Larhyss Journal, ISSN 1112-3680, n°50, June 2022, pp. 125-136

DESIGN OF THE CONTINUOUS WATER SUPPLY SYSTEM USING WATERGEMS SOFTWARE: A CASE STUDY OF SURAT CITY

***PATEL K.*[1]*, MEHTA D.*[2*]**

[1] PG Student, Department of Civil Engineering, Dr. S. & S. S. Ghandhy Government Engineering College, Surat, India
[2] Assistant Professor, Department of Civil Engineering, Dr. S. & S. S. Ghandhy Government Engineering College, Surat, India

(*) *darshanmehta2490@gmail.com*

Research Article – Available at http://larhyss.net/ojs/index.php/larhyss/index
Received March 2, 2022, Received in revised form June 5, 2022, Accepted June 7, 2022

ABSTRACT

Water shortage is one of the most important challenges as the water demand increases with the growth of the population. To fulfil the demand a water-efficient water distribution network must be needed. The design of a water distribution network is an important task for designers in that the network should be sufficient to provide adequate water with minimum pressure, velocity and flow. The 24x7 water supply is delivered continuous water services 24 hr a day, every day of the year to the consumers. In this study, WaterGEMS software is used to analyze the existing water distribution network. WaterGEMS is a software programme for designing and analyzing water-supply networks, such as observing and recording the pressure heads at each node, the flow, the velocity in each pipe, the hydraulic gradient, etc. All these hydraulic parameters are analyzed by using WaterGEMS software. It was found that the flow in the network is adequate to provide a sufficient amount of water.

Keywords: Heads, Hydraulic Parameters, Junction, Node, Pressure, WaterGEMS.

INTRODUCTION

The life cycle on Earth cannot proceed without water. No rule or equation may represent the value of water to survive in human, plant and animal forms (Urban Water II, 2014). Water is required at any time in the day; we used it to drink, wash, cook, take bathe, swim, etc. (Salunke, 2018). Currently, the daily demand for drinking water is increasing with the increase in population. This demand is fulfilled by providing an adequate water distribution network (Lunagariya, 2016). The design of a water distribution network is the most important infrastructure for water supply (Dhumal, 2018).

The water distribution network is a part of the town and municipality. Hence, its planning and design must be done by city planners and civil engineers with the utmost care, considering the effecting factors such as the location of the town or city, its current water demand, future growth, leakage in the conduits, required pressure in pipes, losses in the pipe etc. (Sultana A and Sultana Q, 2019).

In India, the majority of cities have intermittent water supply systems. Intermittent water supply may be defined as a water supply in a network for less than 24 h per day, every day of the year (Salunke, 2018). This system offers several advantages, including uniform water distribution, reduced water leakage, and time availability for pipe network repair and maintenance (Salunke, 2018; Mehta, 2018). This system also has some disadvantages, such as it is not operated as designed, water is not available at the time of the fire, valves are operated frequently, additional storage is needed, reservoir capacities are often underutilized, more manpower is needed, and during nonsupply hours, it may be contaminated (Dhumal, 2018; Mehta, 2017). Shortages in the intermittent water supply is overcome by a 24x7 continuous water supply, a pressurized water supply that is available for 24 hours a day, every day of the year (Laxman, 2020).

The water distribution network consists of elements such as pipes, pumps, tanks, reservoirs and valves (Shital, 2016). It is crucial to provide water to the consumers; an effective water supply is of paramount importance in designing a new water distribution network or in expanding the existing network. It is also essential to investigate and establish a reliable network ensuring an adequate head (Saminu, 2013).

The analysis and design of pipe networks create a relatively complex problem. WaterGEMS software is a modeling application for the design, analysis and optimization of water distribution networks (Waikhom, 2015; Yadav, 2015). It provides an easy-to-use environment for designers. WaterGEMS software is used for new designs as well as for expansions of existing water distribution networks.

In this study, WaterGEMS software is used to analyze (24x7 continuous water supply) the existing water distribution network of the New North zone of Surat city.

OBJECTIVE OF THE STUDY

The study aims to achieve the following five objectives:

- To study the existing water supply network of a continuous water supply system.
- To collect pipe reports and junction reports of existing network.
- To analyze the data by using WaterGEMS Software.
- To check hydraulic parameters such as pressure heads, velocity, head loss and flow etc.

