DETAILED PROJECT REPORT

January 2021

CONSULTANCY SERVICES FOR

"CARRYING OUT CONSUMER SURVEY AND

WATER AUDIT OF NAGPUR WATER SUPPLY SCHEME

(FOR WATER REFORM WORKS)"

CLIENT

Nagpur Municipal Corporation

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ABBREVIATIONS

AMRUT	Atal Mission for Rejuvenation and Urban Transformation
BPT	Break Pressure tank
CI	Cast Iron
CPHEEO	Central Public Health Engineering and Environmental Organization
DMA	District Metering Area
DPR	Detailed Project Report
ESR	Elevated Service Reservoir
GH	Governor House
GSR	Ground Service Reservoir
IWA	International Water Association
JnNURM	Jawaharlal Nehru National Urban Renewal Mission
lpcd	Litre Per Capita Per Day
lpm	Litre Per Minute
lps	Litre Per Second
LSL	Low Sump Level
MBR	Master Balancing Reservoir
Mm^3	Million cubic meter
Ml	Million liter
Mld	Million liters per day
m^3/day	Meter cube per day
Mm^3	Million meter cube
MS	Mild Steel
MSNA	Maharashtra Sujal Nirmal Abhiyan
NESL	Nagpur Environmental Services Limited
NH	National Highway
NHAI	National Highway Authority of India
NMC	Nagpur Municipal Corporation
NRW	Non-Revenue Water
OCWPL	Orange City Water India Private Limited
PFR	Pre-Feasibility Report
PPP	Public Private Partnership
PSC	Pre Stressed Concrete
PWD	Public Works Department
PWRM	Pure Water Rising Main
RBC	Right Bank Canal
RFP	Request for Proposal
RWRM	Raw Water Rising Main
SH	Seminary Hills
SLIP	Service Level Improvement Plan
ULB	Urban Local Bodies
UFM	Ultrasonic Flow meter
WTP	Water Treatment Plant
WSS	Water Supply System

EXECUTIVE SUMMARY

Executive Summary

➢ OBJECTIVE

Nagpur is a second capital of Maharashtra and has population over 2.5 million spread in 217 square km. Nagpur Municipal Corporation (NMC) is responsible of providing water supply services to the city of Nagpur. The total water supply to city was over 500,000 m3/day (500 Mld) per day through nearly 225,000 connections in 2008. Now water supply capacity upgraded to 786,000 m3/day (786 Mld) & about 370,000 connections. The distribution network consists of over 4000 km of pipe line. Nagpur City Development Plan states that NMC's mission includes achieving "Water for all and 24 x 7 supplies with focus on safety, equity, and reliability".

➢ SCOPE OF WORK

Carrying out random consumer survey of 20% of the total properties in order to collect identification details, socio-economic characteristics, details of consumer's connection, and details of consumption of water usage. Based on these details, preparing database system including all the attribute tables of consumer's data, matching of consumer survey data with billing data, integration of consumer survey in GIS layer, showing coverage of water supply scheme on digitized map using different annotations, attaching the attribute tables to the point feature and representing consumer in appropriate GIS software.

Carrying out water audit by studying and mapping all components of water supply scheme in the town/ areas, finding water losses on the rising mains, from source to ESR's with the help of bulk meter/ portable flow meter at the inlet & outlet of rising main and at suitable place at water Supply Components. Water audit for distribution system shall include identification of system boundaries for DMA, assembling all records and required data, measurement of supply at the entry point of all DMA's from bulk meter if installed or by using potable flow meter reading for corresponding months, showing overall water balance starting from system input to revenue and non-revenue water, water losses, quantifying all component mentioned in IWA standard water balance tables analyzing of water audit result. Preparation of the Pre-Feasibility Report (PFR) and Detailed Project Report (DPR).

➢ EXISTING WATER SUPPLY SYSTEM

Nagpur City gets water from two sources namely Kanhan River and Pench Reservoir. Surface water source from river Kanhan 14 km away from city was considered as perennial source. In 1976, the irrigation department, Govt. of Maharashtra executed a storage dam across river Pench for hydroelectric project at Totaladoh and pickup dam at Navegaon Khairy. In 1982 Pench-I scheme was commissioned, in 1994 Pench II Scheme, in 2003 Pench –III and in 2014-15 Pench-IV scheme was commissioned.

The water extracted from the surface is treated in the WTPs. At treatment plant, the raw water is treated up to the standards of safe drinking water by pre-chlorination, sedimentation, filtration and disinfection. Quality control is assured through laboratory testing at the WTPs. Surface water treatment in Nagpur is done in five WTPs namely Pench-I, II, III, IV, (Godhani) and Kanhan WTP.

After the treatment of water at WTPs, Water is supplied to the city by Master Balancing Reservoirs at Seminary Hills (20.43 ML) & Governor House (22.74 ML). Seminary hills and Governor House are

the two master balancing reservoirs from which the water is supplied to other reservoirs. These two MBR's also supply water to its command area, there are total 67 Nos. storage reservoirs in the city including above MBR's. As per NMC record there are total 368022 Nos. of registered consumers in the Nagpur City.

➢ CONSUMER SURVEY

The survey has to be conducted for 20% of total properties i.e. for 110000 properties which includes each zone of Nagpur city.

The objectives of this survey are as below,

1) Details of consumption of water by different beneficiaries i.e. Domestic, Industrial, Commercial, Non Domestic etc.
2) Determine the perception of water services received
3) Provide information & measures to be taken to improve the efficiency and financial performance of the water distribution system
4) Evaluate the quality of service when reporting problems or making enquiries
5) To trace out the properties having regular connection
6) To trace out the suspected connections, validation of such connections with consumer database and take necessary action if found illegal
7) To trace out the connections where water is being supplied by old as well newly laid pipeline

Zone No	Name	No of Properties Surveyed
1	Laxmi Nagar	1265
2	Dharampeth	11770
3	Hanuman Nagar	7154
4	Dhantoli	1603
5	Neharu Nagar	7485
6	Gandhibagh	7347
7	Satranjipura	954
8	Lakadganj	3308
9	Ashi Nagar	58787
10	Mangalwari	10736

- ***Survey Results***

Description	**Quantity**
Total no of Properties Surveyed	110409
Population	622470
No of Authorized Connections	83081
Disconnected	1916
No Connections	19334
Unregistered Connections	8754

Zone No.	Zone	Total Connection found	Billed Authorized Connections		Unbilled Authorized Connections	
			Consumers with water meter	Consumers without water meter	Consumers with water meter	Consumers without water meter
1	Laxmi Nagar	1192	1189	3		
2	Dharampeth	10610	10324	286		
3	Hanuman Nagar	6637	6513	78	46	
4	Dhantoli	1563	1311	242	9	1
5	Nehru Nagar	6002	5727	275		
6	Gandhibagh	6489	6361	88	40	
7	Satranjipura	763	534	229		
8	Lakadganj	2928	2858	43	26	1
9	Ashi Nagar	38129	31740	6323	66	
10	Mangalwari	8768	8614	79	75	
Total Connections		**83081**	**75171**	**7646**	**262**	**2**

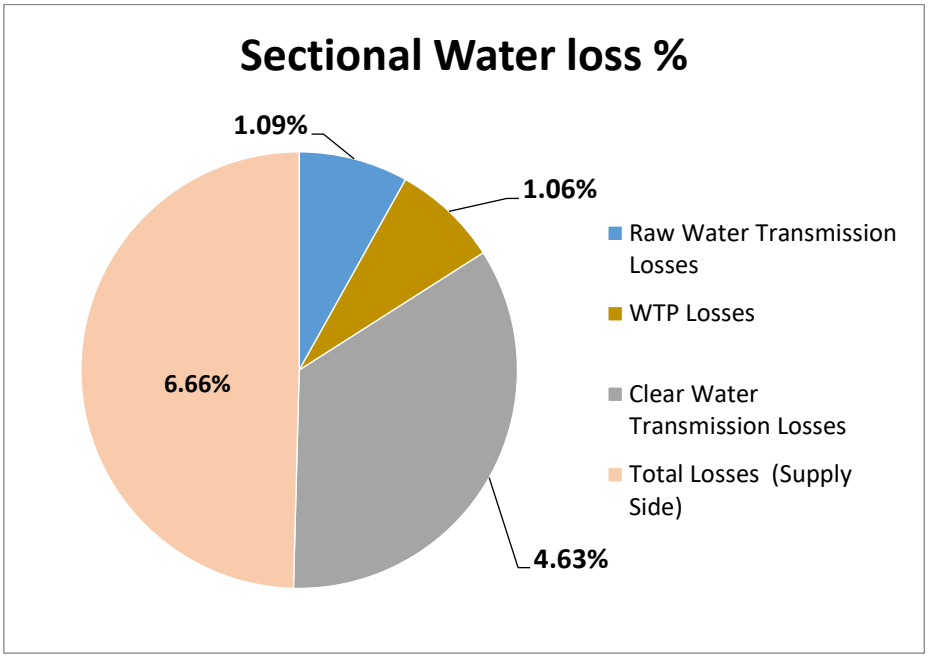
➢ WATER AUDIT

As per existing situation, Nagpur water supply scheme draws water from two surface water sources. Here, system input volume is considered as sum of both. There are fixed type inline bulk flow meters in the water supply system. During the study, portable clamp on type portable ultra-sonic flow meters were used for taking the reading on quantum of water flowing through. The readings were taken by deploying teams with the instruments at various stages for measurement for total of 24 hours' period for the analysis of system input as well as the comparison of fixed type inline meters. The results of the study for surface water is summarized below.

- ***Results of Bulk Water Audit***

Sr. No.	Description	Total
1	Raw Water Output (ML)	686.11
2	Raw Water Inlet at WTP (ML)	678.64
(1-2)	**Raw Water Transmission Losses (ML)**	**7.47**
	Raw Water Transmission Losses (%)	**1.09%**
3	WTP Outlet (ML)	671.47
(2-3)	**WTP Losses (ML)**	**7.17**
	WTP Losses (%)	**1.06%**
4	Total ESR Inlet (ML)	640.4
(3-4)	**Clear Water Transmission Losses (ML)**	**31.07**
	Clear Water Transmission Losses (%)	**4.63%**
(1-4)	**Total supply side losses (ML)**	45.71
	Total supply side losses (%)	**6.66%**

As per above study, total 45.71 MLD of water losses are measured in the supply side of the water supply system (i.e. Headwork's to ESR's)



➢ FORMATION OF DMA AREA'S

Nagpur Municipal Corporation has moderate condition of water supply. City administration has divided the service area in ten zones. Water supply is observed on daily basis. Water is supplied to Nagpur city areas are through ESRs and GR & MBR's, considering this scenario and consultation with NMC officials, we are divided this activity in to two parts i.e. first part is Ashi Nagar Zone No 9 which has selected as a complete DMA and remaining area as considered as random sample area; we can achieve the results closer to the reality. The methodology for this method of sampling is elaborated here. Some of the key points are as below,

- Selection of the consumers as per the details available from survey.
- Then as per connection status; total authorized consumption will be calculated.
- Consumption of PSPs and tanker supply to be added in this quantum.
- Then the total consumption for the connections w.r.t each ESRs is compared with the total ESRs outlet volume flow for that supply area during the period of supply. Thus the difference is distribution losses in that zone.
- Major advantage of this process is all the area of consumers with equal proportion can be covered. Even all the localities can be covered to get very realistic approach of the calculation of consumption pattern.

As per above scenarios and consultation with NMC officials we have selected random areas for analysis of per HSC water consumption & LPCD. Out of ten zones, one Zone i.e. Ashi Nagar Zone have been selected as a whole DMA for the study.

- ***Details of DMA Area's***

Sr. No.	Zone	Name of Study Area	Total No. of consumers selected for study
1	Ashi Nagar	Ashi Nagar DMA	1242
2	Laxmi Nagar	Agney Layout , Shastri Layout	290
3	Dharampeth	Bharat Nagar, Shivaji Nagar	111
4	Hanuman Nagar	Suyog Nagar Area	282
5	Dhantoli	Vishwakarma Nagar Area	211
6	Nehru Nagar	Chitnis Nagar Area	211
7	Lakkadganj	Garoba Maidan Jagjeevan Nagar Area	264
8	Mangalwari	Bardey Layout Area	310
			2921

- ***Results of DMA Study***

Sr. No.	Description	Amount	Unit
1	Total output of ESR's	640.40	ML
2	Total connections in the City	368022	Nos.
3	Average Population per connection	6.61	Nos.
4	Total connected population to WSS	2319458	Nos.
5	Average HSC consumption through analysis	991.43	Lit.
6 = 5x2	Total consumed quantity	364867129	Lit.
		364.87	**ML**
7 = 6/4	LPCD	**157**	**Lit.**

➢ OVERALL WATER BALANCE

Following table shows the Water Balance Diagram in this we calculate

<table>
<tr><td rowspan="9">System Input Volume
686.11 MLD
100.00 %</td><td rowspan="3">Authorized Consumption
364.87 MLD
53.18 %</td><td rowspan="2">Billed Authorized Consumption
363.71 MLD
53.01 %</td><td>Billed Metered
330.13 MLD
48.12 %</td><td rowspan="2">Revenue Water
363.71 MLD
53.01 %</td></tr>
<tr><td>Billed Unmetered
33.58 MLD
4.89 %</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption
1.16 MLD
0.17 %</td><td>Unbilled Metered
1.15 MLD
0.17 %</td><td rowspan="7">Non Revenue Water
322.40 MLD
46.99 %</td></tr>
<tr><td>Unbilled Unmetered
0.01 MLD
0.001 %</td></tr>
<tr><td rowspan="6">Water Losses
321.24 MLD
46.82 %</td><td rowspan="2">Apparent Losses
46.96 MLD
6.84 %</td><td>Unauthorized Consumption
38.44 MLD
5.60 %</td></tr>
<tr><td>Customer Metering
8.52 MLD
1.24 %</td></tr>
<tr><td rowspan="4">Real Losses
274.28 MLD
39.98 %</td><td>Leakages in Raw Water Transmission
7.47 MLD
1.09 %</td></tr>
<tr><td>WTP Losses
7.17 MLD
1.05 %</td></tr>
<tr><td>Leakages in Pure Water Transmission
31.07 MLD
4.53 %</td></tr>
<tr><td>Distribution mains Losses & Leakages on Service Connections up to Point of customer Meter
228.57 MLD
33.31 %</td></tr>
</table>

Notes: - i) Above measurement figures are for the study Period from October 2019 to April 2020.

ii) NRW stands for Non-revenue water which is inclusive of metering inaccuracies, visible/ invisible leaks, physical losses etc.

iii) NRW may vary on daily basis as per actual inlet and outlet supply depending on variations with respect to voltage and power quality which affects pump discharge. Also Ultrasonic flow meter measurement accuracy may vary from 0.5% to 2% depending on site measurement conditions.

As per above water water balance the observations are tabulated below:

1. RW trasnsmission losses are seems within a limit i.e. **1.09%** against 1%
2. Treatment losss are also seems within a limit i.e. **1.05%** against 1%
3. Pure water transmission losses are **4.53%** which should be reduce on priority basis.
4. Distribution losses are **40.33%** which are required to be reduced.

➢ SERVICE LEVEL BENCHMARKS

Sr. No.	Key Performance Indicators (KPI)	Benchmark as per Urban Development	Existing Status for NMC
1	*Coverage of Water Supply*	*100%*	***(77%)***
2	*Per Capita Supply of Water*	*135 LPCD*	***157 LPCD***
3	*Extent of Non-revenue water*	*20%*	***46.99%***
4	*Extent of Metering of Water Connections*	*100%*	*90%*
5	*Continuity of Supply*	*24 Hrs*	***6 to 7 Hrs***
6	*Efficiency in Redressal of Complaints*	*80%*	*100%*
7	*Quality of Water Supplied*	*100%*	*97%*
8	*Cost Recovery*	*100%*	***50.92%***
9	*Efficiency in collection of water related charges*	*90%*	***97.07%***

➢ OUTCOME OF STUDY

- ***Raw Water Transmission Main***

Raw water transmission main losses are worked out to be 7.47 MLD i.e. 1.09%.

- ***WTPs***

1. Losses of Pench-I WTP are worked out to be 1.24 MLD i.e. 0.86%.
2. Losses of Pench-II WTP are worked out to be 1.06 MLD i.e. 0.74%.
3. Losses of Pench-III WTP are worked out to be 1.10 MLD i.e. 1.19%.
4. Losses of Pench-IV WTP are worked out to be 0.82 MLD i.e. 1.03%.
5. Losses of Kanhan WTP are worked out to be 2.96 MLD i.e. 1.34%.
6. **Overall WTPs losses are worked out to be 7.17 MLD i.e. 1.06%**

- ***Clear Water Transmission Main***

✓ 2 no's of Transmission main of Pench-II & Pench-III and seminary Hills MBR losses are worked out to be 2.14 MLD i.e. 1.06%.
✓ Transmission main losses from Pench-I WTP to Governor House MBR are worked out to be 0.92 MLD i.e. 0.69%.
✓ Total Losses of Governor House MBR are worked out to be 1.57 MLD i.e. 1.19%.
✓ Pande lay out feeder main losses are worked out to be 1.11 MLD i.e. 1.34%
✓ Laxmi Nagar feeder main losses are worked out to be 1.24 MLD i.e. 3.73%
✓ Takli sim feeder main losses are worked out to be 2.03 MLD i.e. 5.83%
✓ Semi to fort feeder main losses are worked out to be 4.36 MLD i.e. 9.68%

- ✓ Average clear water Output from Seminary Hills MBR to ESRs & DT is 199.90 MLD.
- ✓ Average clear water received at ESRs/GSRs & DT is 191.15 MLD against 199.90 MLD measured at the outlet point of Seminary Hills MBR.
- ✓ Pench-IV Transmission main clear water losses are worked out to be 1.36 MLD i.e. 1.72%.
- ✓ Omkar Nagar feeder main losses are worked out to be 1.02 MLD i.e. 3.43%
- ✓ Average clear water Output from Governor House MBR to ESRs & DT is 209.14 MLD.
- ✓ Average clear water received at ESRs/GSRs & DT is 206.76 MLD against 209.14 MLD measured at the outlet point of Governor House MBR.
- ✓ Kanhan 1300 mm Transmission main clear water losses upto automotive sq. are worked out to be 0.80 MLD i.e. 0.56%
- ✓ Kanhan 900 mm Transmission main clear water losses upto Sai Mandir @ automotive sq. are worked out to be 0.62 MLD i.e. 0.83%
- ✓ Onwards Sai Mandir, 900 mm clear water feeder main losses upto ESRs/ DT are worked out to be 0.94 MLD i.e. 1.46%
- ✓ Auto 700 mm feeder main losses are worked out to be 0.26 MLD i.e. 2.80%
- ✓ Auto 900 mm feeder main losses upto ESRs/DT are worked out to be 12.91 MLD i.e. 9.71%
- ✓ Average Clear water lifting from Kanhan WTP is 217.47 MLD.
- ✓ Average clear water received at ESRs/GSRs & DT is 201.94 MLD against 217.47 MLD measured at the outlet point of Kanhan WTP.

➢ RECOMMENDATIONS

1. During system study we have identified 04 No's of leakages on 2300 mm section of gravity main from BPT to Mahadula. These identified leakages should be repaired;
2. Leaking air valve is identified behind Pench IV WTP on Pench II RWGM Line. Leaking air valve should be Repairs on priority.
3. Suspected tapping arrangements on air valve observed near Gorewada BPT. Action required for removal of tapping
4. Insertion type flow meter installed at Mahadula on 2300 mm MS line is not in function, should be repaired/replaces.
5. Insertion type flow meter installed at Pench-III WTP Outlet point on 1200 mm MS line is not showing correct reading, it is recommended to replace it with minimum 1000 mm diameter electromagnetic flow meter.
6. It is observed that electromagnetic meter is not installed at various point of MBRs; hence it is recommended to install electromagnetic flow meter for better monitoring of water supply system.

- **Summary of the Proposed electromagnetic flow meters at various points are tabulated below: -**

2300 mm raw water transmission main section

Sr. No.	Pipe Size and Material	Proposed Flow Meter Size	Location
1	2300 mm MS	2000 mm	At Pench Reservoir Head Work
2	2300 mm MS	2000 mm	Near Bharat Petroleum, Parseoni to Saoner Road
3	1400 mm MS for Pench-I	1200 mm	Mahadula Pumping Station
4	1400 mm MS for Pench-II	1200 mm	Mahadula Pumping Station
5	1400 mm MS for Pench-IV	1200 mm	Mahadula Pumping Station
6	1600 mm MS	1200 mm	Inlet to Gorewada BPT
7	1600 mm MS	1200 mm	Inlet to Gorewada BPT

Pench-III WTP

Sr. No.	Pipe Size	Proposed Flow Meter Size	Location
1	1200 mm	1000 mm	Pench-III Outlet

Seminary Hills MBR

Sr. No.	Pipe Size	Proposed Flow Meter Size	Location
1	1200 mm	1000 mm	Pench-II inlet at Seminary Hills MBR
2	1200 mm	1000 mm	Pench-III inlet at Seminary Hills MBR
3	200 mm	150 mm	CPWD DT at Seminary Hills MBR
4	150 mm	100 mm	MES DT at Seminary Hills MBR
5	150 mm	100 mm	Governor House Bunglow DT at Seminary Hills MBR

7. During system study, many Leakages/ seepages are observed in Governor House MBR Premises. It is recommended to rehab/repair on priority.
8. Heavy Leakages are observed on Killa DT line at Governor House MBR. It is recommended to repair on priority.
9. Electromagnetic flow meter installed at Kanhan WTP Inlet point on 1500 mm MS line is not showing correct reading, should be repaired/replaced. All other meters in this study section are working properly.
10. It is observed that electromagnetic meter installed on Kanhan WTP outlet 1300 mm line is of 800 mm size, it is recommended to replace it with minimum 1000 mm diameter electromagnetic meter.
11. Leakages are observed in the interlinking valves between Kanhan WTP Outlet 1300 mm and 900 mm pumping mains, it is recommended to repair.
12. There is considerable amount of wastage of water used for cooling of pump bearings, it is recommended to recirculate this water for reuse.

13. It is observed that the water loss on Takli sim feeder is 2.03 MLD i.e. 5.83%. Most of the losses has been observed on Jaitala GSR feeder due to direct tapings which need to discard from feeder main on priority.
14. It is observed that the water loss on Auto 900 mm network is 12.91 MLD i.e. 9.71 %. The total pipe network length including Auto 900 mm feeder is approx. 27 Km and also water supplied to three zones i.e. Ashi Nagar, Lakadganj & Nehru Nagar Zone. Auto 900 mm transmission main is approx. 38 to 40 years old and line alignment is not traceable of some parts due to encroachment of slums on line, very difficult for leak detection hence, *It is recommended that to replace Auto 900 mm transmission main with new 900 mm MS pipe upto Sakkardara ESR*.
15. All Direct tapings and bulk connections are need to be shifted from feeder to distribution mains. Working for parallel pipe lines is proposed.
16. All working Flow meters in system are need to be calibrated on time to time.
17. All hydrants are need to be shifted from inlet of ESR to outlet with flow meters for better accountability of water.
18. All old and rusted sluice valves are need to be replaced on priority with new butterfly valves.

➢ OBSERVATIONS & RECOMMENDATIONS OF DMA STUDY.

1. High quantity of Un- registered consumers are found during consumer survey study, needs to be regularized on priority. (i.e. Ashi Nagar Zone)
2. Consumer meters are found rusted/ damages, not showing proper reading, placed under concreting during DMA study should be replaced on priority basis.
3. It is also observed that, some of the consumer's meters are placed & fix in the storage tank and it is very difficult for meter reader for taking reading properly, hence it is recommended that all the meters need to be shifted on ground level for better monitoring for meter reading.
4. There is often damaged taps or no taps to the stand post. It is recommended that all Public stand post should be removed.
5. It is observed that high quantity of average consumer billing (i.e. Ashi Naga Zone), It is strongly recommended that all these billing should be identifying and produce actual volume reading billed to the consumer.
6. Particularly in Garoba Maidan, the Study area that we had selected previously there is double connection in which consumers are getting water from old connection (damaged meters) and Water has not been supplying by the new one.
7. Certain connection has been reported where usages of consumer were less and not according to the size of the family and they were not cooperative.
8. Some consumers were complaining about not getting adequate water because other consumers are using water pumps directly.

➢ ACTIONS TAKEN ON RECOMMENDATION

As per above observation and recommendation mentioned in Deficiency report & draft DPR, NMC prepared an action plan on priority basis to reduced water losses which includes losses reduced till date and losses which will be reduce as per action plan which is immediately recoverable. the action plan of NMC is tabulated below.

Annexure III
FEEDERMAIN LOSSES AND ACTION TAKEN

Sr. No	Section	Ceinsys (MLD)	Current Loss (MLD)	Quantum Saved (MLD)	Action Taken	Action Proposed	Target Date
1	P2 & P3 Plant to SH MBR	2.14	1.28	0.86	Bus Bar Activated and shifted Bulk consumer on bus bar. Actual Measurement Done through permanent Flowmeter	Differecne is due to P3 FM fluctuation . P3 Flowmeter Replacement is proposed under R&R	07.01.2021
2	P1 Plant to Governor Hou	0.92	0.92	0	Cause of loss searching is in progress		
3	Loss at GH MBR	1.57	0.77	0.8	Red Tank structural losses saved		
4	Pandey Layout Feeder	1.1	1.1	0	Electric meter stolen, FIR done . MSEB Demand awaited	Activation of Gandhi T-Point FM to calculate actual loss	10.01.2021
5	Taklisim Feeder	2.03	2.03	0	Initiated leak detection on Jaitala 500mm feeder line. Shivpriya tower 500mm valve found heavily passing. Flow difference observed when Jaitala Feeder valve open for Jaitala Supply	Replecement of Shivpriya Tower 500mm Valve	04.01.2021
6	Laxminagar Old Feeder	1.24	1.24	0	After surveliance leakage observed near bajiprabhau Statue at Ramnagar Sq	Leakage near Baji Prabhu Statue at Ramnagar. Feeder is under replcment in amrut.	
7	Semi-fort Feeder losses	4.36	4.36	0	One suspected online valve found at bhagwaghar sq, we have closed the valve and checked, SBI flow meter flow reduced to 40m3/hr from 200 m3/hr . Again we have closed the both Ganjakhet tapping valve and open the Bhagvaghar sq valve and observed 200-250m3/hr flow on SBI flow meter. It is concluded that approx. 200-250 m3/hr missing flow observed from Bhagavaghar to Ganjakhet Sq (700 mtr) .	Replacement of 700mtr pipeline from bhagavaghar sq to Ganjakhet sq. or Volume to be considered as a "billed and collected" by installing portable flow meter on both end . Encasing proposed under R&R.	06.01.2021
8	P-4 Feeder	1.36	0.8	0.56	Srinagar DT valve was freely rotating , by leak detection team it is detected and valve was closed permanantly .		
9	Omkar Nagar Feeder Mai	1.02	0.5	0.52	Actiual measurement done by installing permanent flowmeter	Siraspeth DT Measurement and Closure	15.01.2021
10	Kanhan 1300 to Automot	0.8	0	0.8	closed Akashwani DT		
11	Central KN 900	1.56	0.6	0.96	Close Pili Nadi Scour Valve which was fond 1 thread leak	Leakage on KN900X600 line at Indora Sq	04.01.2021
12	Auto KN700 Feeder	0.26	0.26	0			
13	Auto KN900	12.91	3.41	9.5	1. After leak detection on Kanhan Auto 900mm pipeline , one leakage with losses of 96M3/Hr is found in front of Cancer Hospital, Kalamana Road which is attended and saved Approx. 1.9 MLD		
					2. After portable flow meter installation and investigation , it is observed that water enters in 700mm KN700 feeder line through Kalmna ESR Premises and Nagoba Mandir valve. We have inserted end plate at both section and saved approx. 4 MLD.		
					After leak detection on 900mm Kanhan pipeline at Gangabai Ghat on Kilmahal 400mm tapping, valve found partially open 6 thread open . We have closed the valve and saved approx. 150m3/hr flow and saved 3.6 MLD		
		31.27	17.27	14			

(OCW) 11/01/2021

(OCW)

As per above action plan total 13.20 MLD of pure water loss is recovered by NMC till 11.01.2021 against 31.27 MLD of physical loss 0.8 MLD of loss will be reduce till 15.01.2021, now the physical loss is 18.07 ML

Sr. No.	Description	Recommendation	Complainces	Remarks
1	Raw Water Transmission Main	1. During system study we have identified 04 No's of leakages on 2300 mm section of gravity main from BPT to Mahadula. These identified leakages should be repaired;	Leakages Repaired between 6 to 17 Jan. 21	
		2. Leaking air valve is identified behind Pench IV WTP on Pench II RWGM Line. Leaking air valve should be Repairs on priority.	Leakages Repaired	
		3. Suspected tapping arrangements on air valve observed near Gorewada BPT. Action required for removal of tapping	Removed	
		Proposed Flow Meter for Raw Water Transmission main		
		1. 2000 mm dia flow meter proposed at Pench Reservoir Head Work on 2300 mm dia pipe	Will be installed up to 10th Feb. 21	
		2. 2000 mm dia flow meter proposed at Near Bharat Petroleum, Parseoni to Saoner Road on 2300 mm dia pipe		
		3. 1200 mm dia flow meter proposed at Mahadula Pumping Station on 1400 mm dia pipe for Pench-I	Flow Meter Installed between 6 to 18 Jan. 21	
		4. 1200 mm dia flow meter proposed at Mahadula Pumping Station on 1400 mm dia pipe for Pench-II		
		5. 1200 mm dia flow meter proposed at Mahadula Pumping Station on 1400 mm dia pipe for Pench-IV		
		6. 1200 mm dia flow meter proposed at Gorewada BPT Inlet on 1600 mm dia Pench-I line		
		7. 1200 mm dia flow meter proposed at Gorewada BPT Inlet on 1600 mm dia Pench-II line		

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Nagpur Mpl. Corporation

2	Water Treatment Plant	1. Electromagnetic flow meter installed at Kanhan WTP Inlet point on 1500 mm MS line is not showing correct reading, should be repaired/replaced. All other meters in this study section are working properly.	New Flow Meter Installed	
		2. It is observed that electromagnetic meter installed on 1300 mm line is of 800 mm size at Kanhan WTP Outlet, it is recommended to replace it with minimum 1000 mm diameter electromagnetic meter.	In process	
		3. Leakages are observed in the interlinking valves between 1300 mm and 900 mm pumping mains at Kanhan WTP Outlet, it is recommended to repair.	Leakage Repaired	
		4. 1000 mm dia flow meter proposed at Pench-III WTP Outlet on 1200 mm dia pipe.	flow meter procured	
		5. In the premises of all WTP's there are minor leakage on valves is observed during survey, it is recommended to repaired/replace such valves .	In process	

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Nagpur Mah. Corporation

3	Distribution losses	1. Un- registered consumers are found during consumer survey study, needs to be regularized on priority.	Total 1684 Nos. Un-registered Consumers are disconnected till date	Total 15.79 MLD water saved till date
		2. Consumer meters are found rusted/ damages, not showing proper reading, placed under concreting during DMA study should be replaced on priority basis.	In process	
		3. It is also observed that, some of the consumer's meters are placed & fix in the storage tank and it is very difficult for meter reader for taking reading properly, hence it is recommended that all the meters need to be shifted on ground level for better monitoring for meter reading.		
		4. There is often damaged taps or no taps to the stand post. It is recommended that all Public stand post should be removed.		
		5. It is observed that high quantity of average consumer billing (i.e. Ashi Naga Zone), It is strongly recommended that all these billing should be identifying and produce actual volume reading billed to the consumer.		
		6. Particularly in Garoba Maidan, the Study area that we had selected previously there is double connection in which consumers are getting water from old connection (damaged meters) and Water has not been supplying by the new one.	Total 660 Nos. double connections and 284 Nos. double lines are disconnected till date	

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Nagpur Mpl. Corporation

➢ OVERVIEW OF NRW LEVELS

The following table shows NRW levels of some of the cities which is assessed in last 3 years.

