ANALYZING THE EXISTING WATER DISTRIBUTION SYSTEM OF SURAT USING BENTLEY WATERGEMS

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Abstract*—The physical infrastructure plays and vital role in urban planning. The water distribution system for potable water supply is necessary in all human life. The water distribution system supplied the water from the distribution center to the end consumer. Due to rapid urbanization, the burden on the existing network is increasing along with widening of gap between supply and consumer demand. In the Rander area of Surat city, the water is supplied to a largely populated area from a WTP based at Ugat. The pressure in network nodes are identified to be lower than the standard requirement. Surat Municipal Corporation at present, have not employed any means to measure pressure in the water distribution system on a regular or at an interval. Current work discusses simulation performed using the Bentley WaterGEMS tool for the existing system of West Zone. The WaterGEMS reveals the scenario computed about the conduit pressure, flow characteristics as discharge, velocity, head-loss and so on. Crucial locations in the study area are identified because of the simulation exercise. Focus of the study is centered at identification of locations/spots with inadequate supply pressure. A complete shift of existing database to similar tools and online monitoring using SCADA installations will certainly result in making the city yet smarter.

Index Terms*— Pressure, Smart water supply, Surat, Surat Municipal Corporation, Water distribution system, WaterGEMS.

I. INTRODUCTION

Water is one of the most important natural resource and water scarcity is the most challenging issue at a global level. The water is most crucial for sustaining life and is required for almost all the activities of humankind, i.e., industrial use, domestic use, for irrigation; to meet the growing food and fiber needs, power generation, navigation, recreation, and also required for animal consumption. Due to population growth, climate change at. al. there developed a huge gap between the supply and demand of water. In developing countries like India, the gap in supply and demand of water is increasing and predominant. The existing system of water supply is facing problems like a higher rate of leakage, poor maintenance, poor customer service, and poor quality of water [1].

A water distribution system is a hydraulic infrastructure that consists of different elements like pipes, valves, pumps, tanks and reservoirs. This infrastructure helps to convey water from the source to the consumers. Designing and operation a water distribution system is the most important consideration for a lifetime of expected loading conditions. Furthermore, a water distribution system must be able to assist the abnormal conditions such as pipe breakage, mechanical failure of pipes, valves, and control systems, power outages and inaccurate demand projections.

II. STUDY AREA

Surat is located at the tail end of the 750 Km. long River Tapi which has been the main source of water for the city since centuries. On 23rd April, 1852 the collector Mr. Rogers established Surat Municipality. But there was no provision of water supply at that time. In 1864, Sir Kawasji Jahangir donated 1.25 Lakhs for the construction of water works. In 1867, a plan was prepared by Mr. Gragery to draw water from river Tapi near Kamrej as well bring the same up to Delhi Gate by Pipeline [2].

Initially, water was supplied from surface water obtained from the River Tapti. Gradually, other sources of water came into existence as the need increased with respect to population and industrial growth in the city. Surface water is taking by intake wells from perpetual channel of the river throughout the year. This drawn water is treated by the water treatment plants and then the same is supplied to the citizens after post chlorination [2].

III. WORKING OF EXISTING WATER DISTRIBUTION SYSTEM

In January 2003, 200 MLD capacity Water Treatment Plant & 360 MLD capacity raw water Intake Well were commissioned at Rander Water Works at total project cost of about INR 35 Crores. During the month of January 2011, a 50 MLD water treatment plant was commissioned at Rander water works under JnNURM at a project cost of INR 760 Lakhs [2]. The network of Water Distribution System flow from the intake to water works, and water works to water distribution station is shown thus by the Figure 1.

