Grenze International Journal of Engineering and Technology, June Issue

Design and Analysis of a 24x7 Water Distribution Network using WaterGEMS for Bhilai's DMA Zoning

R.A. Borkar[1], R. M. Bhagat[2], A. S. Kurzekar[3], H. M. Warhade[4], P. B. Pande[5] and A.V. Rasekar[6]
[1-6]Civil Engineering Department, Yeshwantrao Chavan College of Engineering, Nagpur, Maharashtra, India
Email: rushalborkar16@gmail.com, rmbhagat@ycce.edu, askurzekar@ycce.edu, hmwarhade@ycce.edu, pbpande@ycce.edu, aartirasekar202@gmail.com

***Abstract*— The following research is aimed at the design of a 24x7 water distribution at Bhilai with the help of WaterGEMS to combine DMA and Sub-DMA zoning which provides uninterrupted supply and velocity with constant pressure in the system. The design is based on CPHEEO standards and its goals are 135 LPCD, taking into account the financial and technical limitations. The study forecasts population and demand on three levels, 2026 (63,383 people; 10.81 MLD), 2041 (82,062 people; 13.79 MLD) and 2056 (104,431 people; 17.35 MLD). Leaks and maintenance are easily detected and maintained with the implementation of DMAs. The network is designed to reduce the head loss and energy use whilst being hydraulically efficient. One of the key elements is the incorporation of an IoT-based SCADA system to monitor it in real-time and remotely control it. In this system smart sensors, ultrasonic level switches, electromagnetic flow meters, and pressure transmitters are used to measure flow, pipe pressure, and tank levels. This suggested system will provide fair, non-stop water supply and management of the resources. The findings will offer a cost-effective method to modernize urban networks of water supply by offering a practical reference in the optimization of infrastructures to meet the demands of dynamic urbanities.**

***Keywords*— Water distribution network, WaterGEMS, DMA, Sub-DMA, Network, Continuous Water-supply.**

I. INTRODUCTION

The need of water is a very crucial thing in our life nowadays. One of the significant emerging trend in the management of water supply is the provision of continuous water supply i.e. 24x7 water supply to all the consumers all the year round. The supply is made by the accurate design of the water distribution network with optimum design of pipes, pumps and tanks, etc. to minimize the overall cost of the project [1-3]. 24x7 Water supply refers to provide water at full pressure 24 hours a day. The system ensure that every consumer receive water continuously which is crucial for public health and reducing the need for water storage [4-6]. 24x7 continuous pressured water supply overcomes deficiencies in intermittent supply, ensuring comfort for the user and helps the vulnerable [7,8]. The distribution network includes pumps, pipes, valves and other infrastructure so that water reaches consumers efficiently and at the desired pressure [9,10].

A. Project Location

Water is needed in all the living organisms; it is also essential in socio-economic development of a nation. Water supply infrastructure is water distribution network that is mandatory.

Grenze ID: 01.GIJET.12.2.89_22

The current research on design of water distribution network. of Drug Bhilai city. Chhattisgarh is located in the central part of India as shown in fig 1. It was originally part of the state of Madhya Pradesh and is positioned between 21.270N & 81.600E. It is the 10th biggest state in India with a territory of 1,35,194 km2 (52,199 mi2). With a population of 25,545,198 (2011). The state of Chhattisgarh ranks as the 17th most populated state in India. The country uses it to produce electricity and steel (15% of the Total production) that India uses. Water supply is important of it. The quality provided to each citizen is adequate and cost effective the quantity falls short of expectations. According to data gathered from a government organization, the amount of water delivered to consumers does not meet satisfactory levels based on our survey. Despite the area being well planned, consumers do not meet satisfactory levels based on our survey. Despite the area being well planned, consumers have reported certain issues. To address these concerns, we have decided to design the water distribution network using Bentley WaterGEMS software, which will be beneficial for the Gram Panchayat in the future.