Sr. No.	ULB	State	Assessment year	Name of Project	NRW
1	Vasai Virar	Maharashtra	2018	MSNA	43%
2	Nagpur	Maharashtra	2020	NRW	47%
3	Pimpri Chinchwad	Maharashtra	2018	NRW	50%
4	Lucknow	Uttar Pradesh	2018	Smart City	55%
5	Korba	Chatisgarh	2018	AMRUT	57%
6	Rajnandgaon	Chatisgarh	2018	AMRUT	59%
7	Jalgaon	Maharashtra	2017	MSNA	65%

MAIN REPORT

1 INTRODUCTION

1.1 NAGPUR CITY

Nagpur (formerly **Nagpore**) is the third largest city and the winter capital of the Indian state of Maharashtra. It is the 13th largest city by population in India. According to an Oxford Economics report, Nagpur is projected to be the fifth fastest growing city in the world from 2019-2035 with an average growth of 8.41%. It has been proposed as one of the Smart Cities in Maharashtra and is one of the top ten cities in India in Smart City Project execution. Nagpur is the seat of the annual winter session of the Maharashtra state assembly. It is a major commercial and political centre of the Vidarbha region of Maharashtra. Nagpur is also known for Deeksha bhoomi, the largest hollow stupa among all the Buddhist stupas in the world.

The city was founded in 1703 by the Gonds King Bakht Buland Shah of Deogarh and later became a part of the Maratha Empire under the royal Bhonsale dynasty. The British East India Company took over Nagpur in the 19th century and made it the capital of the Central Provinces and Berar. After the first re-organization of states, the city lost its status as the capital. Following the informal Nagpur Pact between political leaders, it was made the second capital of Maharashtra.

Figure 1: Nagpur City Map

1.2 CITY STATISTICS

Name of Urban Local Body	Nagpur Municipal Corporation
Location	Toposheet No. 55 O/4 21.15° N 79.08° E
District	Nagpur
State	Maharashtra, India
Altitude	300 meters above MSL
Area	217.56 km^2
Population (As per Census 2011)	2405665
Rank	India: 13th Maharashtra : 3rd Vidarbha: 1st
Density (As per Census 2011)	11,000/km^2 (30,000/sq mi)
Climate	
Summers	➢ March to June (Avg high 46^0 C)
Winters	➢ November to Jan (Avg low 10^0 C)
Monsoon	➢ June to September
	1. (Annual Max. 1933 mm)
	2. (Annual Avg. 1242 mm)
	3. (Annual Min. 606 mm)
Present Water Resources	Kanhan River
	Pench Dam Reservoir
Water Treatment Plants	5 Nos.
Water Treatment Plants Capacity	786,000 m^3/day (786 Mld)
Storage Reservoirs	68 Nos.
Water Supply Zone	10 Nos.

Table 1: Nagpur City statistics

2 EXISTING WATER SUPPLY SYSTEM SCENARIO

2.1 BACKGROUND

Water Works department of NMC is responsible for water supply to the Nagpur city. In 2008 onwards, privatization had started for major utility services. NMC formed 100% own subsidiary called Nagpur Environmental Services Ltd (NESL). This subsidiary and NMC has granted 25 years performance based contract with The Orange City Water Private Limited (OCWPL), a joint venture of Veolia Water India Pvt. Ltd and Vishwaraj Infrastructure Ltd., to manage the water supply for the city as well as Nagpur Municipal Corporation's water treatment plants at Gorewada, all the ESRs, GSRs, MBRs. This joint venture was established in November 2011 and awarded the contract to execute 24x7 water supply project and operation and maintenance of waterworks for 25 years under the PPP Model. This was among the first few initiatives in India, where Nagpur Municipal Corporation (NMC) attempted to implement a 25-year Public-Private Partnership (PPP) project for provision of continuous water supply on a city-wide scale.

2.2 EXISTINGWATER SUPPLY SITUATION

Nagpur City gets water from two sources namely Kanhan River and Pench Reservoir. Surface water source from river Kanhan 14 km away from city was considered as perennial source. In 1976, the irrigation department, Govt. of Maharashtra executed a storage dam across river Pench for hydroelectric project at Totaladoh and pickup dam at Navegaon Khairy. In 1982 Pench-I scheme was commissioned, in 1994 Pench II Scheme, in 2003 Pench –III and in 2015 Pench-IV scheme was commissioned.

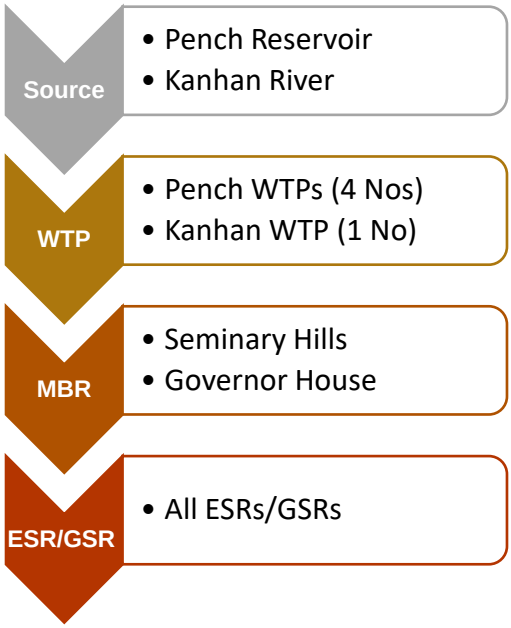


Figure 2: Existing Water Supply System of Nagpur

2.3 EXISTING SOURCE OF WATER SUPPLY

The main sources of water supply for NMC are the Kanhan River and right bank canal of Pench project. Water for the Nagpur city is drawn from the following two major surface sources:

- Kanhan river
- Pench Dam Reservoir

2.3.1 PENCH RESERVOIR

The Pench Reservoir located at Navegaon Khairi village in the Parseoni forests from which the Nagpur City receives its raw water is a part of Pench Project, which incidentally includes the Pench Tiger Reserve. The dam was constructed in 1977. The total water available for utilization at Navegaon Khairi dam is 965 Mm^3 (75% dependability). PRAYAS Resources & Livelihoods Groups has conducted a detailed case study of water allocation for the Nagpur City. The report discloses the facts that originally the project was constructed primarily for irrigation purpose, with 79% of the planned water allocated for agriculture development and 21% allocated for non-irrigation purpose. NMC started drawing 112 Mm^3 water from the Navegaon Khairi dam between 1982 and 1984. In 2001, NMC demanded allocation of additional 78 Mm^3 water to supply for the increased population. Allocating this share of water to NMC would essentially have to be at the cost of loss of irrigation potential. Hence temporary permission was granted to NMC and the city was specifically asked to lower their dependence on the Pench River. The water allocation was made permanent in August 2008 on two conditions –

1) NMC should pay the restoration cost of 8445 ha at the rate of Rs 100 000/ha
2) NMC shall undertake treatment of waste water

The current water allocation to NMC from Pench is 190 Mm^3.

2.3.2 KANHAN RIVER SOURCE

River Kanhan serves as a major drinking source for Nagpur city. Nagpur city is presently getting water from Kanhan River, Head work located near village Juni Kamptee. Surface water intake located approximately 14 km from Nagpur City and 300 m downstream of the confluence of the River Kolar and the River Kanhan was constructed in year 1940. In 1956, a barrage was constructed across Kanhan River about 500 m upstream of Kanhan head works with a storage capacity of 7.82 Mm^3.

After diverting the water from irrigation to urban water supply, NMC is all set to augment a fresh water source for the city's growing demand. The DPR (Detailed Project Report) prepared for 24×7 water supply states that NMC has prepared the master Plan for Water Supply to meet the water supply up to 2031 from identified sources. The future source for city would be proposed barrage on

Kanhan River which will meet the water demand up to Year 2031. The project aims to increase water supply from Kanhan water treatment plant, which would benefit East, North and few parts of South Nagpur.

2.3.2.1 NAGPUR WATER SUPPLY UNDER PENCH PROJECT

NMC undertook a series of measures to reduce losses in its water intake and sources. The water audit observed that out of 625,000 m3/day (625 MLD) water that was made available to NMC, approximately 120,000-140,000 m3/day (120-140 MLD) water was lost in the canals from where NMC was receiving the water. The reasons attributed for the losses were seepage, illegal use and evaporation losses in the canals. To address this issue, NMC initiated a project with funding under JnNURM to replace water supply with pipe lines instead of canals.

The highlights of the scheme are mentioned below: -

- **Intake Tower:** 630 MLD capacity of intake tower of internal diameter of 18.00 m intake well with height of 28.00 m is constructed in RCC structure in the submergence of the Pench Dam.
- **Connecting Pipe:** Twin Conduit pipe line of 2200 mm internal Diameter of RCC-NP4 pipe of 350 m each is being in function as connecting pipe. Design capacity of these conduits is 630 MLD.
- **Approach Bridge:** An approach bridge from pump house to intake tower is constructed. Length of the bridge is 380 m and width is 4 m.
- **Raw Water Sump and Overhead Pump House:** RCC sump with design capacity of 630 MLD is constructed at the bank of Pench Reservoir. An Overhead Pump House with 8 No's of installation capacity having rated discharge 86.83 MLD and rated head of 43 m is constructed over the sump. Five pumps runs at a time to pump raw water from the sump to BPT located at 483 m from the pump house. HT Electrical substation with 5.5 Mva capacity transformers is available in the premises of the pumping station.
- **Raw Water Pumping Main:** Total 483 m length of MS pipe is laid from pumping station to BPT comprising of 2032 mm MS pipe of length 97 m and 2300 mm MS pipe of length 386 m.
- **Break Pressure Tank:** Break pressure tank of 630 MLD design capacity is constructed on nearby hillock located at 483 m from pump house in Navegaon Khairi village. Rest of flow hence forth is with gravity from BPT to Mahadula and further to WTPs.
- **Raw Water Gravity Main:** Pertaining to the permission of topography raw water conveyance forth BPT is with Gravity. The sectional details are as below,
  - 2300 mm MS pipe of approximate length of 27 km is laid from BPT to Mahadula.
  - From Mahadula to Pench IV WTP 1400 mm MS pipe of length 2.5 Km.
  - From Mahadula to BPT at Gorewada one line of 1626 mm MS pipe of length 5.7 Km approx.

- From Mahadula to Gorewada BPT second line of 1660 mm MS pipe of length 5.7 Km approx.
- Outlet of BPT is 2000 mm MS line to Gorewada WTP, its approximate length is 1.8 Km and one dedicated 600 mm line for Pench II WTP.
- This line is further reduced to 1700 mm MS pipe for 115 m length and one line of 1300 mm MS pipe of length 340 m for Pench II WTP before the bifurcation of the 2000 mm MS line.
- This line bifurcated further to 1100 mm MS pipe of length 90 m for Pench III WTP and 1200 mm MS pipe of length 70 m for Pench I WTP.

2.3.2.2 KANHAN WATER SUPPLY SCHEME

- **Source: -** Kanhan River serves as a major drinking water source for Nagpur city. Nagpur city is presently getting water from Kanhan River, Head work located near village Juni Kamptee.
- **Intake Wells: -** Two intake wells in Kanhan River bed and two dry wells on the right bank of Kanhan River are constructed in RCC structure.
- **Water Treatment Plant: -** New modern Multi Flow Technology water treatment plant with installed capacity to treat 240 MLD water is in operation. This plant operate for 24 hours and responsible to cater major demand of Nagpur City.

2.4 WATER TREATMENT PLANTS

The water extracted from the surface is treated in the WTPs. At treatment plant, the raw water is treated up to the standards of safe drinking water by pre-chlorination, sedimentation, filtration and disinfection. Quality control is assured through laboratory testing at the WTPs. Surface water treatment in Nagpur is done in five WTPs namely Pench-I, II, III, IV, (Godhani) and Kanhan WTP.

Sr. No.	Name of Water Works	Capacities of Water Treatment Plants
1	Pench-I	136,000 m^3/day (136 MLD)
2	Pench-II	175,000 m^3/day (175 MLD)
3	Pench-III	120,000 m^3/day (120 MLD)
4	Pench-IV (Godhani)	115,000 m^3/day (115 MLD)
5	Kanhan WTP	240,000 m^3/day (240 MLD)
Total Capacity		786,000 m^3/day (**786 MLD)**

Table 2 Capacities of WTP

2.4.1 PENCH PHASE-I WTP

A Conventional Water Treatment Plant of 136 MLD capacity constructed at Gorewada during Pench Project Phase-I. Raw Water is drawn from Pench reservoir for this WTP by 1200 mm Gravity main. The filtered and chlorinated water from the treatment plant is pump to Governor House MBR via 1200 mm MS through HT Pumps and for newly constructed GSR at Gorewada via 600 mm MS through LT pumps.

2.4.2 PENCH PHASE-II WTP

Under Pench Project Phase-II a Conventional Water Treatment Plant of 175 MLD capacity constructed at Gorewada. Raw Water is drawn from Pench reservoir for this WTP by 1300 mm & 600 mm Gravity main. The filtered and chlorinated water from the treatment plant is pump to Seminary Hills MBR via 1200 mm MS through HT Pumps and for Dhabha & Wadi Tekdi Sump via 600 mm MS through LT pumps.

2.4.3 PENCH PHASE-III WTP

Under Pench Project Phase-III a new Water Treatment Plant of 120 MLD capacity constructed in 2003. Raw Water is drawn from Pench reservoir for this WTP by 1100 mm Gravity main. The filtered and chlorinated water from the treatment plant is pump to Seminary Hills MBR via 1200 mm MS through HT Pumps.

2.4.4 PENCH PHASE-IV GODHANI WTP

Under Pench Project Phase-IV, NMC had constructed a new Water Treatment Plant of 115 MLD capacity constructed in 2014-15. Raw Water is drawn from Pench reservoir for this WTP by 1400 mm Gravity main. After Treatment, water is pumped through 2398 m3/hr capacity with 33 m head of vertical turbine pumps through 1400 mm dia MS line to Governor House MBR and ESRs.

2.4.5 KANHAN WTP

New modern Multi Flow Technology water treatment plant with installed capacity to treat 240 MLD water is in operation. This plant operate for 24 hours and responsible to cater major demand of Nagpur City.

Clear water pumping machinery installed at WTP; the details are tabulated below:-

Clear Water Pump Details					
	1300 mm	**900 mm**	**600 mm**	**MES**	**CBK**
Pump Type	VT	VT	VT	VT	VT
Name	M &P	M &P	M &P	M &P	M &P
Pump Nos.	3 Nos. (2W + 1S)	3 Nos. (2W + 1S)	2 Nos. (1W + 1S)	2 Nos. (1W + 1S)	2 Nos. (1W + 1S)
Discharge (M^3/Hr.)	2500	1896	1250	342	144
Head (m)	95.02	104.99	86.8	36.16	33.13
Speed (RPM)	991	1488	1487	1470	1460
Power (KW)	900	750	400	55	22

Table 3 Kanhan WTP Clear water pump details

After treatment, water is supplied to the various ESRs/GSRs in the Nagpur city via 1300 mm & 900 mm dia MS pipe. 600 mm Dia MS pipe is interconnected to the 1300 mm dia. Treated water from

this plant is supplied to East, North and some parts of South Nagpur.

Kanhan WTP also provides Clear water to the MES (Military Engineering Services) & CBK (Cantonment Board Kamptee) which are main Bulk Consumers.

2.5 STORAGE RESERVOIRS

After the treatment of water at WTPs, Water is supplied to the city by Master Balancing Reservoirs at Seminary Hills (20.43 ML) & Governor House (22.74 ML). Seminary hills and Governor House are the two master balancing reservoirs from which the water is supplied to other reservoirs. These two MBR's also supply water to its command area.

Details of MBR/GSR/ESR are tabulated below: -

Details of Existing MBR, ESR, GSR

Sr. No	Name of ESR/GSR/MBR	No's	Capacity (ML)	Sr. No	Name of ESR/GSR/MBR	No's	Capacity (ML)
1	Seminary Hills Old GSR	1	4.54	27	Reshimbagh	1	2.27
2	Seminary Hills MBR	2	20.43	28	Boriyapura	1	2.27
3	Seminary Hills ESR	1	2.27	29	Gayatri Nagar	1	2.27
4	Governor House MBR	3	22.74	30	Chinchbhuwan	1	2.27
5	Ram Nagar GSR	1	0.91	31	Killa Maidan	1	2.27
6	Ram Nagar ESR	1	2.27	32	Bezanbagh	1	2.27
7	Wanjari Nagar	2	4.54	33	Kalamna	1	2.27
8	Laxmi Nagar	2	4.54	34	Bharatwada	1	2.27
9	Gittikhadan G.S.R	1	5.94	35	Dighori	1	2.27
10	Sitabuldi Fort G.S.R	2	22.74	36	Wadi Tekadi	1	0.85
11	Minimata Nagar	1	2.27	37	Shri Nagar	1	2.27
12	Sakkardara I, II & III	3	6.81	38	Nalanda Nagar	1	2.27
13	Lakadganj	2	4.54	39	Hanuman Nagar	1	2.27
14	Jaripatka	1	2.27	40	Kharbi Road	1	2.27
15	Jaripatka (Nari)	1	2.27	41	Bhandewadi	1	2.27
16	Nara	1	2.27	42	Pardi Road 1 & 2	2	4.54
17	Binaki	3	6.81	43	Shanti Nagar	1	2.27
18	Khamla (Pande Layout)	1	2.27	44	Indora 1 & 2	2	4.54
19	Omkar Nagar	2	4.54	45	Bastarwari 1 & 2	2	4.54
20	Nandanvan	3	6.81	46	Pratap Nagar	1	2.27
21	Subhan Nagar	1	2.27	47	Trimurti Nagar	1	2.27
22	Takali Seem	1	2.27	48	Jaitala Sump	1	1.50
23	Mhalgi Nagar	1	2.27	49	Gorewada GSR	1	3.00
24	Wanjri	1	2.27	50	University Sump	1	
25	Dhaba	1	2.27	51	Lakadganj (Babulvan) under construction	1	2.27
26	Dhantoli	1	2.27		**Total**	**68**	**205.23**

Table 4 Details of Water Storage Reservoir

2.6 DISTRIBUTION SYSTEM

The existing water distribution system of Nagpur city consists of piped network has been broadly divided in to three areas:

- North / east / south part of Nagpur city with water supply from Kanhan Head Works and WTP;
- North / west / south / central part of Nagpur city with water supply from Pench project and WTP at Gorewada;
- North / central part of Nagpur city with water supply from both the sources i.e. Pench and Kanhan.

The total city area has been divided into ten water supply zones for better operation and maintenance. Water is supplied to the city by Master Balancing Reservoirs at Seminary Hills (SH) and Governor House (GH).

Water Supply Zones: **-** (1) Dharampeth (2) Laxmi Nagar (3) Hanuman Nagar (4) Dhantoli (5) Nehru Nagar (6) Gandhibagh (7) Sataranjipura (8) Lakadganj (9) Ashinagar (10) Mangalwari.

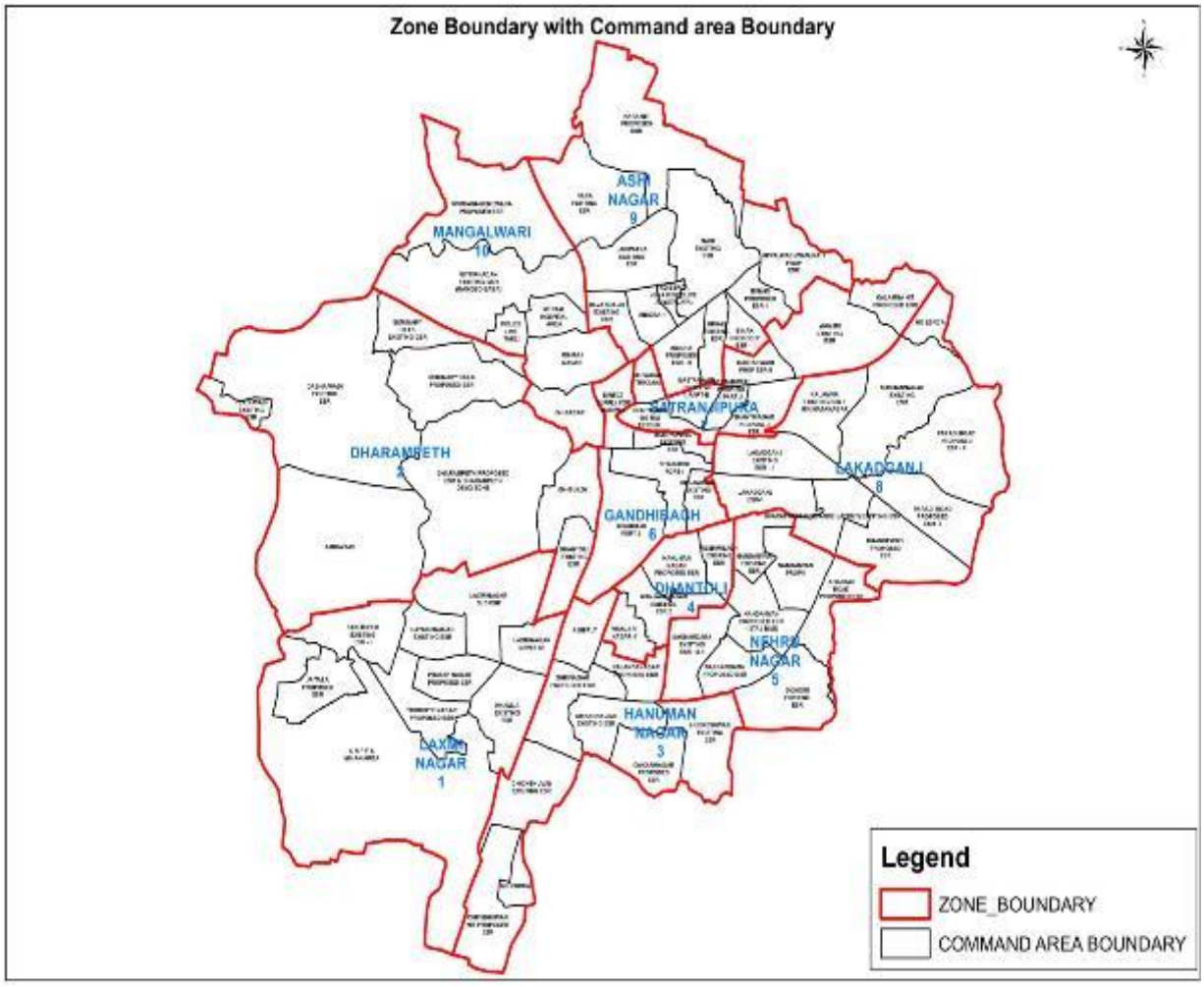


Figure 3 NMC Zone boundary with command Area

Summary of Length : Pure Water Transmission Main & Feeder Main In Yr. 2016															
Particulars	Diameter in mm														Total Length in M
	300	400	450	500	525	600	700	800	900	1000	1100	1200	1300	1400	
NMC (Existing) pipeline	1900	5421	7592	12236	4204	11955	28289	4284	25463	4814		14127	9825		**130110**
NIT (Existing) pipeline		9748													**9748**
Pench -IV Project		3611		6101		11062	6707	4515	1092	3114	4907			8738	**49847**
24*7 Project				69		1697									**1766**
Proposed In Master Plan (Yr.2016)				2521											**2521**
TOTAL	**1900**	**18780**	**7592**	**20927**	**4204**	**24714**	**34996**	**8799**	**26555**	**7928**	**4907**	**14127**	**9825**	**8738**	**193992**

Summary of Distribution Network, (Existing & going to be laid under ongoing Project) In NMC/NIT area under Nagpur Municipal Corporation,

Statement of existing pipe line & pipe line proposed to be laid under on going project of NMC & NIT

Particulars	Inner Diameter of pipe in mm																													Grand Total (M)	Grand Total (Km)
	50	52	62	80	92	100	125	134	150	167	175	200	209	225	250	263	300	325	350	375	376	400	450	500	525	600	675	700	750	900		
Existing	235			14875	15196	932431	1021	1572	419059		7	208071		6465	72504		103246	1388	13293	10742		40422	14246	20616	1204	25868	6643	6107	1063	105	**1916378**	**1916**
Pench-IV						2362			92716			57961			24516		28896		6577			9592	4641	5166		6175		216			**238818**	**239**
ENP (NIT)						283189			180605			24365			2976		7384		810			1439									**500769**	**501**
R (24*7)		306	4041		236657	560		79028	245	24741		41	2286		698	424	1488				140	1545	120	119		684					**353124**	**353**
RPR (NMC)			623		21609	231		1299		560					36																**24358**	**24**
N (24*7)		1807	14307		281883	22500		59411	14841	19764		4550	6513		4236	775	8686		971			2455	868	1241		426		53			**445287**	**445**
N 2031 (24*7 PROP)								770		1989		1425			1940		3006		116			5002		6006							**20137**	**20**
UNP (NIT PROP)			173		39351	244020		6302	77083	1340		20824			4229		4097					1979									**399515**	**400**
TOTAL	**235**	**2113**	**19144**	**14875**	**594696**	**1485294**	**1021**	**148383**	**784550**	**48394**	**7**	**317236**	**8799**	**6465**	**111136**	**1199**	**156803**	**1388**	**21742**	**10742**	**140**	**62434**	**19876**	**33148**	**1204**	**33153**	**6643**	**6376**	**1063**	**105**	**3898387**	**3898**

1. Pench-IV : Pipe Line lay under Pench-IV augmentation Project.
2. ENP (NIT) : Pipe line lay under NIT WSS Project.
3. R : Pipe line going to be replace by OCW under 24*7 Project
4. RPR (NMC) : Pipe line Replaced by OCW as per the instructions of NMC
5. N (24*7) : Pipe line going to be laid to upgrade existing system into (24*7) Continous WSS & 10(
6. N 2031 (24*7) : Proposed Replacement in 2013 as per hydraulic design
7. UNP (NIT) : Proposed pipe length considered for NIT Layouts, which are under sanctioning proce:

Table 5 Summary of Transmission & Distribution

3 OBJECTIVE AND SCOPE OF THE PROJECT

3.1 OBJECTIVE OF THE PROJECT

Nagpur is a second capital of Maharashtra and has population over 2.5 million spread in 217 square km. Nagpur Municipal Corporation (NMC) is responsible of providing water supply services to the city of Nagpur. The total water supply to city was over 500,000 m^3/day (500 Mld) per day through nearly 225,000 connections in 2008. Now water supply capacity upgraded to 786,000 m^3/day (786 Mld) & about 370,000 connections. The distribution network consists of over 4000 km of pipe line. Nagpur City Development Plan states that NMC's mission includes achieving "Water for all and 24 x 7 supplies with focus on safety, equity, and reliability".

In 2008, there was no water supply coverage for about 20% of population, intermittent water supply with many areas getting water on alternate day & Non-Revenue-Water was well above 50%. As the effectiveness of the investment plan and tariff revision mostly depends on improved operational efficiencies and better accountability of service provider towards consumers, NMC has decided to share the risks of implementing the project and of operating the water supply system with private operator. The Public Private Partnership (PPP) structured on the following principles.

- NMC's Control in providing water resources and in setting up the tariff and Ownership of assets.
- Achieving required operational & performance efficiency assigned to Private Operator.
- Share the capital cost in 70:30 ratio between NMC & Private Operator.

3.2 SCOPE OF WORK

3.2.1 WATER AUDIT

Carrying out water audit by studying and mapping all components of water supply scheme in the town/ areas, finding water losses on the rising mains, from source to ESR's with the help of bulk meter/ portable flow meter at the inlet & outlet of rising main and at suitable place at water Supply Components. Water audit for distribution system shall include identification of system boundaries for DMA, assembling all records and required data, measurement of supply at the entry point of all DMA's from bulk meter if installed or by using potable flow meter at least for 5 days in every month and correlate its reading for corresponding months, compiling volume of water imported or purchased from outside and exported to outside water utilities jurisdiction to get net volume of water supplied into the system, compiling volume of authorized billed metered consumption, compiling volume of unmetered authorized billed consumption by installing meter on at least 10% of total unmetered consumer connections and measure to get representative consumption for billed

unmetered connections, calculating non-revenue water by deducting billed authorized volume of water from volume supplied in to the system, quantifying unbilled authorized use in to the system quantifying unbilled authorized use in form of metered as well as unmetered consumption quantifying water losses by deducting unbilled authorized water from non-revenue water, further quantifying water losses in the form of **a)** Apparent losses from authorized connection from the data collected during consumer survey if done and matching it with billed data **b)** Real losses by total water losses minus apparent losses, preparing monthly water audit report after establishing whole system for water audit, showing overall water balance starting from system input to revenue and non-revenue water, water losses, quantifying all component mentioned in IWA standard water balance tables analyzing of water audit result. Preparation of the Pre-Feasibility Report (PFR) and Detailed Project Report (DPR).