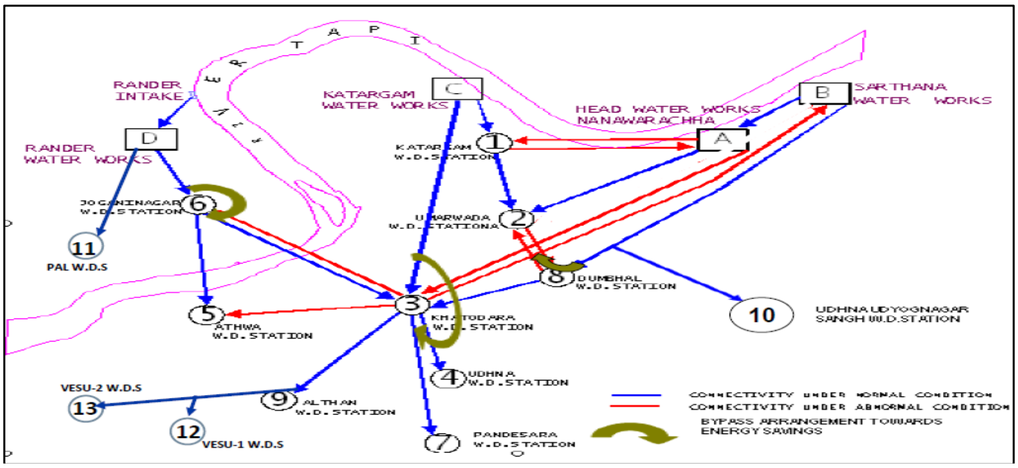

Figure 1 Water supply grid network

(Source: http://icrier.org/pdf/surat_water.pdf)

The raw water is taken from river Tapi by intake well located opposite side on the Gujarat Gas CNG pump and near Dabholi-Jhangirpura Bridge. The capacity of rander intake well is 360 MLD. For extracting the water of river there are 6 pumps in intake well. Through this two pipes having 1,524 mm diameter carry the water from intake well to Rander Water Treatment Plant located at Ugat. The distance from intake well to treatment plant is 2,220 m. From Ugat, the treated water supplied to Joganinagar, Pal and Athwa.

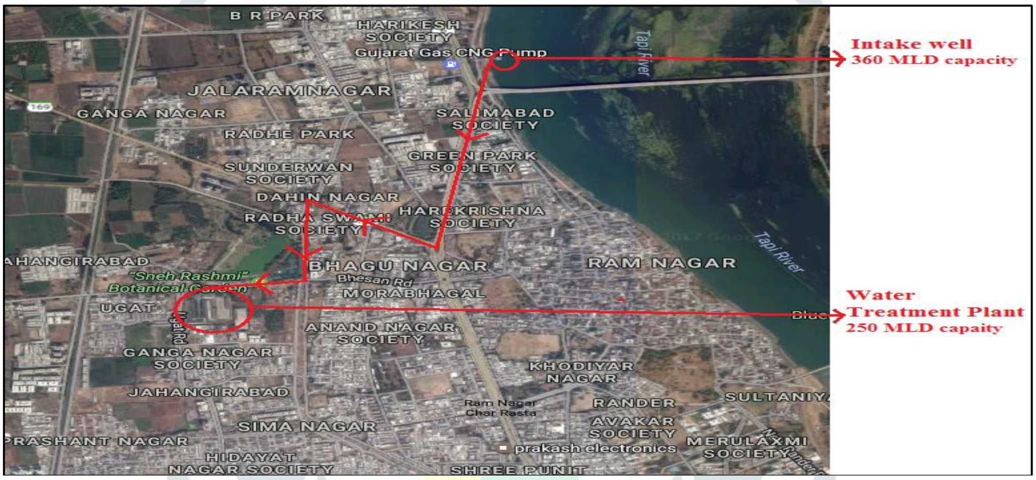

Figure 2 Flow of water from intake to treatment plant

At Rander Water works the water is treated. The process of water treatment plant is given below in the chart. The capacity of treatment plant is 250 MLD. The plant is working 24x7. The treated water is stored in Under Ground Storage Reservoir having capacity of 25 ML. There are 3 pumps working at pumping station. Each pump is having 300 HP and flow of water per hour is 2 MLD. The total flow of water from the Reservoir is 219.907 Liter/sec. The pressure at staring node is carried at 2.2 kg/cm^2 and at the end node it is dropped down at 0.7 kg/cm^2.