STUDY AREA

Surat is the western city of the state of Gujarat, India, known for the popularity of diamonds and the textile industry. Surat's population in 2022 is 7.2 million; it is the eighth-largest city in India popularly called the Silk city of India. Surat is a port city situated on the banks of the Tapi River and one of the fastest-growing cities in India (Fig. 1). Surat city covers approximately 326 sq km, and the population density is 14,000 people per sq km, which is a highly densely populated area.

Surat has seven zones and Kosad is located in the New North Zone. In 2011, Surat had a population of 4,466,826, of which 2,543,145 and 1,923,681 were male and female, respectively. The population of the study area, Kosad, is 88,224. The study area covers 4.3 sq. km. The water distribution systems of the New North Zone are, i.e., WDS-K point network systems ESR-K1, ESR-K2 and ESR-K3. The study area covers a large portion of residential areas. In the present paper, the analysis of ESR-K1 is performed using hydraulic simulation software WaterGEMS.

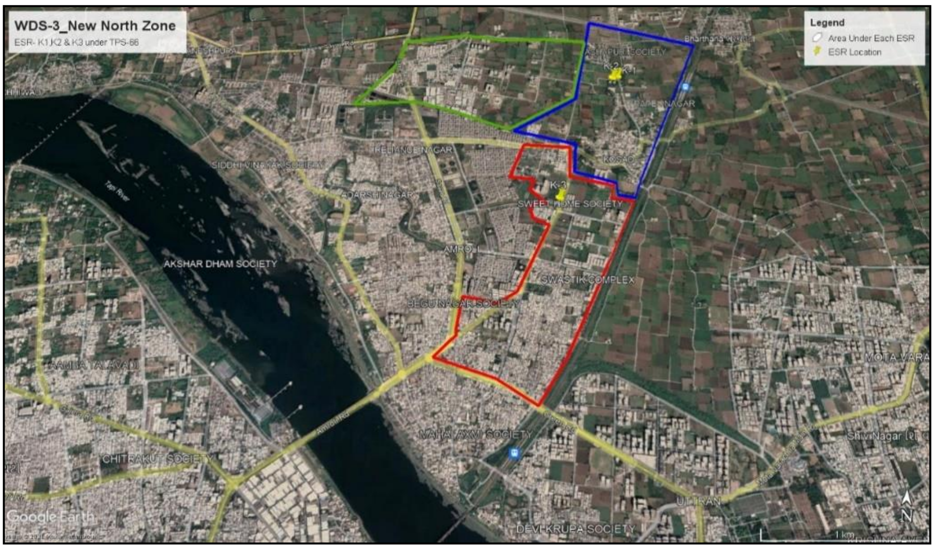

Figure 1: Study Area - The New North Zone of Surat City

DATA COLLECTION

The map of the existing Water Distribution System of the West zone is collected from the Hydraulic Department of S.M.C. (Surat Municipal Corporation). In WaterGEMS software, different input parameters are needed, such as the length of the pipe, the diameter of the pipe, the elevation of junctions, the demand at every node and junction, the definition of the pump, and the location of the reservoir. All the data were collected from the Hydraulic Department of the S.M.C.

METHODOLOGY

The methodology followed in the analysis of the water distribution network is given below.

As discussed earlier the data required in WaterGEMS Software are collected from the S.M.C. and Consultant. WaterGEMS provides a comprehensive yet easy-to-use decision-support tool for water distribution networks. The following steps are used in WaterGEMS software:

Drawing the Layout

The first step is to create a new hydraulic model. As per the existing network drawing first, draw the drawing in WaterGEMS software (Fig. 2).

