection for the design years has been arrived at as detailed below.

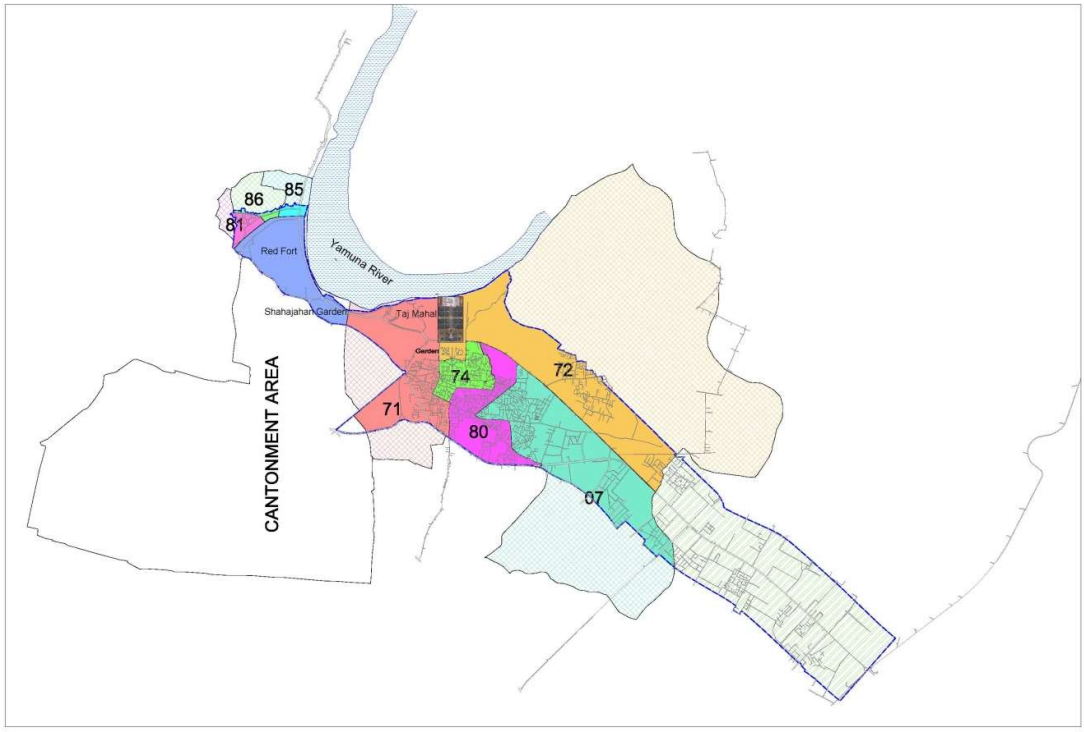


Figure 3: Ward Boundary

3.2 Population

The town has been growing steadily since 1951. The growth of the town has been phenomenal during 1951-81 However, thereafter also the growth was not stable. The average decadal increase is 30%. However, the last decadal (2001-2011) growth is only 24%, vide the Table below and Fig.4

Table 6: ***Details of decadal population growth rate of Agra city***

Census Figures		Decadal % of Increase/Decrease
Decade year	Population	
1951	333530	
1961	462020	139%
1971	591917	128%
1981	694191	117%
1991	891790	128%
2001	1275134	143%
2011	1585704	124%

Population projection has been prepared for Agra project area based on different methods with census population for the year 2011 and past decades. Population projection has been done for 30 years for the year 2050 as per Guidelines in CPHEEO Manual. Population projections from different methods are as follows:

Table 7:***Population projection by various methods***

Calendar Year	Arithmetic Increase Method	Incremental Increase Method	Geometrical Progression Method	Line of Best Fit Method	Exponential Method
2018	1731791	1753459	**1891923**	1870682	1847121
2020	1773530	1804666	**1989814**	1967886	1929437
2035	2086574	2235152	**2904890**	2877398	2675747
2050	2399617	2747573	**4240791**	4207266	3710729
Density per Hec. for 2050	191	218	**337**	334	295

The population forecast has been calculated considering three above mentioned five methods. Based on population projection with different methods, population projection data with geometrical progression method is close. Therefore, population projection by Geometrical progression method has been adopted which is matching with the population growth trend in Agra

Table 8: ***Projected population for ABD area by various stages of project***

Year	2011	2020	2025	2030	2035	2040	2045	2050
Population	82342	103327	117216	132971	150844	171121	194122	220214

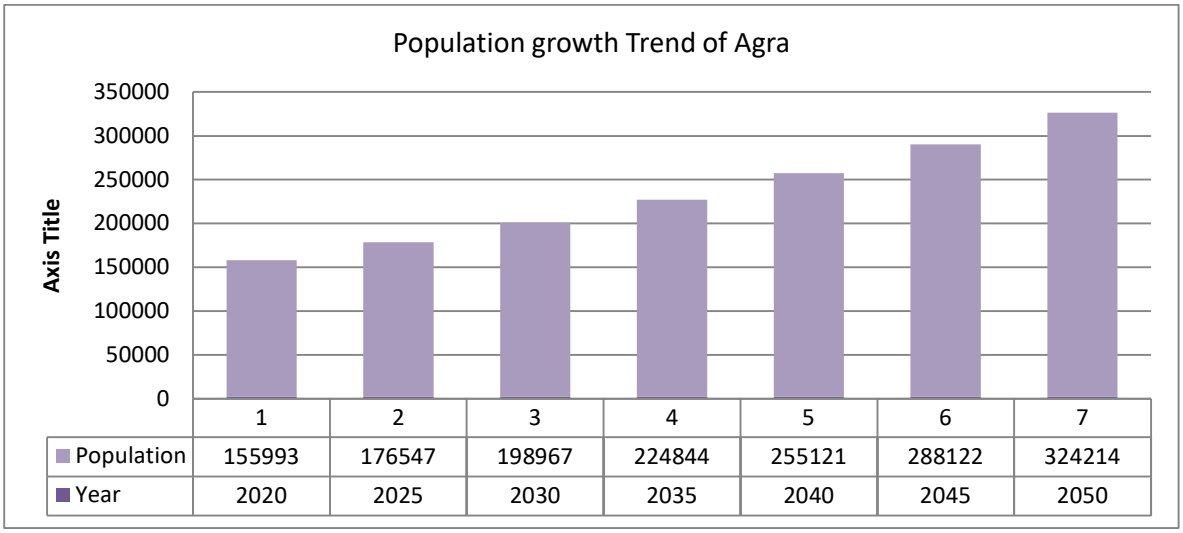


Figure 4:Population growth Trend of Agra

Table 9: ***Wardwise population projection for various stages of project***

Sl.No	Ward Number	% of coverage	Total ward Population 2011 (Nos)	Project area population in Nos.							
				2011	2020	2025	2030	2035	2040	2045	2050
1	Ward -7 (P)	46%	19397	8851	11107	12600	14293	16214	18394	20866	23671
2	Ward -71 (P)	60%	17695	10581	13278	15062	17087	19384	21989	24945	28298
3	Ward -72 (P)	23%	8684	1992	2500	2836	3217	3649	4140	4696	5327
4	Ward -74	100%	25530	25530	32036	36342	41227	46769	53056	60187	68277
5	Ward - 80	100%	22570	22570	28322	32129	36447	41347	46904	53209	60361
6	Ward - 81 (P)	50%	5948	2976	3734	4236	4806	5452	6185	7016	7959
7	Ward - 85 (P)	20%	14741	2932	3679	4174	4735	5371	6093	6912	7841
8	Ward - 86 (P)	12%	12271	1468	1842	2090	2371	2689	3051	3461	3926
9	KalalKheria&Mayapura (Village)	100%	5442	5442	6829	7747	8788	9969	11309	12830	14554
			132278	**82342**	**103327**	**117216**	**132971**	**150844**	**171121**	**194122**	**220214**
10	Floating population for TajGanj-I				52666	59331	65996	74000	84000	94000	104000
	Total				**155993**	**176547**	**198967**	**224844**	**255121**	**288122**	**324214**

3.3 Water Supply Demand

Water demand is the water required by an individual or a group of people and is categorised based on the type of usage. The water demands are generally of following types:

- Domestic demand comprises of all residential usage,
- Institutional demand that includes demand of offices such as government and private, institutions such as educational institutes such as schools, colleges and hostels etc;
- Industrial demand comprises of all industries with bulk consuption,
- Fire demandis water required for fire fighting emrgecies.

3.3.1 Domestic and institutional demand

The water demand of towns where sewerage is contemplated is the same as per CPHEEO manual on water supply and treatment. The requirement as specified in IS1172(1993). ”Code of Basic Requirements for water supply, drainage and sanitation” specifies the water demand for communities with population more than 1,00,000 with full flushing system to be 150 to 200.

3.3.2 Floating population demand

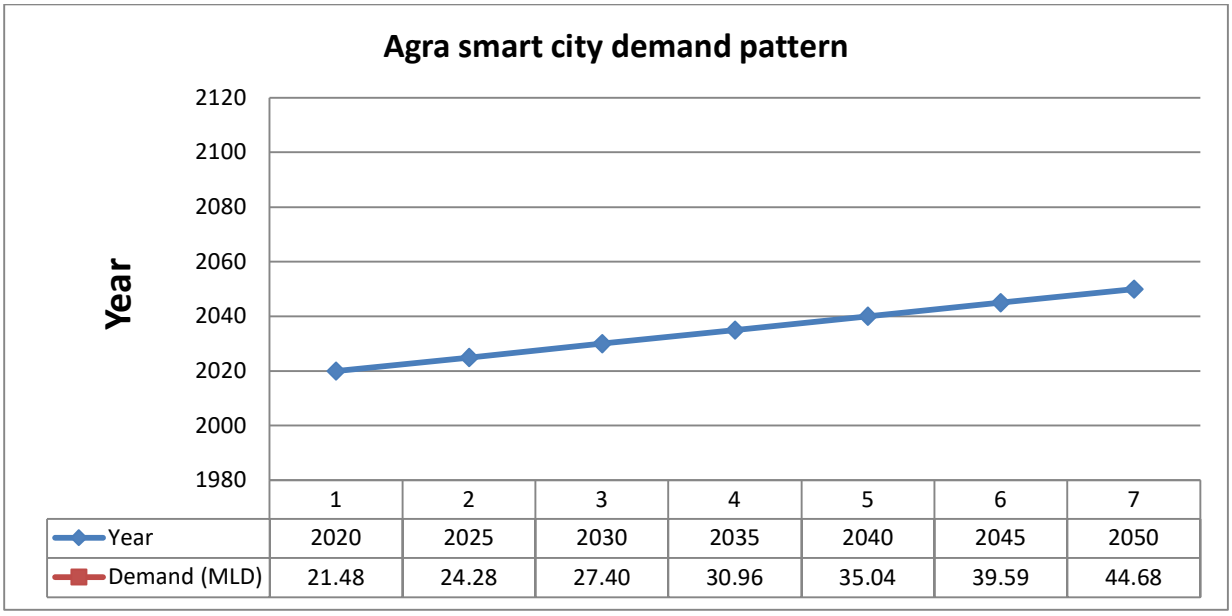
Agra being a international tourist destination. The city is experiencing growing trend in national and international tourism population. As a result many hotels of various levels are emerged. Study has been conducted and reported for influx of tourism. Water being basic need it is very essential to provide safe water supply for travellers. The ABD area is having proximity to TajMahal and the most of the tourist population is inhibited across TajGanj area.

3.3.3 Fire demand

Fire demand has been computed as per the formula stipulated in CPHEEO manual as (100 x sq.ft (Population in 1000) in KL. Based on the above the water demands for various years are shown in the following table.

Table 10: **Water supply demand requirement for Agra Smart City Project**

WATER SUPPLY DEMAND CALCULATION FORAGRA SMART CITY (ABD AREA)																																				
Sl. No	Ward Number	Base demand @ 150 LPCD							Demand with 10% Distribution lossess							Base demand with 3% Transmission losses							Fire fighting demand 100 (P/1000)^0.5							Total water demand						
		2020	2025	2030	2035	2040	2045	2050	2020	2025	2030	2035	2040	2045	2050	2020	2025	2030	2035	2040	2045	2050	2020	2025	2030	2035	2040	2045	2050	2020	2025	2030	2035	2040	2045	2050
1	Ward -7 (P)	2.07	2.35	2.67	3.03	3.44	3.90	4.42	2.30	2.61	2.97	3.36	3.82	4.33	4.91	2.38	2.70	3.06	3.47	3.94	4.46	5.06	0.14	0.14	0.15	0.16	0.18	0.19	0.20	2.51	2.84	3.21	3.63	4.11	4.65	5.26
2	Ward -71 (P)	1.69	1.92	2.18	2.47	2.80	3.18	3.61	1.88	2.13	2.42	2.75	3.12	3.53	4.01	1.94	2.20	2.50	2.83	3.21	3.64	4.13	0.11	0.12	0.13	0.13	0.14	0.15	0.16	2.05	2.32	2.62	2.97	3.35	3.80	4.29
3	Ward -72 (P)	0.38	0.43	0.48	0.55	0.62	0.70	0.80	0.42	0.47	0.54	0.61	0.69	0.78	0.89	0.43	0.49	0.55	0.63	0.71	0.81	0.92	0.02	0.03	0.03	0.03	0.03	0.03	0.04	0.45	0.51	0.58	0.66	0.74	0.84	0.95
4	Ward -74	4.08	4.63	5.26	5.96	6.76	7.67	8.71	4.54	5.15	5.84	6.63	7.52	8.53	9.67	4.68	5.31	6.02	6.83	7.75	8.79	9.97	0.27	0.29	0.30	0.32	0.34	0.37	0.39	4.95	5.59	6.32	7.15	8.09	9.16	10.36
5	Ward - 80	4.25	4.82	5.47	6.20	7.04	7.98	9.05	4.72	5.35	6.07	6.89	7.82	8.87	10.06	4.87	5.52	6.26	7.10	8.06	9.14	10.37	0.28	0.30	0.32	0.34	0.36	0.38	0.41	5.14	5.82	6.58	7.44	8.42	9.52	10.78
6	Ward - 81 (P)	0.48	0.54	0.61	0.70	0.79	0.89	1.01	0.53	0.60	0.68	0.77	0.88	0.99	1.13	0.55	0.62	0.70	0.80	0.90	1.02	1.16	0.03	0.03	0.04	0.04	0.04	0.04	0.05	0.58	0.65	0.74	0.83	0.94	1.07	1.21
7	Ward - 85 (P)	0.47	0.53	0.60	0.68	0.78	0.88	1.00	0.52	0.59	0.67	0.76	0.86	0.98	1.11	0.54	0.61	0.69	0.78	0.89	1.01	1.15	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.57	0.64	0.73	0.82	0.93	1.05	1.19
8	Ward - 86 (P)	0.23	0.27	0.30	0.34	0.39	0.44	0.50	0.26	0.30	0.34	0.38	0.43	0.49	0.56	0.27	0.31	0.35	0.39	0.45	0.51	0.57	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.28	0.32	0.36	0.41	0.47	0.53	0.60
9	KalalKheria& Mayapura (Village)	1.84	2.09	2.37	2.69	3.05	3.46	3.93	2.05	2.32	2.64	2.99	3.39	3.85	4.37	2.11	2.40	2.72	3.08	3.50	3.97	4.50	0.12	0.13	0.14	0.15	0.16	0.17	0.18	2.23	2.52	2.86	3.23	3.65	4.13	4.68
	Total	15.50	17.58	19.95	22.63	25.67	29.12	33.03	17.22	19.54	22.16	25.14	28.52	32.35	36.70	17.75	20.14	22.85	25.92	29.40	33.35	37.84	1.02	1.08	1.15	1.23	1.31	1.39	1.48	18.77	21.22	24.00	27.15	30.71	34.75	39.32
10	Floating population for TajGanj-I	2.37	2.67	2.97	3.33	3.78	4.23	4.68	2.63	2.97	3.30	3.70	4.20	4.70	5.20	2.71	3.06	3.40	3.81	4.33	4.85	5.36								2.71	3.06	3.40	3.81	4.33	4.85	5.36
	Total	17.87	20.25	22.92	25.96	29.45	33.35	37.71	19.85	22.50	25.46	28.84	32.72	37.05	41.90	20.47	23.20	26.25	29.73	33.73	38.20	43.20	1.02	1.08	1.15	1.23	1.31	1.39	1.48	21.48	24.28	27.40	30.96	35.04	39.59	44.68