Figure 1: Project Location (Map of Chhattisgarh and Bhilai)

B. WaterGEMS

The WaterGEMS has been first invented by the Company Haestad Methods, Inc. headquartered at Watertown, CT. In mid-2004, this firm was acquired by Bentley Systems, out of which the product starting to be commercially known as Bentley WaterGEMS. WaterGEMS is an effective but simple to use software that enables engineers to analyse complicated pumping systems and piping networks when they shift between one steady state to the next. Hydraulic transients are temporary events only of a few minutes or seconds but can cause damage to a system and result in serious operational challenges. Engineers can develop safe and cost-effective surge-control systems by using WaterGEMS to better understand their pumping and piping networks [11-13]. WaterGEMS is supported by a long-term partnership between GENIVAR and Bentley and is based on technology initially developed by GENIVAR, the water WaterGEMS specialists. Bentley & GENIVAR are committed to continuously improving WaterGEMS [14,15].

C. PLC SCADA

PLC (Programmable Logic Controller) are industrial computers, which allow the real-time and direct control of machine such as motors and conveyors based on logic-based programming. They offer device-level automation, which is very accurate, by checking on the inputs and carrying out instantaneous control operations. On the contrary, SCADA is a software product with high level that is employed to perform central supervision, data presentation, and coordination of large-scale factories [16,17]. It communicates with PLCs to offer operators graphical Human-Machine Interfaces (HMIs), data logging and alarms as well as performance analysis. Whereas PLCs do not include the real-time equipment interfaces in their localized approach, SCADA provides extensive monitoring and supervisory control. Collectively, these technologies combine to take industrial automation to the utmost level, increase operational efficiency, and make better decisions based on wholesome data management and coordination at a distance [18,19].

D. District Metering Area (DMA)

The DMA is a methodology applied in an effort to improve the management of water distribution networks with the division of the system into small segment DMA. This is achieved through the installation and closure of isolation valve on some pipes that connect one DMA to the other (closed links) and installation of flow meter on the rest of the connecting pipes (open links). The water balance of the DMA can be obtained based on the measured inflow and outflow of each DMA taking into consideration storage hence to monitor the minimum night flow. This data would be significant in identifying the leakages in the district. The data of demand that is gathered on DNA level can also be effectively deployed in real time management system [20,21].

E. Literature Review

Salunke et al. developed an optimal water network at Bakori, Pune to replace the poor water supply systems of tanker and borewell through the use of Bentley WaterGEMS. The authors used Hazen-Williams, Manning and Darcy-Weisbach hydraulic simulation equations by combining GPS surveys and population prediction. The model that comes out is sufficient in the pressure and cost-effectiveness aspects proving that modern hydraulic tools are crucial in handling the increasing urban water pressures [22]. Tina Mavi and D.R. Vaidya came up with a 24/7 continuous water supply system that is designed on the basis of GIS-based hydraulic modelling and 3D contour loading. They optimized networks over 30-year of projection through District Metering Areas (DMAs) and 135 LPCD estimates of demand. The research confirms that conversion of the unequal flat-rate intermittent supply to the 24/7 monitored service is cost-efficient, decreases the water waste, and results in equitable, sustainable administration of urban water [23]. Hamjad Ali Umachaki et al. designed a model of water that is automated using PLC and SCADA to end human intrusion and theft. The real-time monitoring provides leak detection and automation of pumps using sensors and GSM modules, which save up to 75% of water. This is an economic remedy that will guarantee the urban setting efficiency and sustainability in terms of water management [24]. Dhumal J.R. et al. applied WaterGEMS to develop water supply system that would be 24/7 and it will involve network drawing, demand calculation, EPS, and ESR sizing. They optimized the hydraulic performance and costs by using the Darwin Designer genetic algorithm. The methodology used in Malkapur demonstrates the effectiveness of WaterGEMS in saving time on design, and developing water infrastructure in urban areas in an accurate and sustainable way [25].

II. Materials and Methods

An overview of the methodology is presented in the figure below fig 2.