TPS-29 (Rander) TPS-30 (Rander) details

At present, the Surat Municipal Corporation (SMC) supplying water for 2 to 4 hours per day in TPS 29 and 30 [3]. The water is distributed from Rander Water Distribution Station to the service area. The location of TPS 29 & 30 in the West zone is illustrated below in the Figure 3.

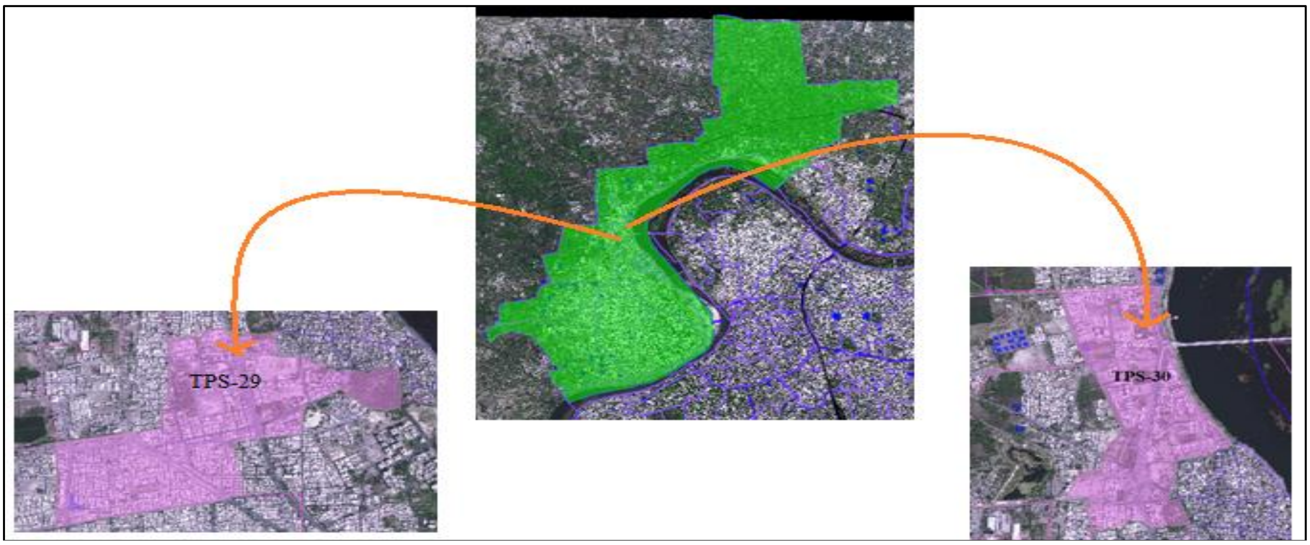

Figure 3 Location of TPS 29 and TPS 30

The Water demand as per 135 lpcd [4] for the given area is given below in the Table 1.

Table 1 Water demand in the area

TPS	Area (in Hector)	Population	Water demand (in MLD)	Number of Households
29	94.64	21,189	3.18	269
30	84	18,807	2.82	240

(Source: Surat Municipal Corporation)

The water is distributed through the pumping from the distribution center to the consumer. The head of the pump is 33 Mt. There is a Under Ground Storage Reservoir of 25 ML capacity. There ESR is not present in existing condition. The pipe material used in the area is Ductile Iron. The total length of pipeline in the TPS 29 and 30 is 23.023 Km. The main line in the system is having length of 727 Mt. of mild steel material. The type of existing water distribution system is tree system and network is loop network. In the case study, 509 number of households [5] are situated and water is supplying by the rander water works. The material of distribution pipeline is Ductile iron.

IV. DATA COLLECTION

The map of existing Water Distribution System of West zone is collected from Hydraulic Department of SMC in the form of CAD file. The file consist diameter of each pipe. In WaterGEMS software different input parameters are needs like, length of pipe, diameter of pipe, elevation of junctions, demand at every node and junctions, definition of pump, location of reservoir. All the data was collected from Hydraulic Department of the SMC. The detail of existing network from the CAD file the extracted which is given in Figure 4.