	1	2	3	4	5	6	7
Year	2020	2025	2030	2035	2040	2045	2050
Demand (MLD)	21.48	24.28	27.40	30.96	35.04	39.59	44.68

Figure 5: Agra Smart City demand pattern

4 SYSTEM SIZING AND BRIEF DESIGN CRITERIA

4.1 Water Demand

Agra ABD area

Domestic &Non-Domestic Demand @ 150 lpcd

Floating population @ 45 lpcd

4.2 Allowance for losses in the water system

Water Distribution - 10% net demand due to leakages in distribution

Transmission mains - 2% due to leakages in transmission and feeder mains

4.3 Sizing of Conveyance System

Parameter	Distribution System	Transmission System
Minimum Residual Head	17 mat ferrule point	5m at delivery point
Hazen-Williams C-value for pipes	**For deign periodof 30 years,** 140 forDuctile IronPipesinternallymortar-lined atfactoryordesignyear 140 forMild SteelPipesinternallycementmortar-lined and externallyunited 145for HDPEpipes	
Minor Losses	10%overand abovetheenergylossesduetofrictionwith pipewallduetolowing water	
Peak Flow Rates	2 timesovertheaverage day demand;	Overand abovethe averagedailyflows(equivalentto 23 hourspumping)
Velocity	Notlessthan0.6 m/sec,andNotmorethan1.8 m/sec;	Notlessthan0.6m/sec andnotmorethan 1.8 m/sec; Preferably as per economic analysis
Head Loss due to friction	Generallynotmorethan3m/km.	Nospecificrestrictionon head-loss
Selection of Pipe Material	Bytypeof system HDPEpipestobeused forgravity mainsupto OD 225 and above DI-K7 DI &MS pipestobeused forpumpingmains	

Bypipesize	GravityMains	PumpingMains
Upto225 (OD)mmdia	HDPE	DI-K9
Above 200 (ID) mm dia	DI-K7	DI-K9
Above 800mm dia& at specific difficult location such as canal/ crossings	MS	MS

4.4 Sizing of Storages

ServiceReservoir storage - 1/3rd of Ultimate demand requirement

StorageatPumping Stations	-	30 minutes storage capacity for equal hours of pumping

4.4.1Distribution Stations

There are seven distributionzones, for efficient O&M purpose Zone-2 is further divided into three sub zones and two OHTs for zone-2. So, there are six distribution stations with new OHTs of staging height to produce minimum residual pressure of 17m. Zone-7 will be served by direct pumping system.

The pumps shall also be backed upwith Variable Frequency Drives (VFDs) for direct pumping

4.4.2Valves in distribution system

Necessary valves to enable to isolate the system to carryout O & M. Necessary scour valves are provided to flush out organic and sediments from surface water.

4.4.3Appurtenance

Following appurtenances shall b e provided on the transmission mai ns for raw water and treated water:

a) In-lineSluice Valves /Butterfly valves at suitable locations for flow control and for isolation during maintenance shall be provided with a minimum distance between two valves on the same pipeline not exceeding2km.

b) Scour valves at lowest points for drai ning the pipelines when required.These valves will be provided at locations where the water taken out of the pipes could be drained away from the pipelines through natural drains.

c) Air valves for removal of air from the pipelines and for air entry into the pipelines. The air release valves shall be sized not less than1/8th of the size of the mains on which it will be fitted. The dual-purpose air valves(e.g.double kinetic valve) will be sized not less than1/12thof the size of the main.

d) The entry point battery limitshall be fitted with a sensor having arrangement of permissible fixed flowrate with a predetermined value that can be set by the system operators time and again when necessary. The valve should provide indication automatically when the flowrate exceeds the preset value equivalent to the average daily flow from the entry point.

e) Appropriate surge protection devices shall be designed and provided along the alignment of pipelines in order to ensure safety against bursts due to positive and negative surges.

f) Non-return valves shall be installed near the pumping stations to ensure pump safety.

g) Adequate care needs to be exercised during selection of location for valves,anchor blocks and thrust blocks so that the reare no obstructions created by construction in the regular access for transport and movement of local populace.

Following minimum and maximum limits will be considered:

Size of distribution main No.ofpipe lines in by lanes (roads less than or equal to10 min width)	Minimum 110 mm dia
No.ofdistribution pipe lines in main roads (roads more than10min width) for providing consumer service connections	2 (one on each side of the road)

4.4.4 Fire Hydrants

Thefirehydrantsofnon-post typeshallbeprovidedat service reservoir location enable to feed the fire extinguishing tank mounted vehicles. Necessary arrangements for free flow of vehicles shall also be provided.

Raw Water Pumps at WTP

a. Total flow rate shall be taken as the Capacity of the WT

b. Head: Static head shall be computed based on Average water level in the suction side and HGL at the delivery of Inlet at WTP & frictionlosses in the system

Treated Water Pumps at WDS

a. Total Flow Rate shall be computed based on the total water demand of the distribution area covered

b. Design Head: As the distribution is recommended through the Service Reservoir, the design head shall be calculated as the sum of the following.

i) Static head: The difference in head between the HWL in the SR and the average water level in the sump

ii) Dynamic head: Friction losses within pump room+ friction loss in the delivery main from pump delivery to ESR delivery point.

iii) Residual head: 5 (one) metre

Maximum HGL of the distribution system shall be taken as the LWL of the ESR and in this case, it is 25 m.

Net Positive Suction Head (NPSH) available in the system

Details of calculation of NPSH is shown pictorially in Fig 4.2 While selecting a pump for a system, the NPSH available in the system shall always be more than the NPSH Required by the pump.

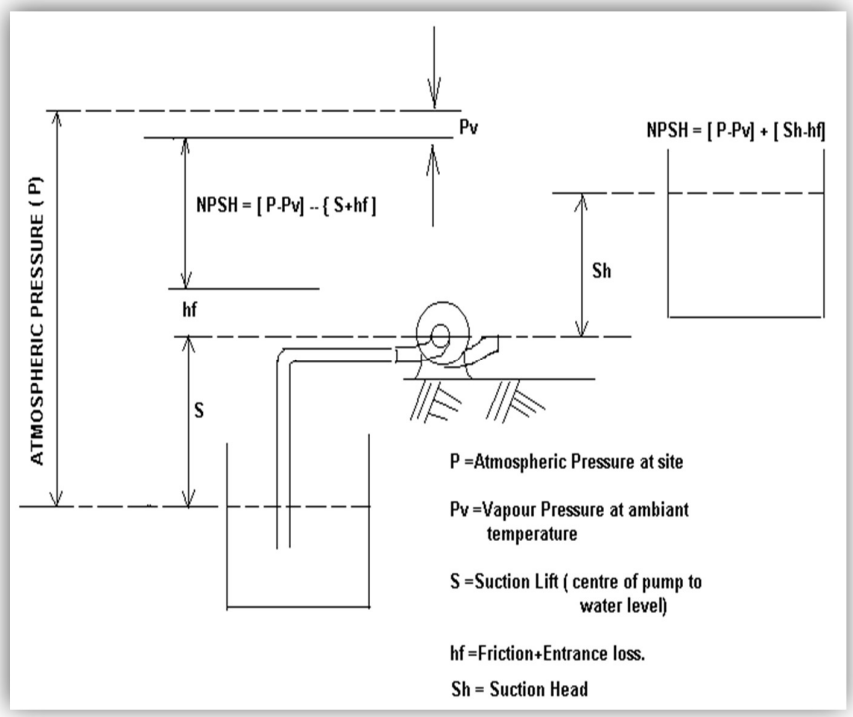


Figure 4.1 Selecting operating speed

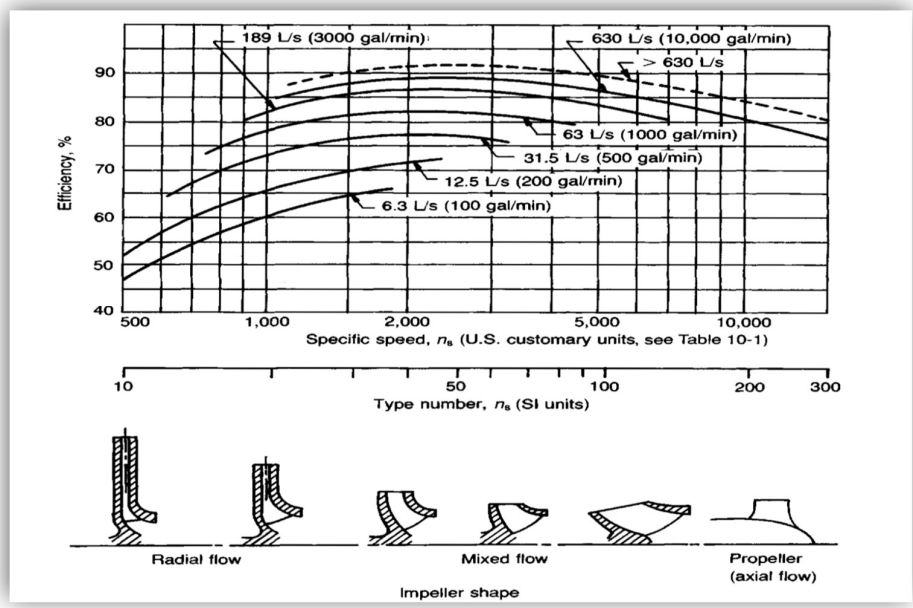
The speed of a pump may be determined based on the NPSHa in the system. For a pump to operate satisfactorily, experts defined a term, **suction specific speed** of the pump and in FPS system, it may be around 8500, a unit-less number. The speed may be derived from the formula N = 8500x (NPSHa in ft)3/4/(Qin US GPM)0.5

(1 m^3 = 264.17 US gallons & 1m = 3.28 ft)

Based on the NPSH available at site and flow rate per pump (for single suction), speed of the pump may be selected

Selecting Efficiency of Pump

i) Based on capacity, maximum attainable efficiency of a pump may be derived at using the graph noted below
ii) Based on specific speed, the efficiency of a pump can be accurately specified based on the graph.



Specific speed, n_s (Type Number)

In SI Unit, the specific speed n_s is expressed as

$n_s = 3.65\ n\ Q^{1/2}/H^{3/4}$, where

n_s= specific speed, n = speed in rpm, Q = flow rate in m^3/s and H = total dynamic head in m.

Flow range and Shut-off head:

- Flow Range

A pump operates best at its best efficiency point. Not only is the efficiency maximum, but radial loads on the impeller and the problems of cavitation are minimized. It is good practice to limit the operating range of pumps — especially radial-flow centrifugal pumps — to within approximately +20% and *-40%* of the discharge

- Shut-off Head

Shut-off head shall be +30% of the design head

Number of pumps with duty of each pump to be operated in parallel**.**

a) Total capacity of Raw water pumps at WTP: 120% of plant capacity
   i. Number of pumps preferred: 4 working+2 standby
   ii. For small capacity WTP, number of pumps: 2 working+1 standby
b) Total Capacity of Treated water pump station at WTP: 120 % of Plant Capacity.
   i. Number of pumps preferred: 4 working+2 standby

c) Total Capacity of distribution pumping plant: 145% of total daily demand of the area covered.

i. Number of pumps preferred: 4 working+2 standby

(Courtesy: Water Works Engineering by Syed R.Qasim& Edward M. Motley)

Peak factor adopted for distribution system (As per CPEEHO norms)

For population less than 50,000 : 3.0

For a population range of 50,000 to 2,00,000 : 2.25

For population above 2,00,000 : 2.0

Residual Pressure at ferule point to residence :12.0m.

Design Parameters – Sizes of Pipes inside Pump Room. & Switch Gears

1. The design of adequate size of suction and delivery pipes has to be made to maintain the velocities noted below.
   a) Bell Mouth at Suction Inlet : 0.6 m /Sec.
   b) Suction Pipe :1.5 m/Sec.
   c) Delivery pipe and specials inside pump room : 2.4 m/Sec.
   d) Column pipes :2.5 to 3.00 m/Sec.
   e) Bell Mouth for Delivery Point : 0.8 m/Sec.
2. Cubical type panel Board shall be preferred to Industrial Type Panel Board for new designs. If space is not available in the existing control / pump room. Industrial type may be adopted for replacement purposes.
3. The VCB, ACB, MCCB & MCB may be utilised instead of OCB, rewire able& HRC fuse switches etc. For higher rated pump sets, namely 300 HP and above it is preferable to provide fuse-switches to have better accessibility for cables of higher sizes.
4. The instrumentation with digital meters only are to be provided for Ammeter, Volt Meter, Energy Meter, P.F. Meter etc. instead of AnalogMeters.
5. For submersible pump sets, three core flat PVC sheathed copper submersible cables should be provided for only up to isolator to be provided near the top of the source such as Bore well, Infiltration well etc. For laying cable from isolator near the top of source to control panel, only steel armoured Aluminium cable has to be provided to take care of mechanical damages. The GI encasing of Al./Copper cable is not necessary.
6. The standby submersible pump sets should be installed in the infiltration well.
7. The selection of cable should be for a total drop of voltage + / - 2.5%

8. The supply cable from TNEB should have sufficient cushion to take care of anticipated ancillary load.
9. The electrically operated Actuators may be provided for valves.
10. The pressure rating for Sluice valves, Butterfly valves and Reflux valves within the pump house should commensurate with the maximum shut-off head of the pump sets or the pressure rating shall be PN 1.6, whichever is higher.
11. The electrolytic type capacitor should be provided for each and every load with necessary controlling device and Ammeter to maintain the power factor above 0.95.
12. The Automatic power factor control unit may be provided whenever there is Variable load or the total load is above 100 HP.
13. If more than one cable is involved, rack system with 0.15M separation should be followed or tray system with the above clearance should be followed to avoid the losses due to eddy current
14. The Electronic flow meter with totalizer for flow above 2000 LPM only should be provided and Mechanical water meter with pulse generator and remote totalizer should be provided for the flow less than 2000 LPM.
15. The Soft starter should be provided for motor H.P. 50 and above
16. The digital water level indicator should be provided in each pump house.
17. The delivery pipe line should be laid in trenches within the pump house to have clear working space inside the pump house.The cables within the pump house should be aid in cable trenches only

5 PROPOSED WATER SUPPLY SYSTEM

5.1 Introduction

The proposed water supply scheme includes the following components

At headworks

(i) Treated water pumping station at Geoni Mandi Headworks
(ii) Electrical and mechanical arrangment for pumping station
(iii) Direct distribution system to Zone-7

Transmission Mains from WTP headworks

(i) Transmission main from Geoni mandi to CWR at Taj Ganj ZPS

Clear water pumping stations

(i) Pumping station at Taj Ganj ZPS with electrical and mechanical arrangements to supply water from CWr to zonal OHTs.

