Design and Analysis of Rural Water Supply System using Branch 3.0 and Water Gems v8i for Nava Shihora region 2

[*]Vidhi N. Mehta , [#]Dr. Geeta S. Joshi

[*]Assistant professor, [#]Associate Professor, Civil Engineering Department, Faculty of Technology & Engg., The Maharaja Sayajirao University of Baroda, Vadodara, India.

[*]mehta.vidhi-ced@msubaroda.ac.in, [#]rs_geeta@yahoo.com

Abstract – **This study presents Water distribution system designed for rural area to deliver water from source in adequate quantity and at satisfactory pressure to the house hold of the region for future population estimated for 30 years. Shihora region is facing problem of Water supply so for study purpose, Zone II of Nava shihora region of the state of Gujarat is selected for Design and analysis of water distribution system. For the solution of this problem, Branch 3.0 and Water Gems v8i software have been used and the economical size of pipes for water distribution system is determined. The economical size of pipes of water supply distribution system is designed under the system constraints. The main objective of the study is to design and analyze the water delivery system (WDS) economically and to provide water supply of appropriate quantity and pressure which may provide water to the community in accordance with their demand and requirements. Further WDS has been analyzed using Water Gems v8i for extended period simulation (EPS) for the present population scenario for intermittent water supply of total 4 hours per day. The results obtained verified that the pressures at all junctions and the flows with their velocity at pipes are feasible enough to provide adequate water to the network of the study area. Further water supply system, is analyzed for the residual chlorine concentration at nodes and in the pipe links and also estimated the total cost of water supply system for this study area.**

Keywords — Water distribution network design, Branch version 3.0, WATERGEMS v8i, Economical diameter, Extended period simulation, Chlorine concentration analysis, Cost estimation

I. INTRODUCTION

In rural area, conventionally people carry water in cans or buckets from their nearby ponds and wells for their day to day activities [38]. With the advent of modern technologies, it has become convenient to distribute water to every household from the water bodies (source) nearby through pipes (distributing channels). Distribution system involves the determination of storage reservoir, location and size of feeders, location and sizes of distribution pipes, valves, and hydrants and the determination of the pressure required in the system [38]. A typical water distribution system consists of network of pipes, nodes linking the pipes, storage tanks, reservoirs, pumps, additional appurtenances like valves etc [39].

As per the existing system of this study area, it required to redesign the water supply network or proposed water supply network with increasing their utility and number of population living in village. Water supply network having an effective supply route, with connecting pipes to each other. It is a way to supply the water at a good pressure as well as we are able to fulfil needs of their demand and also clean water is reached up to their home with uses of chloride in distribution network. For the good network system, proper layout and design of the system is very important. The geometrical configuration of pipes, reservoirs and boosters, etc. is important for the functioning of the system. Adequate residual pressure at maximum demand depends upon the hydraulic characteristics of the water distribution system. For the present study, the average daily consumption is assumed to be 100 litres per person per day (lpcd).

Water distribution system consists of elements such as pipes, tanks, reservoirs, pumps and valve etc., is crucial to provide water to the consumers. 'Effective water supply system is of paramount importance in designing a new or proposed water distribution network or expanding the existing water distribution system' [1]. Pipe water system is one of the best systems to provide water safely, adequately

 DOI : 10.35291/2454-9150.2019.0060

and continuously to the consumer. In regional water supply schemes, more than one village are formed to serve a water from a common source through pipe system' [2], [7]. 'In water supply systems, distribution network considers as an essential part.' Distribution system costs within any water supply scheme may be equal to or greater than 60 % of the entire cost of the project' [1], [8]. 'Design and analysis of pipe networks are important, because availability of water is an important economic development parameter' [3], [9].

A number of software's developed for design & modelling of Water Distribution Network which differs by various aspects such as functionality, compatibility to different computational systems; graphical user interfaces (GUIs), searching and optimizing algorithms, languages and programs used in their developments [19].

Branch 3.0 software can be used advantageously for water distribution network design and cost analysis. Generally almost 50% to 70% of the total cost of the water distribution system is occupied only for piping cost [1], [3], [7], [14].

Some of the researchers [2], [9], [15] provided the design for regional water supply system using Branch 3.0 software for existing distribution network for some modification and recommended the appropriate improvement.

Water gems, EPANET software are convenient for the effective design of complex pipe networks. Reference [20] has used EPANET, to found the residual head at each and every node by having the elevation as input and thereby the corresponding flow quantities were derived like residual head, velocity and nodal demand etc.

Water distribution network is analyzed using EPANET software for Intermittent and continuous water supply system by some of the researchers [4], [12], [13], [17], [23], [24], [27], [28], [29], [30].

Reference [30] presented designed water distribution network using EPANET to carried out the hydraulic analysis of the distribution network and the results obtained verified that the pressures at all junctions and the flows with their velocities at all link are feasible enough to provide adequate water to the network of their study area and also recommended some measures like replace the appropriate diameters to the distribution main and as well expanding the distribution network in order to obtain a proper coverage in the area to save the consumers in having the water shortages in future.

Reference [31] presented Simulation of Hydraulic Parameters in Water Distribution Network Using EPANET and GIS. This paper has demonstrated an application of stochastic simulation for reliability analysis of water distribution systems using EPANET 2.0, taking into account the hydraulic considerations such as pressure, head, velocity etc. Obtained results of the simulations are checked using hydraulic equations and it showed that the results are correct and can be used for modeling water supply system.

Reference [32] presented water quality modelling in water distribution network using EPANET software 2.0 in which Two networks one with single loop network and the other one with two source two looped networks are discussed and steady state chlorine concentration at different nodes are determined for maintaining a particular concentration of chlorine which is added at the reservoir only and Chlorine Concentration at the nodes is determined.

Reference [34] carried out work on real-time forecasting with EPANET 2.0 in order to implement the automatic hydraulic simulation decision support tool, which can be used by the water utility operators on real-time basis, the coupling between EPANET 2.0 toolkit and SCADA system has been developed and discussed the experience from development and implementation of a system, which performs real-time forecasting of hydraulic behavior of water distribution systems.

Some of the researcher also studied using the combination of software's to design and analyse the water distribution system [8], [16], [22], [25].

Design and analysis of water distribution network using Water Gems software found to be user friendly and it has graphical interface which facilitate analyses more effective and also, lesser time is required to reanalyze the network. In addition, Water Germs, also permit to analyse chlorine concentration at various nodes in the network [10], [21], [26].

Reference [35] focused on Modernization in Water Distribution System using EPANET and Watergems software. The main concentration is to modernize the existing water distribution system in which, due to the loss of water in the system, user may be suffering and found that is loss is very important for the sufficient supply. So by applying modern tools and equipments the water distribution system may work more efficiently. By using WaterGEMS the operation of the system is so easy and if some problem is noted than it can be tracked easily by the software.

Reference [33] presented Simulation of Existing Water Distribution Network at Punagam Area of surat city Using WATERGEMS software.The objective of the study is to analyze the existing water distribution network of Punagam area using WATERGEMS V8i and to recommend some measures if present network does not fulfil future demand by existing network and verified the obtained results that the pressures at all junctions and the flows with their velocities at all pipes are feasible enough to provide adequate water to the consumer of the study area.