3.2.2 CONSUMER SURVEY

Carrying out random consumer survey of 20% of the total properties in order to collect identification details, socio-economic characteristics, details of consumer's connection, and details of consumption of water usage. Based on these details, preparing database system including all the attribute tables of consumers data, matching of consumer survey data with billing data, integration of consumer survey in GIS layer, showing coverage of water supply scheme on digitized map using different annotations, attaching the attribute tables to the point feature and representing consumer in appropriate GIS software.

4 EARLIER SUBMISSIONS TO NMC

4.1 INCEPTION REPORT

This report consists of approach and methodology of NRW assessment work, and detailed work break down structure and manpower proposed in align with the ground reality of the Nagpur Municipal Corporation.

4.2 REPORT ON RAW WATER TRANSMISSION LOSSES

This report consists water audit results with observation and recommendations on raw water transmission main losses.

4.3 REPORT ON TREATMENT AND PURE WATER TRANSMISSION LOSS UPTO MBR

This report consists water audit results with observation and recommendations on treatment losses & pure water transmission main losses.

4.4 SUBMISSION OF COMPUTERIZED CONSUMER SURVEY DATA

This submission consists computerized data in excel worksheet for checking

4.5 DEFICIENCY REPORT

This report consists observation on existing water supply system, existing condition of water supply infrastructure, water audit of various sub- works in existing water supply scheme with water balance and existing performance indicator.

4.6 SUBMISSION OF ANALYSIS OF CONSUMER DATA AND REPORT ON COMPUTERIZED DATA

This report consists zone wise consumer survey report with observation and recommendations.

4.7 DRAFT DPR

The report consists of all necessary technical information in comprehensive and coherent appendices. It shall include summary of methodologies used, assumptions made, input data and results of such studies. Further the report will summarize results of an IWA standard water balance; based on the usual data collection and verification (The strategy for reduction of NRW shall include description of the NRW assessment activities & their results, water balance and performance indicators, analysis of alternatives and options for physical and commercial loss reduction; with cost abstract of proposed works for NRW reduction.

4.8 FINAL DETAILED PROJECT REPORT (DPR)

This report is an umbrella report with comprehensive summaries of previously submitted reports and appendices

5 CONSUMER SURVEY

5.1 OBJECTIVES

The survey has to be conducted for 20% of total properties i.e. for 110000 properties which includes each zone of Nagpur city.

The objectives of this survey are as below,

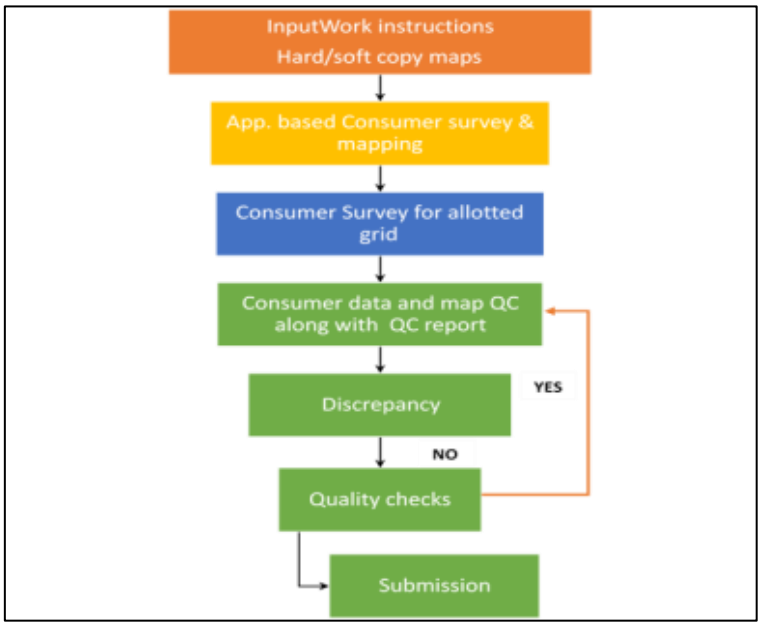
8) Details of consumption of water by different beneficiaries i.e. Domestic, Industrial, Commercial, Non Domestic etc.
9) Determine the perception of water services received
10) Provide information & measures to be taken to improve the efficiency and financial performance of the water distribution system
11) Evaluate the quality of service when reporting problems or making enquiries
12) To trace out the properties having regular connection
13) To trace out the suspected connections, validation of such connections with consumer database and take necessary action if found illegal
14) To trace out the connections where water is being supplied by old as well newly laid pipeline

5.2 INPUTS FROM CLIENT

1) AOI for all zones and command areas
2) GIS base map in shp format (Buildings & Roads)
3) Latest Consumer /Billing database
4) Authorization letter to carry out consumer survey
5) Identity cards for surveyors

5.3 CONSUMER SURVEY PROCESS

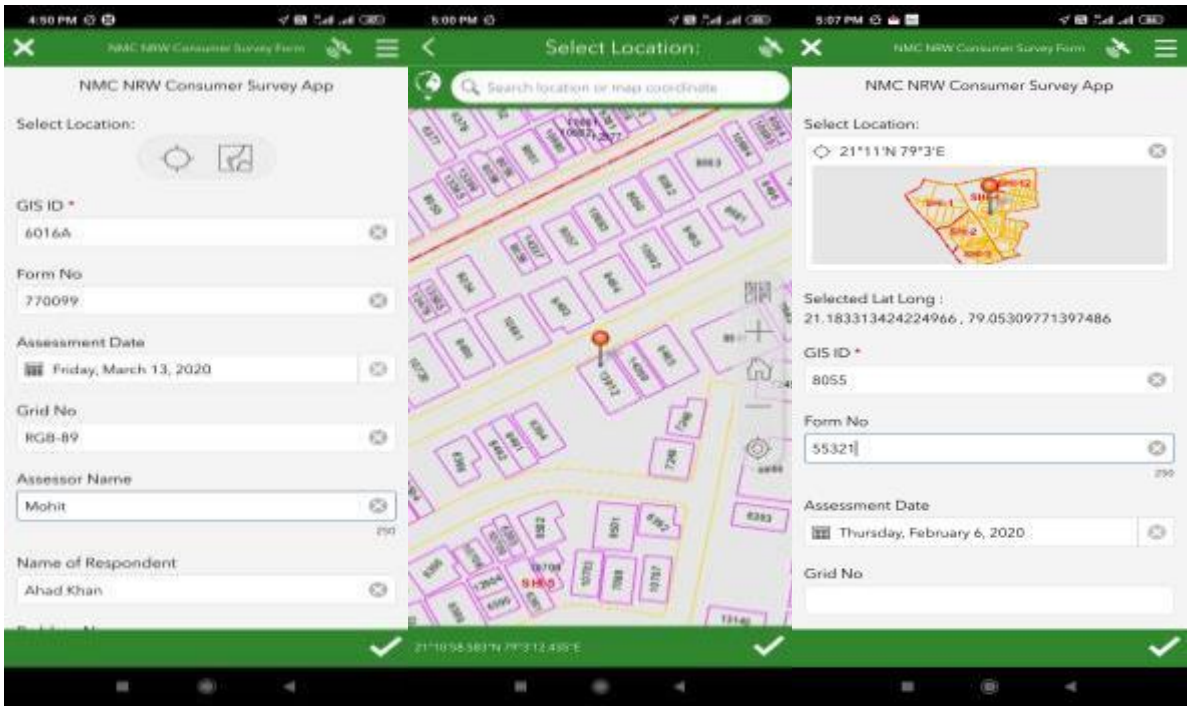
5.3.1 FLOW CHART



5.3.2 MOBILE APPLICATION FOR CONSUMER SURVEY

Considering no of fields to be collected during consumer survey and to avoid location & attribute inaccuracy, mobile base consumer survey application has been developed which is based on android application.

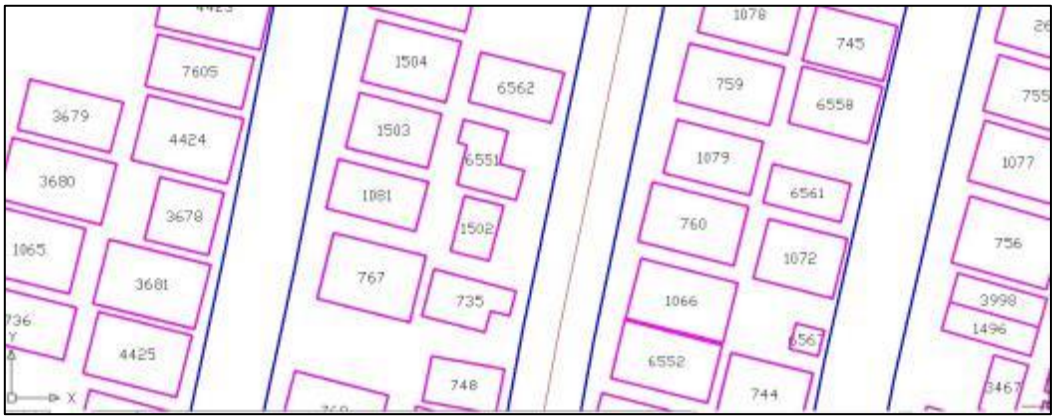
All fields given in consumer survey format have been provided in this application. The surveyor just need to go to the consumer location and to fill all necessary details in this application and the data is automatically sent to centralized server with all details and latitude & longitude of the particular location.



5.3.3 BASEMAP FOR CONSUMER SURVEY

As the preparation of base map is not in scope of consultant, building footprints and road features of selected areas has been provided by NMC.

After receipt of this data, unique ids were generated for each building feature. The data is collected from field during consumer survey against these unique ids.



5.3.4 GRID PREPARATION

After preparation of base map, the selected area has been divided into no of grids. These grids are prepared based on road features to avoid duplicate building features.

.tpk file of each grid has been prepared and allotted to surveyors so that he can download this file in survey application and use it during consumer survey.

5.3.5 CONSUMER SURVEY FORM

Appendix-A

NAGPUR MUNICIPAL CORPORATION (REFORMS)

Consumer Survey Form

Grid No.: _____ From No. :_____

Assessor Name : _____ Assessment Date : __/__/2019

Plot Details :

GIS Plot ID :	City Name:	Plot Name :
Ward Name :	Ward No. :	DMA No.:
Operation Zone :	Property/ City Survey No.:	storage Facility : (I-UGT Only, 2-OHT, 3-Both, 4-None)
No. of Connection :	Source: (1-Open well, 2- Bore well, 3- Both, 4- Public stand post, 5- None)	Tanker Supply : (1- Yes, 2-No)
For School : No. of Students ___ For Hospitals : No. of Beds ___ For Offices : No. of Employees ____ For Hotels : No. of Chairs/ Beds __		
For Slums : Stand Post No. of Group Connections, No. of families on one stand post, No. of families on group conn.		

Connections Details :

GIS Plot ID :	Connection count.:	Bill Conn. No.:
Conn. First Name:	Plot No. Street Name::	Cons Family Size:
Conn. Middle Name:	Area Name / Location:	City
Conn. Last Name:	Contact No.:	Pin Code:
E-Mail:	Source: (l-municipal supply, 2-municipal council)	Connection (1-legal, 2-illegal)
Conn. Type : (l-Metered, 2-unmetered)	Connection Size: (1-15mm, 2-20mm, 3-25mm,4-32mm, 5-40mm,)	Connection Use: (1-domestic, 2-Non Domestic, 3-Institution)
Connection Meter No. :	Meter Make :	Meter Status : (1-working, 2-non working, 3-disconnected)
Billing Period : (1-Monthly, 2-bimonthly, 3-quarterly, 4-half yearly, 5-yearly)	Billing Method: (1-as per quantity, 2-flat rate)	Total Charges if flat rate (Rs.):
Conn. Distance (in meter)	Meter Ownership: (1-Own , 2-Council, 3- Municipal Corporation)	Supply Hrs.
Water Quantity : (1-Excess, 2-Adequate, 3-Insufficient)	Water Quality : (1-Satisfactory, 2-Not Satisfactory)	Water Pressure : (1- High, 2-Medium, 3-Low)

Flat Details :

GIS Plot ID :	Flat ID :	Flat No :
Flat First Name :	Flat Middle Name :	Flat Last Name :
Flat Family Size :	House Locked (1- Yes, 2- No)	Taps Total:
Education : 1-Illiterate, 2-Lirerete but not formal schooling, 3-Schooling	Occupation : 1- Self Employee, 2-Private Sector Employee, 3- Govt Employee, 4-	Annual Income : 1- Low Income (<1,00,000), 2-Middle income Group

up to 4 years, 4- Schooling between 5-10 yrs., 5-upto HSSC, 6-Graduate 7-Post graduate, 8- PhD.	Housewife, 5-Unorganised sector, 6- other,	(1,00,000 to 3,00,000), 3-High Income Group(>3,00,000),
Building Type : [1-House, 2-Bunglows, 3-Flat] 4-Chawl, 5-Slum tenement, 6-Industry, 7-Hospital, 8-Dispensary, 9-Shop, 10-School,/College, 11-Hotel/Lodge, 12-Religious Institutions, 13-Govement Office, 14-Govement Quarter, 15-Cattles Shed, 16- others)		Total Floors : / Floor No. : / Connection Requirement :

Remark :-
(1-Municipal Connection, 2-Non-Registered Connection, 3-No Connection, 4-House Locked, 5-Permanent Locked, 6-No Cooperation, 7-Water use from Neighbor Tap, 8-Bill Not Received, 9-No Billing, 10-New Connection, 11-Under Construction, 12-Demolish Property)

5.3.6 DATA COLLECTION

The data is collected considering below mentioned main categories,

1) **Identification:**
   Under this category basic information has to be collected like GIS id, Plot No, Address/Locality, contact no etc.

2) **Connection Details:**
   Under this category, all information related to connection like consumer name, no of connections, size of connection, type of connection, meter no, meter make etchas to be collected.

3) **Water Quantity, Quality & Pressure:**
   Under this category information related to water quantity, quality provided to consumer and water pressure whatever consumer is getting has to be collected.

4) **Details of Building:**
   In this category all information related to building like building name if available, building type like House, Bunglow, Apartment, Shop, School/College etc. has to be collected

5) **Socio-economic Details:**
   Under this category data has to be collected like Education, Occupation, Annual income of property owner, no of family members etc.

5.3.7 BASEMAP UPDATIONS:

It is always observed that while consumer survey some of the properties which are available on map are not actually present on ground whereas some properties are on ground but not present on map those are called new buildings constructed after preparation of base map.

Considering this scenario, surveyor always carry A3 size hard copy map with him so that updations can be done during survey itself. Following functions need to be performed to update base map as per ground reality,

1) Addition of Building
2) Deletion of Building
3) Splitting of Building
4) Merging of more than 1 Building features

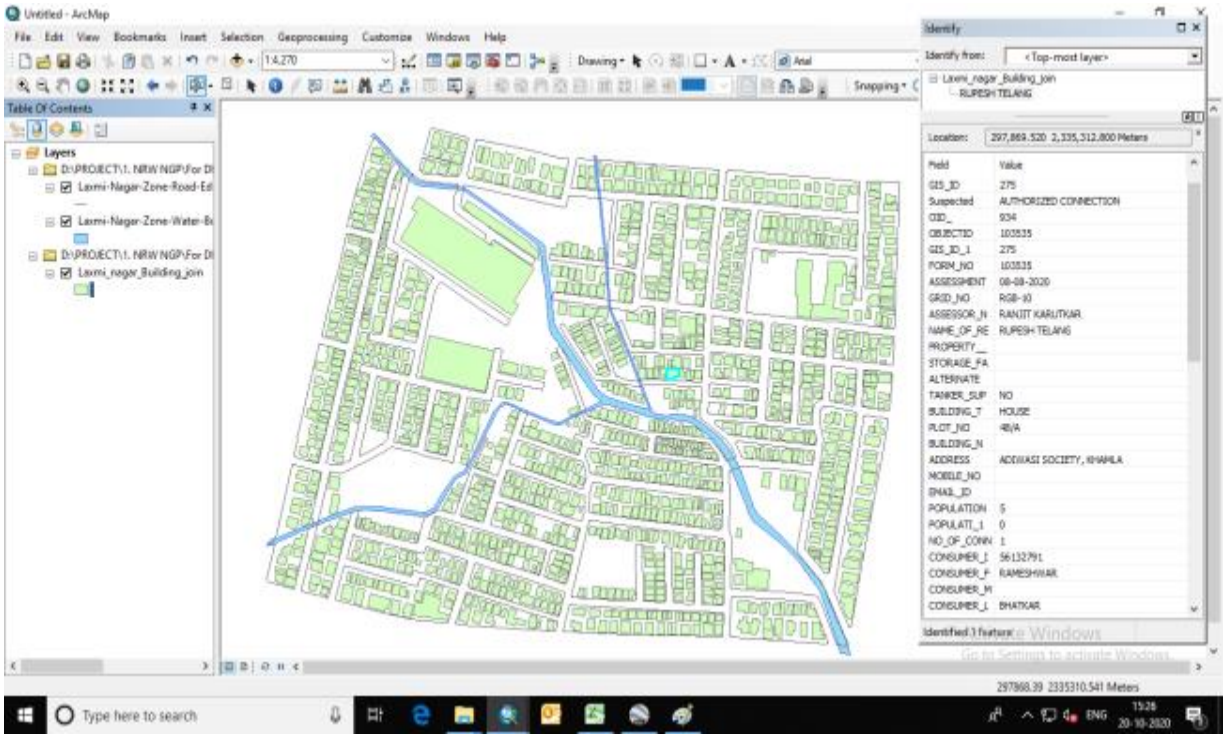
5.3.8 EDGEMATCH & MOSAIC:

After receipt of grid wise maps from site and after completion of updation part, all the grids of selected area are merged into single drawing.

The process is carried by matching edges of adjoining grids of the geo-referenced maps so as to create a seamless integrated map file. Due care has to be taken to maintain continuity of linear features

5.4 GEOSPATIAL DATA INTEGRATION:

The process of linking survey database with unique id's of building features is called geospatial data integration.



5.4.1 MAP CLEANUP & TOPOLOGY BUILDING:

Mosaic drawing is cleaned for mapping errors described as below,

1. Duplicate Objects
2. Short Objects

3. Break Crossing Objects
4. Undershoots
5. Clustered Nodes
6. Pseudo Nodes
7. Dangling Objects
8. Zero length objects
9. Sliver Polygon

Topology is built as per feature types as below,

Sr. No.	Feature Type	Topology Type
1	Buildings	Polygon
2	Water Bodies	Polygon
3	Containment Area	Polygon
4	Road Edge	Line
5	Road Centerline	Line
6	Railway Line	Line

5.4.2 SHP FILE CONVERSION:

After process of map cleanup and topology, shp files are converted from .dwg to .shp files

Shp files are converted as per type of topology mentioned in above table.

5.4.3 DELIVERABLES:

The data has to be submitted in following deliverables,

1) Zone wise shp files of all land base features and dbf files of survey database
2) Consumer Survey Report
3) Maps showing Connections, No Connections, Suspected Connections & Double Connections

5.4.4 SURVEY FIELD & DESCRIPTION:

Sr. No	Field in DBF	Description of Field
1	Objectid	Unique Object Id
2	Gis_id	GIS Plot Id
3	Form_No	Form No
4	Assessment	Assessment Date
5	Grid_no	Grid No
6	Assessor_n	Assessor Name
7	Name_of_re	Name of Respondent
8	Property__	Property No
9	Storage_fa	Storage Facility
10	Alternate	Alternate Source

Sr. No	Field in DBF	Description of Field
11	Tanker_sup	Tanker Supply
12	Building_t	Building Type
13	Plot_no	Plot No
14	Building_n	Building Name
15	Address	Address
16	Mobile_no	Mobile No
17	Email_id	Email Id
18	Population	Population-Owner
19	Populati_1	Population-Tenant
20	No_of_conn	Connection Count
21	Consumer_i	Bill Connection No
22	Consumer_f	Consumer First Name
23	Consumer_m	Consumer Middle Name
24	Consumer_l	Consumer Last Name
25	Connection	Connection (Legal/illegal)
26	Connecti_1	Connection Type
27	Connecti_2	Connection Size
28	Connecti_3	Connection Use
29	Meter_make	Meter Make
30	Meter_no	Connection Meter No
31	Meter_stat	Meter Status
32	Billing_pe	Billing Period
33	Billing_me	Billing Method
34	Water_bill	Total Charges if Flat Rate
35	Meter_owne	Meter Ownership
36	Supply_hou	Supply Hours
37	Water_quan	Water Quantity
38	Water_qual	Water Quality
39	Water_pres	Water Pressure
40	Name_of_ap	Name of Apartment

Sr. No	Field in DBF	Description of Field
41	No_of_flat	No of Flats
42	No_of_occu	No of Occupied Flats
43	Education	Education
44	Occupation	Occupation
45	Annual_inc	Annual Income
46	Total_floo	Total Floors
47	Floor_no	Floor No
48	Connecti_4	Connection Requirement
49	Remark	Remark
50	Name_of_in	Name of Institution
51	No_of_stud	No of Students
52	No_of_hosp	No of Beds

Sr. No	Field in DBF	Description of Field
53	No_of_hote	No of Beds
54	No_of_chai	No of Chairs
55	No_of_empl	No of Employee
56	No_of_stan	No of Stand Posts
57	Families_d	No of Families on one Stand Post
58	No_of_grou	No of Group Connections
59	Families_1	No of Families on one Group Connection
60	Con_status	Connection Status

5.5 ADVANTAGES OF GIS

GIS benefits an organization of all sizes and in almost every industry. The benefits of GIS generally fall into some basic categories as below.

Cost savings resulting from greater efficiency:

GIS benefits enormously in reducing the costs with greater efficiency i.e. labour savings from automating or improving a workflow.

Better Decision Making:

This typically has to do with making better decisions about location. Common examples include real estate site selection, route/corridor selection, zoning, planning, conservation, natural resource extraction, etc. People are beginning to realize that making the correct decision about a location is strategic to the success of an organization.

Improved Communication:

GIS-based maps and visualizations greatly assist in understanding situations and story telling. They are a new language that improves communication between different teams, departments, disciplines, professional fields, organizations, and the public.

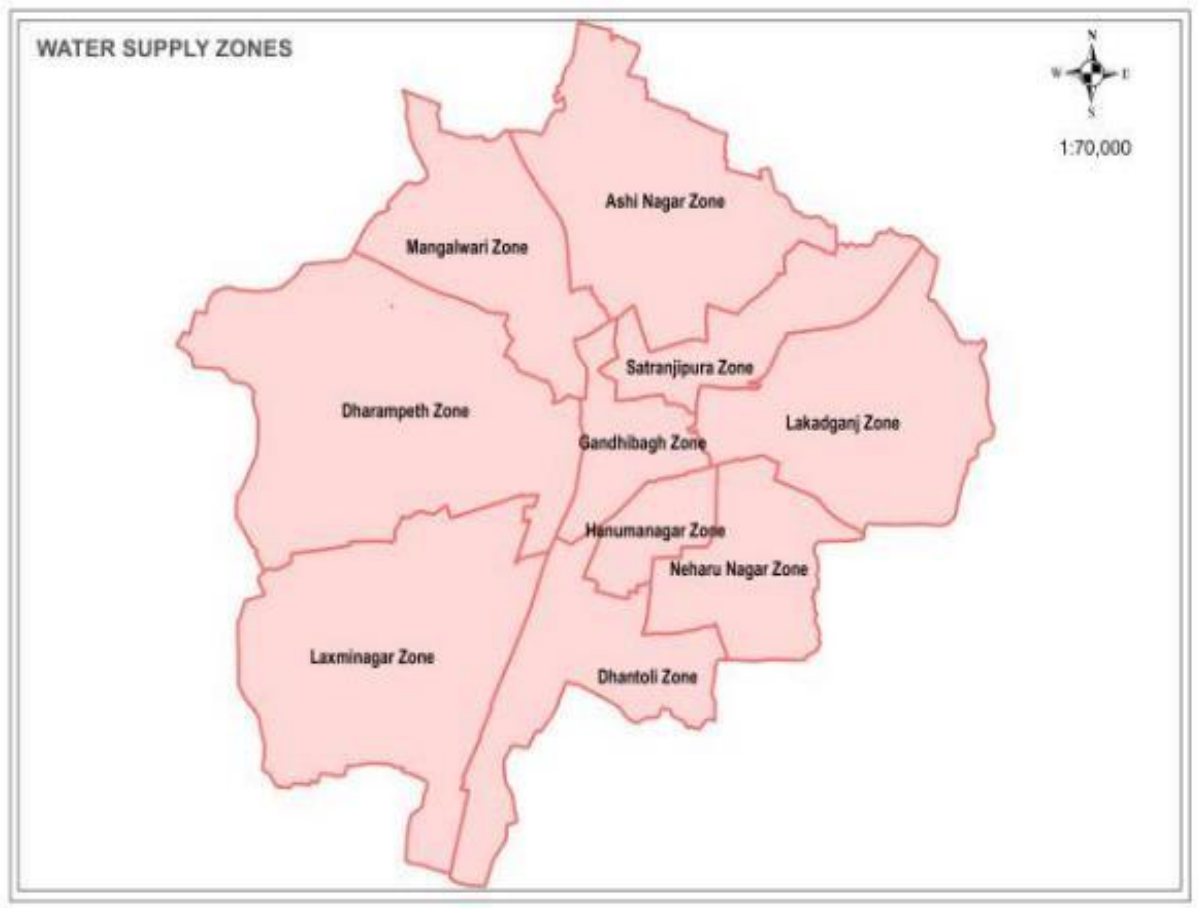
Better Geographic Information Recordkeeping:

Many organizations have a primary responsibility of maintaining authoritative records about the status and change of geography (geographic accounting). Cultural geography examples are zoning, population census, land ownership, and administrative boundaries. Physical geography examples include forest inventories, biological inventories, environmental measurements, water flows, and a whole host of geographic accountings. GIS provides a strong framework for managing these types of systems with full transaction support and reporting tools. These systems are conceptually similar to other information systems in that they deal with data management and transactions, as well as standardized reporting (e.g., maps) of changing information. However, they are fundamentally different because of the unique data models and hundreds of specialized tools used in supporting GIS applications and workflows.

Managing Geographically:

In government and many large corporations, GIS is becoming essential to understand what is going on. Senior administrators and executives at the highest levels of government use GIS information products to communicate. These products provide a visual framework for conceptualizing, understanding, and prescribing action. Examples include briefings about various geographic patterns and relationships including land use, crime, the environment, and defense/security situations. GIS is increasingly being implemented as enterprise information systems. This goes far beyond simply spatially enabling business tables in a DBMS. Geography is emerging as a new way to organize and manage organizations. Just like enterprise-wide financial systems transformed the way organizations were managed in the '60s, '70s, and '80s, GIS is transforming the way that organizations manage their assets, serve their customers/citizens, make decisions, and communicate. Examples in the private sector include most utilities, forestry and oil companies, and most commercial/retail businesses. Their assets and resources are now being maintained as an enterprise information system to support day-to-day work management tasks and provide a broader context for assets and resource management.