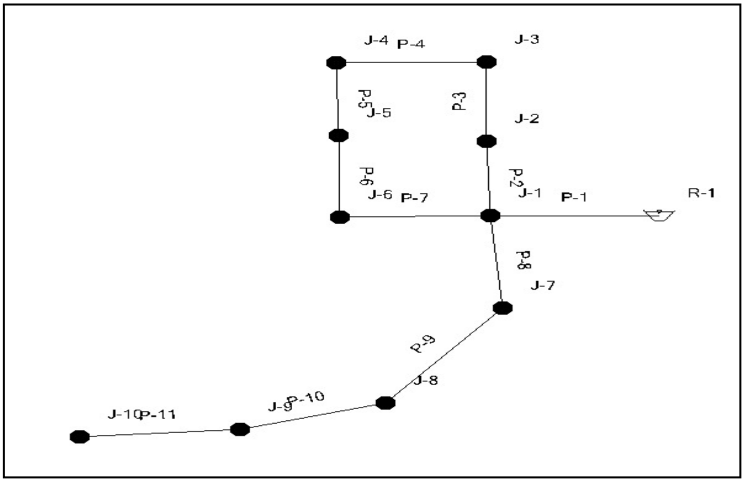

Figure 2: Import the Network

Data entry

With the help of collected data, the following data were entered into the software: length of pipes, diameter, demand, elevation, material, etc. (Fig. 3). Form property editor imports data for Reservoir, Junction and Pipes.

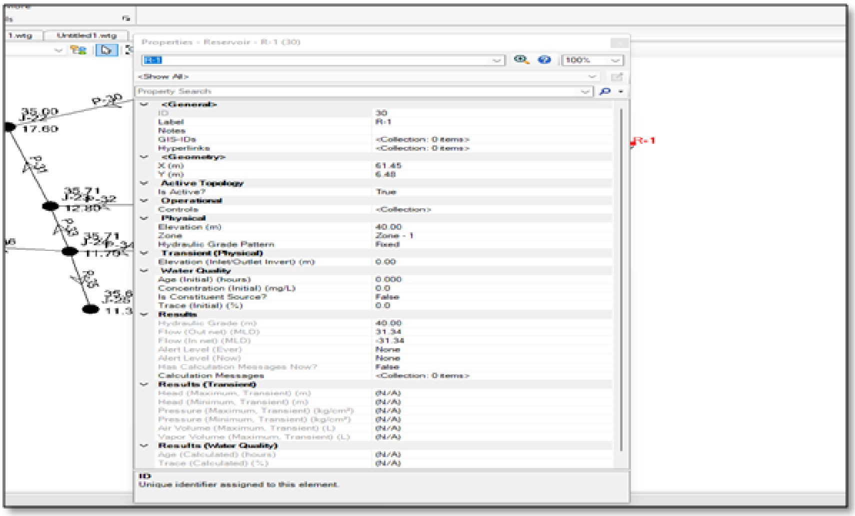

Figure 3: Import data

Import Demand Pattern

For a continuous water supply system, the demand pattern is chosen as and extended period simulation (EPS) (Fig. 4). The multiplying factors were entered for 24 hr.

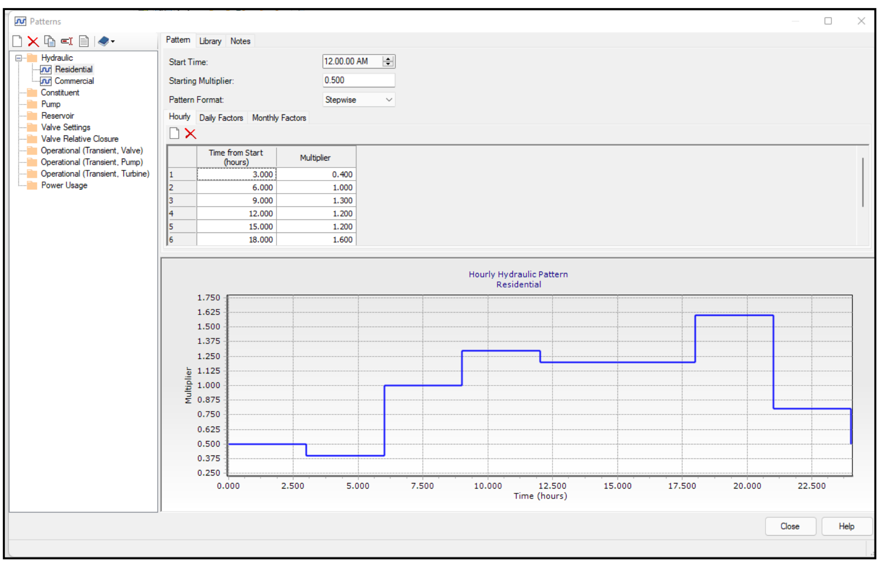

Figure 4: Demand Pattern

Run the model

After all the necessary data are imported, the model is run. Then, flow in the network will be shown in WaterGEMS, as shown in Fig. 5.