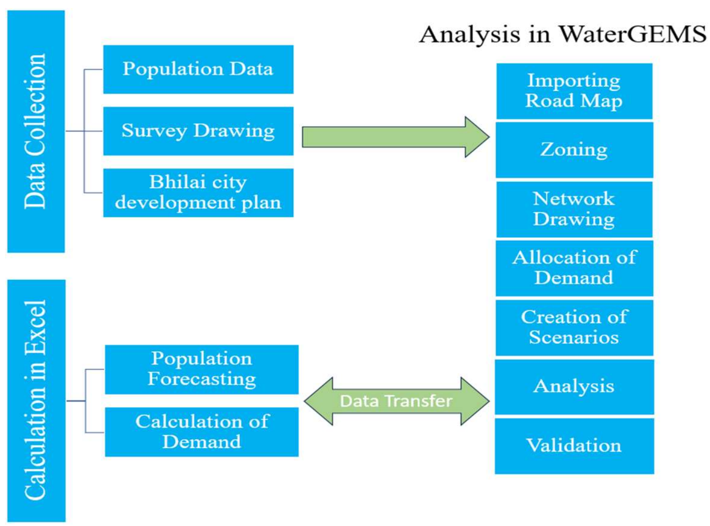

Figure 2: Procedure for Data Collection & Analysis

A. Data Collection

Necessary project information like project area maps as shown in fig 3, topographic sheets, past and ward-wise population census as shown in table I, ward boundary plans, Bhilai city development plan, and land availability of important infrastructure like pumping stations and water treatment plants etc. As per census population data collected from bhilai nagar nigam for 2011 is 625700. will have to be gathered and examined to aid in designing water systems. Bhilai development plan combines elaborate architectural and engineering designs that involve the site layout, structural designs, water supply, services, periodically site visits and adherence to the statutory requirements. This integrated data provides proper analysis of demand, proper site choice of facilities, consistency with city development policies and sustainable infrastructure expansions in accordance with the Bhilai industrial and urban development setting.

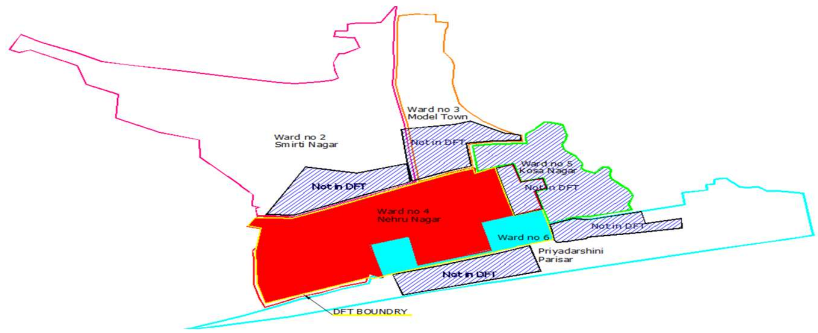

Figure 3: Ward Image of Bhilai city

TABLE I: CENSUS POPULATION PROVIDE BY BHILAI NAGAR NIGAM

Sr. No	Year	Census Population	WARDS NO	WARDS NAME	% area	2011
1	1971	174370	Ward No 2	Smrti Nagar	11%	1426
2	1981	319450	Ward No 3	Model town	35%	5890
3	1991	461352	Ward No 4	Nehru Nagar	100%	15730
4	2001	556366	Ward No 5	Kosa Nagar	100%	16583
5	2011	625700	Ward No 6	Priyadarshini parisar	100%	9750
						49376

B. Population Forecasting and Demand Calculation

As per guideline of Central Public Health and Environmental Engineering Organisation (CPHEEO) Manual on Water supply and treatment, government of India guidelines, the population is forecasted for next 30yr from the base design period. The losses are considered as 10% of gross water demand supplied through distribution network. As shown below in the table II.

TABLE II: CALCULATE POPULATION AND DEMAND OF BHILIA CITY

WARDS NO	WARDS NAME	DFT WARDS	% area	2026	2041	2056
Ward No: 2	Smrti Nagar	NON DFT AREA	11%	2153	2800	3554
Ward No: 3	Model town	NON DFT AREA	35%	6092	7827	10007
Ward No: 4	Nehru Nagar	DFT AREA	100%	23504	30565	38793
Ward No: 5	Kosa Nagar	NON DFT AREA	100%	17162	22051	28192
Ward No: 6	Priyadarshini parisar	DFT AREA	100%	14472	18819	23885
		Population		63383	82062	104431
		Demand		10.81	13.79	17.35

C. Network Marking

First import and scale the image, then draw the pipe on top of the image using AutoCAD's drawing tools as shown in fig 4.