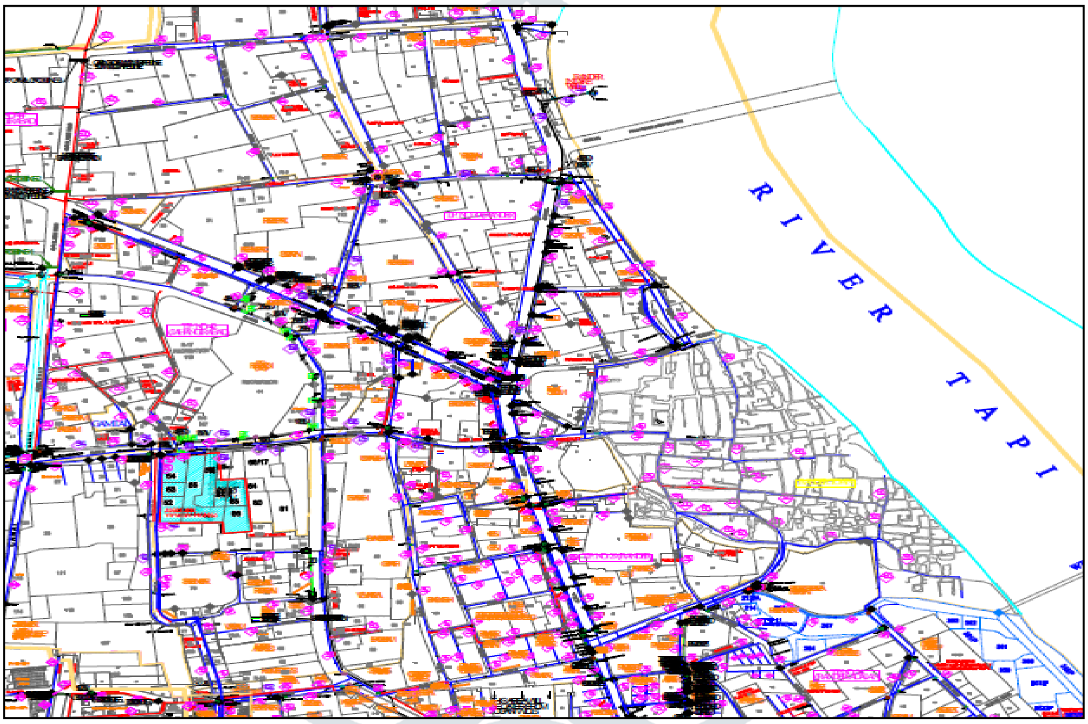

Figure 4 Network information availed by the SMC

(Source: Hydraulic department, SMC)

V. MODEL FORMULATION AND VALIDATION

Model Formulation

WaterGEMS V8i uses an assortment of data, input and output files. It is important to understand which are essential, which temporary holding places for results are and which must be transmitted when sending a model to another user. In general, the model is contained in a file with the wtg.mdb extension. This file contains essentially all of the information needed to run the model. WaterGEMS models a water distribution system as a collection of links connected to nodes. The links represent pipes, pumps, and control valves. The nodes represent junctions, tanks, and reservoirs[2]. The Figure 5 below, illustrates how these objects can be connected to one another to form a network.