 DOI : 10.35291/2454-9150.2019.0060

ISSN : 2454-9150 Vol-05, Issue-02, May 2019

Reference [36] analysed Proposed Drinking Water Distribution Network Using Watergems And Gis. The purpose of this paper is to design safe drinking water networks through gravity cum pumping system and analyzed pipe networks for virtual-time realization of pressure head and average daily flows through the house connections and stand-posts using Watergems software. To achieve the desired results, Hydraulic simulation has been carried out for daily 24 hours continuous water supply and gives suggestive conclusions for practical implementations.

Reference [37] has developed water distribution network of hydraulic model by using Water GEMS to optimize an effective means of scheduling and science operations for municipal water supply network by establishing a precise model which includes the basic data collection, flow and pressure points SCADA data; acquisition and importing of model work. GIS data in an urban pipeline network, for instance, creates a dynamic water supply network model. Based on SCADA data, a detailed analysis of the operation, using Water GEMS provides practical examples to establish a water supply network.

Objective of the Paper:

- Design and analyze the water delivery system to provide water supply appropriate quantity and pressure which may provide water to the community in accordance with their demand and requirements.
- To design the distribution network considering the increase in the future population for 30 year.
- Study and use of Branch 3.0 software to design economical diameter for water distribution network.
- Study and use of Water GEMS V8i software to design and analyzed network of the water distribution system.
- Analyze the result obtained of zone 1 from the software i.e. Pressure head, hydraulic gradient line, velocity.
- To decide the chlorine inputs

II. STUDY AREA AND DATA COLLECTION

A. Introduction about Study Area

The Nava Shihora village is newly developed area of Shihora village which is situated at distance of about 15 Km from the Savli Taluka, and the Savli is located at the distance of around 32 km towards North from district head quarter Vadodara as shown in Figure 1. The general topography of the terrain is moderately undulating.

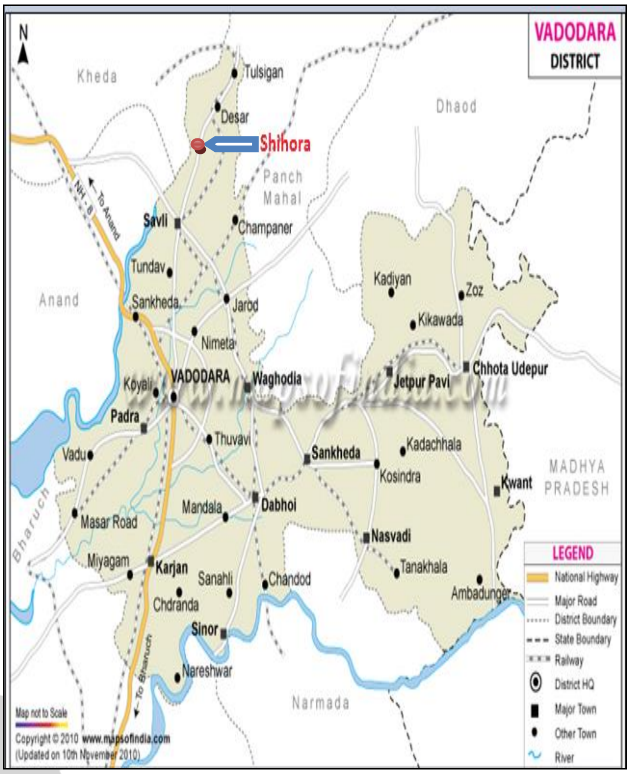


Figure 1 Index map of Vadodara District

In current situation, main water resource of the study area is surface water i.e. Mahi river. There are 136 villages forms Savli taluka but regional water supply scheme include only 90 villages of Savli taluka. Shihora village is one of them. In this regional water supply scheme, water is extracted by the pump from the main source to the water treatment plant (WTP). From water treatment plant, water conveyed to the master sump of 41 lakhs liter capacity. Water is pumped from the master sump to the elevated service reservoir, having capacity 21 lakh liter. This forms primary network. In the secondary network, water conveyed through pipe from elevated service reservoir to the sump of shihora village and then water conveyed to the Shihora village elevated service tank. In tertiary network, water conveyed from elevated service tank to the consumer of the village through pipe system. The village of Shihora is divided into two zones for proper distribution of water. In the present study, Water supply system has been analyzed for only zone 2 for village of Nava Shihora region.

Figure 2 shows the map of Savali taluka in the state of Gujarat. The village is located between 22º39’42” N longitude and 73º16’56” E latitude. The area is about 1242 Ha. and population of the village is 6021 people as per 2011 census of India, 2011.

 DOI : 10.35291/2454-9150.2019.0060

Figure 2 Map of Savli taluka, Gujarat

(Source: WASMO)

B. Data Collection

The data has been collected from Water and Sanitation Management Organization (WASMO). The following data has been collected for Design and analysis of water supply system.

The data required can be classified into four categories:

Geometric data - Node to node connectivity of pipe, Length of pipes, Reduce levels of nodes in a study area.

Hydraulic data – Flow requirement at all nodes, Pipe resistance coefficient in terms of Hazen William's C, Hydraulic gradient desired.

Existing water Source data - Elevations of service reservoir and capacity (if any). .

Historical population data – The population of Shihora village of year 2011 have been collected from census of India, 2011. The population of 2011 is 6201.

Data of cost estimation parameters - Available commercial diameters with data on unit cost as shown in table 1 and allowable working pressure, Newton-Raphson stopping criterion (viz. Maximum allowable error in flow balance), Maximum and minimum pressure at nodes.

Table 1 Cost of commercial pipes diameter

Diameter of pipe in mm	Unit Cost in Rs. per meter
75	86.11
90	123.31
110	175.87
130	290.81
150	374.51
175	479.27
200	587.37

Estimation of the population:

Present and future population can be predicted as under

$P_n = P_0 (1 + GR)^n$ __________ (1)

where,

Pn = the projected population after nth year from initial year

P0 = the population in the initial year of the period concerned

GR =average annual growth rate considered 1.7 % for the village as per the Gujarat Water Sewage Supply Board (GWSSB, Gujarat, India) guide lines.

n = number of years

Present population is estimated for zone 2 is 3000 people from the above equation. Also, the forecasted population of 2047 (future 30 years) is 4975 for zone 2. The essential parameters for network design are per capita water consumption, peak flow factors, available pipe sizes and pipe material etc. Another important parameter for the design of the water distribution system is the design period.

Figure 3 shows Layout map of proposed pipe distribution network of water supply system of zone 2

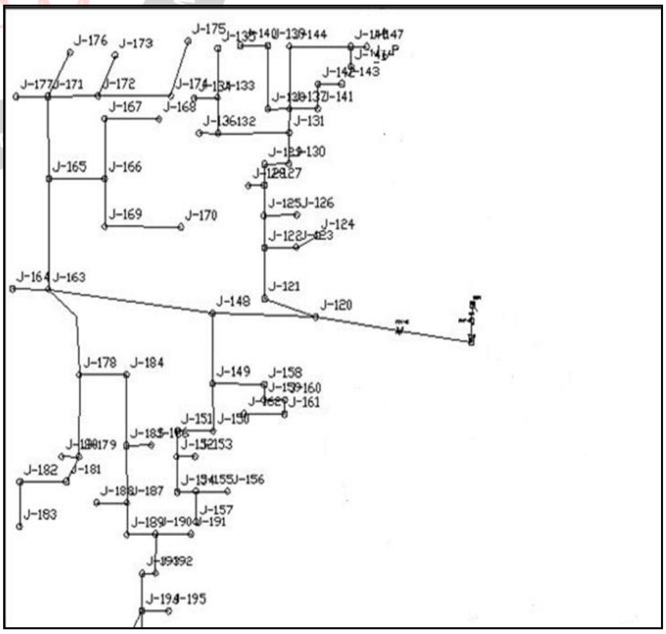


Fig 3 Layout map of proposed pipe distribution network of zone 2

It is prepared in Auto-cad by conducting level surveying and linear measurement of length of streets of the study area. The route of the pipeline is proposed along the road. Material of pipe PVC 6 kg/cm2 has been used for

 DOI : 10.35291/2454-9150.2019.0060

distribution network in Shihora village.