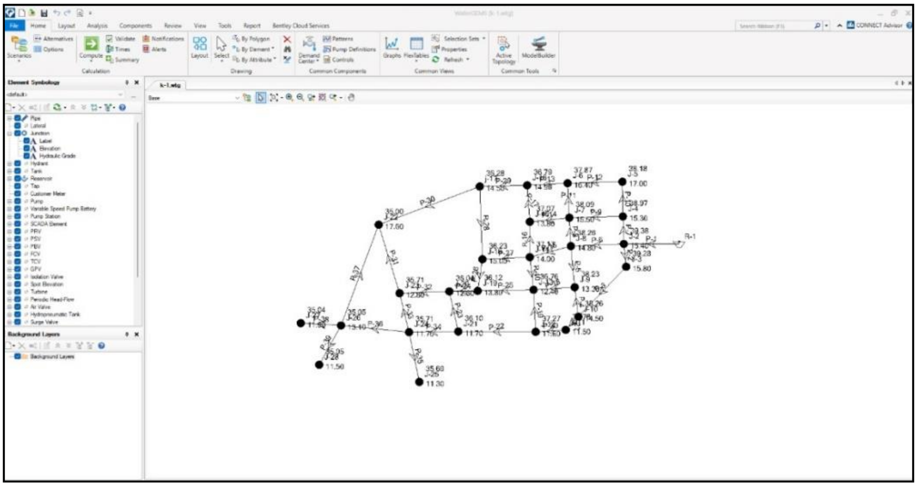

Figure 5: Water Distribution Network of ESR K-1

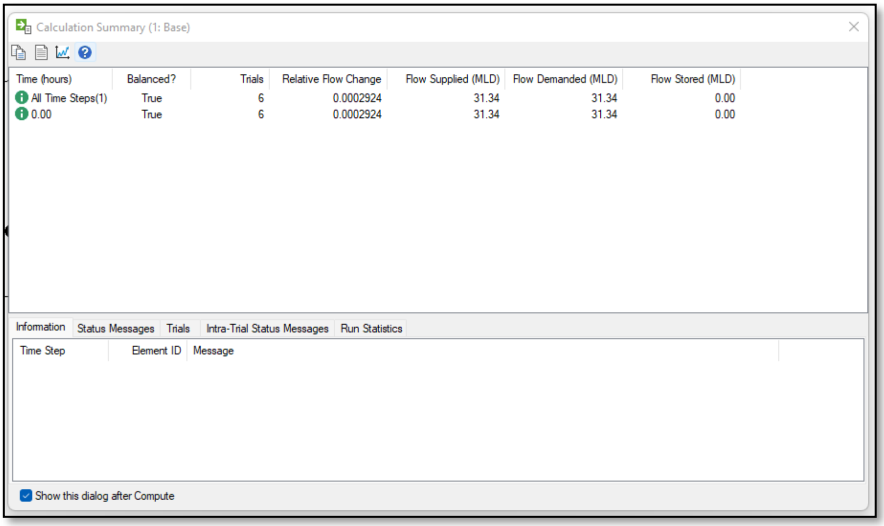

Figure 6: Calculation summary

CALCULATION SUMMARY

The model run calculation summary opens and provides information about the analysis. If the notes are given in green color, then it means that the network is ok (Fig. 6); if it is blue then it gives some information and if it is red then it indicates that there is some issue. Then, open the flex table for the Junction report and Pipe report.

RESULTS AND DISCUSSION

The pipe report of ESR K-1 includes 40 pipes. The material of all pipes is ductile iron and their Hazen-Williams coefficient C value is 140. The range of velocity in the network is between 0.06 and 1.33 m/s. The diameter of the pipes lies between 150 and 600 mm. The maximum error is 0.3, and the minimum error is -0.23 between the existing network and the result of WaterGEMS. The head loss gradient in several of the pipes exceeds 3 m/km, which exceeds the CPHEEO limits. The amount of water flowing through the pipe is sufficient to meet the needs of the end customers. The results obtained using WaterGEMS software are presented in table 1.