5.6 PROJECT AREA & SURVEYED PROPERTIES:

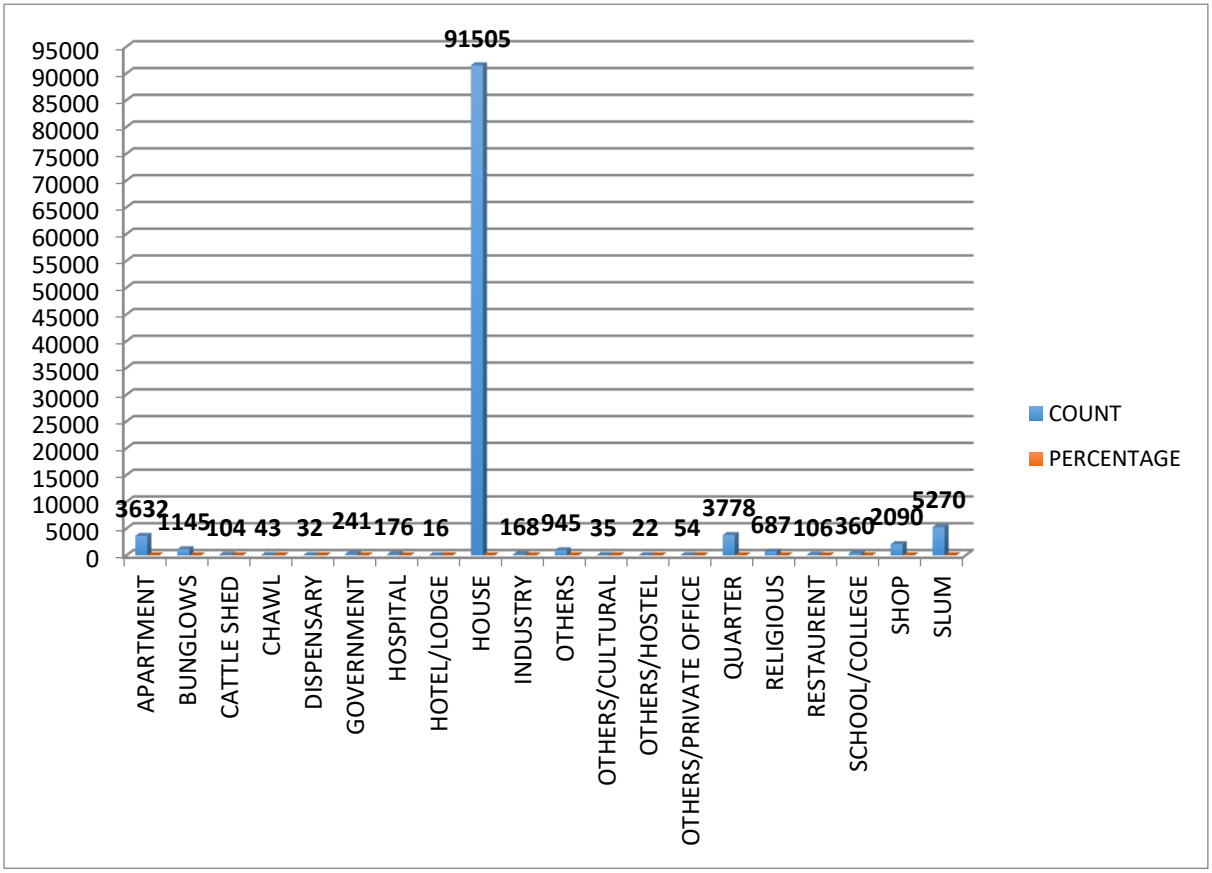


Zone No	Name	No of Properties Surveyed
1	Laxmi Nagar	1265
2	Dharampeth	11770
3	Hanuman Nagar	7154
4	Dhantoli	1603
5	Neharu Nagar	7485
6	Gandhibag	7347
7	Satranjipura	954
8	Lakadganj	3308
9	Ashi Nagar	58787
10	Mangalwari	10736

5.6.1 SURVEY SUMMARY

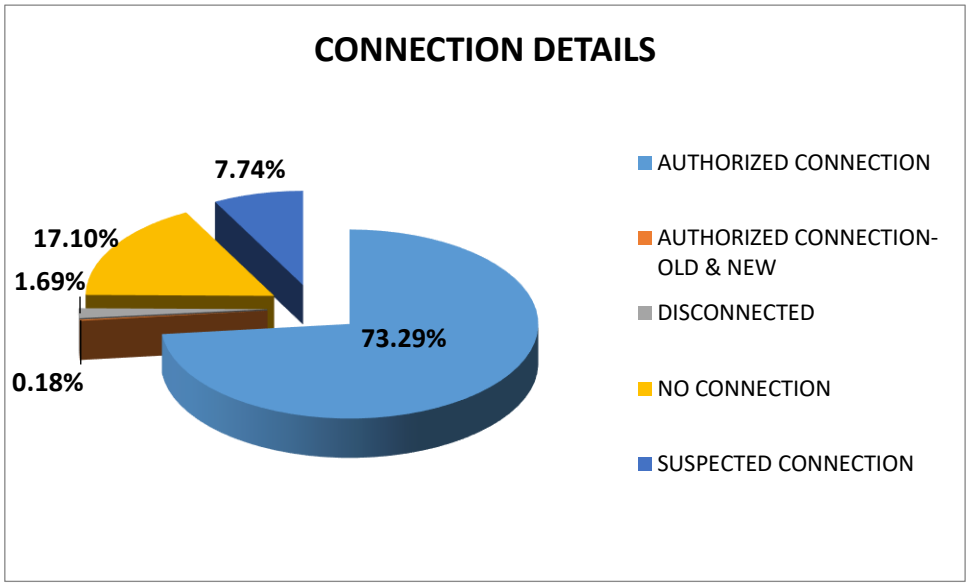
Description	**Quantity**
Total no of Properties Surveyed	110409
Population	622470
No of Authorized Connections	83081
Disconnected	1916
No Connections	19334
Suspected Connections	8754

5.6.2 DETAILS OF PROPERTIES



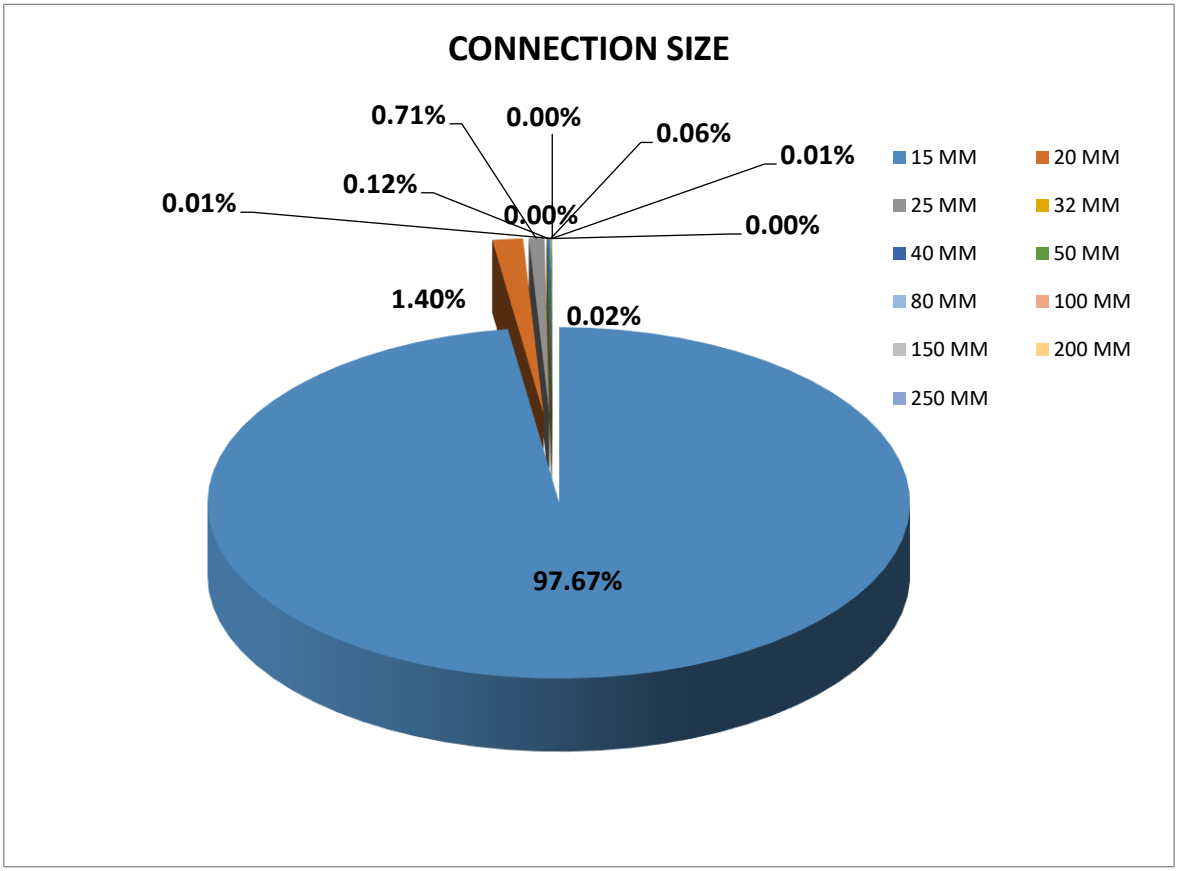
PROPERTIES	COUNT	PERCENTAGE
APARTMENT	3632	3.29%
BUNGLOWS	1145	1.04%
CATTLE SHED	104	0.09%
CHAWL	43	0.04%
DISPENSARY	32	0.03%
GOVERNMENT	241	0.22%
HOSPITAL	176	0.16%
HOTEL/LODGE	16	0.01%
HOUSE	91505	82.88%
INDUSTRY	168	0.15%
OTHERS	945	0.86%
OTHERS/CULTURAL	35	0.03%
OTHERS/HOSTEL	22	0.02%
OTHERS/PRIVATE OFFICE	54	0.05%
QUARTER	3778	3.42%
RELIGIOUS	687	0.62%
RESTAURENT	106	0.10%
SCHOOL/COLLEGE	360	0.33%
SHOP	2090	1.89%
SLUM	5270	4.77%
TOTAL PROPERTIES	**110409**	**100.00%**

5.6.3 DETAILS OF CONNECTIONS



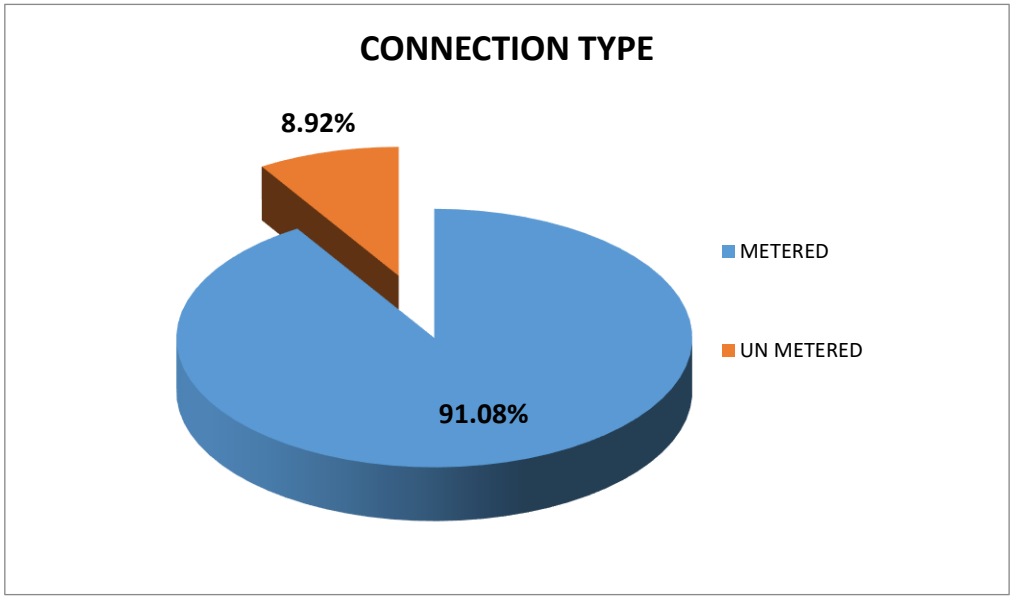
CONNECTION DETAIL	COUNT	PERCENTAGE
AUTHORIZED CONNECTION	82875	73.29%
AUTHORIZED CONNECTION-OLD & NEW	206	0.18%
DISCONNECTED	1916	1.69%
NO CONNECTION	19334	17.10%
SUSPECTED CONNECTION	8754	7.74%
TOTAL	**113085**	**100.00%**

5.6.4 DETAILS OF CONNECTION SIZE



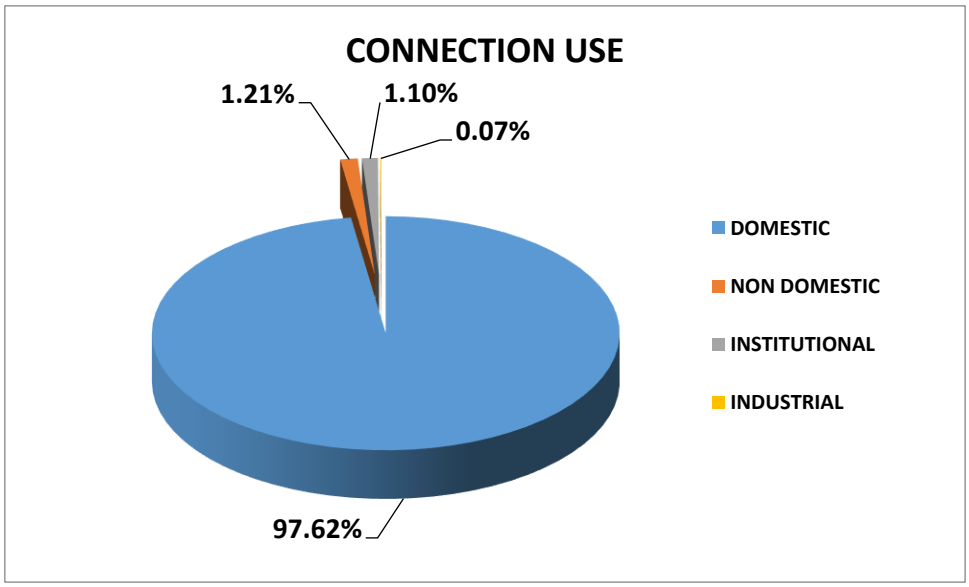
CONNECTION SIZE	COUNT	PERCENTAGE
15 MM	81143	97.67%
20 MM	1166	1.40%
25 MM	587	0.71%
32 MM	14	0.02%
40 MM	100	0.12%
50 MM	51	0.06%
80 MM	10	0.01%
100 MM	5	0.01%
150 MM	3	0.00%
200 MM	1	0.00%
250 MM	1	0.00%
TOTAL CONNECTION	**83081**	**100.00%**

5.6.5 DETAILS OF CONNECTION TYPE



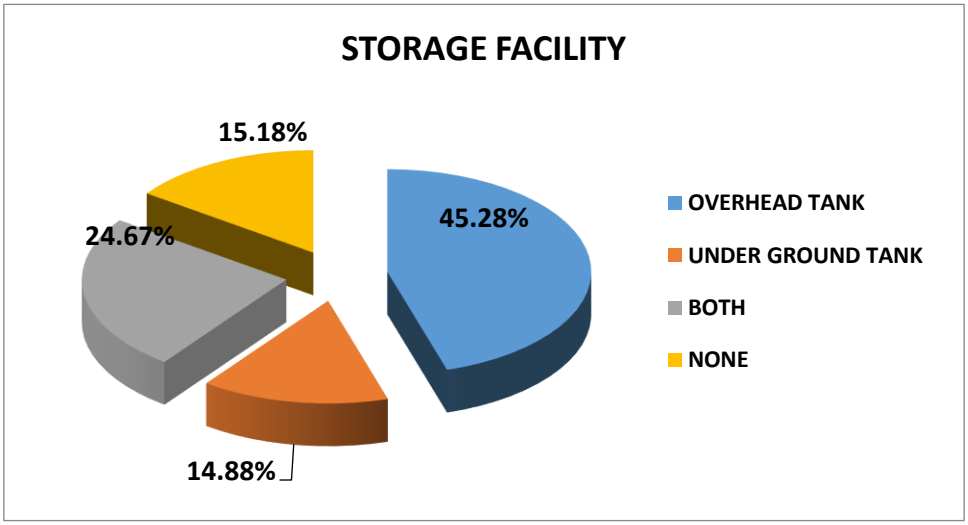
CONNECTION TYPE	COUNT	PERCENTAGE
METERED	75672	91.08%
UN METERED	7409	8.92%
TOTAL CONNECTION	**83081**	**100.00%**

5.6.6 DETAILS OF CONNECTION USE



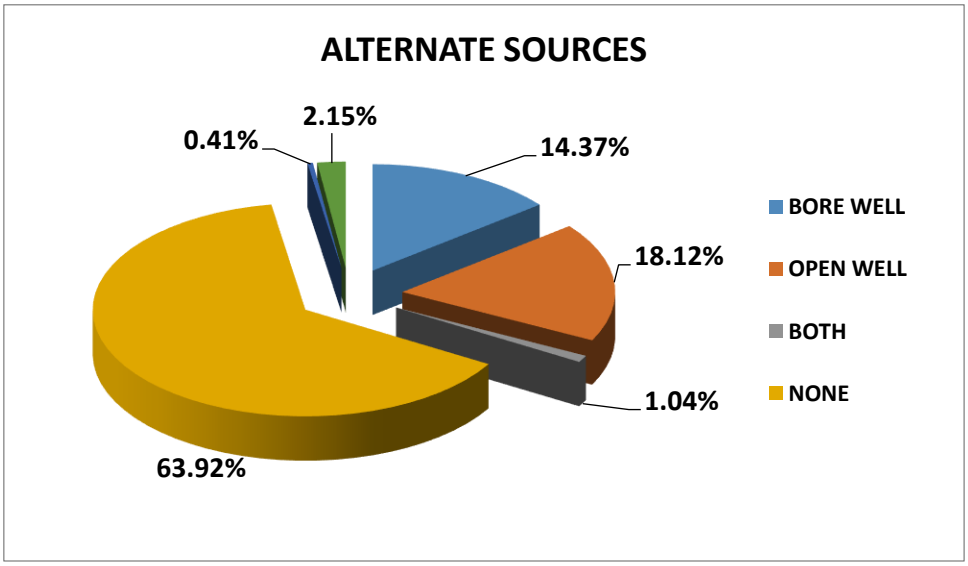
CONNECTION USE	COUNT	PERCENTAGE
DOMESTIC	81107	97.62%
NON DOMESTIC	1002	1.21%
INSTITUTIONAL	911	1.10%
INDUSTRIAL	61	0.07%
TOTAL	**83081**	**100.00%**

5.6.7 DETAILS OF STORAGE FACILITY



STORAGE FACILITY	COUNT	PERCENTAGE
OVERHEAD TANK	49988	45.28%
UNDER GROUND TANK	16424	14.88%
BOTH	27238	24.67%
NONE	16759	15.18%
TOTAL PROPERTIES	**110409**	**100.00%**

5.6.8 DETAILS OF ALTERNATE SOURCES



ALTERNATE SOURCES	COUNT	PERCENTAGE
BORE WELL	15864	14.37%
OPEN WELL	20002	18.12%
BOTH	1144	1.04%
NONE	70568	63.92%
PUBLIC HAND PUMP	453	0.41%
STAND POST	2378	2.15%
TOTAL PROPERTIES	**110409**	**100.00%**

6 NON-REVENUE WATER (NRW) AT A GLANCE

6.1 INTRODUCTION

NRW is water that has been produced but does not result in revenues for the utility. NRW may be due to "real losses" (as a result of leaks and wastage, sometimes called as "physical losses") and "apparent losses" (as a result of metering inaccuracies, theft, meter taping, etc. sometimes called as "commercial losses"). High levels of NRW are detrimental to the financial viability of the utility as well as to the quality of water. NRW is thus calculated as volume of water lost.

$$\text{NRW (\%)} = \frac{\{System\ Input\ Volume\ (m\text{^}3) - Billed\ Consumption(m\text{^}3)\}}{System\ Input\ Volume\ (m\text{^}3)}\ x\ 100\%$$

The total quantity of water in the world is roughly 1357.5[1] million cubic kilometers (Mkm^3). About 97% of this water is contained in the oceans as saline water and only 37.5 Mkm^3 is fresh water. Out of this about 8.5 Mkm^3 is both liquid and fresh and the remaining is contained in frozen state as ice in the Polar Regions and on mountains tops and glaciers. Water demand is increasing day by day due to increase in population, urbanization, agriculture, industrialization etc. The groundwater table is falling rapidly throughout the world due to wide spread over pumping using powerful pumps. More than 2.6 Billion people – over 40% of the world's population do not have access to safe drinking water. Water Scarcity in India is widespread in all states.

6.2 NRW LEVELS IN THE WORLD

The World Bank has estimated the total cost of NRW to utilities worldwide at US$14 billion per year. Reducing by half the current levels of losses in developing countries, where relative losses are highest, could generate an estimated US$ 2.9 billion in cash and serve an additional 90 million people. Most available data on NRW levels are expressed in percentage terms, ranging from 7% in Germany to more than 90% in Lagos, Nigeria. NRW levels are 10% in Denmark, 19% in England and Wales, 26% in France, 29% in Italy. In Asian large city NRW varies from 10% to 60%. According to a report by the European Environment Agency NRW in Yerevan, Armenia, was almost 80%.

6.3 NRW LEVELS IN INDIA

In developing countries, roughly 45[2] million cubic meters of water are lost daily with an economic value of over US$3 billion per year.

A World Bank study puts the global estimate of physical water losses at 32 billion cubic meters each year, half of which occurs in developing countries. Water utilities suffer from the huge financial costs of treating and pumping water only to see it leak back into the ground, and the lost revenues from water that could have otherwise been sold. If the water losses in developing

[1] IOSR Report on NRW, 2013
[2] http://blogs.worldbank.org/water/what-non-revenue-water-how-can-we-reduce-it-better-water-service, 2016

countries could be halved, the saved water would be enough to supply around 90 million people.

From the study[3] conducted in India, components of NRW are 1.5 to 3.5% public use, 3.5 to 6.5% illegal / unmetered connection, 10 to 15% meter under registration and 75 to 85% is leakages.

6.4 NRW LOSSES

Source: Tata and Howard Unsurpassed Solution in Water Environment

NRW related inefficiencies are displayed in below diagram. It is called Vicious NRW Cycle. Desired state is Virtuous Cycle; this requires transformation as described below.

[3] http://blogs.worldbank.org/water/what-non-revenue-water-how-can-we-reduce-it-better-water-service, 2016

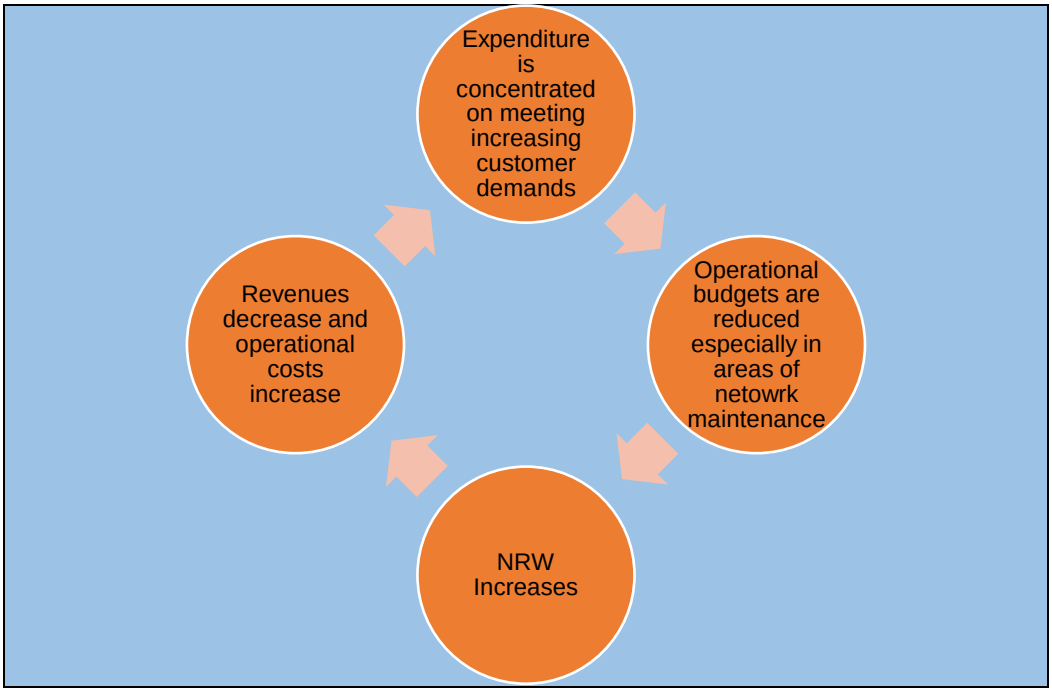


Figure 4: The Vicious NRW Cycle

The challenge for water utility managers is to transform the Vicious Circle into the 'Virtuous Circle'. In effect, reducing NRW releases new sources of both water and finances. Reducing excessive physical losses results in a greater amount of water available for consumption and postpones the need for investing in new sources. It also lowers operating costs. Similarly, reducing commercial losses generates more revenues.

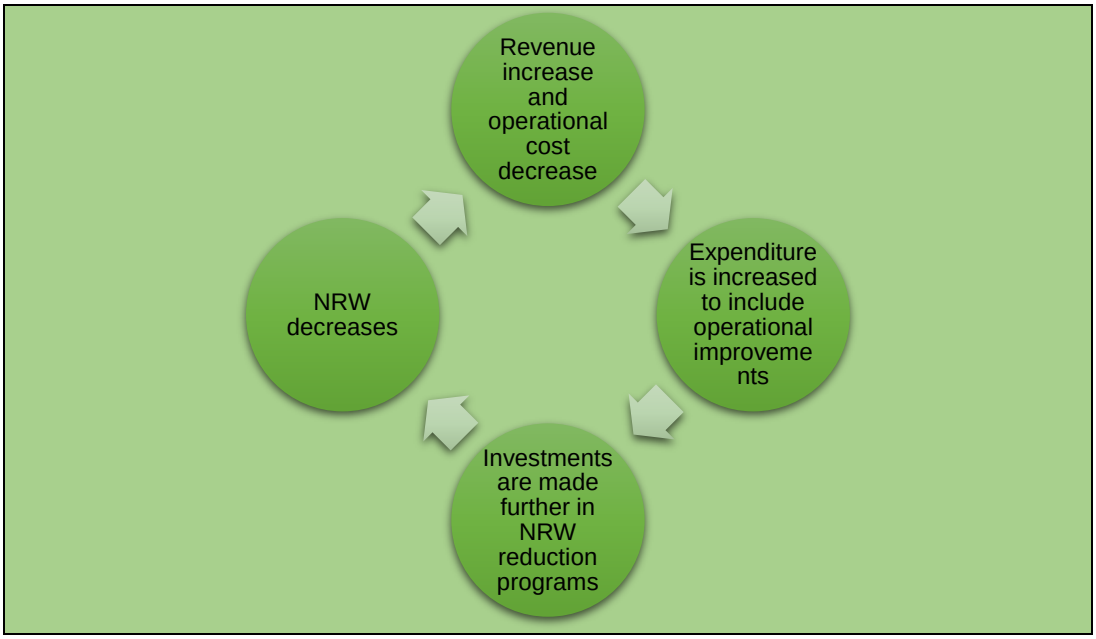


Figure 5: The Virtuous NRW Cycle

Poor governance also affects NRW reduction. Utility managers often lack the autonomy, accountability, and technical and managerial skills necessary to provide reliable service. The utility's management should also tackle organizational challenges, such as policy barriers, inadequate

technical capacity, and aging infrastructure. Finally, poor project design hinders efforts to reduce NRW, particularly underestimating the required budget.

As per of next few reports, we will cover detailed analysis in below format.

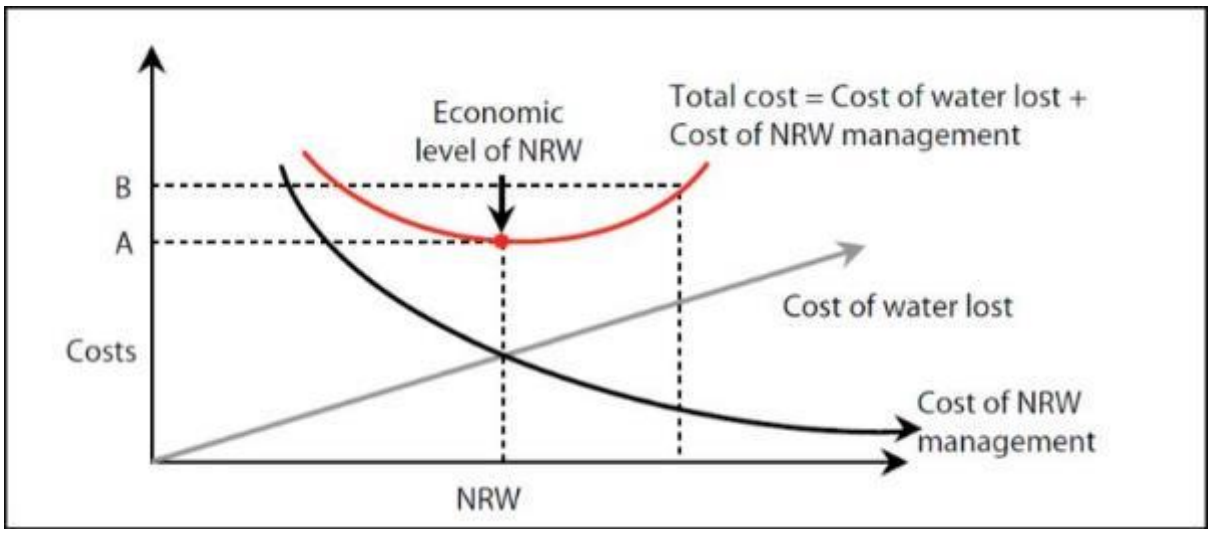


Figure 6: Economic Level of NRW

The cost of water lost is the value of the water lost through both physical and commercial losses. The volume of physical losses should be multiplied by variable operational costs, including manpower, chemicals, and electricity. The volume of commercial losses should be multiplied by the average customer tariff. As NRW increases, the cost of water lost increases proportionally.

The cost of NRW management is the cost of reducing NRW, including staff costs, equipment, transportation, and other factors. As NRW decreases, the cost of NRW management increases.

Table 6: Volume and Cost Analysis for NRW Management activities

NRW Type: U=Unbilled authorized consumption, C=Commercial Losses, P=Physical losses

		Cost		
		High	Medium	Low
Volume	High	Leakage on Mains (P) Leakage on service connections (P)	Unauthorised Consumption (C)	Unbilled unmetered consumption (U)
	Medium	Customer meter replacement (C)	Customer metering inaccuracies and data handling errors (C)	Pressure Management (P)
	Low	Reservoir leakage (P)	Unbilled unmetered consumption (U)	Reservoir overflows (P)[1]

7 BENEFITS OF NRW REDUCTION

Reducing water loss directly improves water utilities' bottom line, in addition to offering social and environmental benefits.

7.1 INCREASED REVENUE

Water loss is always very costly to water utilities. It impacts every part of the utility's business. The water lost, if saved, would result in –

- Less treatment required,
- Less operation finance,
- Reduced debt and depreciation,
- Longer life of existing water resources without the need to supplement,
- Capital deferments,
- Asset life is increased,
- Organizational speed increases,
- Improved measurement knowledge, and
- Positive impact on management success planning and all corporate decisions

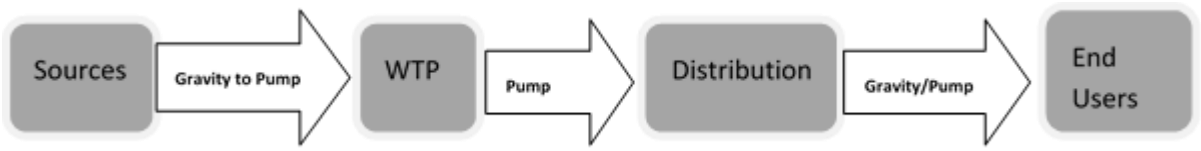
It is mostly found that the water loss reduction and the associated revenue loss recovery are among the most promising areas of water resource improvements. Based on a simple assumption of a water loss tariff of 13/m^3 and 19.5/m^3 of water for developing and developed countries, respectively, a total cost[4] of 948.78 billion was estimated for annual water loss around the world.

7.2 ENERGY CONSERVATION

Energy is consumed at every step of water supply scheme. It is used to extract water from source, treat and then distribute the water to the consumers depicts a typical water distribution system. The raw water from water body is lifted through pumps or gravity from source to water treatment plant. After being treated, the water is then pumped to the ELSR / GLSR which helps in storage and used for distribution further. The water is then pumped or through gravity flows to the consumer end. At every stage, water is transmitted or distributed by pumping which requires electric energy.

Therefore, the leaks and breakages in the distribution system also consumes electricity and incurs costs. Thus, reducing water losses will help save the costs on energy.

Figure 7 Water Distribution System



7.3 REDUCED CARBON FOOTPRINT

Energy consumption due to water loss is increasing the carbon emission, namely the carbon footprint[5].

Many large-scale resource development options such as pumped storage reservoirs and distribution are recognized as energy intensive activities in terms of construction and operation.

The studies have shown that the carbon footprint of water losses is proportional to the pressure head and the magnitude of the losses. The greater the pressure head and water loss, the greater the carbon footprint. Reducing water loss directly reduces the carbon footprint.

7.4 SOCIAL AND ENVIRONMENTAL BENEFITS

In addition to reducing the carbon footprint, reducing NRW also gives social and environmental benefits. By actively detecting and repairing leaks, pipeline integrity will be improved to avoid possible contamination ingress; thus, water quality is better assured as leaks are detected and repaired. The improved pipeline integrity will effectively reduce the possibility of pipe bursts. It will thus, minimize the disturbance of social life in local communities.