III. METHODOLOGY

Computation of Storage Capacity and diameter of Sump and ESR:

The storage capacity of sump for combined zone 1 and zone 2 of this Nava shihora village is computed by the storage mass curve calculations for 16 hours incoming inflow and 8 hours supply with forecasted population of 11046 people in future for 30 years.

Similarly, the storage capacity of elevated service reservoir (ESR) of zones 2 is computed by the storage mass calculations for 8 hours incoming flow and 4 hours supply to the consumer with forecasted population of 4975 people in future for 30 years. It is found that storage capacity required is 0.5 Million Litter for sump and 0.168 Million Litre for ESR which is to feed water to the consumer of zone 2. The existing ESR capacity 1.6 lac liters is matches with the required storage capacity of ESR in zone 2, therefore there is no need for constructing new ESR for zone 2.

Diameter of the ESR and sump is computed as under for input in the software Water Gems V8i.

$V = \frac{1}{4} \times \pi \times D^2 \times H$

Where,

V = ESR/Sump capacity in m3

D = diameter of ESR/Sump container (m)

H = Height of the ESR/Sump (m)

H is considered as 3 m for ESR and 5 m for Sump.

Pumping machinery calculation:

Horse power (HP) required to run the pump for supplying water in ESR from sump is calculated by using the excel with the help of formula mentioned below

H.P. of the pump required = Q x H x 1.1/75 x E _____ (2)

where,

Q = discharge in Litres per second (LPS)

H = Total lift in m

= static lift + residential head + Head loss

E = Pump efficiency = 60% = 0.6

The input data for the head (total lift) is considered as 21 m and design discharge is considered as 14 LPS, considering the life of the pump as 15 years and water requirement (liters) of the population forecasted. Using equation (2), the required pump capacity is obtained as 6 K.W. to lift the water in sufficient quantity from sump to ESR for zone 2.

Computation of Flow requirement at each node:

Flow requirement (LPS) for each node = 1.5 x Pn x Dpc x Cf ___________ (3)

Where,

Pn = population catered for each node,

Dpc = water demand in litre per capita per day

Cf = conversion factor (1/24 x 60 x 60)

Using equation (3), the inflow requirement at each node of the water supply distribution (WSD) network of the study area has been computed. Figure 4 shows the flow chart of methodology followed in this study.

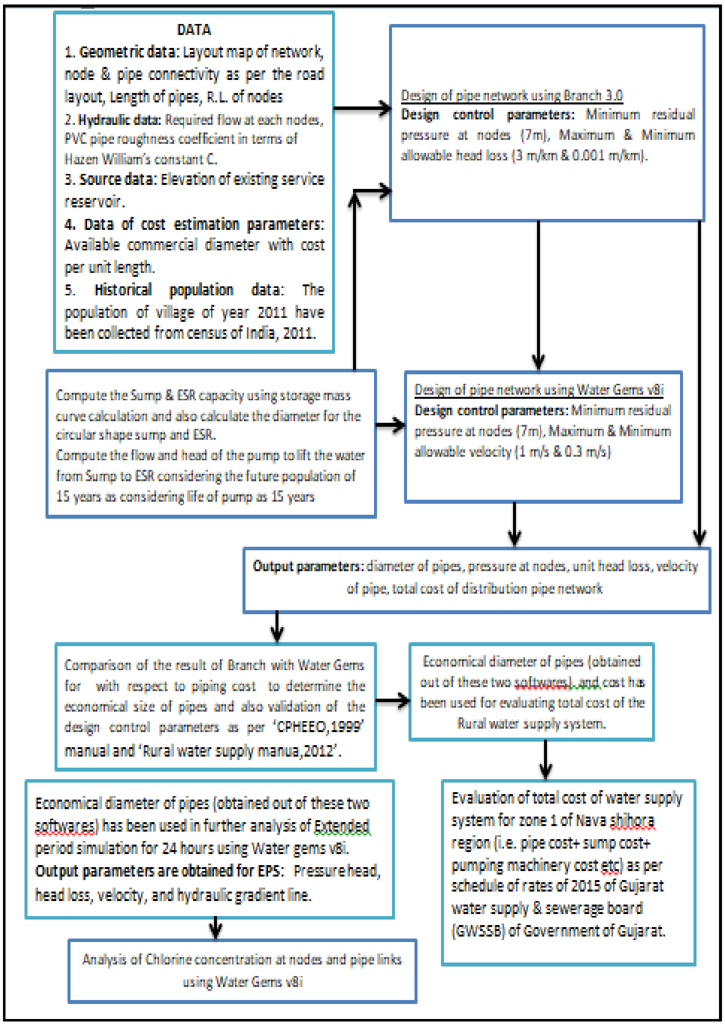


Figure 4 Flow chart of Methodology

It is The water supply distribution network design and analysis have been carried out in this study using CPHEEO Manual (Central public health and environmental engineering organisation, 1999) [6] and Rural Water Supply Manual (World Bank, 2012) [5].

A. About Branch software

Branch version 3.0 is a program that is developed by the World Bank to simulate the design & to optimize of Branched water distribution networks. The program is free and is in the public domain. The algorithm is applied for determining the economical sizes of pipes. 'The Branch is a tool to provide a good starting solution for the user to further improvement in the solutions' [11].

Branch simulates the hydraulic characteristics of a pressurised, dead end water distribution network' [11]. Data required are the description of the elements of the network

 DOI : 10.35291/2454-9150.2019.0060

such as pipe lengths, diameters, friction coefficients, nodal demands and ground elevation, and data describing the geometry of the network. 'The program outputs shows the flows and velocities in the links and pressures at the nodes'. 'Branch 3.0 handles up to 119 no. of pipes & 120 no. of nodes for simulate and design. 'Branch is normal use is to simulate and design the hydraulic response of a network to a single or multiple inputs with at least one known hydraulic gradient line elevation'[11].

Input data file for water distribution system as shown in Table is run into the software.
Encoding of Input Data as follows:
Title of the project -Nava shihora zone 2
Name of the project -vidhi
Number of pipes in network- 78
Type of pipe material used -PVC
Peak design factor -3
Newton Raphson criterion in lps- 0.001
Minimum residual pressure -7
Type of formula -Hazen's
Minimum head loss (m in Km) -0.001
Maximum head loss (m in Km) -3

Pipe input data: from node - To node, Length of pipe (m) and Hazen constant. Hazen constant is considered as 140 recommended in CPHEEO Manual, for PVC pipe.

Node input data: peak factor, flow (m/s) (i.e. required demand), reduce level of nodes, minimum residual pressure and maximum pressure.

Water source data of Elevation of service reservoir have been incorporated as an input. - 112.1 m

These pipe data and node data are incorporated into Branch 3.0 software to distribution network design for zone- 2 of Shihora village.