Figure 4: Network Marking in branch network

D. WaterGEMS

WaterGEMS, follow these steps: First, layout the network by drawing or importing CAD/GIS data for pipes and nodes. Second, allocate demands using the Load Builder tool based on population or flow data. Third, input elevations via Trex using digital elevation models. Fourth, define components like pump curves and tank levels. Finally, validate and compute the model to analyse hydraulic results like pressure and velocity.

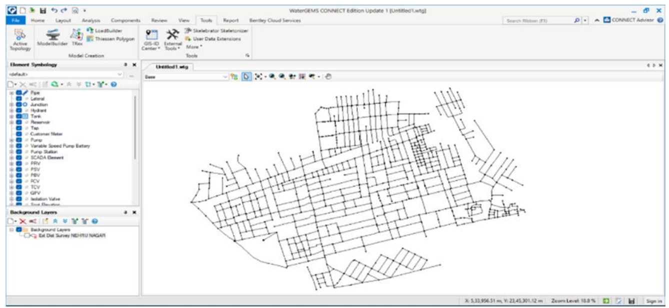

Figure 5: Hydraulic Model of Water Distribution Network

F. Validation

WaterGEMS Model validation makes sure that simulations are realistic. Through a comparison between field data which comprises of pressures, flows, and pump curves against model output, the engineers also tune parameters such as pipe roughness and the settings of valves. This process helps in reducing errors and the hydraulic model is accurate to capture the performance of the real distribution network as shown in fig 6.

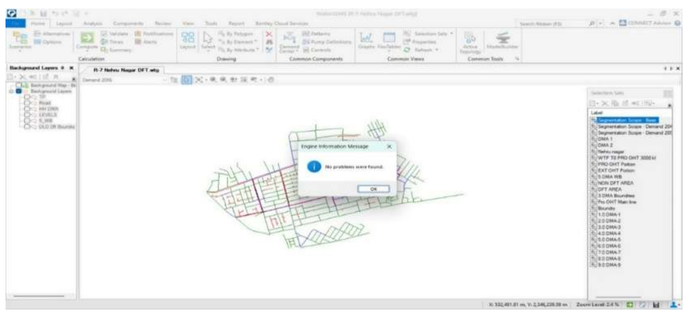

Figure 6: Validation of Network No Error found

III. Results and Discussion

WaterGEMS Software was used to test the developed 24x7 water distribution network of the DMA and Sub-DMA zones of Bhilai as shown in fig 7. The Hydraulic simulation outcome indicates that the pressure in all the junctions is more than 17 mH2O and this guarantees good service levels within the network. The head loss remains below 10m in all pipes, confirming efficient hydraulic performance and minimum energy loss within the system as shown in table III.