Feeder Mains from Taj Ganj ZPS to existing& proposed OHT's

(i) Clear water feedermain to supply zonal demand of Zone-1, Zone-2A& 2C
(ii) Clear water feedermain to supply Zonal demand of Zone-3, Zone-4, Zone-6
(iii) Clear water rising main for proposed OHT and Taj Ganj ZPS Zone-5

Direct Pumping to distribution system

(i) From Geoni Mandi WTP to Zone-7

Gravity supply to distribution system from existing & proposed OHT's

(i) From proposed OHT opp. to Bhumi marrige hall 25 LL 25m staging
(ii) From proposed OHT at park near hotel Raj palace Telepara 20 LL 25m staging to Zone 2A & 2C
(iii) From proposed OHT at Telipara EWS 20 LL 25m staging to Zone 2B
(iv) From proposed OHT at Nanda Bazar 15 LL 15m staging to Zone 3
(v) From proposed OHT at Nanda Bazar 27 LL 15m staging to Zone 4
(vi) From proposed OHT at Taj Ganj ZPS 25LL 25m staging to Zone-5
(vii) From proposed OHT at Kolhai 3.0 LL 25m staging to Zone-6

House Service connections to all consumers

SCADA system for entire water supply system

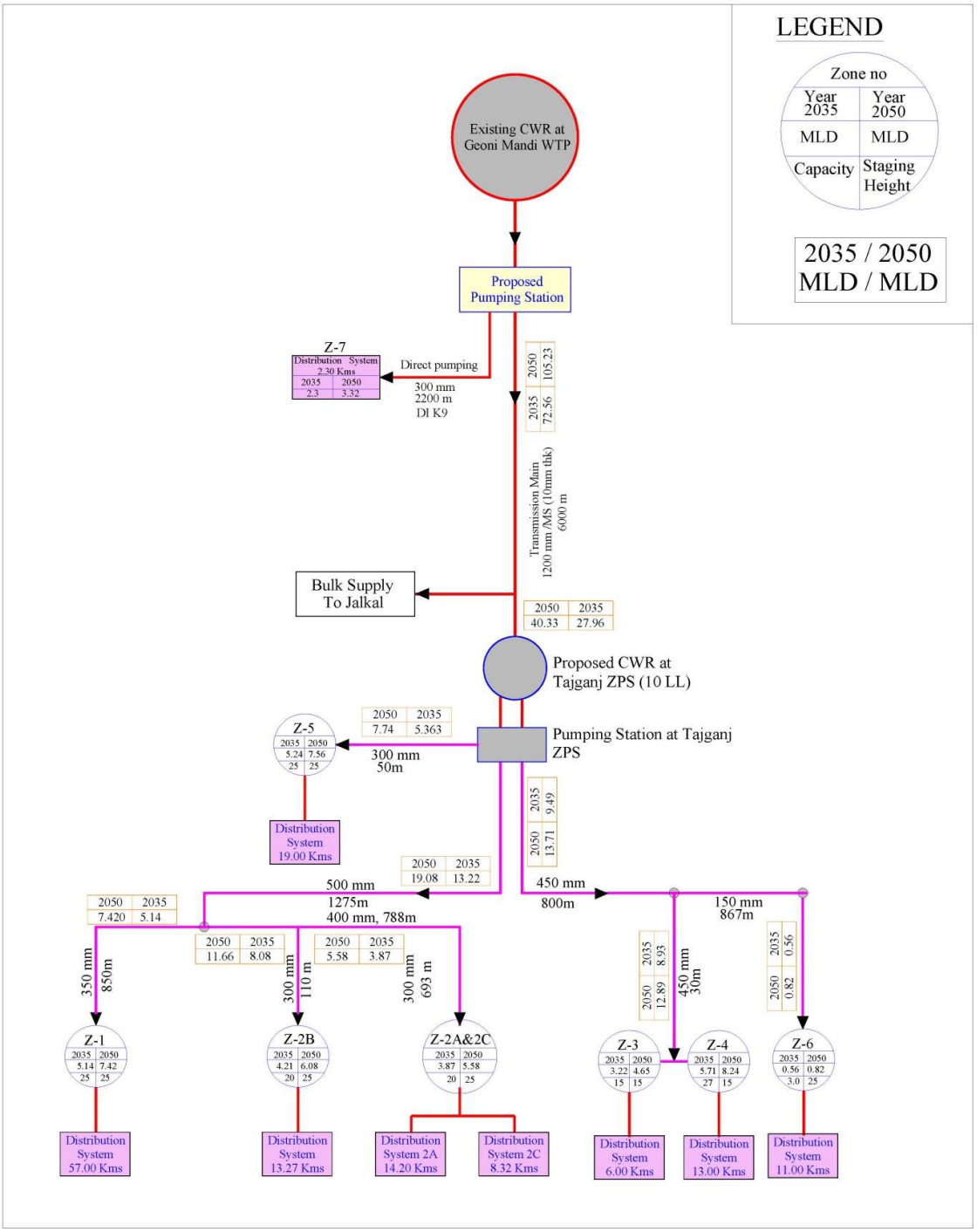


Figure 6:***Schematic Diagram of Agra smart city Water Supply***

5.2 Proposed pumping station at GeoniMandi WTP

The treated water demand requirement for ABD area is about 43.66 MLD. During technical review meeting with JalKal on 23.05.2012 with Project Engineer it was decided to propose pumping station with capacity to pump the entire TajGanj zone demand of 105 MLD. However, the pumps for ABD area demand alone will be installed by Agra smart city limited, provision for installing additional pumps for bulk supply and adequate electrical load and arrangements are made at the pumping station. Proposed layout of the pumping station is shown in Fig.7 below.

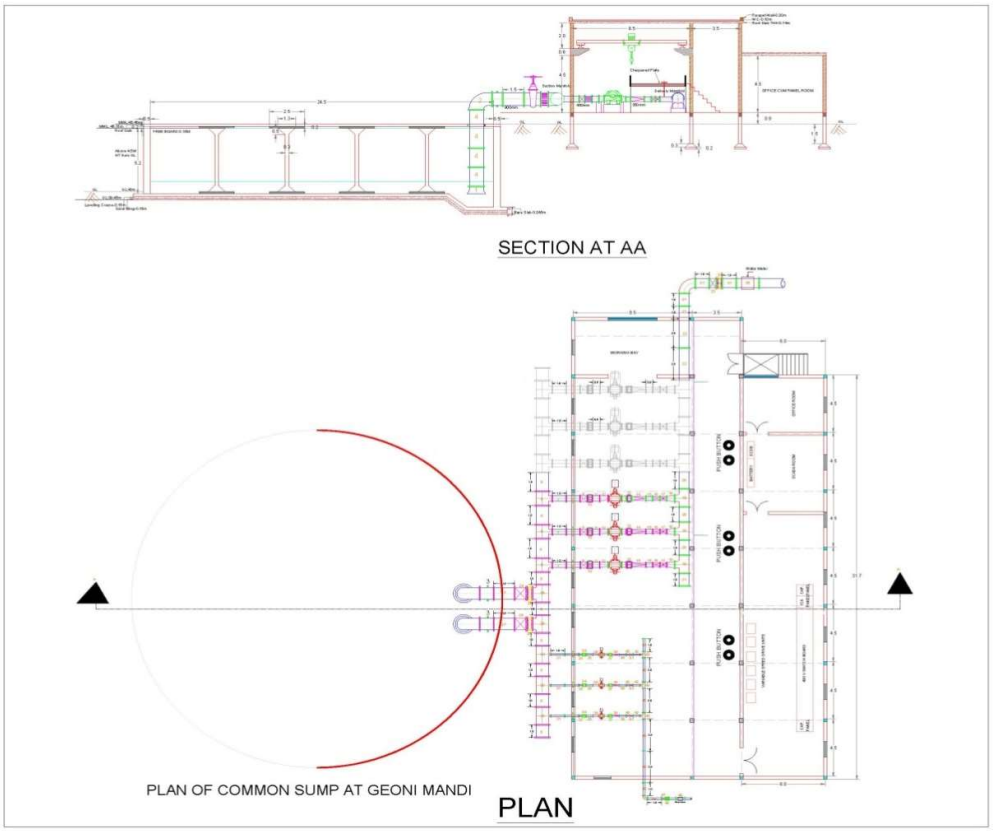


Figure 7:***General arrangement drawing of pumping station***

The duties of the proposed pumping system are as below.

Pump No.	Location	Zones covered	Number of pumps		Duty of each pump		Rating of motor
			W	S	Flow rate lpm	Head in m	HP
1	GeoniMandi WTP to Zone-7 direct pumping	7	2	1	834	39	9
2	GeoniMandi WTP to CWR at TajGanj ZPS		2	1	10145	35	110
3	GeoniMandi WTP to Bulk Supply to Jalkal		2	1	16076	35	150

5.3 Proposed transmission main from GeoniMandi WTP to TajGanj ZPS

Various feasible alignment for laying new transmission main from GeoniMandi WTP to TajGanj ZPS were studied. The process of getting clearance from Archelogical survey of India, National Green Tribunal and Yamuna pollution control board are avoided as much as possible to reduce impact. The alignment traverse through Yamuna Kinara road Agra Bah road, Fatebad road and reach TajGanj ZPS. As reported in above Para the transmission main is proposed for demand requirement of Entire TajGanj area. The demand for ABD area will be tapped at proposed CWR at TajGanj ZPS and rest of TajGanjaree demand will be tapped by JalKal as bulk supply.

As per economical pipe analysis 1200 mm dia MS pipe of 10mm thick is proposed. The existing road wider enough to lay 1200mm MS pipe. Before commencing the work, a GPR study shall be conducted to identify the existing underground utilities and accordingly the side of laying of transmission main shall be provided.

Necessary appurtenances like butterfly valves, scour valves, air valves are provided as per CPHEEO for efficient O & M purpose. The terrain is almost flat. The surge wave is only from pump operations. The wall thickness of the pipe is selected to withstand the surge pressure. Flow meters at pumping location and delivery point is proposed to monitor loss in transmission main.

Internationally, MS Pipes have been used for the transmission of water from the 1850s. In India, they seem to have been in use at least since the 1950s for large dia pipelines. Steel pipes were initially manufactured by reverting. Presently, they are manufactured by welding. MS Pipes are covered by IS 3589 - 2001. Equivalent AWWA specification is M11. IS provides for only welded jointing of the pipes while AWWA provides for welded or rubber ring jointing. For the present Project, welded joints shall be preferred as it will more or less eliminate the problem of joint leaks.

MS Pipes are usually protected against internal corrosion by cement mortar lining. Externally, either cement mortar coating or a flexible coating such as coal tar enamel, reinforced with glass fiber. For the present project, CTE coating may be preferred as they will be flexible and therefore less liable to damage during impact, water hammer or pipe settlement.

IS 3589 covers pipe sizes upto 2540 mm shell OD with other sizes to be supplied as specified by the purchaser. AWWA standard covers upto 3600 mm OD. Both standards do not specify any limiting works test pressure or working pressure

The only factor requiring to be designed for steel pipes is the thickness of steel. IS does not furnish the diameter wise plate thicknesses for various internal pressures and external loading conditions. The plate thickness will have to be designed by the purchaser and specified while tendering. IS does not lay down detailed design criteria for designing the pipe thickness and we will have to resort to AWWA M 11 for design of shell thickness.

Another factor that has to be considered is the huge quantity of soil that will be excavated during laying of pipeline, considering the availability of site for disposal and the TTZ/NGT and other environmental norms , excavated soil cannot be kept in site for long hence the same soil can be used for backfilling , landscaping and other uses based upon the need during time of construction and if these options are not available then officials may decide on policy for soil disposal and location of balance soil disposal/ usage of same , appropriate decision can be taken by officials at the time of construction. In the event of entire soil being disposed of fully, then based on distance of disposal site project cost may increase significantly, hence it's prudent and advisable to reduce the quantity of soil to be disposed by exploring other options.

Other than failure due to design errors which have to be avoided, steel pipes will fail only due to loss of integrity at welds or external corrosion causing severe pitting and weakening of pipe wall. The loss of joint integrity and through-wall corrosion can lead to leakage long before failure. Steel pipes have the following advantages.

- Available in long length (7-14m) which will reduce jointing.
- With external CTE coating, the coating will be flexible and therefore will be less liable to damage under repeated water hammer, as in pumping mains subsidence of trench and impact loads than rigid pressure pipes like PSC and PCC pipes.
- Weight will be less than for cement concrete pressure pipes and therefore they will be easier to handle.
- Repairs require only affected portions to be cut out and replaced.

The transmission main the demand calculations for TajGanj area is given in Annexure-5.1

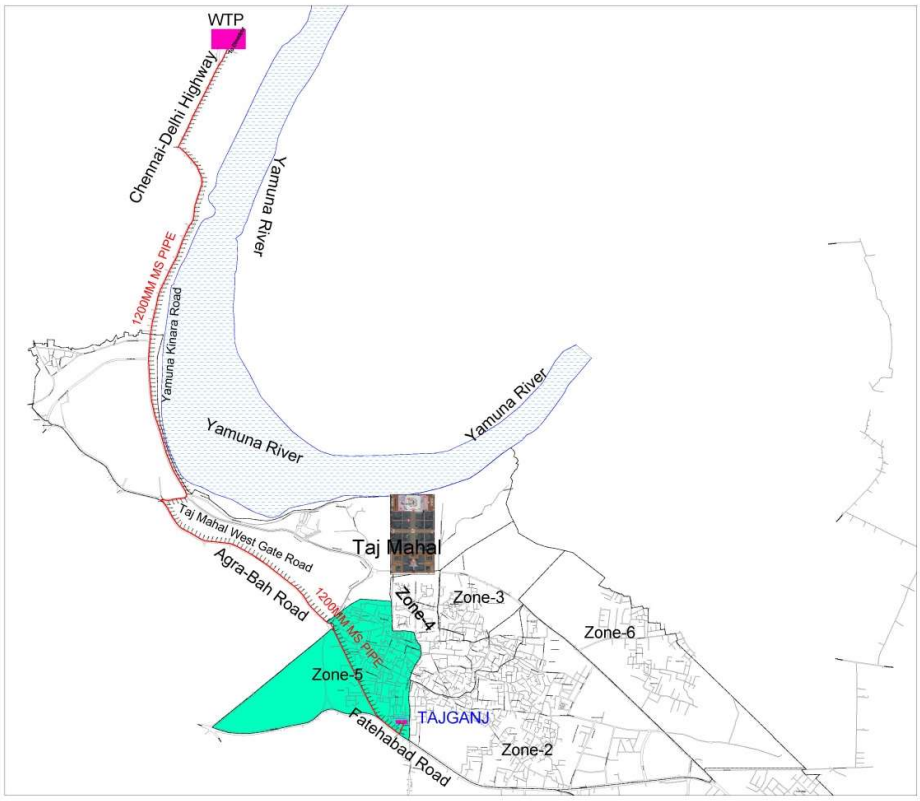


Figure 8:***Alignment drawing of transmission main***

5.4 Proposed pumping station at TajGanj ZPS

A new pumping station capable of pumping the clear water demand for Zones 1,2,3,4,5 & 6 is proposed at TajGanj ZPS.