Table 1: Pipe Report

Label	Flow rate (L/s)		Velocity (m/s)		Head loss Gradient (m/km)	
	Actual	Water-GEMS	Actual	Water-GEMS	Actual	Water-GEMS
P-1	362.8	362.79	1.28	1.28	2.082	2.082
P-2	132.4	132.36	0.67	0.67	0.782	0.783
P-3	130.1	130.1	1.04	1.04	2.246	2.248
P-4	16.06	16.06	0.23	0.23	0.189	0.186
P-5	12.28	12.28	0.17	0.18	0.115	0.126
P-6	167.4	167.45	1.33	1.33	3.584	3.581
P-7	57.9	57.9	0.82	0.82	2.036	2.038
P-8	24.16	24.16	0.49	0.5	0.981	0.993
P-9	42.52	42.52	0.87	0.87	2.794	2.795
P-10	11.72	11.72	0.66	0.66	3.092	3.1
P-11	22.53	22.53	0.46	0.46	0.862	0.88
P-12	6.26	6.26	0.35	0.36	0.968	0.972
P-13	12.26	12.26	0.69	0.71	3.361	3.499
P-14	25.79	25.79	0.82	0.82	3.282	3.262

P-15	119.9	119.97	1.25	1.24	3.704	3.656
P-16	20.69	20.69	0.29	0.31	0.303	0.379
P-17	24.88	24.88	0.51	0.53	1.036	1.27
P-18	14.3	14.3	0.81	0.83	4.468	4.733
P-19	7.92	7.92	0.45	0.49	1.495	1.753
P-20	98.86	98.87	1.03	1.03	2.589	2.598
P-21	103.0	103.04	1.07	1.07	2.794	2.804
P-22	72.41	72.42	1.02	1.02	3.081	3.04
P-23	6.54	6.54	0.21	0.21	0.259	0.272
P-24	26.67	26.67	0.54	0.48	1.178	0.947
P-25	37.15	37.15	0.76	0.72	2.175	1.971
P-26	16.73	16.73	0.34	0.32	0.497	0.441
P-27	41.62	41.62	0.85	0.87	2.685	2.836
P-28	7.19	7.19	0.23	0.16	0.308	0.152
P-29	30.72	30.72	0.63	0.65	1.53	1.642
P-30	15.79	15.79	0.5	0.61	1.323	1.912
P-31	18.91	18.91	0.39	0.09	0.623	2.74
P-32	28.47	28.47	0.58	0.52	1.329	1.099
P-33	15.09	15.09	0.31	0.06	0.41	0.023
P-34	47.98	47.98	0.68	0.67	1.438	1.4
P-35	1.29	1.29	0.07	0.07	0.052	0.052
P-36	22.75	22.75	0.46	0.69	0.877	1.844
P-37	6.35	6.35	0.2	0.16	0.245	0.15
P-38	2.61	2.61	0.15	0.15	0.192	0.192
P-39	2.04	2.04	0.06	0.06	0.03	0.03
P-40	40.05	40.05	0.57	0.52	1.029	1.017

The junction report contains 27 nodes. The pressure head in the pipes is calculated using Hazen William's formula. According to the CPHEEO manual, a minimum pressure head of 17 m is necessary. There was fluctuation found in the pressure head at junction nodes. The range of the demand was 2.04 l/s to 28.35 l/s. At junction J-22, the pressure head was 15.2 m and demanded 28.35 l/s. It is observed that on junction J-22, the demand is maximum, and the pressure head is less than the minimum value. The results obtained using WaterGEMS software are presented in table 2.

Table 2: Junction Report

Label	Elevation (m)	Demand (l/s)	Pressure (kg/cm2)			Pressure Head (m)
			WaterGEMS	Actual	%Error	
J-2	15.4	5.07	2.394	2.4	1%	23.98
J-3	15.8	2.25	2.344	2.3	-4%	23.48
J-4	15.3	3.66	2.362	2.4	4%	23.67
J-5	17	5.46	2.114	2.1	-1%	21.18
J-6	16.4	16.53	2.143	2.1	-4%	21.47
J-7	15.5	18.36	2.254	2.3	5%	22.59
J-8	14.8	11.04	2.341	2.3	-4%	23.46
J-9	13.3	14.04	2.488	2.5	1%	24.93
J-10	14.5	11.01	2.372	2.4	3%	23.76
J-11	11.5	4.17	2.622	2.6	-2%	26.28
J-12	11.5	18.54	2.572	2.6	3%	25.77
J-13	12.4	25.11	2.432	2.4	-3%	24.36
J-14	14	17.61	2.308	2.3	-1%	23.13
J-15	13.8	21.6	2.323	2.3	-2%	23.27
J-16	14.9	6.42	2.184	2.2	2%	21.89
j-17	14.5	7.74	2.174	2.2	3%	21.78
J-18	15	32.07	2.119	2.1	-2%	21.23
J-19	13.8	27.21	2.227	2.2	-3%	22.32
J-20	12.6	4.74	2.339	2.3	-4%	23.44
J-21	11.7	17.88	2.435	2.4	-4%	24.4
J-22	17.6	28.35	1.736	1.8	6%	15.2
J-23	12.8	24.66	2.286	2.3	1%	22.91
J-24	11.7	8.85	2.396	2.4	0%	24.01
J-25	11.3	1.29	2.434	2.4	-3%	24.39
J-26	13.1	24.45	2.191	2.2	1%	21.95
J-27	11.9	2.61	2.309	2.3	-1%	23.14
J-28	11.5	2.04	2.350	2.4	5%	23.55