B. About WATERGEMS

Water Gems V8i is a hydraulic modelling application for water distribution systems with advanced interoperability, geospatial model building, optimization, and asset management tools'. 'Water Gems V8i provides an easy-to-use environment for engineers to design and analyse water distribution systems' [10]. WaterGems V8i is a computer program that performs extended period simulation(EPS) of hydraulic and water quality behavior within pressurized pipe networks. A network consists of pipes, pipe junctions (i.e. nodes), pumps, valves and storage tanks or reservoirs. 'Water Gems tracks the flow of water in each pipe, the pressure at each node, the height of water in each tank'. 'It is possible to analysed calculated residual chlorine at all nodes' [10].

WATERGEMS v8i provides an integrated environment to network input data editing , running hydraulic and water quality simulations, and viewing the results in a variety of formats'. 'These include color-coded network maps, data tables, time series graphs, and contour plots' [10]. Figure 5 shows the layout map of water distribution system of zone 2

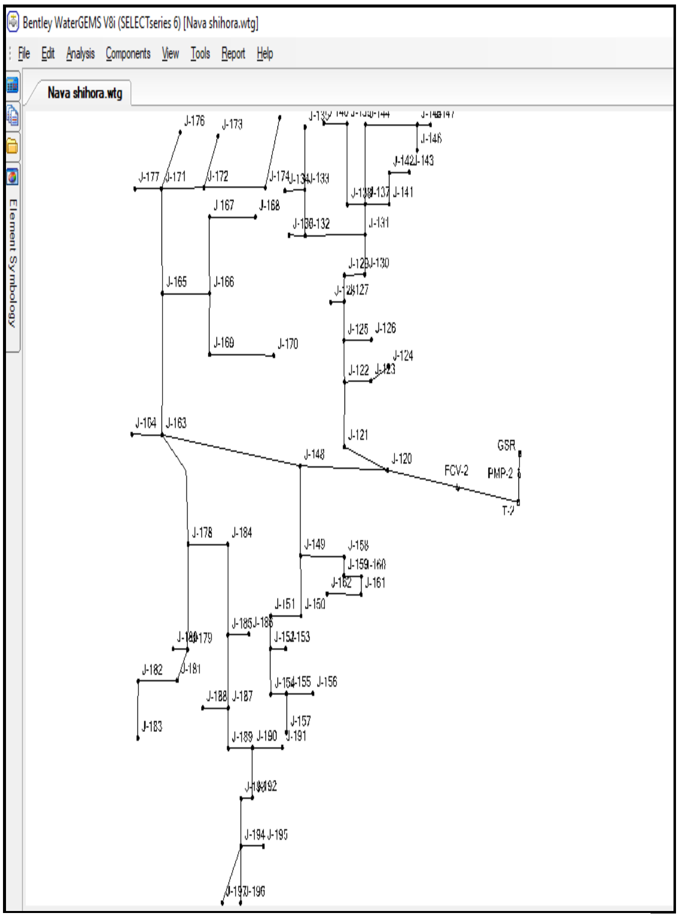


Figure 5 Lay out map of distribution system of Nava shihora village of zone 2

Network is developed in WaterGems V8i using different elements. (i.e. pipe, node, tank, sump, pump and valve)

Water Gems V8i contains a hydraulic analysis engine that includes Darwin designer tool, Hazen-Williams and Darcy-Weisbach formulas to compute losses, constant or variable speed pumps, various types of valves, different shape of storage tanks, considers multiple demand categories at each nodes with its own pattern of time variation, computes pumping energy and cost, can operate on both simple tank level or timer controls and analyse chlorine concentration in the network. There is no limit on the size of the network that can be analysed for EPS in cracked version of software but in student server it is limited up to 250 nodes of network.

Input data required in Water Gems V8i:

The required data has been incorporated in Water Gems V8i as under.

Node input data: Elevation of node and demand at nodes

 DOI : 10.35291/2454-9150.2019.0060

International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-05, Issue-02, May 2019

Pipe input data: length of pipe, pipe material, Hazen constant

Table 2 shows the ESR, sump (GSR) input parameters required in terms of their capacity container (i.e. Minimum, initial and maximum level of container).

Table 2 Source Input parameter in WG

Label	Elevation (Base) (m)	Elevation (Minimum) (m)	Elevation (Initial) (m)	Elevation (Maximum) (m)	Diameter (m)
SUMP	96	96	100.5	101	11.28
ESR	112	112	112.1	115	8.45

Minimum level of ESR / Sump given as an input indicates lowest allowable water surface level. If the ESR/Sump drains below this point, it will be automatically shut down the system. Initial level is indicates starting water surface level in simulation and the water level ESR/Sump. Maximum level is indicates highest allowable water surface level of ESR/Sump.

In Water Gems V8i software diameter of the pipe has been designed using Darwin designer tool.

Input parameter of Darwin designer tool: maximum pressure (60 m), minimum pressure (7 m) and pressure constrain elements (i.e. nodes of distribution network), minimum velocity (0.3 m/s), maximum velocity (1 m/s) and flow constrain elements (i.e. pipes of distribution network) of zone 2.

Output parameter: Economical diameter of the pipe.

The procedure is followed to compare total costing of the pipes, and the diameter at various nodes have been obtained as a result of the design of the network, for the software which has given the lower costing of the pipes. The economical design of the network (with respect to the pipe cost) has been used for further extended period simulation (EPS) through water Germs v8i.

IV. RESULTS

A. Results of the economical design of the water supply network with respect to the piping cost

Figure 6 shows the cost of the pipes in network of the respective diameter in Branch 3.0 and water Germs v8i software. The total cost of the various sized (diameter of pipe designed by the respective software) pipe have been represented in figure 7.