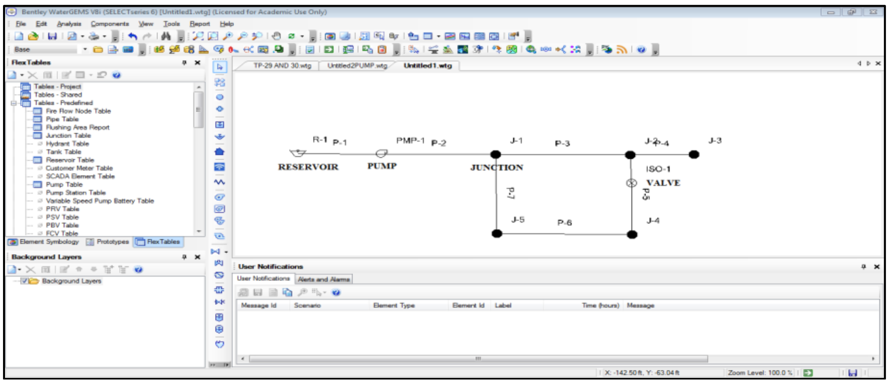

Figure 5 Physical component in Water distribution system

Steps to run the model for analyzing the existing water distribution system using WaterGEMS:

1. Tracing of existing network on WaterGEMS by putting AutoCAD file on background;
2. Color coding the network on the bases on diameter of pipe;
3. Inserting elevation, base demand at each junction;
4. Inserting reservoir elevation;
5. Inserting pump definition (flow and head) in the software;
6. Validate and simulate the programme.

After running the program successfully, the software computes the head losses (Mt.) the flow(Liter/sec.) and the velocities (Mt./sec.) in each pipe, and the pressure (kg/cm^2) and the hydraulic grade (Mt.), in each node.

Validation

The output computed by the WaterGEMS from the input data need to be validated for analyzing the actual scenario of water distribution system. In this study, the software generated the value of the pressure at end node 0.8 kg/cm^2. This result is validated by comparing the actual data of pressure at given node based on records of the SMC. In addition of checking water conduit pressure at nodes, the validation for flow was also checked. Using real-time measurement of water collected in buckets at various locations, the discharge released from the system was obtained and compared with software results. It showed that the model computations by the software for actual system is very well able to represent the situation on the field and there lies no lacuna in the formulated model by the authors.

VI. ANALYSIS USING WATERGEMS

After computing successfully, the flux table of pipe and junction is studied out. There are 104 pipes and 73 junctions in the area. The network of existing distribution system in WaterGEMS is given below in the Figure 6.