Reduced water loss also means an increased water supply that allows more people to be served with drinking water. This is particularly important for developing countries like India where there is high water loss and scarce fresh water availability. Research[6] suggest that in developing countries, reducing NRW to just half the current level would deliver 8 billion m3 of already treated water to 90 million more people without increasing the demand for endangered water resources. The increased supply with socially uplift the standard of living of people improving their quality of life.

The unauthorized consumption of water resources forms a large chunk of total water loss for a utility. It is important to eliminate the unauthorized use and give fair and equal treatment to all. There are number of tapings thefts and illegal consumption cases, which is a cost to the utility as well as to the authorized consumers. All efforts to remove this will increase revenue efficiency of the utility along with improvement of public reputation and ability to serve its consumers with better facilities transparently.

7.5 CAUSES OF WATER LOSSES

7.5.1 REAL LOSSES

Real losses comprise of leakage from pipes, joints and fittings, through service reservoir floors and walls and from reservoir overflows.

[5] Water Loss Reduction, Bentley Institute Press (2011)
[6] Water Loss Reduction, Bentley Institute Press (2011)

7.5.2 ASSESSING REAL LOSSES

The real loss assessment methods can be broadly classified into the following two main groups:

- Top-Down Real Loss Assessment

In this method, the volume remaining after the volumes of authorized consumption and apparent losses have been deducted from the system input volume is the real loss component. However, this analysis does not provide any information about the components of the total volume of real losses. Also, it does not give information about the quantum of losses due to detectable bursts (which can be reduced by active leakage control) or due to background losses (which can only be reduced by pressure management or infrastructure renewal) in the total real loss.

Despite the simplicity of a top-down type assessment, the leakage estimate obtained via this method is referred to as a crude estimate. So, it is recommended that, the top down annual water balance be undertaken along with the other two assessment methods.

- Bottom-Up Real Loss Assessment

Bottom-up assessment calculations are based on analysis of flows into District Metered Areas. This analysis, if carried across the entire distribution system, the areas of high real losses can be identified and prioritized for active leakage control. This method provides an independent determination of the volume of real losses.

Bottom-up type leakage assessment can be considered the second part of the audit process. The audit's main purpose is to find out the efficiency of the water distribution system and the measures needed to achieve these. Bottom-up audits require the most accurate and up-to-date data possible.

Bottom-up real loss assessment can be carried out using following methods:

1. 24 Hour Zone Measurement (HZM)
2. Night Flow Analysis

7.6 APPARENT LOSSES

Apparent losses are those that are caused by faulty or badly read meters and meter under-registration, and water that is taken from the network without permission.

7.6.1 ASSESSING APPARENT LOSSES

Detailed method is covered in below Section.

7.7 ESTABLISHING WATER BALANCE

7.7.1 DETERMINING SYSTEM INPUT VOLUME

The volume of treated water input to that part of the water supply system to which the water balance calculation relates.

System Input Volume = Own Sources + Water Imported

- Own Sources: The volume of (treated) water input to a distribution system from the water supplier's own sources allowing for known errors (for example source meter inaccuracies). The quantity should be measured after the utility's treatment plant(s). If there are no meters installed after the treatment plant, the output must be estimated based on raw water input and treatment losses.
- It is important to note that water losses at raw water transmission pipelines and losses during the treatment process are not part of the Annual Water Balance calculations shown in this report. However, a separate audit of the transmission system and water treatment works can be performed if desired.
- Water Imported: The volume of bulk supplies imported across operational boundaries. Water imported can be either
  - Measured at the boundary meter (if already treated)
  - Measured at the outflow of the treatment plant (if raw water is imported and there is a separate treatment plant)
  - In either case, corrected for known errors (for example transfer meter inaccuracies)
- Mix of raw water: If raw waters imported are mixed with own source raw water in the treatment plant, there is no need for a differentiation and the total production (output) of this one or more plant(s) is used as basis for the System Input. As always, corrections must be made for known errors as with the 'Own Sources', it is important to note that water losses at raw water transmission systems and losses during the treatment process are not part of the Annual Water Balance calculations. In case the utility has no distribution input meters, or they are not used, and the key meters are the raw water input meters, because these are the meters that they buy the raw water on, the system input must be based on the raw water meters and treatment plant use/loss has to be considered

7.7.2 DETERMINING AUTHORISED CONSUMPTION

The authorized consumption includes volume of metered and/or unmetered water taken by registered customers, the water supplier and others who are implicitly or explicitly authorized to do so by the water supplier, for residential, commercial and industrial purposes. It also includes water exported across operational boundaries.

Authorized consumption may include items such as firefighting and training, flushing of mains and sewers, street cleaning, watering of municipal gardens, public fountains, frost protection, building water, etc. These may be billed or unbilled, metered or unmetered.

7.7.3 BILLED METERED CONSUMPTION

All metered consumption which is also billed. This includes all groups of customers such as domestic, commercial, industrial or institutional and includes water transferred across operational boundaries (water exported) which is metered and billed.

7.7.4 BILLED UNMETERED CONSUMPTION

All billed consumption which is calculated based on estimates or norms but is not metered. This might be a very small component in fully metered systems (for example billing based on estimates for the period a customer meter is out of order) but can be the key consumption component in systems without universal metering. This component might also include water transferred across operational boundaries (water exported) which is unmetered but billed.

7.7.5 UNBILLED METERED CONSUMPTION

The unbilled metered consumption calculation is similar to the billed metered consumption calculation.

7.7.6 UNBILLED UNMETERED CONSUMPTION

Any kind of Authorized Consumption which is neither billed nor metered is called unbilled unmetered consumption. The components typically include items such as firefighting, flushing of mains and sewers, street cleaning, frost protection, etc. Thus, for the calculation of unbilled unmetered consumption, each component needs to be identified and individually estimated. In a well-run utility it is a small component which is very often substantially overestimated.

7.7.7 CALCULATING APPARENT LOSSES

Includes all types of inaccuracies associated with customer metering as well as data handling errors (meter reading and billing), plus unauthorized consumption (theft or illegal use). It is important to note that reducing apparent losses will not reduce physical water losses but will recover lost revenue. Note: Over-registration of customer meters, leads to under-estimation of Real Losses. Under-registration of customer meters, leads to over-estimation of Real Losses.

Apparent Losses = Un-authorized Consumption + Metering Inaccuracies

7.7.8 UN-AUTHORIZED CONSUMPTION:

Unauthorized consumption can include:

1. Illegal connections
2. Misuse of fire hydrants and firefighting systems
3. Vandalized or bypassed consumption meters
4. Corrupt practices of meter readers

Estimation of unauthorized consumption is a very difficult task. A DMA or pilot area representative of the network can be used as a basis for finding unregistered and illegal customers, and also vandalized and bypassed meters.

7.7.9 METERING INACCURACIES:

The extent of consumer meter inaccuracies whether under- or over-registration has to be estimated based on tests of representative sample of meters. The composition of the sample should reflect the various brands and age groups of consumer meters.

7.7.10 CALCULATING REAL LOSSES

Real losses are physical water losses from the pressurized system and the utility's storage tanks, up to the point of customer use. In metered systems this is the customer meter. In unmetered situations this is the first point of use within the property. The annual volume lost through all types of leaks, breaks and overflows depends on frequencies, flow rates, and average duration of individual leaks, breaks and overflows.

7.7.11 OVERALL WATER BALANCE

<table>
<tr><td rowspan="10">System Input Volume</td><td rowspan="4">Authorized Consumption</td><td rowspan="2">Billed Consumption</td><td>Billed Metered Consumption</td><td rowspan="2">Revenue Water</td></tr>
<tr><td>Billed Unmetered Consumption</td></tr>
<tr><td rowspan="2">Unbilled Consumption</td><td>Unbilled Metered Consumption</td></tr>
<tr><td>Unbilled Unmetered Consumption</td></tr>
<tr><td rowspan="6">Water Loss</td><td rowspan="3">Apparent Losses</td><td>Customer Metering Inaccuracies</td><td rowspan="6">Non-Revenue Water</td></tr>
<tr><td>Data Handling Errors</td></tr>
<tr><td>Unauthorized Consumption</td></tr>
<tr><td rowspan="3">Real Losses</td><td>Leakage on Mains Pipes</td></tr>
<tr><td>Leakage and Overflow on Tanks</td></tr>
<tr><td>Leakage on Service Connections</td></tr>
</table>

Figure 8 Overall Water Balance

8 STANDARD NRW REDUCTION STRATEGY

Understanding different components of NRW, their causes and effects is the cornerstone to successful NRW reduction program. Figure 9 gives a holistic framework and process for NRW reduction. It has four key components:

- **Base Map and Audit:** As the first step, it is important to have all water asset information properly documented, conduct detailed water audit and establish water loss reduction goals; this will help keep the water management staff informed and guided.
- **Source side R&M and Metering:** Source or supply side water network from raw water lifting to ELSRs is relatively better visible, known and has relatively lower NRW share. This section of water can be taken up for dedicated leakage identification, repair and bulk metering.
- **Apparent Loss Reduction:** Apparent loss or Commercial loss primarily surface on the distribution side at the end-consumer interface with water network and will require improving water utility functions including new service connection, regularisation, metering, billing and collection.
- **Real Loss Reduction:** Most part of the NRW Physical loss is on distribution side after the ELSRs, and it is this part that is less known and requires elaborate and systematic leakage detection, repairs and pressure management in smaller decentralised DMAs. Advanced computation tools linking network maps to hydraulic modelling and simulation in combination with strong field measurements and execution can give further speed to leakage detection. Leak detection and repair should be a continuous process throughout the water distribution system's lifetime.

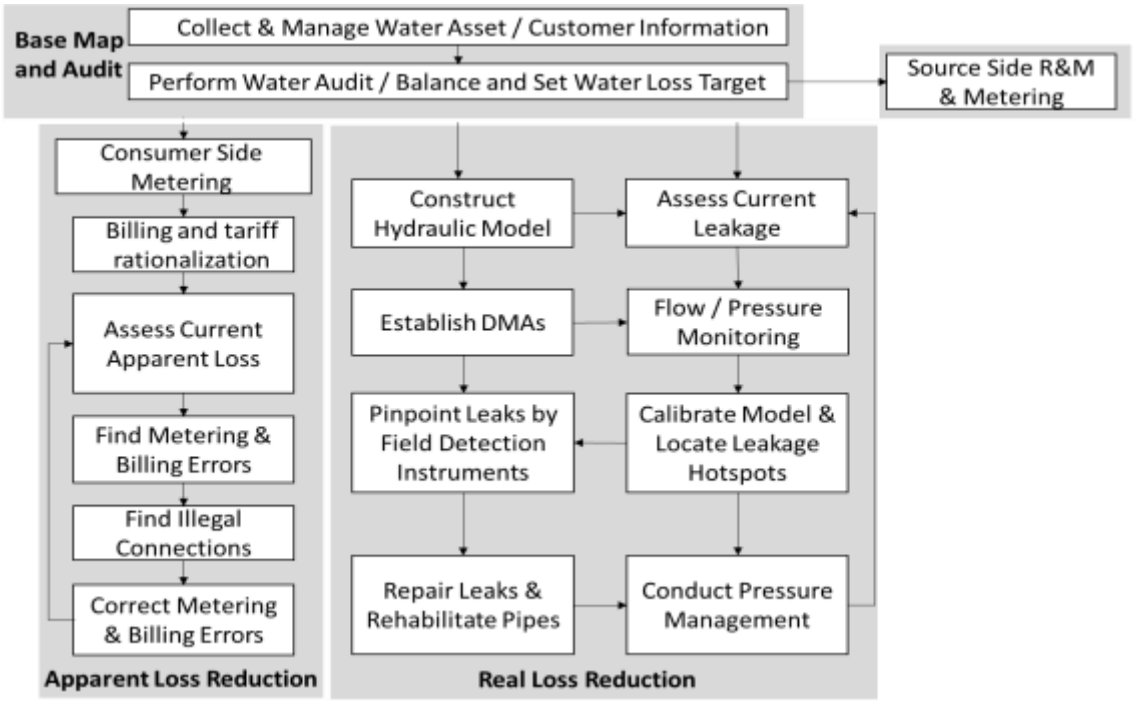


Figure 9: Flow Chart for NRW Reduction

Above approach is an ideal state and should be taken up by MCT Water Supply System, to maintain global benchmark of NRW value. These are standard set of activities to be undertaken as a continuous process by prevention, correction and proper operation and maintenance to attain 24 X 7 water sup-ply.

8.1 BASE MAP AND AUDIT

8.1.1 COLLECT AND MANAGE WATER ASSET AND CUSTOMER INFORMATION

The first set of activities involve doing GIS mapping, preparing network base maps, conducting topographical and consumer door-to-door surveys.

8.1.2 PREPARATION OF NETWORK BASE MAPS

The digital elevation model (DEM) is a raster-based digital dataset of the topography of all or part of the Earth. The pixels of the dataset are each assigned an elevation value, and a header portion of the dataset defines the area of coverage, the units each pixel covers, and the units of elevation (and the zero-point). DEMs may be derived from existing paper maps and survey data, or they may be generated from new satellite or other remotely sensed radar or sonar data.

Once DEM is prepared all available network data should be transposed as overlays using AutoCAD software. A complete set of network maps covering the entire area of supply should be built up. All data capture would initially be carried out by walking along streets with the local valve operators and oral enquiry. Trial excavations will be needed at critical locations to confirm pipe diameters, materials. Locations of all valves and other properties should be marked. This shall be an ongoing process to increase reliability of data. Any built drawings of the new networks as available should be integrated into the network map. A simple format in local language for capturing leak repair data may be instituted and insisted upon and as the data is reported from each leak the respective asset data shall be corrected and validated.

8.1.3 SET UP OF GIS PLATFORM

GIS platform shall integrate the hardware, software, and data management process for capturing, managing, analyzing and displaying all forms of geographically referenced information for the water network. GIS shall allow the user to view, understand, question, interpret, and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts.

GIS can link the asset and infrastructure information of the entire water supply scheme with consumer data including metering, billing, collection and complaints data.

8.1.4 TOPOGRAPHICAL AND CUSTOMER DOOR-TO-DOOR SURVEY

A ground profiling topo-survey using Total Station equipment shall capture all the ground features like road width, property boundaries, valve chambers, transformers, trees, culverts etc. including spot elevations of each of the water supply or sewerage node.

A geographic information system (GIS) can recognize and analyze the spatial relationships that exist within digitally stored spatial data. These topological relationships allow complex spatial modelling and analysis to be performed. Topological relationships between geometric entities traditionally include adjacency (what adjoins what), containment (what encloses what), and proximity (how close something is to something else).

8.1.5 ASSET MANAGEMENT

Asset management is good engineering and business practice, and it spans different aspects of utility management and operations, and it starts with good data management. Good asset management is a necessity for long-term economic leakage management, and the objective is to tackle leaks in the most cost-effective way. The critical factors of asset management are:

- Understanding how assets are currently performing
- Collecting data and turning it into useful information for planning
- Good information systems

Particularly relevant to developing an NRW reduction strategy is the aging of the pipe network and making decisions on when to replace or renew the network infrastructure. This requires an understanding of the assets' conditions and deterioration rates. Burst frequency modelling, using data from burst records, helps prioritize pipe rehabilitation, renewal, or replacement. In addition, active leakage control will identify clusters of pipes in the network where bursts and repairs are a continuous occurrence. When these activities do not lead to reduced leakages, utility managers should undertake a condition assessment program to decide whether to replace pipes or conduct further repairs.

8.2 PERFORM WATER AUDIT / BALANCE AND SET WATER LOSS TARGET

8.2.1 ESTABLISHING THE STRATEGY DEVELOPMENT TEAM

The NRW reduction strategy team ensures that all components of NRW are covered and that the proposed strategy is feasible in terms of physical application and financial requirements. The team should comprise of members from each operational department, including production, distribution, and customer service. It may also include members from the finance, procurement and human resource departments. Choosing the right members promotes ownership by the utility's various departments involved in the strategy's implementation, and ensure consensus by senior management.

8.2.2 CONSUMER AWARENESS

One of the goals of reducing NRW is also to provide better and more efficient services to the public. To accomplish this, the public must also understand how they can help manage NRW by reporting burst pipes, faulty valves, leaks, or other problems that limited utility crews may not detect. The earlier the utility becomes aware of a burst pipe or leak, the faster it will be repaired, thus reducing the losses. Awareness programs should be organized with a variety of stakeholders from the public, including politicians, community leaders, and household and industrial consumers. Programs generally focus on basic NRW concepts and how reducing NRW helps ensure that communities receive better water supply and services. After awareness programs are conducted in each community, all staff should work to ensure that customer confidence in the utility's services is maintained. A key element in this is open communication. For example, the public should be able to easily contact the utility to report burst pipes, leakages, or other concerns. The utility should establish a system to receive information or complaints from customers, and then to disseminate it to the relevant operational units so action is taken quickly.

8.2.3 SETTING THE TARGETS AND MEASUREMENT INDICATORS

The selection of outcome indicators and target values is more an art than a science. The process must account for the project's objectives and scope, the level and reliability of baseline information, engineering calculations regarding the amount of reduction that can be expected, and the feasibility of measurement. The most common indicator is the NRW volume, with a specific reduction target designated in terms of m^3/day, or m^3/connection/day. However, if the utility is also trying to expand coverage at the same time as reducing NRW, the indicator must be adjusted for network or customer growth, and perhaps also for pressure changes. This is an important exercise that will benefit from expert advice.

In some cases, adjusting NRW volumes to account for intermittent supply and changes in pressure can become too challenging. Thus, some contracts whose primary objective is to increase the hours of supply (continuity) have opted to measure and reward performance based on this indicator. The reduction of losses is indirectly captured by the increase in the hours of supply, where no new sources of water are introduced into the system.

8.2.4 TECHNOLOGY TRANSFER, TRAINING AND STAFF AWARENESS

Training staff in new skills and techniques features highly in developing a leakage management strategy ensuring sustainability. It encompasses the motivation of staff, transfer of skills in the techniques and technology of leakage management, and system operation & maintenance. There is a need to address the tasks, the problems and the constraints associated with introducing a leakage management program at all levels within the company. It is important that an understanding of the principles of the program, the steps in its design and implementation, and support for the tasks involved, filters down from senior management level to operations level. A training program will therefore include; awareness seminars for senior staff and decision makers (and to raise public awareness), training workshops for engineering and technical staff and continuous practical training for operations staff.

8.3 SOURCE SIDE R & M AND METERING

8.3.1 MAINTENANCE OF SERVICE RESERVOIRS

- Service Reservoirs (SRs) must be inspected regularly and the line department can prescribe frequency of inspections.
- Leakage from structure of SR and through the pipes and valves must be attended to on priority. It is advisable to resort to pressure grouting to arrest leaks from structures and sometimes an additional coating of cement mortar plastering is also done using water proof compound to arrest leaks from the structure
- Maintenance is concerned with mainly protection against corrosion both externally and internally. Corrosion of roof slab of RCC reservoirs because of chlorine is also common. Internal corrosion is prevented by cleaning and painting at regular intervals. Quite Toxic paints should not be used for painting interior surface of SRs. food grade epoxy painted shall only be used for internal surface of SRs. Anticorrosive painting (epoxy) is also done to the interiors when corrosion due to chlorine is expected. Painting of steel tanks once in a year and external painting with waterproof cement paint for exteriors of RCC Tanks once

in 5 years is usually done. The inside of painted SR shall be disinfected before putting into use for a period sufficient to give chlorine residuals of at least 0.2 mg/l. Manhole covers & vent pipes shall always be properly placed and maintained

- The maintenance procedures shall include step by step procedure for every piece of equipment in SRs such as pipes inside the tank (In-let, out-let, wash-out, over-flow) valves, specials and flow meters following the procedures as per the manufacturers' catalogues:
- Pipes (In-let, out-let, wash-out, over-flow) and specials
- All the pipe fittings should be leak proof, any leakage nearby reservoir may affect the safety of reservoir
- Overflow pipe should relate to the distribution system after the sluice valve installed on delivery pipeline.
- Concrete platform as protection works shall be provided around the service reservoir, if not provided, to safeguard the reservoir foundation from any leakages/overflow of water
- Valves
- All valves should be inspected regularly in specified frequency of inspection and following activities shall be undertaken.
- Lubrication is required to be done regularly
- Spindles that develop leaks should be repacked
- Rust and sediment in the valve is removed by shutting the disc hard in the seat, then opening about a quarter way and closing tightly several times; the increased velocity usually flushes the obstructions away
- Valve chambers of the SR also require maintenance to ensure that the interiors of chambers are not silted up and ensure that the covers are in good condition and are in position.
- Sluice valve chamber shall not be water logged
- Cleaning of reservoirs

Routine inspection is the best way to determine when a tank requires maintenance and cleaning. A visual inspection can be made from the roof manhole with water level lowered to about half full or less. Alternatively, a detailed inspection can be made after draining the tank and then cleaning or washing. Best time of the year to take up cleaning of SRs is during the period of lowest water consumption.

The following activities are normally involved in cleaning of a tank/SR:

- Make alternate arrangement for water supply to consumers served by the SR.
- Close the inlet line before commencing cleaning of SR.
- Do not empty S.R. and always keep minimum water level at 200-300 mm in the SR.
- Close the outlet valve so that no water will be used while the tank is being cleaned.
- Drain and dispose of the remaining water and silt.
- Wash the interior of tank walls and floor with water hose and brushes.
- Inspect the interior of walls and ceiling of tank for signs of peeling off or deterioration.
- Apply disinfectant (Supernatant of Bleaching powder) to the walls and floor before start of filling the tank/SR.

- The higher frequency of cleaning of SR depends on the extent of silting, development of bio films and results from water quality monitoring. Generally cleaning of Service Reservoir may be periodically done.
- Date of last cleaning and the next due date of cleaning may be displayed on the outer surface of the SRs.

8.3.2 OPERATION AND MAINTENANCE (O&M)

O&M is crucial to the successful management and sustainability of water supply networks, whatever the level of technology, infrastructure, and institutional development. It requires forward planning and technology transfer at all stages from installation of plant and equipment, through operator training and hand-over, to routine operation and upkeep. O&M therefore encompasses equipment selection, spares purchasing and repair procedures as well as best practice in operating and maintaining the system. It is essential that an O&M program is built into the project from an early stage and not as an afterthought.

8.4 CONSUMER SIDE METERING

8.4.1 INSTALLING METERS PROPERLY

Meters should be installed properly according to the manufacturer's specifications. For example, some meters require a specific straight length of pipe upstream and downstream of the meter. Therefore, a standard meter stand should be designed and constructed onsite. Utilities should purchase the meters on the customers' behalf, so that only standard, high quality meters are used. Meters should also be installed where meter readers can easily read them, and where it is easy to identify each property's meter. In addition, the management and staff responsible for meter installations should be trained on proper handling of meters. Meters should be installed at every processing stage to measure the water lost in the process.

8.4.2 SIZING METERS PROPERLY

Customer meters work within a defined flow range, with the maximum and minimum flows specified by each manufacturer. Large meters will not register low flows when the flow rate is lower than the specified minimum. Therefore, utilities should conduct customer surveys to understand the nature of each customer's water demand and their likely consumption. This information helps to determine the proper meter size for households and businesses. For customers with a high demand, checking the flow pattern and the newly installed meter verifies whether the correct meter size is used.

8.4.3 USE OF APPROPRIATE TYPE AND CLASS OF METER

Choosing the appropriate meter helps to ensure the accuracy of customer consumption data.

8.4.4 METERING

a) Multi-jet Meters

The multi-jet water meter is used both in the domestic and the industrial field. The principle of operation is to force the passage of the inlet water flow through a series of ducts open in a capsule, called distributor, containing the turbine. The entrance of the water through the ducts generates a series of symmetrical jets that impact the turbine keeping it in perfect balance.

Example of key brands for multi-jet meters – Elster, Itron, etc.

The most common type of meter for domestic and small commercial installations is the 15 mm and 20 mm PD meter. Single-jet and multi-jet meters are more accurate for small commercial and industrial installations that require 20 mm to 50 mm sizes. Electromagnetic meters are the best choice for sizes 100 mm and above.

b) Class of meters – A, B, C, D

- The Class does not indicate the accuracy of the water meter but the flow rate at which the water meter meets the common accuracy figures. These are ± 5% at the minimum flow rate and ± 2% in the meter's normal range for cold water meters
- The figures for hot water meters are greater at ± 6% and ± 3% respectively
- The higher the class designation (A to D) of water meters the higher the accuracy at very low flow rates with Class D having the highest accuracy, and class A the lowest
- When deciding if a low flow reading is required even a class A will start to read, within its tolerance band, at a flow rate of 1.66 l/m (e.g. 12.5mm basin tap will have a flow rate of between 6 and 10 l/m)
- If the only requirement is an overall indication of the amount of water used, then a class A or B meter is sufficient.
- If the total of secondary meters should relate very closely to a master meter, then a Class C meter should be used.
- Class B meters are a good choice where water quality is low, as the sediments will not greatly affect the meter
- Class D meters are more preferable where roof tanks are used, and water quality is good, since they have a lower minimum flow specification and will measure the roof tank inflow more accurately
- Class C meters are a suitable compromise in most situations, since they can measure low flows better than Class B meters and are not as expensive as Class D meters

  Overall, Class D meter offers best configurations with accuracy results.

8.5 BILLING AND TARIFF RATIONALIZATION

8.5.1 RATIONALIZATION OF TARIFF

Financial sustainability is a key success factor in any reform process. The service suffers due to unavailability of adequate funds.

Tariff should be rationalized in such a way that full cost recovery is obtained. This implies that Opex costs as well as capex costs should be recovered. Opex involves operations and maintenance costs and capex involves debt and depreciation costs. Appropriate tariff rates facilitate availability of revenue for NRW reduction activities.

Various policy parameters that can be considered for tariff setting are as follows:

- Setting quantity of water, as life line consumption to be made available on affordable prices
- To define higher consumption level beyond which O&M Recovery and full cost recovery is to be made
- To define very high consumption level beyond which full cost recovery plus suitable (15% to 30%) surcharge is to be levied
- Level of NRW to be considered for calculation of unit cost of water (per KL)
- Level of pumping operation efficiency to be considered for calculating unit cost of water (as % of the theoretical best efficiency)
- Tariff to be based on LPCD in place of KL.

8.5.2 SMART METER BILLING SYSTEM

Smart meter billing system can be defined as Data management facility at the utility company that can validate data, has the capacity to store the high volume of data received, and that interfaces with the existing billing system, and is accessible to customer service representatives and to the customers.

8.5.3 Assess Apparent Loss

Apparent Losses is always a challenging task to estimate. Unauthorized consumption estimation should be done in a transparent, component-based way so that the assumption can be easily checked and / or modified later. A DMA or pilot area representative of the network can be used as a sample for finding unregistered and illegal connections.

For consumer metering inaccuracies and data handling errors, large customer's meters are usually testing by a test rig. Based on the accuracy tests, average meter inaccuracy values will be established for different user groups.

8.5.4 MONITORING INTERMITTENT WATER SUPPLY

Where water supply is intermittent, i.e. the customer receives water only a few hours a day, customer meters will register a certain volume of air when the water supply is first turned on.

In addition, the sudden large increase in pressure can damage the meter's components. Intermittent supply should be avoided for a number of reasons, including the negative impact on customer meter accuracy.

8.5.5 MAINTAINING AND REPLACING METERS PROPERLY

All meters should be installed above ground and located where they can be audited easily, including by the meter readers during their regular rounds. The utility should replace the meters systematically, beginning with the oldest meters and those in the worst condition. Poor maintenance will not only encourage inaccuracy but may shorten the life span of the meter. A scheduled maintenance and replacement program should be in place to manage this problem. The water utility should regularly test a sample of its customer meters, including a range of meter brands and ages, using a calibrated meter test bench. This testing will determine the optimum age at which customer meters should be replaced.

8.5.6 ADDRESSING METER TAMPERING

Customers sometimes tamper with their meters to lower the measured volume. Utility managers should conduct customer surveys to assess expected water usage according to the number of household occupants or the nature of businesses in commercial areas. A comparison of expected and actual water use will highlight cases of likely meter tampering. Utility should increase use of tamper resistant meters.

8.5.7 METER READING ERRORS

Errors can be easily introduced through negligence, aging meters, or even corruption during the process of reading the meters and billing customers. Incompetent or inexperienced meter readers may read the meter incorrectly or make simple errors, such as placing a decimal in the wrong place. Dirty dials, faulty meters, and jammed meters can also contribute to meter reading errors. The meter readers should immediately report any observed problems, and the maintenance team should act to remedy the problem immediately. If remedial action is too slow, meter readers may become demoralized and less inclined to report problems. Because meter readers are the utility's frontline in liaising with customers, their activities have an immediate impact on cash flow. Utility managers should therefore invest in training and motivating their meter readers to record and report information effectively and efficiently. The manager should also establish systems and procedures to prevent meter reading errors by improving its meter reading and billing processes through greater supervision of meter readers, implementation of rotating reading routes, and frequent spot checks.

8.5.8 DATA HANDLING AND ACCOUNTING ERRORS

The typical method of data handling and billing requires a meter reader to visit each property and read the customer meter. The data is then recorded by hand on a form, taken back to the office, given to the billing department, and typed into the billing system. A bill is then printed and mailed to the customer. In this scenario, a variety of errors may occur at the different stages: the meter reader writes down incorrect data; the billing department transfers incorrect data into the billing system; or the bill is sent to the wrong address. A robust billing database is

one of the key elements of minimizing these errors and should be the initial purchase of any water utility striving to improve its revenues. The latest billing software has built-in analysis functions that can identify potential data handling errors and report them for verification. In addition, billing software will report monthly estimate readings and zero reads, both of which may indicate a problem with the customer's meter.

8.6 FIND ILLEGAL CONNECTIONS

8.6.1 FINDING AND REDUCING ILLEGAL CONNECTIONS

Illegal connections involve the physical installation of a connection to water distribution pipelines without the knowledge and approval of the water utility. Illegal connections can occur during the installation of a new supply connection, or sometimes the customer's supply is cut off after non-payment and the customer cannot afford, or does not want to pay, to be reconnected. During customer awareness programs, customers should be encouraged to report illegal connections, and regulations should be in place to penalize the water thieves. Meter readers should also report cases of direct connections without accompanying meters that they see during their rounds.