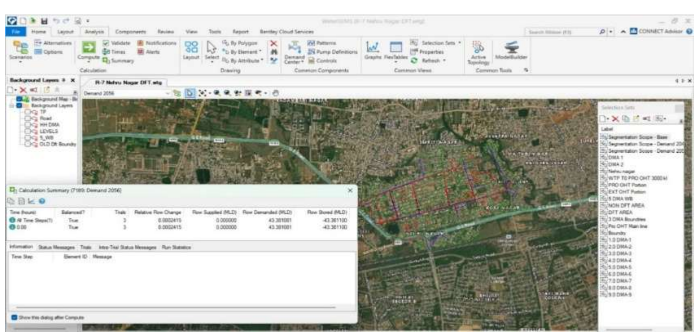

Figure 7: Computed Hydraulic Model of Water distribution network using WaterGEMS

TABLE III: ANALYSIS OF JUNCTION REPORT BY WATERGEMS

Label	Elevation(m)	Demand (MLD)	Hydraulic Grade(m)	Pressure (m H2O)
J-1	317.61	0.007825	336.66	19
J-2	317.61	0.025912	336.62	18.98
J-3	317.54	0.018827	336.49	18.91
J-4	317.94	0.147806	336.01	18.04
J-5	317.73	0.117139	336	18.23
J-6	317.54	0.051678	335.99	18.41
J-7	317.45	0.008684	335.99	18.5
J-8	317.55	0.034345	335.99	18.4
J-9	317.41	0.13585	335.99	18.54
J-10	316.87	0.003145	335.99	19.08
J-11	317.77	0.025066	335.98	18.17
J-12	318.06	0.013541	335.98	17.89
J-13	318.04	0.019104	335.98	17.9
J-14	317.79	0.012947	335.98	18.16
J-15	318.19	0.070167	335.97	17.75
J-16	317.93	0.003913	335.95	17.98
J-17	317.28	0.021975	335.95	18.63
J-18	317.89	0.01529	335.95	18.02
J-19	317.78	0.014328	335.95	18.13
J-20	318.02	0.019384	335.94	17.88
J-21	318.36	0.016641	335.94	17.54
J-22	318.18	0.00533	335.94	17.72
J-23	318.07	0.007346	335.94	17.83
J-24	318.26	0.023452	335.94	17.64
J-25	317.48	0.008712	335.94	18.42
J-26	317.73	0.014133	335.94	18.17
J-27	317.51	0.012162	335.93	18.39

The table III shows the hydraulic parameters at every node, elevation, demand, hydraulic grade and pressure. Analysis of table shows the distribution pressure across network.

In Node J-69 and J-71 pressure is highest (around 21 mH2O) and Node J-32 and J-71 have lowest pressure (around 17 mH2O).

TABLE IV: ANALYSIS OF PIPE TABLE REPORT BY WATERGEMS

Start Node	Stop Node	Length (m)	Diameter (mm)	Material	Hazen-Williams C	Flow (MLD)	Headloss Gradient (m/km)	Velocity (m/s)
T-1 NEHRU NAGAR EXT OHT-1 CAP 3200 KL	FCV	16	500	DI K-7	130	43.381044	10.5977	2.557
FCV	J-1	85	500	DI K-7	130	43.381044	10.597	2.557
J-1	J-2	7	500	DI K-7	140	29.78298	4.6012	1.756
J-2	J-181	282	400	DI K-7	140	23.379692	8.7185	2.153
J-185	J-305	408	400	DI K-7	140	19.154648	6.0272	1.764
J-305	J-311	72	400	DI K-7	140	17.223867	4.9505	1.586
J-1	J-3	53	400	DI K-7	140	13.590239	3.1922	1.252
J-3	J-35	109	350	DI K-7	140	13.571412	6.1017	1.633
J-311	J-396	284	400	DI K-7	140	12.446729	2.7127	1.146
J-35	J-37	5	350	DI K-7	140	11.730581	4.6546	1.411
J-396	J-402	172	300	DI K-7	140	6.768509	3.5645	1.108
J-402	J-417	41	250	DI K-7	140	6.764296	8.6535	1.595
J-417	J-528	120	250	DI K-7	140	6.753925	8.6288	1.592
J-528	J-589	100	250	DI K-7	140	6.708949	8.523	1.582
J-396	J-405	130	250	DI K-7	140	5.673008	6.2469	1.338
FCV-1	J-38	3	350	DI K-7	140	5.440707	1.1208	0.655
J-37	FCV-1	6	350	DI K-7	140	5.4407	1.1243	0.655
J-405	J-416	48	250	DI K-7	140	3.616434	2.7138	0.853
J-416	FCV-7	9	200	DI K-7	140	3.600766	7.9827	1.327
FCV-7	J-435	106	250	DI K-7	140	3.600761	2.6918	0.849
J-589	FCV-8	13	250	DI K-7	140	3.521694	2.5833	0.83
FCV-8	J-595	4	250	DI K-7	140	3.52169	2.5825	0.83