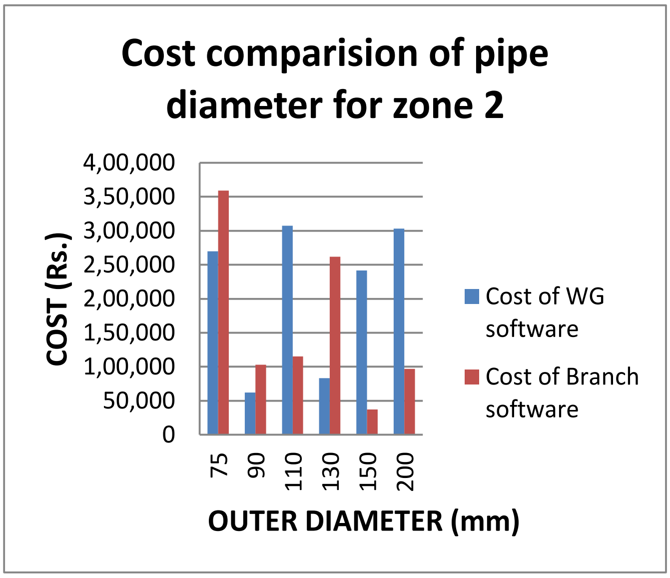


Figure 6 Cost comparison of pipe diameter for zone 2

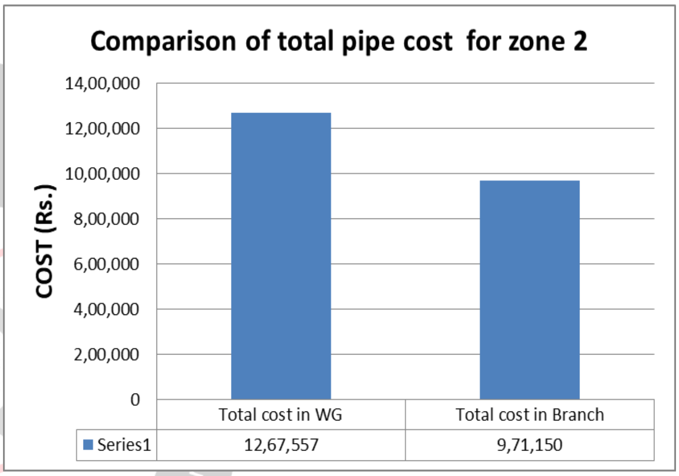


Figure 7 Comparison of total pipe cost for zone 2

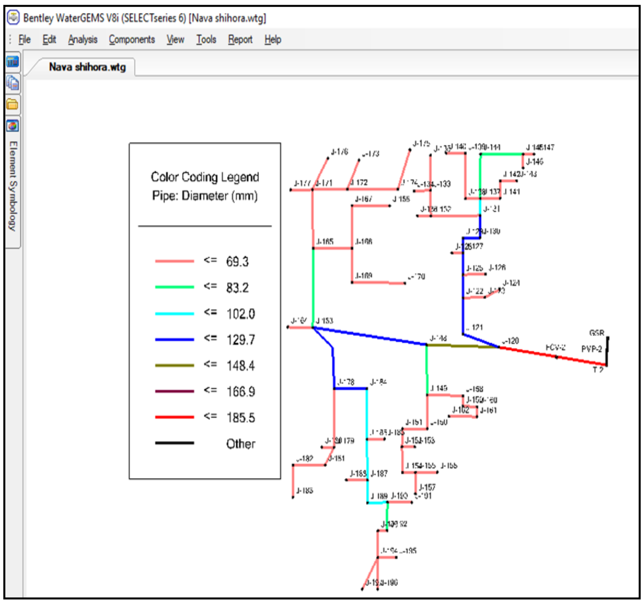
It is found from figure 7 that Branch 3.0 software yields the most economical design of the water supply network with respect to the total cost of the pipes.

It may be summarized that the designed diameters differ in both the software may be found due to change in the design control parameters of the respective software. In Branch software, design control parameters are Minimum residual pressure (m) and Maximum and Minimum Head loss (m) constraint. Whereas in Water Gems software, design control parameters are considered as Minimum residual pressure (m) and Maximum and Minimum velocity constraints (m/s).

Figure 8 shows the economical size of inner diameter of pipe for water supply network with the help of colour coding.

 DOI : 10.35291/2454-9150.2019.0060

International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-05, Issue-02, May 2019



This network design of the pipe diameter obtained in Branch 3.0 is further used for extended period simulation for 24 hrs. for distribution network of water supply system.

B. Extended Period of Simulation using Water Gems V8i

These economical design of the water distribution system network as shown in figure 8, obtained through the Branch 4.0 software is considered and incorporated as an input to the Water Gems v8i for extended period simulation (EPS).

The analysis of the extended period simulation (EPS) of the water supply distribution system for each of hours during a water supply has been carried out in Water Germs v8i. As, in India, in the area around the study area, the intermittent water supply system is followed, In this study also, the intermittent water supply system for 4 hours (i.e. 2 hrs in morning and 2 hrs in evening), have been considered from ESR in a one day. .

Input data required for EPS in Water Gems V8i:

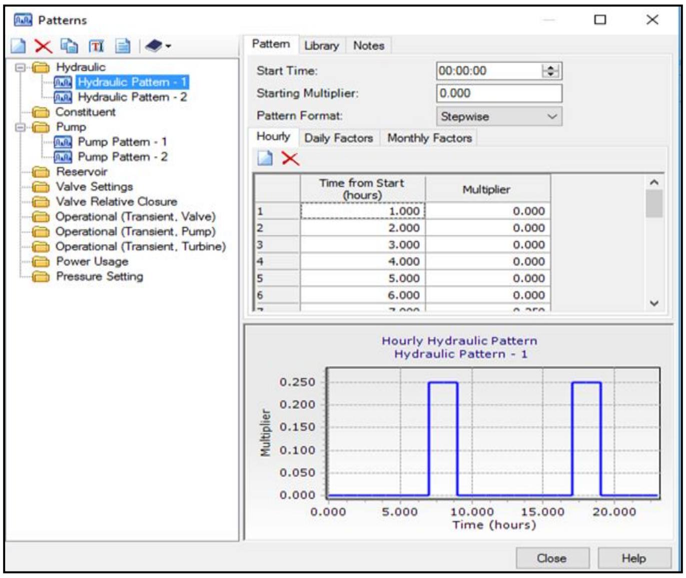
Node input data: Elevation of node and demand at nodes

Pipe input data: length of pipe, pipe material, Hazen constant and inner diameter (mm).

Inner diameter is taken from output of Branch 3.0 software which is given economical diameter for zone 2.

The ESR is receiving water supply from common sump in duration of 8 hours incoming but for 4 hours outgoing i.e. for supply of water (i.e. 7.00 a.m. to 9.00 a.m. & 5.00 p.m. to 7.00 p.m.). The above mentioned data are incorporated into WATERGEMS v8i software to analysis of EPS for distribution network of zone- 2 of Nava Shihora village.

Figure 9 shows the demand pattern input parameter.



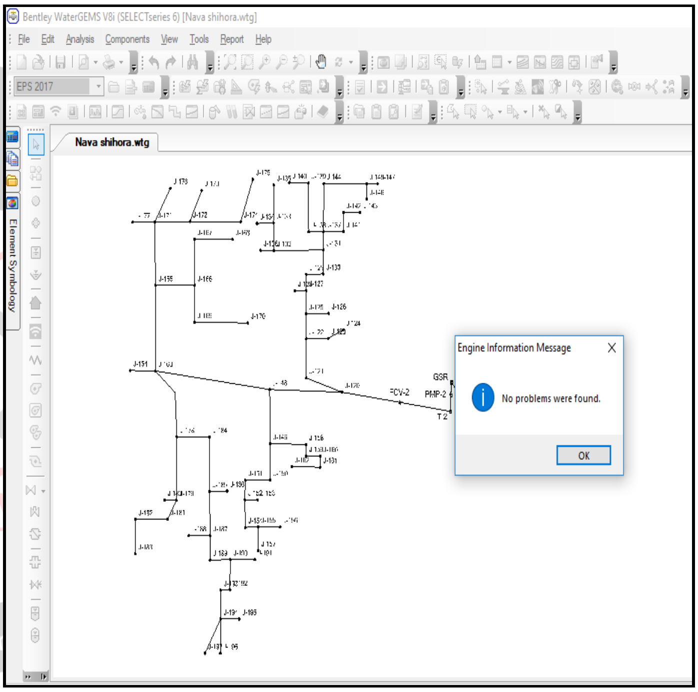


Figure 10.Validation of Model

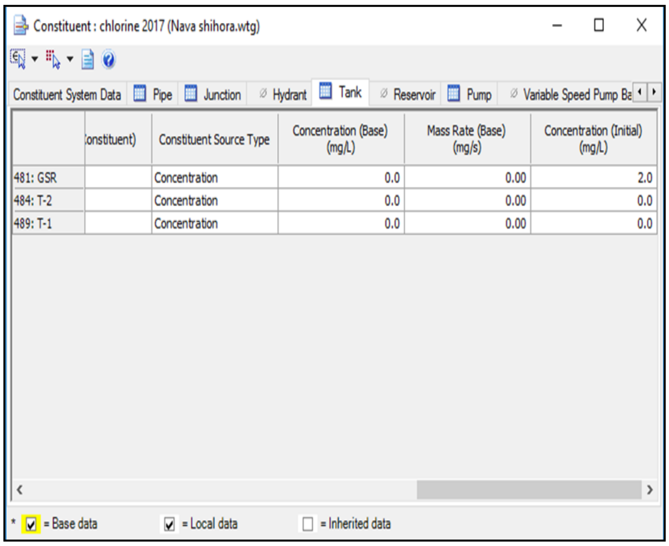
Figure 10 shows the validation procedure from the software Water Gems v8i for inputting parameters to run successful extended period simulation. After this validation procedure, it is possible to run extended period of simulation.