8.6.2 TACKLING METER BYPASSING

Some customers try to reduce their water bills by using a meter bypass, which is an additional pipe installed around the meter. This bypass pipe is often buried and very difficult to detect. This type of unauthorized consumption is usually committed by industrial and commercial premises to steal large volumes of water. The discrepancy will show up when the utility conducts a flow balance analysis. The utility should then undertake customer surveys and leakage step tests to determine where the missing flow occurs.

8.6.3 PREVENTING ILLEGAL USE OF FIRE HYDRANTS

Although the only legal use of fire hydrants is for firefighting, some use them illegally to fill tankers (normally at night) or to provide water supply to construction sites. The utility staff can detect these flows, often high volume over a short period of time, through appropriate flow measurements at DMA meters. Such high flows are not only incidences of water theft, but also a detriment to the pipe network and water quality, which affects the service to the customer. Through customer awareness programs, the utility staff should encourage customers to report cases of illegal uses of fire hydrants. Developing and enforcing regulations to penalize water thieves together with local agencies will also deter unauthorized consumption.

8.7 CORRECT METERING AND BILLING ERRORS

8.7.1 AVOIDING CORRUPT METER READERS

Corrupt meter readers can significantly impact a utility's monthly billed consumption. For instance, the same meter reader who walks the same route for an extended period of time, thus becoming familiar with the customers and their monthly billed consumption, may collude with those customers to record lower meter readings in exchange for a monetary incentive. To

reduce this risk, the utility manager needs to rotate meter readers to different routes on a regular basis.

8.7.2 ACTIVELY CHECKING THE CUSTOMER BILLING SYSTEM

Sometimes connections are made legally, but the billing department is not notified of the new connection; therefore, the customer is never billed. These unregistered customers can be detected during the regular meter reading cycle when diligent meter readers find meters that are not in their reading book. However, this process may not identify all of the errors in the billing system. Conducting a complete customer survey within each DMA, whereby utility representatives visit every property in the DMA—whether or not they are recorded in the billing system—is the best method of comprehensively identifying billing system errors. The survey should include the following information: property address, name of owner, and meter make and number. The representative should also conduct a meter test to ensure that the accurate flow is recorded. For metered areas, utilities should focus on large users by encouraging good customer relationships through frequent visits. Checking large customers' accounts monthly will help detect anomalies, which may be due to water theft. In areas of suspected high commercial losses, temporary DMAs can be established to analyze flows through standard monitoring activities, such as step testing and flow balancing, to pinpoint problematic areas.

8.7.3 IMPROVING BILL COLLECTION EFFICIENCY

Tightening enforcement of collections policy may improve customer satisfaction at utilities. Customer service satisfaction is higher at the utility that strictly enforces their collections policy and has lower bad debt write-offs. Utilities that consistently enforce their collections policy spend less time interacting with delinquent customers, leaving more time to provide high-quality customer service. Staff availability to service paying customers could be the key source of increased customer satisfaction. Additional benefits of a consistently enforced collection policy include higher revenue and lower customer operations costs, both of which help keep water rate increases in check.

The best practices for improving collections are as follows:

The best practices for improving collections are as follows:

a) Collect and Maintain Good Customer Data
b) Practice premises-based billing
c) Employ Customized, Risk-Based Processes
d) Make it Easy to Pay
e) Leverage State Laws and Local Ordinances
f) Make Utilities Accessible

8.8 REAL LOSS REDUCTION

8.8.1 CONSTRUCT HYDRAULIC MODEL

This is required to simulate the operation of the real network in all its key elements. In Indian water utilities, network future design is often interpreted as hydraulic modelling. The design is

primarily for sizing of pipes for future projected demand capacities. Hydraulic modelling is simulating the network for the current consumption pattern which is developed through an iterative simulation process duly capturing the flow and pressure data of the current network functioning scenario. When the network has been properly calibrated, it enables the current operation of the network to be fully understood, identify anomalies and most importantly optimize the design of any modifications to the configuration of the network before they are created in the field, thus assuring pipes are correctly sized and customer complaints are avoided.

8.8.2 BRIEF ON HYDRAULIC MODELLING:

GIS based study of existing water supply system and analysis using international standard design software. It is the calibration of distribution network to find out lacunas in the system. It involves preparation of rehabilitation plan for existing system while additional components were proposed to cater the demand of future population.

Hydraulic modelling which is heart of water network is used to evaluate important elements of free surface fluid flow. Generally, hydraulic modelling can refer to both numeric modelling (in which a simulation is performed on a computer), or physical modelling (where the physical flow geometry is scaled in such a way that it can be modelled in the laboratory). Numeric models are usually two- or three-dimensional, whereas physical hydraulic models are always three-dimensional. Geometry is sometimes easier to manipulate and modify in a numeric model, and wider areas (larger volumes) can often be more cost-effectively simulated in a numeric model. Physical hydraulic modelling, however, must be used when unsteady vortex dynamics is a concern, such as in pump or turbine intakes. Hydraulic modelling is often most cost effective when the two methods are used together, simulating wide areas with a numeric model, using results to develop boundary conditions for a smaller physical hydraulic model in locations where vortexing or some other physical phenomena not easily captured by numeric modelling is of interest.

Hydraulic models are often used to validate the design of new or rehabilitated pipelines. They are also used to verify the system capacity or to analyze the effect of modified infrastructure within the context of the entire water distribution system or its sub-system. They provide understanding of the distribution system such as flow patterns and pressure variations. It can also simulate impacts of new customers. It helps in identifying the operation and maintenance needs and future improvements.

To develop Hydraulic model, GIS mapping is required along with historical data, network and physical data and field data. Physical information such as dimensions, main sizes, connectivity, mapping, closed valves, pump curves, control valves locations are required. Water demands of residential, commercial, industrial, wholesale consumers are also required.

8.8.3 ESTABLISH DMAS

The establishment of DMAs involves sub-division of network into DMAs supplied by a limited number of key mains on which flow meters are installed. DMA approach is incorporated to a specific area typically to gauge details on a sample area with certain qualifying criteria. Each DMA is a hydraulically separate portion of the network.

Once the DMA has been established, it becomes an operational tool for monitoring and managing both major components of NRW, physical and commercial losses.

8.8.4 PINPOINT LEAKS BY FIELD DETECTION INSTRUMENTS

There are several modern technologies that employ insertion meters to identify leaks by measuring fluctuations in flow. Leak pinpointing to a small area and then to the actual point for excavation is carried out using combination of one or more of the following pieces of equipment,

1. Basic (acoustic) listening stick
2. Electronic sounding stick
3. Ground microphone (or an “array” of microphones laid along the line of the pipe)
4. Leak noise correlator
5. Noise Loggers
6. Gas Tracing Methodology

8.8.5 REPAIR LEAKS AND REHABILITATE PIPES AND OTHER ASSETS

Existing leaks and pipes should be repaired considering life of the assets as well as using latest technologies.

8.9 ASSESS CURRENT LEAKAGE

8.9.1 AWARENESS, LOCATION AND REPAIR (ALR)

Real losses comprise of leakage from pipes, joints and fittings; through service reservoir floors and walls and from reservoir overflows. They can be severe and may go undetected for months or even years.

The volume lost will depend on the characteristics of pipe network, the leak detection and repair policy practiced by the utility other factors such as:

- Pressure in the network
- Frequency and typical flow rates of new leaks and bursts
- Proportions of new leaks that are reported
- The level of background leakage

The level of leakage due to both reported and unreported bursts will depend on time for which they run. The run time comprises of following three elements:

- Awareness time—time required for the utility to become aware of the leak
- Location time—time required to locate the leak
- Repair time—time required to repair the leak

The volume of water lost will continue to increase until the water utility is aware of the problem, locates or pinpoints it, and finally repairs or resolves it. Therefore, the NRW strategy must ensure that the company reduces its awareness, location, and repair times for all NRW components. Many losses occur because of poor or limited maintenance, so in

addition to reducing ALR, a fourth element of the NRW strategy should be system maintenance. This is critical to maintaining incidence of new leaks, meter failures, reservoir leaks, and other problems.

8.9.2 ACTIVE LEAKAGE CONTROL (ALC)

Active leakage control (ALC) is vital to cost-effective and efficient leakage management. The quicker the operator can analyze DMA flow data; the quicker bursts or leaks can be located. This, together with speedy repair, limits the total volume of water lost.

8.9.3 REGULAR SURVEY

Regular survey is a method of starting at one end of the distribution system and proceeding to the other, using one of the following techniques:

- Listening for leaks on pipework and fittings
- Reading metered flows into temporarily zoned areas to identify high-volume night flows
- Using clusters of noise loggers

8.9.4 LEAKAGE MONITORING

Leakage monitoring is flow monitoring into zones or district metered areas (DMAs) to quantify leakage and to prioritize leak detection activities. This has now become one of the most cost-effective activities (and the one most widely practiced) to reduce real losses. The most appropriate leakage control policy for a utility will mainly be dictated by the characteristics of the network and local conditions, which may include financial constraints on equipment and other resources.

It is a methodology which can be applied to all networks. Even in systems with supply deficiencies, leakage monitoring zones can be introduced gradually. One zone at a time is created and leaks detected and repaired, before moving on to create the next zone. This systematic approach gradually improves the hydraulic characteristics of the network and improves supply. Leakage monitoring requires the installation of flow meters at strategic points throughout the distribution system, each meter recording flows into a discrete district which has a defined and permanent boundary. Such a district is called a district metered area (DMA). A leakage monitoring system will comprise a number of DMAs where flow is measured by permanently installed flow meters. The DMA meters are sometimes linked to a central control station via telemetry, so that flow data are continuously recorded.

Analysis of these data, particularly of flow rates during the night, determines whether consumption in any one DMA has progressively and consistently increased, indicating a burst or undetected leakage. It is important to understand the composition of night flow, as this will be made up of customer use as well as losses from the distribution system. DMA maintenance is crucial to maintain the accuracy of the data. It includes maintaining the integrity of the DMA boundary as well as plant and equipment, i.e. it involves checks on the accuracy of meters and secondary instrumentation.

8.9.5 LEAK LOCALIZING

Once the network is divided into DMAs, those showing a greater volume of night flow per connection than the others, can then be inspected more thoroughly by carrying out a leak localizing exercise. Inspectors can then be deployed to locate the precise leak position in the culprit section of pipe. Examples of these are:

- Step test – a technique which requires the progressive isolation of sections of pipe by closing line valves, beginning at the pipes farthest away from the meter and ending at the pipe nearest the meter. During the test the flow rate through the meter is observed, and the times when each section of pipe is isolated are noted. A large decrease in flow, or "step", indicates a leak in the section of pipe which has just been isolated.
- Correlator survey
- Acoustic logger survey (sometimes combined with correlation)

8.10 FLOW/PRESSURE MONITORING

8.10.1 SUPERVISORY CONTROL AND DATA ACQUISITION

To enable appreciable metering in Municipal Corporation of Lucknow water supply scheme, SCADA systems can be deployed in the distribution system.

Supervisory control and data acquisition (SCADA) is a control system architecture that uses computers, networked data communications and graphical user interfaces for high-level process supervisory management, but uses other peripheral devices such as programmable logic controllers (PLC) and discrete PID controllers to interface to the process plant or machinery. The operator interfaces that enable monitoring and the issuing of process commands, such as controller set point changes, are handled through the SCADA supervisory computer system. However, the real-time control logic or controller calculations are performed by networked modules which connect to the field sensors and actuators.

A SCADA system usually consists of following main elements:

- Supervisory computers

This is the core of the SCADA system, gathering data on the process and sending control commands to the field connected devices. It refers to the computer and software responsible for communicating with the field connection controllers, which are RTUs and PLCs, and includes the HMI software running on operator workstations. In smaller SCADA systems, the supervisory computer may be composed of a single PC, in which case the HMI is a part of this computer. In larger SCADA systems, the master station may include several HMIs hosted on client computers, multiple servers for data acquisition, distributed software applications, and disaster recovery sites. To increase the integrity of the system the multiple servers will often be configured in a dual-redundant or hot-standby formation providing continuous control and monitoring in the event of a server malfunction or breakdown.

8.10.2 CALIBRATE MODEL AND LOCATE LEAKAGE HOTSPOTS

Calibration of hydraulic models can be described as a 2-step process consisting of,

1. Comparison of pressures and flows predicted with observed pressure and flows for known operating conditions i.e. pump operation, tanks levels, pressure reducing valve settings, and
2. Adjustment of input data for the model to improve agreement between observed and predicted values.

8.10.3 CONDUCT PRESSURE MANAGEMENT

As system operating pressures are increased or decreased, the volume of annual real losses will increase or decrease proportionally.

Pressure management for leakage control, in its widest sense, can be defined as "The practice of managing system pressures to the optimum levels of service ensuring sufficient and efficient supply to legitimate uses and consumers, while reducing unnecessary or excess pressures, eliminating transient s and fault y level controls all of which cause the distribution system to leak unnecessarily."

There are a number of important factors that relate to the monitoring of the effectiveness of a Pressure Managed Area (PMA):

- Flow data monitoring – Daily Input volume and Night line monitoring
- Inlet and Outlet Pressure monitoring – indicative of PRV effectiveness, servicing requirement and available night time pressure control
- Burst frequency – Measure of burst frequency before and after installation.
- Reducing the water pressure in a system can be achieved in a number of ways each of which has advantages and disadvantages.

The following techniques are discussed:

- Fixed outlet pressure control
- Fixed outlet pressure control involves the use of a device, normally a pressure reducing valve (PRV) which is used to control the maximum pressure entering a zone.
- PRVs are instruments that are installed at strategic points in the network to reduce or maintain network pressure at a set level. The valve maintains the pre-set downstream pressure regardless of the upstream pressure or flow-rate fluctuations. PRVs are usually sited within a DMA, next to the flow meter. The PRV should be downstream of the meter so that turbulence from the valve does not affect the meter's accuracy. It is good practice to install the PRV on a bypass pipe to enable future major maintenance works.
- Time-modulated pressure control
- The time-modulated pressure management option is effectively the same as the fixed-outlet system with an additional device which can provide a further reduction in pressure during off-peak periods. This form of pressure control is useful in areas where water pressures build up during the off-peak periods – typically during the night when most of the consumers are asleep.
- Flow modulated pressure control
- Flow modulated pressure control provides even greater control and flexibility than the time-modulated option. It will normally provide greater savings than either of the two previously mentioned options but this greater flexibility (and savings) comes at a price. The electronic controller is more expensive, and it requires a properly sized meter in

addition to the PRV. It may not always be cost effective to use the flow modulated option and careful consideration should be given to the specific application before selecting flow-modulated control.

It should be noted that there are numerous other forms of pressure control techniques which can be considered when trying to reduce losses from a water distribution system.

9 BULK WATER AUDIT FOR WATER SUPPLY SYSTEM OF NMC

After the system review study, Ceinsys audit team finalized the locations of flow measurement at various entry points of the system and started the site preparation activities. Audit team cleared site and pipes for measurements by excavation also wherever necessary. Audit team conducted a demo study to confirm the installation of the ultrasonic portable flow meters prior to start with 24 hours simultaneous flow measurements.

As part of water audit Ceinsys Team carried out flow measurement study of Nagpur water supply system starting from Raw water HW to WTPs for identify raw water transmission main losses and then Flow Measurement study from WTPs to ESRs and Distribution system during the period October 2019 to April 2020. Ultrasonic Flow Meter (Portable) were used and installed at various supply points for Flow Measurement. The details of field measurement activity and results of Flow measurement are tabulated below.

9.1 OVERALL SYSTEM LOSSES UPTO ESRS/GSRS/DT

9.1.1 RAW WATER TRANSMISSION MAIN LOSSES

RW Transmission main Losses			
1	Raw Water Output (Pench)	686.11	ML
2	RW Input @ WTPs (Pench)	678.64	ML
1-2	**Total RW Transmission Losses**	**7.47**	**ML**
		1.09%	

Table 7 Losses of Raw Water Transmission Main

Raw Water transmission main losses are worked out to be 7.47 MLD i.e. 1.09%.

There is no raw water transmission main loss at kanhan WSS due to raw water head works and water treatment plant are in same premises.

9.1.2 WATER TREATMENT PLANT LOSSES

Sr. No.	WTPs	RW Input (ML)	PW Output (ML)	WTP Losses (ML)	Losses WTP (%)
1	Pench-I	143.50	142.27	1.24	0.86%
2	Pench-II	142.59	141.53	1.06	0.74%
3	Pench-III	92.53	91.44	1.10	1.19%
4	Pench-IV	79.58	78.76	0.82	1.03%
5	Kanhan WTP	220.43	217.47	2.96	1.34%
Total (Overall)		**678.64**	**671.47**	**7.17**	**1.06%**

Table 8 Losses of Water Treatment Plants

Water treatment plants losses (Overall) are worked out to be 7.17 MLD i.e. 1.06%.

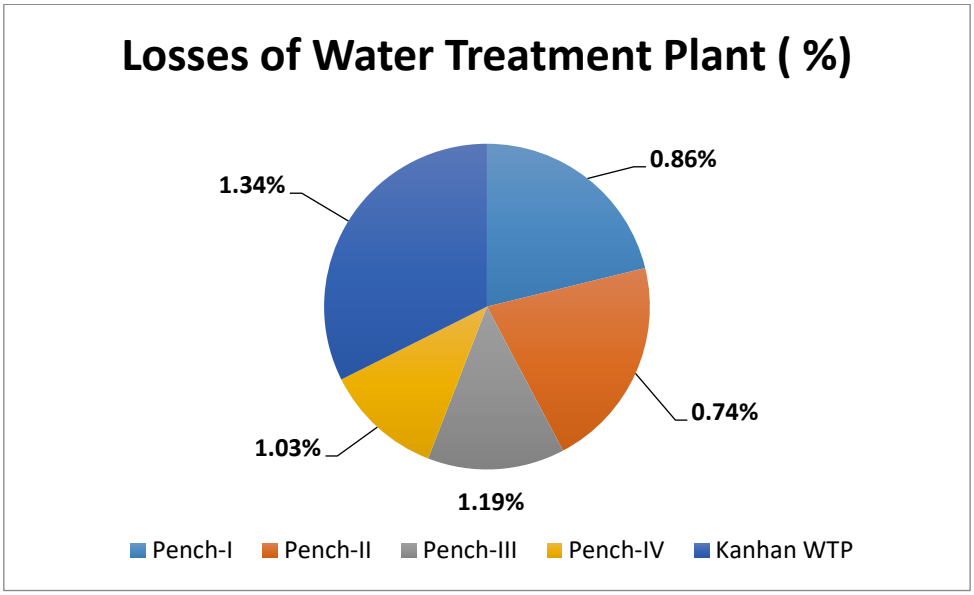


Figure 10 Losses of Water Treatment Plants

9.1.3 CLEAR WATER TRANSMISSION LOSSES UPTO ESRS/GSRS/DT

A	Total Outlet from WTPs	671.47	ML
	ESRs/GSRs/DT Input		
1	Gorewada GSR	9.40	ML
2	Gittikhadan GSR	20.65	ML
3	Dabha/Wadi Tekdi ESR	10.08	ML
4	Semi Old GSR Inlet	21.34	ML
5	Buldi Fort New	9.41	ML
6	Buldi Fort Old	16.78	ML
7	Killa Mahal ESR	12.07	ML
8	Boriyapura ESR	2.47	ML
9	Riffle Line	6.41	ML
10	Futala Line	5.45	ML
11	MES DT (150 mm)	2.51	ML
12	CPWD DT (200 mm)	1.47	ML
13	for Governor House Bungalow DT (150 mm)	1.76	ML
14	Civil Line DT	6.91	ML
15	IBM DT	3.02	ML
16	Ram Nagar ESR	16.01	ML
17	Ram Nagar GSR	9.13	ML
18	Takli Sim	11.70	ML
19	Jaitala Sump	1.61	ML
20	Trimurti Nagar	8.90	ML
21	Gayatri Nagar	10.62	ML
22	Pratap Nagar	8.10	ML
23	Khamla	12.14	ML

A	Total Outlet from WTPs	671.47	ML
24	Chichbhuwan	10.30	ML
25	Laxmi Nagar Old	13.03	ML
26	Nara ESR	4.14	ML
27	Nari/Jariptka ESR	18.57	ML
28	Boriyapura at GH	34.86	ML
29	Chhaoni at GH	3.69	ML
30	Medical at GH	14.48	ML
31	Buldi at GH	9.53	ML
32	Railway at GH	4.74	ML
33	Vena line at GH	4.22	ML
34	Itarsi at GH	7.69	ML
35	Sadar line at GH	1.38	ML
36	Raj Nagar line at GH	8.84	ML
37	Kanhan 600 at GH	6.74	ML
38	Kanhan 900 at GH	1.75	ML
39	Red Tank at GH	8.48	ML
40	Reshimbagh ESR	7.17	ML
41	Hanuman Nagar ESR	6.21	ML
42	Wanjari Nagar Old	8.01	ML
43	Wanjari Nagar New	6.02	ML
44	Nalanda Nagar	3.80	ML
45	Dhantoli ESR	5.89	ML
46	Laxmi Nagar New	6.46	ML
47	Shri Nagar	4.62	ML
48	Omkar Nagar New	3.04	ML
49	Omkar Nagar Old	10.18	ML
50	Hudkeshwar ESR	11.25	ML
51	Hudkeshwar/Narsala DT	1.67	ML
52	Siraspeth DT	0.40	ML
53	100 mm DT @ Loha Pool	0.70	ML
54	Binaki -1	5.63	ML
55	Binaki -2	4.30	ML
56	Binaki Exist	8.23	ML
57	Bastarwadi-1	14.61	ML
58	Bastarwadi-2	6.88	ML
59	Shanti Nagar	6.84	ML
60	Wanjri	8.35	ML
61	Kalamna	6.99	ML
62	Minimata Nagar	8.06	ML
63	Bharatwada	9.16	ML
64	Subhan Nagar	3.30	ML
65	Pardi-1	4.73	ML
66	Pardi-2	6.94	ML
67	Bhandewadi	3.11	ML
68	Lakadganj-1 & 2	14.16	ML
69	Nandanwan Old	7.59	ML
70	Nandanwan New	6.89	ML
71	Nandanwan (Rajiv Gandhi)	5.00	ML

A	Total Outlet from WTPs	671.47	ML
72	Kharbi	5.32	ML
73	Dighori	5.10	ML
74	Sakkardara I,II & III	20.97	ML
75	Indora-I	4.14	ML
76	Indora-II	6.23	ML
77	Bezanbagh	11.55	ML
78	Akashwani DT	0.80	ML
79	900x600 Interconnection	8.98	ML
80	Itabhatti DT	0.70	ML
81	100 mm Karuna Nagar DT	0.10	ML
82	Sai Nagar DT	1.94	ML
	Hydrants		
83	Seminary Hills Hydrant	0.41	ML
84	Kalamna Hydrant	0.75	ML
85	Bhandewadi Hydrant	2.70	ML
86	Sakkardara Hydrant	0.21	ML
87	Bezanbagh Hydrant	0.91	ML
88	Binaki Hydrant	0.75	ML
89	Reshimbagh Hydrant	0.30	ML
90	Wanjari Nagar Hydrant	0.61	ML
91	Sugat Nagar Hydrant	0.99	ML
92	Mhalgi Nagar (Gramin)	0.33	ML
B	**Total Inlet to ESR/GSR + Hydrants**	**640.40**	**ML**
A-B	**Clear Water Transmission Losses**	**31.07**	**ML**
		4.63%	

Table 9 Clear water transmission main losses upto ESRs/GSRs/DTs

Clear Water transmission main losses are worked out to be 31.07 MLD i.e. 4.63%.

9.1.4 SECTIONWISE WATER LOSSES

Sr. No.	Description	Total
1	Raw Water Output (ML)	686.11
2	Raw Water Inlet at WTP (ML)	678.64
(1-2)	**Raw Water Transmission Losses (ML)**	**7.47**
	Raw Water Transmission Losses (%)	**1.09%**
3	WTP Outlet (ML)	671.47
(2-3)	**WTP Losses (ML)**	**7.17**
	WTP Losses (%)	**1.06%**
4	Total ESR Inlet (ML)	640.4
(3-4)	**Clear Water Transmission Losses (ML)**	**31.07**
	Clear Water Transmission Losses (%)	**4.63%**
(1-4)	**Total supply side losses (ML)**	45.71
	Total supply side losses (%)	**6.66%**

Table 10 Section wise Water Losses

As per above study, total 45.71 MLD of water losses are measured in the supply side of the water supply system (i.e. Headwork's to ESR's)

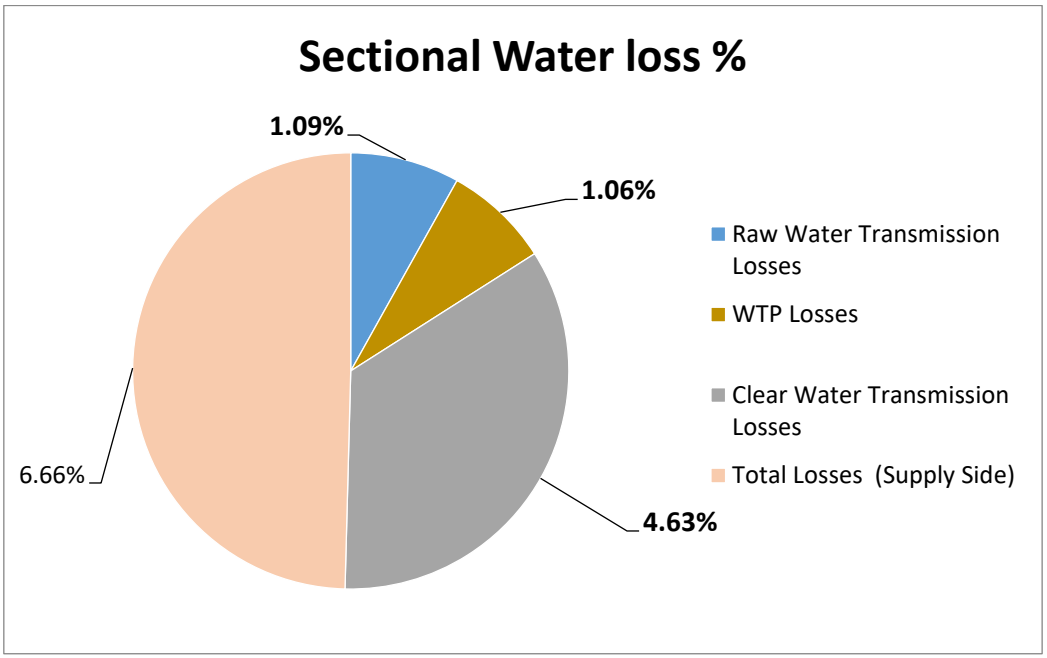


Figure 11: Section wise water losses

9.1.5 GRAFICAL REPRESENTATION OF WATER BALANCE

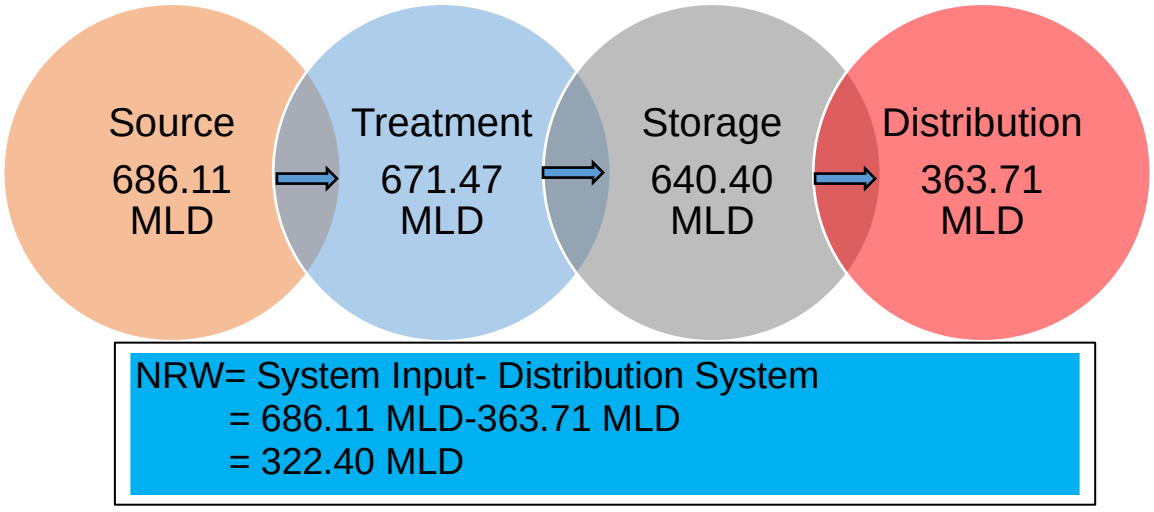


Figure 12 Graphical Representation of Water Balance

10 FORMATION OF STUDY AREA FOR WATER AUDIT

10.1 FORMATION OF SAMPLE STUDY AREAS FOR NMC WSS:

Nagpur Municipal Corporation has moderate condition of water supply. City administration has divided the service area in ten zones. Water supply is observed on daily basis. Water is supplied to Nagpur city areas are through ESRs and GR & MBR's, considering this scenario and consultation with NMC officials, we are divided this activity in to two parts i.e. first part is Ashi Nagar Zone No 9 which has selected as a complete DMA and remaining area as considered as random sample area; we can achieve the results closer to the reality. The methodology for this method of sampling is elaborated here. Some of the key points are as below,

- Selection of the consumers as per the details available from survey.
- Then as per connection status; total authorized consumption will be calculated.
- Consumption of PSPs and tanker supply to be added in this quantum.
- Then the total consumption for the connections w.r.t each ESRs is compared with the total ESRs outlet volume flow for that supply area during the period of supply. Thus the difference is distribution losses in that zone.
- Major advantage of this process is all the area of consumers with equal proportion can be covered. Even all the localities can be covered to get very realistic approach of the calculation of consumption pattern.

As per above scenarios and consultation with NMC officials we have selected random areas for analysis of per HSC water consumption & LPCD. Out of ten zones, one Zone i.e. Ashi Nagar Zone have been selected as a whole DMA for the study.