J-589	J-609	64	250	DI K-7	140	3.165015	2.1199	0.746
J-609	FCV-9	18	250	DI K-7	140	3.1198	2.0632	0.736
FCV-9	J-639	114	250	DI K-7	140	3.119797	2.0641	0.736
J-639	J-648	47	200	DI K-7	140	2.913101	5.3912	1.073
J-648	J-655	39	200	DI K-7	140	2.684328	4.6333	0.989
J-38	J-61	54	200	DI K-7	140	2.60024	4.3678	0.958
FCV-3	J-188	2	200	DI K-7	130	2.599697	5.0119	0.958
J-185	FCV-3	6	200	DI K-7	130	2.599693	5.0061	0.958
J-655	J-657	31	200	DI K-7	140	2.541235	4.1852	0.936
J-595	J-610	87	250	DI K-7	140	2.476022	1.3452	0.584
J-38	J-101	177	200	DI K-7	140	2.376472	3.6975	0.876
J-435	J-517	175	200	DI K-7	140	2.347872	3.6156	0.865
J-657	J-667	123	200	DI K-7	140	2.325466	3.5519	0.857
J-188	J-219	47	200	DI K-7	130	2.239463	3.8	0.825
J-116	J-129	138	250	DI K-7	140	2.097376	0.9894	0.495
J-667	J-669	45	200	DI K-7	140	2.081999	2.894	0.767
J-405	FCV-6	5	200	DI K-7	140	2.051016	2.8208	0.756
FCV-6	J-406	3	200	DI K-7	140	2.051011	2.8034	0.756
J-517	J-518	4	200	DI K-7	140	1.952049	2.5632	0.719
J-305	FCV-4	6	200	DI K-7	130	1.91891	2.8549	0.707

TABLE V: SPECIFICATIONS OF PIPES (LENGTH AND DIAMETER) USED IN THE PROJECT

WARD NAME	DI K-7 PIPE DIAMETER (mm)								TOTAL LENGTH (m)
	100	150	200	250	300	350	400	500	
PIPE ABSTRACT	13741	3219	1688	1575	444	123	1099	7	21896

The Pipe table V show the distribution of DI K-7 pipes across different ward in the project area and showing number of pipes of each diameter and its total lengths. In Nehru Nagar extension (OTH capacity is 3200 KL) most of the network consists of 100mm pipes (13,741m) followed by 150mm (3,219m) and 200mm (1,688m) with larger diameters being less frequent.

The overall length of pipes in the area is 21,896 m and this distribution helps in assessing network capacity, flow characteristics and planning maintenance.

TABLE VI: TABLES OF DMA, FLOW METERS AND PRESSURE VALVES USED IN PROJECT

DMA ISOLATION VALVE ABSTRACT		
LABEL	DIAMETER(MM)	NOS
ISO VALVE	100	21
	150	12
	200	17
	250	5
	300	1
	350	1
	400	1
	500	2
TOTAL		60

FLOW METER ABSTRACT		
LABEL	DIAMETER(MM)	NOS
OHT FCV	500	1
DMA FCV	200	5
	250	3
	350	1
TOTAL		10

FLOW CONTROL VALVE ABSTRACT		
LABEL	DIAMETER(MM)	NOS
OHT FCV	500	1
DMA FCV	200	5
	250	3
	350	1
TOTAL		10

PRESSURE RELIEF VALVE ABSTRACT		
LABEL	DIAMETER(MM)	NOS
PRV	100	3
	300	1
TOTAL FLOW METER		4

The valve abstract summarizes the range and distribution of components used in the DMA system. Total 60 isolation valves with diameter ranging from 100mm to 500mm were incorporated, ensuring effective network segmentation. 10 flow control and flow meter, with diameters up to 500mm, were used to regulate and monitor flow across both overhead tank and DMA zones. Four pressure relief valves of diameter 100mm and 300mm is installed to maintain network safely by mitigating pressure surges as shown in table VI.