In Water Supply System, concentration of chlorine mg/ l is added in order to make water drinkable by consumer. Figure 11 shows the Initial chlorine concentrations in Sump and ESR.

C. Chlorine concentration analysis

 DOI : 10.35291/2454-9150.2019.0060

ISSN : 2454-9150 Vol-05, Issue-02, May 2019



So, initially on trial bases, 2 mg/L chlorine concentration is decided to add with water in Sump/GSR, to check that the residual chlorine at all nodes that is higher than the minimum requirement i.e. 0.1 mg/l, as per IS specification 1992.

The trial is taken considering the 2mg/l in Sump because the limit over 2 mg /l may be toxic for consumer.

V. RESULTS OF EXTENDED PERIOD SIMULATION AND DISCUSSION

EPS analysis is done for present scenario of zone 2 (i.e. node analysis and link analysis). After simulation of Distribution Network of water supply system, obtained results have been shown as below in terms of graph at an evening hour (i.e. for 1 hr. (6 to 7p.m.)) which is the last hour of water supply system in a day. Other than that has not been shown here but it is observed that it is yielding under the limit.

In the course of the research and the simulation process, the following assumptions were made: The contribution of leaks and bursts to pressure loss is negligible, since it is not possible to estimate leakage losses in software. Local losses resulting from added turbulence that occurs at bends and fittings are neglected.

Figure 12 shows the results represented graphically for zone 2 to visualize the maximum and minimum pressure at particular time instant at each node. After running the model, it has been observed that the pressure in all the nodes during supply hours at 6 p.m. is ranging from 9.00 to 14.00 m for zone 2, which above the criteria of the minimum pressure given as an input criteria in Water Germs v8i.

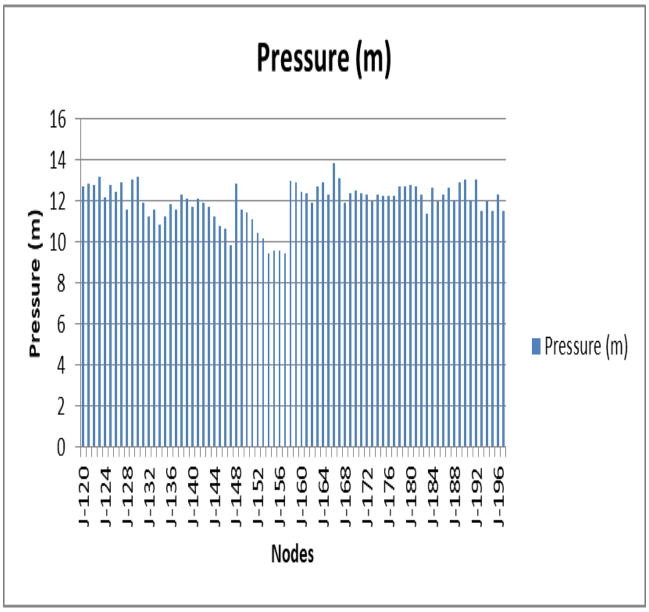


Figure 13 shows the results for the head loss (m/km) in each pipe links.

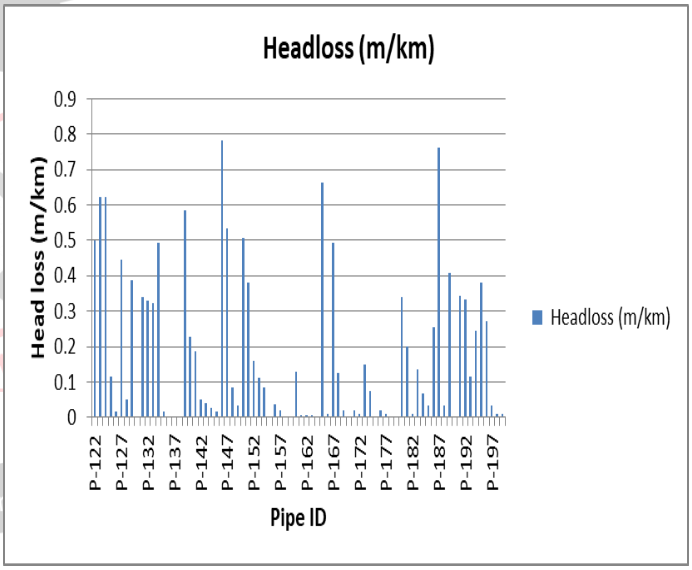


Figure 13 Head Loss Representation of zone 2

After running the model, it has been observed that the unit head loss in all the links during supply hour at 6 p.m. is ranging from 0 to 0.8 m/km which is less than maximum limit i.e. 10 m/km (specified by rural water supply manual).

Figure 14 shows hydraulic gradient line (HGL) (m), R.L. (m) and pressure (m) for selective nodes which is coming in one link of the pipe in distribution network of water supply system. It is seen from figure 14 that HGL is declined because of head loss and friction loss occurring in pipe of the system.

 DOI : 10.35291/2454-9150.2019.0060

ISSN : 2454-9150 Vol-05, Issue-02, May 2019

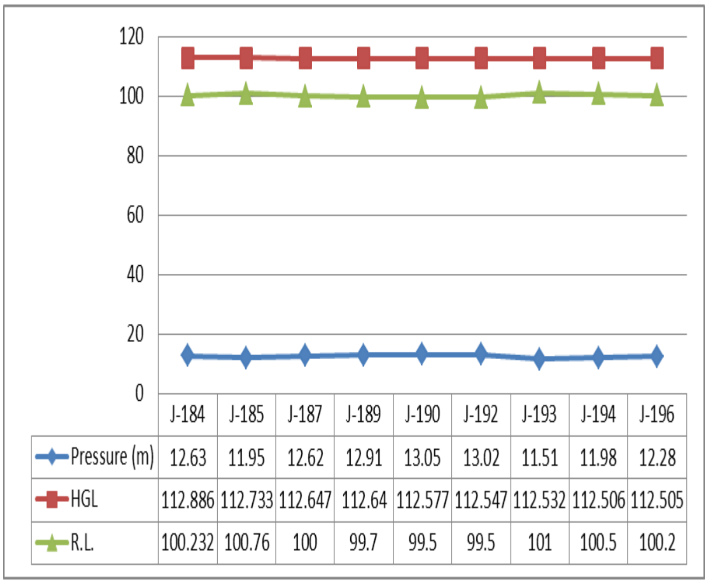


Figure 15 shows Time series plot pressure value versus time for selected nodes on pipe link over the time period of 24 hours.