Table 11: Proposed pumping system

Pump No.	Location	Zones covered	Rate of pumping in (cum/hr)	Number of pumps		Duty of each pump			Head
				W	S	cum/hr	cum/s	lpm	m
1	From TajGanj ZPS to Zone 1, 2B & 2C	1 2B 2C	575	1	1	575	0.160	9584	47
2	From TajGanj ZPS to Zone 3,4,6 & 2A	3 4 6 2A	413	1	1	413	0.115	6879	44
3	From TajGanj ZPS to OHT at TajGanj ZPS	5	228	1	1	228	0.063	3798	43
4	GeoniMandi WTP to Zone-7 direct pumping	7	100	2	1	50	0.014	834	39
5	GeoniMandi WTP to CWR at TajGanj ZPS		1216	2	1	608	0.169	10131	35
6	GeoniMandi WTP to CWR for bulk supply		1868	2	1	934	0.259	15565	35
7	Total drawal at GeoniMandi WTP (including bulk supply to jalkal)		3184						

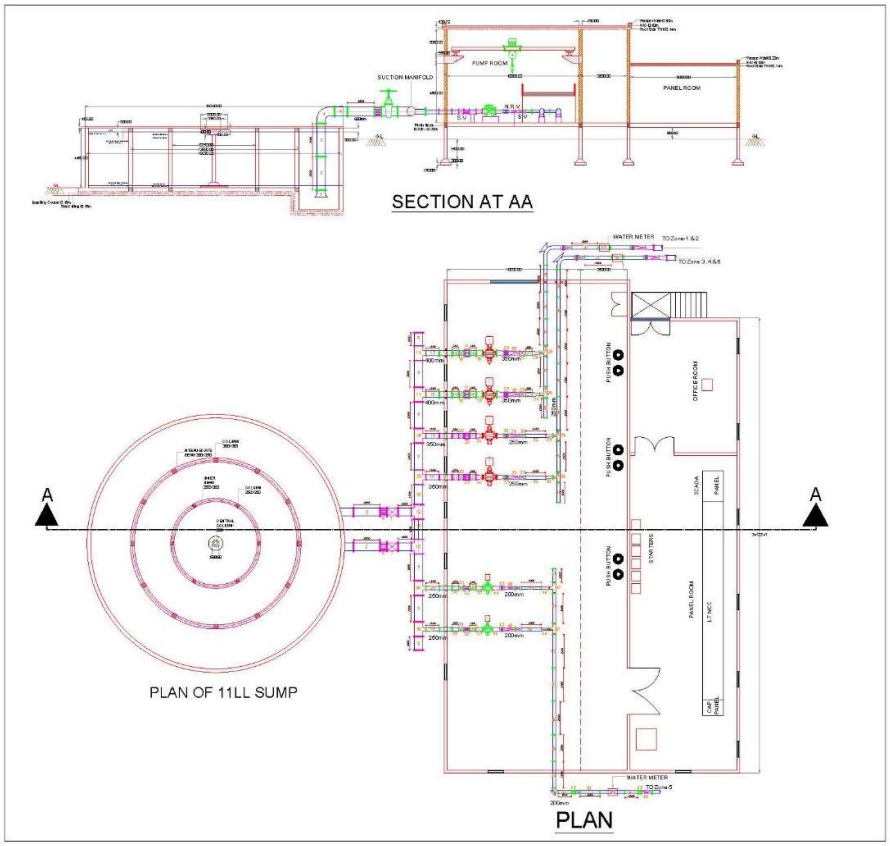


Figure 9:***General arrangement drawing of pumping station***

5.5 Clear water reservoir at TajGanj ZPS

To balance the treated water inflow from Geonimandi WTP for 23 hours of pumping and to deliver disinfected water to zonal OHTs it is adopted 30 minutes of detention time to balance the pump operation and valve operation. The capacity of CWR is tabulated below.

Table 12:Clear water reservoir balancing quantity

Zone No	Flow from design (MLD)	Demand 2035 (MLD)	Demand 2050 (MLD)
1	14.84	5.14	7.42
2A	6.48	2.25	3.24
2B	12.16	4.21	6.08
2C	4.68	1.62	2.34
3	9.29	3.22	4.65
4	16.47	5.71	8.24
5	15.12	5.24	7.56
6	1.63	0.56	0.82
	Total	**27.96**	**40.34**

- For intermediate demand it works out to be 582.50 cum. Say 600 cum (or) **6 LL capacity**
- For ultimate demand it works out to be 840 cum say 1000 cum (or) **10 LL capacity**

Clear water reservoir shall be in RCC construction. Necessary pipe connections shall be provided from Chlorine contact tank to the sump. Further water will be let into this sump from other sources. Hence provision shall be made for pipe connections in the sump.

Outlets from the reservoir shall be provided for the suction side of the pumps.

The walls & floor of the CWR shall be designed considering empty conditions & the dead weight of the empty structure shall provide a safety factor of 1.2 during against up lift during construction & service. The walls shall be designed under operating conditions to resist earth quake forces earth pressure mobilization & dynamic water load. The liquid depth shall be taken as full depth including free board for structural design of CWR.

The minimum cover for reinforcement shall be taken as 40 mm on inner face of CWR facing water & 25 mm from the main bars on other surfaces as per IS- 3370 Part- II with latest amendments. Earth placed on top of CWR slab shall be continuous up to ground level all around the CWR at a slope not greater than 1 in 1.5 M & shall be well compacted after watering & ramming. The minimum reinforcement shall be as per clause 7.1 of IS- 3370 Part- II with latest amendments. The maximum aggregate size foe floor & slab shall be 40 mm & 20 mm aggregate size for all other structures.

Joints: -

Expansion joints of suitable gap at suitable intervals not more than 30 metres shall be provided in walls, floors & roof slabs of CWR.

Movements' joints such as contraction joints/ partial contraction joints & sliding joints shall be designed as per requirement however contraction joints shall be provided at specified locations not more than 7.5 meters at both right-angle directions for walls & raft.

Ventilators:

Ventilators shall be U type of 200 mm Ø, in CI Construction, minimum 8 numbers properly spaced fitted with SS mesh & Glass Wool to make it dust & mosquito proof shall be provided.

Sky Light:

There shall be minimum 6 numbers of skies lights of reinforced glass of minimum area 1M^2 in roof slab, properly spaced.

Bitumen Coating:

Two coats of bitumen at the rate of 1.6 Kg/ M^2 laid hot with sand shall be provided on the outer surface of the walls & on top of roof slab before filling/ laying earth.

Valve Chamber:

The Valve chamber shall be a reinforced concrete (M-25) structure of minimum 3 x 3 M size shall be extended up to a height so that its top is 600 mm above the general ground level.

The chamber shall have a CI manhole cover 900 mm Ø with frame & CI rungs inside for the access.

5.6 Feedermains from TajGanj ZPS to Zonal OHTs

Two feedermains are proposed from TajGanj ZPS to deliver treated and disinfected water to zonal OHT's. These feedermains shall be laid along the berm of the road not disturbing other utilities. The feeder mains are pressure mains exclusively to supply water to OHTs. Tapping at any location for domestic or non-domestic requirement should be restricted to achieve optimum efficiency of the system.

Two feeder mains are proposed to serve the entire ABD area demand.

Feedermain-1 will be laid through Fatebad road to reach OHT at Zone-1, a branch near Tajnagari crossing is branched along shilpgram road to reach OHT for Zone-2B and further to reach OHT for Zone-2A & 2C.

Feedemain-2 will be taken through Fate bad road and diverted through GobarChowki road to reach OHTs for Zone-3 & Zone-4 at Nanda Bazar. Further it is extended to OHT at Zone-6

These feeder mains are economically designed for ultimate demand for 23 hours of pump operation. Necessary valves to control the flow, to drain water during O & M and to attend maintenance works are proposed. Feeder mains are laid not less than 1.0m deep from ground level and shall be protected well to avoid interference with sewer manholes and drainage channels to prevent corrosion and bursting of pipes thereby mixing of polluted water in drinking water. To measure UFW flow meters at delivery points and branching locations are provided to ensure equitable supply. The pipe material shall be DI-K9 S&S pipes as per IS:8329-2000. The flow meters shall be SCADA compatible and connected to master control centre. The valves shall be operated with actuators at pumping station and OHT locations. Intermediate valves shall be manually operated during O & M process.Details of feeder main pipe and alignment drawing is shown below.

Table 13: Feedermain flow calculations

ID	Location	Zones covered	Intermediate period (2035)			Ultimate period (2050)		
			Demand (MLD)	Zonewise feeder demand (23 hrs)	Total feeder quantity (cum/hr.)	Demand (MLD)	Zonewise feeder demand (23 hrs)	Total feeder quantity (cum/hr.)
Feeder main-1	From TajGanj ZPS to Zone 1, 2B, 2A & 2C	1	5.14	5.37	**575**	7.42	7.74	**830**
		2B	4.21	4.40		6.08	6.34	
		2A & 2C	3.87	4.04		5.58	5.82	
Feeder main-2	From TajGanj ZPS to Zone 3,4&6	3	3.22	3.36	**413**	4.65	4.85	**595**
		4	5.71	5.96		8.24	8.59	
		6	0.56	0.59		0.82	0.85	

Table 14: Pipe details of feedermain

Feedermain pipe details DI-K9							
Pipe diameter (mm)	**150**	**300**	**350**	**400**	**450**	**500**	**Total**
Length (m)	874	863	859	789	865	1305	**5555**

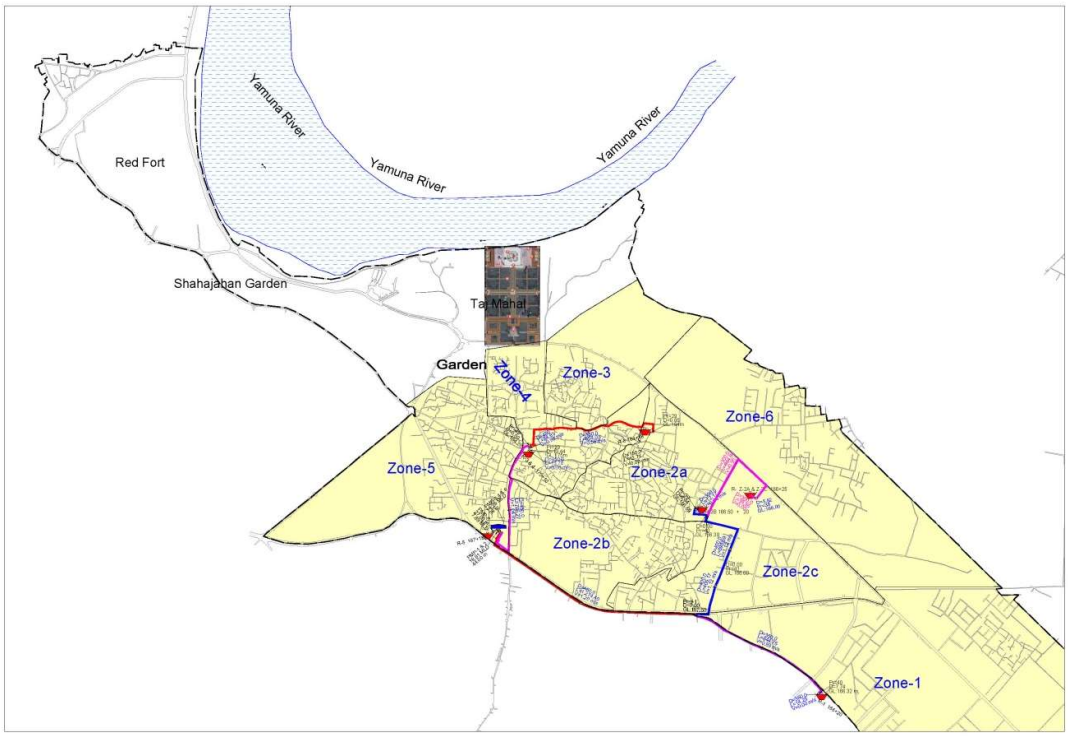


Figure 10: ***Feedermain alignment drawing***

5.7. Over Head Service Reservoirs (OHTs)

The entire water supply system is designed for 24 x 7 supply. The consumption of water throught the day varies depending upon the social status, lifestyle, climate etc.. Normally the peak hours are from 7.30 am to 10.30 am and 4.00 pm to 7.00 pm. To cater the variation in demand and to ensure adequate constant pressure at consumer end it is proposed supply the water from over head tanks (OHT's). As per CPHEEO the capacity of OHTs are calculated as 1/3rd of daily demand. However during technical review meeting held with Project Engineer, Jal Kal it is considered to adopt 1/3rd of Ultimate daily demand. It is acceptable as the availability of land for during Ultimate demand is difficult to identify in urban areas.

Municipal limits of ABD area is already saturated and developed. Land for proposed OHTs are identified with help of elected representativess (Ward councelors) and accordingly hydraulic design of distribution system is carried out. Five locations are identified and proposed in this project. The proposed OHTs shall be constructed on DBO (Design Build & Operate) contract basis.

The entire structure shall be constructed in R.C.C. framed structure as per IS:3370. The structure shall be designed considering the following considerations. Different types of loading shall be considered like wind load, earthquake load as per IS standards.

Necessary appurtanances like non return valve, sluice valves, inlet arrangements, outlet arrangements, level indicators, chlorine mixing equipments, flow meters at inlet and outlet, level indicators and SCADA compatible valves with actuators are proposed in this proposal

The quantity calculations for the existing and proposed OHTs are tabulated below.

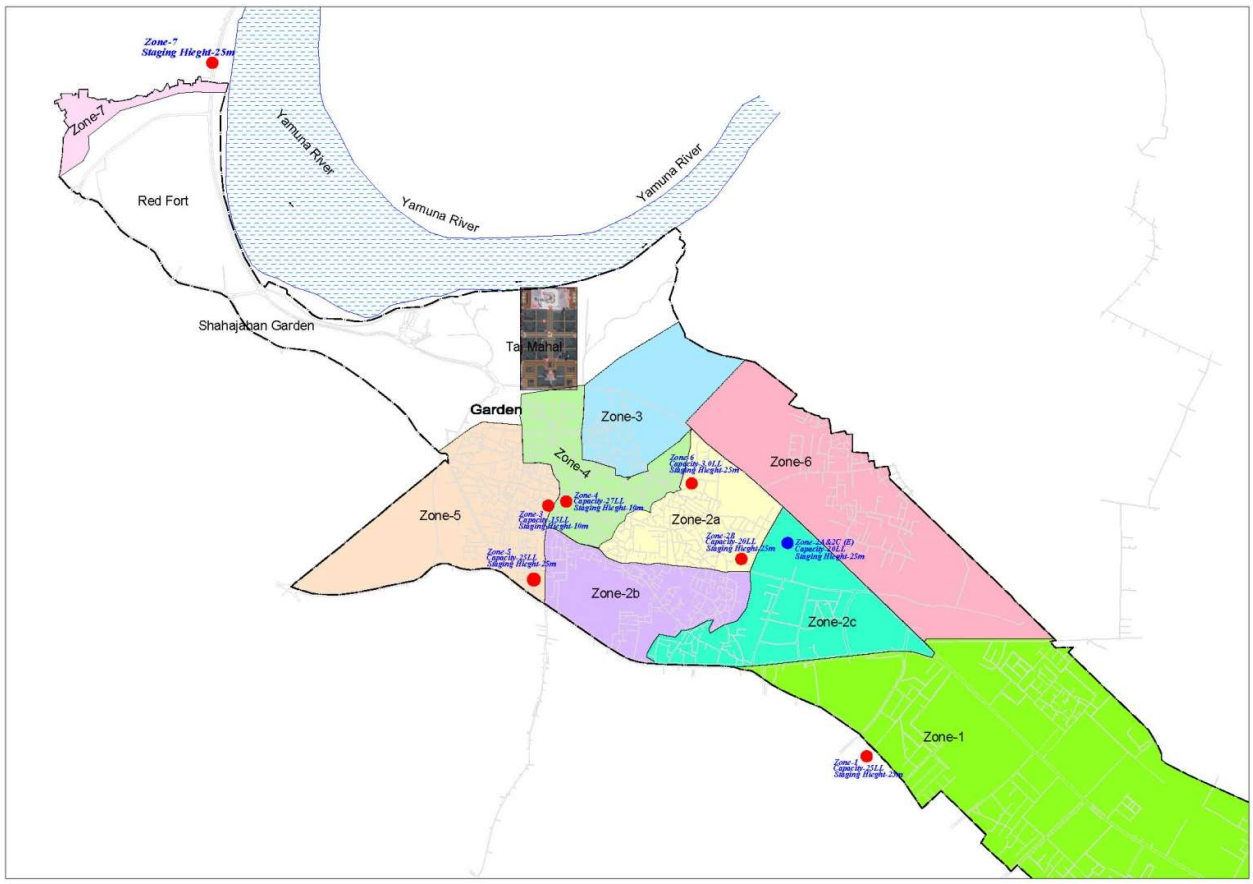


Figure 11: ***Zonewise OHT locations***

Table 15: Proposed OHT capacity calculations

Zone No	Ward no & Location	Location	Construction status	Demand 2035 (MLD)	Ultimate demand (2050)	OHT capacity 2035 (LL)	OHT capacity 2050 1/3rd (LL)	Say (LL)	Staging height (m)
Zone-1	Ward-7	Opp to Bhumi marriage hall	Proposed	5.14	7.42	17.13	24.73	**25.00**	**25.00**
Zone-2B	Ward-7	Telipara-EWS	Proposed	4.21	6.08	12.90	18.60	**20.00**	**25.00**
Zone-2A &2C	Ward-7	Partk near Hotel Raj palace	Proposed	3.87	5.58	14.03	20.27	**20.00**	**25.00**
Zone-3	Ward-80	Nanda Bazar	Proposed	3.22	4.65	10.73	15.50	**15.00**	**15.00**
Zone-4	Ward-80	Nanda Bazar	Proposed	5.71	8.24	19.03	27.47	**27.00**	**15.00**
Zone-5	Ward-71	TajGanj ZPS	Proposed	5.24	7.56	17.47	25.20	**25.00**	**25.00**
Zone-6	Ward-7	Kolhai	Proposed	0.56	0.82	1.87	2.73	**3.0**	**25.00**

5.8. Distribution system

The existing Distribution system is very old. The existing pipes are of AC and PVC. During NRW study conducted recently there is about 40% of loss in distribution system. The pipes are experiencing loss in joints and house service connections. To reduce NRW and loss of water due to leakages it is proposed to lay new pipes. New pipes have now been proposed for the distribution system which is designed using EPA NET software covering entire project area.