IV. CONCLUSION

The study focused on design and hydraulic analysis of 24x7 water distribution network for Bhilai using WaterGEMS Software. The software offered a strong platform on which the system could be modelled, simulated and optimized to bring efficiency in performance and cost. The WaterGEMS environment was used to conduct a detailed hydraulic simulation to determine the suitability of the given design parameters of flow, head loss, and pressure distribution. The analysis results indicated that pressure of all junctions was bigger than the minimum pressure needed of head of water 17 m and this guarantees stability in the service delivery of the entire network. Additionally, the value of heads loss in each pipeline was not more than 10 m, which shows that there was minimal energy loss and effective hydraulic operation. These results indicate that designed system is hydraulically balanced and has the capability of delivering uninterrupted water supply without affecting the quality of service and integrity. The proposed model can be used to change the current intermittent network system into an efficient 24x7 water supply network through the optimization of the network layout, pipe sizes, and valve functions. The research establishes that using adequate network zoning, valve regulation and pressure control, it is possible to have continuous water supply even on the current infrastructures through the redesign and operation. All in all, this study determines that the WaterGEMS CONNECT Edition is a potent yet trustworthy program in designing and optimization of 24x7 water distribution network. The approach and findings provided can be used as a guideline to future initiatives to introduce a sustainable and efficient water distribution system in the urban and semi-urban areas.

REFERENCE

[1] CPHEEO Manual on Water Supply and Treatment Systems (Drink from Tap) Manual on Water Supply and Treatment Systems - Drink From Tap - March 2024 : Ministry of Urban Development

[2] Suribabu C.R., Thurvas N.R., Sivakumar P., “Supply Driven Analysis for a Continuous Water Supply Network Based on a Pressure Based Outflow at the House Outlets under Peak Withdrawal Scenarios”, Modelling, 2023, 4(4): 515–528. https://doi.org/10.3390/modelling4040029

[3] Varu S., Shah D., “Design of 24×7 Water Supply Systems – A Case Study: Ahmedabad City”, Drinking Water Engineering and Science Discussions, 2018. https://doi.org/10.5194/dwes-2018-14

[4] Garad A., Shelorkar A., “Risk Identification and Assessment in 24×7 Water Supply Scheme for DMA under Smart City Project”, International Journal of Research in Engineering and Science, Vol. 11, Issue 6, pp. 245–250, 2023. https://doi.org/10.22214/ijraset.2023.52978

[5] Ministry of Urban Development, Government of India, “Guidance Notes for Continuous Water Supply (24x7 Supply)”, Government of India Publication. https://mohua.gov.in/pdf/624eb498862a7Guidelines-for-Planning-Design-and-Implementation-of-24x7-Water-Supply-Systems.pdf

[6] Mukund M. Pawar, Nitin P. Sonaje, “Converting Traditional Water Supply Network Into 24x7, using WaterGEMS to Optimize Design”, International Journal of Recent Technology and Engineering, Vol. 10, Issue 1, pp. 280–285, 2021. https://doi.org/10.35940/ijrte.A5937.0510121

[7] Simukonda K., Farmani R., Butler D., “Development of Scenarios for Evaluating Conversion from Intermittent to Continuous Water Supply”, Urban Water Journal, Vol. 19, Issue 4, pp. 322–334, 2022. https://doi.org/10.1080/1573062X.2021.2024582

[8] Patel H. J., et al., “Analysis and Redesign of 24/7 Water Distribution Network Using Hydraulic Modelling”, International Journal for Research in Applied Science and Engineering Technology, Vol. 10, Issue 6, pp. 1804–1810, 2022. https://doi.org/10.22214/ijraset.2022.44021

[9] BENTLEY Systems., “WaterGEMS CONNECT Edition Update 2 User Manual”, Available at: https://docs.bentley.com/LiveContent/web/Bentley%20WaterGEMS%20SS6v1/en/GUID-7729EB68-D805-4E81-ADD1-6C66FF34C11E.html