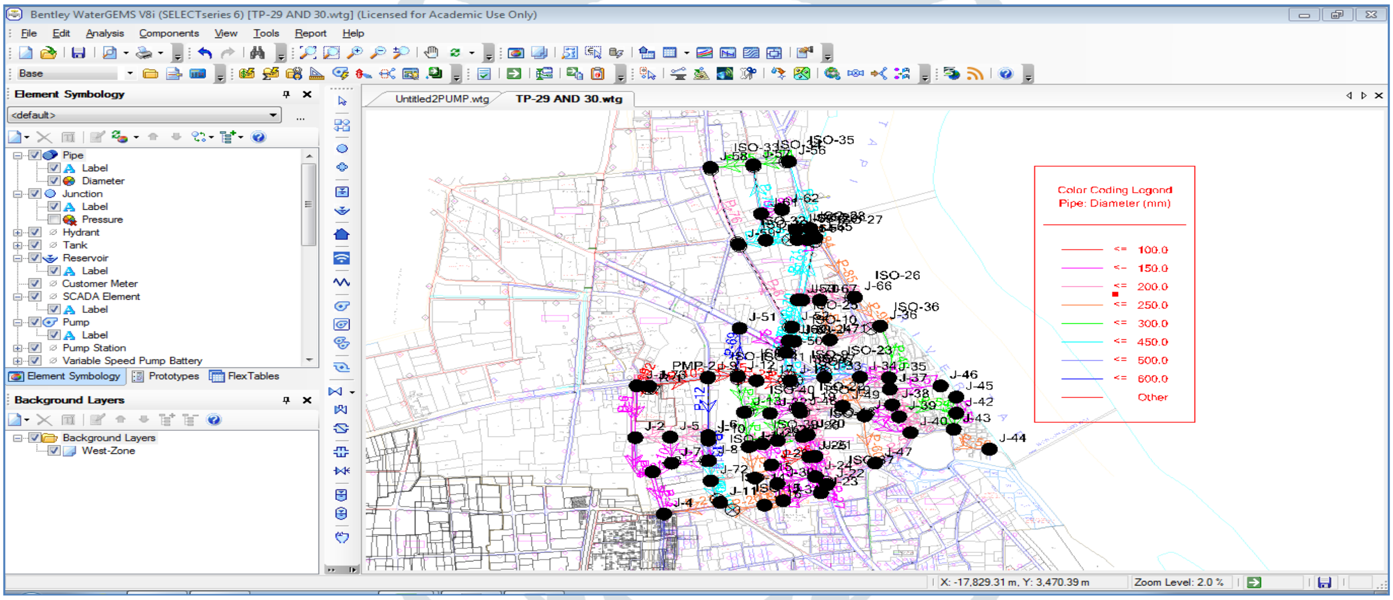

Figure 6 Screenshot of Water Distribution System in WaterGEMS

In some cases, there is back flow in the system in number of pipes. The whole system is looped so that there is a possibility of back flow. To meet the water demand in the area, water is directly supplied from the UGSR by pumping service. Also, in junctions, the pressure at starting node is kept 2.2 kg/cm^2 but at the end consumer it is 0.8 kg/cm^2, which is low and flow supplied is less than starting node.

Study of pipes

There are 104 pipes in the system. The material of the main pipe is mild steel while distribution line is ductile iron and value of Hazen-Williams C is 140 and 130 respectively. The pipe diameter and length are input manually, while flow, velocity and head loss are calculated by the WaterGEMS. For ductile iron material, the velocity may vary in 0.3 Mt./sec. to 1.2 Mt./sec. As the system is looped in Surat, there are negative flow in the pipe. This obtained results are verified. The result from the WaterGEMS is given below in Table 2.

The length of pipes had variation from a minimum 10 Mt. to 677.00 Mt. having total length of network as 22,613.00 Mt. The pipe diameters were in a range of 100 mm to 1524 mm having circular shape in a material of ductile iron and the main lines installed of mild steel. The flow in the conduits was ranging from -92.62 Liter/sec. (due to looping in the network) to 373.61 Liter/sec. The velocities in the pipes were obtained as 0.02 Mt./sec to 2.63 Mt./sec which were well within the desired range. The output head-loss in pipes were in a range of 0.00 Mt./Km. to 62.54 Mt./Km. at different instances.

Study of junctions

The input parameters of junction are elevation and demand. By computing network the software generates simulated values of pressure and hydraulic grade. In the system, the coverage area of Rander water works is very high, so that at starting junctions the pressure picks a high of 2.2 kg/cm^2, but as the distance from the water works increases the pressure lowers down to a low of 0.7 kg/cm^2. It shows that the quantity of water in delivery by the system has vast variations and the distribution is not equal. The simulated results were verified by the process of validation discussed in earlier section of the paper.

The junctions had a variation of elevation ranging from a minimum of 6.95 Mt. to a high of 18.58 Mt. depending on the natural topography of the network covered area. The demands in the system at various junctions were in a range of 0.19 Liter/sec. to 11.09 Liter/sec. based on the service population. The demands were matched by means of computation of hydraulic grade that were in a reflective range of 34.23 Mt. to 24.69 Mt with pressure variations as mentioned above.

VII. CONCLUDING REMARKS

In the current study, the existing water distribution system is simulated through construct of a model using Bentley WaterGEMS. It helped in analyzing the entire network system and visualized the effects of constituent components and parameters. In the present research, the pressure at end node is detected low, that shows that the consumer near the reservoir having more advantages of water than the one that resides away from the reservoir. The norm of delivering 135 lpcd at the consumer end is not attained in the existing water supply network. Henceforth, the established network need certain modifications as change of pipe diameter, increasing pressure using booster pumps at identified locations. The use of WaterGEMS in real-time monitoring clubbed with a SCADA based installations will allow for quality of network and quantity of water delivery monitoring. It certainly will elevate the service delivery levels for the Surat Municipal Corporation uplifting the status of a smarter city.

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