The whole project are is divided into 7 distribution zones. will be distributed by gravity from existing two nos. of OHSR,s and six nos. of newly proposed OHRs. Zone-7 is located near to WTP and will be served through direct pumping.

.HDPE pipes are proposed from 110mm to 225 mm outer dia and above 200mm DI-K7 is proposed.

The design criteria for distribution mains are as follows.

- The formulae for friction loss: Hazens williams
- 'C' value for HDPE pipes: 145
- 'C' value for DI-K7 pipe: 140
- Minimum residual pressure: 17m
- Velocity range: Min 0.60 m/s Max 3.0 m/s
- Service llines for DI pipes for providing HSCs

Each distribution zones are having independent command area. There are seven distribution zones in ABD area. Each zones are sub divided into DMA's (subzones) with valves and flow meters. These DMAs will be isolated by sluice valves and bulk flow meters to measure the total flow to the respective DMA. During step test these valves are used to close and open to measure losses through distribution pipes between lean period of 11pm to 4 am.

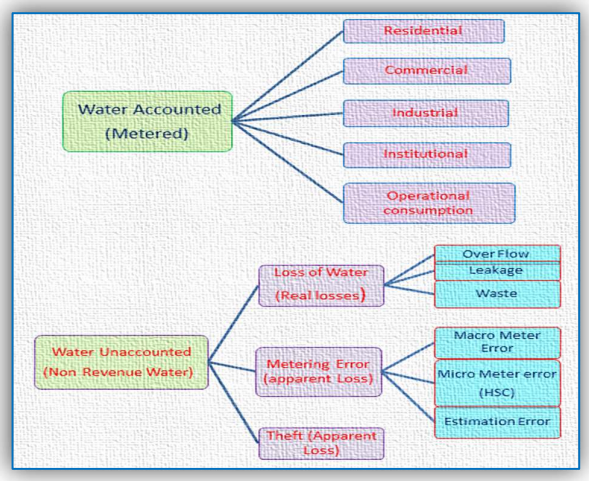
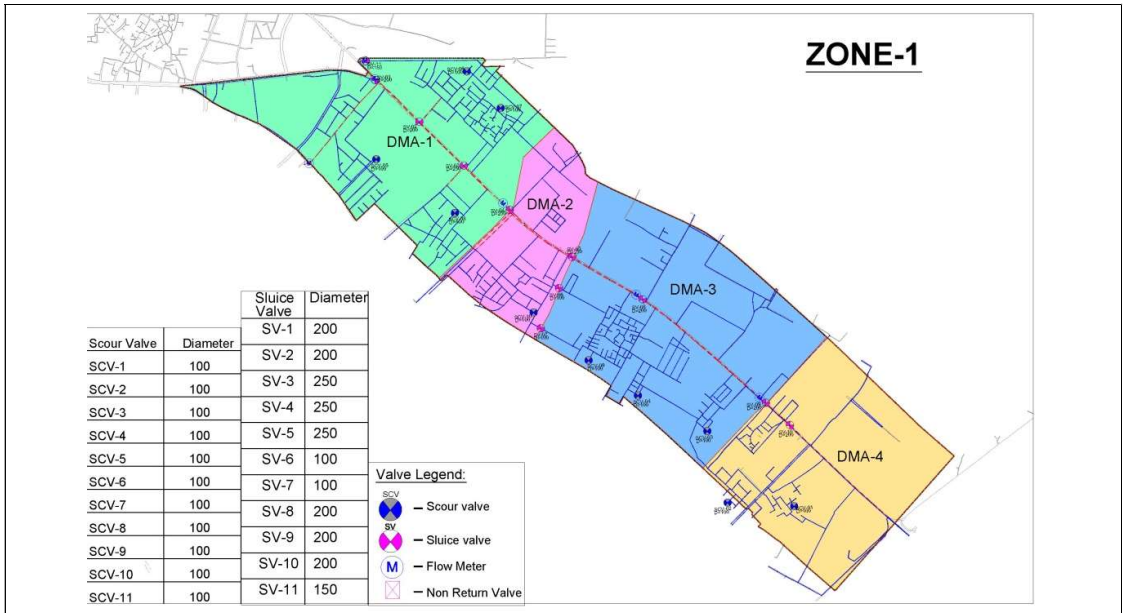


Table 16: Zone wise distribution mains

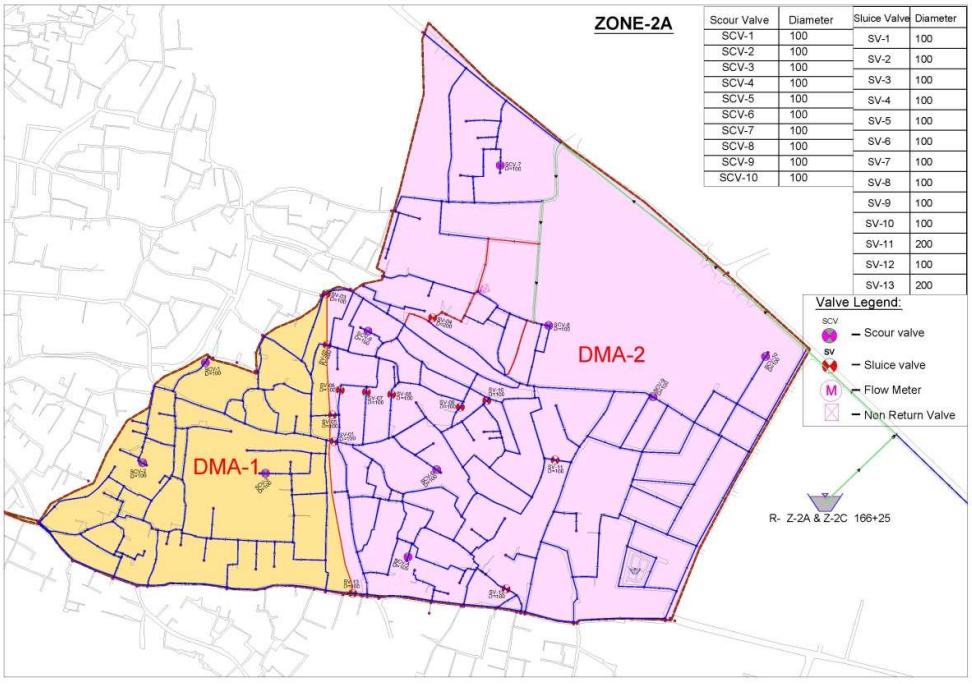
Zone No.	HDPE PIPE DIA (mm) & LENGTH (m)						DI-K7 PIPE DIA (mm) & LENGTH (m)						Total (m)
	110	125	140	160	180	225	200	250	300	350	400	450	
Zone Z1	38464	0	0	0	9418	573	3790	1850	807	183	849	624	**56557**
Zone Z2A	11336	0	0	0	1688	353	0	652	157	0	0	125	**14311**
Zone Z2B	10095	33	0	0	3560	0	833	1360	110	79	239	0	**16308**
Zone Z2C	4197	0	0	0	398	0	0	474	707	0	0	0	**5776**
Zone Z3	3942	0	148	149	659	100	126	147	0	319	0	0	**5591**
Zone Z4	9652	151	0	819	553	81	429	811	161	0	0	70	**12726**
Zone Z5	15534	0	0	0	1314	74	1281	813	0	216	106	0	**19338**
Zone Z6	9196	0	0	1233	362	0	545	0	0	0	0	0	**11336**
Zone Z7	1283	0	0	0	464	0	111	0	628	0	0	0	**2486**
Total	**103699**	**184**	**148**	**2201**	**18415**	**1181**	**7115**	**6107**	**2570**	**797**	**1194**	**820**	**144431**

Necessary scour valves are provided to flush and clean the distribution mains periodically.



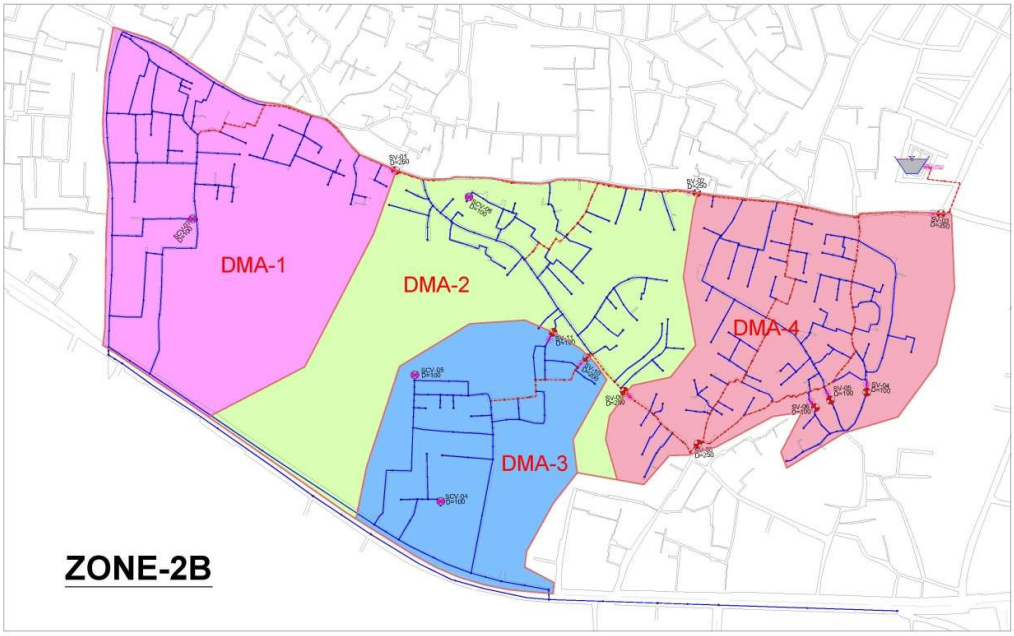
Scour Valve	Diameter
SCV-1	100
SCV-2	100
SCV-3	100
SCV-4	100
SCV-5	100
SCV-6	100
SCV-7	100
SCV-8	100
SCV-9	100
SCV-10	100
SCV-11	100

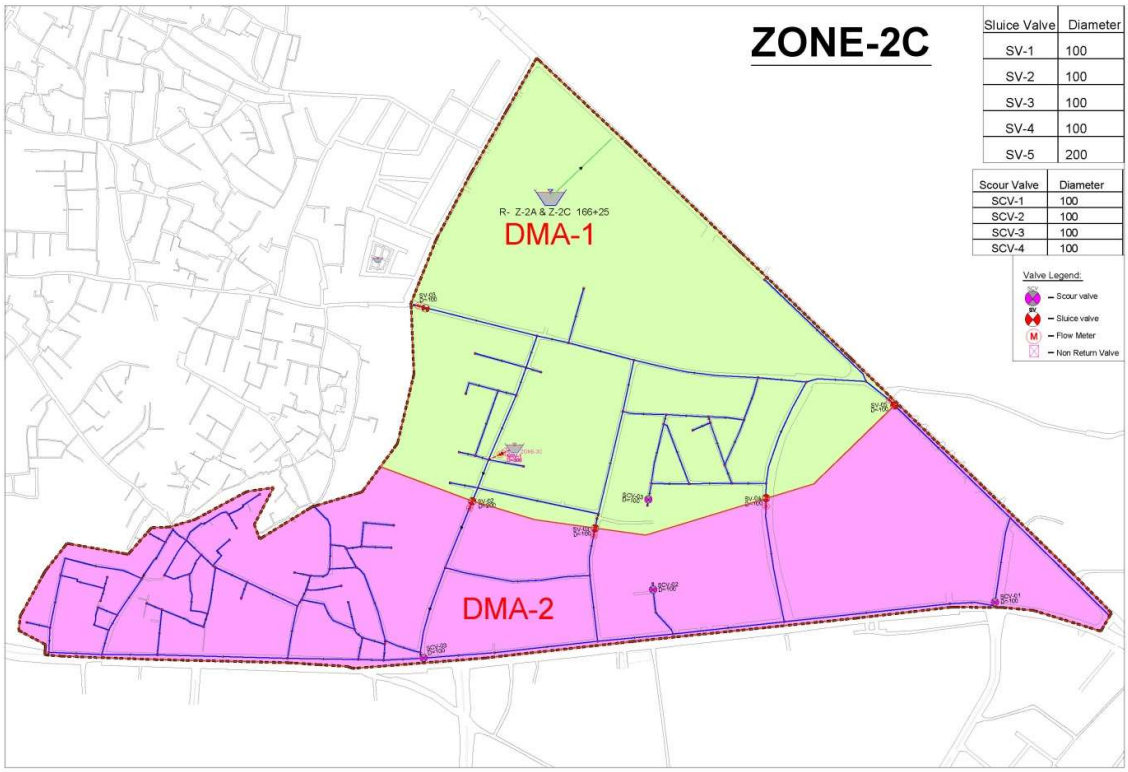
Sluice Valve	Diameter
SV-1	200
SV-2	200
SV-3	250
SV-4	250
SV-5	250
SV-6	100
SV-7	100
SV-8	200
SV-9	200
SV-10	200
SV-11	150