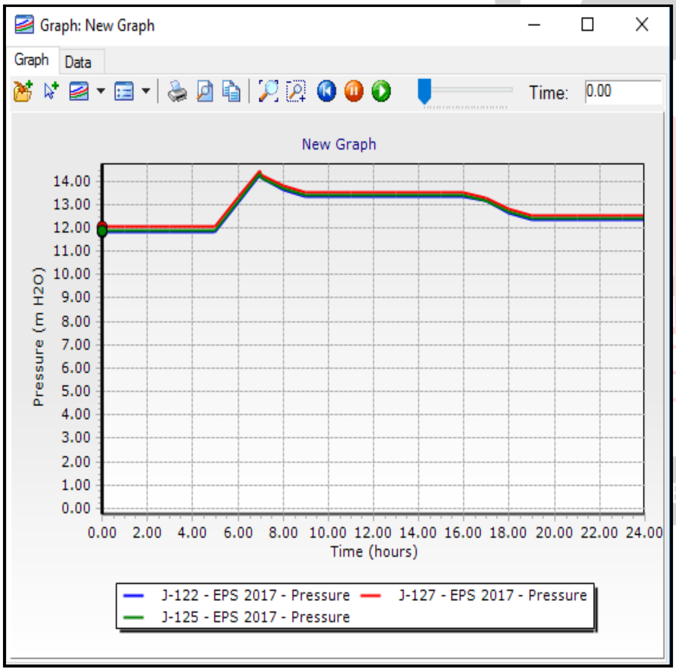
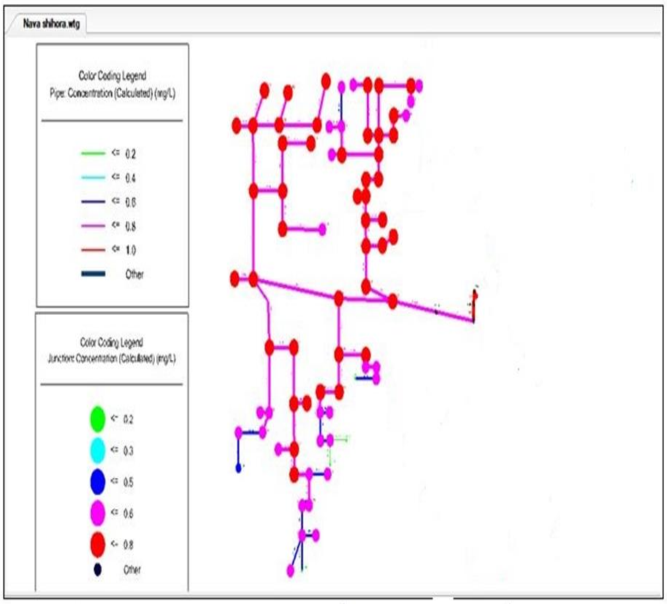


Figure 15 Time series Graph of Water-Gems V8i for the system

It is seen from the figure 15 that pressure increases between 5 a.m. to 7 a.m. which indicates pumping hours to lift the water from sump to ESR. Pressure at nodes reduces between 7 a.m. to 9 a.m. and 5 p.m. to 7 p.m. which indicates the water supply hours from ESR to the consumer in the water distribution system.

VI. RESULTS AND DISCUSSION OF CHLORINE CONCENTRATION IN THE WATER DISTRIBUTION SYSTEM

Figure 16 shows chlorine concentration in water distribution network obtained Water Germs v8i.



through Water Germs v8i.

Figure 16 shows that the chlorine concentration with respect to the given initial concentration at inlet in water supply network as 2 mg /l.

It is found from the from figure 16 that chlorine concentration is obtained within the range of 0.2 to 0.8 mg/l at Nodes and range within 0.2 to 1 mg/l in pipes, which is found to be greater than the minimum residual chlorine 0.1 mg/l (Drinking Water specification IS: 1992).

VII. RESULTS AND DISCUSSION ON THE COST ESTIMATION OF WATER DISTRIBUTION SYSTEM

In the economic assessment of water supply projects, costing is the important step and an economic assessment is one part of the full set of information to take decision in selecting specifications of the system to implement. The cost for water supply distribution network of zone 2 of Nava shihora village is estimated as per GWSSB SOR, 2015.

The specifications, for which, the estimates are made are as follows.

- Distribution network Providing and supplying in standard length ISI mark rigid plasticized PVC 6 kg/cm2 pipes suitable for potable water with ring fit joints including cost of rings, as per IS specification no. 4985/1988 including all local and central taxes, transportation, freight charges, inspection charges, loading, unloading conveyance to departmental stores, including cost of jointing material etc.

- The structural design of GSR and ESR shall be in accordance with provisions relevant I.S. 3370-1965 or revised.

 DOI : 10.35291/2454-9150.2019.0060

• Submersible Pumping machinery has been used for the distribution of water supply network. (Cat: SM 3.3 and SM 4.4).

Table 3 shows the cost of each component of the water supply distribution network.

Table 3 :Total Project Cost

Sr. No.	Name of work	Cost (Rs.)
1	Distribution network	9,71,150
2	Underground sump	14,10,000
3	Pumping machinery	28,552
Total cost of zone 2 for water supply network of Nava shihora village in Rs.		24,09,702

Note: The cost of ESR is not estimated as the existing ESR capacity 1.6 lac liters is matches with the required storage capacity of ESR in zone 2, therefore there is no need for constructing new ESR for zone 2.

The cost for providing and supplying ISI mark CI D/F Sluice Valves, Butterfly Valves & Reflux Valves is not considered. Costs for excavation for pipe line trenches, for providing bedding, for construction of valve chambers are not included here. Cost for lowering, laying, jointing of ISI standard pipes is not estimated in this cost analysis.The cost for construction of chlorination plant and underground pump house are not included here in analysis.

VIII. CONCLUSION

For this study area of i.e. zone 2 of Nava Shihora village of Savli taluka of Vadodara district of the state of Gujarat, India is summarized that the designed diameters through both the software are varying, it may be due to change in the design control parameters of the respective software. In Branch 3.0 software, design control parameters are Minimum residual pressure (m) and Maximum and Minimum Head loss (m) constraint; whereas in Water Gems software, design control parameters are as Minimum residual pressure (m) and Maximum and Minimum velocity constraints (m/s). Further it is found, on comparison of the piping cost obtained through the design of both the software, the Branch 3.0 software provides successful solutions for economical water supply distribution system design with respect to the piping cost.

This paper also describes hydraulic analysis for Extended Period Simulation (EPS) of 24 hrs using Watergems v8i software for this regional water supply scheme. For economical design of water distribution network, the obtained results through the branch 3.0 software is considered and incorporate as an input data to Watergems v8i software for extended period simulation (EPS). It is resulting into representation and verification for velocity and head loss in the links, pressures at the nodes etc. Further, it is verified through Water Gems v8i software that residual chlorine concentration at all nodes in the distribution system remains within the limit, when 2mg/l of chlorine is introduced at the inlet (Sump). The total cost of water supply system for Nava shihora village zone 2 has been estimated as per GWSSB SOR, 2015 which is found 24,09,702 Rs.

ACKNOWLEDGEMENTS

The authors are thankful to the Water and Sanitation Management Organization (WASMO), Vadodara for providing necessary data for this study.