10.2 CONSUMER SURVEY

Before starting DMA activity, initially we have started zone wise consumer survey for connection related details from the consumers and details are tabulated below

Table 11 Consumer Survey Details

As Per Consumer Survey						
Zone No.	**Zone**	**Total surveyed Quantity**	**Against 110409 survey, total Connection found with double, suspected & no connections**	**Total Connection found**	**No Connection / Disconnected**	**Unregistered Consumers**
1	Laxmi Nagar	1265	1265	1192	71	2
2	Dharampeth	11770	11770	10610	1160	
3	Hanuman Nagar	7154	7271	6637	584	50
4	Dhantoli	1603	1687	1563	87	37
5	Nehru Nagar	7485	7593	6002	1387	204
6	Gandhibagh	7347	7719	6489	983	247
7	Satranjipura	954	954	763	88	103
8	Lakadganj	3308	3393	2928	364	101
9	Ashi Nagar	58787	60411	38129	14667	7615
10	Mangalwari	10736	11022	8768	1859	395
Total Connections		**110409**	**113085**	**83081**	**21250**	**8754**

Above table shows total surveyed quantity of 10 zone which is 110409. During this survey it is observed that some of the area has double connections i.e. new connection with water meter and old connection without water meter. Also observed that some area has same type of double connections with water meters therefore including these connections, total connections survey is considered 113085 for water audit purpose. Following table shows bifurcation of connections found during survey.

Zone No.	Zone	Total Connection found	Billed Authorised Connections (Those whose name is in billing Database)		Unbilled Authorised Connections (Those whose name is not in billing Database)	
			Consumers with water meter	Consumers without water meter	Consumers with water meter	Consumers without water meter
1	Laxmi Nagar	1192	1189	3		
2	Dharampeth	10610	10324	286		
3	Hanuman Nagar	6637	6513	78	46	
4	Dhantoli	1563	1311	242	9	1
5	Nehru Nagar	6002	5727	275		
6	Gandhibagh	6489	6361	88	40	
7	Satranjipura	763	534	229		
8	Lakadganj	2928	2858	43	26	1
9	Ashi Nagar	38129	31740	6323	66	
10	Mangalwari	8768	8614	79	75	
Total Connections		**83081**	**75171**	**7646**	**262**	**2**

Table 12 Bifurcation of connections found during survey

10.3 TOTAL CONSUMER CONNECTIONS IN THE CITY

As per NMC record there are total 368022 Nos. of registered consumers in the Nagpur City, following table shows the bifurcation of consumer's category:

Sr. No.	Name of Zone	Residential	Slum	Institutional	Commercial	Grand Total
1	Laxmi Nagar	32034	4910	789	741	**38474**
2	Dharampeth	24179	14157	1704	1180	**41220**
3	Hanuman Nagar	31903	2300	215	263	**34681**
4	Dhantoli	17130	3728	331	396	**21585**
5	Nehru Nagar	33720	9290	195	251	**43456**
6	Gandhibagh	15020	12108	501	361	**27990**
7	Satranjipura	21334	21894	395	213	**43836**
8	Lakadganj	30613	10568	833	796	**42810**
9	Ashi Nagar	32252	10028	162	249	**42691**
10	Mangalwari	23260	7024	579	416	**31279**
Grand Total		**261445**	**96007**	**5704**	**4866**	**368022**

Table 13 Total Consumer connections in the city

10.4 PART-1 ASHI NAGAR DMA

We have selected following different ESR command area for DMA study also we have taken ESR outlet readings of all ESR's for analysis of DMA losses.

Zone	Command Area	Name of Study Area	No. of consumers selected for study
Ashi Nagar	Indora ESR-2	Vaishali Nagar Area	162
	Indora ESR-1	Laghuvetan Colony Area	109
		Thaware Colony Area	121
	Binaki Existing ESR Old	Ambedkar Garden Area	211
	Binaki ESR-2	Ekta Colony Area	114
	Nari ESR	Kamgar Nagar Area	182
	Jaripatka ESR	Ahuja Nagar Area	85
		Housing Board Colony Area	157
	Bezanbagh ESR	Bezanbagh Area	101
Total Consumer selected in Ashi Nagar DMA			**1242**

Table 14 DMA study in Ashi Nagar Zone

10.4.1 DMA INLET

At the time of DMA analysis following ESR's & DT's supply reading has been noted for DMA inlet

Table 15 Input Volume in Ashi Nagar Zone

Zone	ESRs/GSRs/DT	Total Supply in ML
Ashi Nagar	Bezanbagh ESR	10.80
	Binaki /Mahendra Nagar ESR	7.65
	Binaki-I	4.56
	Binaki-II	3.40
	Nara ESR	5.69
	Jaripatka ESR	17.53
	Indora-I	3.82
	Indora-II	5.87
	Gamdoor DT	6.21
	600 mm kanhan I/C Chappal Karkhana	1.68
	Akashwani DT from K900	0.80
	Jaswant DT	2.33
	Itabhatti Chowk on 900 mm kanhan (80 mm dia)	0.69
	Kaushalya Nagar DT from kanhan 900 (50*100)	0.59
	Deep Apartment DT from Kanhan 600 (50 mm)	0.02
Total Inlet of Ashi Nagar Zone ML		**71.65**

10.4.2 RESULTS OF DMA STUDY AREAS OF ASHI NAGAR ZONE

Sr. No	Zone	Name of Command Area	Name of Study Area	Nos. of Consumers Considered for study	Average Per HSC as per study (Litres)	Consumption in Study Area (Litres)
1	Ashi Nagar	Indora ESR-1	Laghuvetan Colony Area	109	577	62893
			Thaware Colony Area	121	568	68728
2		Indora ESR-2	Vaishali Nagar Area	162	834	135108
3		Binaki Existing ESR Old	Ambedkar Garden Area	211	352	74272
4		Binaki ESR-2	Ekta Colony Area	114	623	71022
5		Nari ESR	Kamgar Nagar Area	182	383	69706
6		Jaripatka ESR	Ahuja Nagar Area	85	541	45985
			Housing Board Colony Area	157	719	112883
7		Bezanbagh ESR	Bezanbagh Area	101	448	45248
				1242	**560.56**	**685845**

Table 16 Results of DMA Study of Ashi Nagar Zone

10.4.3 COMMAND AREA WISE CONSUMPTION DETAILS OF ASHI NAGAR ZONE

Sr. No	Zone	Name of Command Area	Nos. of Consumers in Command Area	Average Per HSC as per study (Litres)	Consumption in Command Area (ML)	ESR Inlet (ML)	Loss of Water (ML)	Loss of Water (%)
1	Ashi Nagar	Indora ESR-1	5242	572	3.00	4.14	1.14	27.57
2		Indora ESR-2	3125	834	2.61	6.23	3.62	58.17
3		Binaki Existing ESR Old	3529	352	1.24	8.23	6.99	84.91
4		Binaki ESR-2	4465	623	2.78	4.24	1.46	34.39
5		Nari ESR	6080	383	2.33	7.00	4.67	66.73
6		Jaripatka ESR	8591	630	5.41	11.57	6.16	53.22
7		Bezanbagh ESR	3446	448	1.54	11.55	10.01	86.63
			34478	**549**	**18.91**	**52.96**	**34.05**	**64.29**

Table 17 Command Area wise Consumption Details of Ashi Nagar Zone

10.4.4 WATER LOSS IN TOTAL ASHI NAGAR ZONE DMA

\Zone	Nos. of Consumers Ashi Nagar Zone	Average Per HSC as per study (Liters)	Consumption in Ashi Nagar Zone (ML)	ESR/DT outlet (ML)	Loss of Water (ML)	Loss of Water (%)
Ashi Nagar	**42691**	**560.56**	**23.93**	**71.68**	**47.75**	**66.61**

Table 18 Results of Ashi Nagar Zone DMA Study

As per above table it is observed that total 47.75 MLD of water loss which is 66.61 in percentage. After these results, we calculated and bifurcated these losses in to following category for find out physical and commercial losses in the Ashi nagar zone.

10.4.5 BIFURCATION OF WATER LOSS

We have calculated the results as per consumer survey we have completed 38129 connection surveys against total connection of 42691 of Ashi nagar, following table shows Ashi nagar consumer survey statistics.

Table 19 Bifurcation of water loss

Zone	Total Connection found	Billed Authorised Consumption (Those whose name is in billing Database)		Unbilled Authorised Consumption (Those whose name is not in billing Database)		Suspected Consumers	Metering inaccuracies
		Consumers with water meter	Consumers without water meter	Consumers with water meter	Consumers without water meter		
Ashi Nagar	38129	31740	6323	66		8754	1939

We have extrapolated per HSC consumption i.e. 66.62 lit/d to above surveyed quantity for assess physical & commercial losses. Following table shows quantity of water as per above table.

Calculation	Total Connection found	Billed Authorized Consumption		Unbilled Authorized Consumption		Commercial Loss		Physical Loss
		Consumers with water meter	Consumers without water meter	Consumers with water meter	Consumers without water meter	Unregistered Consumers	Metering inaccuracies	
As per Survey Nos.	**38129**	31740	6323	66		8754	1939	
A = in %	**100%**	83.24%	16.58%	0.17%		22.96%	5.09%	
B = As per Actual (A * Actual) Nos.	**42691**	35538	7080	74		9801	2171	
Per HSC * B (lit)	**23930677**	19920787	3968467	41423		5494221	1216963	
Quantity in ML	**23.93**	**19.92**	**3.97**	**0.04**		**5.49**	**1.22**	
Water loss against 71.68 MLD	**23.93**	**23.89**		**0.04**		**6.71**		**41.04**

10.5 PART-2 SAMPLE STUDY AREAS IN NAGPUR CITY

After completion of part-1 i.e. Ashi nagar DMA we have started Part-2. In this part we have selected 1679 consumers in random way across the city. The main objective for this random survey is to find out consumption pattern in all area so that we will reach the closer to the reality. Following table shows details of sample study areas which are selected for analysis of distribution losses.

Sr. No.	Zone	Area	No. of Consumer selected
1	Laxmi Nagar	Agney Layout , Shastri Layout	290
2	Dharampeth	Bharat Nagar, Shivaji Nagar	111
3	Hanuman Nagar	Suyog Nagar Area	282
4	Dhantoli	Vishwakarma Nagar Area	211
5	Nehru Nagar	Chitnis Nagar Area	211
6	Lakadganj	Garoba Maidan Jagjeevan Nagar Area	264
7	Mangalwari	Bardey Layout Area	310
Grand Total			**1679**

Table 20 Study Area for DMA Study in City

Following table shows flow measurement results at consumer-end these results will be extrapolated to entire city except Ashi Nagar DMA.

Sr. No.	Name of Study Area	consumers selected for study	HSC consumption Per day (lit.)	Consumption per day of study area (ML)
1	Agney Layout , Shastri Layout	290	1019.00	0.30
2	Bharat Nagar, Shivaji Nagar	111	2236.73	0.25
3	Suyog Nagar Area	282	1114.94	0.31
4	Vishwakarma Nagar Area	211	674.00	0.14
5	Chitnis Nagar Area	211	679.00	0.14
6	Garoba Maidan Jagjeevan Nagar Area	264	805.00	0.21
7	Bardey Layout Area	310	842.19	0.26

Table 21 Results of DMA Study in City

10.6 EXTRAPOLATION OF RESULTS TO ENTIRE CITY

Combining above two parts the results are tabulated below.

Parts	Sr. No.	Zone	Name of Study Area	Total No. of consumers selected for study	Average HSC consumption Per day (lit.)	Total Consumption per day of study area (ML)
Part-1	1	Ashi Nagar	Ashi Nagar DMA	1242	560.56	0.69
Part-2	2	Laxmi Nagar	Agney Layout , Shastri Layout	290	1019.00	0.30
	3	Dharampeth	Bharat Nagar, Shivaji Nagar	111	2236.73	0.25
	4	Hanuman Nagar	Suyog Nagar Area	282	1114.94	0.31
	5	Dhantoli	Vishwakarma Nagar Area	211	674.00	0.14
	6	Nehru Nagar	Chitnis Nagar Area	211	679.00	0.14
	7	Lakadganj	Garoba Maidan Jagjeevan Nagar Area	264	805.00	0.21
	8	Mangalwari	Bardey Layout Area	310	842.19	0.26
				2921	**991.43**	**2.30**

Table 22 Extrapolation of Results to Nagpur City

Above results are extrapolated to 368022 Nos. of total connections in the city (ref. Annexure-1). The quantity of water available for Distribution is 640.40 ML per day (refer Annexure-1). Population and rate of average population per connection are provided by NMC as per Annexure-5. The distribution losses have calculated as in reference to above results and tabulated below.

Table 23 Overall Water Losses

Sr. No.	Description	Amount	Unit
1	Total output of ESR's	640.4	ML
2	Total connections in the City	368022	Nos.
3	Average Population per connection	6.61	Nos.
4	Total connected population to WSS	2319458	Nos.
5	Average HSC consumption through analysis	991.43	Lit.
6 = 5x2	Total consumed quantity	364867129	Lit.
		364.87	ML
7 = 6/4	LPCD	**157**	**Lit.**

11 WATER BALANCE

Data and measurement is analysed to develop the water and cost balance sheet. The total water audit analysis is carried out in nine tasks as explained below

11.1 DETERMINING SYSTEM INPUT VOLUME

The volume of treated water input to that part of the water supply system to which the water balance calculation relates.

System Input Volume = Own Sources + Water Imported

- Own Sources: The volume of (treated) water input to a distribution system from the water supplier's own sources allowing for known errors (for example source meter inaccuracies). The quantity should be measured after the utility's treatment plant(s). In case of Nagpur, we are taking raw water intake as system input volume to the water supply system
- It is important to note that water losses at raw water transmission pipelines and losses during the treatment process are not part of the Annual Water Balance calculations shown in this report. However, a separate audit of the transmission system and water treatment works can be performed if desired.
- Water Imported: The volume of bulk supplies imported across operational boundaries. Water imported can be either
    - Measured at the boundary meter (if already treated)
    - Measured at the outflow of the treatment plant (if raw water is imported and there is a separate treatment plant)
    - In either case, corrected for known errors (for example transfer meter inaccuracies)

In case of Nagpur, imported water is zero

- Mix of raw water: If raw waters imported are mixed with own source raw water in the treatment plant, there is no need for a differentiation and the total production (output) of this one or more plant(s) is used as basis for the System Input. As always, corrections must be made for known errors as with the 'Own Sources', it is important to note that water losses at raw water transmission systems and losses during the treatment process are not part of the Annual Water Balance calculations. In case the utility has no distribution input meters, or they are not used, and the key meters are the raw water input meters, because these are the meters that they buy the raw water on, the system input must be based on the raw water meters and treatment plant use/loss has to be considered
- As per As Is situation, Nagpur water supply scheme draws water from two surface water sources. Here, system input volume is considered as sum of both. There are fixed type inline bulk flow meters in the water supply system. During the study, portable clamp on type portable ultra-sonic flow meters were used for taking the reading on quantum of water flowing through. The readings were taken by deploying teams with the instruments at various stages for measurement for total of 24 hours' period for the analysis of system input as well as the comparison of fixed type inline meters. The results of the study for surface water are summarized below.

Table 24 System Input

Sr. No.	Type of Source	Name of Source	Water Extracted (MLD)
1	Surface Water	Pench Dam	465.68
2	Surface Water	Kanhan River	220.43
Total System Input			**686.11**

Total water extracted from two water source is 686.11 MLD.

System Input Volume = 686.11 MLD

11.2 AUTHORIZED CONSUMPTION

The volume of metered and/or unmetered water taken by registered customers, the water supplier and others who are implicitly or explicitly authorized to do so by the water supplier, for residential, commercial and industrial purposes. It also includes water exported across operational boundaries.

Authorized consumption may include items such as firefighting and training, flushing of mains and sewers, street cleaning, watering of municipal gardens, public fountains, frost protection, building water, etc. These may be billed or unbilled, metered or unmetered.

11.2.1 BILLED AUTHORIZED CONSUMPTION

Those components of Authorized Consumption which are billed and produce revenue (also known as Revenue Water). Equal to Billed Metered Consumption plus Billed Unmetered Consumption.

Please note that average quantity is considered for billing as per consumer data.

BILLED METERED CONSUMPTION

All metered consumption which is also billed. This includes all groups of customers such as domestic, commercial, industrial or institutional and includes water transferred across operational boundaries (water exported) which is metered and billed.

Table 25 Billed Metered Consumption

Calculation for Billed Metered Consumption			
Zone	**Total Connections found**	**Connections with water meter**	**% of connections with water meter**
Laxmi Nagar	1192	1189	99.75%
Dharampeth	10610	10324	97.30%
Hanuman Nagar	6637	6513	98.13%
Dhantoli	1563	1311	83.88%
Nehru Nagar	6002	5727	95.42%
Gandhibagh	6489	6361	98.03%
Satranjipura	763	534	69.99%
Lakadganj	2928	2858	97.61%
Ashi Nagar	38129	31740	83.24%
Mangalwari	8768	8614	98.24%
Total	**83081**	**75171**	**90.48%**

Source: Consumer Survey Report

In NMC with 90.48% metering at consumer end,

Thus,

=Total connections in the city (368022) * % of connections with water meter (90.48%)

= **332983** connections are metered

Billed metered Consumption= HSC per connection (991.43 lit.) x Total metered connections (332983)

= 330128753 lit.

Billed metered consumption is = 330.13 ML

BILLED UNMETERED CONSUMPTION

All billed consumption which is calculated based on estimates or norms but is not metered. This might be a very small component in fully metered systems (for example billing based on estimates for the period a customer meter is out of order) but can be the key consumption component in systems without universal metering. This component might also include water transferred across operational boundaries (water exported) which is unmetered but billed.

Calculation for Billed Unmetered Consumption			
Zone	**Total Connections found**	**Connections without water meter**	**% of connections with water meter**
Laxmi Nagar	1192	3	0.25%
Dharampeth	10610	286	2.70%
Hanuman Nagar	6637	78	1.18%
Dhantoli	1563	242	15.48%
Nehru Nagar	6002	275	4.58%
Gandhibagh	6489	88	1.36%
Satranjipura	763	229	30.01%
Lakadganj	2928	43	1.47%
Ashi Nagar	38129	6323	16.58%
Mangalwari	8768	79	0.90%
Total	**83081**	**7646**	**9.20%**

Table 26 Billed Unmetered Consumption

Source: Consumer Survey Report

In case of NMC there is 9.20% unmetered consumer

=Total connections in the city (368022) * % of connections without water meter (9.20%)

= **33869** connections are unmetered

Billed unmetered Consumption= HSC per connection (991.43 lit.) x Total unmetered connections (33869)

= 33578966 lit.

Billed metered consumption is = 33.58 ML

Thus, Billed Authorized Consumption = Billed Metered Consumption + Billed Unmetered Consumption

= 330.13 MLD + 33.58 MLD

= 363.71 MLD

<table>
<tr><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th></tr>
<tr><td rowspan="2">System Input Volume (686.11 MLD)</td><td rowspan="2">Authorized Consumption --</td><td rowspan="2">Billed Authorized Consumption (363.71 MLD)</td><td>1) Billed Metered Consumption (330.13 MLD)</td><td rowspan="2">Revenue Water 363.71 MLD 53.01%</td></tr>
<tr><td>2) Billed Un Metered Consumption (33.58 MLD)</td></tr>
</table>

Non-Revenue Water = System Input Volume – Revenue Water

= 686.11 – 363.71

= 322.40 MLD

11.2.2 UNBILLED AUTHORIZED CONSUMPTION

Those components of Authorized Consumption which are legitimate but not billed and therefore do not produce revenue. Equal to Unbilled Metered Consumption plus Unbilled Unmetered Consumption.

1. Public stand post water supply
2. Tanker water supply
3. Corporation offices, Schools, Hospitals.
4. Public Parks & Gardens (old)
5. Public Urinals and toilets.

UNBILLED METERED CONSUMPTION

Table 27 Unbilled Authorized Consumption

Calculation for Unbilled Metered Consumption			
Zone	**Total Connections found**	**Consumers with water meter**	**% of connections with water meter**
Laxmi Nagar	1192	0	0.00%
Dharampeth	10610	0	0.00%
Hanuman Nagar	6637	46	0.69%
Dhantoli	1563	9	0.58%
Nehru Nagar	6002	0	0.00%
Gandhibagh	6489	40	0.62%
Satranjipura	763	0	0.00%
Lakadganj	2928	26	0.89%
Ashi Nagar	38129	66	0.17%

Mangalwari	8768	75	0.86%
Total	**83081**	**262**	**0.32%**

Source: Consumer Survey Report

In NMC with **0.32%** unbilled metered consumer,

Thus,

=Total connections in the city (368022) * % of unbilled metered connections (0.32%)

= **1161** connections are metered

Unbilled metered Consumption= HSC per connection (991.43 lit.) x Total unbilled metered connections (1161)

= 1150626 lit.

Unbilled metered consumption is = 1.15 ML

UNBILLED UNMETERED CONSUMPTION

Calculation of Unbilled Unmetered Consumption			
Zone	**Total Connections found**	**Connections without water meter**	**% of connections without water meter**
Laxmi Nagar	1192		0.000%
Dharampeth	10610		0.000%
Hanuman Nagar	6683		0.000%
Dhantoli	1573	1	0.064%
Nehru Nagar	6002		0.000%
Gandhibagh	6529		0.000%
Satranjipura	763		0.000%
Lakadganj	2955	1	0.034%
Ashi Nagar	38195		0.000%
Mangalwari	8843		0.000%
Total	**83345**	**2**	**0.002%**

Table 28 Unbilled Unmetered Consumption

Source: Consumer Survey report

In NMC with **0.002%** unbilled unmetered consumer,

Thus,

=Total connections in the city (368022) * % of unbilled unmetered connections (0.002%)

= **9** connections are unmetered

Unbilled metered Consumption= HSC per connection (991.43 lit.) x Total unbilled metered connections (9)

= 8793 lit.

Unbilled unmetered consumption is = 0.01 ML

Thus, Unbilled Authorized Consumption = Unbilled Metered Consumption + Unbilled Unmetered Consumption

= 1.15 MLD + 0.01 MLD

= 1.16 MLD

Authorized Consumption = Billed Authorized Consumption + Unbilled Authorized Consumption

= 363.71 MLD + 1.16 MLD = 364.87

<table>
<tr><td rowspan="4">System Input Volume (686.11 MLD)</td><td rowspan="4">Authorized Consumption (364.87 MLD)</td><td rowspan="2">Billed Authorized Consumption (363.71 MLD)</td><td>Billed Metered Consumption (330.13 MLD)</td><td rowspan="2">Revenue Water (363.71 MLD) 53.01%</td></tr>
<tr><td>Billed Un Metered Consumption (33.58 MLD)</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption (1.16 MLD)</td><td>Unbilled Metered Consumption (1.15 MLD)</td><td rowspan="2">Non-Revenue Water (322.40 MLD) 46.99%</td></tr>
<tr><td>Unbilled Un Metered Consumption (0.01 MLD)</td></tr>
</table>

11.3 WATER LOSSES

The difference between System Input Volume and Authorized Consumption. Water losses can be considered as a total volume for the entire system, or for partial systems such as transmission or distribution systems, or individual zones. Water Losses consist of Real Losses and Apparent Losses.

Water Losses = System Input Volume - Authorized Consumption
= 686.11 – 364.87
= 321.24 MLD

11.3.1 APPARENT LOSS

Includes all types of inaccuracies associated with customer metering as well as data handling errors (meter reading and billing), plus unauthorized consumption (theft or illegal use). It is important to note that reducing apparent losses will not reduce physical water losses but will recover lost revenue. Note: Over-registration of customer meters, leads to under-estimation of Real Losses. Under-registration of customer meters, leads to over-estimation of Real Losses.

Apparent Losses = Un-authorized Consumption + Metering Inaccuracies

11.3.2 UN-AUTHORIZED CONSUMPTION:

Estimated Unregistered consumers

Calculation for Un-Authorized Consumption			
Zone	**Total Connections found**	**Unregistered Consumers**	**% of connections with water meter**
Laxmi Nagar	1192	2	0.17%
Dharampeth	10610		0.00%
Hanuman Nagar	6637	50	0.75%
Dhantoli	1563	37	2.37%
Nehru Nagar	6002	204	3.40%
Gandhibagh	6489	247	3.81%
Satranjipura	763	103	13.50%
Lakadganj	2928	101	3.45%
Ashi Nagar	38129	7615	19.97%
Mangalwari	8768	395	4.51%
Total	**83081**	**8754**	**10.54%**

Table 29 Un-Authorized Consumption

Source: Consumer Survey Report

In NMC with **10.54%** Unregistered consumer,

Thus,

=Total connections in the city (368022) * % of Unregistered connections (10.54%)

= **38777** connections are Unregistered

Un-authorized Consumption= HSC per connection (991.43 lit.) x Total Unregistered connections (38777)

= 38444974 lit.

Un-authorized consumption is = 38.44 ML

11.3.3 CUSTOMER METERING INACCURACIES:

Table 30 Consumer Metering Inaccuracies

Calculation of Customer Metering Inaccuracies			

	found	readable meters	with water meter
Laxmi Nagar	1192	52	4.36%
Dharampeth	10610	138	1.30%
Hanuman Nagar	6637	73	1.10%
Dhantoli	1563	74	4.73%
Nehru Nagar	6002	158	2.63%
Gandhibagh	6489	162	2.50%
Satranjipura	763		0.00%
Lakadganj	2928	132	4.51%
Ashi Nagar	38129	1003	2.63%
Mangalwari	8768	147	1.68%
Total	**83081**	**1939**	**2.33%**

Source: Consumer Survey Report

In NMC with **2.33%** damaged and not readable meters found during consumer survey,

=Total connections in the city (368022) * % of damaged and not readable meters (2.33%)

= **8589** connections have damaged and not readable meters.

Metering inaccuracies= HSC per connection (991.43 lit.) x Damaged and not readable meters (8575)

= 8515513 lit.

Damaged and not readable meters = 8.52 ML.

Apparent Losses = Un-authorized Consumption + Metering Inaccuracies
= 38.44 MLD + 8.52 MLD
= 46.96 MLD

1.1.1. REAL LOSSES

Physical water losses from the pressurized system and the utility's storage tanks, up to the point of customer use. In metered systems this is the customer meter. In unmetered situations this is the first point of use within the property. The annual volume lost through all types of leaks, breaks and overflows depends on frequencies, flow rates, and average duration of individual leaks, breaks and overflows.

Note: Although physical losses, after the point of customer use, are excluded from the assessment of Real Losses, this does not necessarily mean that they are not significant or worthy of attention for demand management purpose.

Real Losses = Water losses – Apparent losses
=321.24 – 46.96 = 274.28 MLD

There are following reasons of real losses in water system, some of them are applicable in NMC.

i. Leaks at raw water transmission
ii. Evaporation losses.
iii. Water treatment losses.
iv. Leaks / seepage of reservoirs.
v. Overflows of reservoirs.

vi. Leaks of distribution mains.
vii. Leakages from valves & air valves.
viii. Leakages from service connections up to meter.
ix. Leakages in consumer premises after the meter (not in scope of water audit).

Leakages in Raw Water Transmission losses:

Sr. No.	Description	Total
1	Raw Water Output (ML)	686.11
2	Raw Water Inlet at WTP (ML)	678.64

Table 31 Raw Water Transmission Main Losses

Total RW Transmission Loss = Raw Water outlet – Raw Water at WTP Inlet.

= 686.11 – 678.64

= 7.47 MLD

11.3.4 TREATMENT LOSSES AT WTP:

In Nagpur City there are 5 nos. of WTP's i.e. Pench-I, II, II, IV & Kanhan WTP. The following results are combined losses of all WTP's

Sr. No.	Description	Total
1	Raw Water Inlet at WTP (ML)	678.64
2	WTP Outlet (ML)	671.47

Table 32 Water Treatment Losses

Total treatment losses at WTP.

= 678.64 – 671.47

= 7.17 MLD

11.3.5 LEAKAGES IN PURE WATER TRANSMISSION LOSSES UP TO ESR'S.

Sr. No.	Description	Total
1	WTP Outlet (ML)	671.47
2	Total ESR Inlet (ML)	640.40

Table 33 Pure Water Transmission main losses upto ESRs

= Pure water transmission losses

= 671.47 – 640.40

= 31.07 MLD

11.3.6 DISTRIBUTION MAINS LOSSES & LEAKAGE UP TO SERVICE CONNECTIONS

= Distribution mains losses up to service connections = Real Losses – RW, Pure transmission & Treatment Losses

= 274.28 MLD – 45.71 MLD

= 228.57 MLD

11.3.7 DISTRIBUTION LOSSES

Distribution Losses = Distribution mains losses up to service connections + Apparent Losses

Distribution Losses = 228.57 MLD + 46.96 MLD

=275.53 MLD

11.3.8 OVERALL WATER BALANCE

Following table shows the Water Balance Diagram in this we calculate

<table>
<tr><td rowspan="8">System Input Volume
686.11 MLD
100.00 %</td><td rowspan="3">Authorized Consumption
364.87 MLD
53.18 %</td><td rowspan="2">Billed Authorized Consumption
363.71 MLD
53.01 %</td><td>Billed Metered
330.13 MLD
48.12 %</td><td rowspan="2">Revenue Water
363.71 MLD
53.01 %</td></tr>
<tr><td>Billed Unmetered
33.58 MLD
4.89 %</td></tr>
<tr><td rowspan="2">Unbilled Authorized Consumption
1.16 MLD
0.17 %</td><td>Unbilled Metered
1.15 MLD
0.17 %</td><td rowspan="7">Non Revenue Water
322.40 MLD
46.99 %</td></tr>
<tr><td>Unbilled Unmetered
0.01 MLD
0.001 %</td></tr>
<tr><td rowspan="5">Water Losses
321.24 MLD
46.82 %</td><td rowspan="2">Apparent Losses
46.96 MLD
6.84 %</td><td>Unauthorized Consumption
38.44 MLD
5.60 %</td></tr>
<tr><td>Customer Metering
8.52 MLD
1.24 %</td></tr>
<tr><td rowspan="3">Real Losses
274.28 MLD
39.98 %</td><td>Leakages in Raw Water Transmission
7.47 MLD
1.09 %</td></tr>
<tr><td>WTP Losses
7.17 MLD
1.05 %</td></tr>
<tr><td>Leakages in Pure Water Transmission
31.07 MLD
4.53 %</td></tr>
<tr><td colspan="2">Distribution mains Losses & Leakages on Service Connections up to Point of customer Meter
228.57 MLD
33.31 %</td></tr>
</table>

Figure 13 Water Balance Diagram

Notes: - i) Above measurement figures are for the study Period from October 2019 to April 2020.

ii) NRW stands for Non-revenue water which is inclusive of metering inaccuracies, visible/ invisible leaks, physical losses etc.

iii) NRW may vary on daily basis as per actual inlet and outlet supply depending on variations with respect to voltage and power quality which affects pump discharge. Also Ultrasonic flow meter measurement accuracy may vary from 0.5% to 2% depending on site measurement conditions.