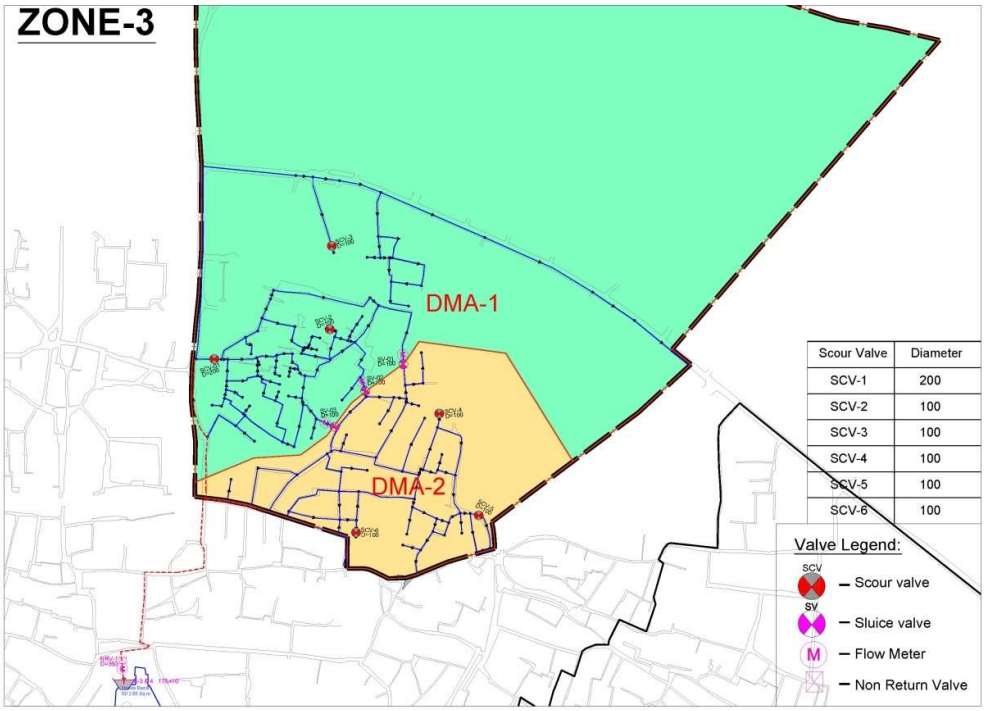


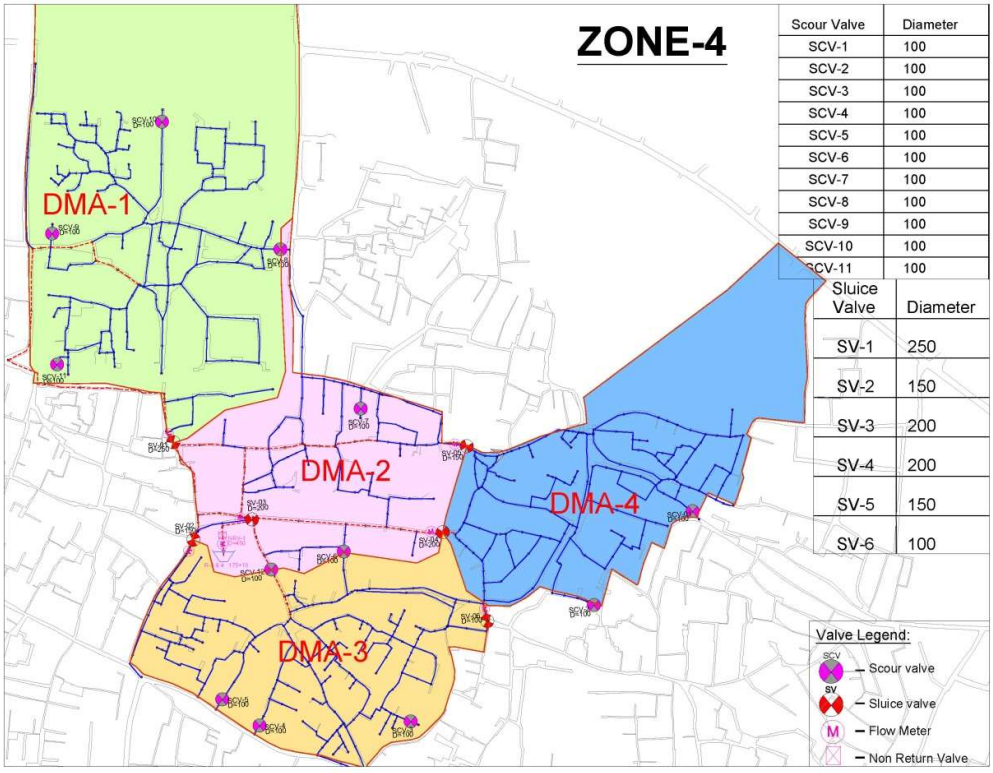
Scour Valve	Diameter
SCV-1	100
SCV-2	100
SCV-3	100
SCV-4	100
SCV-5	100
SCV-6	100
SCV-7	100
SCV-8	100
SCV-9	100
SCV-10	100

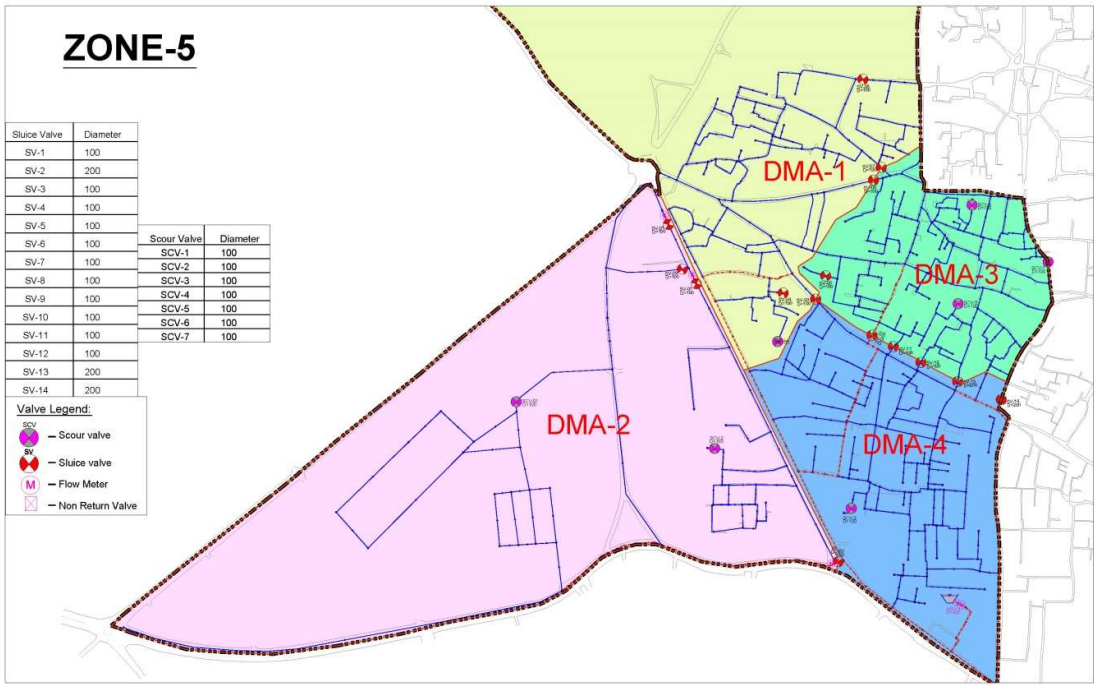
Sluice Valve	Diameter
SV-1	100
SV-2	100
SV-3	100
SV-4	100
SV-5	100
SV-6	100
SV-7	100
SV-8	100
SV-9	100
SV-10	100
SV-11	200
SV-12	100
SV-13	200


DMA-1
DMA-2
DMA-3
DMA-4
ZONE-2B


ZONE-2C
R- Z-2A & Z-2C 166+25
DMA-1
DMA-2
Sluice Valve | Diameter
SV-1 | 100
SV-2 | 100
SV-3 | 100
SV-4 | 100
SV-5 | 200
Scour Valve | Diameter
SCV-1 | 100
SCV-2 | 100
SCV-3 | 100
SCV-4 | 100
Valve Legend:
Scour valve
Sluice valve
Flow Meter
Non Return Valve

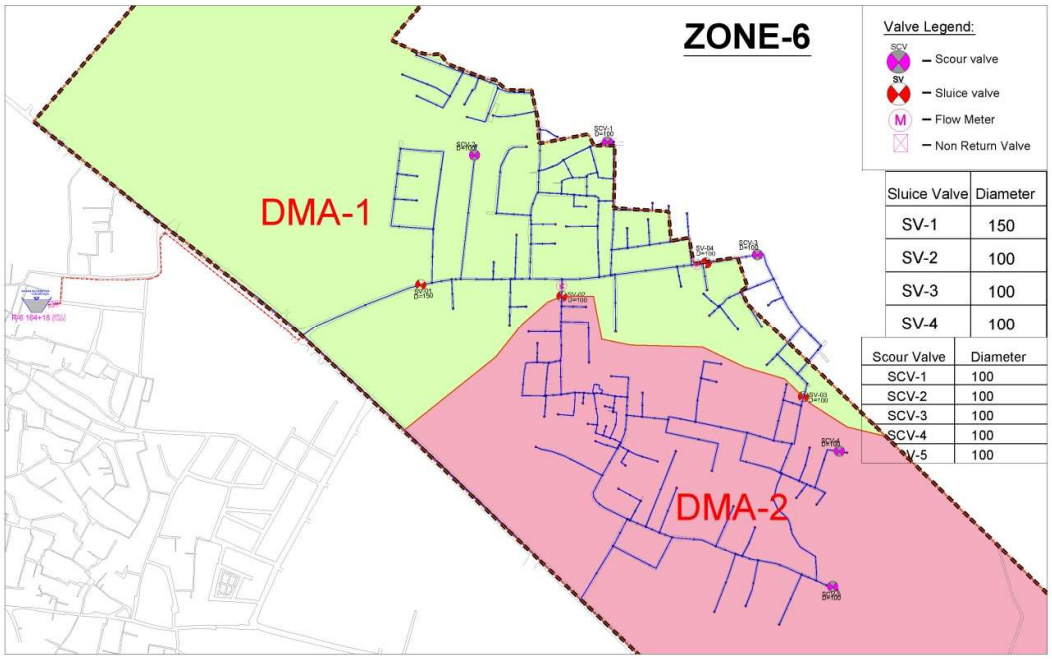

ZONE-3
DMA-1
DMA-2
Scour Valve | Diameter
SCV-1 | 200
SCV-2 | 100
SCV-3 | 100
SCV-4 | 100
SCV-5 | 100
SCV-6 | 100
Valve Legend:
SCV – Scour valve
SV – Sluice valve
M – Flow Meter
– Non Return Valve


ZONE-4
DMA-1
DMA-2
DMA-3
DMA-4
Scour Valve | Diameter
SCV-1 | 100
SCV-2 | 100
SCV-3 | 100
SCV-4 | 100
SCV-5 | 100
SCV-6 | 100
SCV-7 | 100
SCV-8 | 100
SCV-9 | 100
SCV-10 | 100
SCV-11 | 100
Sluice Valve | Diameter
SV-1 | 250
SV-2 | 150
SV-3 | 200
SV-4 | 200
SV-5 | 150
SV-6 | 100
Valve Legend:
SCV – Scour valve
SV – Sluice valve
M – Flow Meter
– Non Return Valve



Sluice Valve	Diameter
SV-1	100
SV-2	200
SV-3	100
SV-4	100
SV-5	100
SV-6	100
SV-7	100
SV-8	100
SV-9	100
SV-10	100
SV-11	100
SV-12	100
SV-13	200
SV-14	200

Scour Valve	Diameter
SCV-1	100
SCV-2	100
SCV-3	100
SCV-4	100
SCV-5	100
SCV-6	100
SCV-7	100



Sluice Valve	Diameter
SV-1	150
SV-2	100
SV-3	100
SV-4	100

Scour Valve	Diameter
SCV-1	100
SCV-2	100
SCV-3	100
SCV-4	100
SCV-5	100

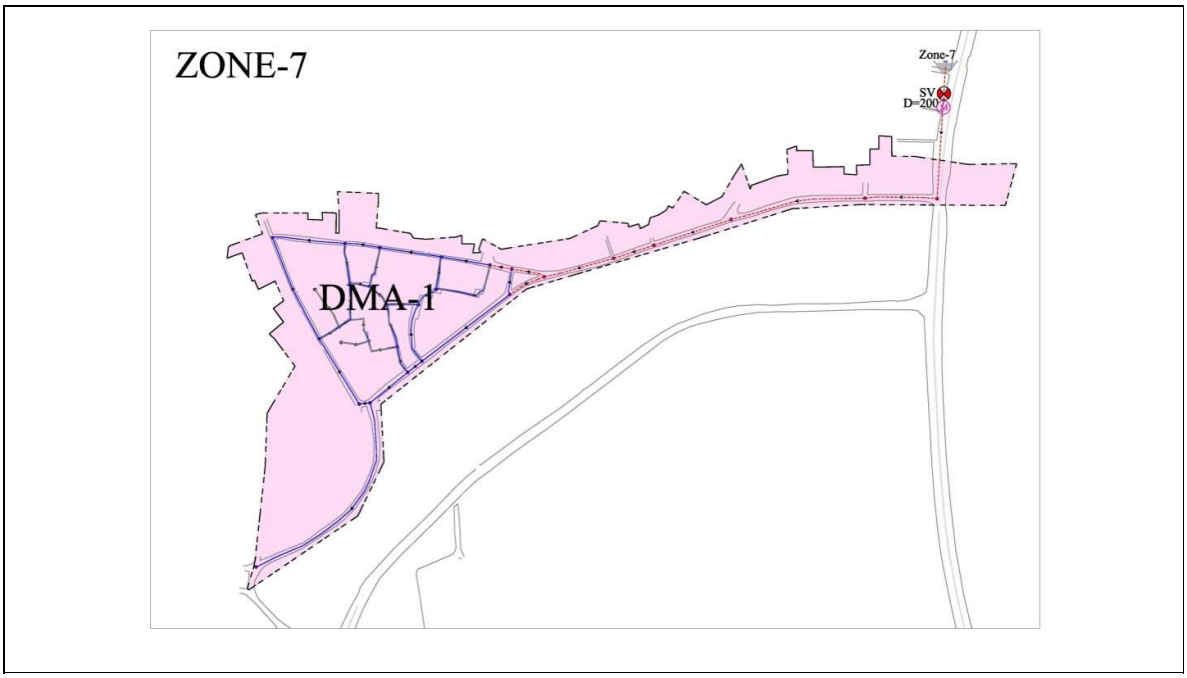


Figure 12: ***Distribution mad DMA map of ABD area***

5.9. Measurement of NRW

Procedures for measuring NRW in a DMA and remedial action to be taken to reduce the NRW are detailed in the following figures.

Sensitive flow measurement and pressure sensor devices are permanently installed onto the inlet pipes to each DMA to establish an intelligent network and flow and pressure profiles are recorded using data loggers. These profiles may be transmitted via Global Systems for Mobile communications (GSM) or any other communication media, to a personal computer in the Area Engineers control room (see following figure.13.3,13.4,13.5& 13.6) and allow real time monitoring of each DMA.