CONCLUSION

The current study simulates the existing water distribution system by building a model with WaterGEMS software. It assisted in the analysis of the overall network system as well as the visualization of the effects of individual components and parameters. It is observed that approximately 50% of pipes have a velocity that is less than the minimum velocity. However, if we try to maintain the velocity, other hydraulic criteria, such as head loss, flow and hydraulic gradient are disrupted. From the above study, it was found that the resultant pressure at other junctions and flows is adequate to provide water within the study area. With the use of this WaterGEMS software, one may examine the network from one's desk and predict any errors in the design, as well as the adjustments that must be made in such designs to be executed successfully.

REFERENCES

ALIGHALEHBABAKHANI F., MCELMURRY S., MILLER C.J., ABKENAR S.M. S. (2013). A case study of energy cost optimization in Monroe water distribution system, In 2013 International Green Computing Conference Proceedings, IEEE, pp. 1-5.

BASMENJI A.B., MOJTAHEDI A., REZAYI A. (2017). Analysis of the urban water requisition demand for the purpose of re-engineering and water network optimization (case study: Tabriz'Eram urban area), Civil Engineering Journal, Vol. 3, Issue 9, pp. 672-681.

BENTLEY WaterGEMS CONNECT Edition Update 2 User Manual, https://docs.bentley.com/LiveContent/web/Bentley%20WaterGEMS%20SS6-v1/en/GUID-7729EB68-D805-4E81-ADD1-6C66FF34C11E.html

BERHANE T., AREGAW T.T. (2020). Optimization of Water Distribution System Using WaterGEMS: The Case of Wukro Town, Ethiopia, Journal of Civil and Environmental Research, Vol. 12, Issue 6, pp. 1-14.

BHAGAT S.S., DESAI M.V. (2016). Existing Scenario of Water Supply System in New North Zone, Surat, International Journal of Advanced Research in Engineering Science and Management, Vol. 2, Issue 8, pp. 1-8.

CPHEEO (Central Public Health and Environmental Engineering Organisation). (1999). Manual on Water Supply and Treatment, Third Addition, Ministry of Urban Development, Government of India, New Delhi.

DHUMAL J.R., DANALE M.S., JADHAV G.H. (2018). 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.

DUMANE M.M., SALUNKE P.S., KAMBLE S.P., NALVADE O.S., PONDKULE S.P. (2018). Water distribution network by using WaterGEMS software, International Journal of Creative Research Thoughts, Vol. 6, Issue 2, pp. 1048 – 1053.

JIANG B., ZHANG F., GAO J., ZHAO H. (2012). Building a water distribution network hydraulic model by using WaterGEMS. Proceedings of the International Conference on Pipelines and trenchless Technology, ASCE, pp. 453-461.

KAWATHE L.N., THORVAT A.R. (2020). Analysis and Design of Continuous Water Distribution System against Existing Intermittent Distribution System for Selected Area in Pandharpur, M.S., India, Aquademia, Vol. 4, Issue 2, ep20028.

LUNGARIYA P., KATHAROTIYA N., MEHTA D., WAIKHOM S. (2016). Analysis of continuous water distribution in Surat city using EPANET: a case study. Global Research and Development Journal of Engineering, pp. 1-7.

MAVI T., VAIDYA D.R. (2018). 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.

MEHTA D.J., PRAJAPATI K.J. (2018). Simulation of existing water distribution network at Punagam Area of Surat City using WaterGEMS software. In Urbanization challenges in emerging economies: Energy and water infrastructure; transportation infrastructure; and planning and financing, Reston, VA: American Society of Civil Engineers, pp. 312-321.