11.4 OVERVIEW OF NRW LEVELS

The following table shows NRW levels of some of the cities which is assessed in last 3 years.

Sr. No.	ULB	State	Assessment year	Name of Project	NRW
1	Vasai Virar	Maharashtra	2018	MSNA	43%
2	Nagpur	Maharashtra	2020	NRW	47%
3	Pimpri Chinchwad	Maharashtra	2018	NRW	50%
4	Lucknow	Uttar Pradesh	2018	Smart City	55%
5	Korba	Chatisgarh	2018	AMRUT	57%
6	Rajnandgaon	Chatisgarh	2018	AMRUT	59%
7	Jalgaon	Maharashtra	2017	MSNA	65%

12 BASELINE INFORMATION OF THE SYSTEM

12.1 NEED FOR SERVICE LEVEL BENCHMARKS

In every sector, there are few key performance indicators that are understood by most stakeholders in that sector. Similarly, in the urban sector too, there have been a number of performance indicators related to urban management and service delivery that have been defined, measured and reported. However, most initiatives in performance management and service delivery that have been defined measured and reported. However, most initiatives in performance management so far have been observed to have some key limitations, viz.

- Different sets of performance indicators have been defined under different initiatives
- Even for the same performance indicator, the definition may vary or the assignment method may vary, thus inhibiting inter-city or intra-city comparisons
- Most measurement exercises have been externally driven (by agencies external to the agency responsible for delivery against those performance parameters), and therefore the key issue of ownership of performance reports
- Most performance measurement initiatives have been one-off exercises and not been institutionalized, limiting the benefits of morning trends in performance over time
- The process of performance measurement has not been taken further into performance management.

All of the above means that systems for measuring performance and taking further action on them have not been institutionalized in urban agencies. It is therefore important that basic minimum standard set of performance parameters are commonly understood and all stakeholders. Depending on the specific need additional performance parameters can be defined and used.

12.1.1 PERFORMANCE PARAMETERS FOR BASIC URBAN SERVICES

As water supply is a basic need, emphasis has been laid on performance related to reach and access to quantify service; and prevalence and effectiveness of the system of manage the water supply networks. As financial sustainability is critical for continued effectiveness in service delivery, performance is measured on this aspect too.

Service Level Benchmark (SLB) fixed by Ministry of Urban Development (MoUD) for urban water supply. This report provides the assessment of baseline service level benchmark which is summarized as following:

1) Coverage of Water Supply connections
2) Per Capita Supply of Water
3) Extent of Non-Revenue Water
4) Extent of Metering
5) Continuity of Water supplied
6) Efficiency in Redressal of customer complaint
7) Quality of Water Supplied
8) Cost Recovery
9) Efficiency in Collection of Water Charges

12.1.2 COVERAGE OF WATER SUPPLY:

i. Definition:

The PI is defined as total number of households in the service area that are connected to the water supply network with a direct service connection, as percentage of total number of households in that service area. The service area may be either an electoral ward, or the ULB as a whole.

ii. Data Requirement:

a) Total number of households in the service area: The total number of households (not properties) in the service area is required to be calculated. Service area refers to either the ward or the ULB limits.

b) Total number of households with direct water supply connection:

This will include households which receive municipal water supply at one common point, from where it is stored and distributed for all households. Households supplied water through public stand posts or tankers should be excluded. Households completely dependent on other water sources such as bore wells, open wells, etc. should not be included.

Therefore,

PI for Coverage of water supply connections = [(b / a) * 100]

iii. Reliability Scale:

[Level A]; Highest/preferred level of reliability: Calculation based on actual number of households with direct service connections (for which data is maintained); and total number of households as revealed in ground level surveys. Data is periodically updated on basis of building units approved, and new household level water connections provided.

[Level B]; Intermediate level: Estimation of households covered computed as total number of connections (for which data is maintained) as a percentage of estimated number of households on basis of population (total population divided by average household size)

[Level C]; Intermediate level: Estimation of households covered on basis of road length in the city covered by pipeline network, as a surrogate indicator for water supply coverage.

[Level D]; lowest level of reliability: Estimation of households covered on basis of geographical area of the city covered with pipeline network, as a surrogate indicator for water supply coverage.

- **Evaluation of PI for coverage of water supply connections:**

The service area for NMC is considered as a whole. The total number of connections within the area is considered as per the consumer's data and total number of households as per the ground consumer's survey & GIS data, as provided by the utility.

a) Total number of households in the service area = 480261 (As per NMC survey data Annexure-1)

b) Total number of households with direct water supply connection = @ 368022,

Therefore,

- Household Coverage for water supply connections

= (368022/480261) *100

= 77%

Hence, the PI for Coverage for water supply connections is = 77%

12.1.3 PER CAPITAL SUPPLY OF WATER:

Rationale -	:	Adequacy to meet city needs for treated water supply.
Definition -	:	Total water supplied in to distribution system (ex treatment) expressed by population served per day.
Data Requirements	:	Total volume of water supplied to distribution system, water supplied measured with help of flow meter.
Calculation	=	Water supplied to the D/sys per day (Domestic consumption).
	=	**364867129 lit/day**
	=	Population served.
	=	**2319458 soul**
	=	(364867129/2319458)
	=	**157 LPCD**

12.1.4 EXTENT OF METERING OF WATER CONNECTIONS:

Rationale - : Water balance for billed volume.

Definition - : Total number of functional metered connection as a percentage of total number of connections.

Data Requirement : Total number of connection & number of registered metered connection.

Calculation = Total number of functional metered connection.

Total number of connection (registered/Unregistered).

= (322983/368022)*100

= **90%**

12.1.5 EXTENT OF NON-REVENUE WATER:

Rationale - : Financial and Environment sustainability.

Definition - : Difference between total water input and total water sold as percentage of total water input.

Data Requirements : Total water input & total billed volume.

Calculation Total water produced – total water sold X 100.

Total water produced.

= 686.11 MLD – 363.71 MLD X 100

686.11 MLD

= **46.99%**

12.1.6 EFFICIENCY IN REDRESSED OF COMPLAINTS:

Rationale : Responsive to consumer needs.

Definition : Total number of complaints redressed within 24 hrs. of receipt of complaint as a percentage of total number of complaints.

Data required : Total number of water supply complaints received per year and total number complaints redressed within 24 hrs. of next working days.

Reference in report = Annexure-2

Calculation Total number of complaints redressed within 24 hrs/next working days.

Total number of complaints received per year.

= (33791/33791)*100 = **100%**

12.1.7 COST RECOVERY IN WATER SUPPLY SERVICES:

Rationale - : Financial sustainability

Definition - : Total operating revenues expressed a percentage of total operating expenses.

Date Requirement : Operating expenses in year operating revenue in the same year from budget of NMC.

Reference in the report - Annexure-3

Calculation Total operating revenue x 100

Total operating expenses.

= (14636.11/28745.38)* 100

= **50.92%**

12.1.8 EFFICIENCY IN COLLECTION OF WATER RELATED CHARGES

Rationale - : Financial sustainability

Definition - : Current year revenues collected expressed as a percentage of total operating revenues.

Data/study requirement: Data from budget for current revenue collected and current revenue billed. (Excluding arrears)

Reference - Annexure-4

Calculation **-** $\frac{\text{Total current year revenue collected}}{\text{Total current year revenue billed}} \times 100$

= (136.51/140.63)*100

= **97.07%**

12.2 COMPARISON OF EXISTING WATER SUPPLY STATUS WITH (SLB)

Sr. No.	Key Performance Indicators (KPI)	Benchmark as per Urban Development	Existing Status for NMC
1	*Coverage of Water Supply*	*100%*	***(77%)***
2	*Per Capita Supply of Water*	*135 LPCD*	***157 LPCD***
3	*Extent of Non-revenue water*	*20%*	***46.99%***
4	*Extent of Metering of Water Connections*	*100%*	*90%*
5	*Continuity of Supply*	*24 Hrs*	***6 to 7 Hrs***
6	*Efficiency in Redressal of Complaints*	*80%*	*100%*
7	*Quality of Water Supplied*	*100%*	*97%*
8	*Cost Recovery*	*100%*	***50.92%***
9	*Efficiency in collection of water related charges*	*90%*	***97.07%***

Table 34 Service Level Benchmark (SLB)

➢ OUTCOME OF STUDY

- ***Raw Water Transmission Main***

Raw water transmission main losses are worked out to be 7.47 MLD i.e. 1.09%.

- ***WTPs***

7. Losses of Pench-I WTP are worked out to be 1.24 MLD i.e. 0.86%.
8. Losses of Pench-II WTP are worked out to be 1.06 MLD i.e. 0.74%.
9. Losses of Pench-III WTP are worked out to be 1.10 MLD i.e. 1.19%.
10. Losses of Pench-IV WTP are worked out to be 0.82 MLD i.e. 1.03%.
11. Losses of Kanhan WTP are worked out to be 2.96 MLD i.e. 1.34%.
12. **Overall WTPs losses are worked out to be 7.17 MLD i.e. 1.06%**

- ***Clear Water Transmission Main***

✓ 2 no's of Transmission main of Pench-II & Pench-III and seminary Hills MBR losses are worked out to be 2.14 MLD i.e. 1.06%.
✓ Transmission main losses from Pench-I WTP to Governor House MBR are worked out to be 0.92 MLD i.e. 0.69%.
✓ Total Losses of Governor House MBR are worked out to be 1.57 MLD i.e. 1.19%.
✓ Pande lay out feeder main losses are worked out to be 1.11 MLD i.e. 1.34%
✓ Laxmi Nagar feeder main losses are worked out to be 1.24 MLD i.e. 3.73%
✓ Takli sim feeder main losses are worked out to be 2.03 MLD i.e. 5.83%
✓ Semi to fort feeder main losses are worked out to be 4.36 MLD i.e. 9.68%

- ✓ Average clear water Output from Seminary Hills MBR to ESRs & DT is 199.90 MLD.
- ✓ Average clear water received at ESRs/GSRs & DT is 191.15 MLD against 199.90 MLD measured at the outlet point of Seminary Hills MBR.
- ✓ Pench-IV Transmission main clear water losses are worked out to be 1.36 MLD i.e. 1.72%.
- ✓ Omkar Nagar feeder main losses are worked out to be 1.02 MLD i.e. 3.43%
- ✓ Average clear water Output from Governor House MBR to ESRs & DT is 209.14 MLD.
- ✓ Average clear water received at ESRs/GSRs & DT is 206.76 MLD against 209.14 MLD measured at the outlet point of Governor House MBR.
- ✓ Kanhan 1300 mm Transmission main clear water losses upto automotive sq. are worked out to be 0.80 MLD i.e. 0.56%
- ✓ Kanhan 900 mm Transmission main clear water losses upto Sai Mandir @ automotive sq. are worked out to be 0.62 MLD i.e. 0.83%
- ✓ Onwards Sai Mandir, 900 mm clear water feeder main losses upto ESRs/ DT are worked out to be 0.94 MLD i.e. 1.46%
- ✓ Auto 700 mm feeder main losses are worked out to be 0.26 MLD i.e. 2.80%
- ✓ Auto 900 mm feeder main losses upto ESRs/DT are worked out to be 12.91 MLD i.e. 9.71%
- ✓ Average Clear water lifting from Kanhan WTP is 217.47 MLD.
- ✓ Average clear water received at ESRs/GSRs & DT is 201.94 MLD against 217.47 MLD measured at the outlet point of Kanhan WTP.

➢ RECOMMENDATIONS

19. During system study we have identified 04 No's of leakages on 2300 mm section of gravity main from BPT to Mahadula. These identified leakages should be repaired;
20. Leaking air valve is identified behind Pench IV WTP on Pench II RWGM Line. Leaking air valve should be Repairs on priority.
21. Suspected tapping arrangements on air valve observed near Gorewada BPT. Action required for removal of tapping
22. Insertion type flow meter installed at Mahadula on 2300 mm MS line is not in function, should be repaired/replaces.
23. Insertion type flow meter installed at Pench-III WTP Outlet point on 1200 mm MS line is not showing correct reading, it is recommended to replace it with minimum 1000 mm diameter electromagnetic flow meter.
24. It is observed that electromagnetic meter is not installed at various point of MBRs; hence it is recommended to install electromagnetic flow meter for better monitoring of water supply system.

- **Summary of the Proposed electromagnetic flow meters at various points are tabulated below: -**

2300 mm raw water transmission main section

Sr. No.	Pipe Size and Material	Proposed Flow Meter Size	Location
1	2300 mm MS	2000 mm	At Pench Reservoir Head Work
2	2300 mm MS	2000 mm	Near Bharat Petroleum, Parseoni to Saoner Road
3	1400 mm MS for Pench-I	1200 mm	Mahadula Pumping Station
4	1400 mm MS for Pench-II	1200 mm	Mahadula Pumping Station
5	1400 mm MS for Pench-IV	1200 mm	Mahadula Pumping Station
6	1600 mm MS	1200 mm	Inlet to Gorewada BPT
7	1600 mm MS	1200 mm	Inlet to Gorewada BPT

Pench-III WTP

Sr. No.	Pipe Size	Proposed Flow Meter Size	Location
1	1200 mm	1000 mm	Pench-III Outlet

Seminary Hills MBR

Sr. No.	Pipe Size	Proposed Flow Meter Size	Location
1	1200 mm	1000 mm	Pench-II inlet at Seminary Hills MBR
2	1200 mm	1000 mm	Pench-III inlet at Seminary Hills MBR
3	200 mm	150 mm	CPWD DT at Seminary Hills MBR
4	150 mm	100 mm	MES DT at Seminary Hills MBR
5	150 mm	100 mm	Governor House Bunglow DT at Seminary Hills MBR

25. During system study, many Leakages/ seepages are observed in Governor House MBR Premises. It is recommended to rehab/repair on priority.
26. Heavy Leakages are observed on Killa DT line at Governor House MBR. It is recommended to repair on priority.
27. Electromagnetic flow meter installed at Kanhan WTP Inlet point on 1500 mm MS line is not showing correct reading, should be repaired/replaced. All other meters in this study section are working properly.
28. It is observed that electromagnetic meter installed on Kanhan WTP outlet 1300 mm line is of 800 mm size, it is recommended to replace it with minimum 1000 mm diameter electromagnetic meter.
29. Leakages are observed in the interlinking valves between Kanhan WTP Outlet 1300 mm and 900 mm pumping mains, it is recommended to repair.
30. There is considerable amount of wastage of water used for cooling of pump bearings, it is recommended to recirculate this water for reuse.

31. It is observed that the water loss on Takli sim feeder is 2.03 MLD i.e. 5.83%. Most of the losses has been observed on Jaitala GSR feeder due to direct tapings which need to discard from feeder main on priority.
32. It is observed that the water loss on Auto 900 mm network is 12.91 MLD i.e. 9.71 %. The total pipe network length including Auto 900 mm feeder is approx. 27 Km and also water supplied to three zones i.e. Ashi Nagar, Lakadganj & Nehru Nagar Zone. Auto 900 mm transmission main is approx. 38 to 40 years old and line alignment is not traceable of some parts due to encroachment of slums on line, very difficult for leak detection hence, *It is recommended that to replace Auto 900 mm transmission main with new 900 mm MS pipe upto Sakkardara ESR*.
33. All Direct tapings and bulk connections are need to be shifted from feeder to distribution mains. Working for parallel pipe lines is proposed.
34. All working Flow meters in system are need to be calibrated on time to time.
35. All hydrants are need to be shifted from inlet of ESR to outlet with flow meters for better accountability of water.
36. All old and rusted sluice valves are need to be replaced on priority with new butterfly valves.

- OBSERVATIONS & RECOMMENDATIONS OF DMA STUDY.

9. High quantity of Un- registered consumers are found during consumer survey study, needs to be regularized on priority. (i.e. Ashi Nagar Zone)
10. Consumer meters are found rusted/ damages, not showing proper reading, placed under concreting during DMA study should be replaced on priority basis.
11. It is also observed that, some of the consumer's meters are placed & fix in the storage tank and it is very difficult for meter reader for taking reading properly, hence it is recommended that all the meters need to be shifted on ground level for better monitoring for meter reading.
12. There is often damaged taps or no taps to the stand post. It is recommended that all Public stand post should be removed.
13. It is observed that high quantity of average consumer billing (i.e. Ashi Naga Zone), It is strongly recommended that all these billing should be identifying and produce actual volume reading billed to the consumer.
14. Particularly in Garoba Maidan, the Study area that we had selected previously there is double connection in which consumers are getting water from old connection (damaged meters) and Water has not been supplying by the new one.
15. Certain connection has been reported where usages of consumer were less and not according to the size of the family and they were not cooperative.
16. Some consumers were complaining about not getting adequate water because other consumers are using water pumps directly.

12.3 ACTIONS TAKEN ON RECOMMENDATION

As per above observation and recommendation mentioned in draft DPR, NMC prepared an action plan on priority basis to reduced water losses which includes losses reduced till date and losses which will be reduce as per action plan which is immediately recoverable. the action plan of NMC is tabulated below.

Sr. No.	Description	Recommendation	Complainces	Remarks
1	Raw Water Transmission Main	1. During system study we have identified 04 No's of leakages on 2300 mm section of gravity main from BPT to Mahadula. These identified leakages should be repaired;	Leakages Repaired between 6 to 17 Jan. 21	
		2. Leaking air valve is identified behind Pench IV WTP on Pench II RWGM Line. Leaking air valve should be Repairs on priority.	Leakages Repaired	
		3. Suspected tapping arrangements on air valve observed near Gorewada BPT. Action required for removal of tapping	Removed	
		Proposed Flow Meter for Raw Water Transmission main		
		1. 2000 mm dia flow meter proposed at Pench Reservoir Head Work on 2300 mm dia pipe	Will be installed up to 10th Feb. 21	
		2. 2000 mm dia flow meter proposed at Near Bharat Petroleum, Parseoni to Saoner Road on 2300 mm dia pipe		
		3. 1200 mm dia flow meter proposed at Mahadula Pumping Station on 1400 mm dia pipe for Pench-I	Flow Meter Installed between 6 to 18 Jan. 21	
		4. 1200 mm dia flow meter proposed at Mahadula Pumping Station on 1400 mm dia pipe for Pench-II		
		5. 1200 mm dia flow meter proposed at Mahadula Pumping Station on 1400 mm dia pipe for Pench-IV		
		6. 1200 mm dia flow meter proposed at Gorewada BPT Inlet on 1600 mm dia Pench-I line		
		7. 1200 mm dia flow meter proposed at Gorewada BPT Inlet on 1600 mm dia Pench-II line		

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2	Water Treatment Plant	1. Electromagnetic flow meter installed at Kanhan WTP Inlet point on 1500 mm MS line is not showing correct reading, should be repaired/replaced. All other meters in this study section are working properly.	New Flow Meter Installed	
		2. It is observed that electromagnetic meter installed on 1300 mm line is of 800 mm size at Kanhan WTP Outlet, it is recommended to replace it with minimum 1000 mm diameter electromagnetic meter.	In process	
		3. Leakages are observed in the interlinking valves between 1300 mm and 900 mm pumping mains at Kanhan WTP Outlet, it is recommended to repair.	Leakage Repaired	
		4. 1000 mm dia flow meter proposed at Pench-III WTP Outlet on 1200 mm dia pipe.	flow meter procured	
		5. In the premises of all WTP's there are minor leakage on valves is observed during survey, it is recommended to repaired/replace such valves .	In process	

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3	Distribution losses	1. Un- registered consumers are found during consumer survey study, needs to be regularized on priority.	Total 1684 Nos. Un-registered Consumers are disconnected till date	Total 15.79 MLD water saved till date
		2. Consumer meters are found rusted/ damages, not showing proper reading, placed under concreting during DMA study should be replaced on priority basis.	In process	
		3. It is also observed that, some of the consumer's meters are placed & fix in the storage tank and it is very difficult for meter reader for taking reading properly, hence it is recommended that all the meters need to be shifted on ground level for better monitoring for meter reading.		
		4. There is often damaged taps or no taps to the stand post. It is recommended that all Public stand post should be removed.		
		5. It is observed that high quantity of average consumer billing (i.e. Ashi Naga Zone), It is strongly recommended that all these billing should be identifying and produce actual volume reading billed to the consumer.		
		6. Particularly in Garoba Maidan, the Study area that we had selected previously there is double connection in which consumers are getting water from old connection (damaged meters) and Water has not been supplying by the new one.	Total 660 Nos. double connections and 284 Nos. double lines are disconnected till date	

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Annexure III

FEEDERMAIN LOSSES AND ACTION TAKEN

Sr. No	Section	Ceinsys (MLD)	Current Loss (MLD)	Quantum Saved (MLD)	Action Taken	Action Proposed	Target Date
1	P2 & P3 Plant to SH MBR	2.14	1.28	0.86	Bus Bar Activated and shifted Bulk consumer on bus bar. Actual Measurement Done through permanent Flowmeter	Differecne is due to P3 FM fluctuation . P3 Flowmeter Replacement is proposed under R&R	07.01.2021
2	P1 Plant to Governor Hou	0.92	0.92	0	Cause of loss searching is in progress		
3	Loss at GH MBR	1.57	0.77	0.8	Red Tank structural losses saved		
4	Pandey Layout Feeder	1.1	1.1	0	Electric meter stolen, FIR done . MSEB Demand awaited	Activation of Gandhi T-Point FM to calculate actual loss	10.01.2021
5	Taklisim Feeder	2.03	2.03	0	Initiated leak detection on Jaitala 500mm feeder line. Shivpriya tower 500mm valve found heavily passing. Flow difference observed when Jaitala Feeder valve open for Jaitala Supply	Replecement of Shivpriya Tower 500mm Valve	04.01.2021
6	Laxminagar Old Feeder	1.24	1.24	0	After surveliance leakage observed near bajiprabhau Statue at Ramnagar Sq	Leakage near Baji Prabhu Statue at Ramnagar. Feeder is under replcment in amrut.	
7	Semi-fort Feeder losses	4.36	4.36	0	One suspected online valve found at bhagwaghar sq, we have closed the valve and checked, SBI flow meter flow reduced to 40m3/hr from 200 m3/hr . Again we have closed the both Ganjakhet tapping valve and open the Bhagvaghar sq valve and observed 200-250m3/hr flow on SBI flow meter. It is concluded that approx. 200-250 m3/hr missing flow observed from Bhagavaghar to Ganjakhet Sq (700 mtr) .	Replacement of 700mtr pipeline from bhagavaghar sq to Ganjakhet sq. or Volume to be considered as a "billed and collected" by installing portable flow meter on both end . Encasing proposed under R&R.	06.01.2021
8	P-4 Feeder	1.36	0.8	0.56	Srinagar DT valve was freely rotating , by leak detection team it is detected and valve was closed permanantly .		
9	Omkar Nagar Feeder Mai	1.02	0.5	0.52	Actiual measurement done by installing permanent flowmeter	Siraspeth DT Measurement and Closure	15.01.2021
10	Kanhan 1300 to Automot	0.8	0	0.8	closed Akashwani DT		
11	Central KN 900	1.56	0.6	0.96	Close Pili Nadi Scour Valve which was fond 1 thread leak	Leakage on KN900X600 line at Indora Sq	04.01.2021
12	Auto KN700 Feeder	0.26	0.26	0			
13	Auto KN900	12.91	3.41	9.5	1. After leak detection on Kanhan Auto 900mm pipeline , one leakage with losses of 96M3/Hr is found in front of Cancer Hospital, Kalamana Road which is attended and saved Approx. 1.9 MLD		
					2. After portable flow meter installation and investigation , it is observed that water enters in 700mm KN700 feeder line through Kalmna ESR Premises and Nagoba Mandir valve. We have inserted end plate at both section and saved approx. 4 MLD.		
					After leak detection on 900mm Kanhan pipeline at Gangabai Ghat on Kilimahal 400mm tapping, valve found partially open 6 thread open . We have closed the valve and saved approx. 150m3/hr flow and saved 3.6 MLD		
		31.27	17.27	14			

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As per above action plan total 13.20 MLD of pure water loss is recovered by NMC till 11.01.2021 against 31.27 MLD of physical loss 0.8 MLD of loss will be reduce till 15.01.2021, now the physical loss is 18.07 ML

13 ANNEXURES

ANNEXURE-1: TOTAL CONNECTIONS

Amol Pande <amol.pande@ocwindia.com>
To: water works nmc <sdehqww@gmail.com>
Cc: Sanjoy Roy <sanjoy.roy@ocwindia.com>

Mon, Aug 24, 2020 at 1:50 P

Dear Sir,

As required below is the data of consumer count zone wise & category wise,

Zone Number	R1	SLUM	IA	IB	C1A	C1B	C2	Grand Total
01	32,034	4,910	107	682	533	207	1	38,474
02	24,179	14,157	223	1,481	832	341	7	41,220
03	31,903	2,300	43	172	180	77	6	34,681
04	17,130	3,728	100	231	297	94	5	21,585
05	33,720	9,290	93	102	181	67	3	43,456
06	15,020	12,108	138	363	312	44	5	27,990
07	21,334	21,894	201	194	200	12	1	43,836
08	30,613	10,568	360	473	686	106	4	42,810
09	32,252	10,028	29	133	190	45	14	42,691
10	23,260	7,024	347	232	368	42	6	31,279
Grand Total	**2,61,445**	**96,007**	**1,641**	**4,063**	**3,779**	**1,035**	**52**	**3,68,022**

Regards

Amol

https://mail.google.com/mail/u/0?ik=548a8bc5dd&view=pt&search=all&permthid=thread-f%3A1675894190448192214%7Cmsg-f%3A1675894190... 1/2

ANNEXURE-2: CONSUMER COMPLAINTS

Zone	2017-18			2018-19			2019-20		
	Complaints Received	Attended	Pending	Complaints Received	Attended	Pending	Complaints Received	Attended	Pending
Laxmi nagar	3174	3174	-	3238	3238	-	3300	3300	-
Dharampeth	3829	3829	-	4277	4277	-	3840	3840	-
Hanuman nagar	3379	3379	-	3467	3467	-	3286	3286	-
Dhantoli	2389	2389	-	2096	2096	-	2032	2032	-
Nehru nagar	2891	2891	-	3146	3146	-	3197	3197	-
Gandhibag	3050	3050	-	2810	2810	-	2199	2199	-
Satranjiura	3881	3881	-	3678	3678	-	3254	3254	-
Lakadganj	3809	3809	-	3335	3335	-	3567	3567	-
Ashi Nagar	4310	4310	-	4653	4653	-	4308	4308	-
Mangalwari	3515	3515	-	3641	3641	-	3823	3823	-
Total	**34227**	**34227**	**0**	**34341**	**34341**	**0**	**32806**	**32806**	**0**

ANNEXURE-3 COST RECOVERY

Water Works Department

Statement of Income & Expenditure in the period 2001-02 to 2018-19

as per Budget Book (All figures are in lacs)

	Year 2001-02	Year 2002-03	Year 2003-04	Year 2004-05	Year 2005-06	Year 2006-07	Year 2007-08	Year 2008-09	Year 2009-10	Year 2010-11	Year 2011-12	Year 2012-13	Year 2013-14	Year 2014-15	Year 2015-16	Year 2016-17	Year 2017-18	Year 2018-19
Expenditure	6166.17	7675.50	6391.34	4824.63	5612.14	6109.74	7271.75	8110.82	7325.32	8766.84	13821.68	16767.32	15862.05	15741.83	16583.84	23602.92	25972.72	24138.17
Debt Service		293.61	1957.61	1664.00	1664.00	3750.00	3750.00	3750.00	1185.85	1970.95	2006.09	5100.95	4390.09	4112.37	3791.69	4118.05	4851.48	3552.79
Depreciation						1620.00	1782.00	1960.00										
Total Expenditure	6166.17	7969.11	8348.95	6488.63	7276.14	11479.74	12803.75	13820.82	8511.17	10737.79	15827.77	21868.27	20252.14	19854.20	20375.53	27720.97	30824.20	27690.96
Total Income	4536.40	4566.00	5021.08	5194.50	4959.98	5081.56	5120.67	5117.00	7139.23	8970.80	7706.81	8269.65	9566.75	10653.75	12017.01	14679.15	15474.66	13754.52
Deficit	-1909.47	-3403.11	-3327.87	-1294.13	-2316.16	-6398.18	-7683.08	-8703.82	-1371.94	-1766.99	-8120.96	-13598.62	-10685.39	-9200.45	-8358.52	-13041.82	-15349.54	-13936.44

Executive Engineer (W.W.)

ANNEXURE-4 DEMAND & RECOVERY

Year	Demand (Cr.)	Recovery (Cr.)
2017-2018	134.08	132.56
2018-2019	142.44	137.31
2019-2020	145.38	139.65

ANNEXURE-5 POPULATION

Annexure V
Poppulation per Connection

Zone No.	Batch 1		Batch 2		Batch 3		Total Count of CAN	Total Sum of No. of Persons		MCM included in zones			
	CANs	No. of Persons	CANs	No. of Persons	CANs	No. of Persons				B1	B2	B3	Total
1	13,639	88,917	10,814	74,396	13,223	1,05,491	37,676	2,68,804		6.52	6.88	7.98	7.13
2	17,248	1,78,285	11,937	61,584	11,262	77,176	40,447	3,17,045		10.34	5.16	6.85	7.84
3	12,056	62,715	11,014	73,443	8,396	44,539	31,466	1,80,697		5.20	6.67	5.30	5.74
4	6,279	40,563	5,598	38,452	9,247	57,423	21,124	1,36,438		6.46	6.87	6.21	6.46
5	14,258	89,657	16,897	99,892	14,584	89,547	45,739	2,79,096		6.29	5.91	6.14	6.10
6	8,783	59,874	11,837	81,236	6,040	48,975	26,660	1,90,085		6.82	6.86	8.11	7.13
7	13,754	95,879	12,951	88,769	9,418	72,698	36,123	2,57,346		6.97	6.85	7.72	7.12
8	15,559	94,879	11,840	75,624	14,892	77,965	42,291	2,48,468		6.10	6.39	5.24	5.88
9	14,029	76,985	16,156	95,254	11,020	69,874	41,205	2,42,113		5.49	5.90	6.34	5.88
10	7,073	40,114	11,533	81,969	10,431	77,283	29,037	1,99,366		5.67	7.11	7.41	6.87
Grand Total	1,22,678	8,27,868	1,20,577	7,70,619	1,08,513	7,20,971	3,51,768	23,19,458		6.59	6.46	6.73	6.61

(OCW) 11/01/2021

(OCW)

ANNEXURE-6 SCHEMATIC FLOW DIAGRAM