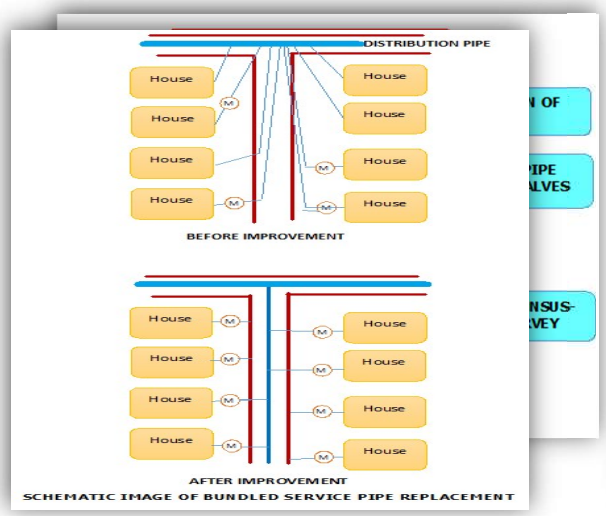


Figure 15: ***Action plan for leak detection***

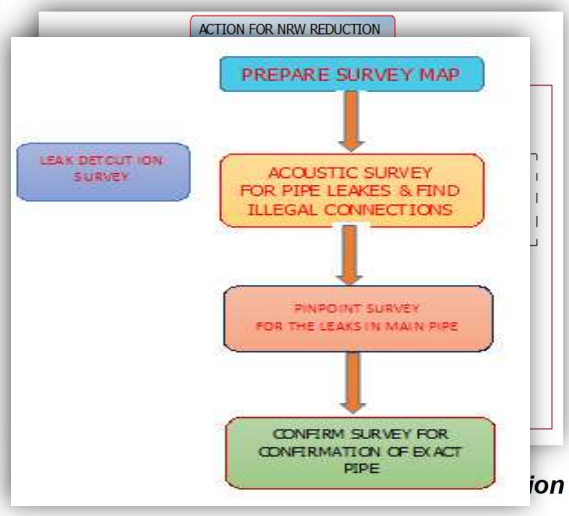


Figure 16: ***Action plan reduction of leakages in HSC***

5.10. Benchmark for NRW

MoUD has fixed the following benchmarks for NRW for guidance.

New distribution system-4%

Old/existing distribution system - 10%

Real time monitoring shall be done in all the DMAs to keep up the above benchmark.

5.11. Pilot scheme and Providing Continuous pressurised Water Supply

To start with, the scheme may be introduced in one zone as a pilot study. After observing the results and rectifying the problems encountered, the scheme may gradually be introduced in all other zones. Pilot DMAs are created and unauthorized connections are legitimized.

- The DMAs are converted to continous pressurised supply and are operated for at least 12 months in a sustainable way.
- Volumetric charging is introduced.
- The changes in customer attitudes and behavior (including coping strategies) are monitored.
- The staff must be trained in modern operational techniques like leak detection and pressure management
- Once these first set of DMAs have successfully supplied water continuously and effectively reduced water losses, then the next set of DMAs can be established for conversion to 24-hour supply

5.12. House Service Connection

The supply from the street main to the individual buildings is made through a house service connections. Saddle with electro fusion technic shall be used to tap service connections. MDPE pipe shall be used from ferrule to the property boundary fitted with ultrasonic AMR meters compatible to connect to SCADA.

Zone No	Base demand 2020 (MLD)	Base demand 2035 (MLD)	Base demand 2050 (MLD)	Population served 2020	Population served 2035	Population served 2050	No. of connections 2020	No. of connections 2035	No. of connections 2050
Zone-1	2.60	3.79	5.61	17329	25296	37428	2888	4216	6238
Zone-2A	1.13	1.66	2.45	7567	11046	16343	1261	1841	2724
Zone-2B	2.13	3.11	4.60	14199	20727	30669	2367	3455	5112
Zone-2C	0.82	1.20	1.77	5465	7977	11804	911	1330	1967
Zone-3	1.63	2.38	3.51	10848	15835	23430	1808	2639	3905
Zone-4	2.88	4.21	6.23	19232	28074	41539	3205	4679	6923
Zone-5	2.65	3.87	5.72	17656	25773	38134	2943	4296	6356
Zone-6	0.29	0.42	0.62	1903	2778	4111	317	463	685
Zone-7	1.37	2.00	2.51	9152	13360	16741	1525	2227	2790
Total	**16**	**23**	**33**	**103351**	**150867**	**220199**	**17225**	**21552**	**31457**

Table 17: House Service Connection

5.13. SCADA

5.13.1. Preamble

In order to monitor the supply quantity and quality point of view it is essential to monitor flow, pressure, level, pH, residual chlorine turbidity etc. at various crucial locations. If the supply is monitored and controlled properly, leakages can be detected well in time, electrical power can be utilized efficiently at the same time optimization of the system can be achieved.

5.13.2. Present System of Data Communication

Presently there is no data communication system other than conveying messages on mobile or landline phones. There is no such parameter monitoring system presently in the water supply.

5.13.3. Scope

The scope of this report includes:

a) Selecting instrumentation, automation and SCADA for proposed as well as existing overhead tanks, pumping stations and distribution network.

b) Selecting modern local and central SCADA system utilizing personal computers, PLCs, GSM/V Sat communication technology. Drg No. 02

c) Providing cost estimates for Instrumentation & SCADA for OHT, Pumping stations, and distribution system

5.13.4. Components under Scope

i) OHTs:

S. No.	Zone No.	Inlet Dia. (in mm)	Outlet Dia. (in mm)	Staging Height (in m)
1	Zone 1	350	600	15
2	Zone 2B	300	600	15
3	Zone 2A & 2C	300	600	15
4	Zone 3	450	600	15
5	Zone 4	450	600	15
6	Zone 5	300	600	15
7	Zone 6	150	600	15

8	Zone 7	300	-	15

ii) Pumping Stations:

S. No.	Pumping Station No.	Location
1	No. 1	Pumping Station at GeoniMandiDrg No. 03
2	No. 2	Pumping Station at TajganjDrg No. 04

5.14. Instrumentation System

5.14.1. General

Instrumentation is normally used to monitor and control operations and carry out information processing associated with observations and adjustment of operation. For effective water supply / distribution management all the important information regarding the flow, level, pressure, chlorine status etc. can be made available, monitored/controlled from centralized place i.e. main (master) control station. In the present case the main (master) control station is proposed at Head Office.

The monitoring and controls include the following:

i) Water discharge from pumping main, inlet and outlet of OHTs

ii) Level of water in OHT and sump

iii) Status of pump in pumping station (running / stopped)

iv) Status of chlorine residual at OHTs

v) Electrical power to pumps in pumping stations i.e. P, V, kVA, pf, kW etc.

vi) pH and Turbidity at pumping stations

vii) Pressures on pumping main

viii) Control of all the pumping stations & water network

In order to make above information available, various parameters such as flow, level, pressure etc. will be measured at strategic points. These parameters will be available in the form of analogue / digital signal from transmitter / sensors located at each measuring point. These signals will be connected by cables to secondary instruments installed in local control room i.e. pump room or on transmission main or at OHTs. At the same time these signals will be transmitted to main (master) control Centre by way of V Sat/GPRS through RTU (Remote Terminal Unit). Thus a measurement as well as controlled information will be available in (1) local control station and (2) Main (Master) control station.

All the equipment i.e. pumps, valves can be operated from centralized control station as well as local control station.

It is also proposed to install a instrument control panel (ICP) in local control room of OHTs and pumping stations. The same room will contain PLC or RTU for automation of OHT or pumping station.

5.14.2. Description of Instruments

5.14.3. Flow Measurement

Normally flow measuring device i.e. flowmeter is selected on the basis of site conditions, accuracy required, flow quality, head loss and quantity.

There are following flowmeters are available on the market.

A. Differential Pressure Type Flow Meters

- i) Orifice
- ii) Venturi
- iii) Flow nozzle
- iv) Pitot tube
- v) Annubar

B. Linear Flowmeters

i)	Turbine wheel	:	Insertion as well as full bore
ii)	Vortex flowmeter	:	Insertion as well as full bore
iii)	Ultrasonic flowmeter	:	Transit time and Doppler type
iv)	Electromagnetic	:	Full bore and insertion

However considering the advantages and disadvantages of each of above flowmeters, electromagnetic full bore type is selected. It is based on faradays electromagnetic principle. It has good accuracy. It requires less approach pipe as compare to other flowmeters. It has minimum 12 years of life. It has good performance over the period of its life.

5.14.4. Level Measurement

There are different types of level measuring systems which are as follows.

A	:	Displacement
B	:	Bubbler
C	:	Hydrostatic pressure
D	:	Capacitive level
E	:	Ultrasonic
F	:	Radar

Out of above ultrasonic type level has been selected for measuring water level in OHT, sump and well. Other types of level measuring systems are not suitable considering the site conditions as well as maintenance aspects point of view.

In addition to level measurement conductivity type level switch is proposed as a backup protection against overflow/ low level of OHT and sump.

5.14.5. Pressure Measurement

It is proposed to measure pressure at the discharge of pumps in both pumping stations.

5.14.6. Water Quality Monitoring

In the present case only chlorine dose in the form of NaOCl will be given to water for disinfection. Chlorine analyzers are proposed for monitoring residual chlorine in water at OHTs.

PH and Turbidity analyzers are proposed at pumping stations.

5.14.7. Electrical Parameters

An energy audit plays very important role in water works installation. Taking into account this fact it is proposed to provide electrical multifunction energy meters (smart energy meters or power manager) on each pumping station installation. This will monitor following parameters.

i) kW, ii) kVA, iii) kVAR, iv) PF, v) Frequency, vi) Voltage, vii) Current, viii) Energy

Using electrical parameters, characteristic of pump and water discharge, efficiency of the pump can be calculated online if required.

5.14.8. Protection against Surges

Outdoor installations viz. flowmeter, level meter etc. are required to be protected against lightning. In view of this lightning protection units will be provided both ends of signal cables.

5.14.9. Objectives of Automation & Local SCADA

In the present case each and every pump will be automated. Due to automation following objectives are achieved.

1) Programmable real time operation of pump
2) Hydraulic monitoring and control
3) Avoids dry running of pumping
4) Electrical parameter monitoring
5) SMS to maintenance staff
6) Pump monitoring and control
7) Improved equipment life
8) Emergency response for stopping pumping
9) Minimization of energy cost
10) Optimization of system
11) Online efficiency monitoring (If required)
12) Aid to manpower
13) Other benefits viz. logging, alarming, reporting, trending, analyzing, predictive maintenance, safety etc.
14) Monitoring working hours of pumping
15) Human errors are eliminated and reduced dependency
16) Ease of operation

5.15. Control Modes

5.15.1. Manual Mode

In the manual mode pump will be operated through push buttons provided on control panel. The pump will be operated independent of PLC function in this mode. For this mode push buttons for 'ON' and 'OFF' will be provided on control panel. This control panel will also show the flow through pump discharge, level in OHT and sump, outflow and inflow from OHT and power quality. In the case of insufficient level in sump or full level in OHT the pump will not start. If the pump is in operative mode and OHT level is full or insufficient water level in sump, the pump will stop automatically. Hard wired protection will also be provided to the motor against dry run and single phasing etc.

5.15.2. Auto Mode

In this mode collection well pump will start automatically when water level in well is sufficient. It will stop automatically sump of pump house is full or low level in sump/well. This sequence will continue automatically without attendant subject to power supply is available. All the protection provided with hard wired will also be applicable in this mode for motor.

In the case of pumping stations pump will start if water level is sufficient in the sump and OHT is not at full supply level. It will stop if sump level is low or OHT is at full supply level.

In auto mode PLC is used for carrying out various operating functions logically. In the case of failure of PLC or RTU, hardwired protection protects the motor.

For automation Inputs / Outputs have been shown in schedule at Page Nos. on 24 & 25.

5.15.3. Control Philosophy of Water Supply Operation:

For Pumping Station at GeoniMandi

I. Starting
   a. All delivery valves must be closed
   b. Switch on control switch of pump no.1
   c. Start pump no.1 through starter
   d. When shut-off head is reached, open the valve to reach the pre-determined operating pressure
   e. Switch on control switch of pump no.2
   f. Start pump no.2

g. When shut-off head is reached, open the valve to reach the pre-determined operating pressure

h. Pump no. 3 idle

II. During Running

a. To adjust the predetermined common flow rate in the common delivery pipe, adjust the valve opening of pump no.1 & pump no.2

III. After Every 6 Hours

a. Close the delivery valve of pump no.1 & after closing, switch off the pump

b. Start pump no.3

c. Continue similar operation as above for pump no.3

The operation of pumps shall be repeated every 6 hours so that, at any time only two pumps work alternatively.

For Pumping Station at Tajganj

I. Starting

a. All delivery valves must be closed

b. Switch on control switch of pump no.1

c. Start pump no.1 through starter

d. When shut-off head is reached, open the valve to reach the pre-determined operating pressure

e. Pump no. 2 idle

II. During Running

a. To adjust the predetermined common flow rate in the common delivery pipe, adjust the valve opening of pump no.1

III. After Every 6 Hours

a. Close the delivery valve of pump no.1 & after closing, switch off the pump

b. Start pump no.2

The operation of pumps shall be repeated every 6 hours so that, at any time only two pumps work alternatively.

5.15.4. Local SCADA Mode

In this mode, each and every equipment from their respective local control room can be operated by means of issuing commands from PC/HMI provided in the control room. All the data pertaining to that control room will be available on PC/HMI to that control room. All the data whatever available will be interfaced with Remote Terminal Unit (RTU) provided in the control room. The RTU will transmit the whole data to the control room which is proposed in the Headquarters. In addition to transmitting the data, it will receive the commands from the central computer which is proposed in Headquarters for remote operation as per client's requirement.

5.15.5. Central SCADA

For optimization of the existing as well as proposed water supply system, Central SCADA plays a vital role.

The operational success of any project depends upon the parameters how they are monitored within limited ranges. In the present case the various parameters viz. Flow, level, pressure, residual chlorine, etc. can be monitored locally or from remote places. When the area of the project is vast, it is not possible to monitor all the parameters at the central place unless some sort of information or data are available at that place. Such information about the parameters can be transmitted through electronic data transmission system which are as follows:

i. Monitoring flows & hydraulic gradient at nodal points

ii. Reduces water losses due to burst

iii. Cost effective yield.

iv. Avoid running trunk mains dry

v. Energy saving

vi. Keep control over operational staff

vii. Monitoring water parameters viz. pH, turbidity, chlorine residual, etc.

viii. Avoids spillage due to overflow, etc.

ix. Help in taking fast and accurate decisions.

x. Ease of data collection for optimization.

xi. Ease of maintenance

xii. Human errors like erroneous readings are eliminated.

xiii. Delay in reading can be avoided.

xiv. Recording electronic data for lateral retrieval

xv. Report generation

xvi. Providing central alarm condition surveillance

The various components of water supply such as trunk mains, pumping stations, OHTs etc. can also be controlled from central place – Central Control Station by issuing commands in the form of electronic data to remote units known as Remote Terminal Units (RTU). This is known as SCADA or Telecontrol. Some of the commands are issued locally through PLC (Programmable Logic Controller) instead of from Central Control Station. This avoids unnecessary handling of the data by the Central Control System which also keep the Central Control Station free for carrying out the important works.

In the SCADA, the system:

a) Polls the various local stations and gathers the data related to operating and process parameters.

b) Processes this data and gives commands to local controls and

c) Generates alarm and other monitoring functions

The SCADA is useful in the present case from following aspects :-

1. To ensure that the demand for water is met upto the maximum capacity of the scheme.

2. To ensure that there is a balance between the incoming water and supplied water.

3. To ensure that the levels in the pumping sumps & service reservoirs remain within the operating limits described.

4. To maintain a regular flow of water and operate control valves such that pipeline does not go empty.

To achieve these objectives, it will be necessary that the whole system is monitored by a system controller who will require access to the existing state of demand, flows, pressures and levels at all times.

SCADA, can be used to gather the data at Main (master) Control station as well as operate the whole system from the system provided the operator knows the pros and cons of operating it remotely. The system consists of Remote Terminal Units at local stations where the various parameters are connected through the wire. These RTU's are polled sequentially and periodically by the main control center. In addition to that any alarming condition at local station is generated, is also informed immediately without waiting for sequential polling to the main control center. Control of the equipment at remote site through RTU by issuing the command from main control center is envisaged.