MEHTA D.J., YADAV V., WAIKHOM S.I., PRAJAPATI K. (2017). Design of optimal water distribution systems using WaterGEMS: a case study of Surat city, E-Proceedings of the 37th IAHR World Congress "Managing Water for Sustainable Development" at Kuala Lumpur, Malaysia, pp. 1-7.

MEHTA D., KATHORIYA N., WAIKHOM S., YADAV V. (2016). Computer Modeling of Water Distribution Network: a Case Study of Punagam Area, Surat City, National Conference on Water Resources and Flood Management with special reference to Flood Modelling, India, pp. WRH 17-1 to WRH 17-11.

MEHTA V.N., JOSHI G.S. (2019). Design and analysis of rural water supply system using loop 4.0 and water gems V8i for Nava Shihora zone 1, International Journal of Engineering and Advanced Technology, Vol. 9, Issue 1, pp. 2258-2266.

PAWAR M.M., SONAJE N., BAGAL S.C. (2020). Commercial Viability Analysis for Converting Conventional Water Supply System into 24× 7 Water Supply Systems by Using Water Gems, Techno-Societal, Springer Nature Switzerland, pp. 887-894.

PEREZ-SANCHEZ M., SANCHEZ-ROMERO F.J., LOPEZ-JIMENEZ P.A., RAMOS H.M. (2018). PATs selection towards sustainability in irrigation networks: Simulated annealing as a water management tool, Renewable Energy, Vol. 116, Part A, pp. 234-249.

RAI R., DOHARE D. (2019). A review on application of water-gems in hydraulic modeling and designing of water distribution network for simhastha mela area in Ujjain, Global Journal of Engineering Science and Researches, Vol. 6, Issue 5, pp. 400-405.

SALUNKE P.S., DUMANE M.M., KAMBLE S.P., NALVADE O.S., MR. S. P. PONDKULE S.P., BINAYKE R.A. (2018). An Overview: Water Distribution Network by Using WaterGEMS Software, Journal of Advances and Scholarly Researches in Allied Education, Vol. XV, Special Issue, Issue 2, pp. 28-31.

SAMINU A., ABUBAKAR N., SAGIR L. (2013). Design of NDA water distribution network using EPANET, International Journal of Emerging Science and Engineering, Vol. 1, Issue 9, pp. 5-9.

SHARMA M., KHARE R. (2015). Effect of genetic algorithm parameters on cost optimization of pipe network: a case study, International Journal of Technical Research and Applications, Vol. 3, pp. 135-139.

SHINDE P., PATIL P., HODAGE R. (2018). Design and Analysis of Water Distribution Network Using WaterGEMS, International Journal of Advance Reasearch in Science and Engineering, Vol. 7, Issue 3, pp. 13-18.

SHITAL K., KRUNALI M., MEHTA D., YADAV V. (2016). Simulation of existing water distribution network by using EPANET: A case study of Surat City. Global Research and Development Journal for Engineering, (Special Issue), pp. 184-192.

SOURABH N., BATLIWALA M., TIMBADIYA P.V. (2019). Design of Water Distribution Network for Educational Institute for Revised Demand, Conference: HYDRO-2018 INTERNATIONAL, Hydraulics, Water Resources and Coastal Engineering, NIT Patna, Patna, Bihar, India.

SULTANA A., SULTANA Q. (2021). Design of Water Supply Distribution System: A Case Study, International Journal of Scientific Research and Review, Vol. 7, Issue 6, pp. 435-453.

URBAN WATER II. (2014). Retrieved from www.witpress.com

VARU S., SHAH D. (2018). Design of 24X7 water supply systems–A Case study: Ahmedabad city, Drinking Water Engineering and Science, Discussions [Preprint], https://doi.org/10.5194/dwes-2018-14, pp. 1-6.

WAIKHOM S.I., MEHTA D.J. (2015). Optimization of Limbayat Zone water distribution system using Epanet. International Research Journal of Engineering and Technology, Vol. 2, Issue 4, pp. 1494-1498.

WaterGEMS® CONNECT Edition, www.bentley.com

YADAV V.G., MEHTA D., WAIKHOM S.I. (2015). To assess the prevailing water distribution network using EPANET, International Research Journal of Engineering and Technology, Vol. 2, Issue 8, pp. 777-781.