[10] Berhane T., "Optimization of Water Distribution System Using WaterGEMS: The Case of Wukro Town, Ethiopia", Civil and Environmental Research, 2020. https://doi.org/10.7176/cer/12-6-01
[11] Navin U., Dohare D., "A Critical Review on Design and Analysis of Water Distribution Network Using WaterGEMS and EPANET Software's", SAMRIDDHI: A Journal of Physical Sciences, Engineering and Technology, 2022. https://doi.org/10.18090/samriddhi.v14i03.21
[12] Switnicka K., Suchorab P., Kowalska B., "The Optimisation of a Water Distribution System Using Bentley WaterGEMS Software", ITM Web of Conferences, Vol. 15, Article 03009, 2017. DOI: https://doi.org/10.1051/itmconf/20171503009.
[13] Sama S., Ramanuj P. S., Patel V. R., "Design and Optimization of Water Distribution Network Using WaterGEMS Software – A Case Study of Adhewada Region of Bhavnagar", International Journal for Research in Applied Science and Engineering Technology, Vol. 13, Issue 4, pp. 649–655, 2025. https://doi.org/10.22214/ijraset.2025.68532
[14] Udhane D., Kataria N., Sankhe S., Pore T., Motegaonkar S., "Hydraulic Modelling and Simulation of Smart Water Distribution Network", International Research Journal of Engineering and Technology (IRJET), Vol. 5, Issue 4, pp. 3636–3640 (or appropriate page range), 2018. https://www.irjet.net/archives/V5/i4/IRJET-V5I4814.pdf.
[15] Darshan J. Mehta, Vipin Yadav, "Design of Optimal Water Distribution Systems Using WaterGEMS: A Case Study of Surat City", IAHR 2024 Proceedings, pp. 155–164, 2017. https://www.iahr.org/library/infor?pid=3016.
[16] Papoutsidakis M., Theocharis E., Piromalis D., Sort A., "SCADA Implementations to Supervise the Water Networks Infrastructures in the City of Athens", International Journal of Computer Applications, 178(25), pp. 14–19, 2019. https://doi.org/10.5120/ijca2019919046
[17] Cheng W., Fang H., Xu G., Chen M., "Using SCADA to Detect and Locate Bursts in a Long Distance Water Pipeline", Water, 10(12), 1727, 2018. https://doi.org/10.3390/w10121727
[18] Beker B. A., Kansal M. L., "Application of SCADA and IoT for Efficient Management of Urban Water Supply System", In Innovation in Smart and Sustainable Infrastructure, Vol. 2, pp. 657–674, 2024. https://doi.org/10.1007/978-981-97-3994-3_44
[19] Kowalska B., Suchorab P., Kowalski D., "Division of district metered areas (DMAs) in a part of water supply network using WaterGEMS (Bentley) software: a case study", Applied Water Science, 12:166, 2022. https://doi.org/10.1007/s13201-022-01688-2
[20] Bui X. K., Marlim M. S., Kang D., "Optimal Design of District Metered Areas in a Water Distribution Network", Water, 13(6), 836, 2021. https://doi.org/10.3390/w13060836
[21] Alvisi S., Franchini M., "A Procedure for the Design of District Metered Areas in Water Distribution Systems", Technical Report. https://doi.org/10.1016/j.proeng.2014.02.006
[22] Salunke P. S., Dumane M. M., Kamble S. P., "An Overview: Water Distribution Network by Using Water GEMS Software", Journal of Advances and Scholarly Researches in Allied Education, Vol. XV, Issue 2 (Special Issue), April 2018, ISSN 2230-7540. https://ignited.in/index.php/jasrae/article/view/7879/15558.
[23] Tina Mavi, Vaidya, "Study and Design of 24/7 Water Supply Distribution System by WaterGEMS", International Journal of Engineering, Science and Mathematics, Vol. 7, Issue 3, pp. 481–486, 2018. https://ijesm.co.in/uploads/68/5358_pdf.pdf.
[24] Hamjad Ali Umachagi, Pavankumar Kulkarni, "Water Distribution Network Design and Analysis using EPANET", 2020 IEEE Bangalore Humanitarian Technology Conference (B-HTC), pp. 1–5, 2020. https://doi.org/10.1109/B-HTC50970.2020.9297887
[25] Dhumal J. R., Danale M. S., Jadhav G. H., "Design of Continuous Water Supply System by Using WaterGEMS", International Journal of Advance Research in Science and Engineering, Vol. 7, Special Issue No. 1, pp. 346–351, 2018. https://www.ijarse.com/images/fullpdf/1526038816_BVNC-21.pdf.