SCADA system provides an interface to the RTUs through the communication networks. The SCADA system stores the data, displays them, analyze them and transfer them to other computers if necessary. A SCADA system often provides a control interface for sending data or commands to RTUs.

5.16. Communication Media

5.16.1. Classification

For SCADA operation a communication medium is essential. This could be one of the following:

1) Wire

a) Private Cable

b) P & T line

c) Fiber optics

2) Wireless

a) VHF

b) UHF / MICROWAVE

c) V sat

d) GSM (Global System for Mobile communication)/CDMA (Code Division Multiple Access)/GPRS(General Packet Radio System)

5.16.2. Cable (Private)

Copper wire has been used for many years to convey analogue and status information. Traditionally they are low cost and are readily available from multiple sources. Service personnel can install and maintain a system with minimal training. The main limitations of copper wire are it's capacitances and it's inductance. Both of these factors limit a parameter wire to a definable distance at a specific frequency.

Twisted pair and coaxial cable are commonly used copper wires for digital communication. Twisted pair wires reduce noise. Shielding provides a barrier to electrostatic, electromagnetic or induced couple paths. Shielded cable increases the relatively distance capacity but twisted pair is restricted for short distance.

Coaxial cables are used for covering higher distance and increasing the data speed.

However laying such cables along all the site will involve a major job itself and it will be costly affair from installation as well as maintenance point of view.

5.16.3. P & T (Land Lines) or Service provider

Telephone system in digital communications use either leased lines or dial up service. Leased lines are special lines provided by the telephone company for the service, which continuously connect the remote sites with the main station. These wires are routed through the switching orifices (Exchanges) of the phone system. In case of failure of this communication in any of the exchange will jeopardies the system. Such wire having low voltage signal level is misguided by the lineman of the telephone co. resulting into treating as dead line by him and using it to other purpose.

A second method of remote telephone service is a dial up network. In this case main station dials the phone number of remote site. Once the connection to the remote modem is made and land shakes validated the data are then transmitted. Dial up systems are the least expensive method of remote communications but also have slowest. In this case data can be transmitted at the rates ranging from 300 to 9.6 kbps. The dial up system does not suffer the same failure rate as leased lines. However, this system may be paralysed intentionally during not or any normal emergency cropped up, by way of shutting it down for avoiding rum ours.

The private service provider may offer cable on rental basis for net. However it is not reliable for real time communication. The same may be useful for data transmission and not suitable for remote control.

5.16.4. Fiber optics

Fiber optics use light to transmit data over a fiber cable. It is immune from electromagnetic interference. It is suitable for high speed data transmission over longer distances in comparison with copper cable. Wherever multi communications are required, it is the most suitable mode of communication. However it is very costly initially. However once it is installed the recurring cost will be very less due to it's ownership. It requires specialized staff for making the joints during maintenance and costly equipment. In the present case a number of parameters required to be monitored from each site is meager and hence it is not worthwhile to adopt Fiber Optic System

5.16.5. Wireless

In this category radio telemetry system offer an alternative to fiber optics, wire line or telephone lines for the purpose of communication with remote sites. However radio frequencies are regulated by the central agencies viz. wireless planning commission of ministry of communication, GOI. It is required to apply for the frequency allotment which is lengthy process.

Radio system works in a similar manner to dial up telephone service. The remote sites are commonly polled in sequence and data is transmitted once the connection is verified.

The major considerations in any radio system are:-

i. Distance to the remote location

ii. Terrain between the master and remote sites.

iii. Frequency used

iv. Output power of transmitted

v. Height of the antenna

vi. Type of antenna

The nomenclature of the frequencies is given as follows:

High frequency (HF)	-	3 to 30 MHZ
Very High Frequency(VHF)	-	30 to 300 MHZ
Ultra High Frequency (UHF)	-	300 to 3000 MHZ
Microwave normally above	-	900 MHZ

Radio systems are terrain sensitive. Radio communications commonly require a line of sight between the transmitter and receiver. Hills, trees, buildings and other obstructions may degrade the reception. The frequency selected will affect the system design. VHF signals are better able to bend around hills than are UHF signals. However those are subject to greater problems with natural and anthropogenic noise and co-channel interference.

5.16.6. VHF

For voice or data transmission normally frequency may be available in the range of higher band of VHF i.e. 146 -174 MHZ. It is less prone to electrical noise. In order to check the feasibility of VHF communication the radio feasibility survey is carried out.

The radio survey is done in three parts as follows:

i. Paper study

ii. Arrangement of radio survey and finalization of frequency band.

iii. Preparation of survey report & recommendations.

On completion of Preliminary Radio Survey an application is submitted to Asst. Advisor (WPC) of ministry of communication for frequency allocation. The ministry of communication subsequently conveys it's agreement in principle to grant a license and also indicates the set of frequencies allotted with the amount towards the license fee and Royalty charges.

The necessary License and Royalty fees are to be paid immediately with a request to issue regular license for the Radio Network after setting mast height / sitting clearance.

After getting receipt of the required number of frequencies, the customer takes the steps towards procurement of the wireless equipment and accessories.

Mast height / sitting clearance:

For the antenna height more than three meters above ground level, the mast height clearance is required.

However the Government may exempt the customer from obtaining the mast height clearance, subject to conditions that the antenna height does not exceed more than 3 meters above the top most part of the constructed structure on which the antenna is proposed to be erected and also subject to the sight being at least 3 Kilometers away from the nearest airport.

A regular license is obtained for installation, maintenance and operation of wireless sets after the issue of mast height / sitting clearance.

It is an obligatory part on the customer to see that each wireless station is abided by all rules and regulations stipulated by Ministry of Communication.

5.16.7. UHF / Microwave

UHF and Microwave frequencies require line of sight and higher antennas. A radio signals ability to penetrate solid walls decreases with an increase in frequency. However a radio signals ability to enter through smaller and smaller openings increases with an increase in frequency. The appearance of improved penetration comes from the increased ability of UHF signals to enter buildings through doors, windows and other small openings and improved ability to bounce around once inside. These higher frequencies however suffer from severe attenuation from anything in their transmission path. Trees can severely reduce system capabilities. The frequency used will also affect cost. Normally, the higher the frequency, the higher the cost of the equipment used.

Microwave Communication Antennas abided by stringent rules / regulations from Ministry of Communication. Due to it's constraints of 100 % line of sight the mast height is more than that of VHF. However in this system multi channel communication with high data speed is possible.

5.16.8. V-SAT

Very small Aperture Terminal: This communication is suitable for isolated communications. It is not limited by terrain or distance. It is a data communication equipment that supports and forms a part of data communication network through satellite. The frequency of communication is in microwave range. The advantages of this system are as follows:

- Easy to install
- Secret and error free point to point communication
- Real time interactive information exchange
- Highly reliable communication media

However this system is costly for the present system.

5.16.9. GSM (Global System for Mobile communication) / CDMA (Code Division Multiple Access)/GPRS (General Packet Radio System)

Nowadays this technology is being widely used. It has cellular system architecture. A cell is the basic geographic unit of a cellular system. Cells are base stations transmitting over small geographic areas that are represented as hexagons. Each cell size varies depending on the landscape.

The frequencies used are in microwave region. This communication system can be used for data transmission with following advantages:

- Remote monitoring & diagnostics
- Reliable Real Time control & monitoring
- Data Retrieving and Remote Alerts
- Interfacing with existing devices like PLCs
- Automated Error Message generation Transmission over GSM/CDMA network
- Optimization of production by use of minimum man power
- Quick response, typically less than 5 secs depending on the GSM/CDMA Service Provider
- Easy to implement integrate
- Wireless measuring, control and configuration
- Data security & reliability
- Use of SMS the most familiar GSM application as medium of alert message transmission
- GPRS is used for mobile net and other communication where time required for data transmission is short. However, no service provider gives guarantee for sure data transmission

5.17. Configuration for SCADA

It is proposed to control the system from the main control center at Head office. It is also proposed to transmit the selected data from all OHTs ,local control centers, pumping stations. Please refer Drawing No. 02

Reasons of providing SCADA carrier I communication of V sat & GPRS type are as follows:

i. V sat signals are available at the proposed sites.

ii. V sat compatible SCADA software easily available.

iii. More service providers than other type service providers.

iv. It will be the most reliable communication as well as guaranteed one.

v. It requires shortest period for implementation.

The system will be backed up by GPRS communication. The GPRS system which is available through cell call is not reliable for remote control and no service provider gives guarantee for assured communication. In the case of V sat, the assured communication will be available. It is therefore V sat communication is recommended with backup with GPRS. Please refer Drawing No. 02

5.18. Proposed Configuration for SCADA System

It is proposed to have a system consisting of a main control center with a single host computer controlling about 9 RTUs. Operators at the MCC will monitor and control the system through the RTUs.

The main control center will house two PCs along with 2 Nos. of printers.

The following points are considered for the network.

- nos. of RTUs for local area and 1 no. of Main Control Centre at Head Office
- 256 KBPS full duplex band width for double hop V sat system for data transmission for entire network
- Due to double hop there will be latency in data which may be approximately 3 to 4 seconds. It is presumed that it is acceptable to the Client.

With a view to get maximum benefit out of Instrumentation, Automation and Local as well as central SCADA following configuration is proposed at each local station.

1. Instrumentation control panel (ICP) and Industrial grade computer along with 2 Nos. of printers 1 Dot matrix + 1 Laser Printer; will be located in pump control cabin.

2. All the controls, alarms, status, indications of instruments/equipment will be available on visual display unit (VDU) of the computer.

3. Selected, Controls, alarms status, indications of Instrument/equipment will be available on ICP at OHTs.

4. Live mimic diagram of the pumping system along with values of the parameters being monitored will be available on VDU.

5. Mimic diagram with limited indications will be available on ICP.

6. All the local stations will be provided with RTUs for local data handling.

Typically a main control center will be provided with V sat/GPRS supporting SCADA software for central control, monitoring and analysis of the various parameters.

A dedicated front end processor will be provided at the master to carry out all the communication related activities with down stream RTUs. These will off load the main PC from their task and thus provide for improved performance. The front end processor will be connected to the PC. In the case of failure of PC the front end processor will store the information received by it.

The master control station will have following functionalities.

A: Central Monitoring & Control

1) OHT

- Inflow
- Outflow
- Status of valves
- Level
- Pressure

2) Transmission Main

- Flow

3) Sump & Pumping Station

- Pump status i.e. ON, OFF, running hours
- Tripping of pump
- Flow of discharge
- Level of Sump
- Electrical Parameters
- Chlorine Residual
- pH
- Pressure

4) Customized Reports and Management Analysis

All operations mentioned above are monitored from the MCC through extensive graphics support of the package which also reduces the learning curve of an average operator. It is easy to identify that the entire production and distribution system is generated at the (MCS) Master Control Station.

The MCC and LCC at pumping station as well as at OHTs will control the equipment locally. Please refer Drawing No. 02

All the data logged on the MCC will be analysed through various meaningful user defined reports, graphs, trends and customized analytical requirements of the system.

i) Reports: These are generated as follows

- yearly, monthly, daily report on water production
- daily water production report for comparison with earlier days

ii) Alarms

- limit cross over
- hardware alarm
- communication link alarm

Each alarm can be time stamped

Severity can be indicated through color coded representation.

iii) Trend Displays

It will cover graphical trends for the critical parameters for immediate access to the behaviorof a particular parameters over a period of time. It shall also cover historical trending of parameters like total water production.

iv) Graphical Displays

The graphs namely water production Vs power consumed or similar one will be helpful and hence the software will be suitable for them.

v) Secured and authenticated access

C: RTU shall have following features

- It will collect the data from field connected instrument and transmit the same to MCC
- It comprises CPU and signal conditioning ends for analogue and digital signals
- It will have programmable memory and data memory
- It will have LCD display for indicating local data along with matrix key board
- It will have minimum 3 communication ports
- It will have all the functionalities of PLC
- It will have data time stamped facility

5.18.1. Conclusion-SCADA

Considering the available systems of Instrumentation, Automation & SCADA on the market with their benefits, life, reliability and suitability at site GMS / GPRS communication system with compatible instrumentation and automation has been proposed for Agra Water Supply.

Input / Output Schedule for each OHT Installation

Total numbers of OHTs: 07

S. No.	Signal Description	RTU/PLC I/O			
		DI	DO	AI	AO
1.	Inlet Valve Status				
i.	Open	✓			
ii.	Close	✓			
iii.	Open (Command)		✓		
iv.	Close (command)		✓		
v.	Trip	✓			
vi.	Local/Remote	✓			
2	Outlet Valve Status				
i	Open	✓			
ii	Close	✓			
iii	Open Command		✓		
iv	Close Command		✓		
v	Trip	✓			
vi	Local/Remote	✓			
3	Inlet flow			✓	
4	Outlet flow			✓	
5	Level in OHT			✓	

6	Inlet Pressure			✓	
7	Residual Chlorine			✓	
8.	Level Low	✓			
9.	Level High	✓			

Input / Output Schedule for each Pumping Station Installation

Total no. of Pumping Stations: 2

S. No.	Signal Description	RTU/PLC I/O			
		DI	DO	AI	AO
1.	Pump Motor				
i.	Running status	✓			
ii.	Stop status	✓			
iii.	Trip status	✓			
iv.	Stop (command)		✓		
v.	Start (command)		✓		
vi.	Available	✓			
vii.	Motor fault	✓			
viii.	Local/Remote	✓			
a)	Input voltage			✓	
b)	Input Amperage			✓	
c)	Power consumption			✓	

d)	Power factor			✓	
2.	Level in Sump			✓	
3.	Sump Level Low	✓			
4.	Sump Level High	✓			
5.	Flow in Pumping Main			✓	
6.	Turbidity			✓	
7.	PH			✓	
8.	Discharge Valve Status				
i.	Open	✓			
ii.	Close	✓			
iii.	Open (Command)		✓		
iv.	Close (command)		✓		
v.	Trip	✓			
Vi	Local/Remote	✓			

6. CONCLUSION

This project will benefit for a population of about 103351 Nos. and 17225 households and tourist of ABD area. By implementing this project the entire population of ABD area will get safe drinking water and this will improve public health of people. The waterborne diseases will be controlled will have considerable reduction in cost on public health. This project will ensure equitable water supply to the project areawith adequate residual pressure. This will save energy cost for individual households for lifting water from sump to over headstorage at residents. Agra being an important tourist destination, Tourists will get safe drinking water and have a positive impact on tourism.

7. WAY FORWARD

To implement this project there are challenges encountered in many areas. Following are the key bottlenecks of the project to be addressed.

- The source of water for various stages shall be ensured with concerned authorities to smooth running of the project
- Uninterrupted power supply at GeoniMandi pumping station and TajGanj pumping station to be provided from separate feeder for effective continuous water supply
- Necessary permissions for implementing this project like transfer of land ownership, NH crossings, Railway crossings, Archaeological survey of India, National green tribunal, etc… needs to be cleared within stipulated time
- Necessary permissions for laying of transmission main along the existing road need to be cleared
- TajGanj being crowded area with narrow roads embedded with many underground utilities like existing sewerage, Torrent power line, Optical fibre cable, water supply pipelines etc.. Challenge is foreseen to implement without destructing other existing utilities
- Fixing of 100% consumer water meters and implementing telescopic tariff will have great impact on effective functioning of the system.

DARASHAW

1926

ALL ABOUT TRUST

Darashaw & Co Pvt. Ltd. 6th Floor, Express Building , 14th "E" Road, Near Government Law College, Churchgate (W), Mumbai -400 020 Tel +91 22 43022300