REFERENCES

[1] Minakshi M.Yengale, P. J. Wadhai, “Analysis of Water Distribution Network for Karanja Village-A Case Study”, International Journal of Engineering; 2(3), pp 2352-2355, 2012.

[2] Janki H. Vyas, Narendra J. Shrimali, “Optimization of Dhrafad Regional Water Supply Scheme using Branch 3.0”, International journal of Innovative Research in Science,Engineering and Technology; 2(10), pp 5762-5767, 2013.

[3] Vinayak. V. Sadafule, Rahul B. Hiremath, “Design and Development of Optimal Loop Water Distribution System”, International Journal of Application or Innovation in Engineering & Management; 2(11), pp 374-378, 2013.

[4] Vipinkumar G Yadav, Darshan Mehta, Sahita I Waikhom, “To assess the prevailing Water Distribution Network using EPANET” , International Research Journal of Engineering and Technology (IRJET), 2(8) , pp 777-781, 2015.

[5] Rural Water Supply Design Manual – World Bank

[6] CPHEEO, “ Manual on Water Supply and Treatment” published by Central Public Health and Environmental Engineering, New Delhi, India, 1999.

[7] Maulik J., Shilpa C., “Design of Water Supply Distribution Network For Kuchhadi Village”, Indian Journal of Research; 3(2), pp 94-97, 2014.

[8] Rajeshwari R, Dr. B. Manoj Kumar, “Evaluation of Intermittent Water Supply System and Design of 24x7 for a residential area in Mysore, Karnataka, India”, International Journal of Informative & Futuristic Research”; 1(11), pp 163-173, 2014.

[9] Yugandhara Lad, Prof. J.S. Main, “Optimization of Hydraulic Design of Water Supply Tree Network Based on Present worth Analysis”, journal of Indian Water Work Association, 2012.

[10] Darshan Mehta, Sahita Waikhom and Vipin Yadav, “SIMULATION OF PRESSURE VARIATIONS WITHIN PUNAGAM WATER DISTRIBUTION SYSTEM USING WATERGEMS” Proceedings of International Conference on Hydraulics, Water Resources and Coastal Engineering (Hydro2016), CWPRS Pune, India, 2016.

[11] Roger Schmid, “Review of modelling software for piped distribution networks”, Water Supply and Environmental Sanitation, 2002.

[12] A. E. Adeniran and M. A. Oyelowo, “An EPANET Analysis of Water Distribution Network of the University of Lagos, Nigeria”, Journal of Engineering Research, 18(2), 2013.

 DOI : 10.35291/2454-9150.2019.0060

[13] Bhagvat Zolapara, Neha Joshipura, "Case Study on Designing Water Supply Distribution Network Using Epanet for Zone-I of Village Kherali", INDIAN JOURNAL OF RESEARCH, 4(7) , 2015.

[14] Bhavna K. Ajudia, Dr. S. M. Yadav et al., "Water Distribution Network Design and Cost Analysis – A Case Study", 2012.

[15] Chavhan Y.A, Piplewar S.K, "Design of Distribution Network for Water Supply Scheme at Pindkepar Village by Branch Software", International Journal of Engineering Research and Applications, 3(5), pp.854-858, 2013.

[16] Dabhade R.R. and Dr. Sadgir P.A., "Design of multi-village water supply system with reference to technical sustainability by using BRANCH and EPANET." International journal of advance foundation and research in science and engineering (IJAFRSE) vol. 1, special issue, 2015.

[17] Dave Brinda H., Gargi Rajpara, Ajay Patel and Manik H. Kalubarme, "Continuous Water Distribution Network Analysis Using Geo-informatics Technology and EPANET in Gandhinagar City, Gujarat state, India", International Journal of Scientific & Engineering Research, 6(4), 2015.

[18] Kleiner Y., Adams B. J., Rogers J. S., "Water Distribution Network Renewal Planning", American Society of Civil Engineers, 2011.

[19] Nitin P. Sonaje, Mandar G. Joshi2, "A REVIEW OF MODELING AND APPLICATION OF WATER DISTRIBUTION NETWORKS (WDN) SOFTWARES", International Journal of Technical Research and Applications, 3(5), PP. 174-178, 2015.

[20] Ramanaa G. V., Sudheerb V. S. S., Rajasekhar B., "Network analysis of water distribution system in rural areas using EPANET", 13th Computer Control for Water Industry Conference, CCWI, ELSEVIER, 2015.

[21] Sajedkhan S. Pathan and Dr. U. J. Kahalekar, "Design of Optimal Water Supply Network and Its Water Quality Analysis by using Water GEMS" International Journal of Science and Research (IJSR), 10(11), 2015.

[22] Sameena G. A, Shivkumar B. P, "Remodelling of Water Supply Scheme for Sriranagapatna Town-A Review", International journal of modern trends in engineering and research, ISSN: 2393-8161, 2016.

[23] Sayyeda A., Guptaa R., Tanyimbohb T. T., "Modelling Pressure Deficient Water Distribution Networks in EPANET", 16th Conference on Water Distribution System Analysis, WDSA, Elsevier, 2014.

[24] Senyondo S. N., "Using EPANET to optimize operation of the rural water distribution system at Braggs, Oklahoma", International Journal of Innovative Research in Science, Engineering and Technology, 2(10), October 2013.

[25] Sumithra R. P, Nethaji Mariappan V.E, " Feasibility analysis and Design of Water distribution system for Tirunelveli corporation using Loop and Water Gems software",Iternational journal on applied bioengineering; vol. 7, 2013.

[26] Utkarsh Nigam, Kaoustubh Tiwari, Dr. S. M. Yadav, Darshan Mehta, "WATER DISTRIBUTION NETWORK RE-DESIGN FOR SVNIT SURAT CAMPUS", International Journal of Advance Research in Engineering, Science & Technology(IJAREST), 2(5), 2015.

[27] Yesha Desai, Suvarna D. Shah, "Cost Analysis: A Case Study of Sayajipura Village", Journal of Civil Engineering and Environmental Technology; 3(4), pp. 317-321, 2016.

[28] Kakadiya Shital , Mavani Krunali , Darshan Mehta and Vipin Yadav, "Simulation of Existing Water Distribution Network by using EPANET: A Case Study of Surat City", Global Research and Development Journal for Engineering, pp. 184-192, 2016.

[29] Christopher Bwire, Richard Onchiri, Njenga Mburu, "SIMULATION OF PRESSURE VARIATIONS WITHIN KIMILILI WATER SUPPLY SYSTEM USING EPANET", 6(4), pp. 28-38, 2015.

[30] A Saminu, Abubakar, Nasiru, L Sagir, "Design of NDA Water Distribution Network Using EPANET", International Journal of Emerging Science and Engineering ; ISSN: 2319–6378, Volume-1, Issue-9, pp 5-9, 2013.

[31] Dr. H. Ramesh, L. Santhosh and C. J. Jagadeesh, "Simulation of Hydraulic Parameters in Water Distribution Network Using EPANET and GIS", International Conference on Ecological, Environmental and Biological Sciences, pp 350-353, 2012.

[32] Ms. Khashfina kapadiya, "Modelling chlorine residuals in Water Distribution Network Using EPANET 2.0 software",

[33] D.J.Mehta and K.J.Prajapati, " Simulation of Existing Water Distribution Network at Punagam Area of surat city Using WATERGEMS software", ASCE India conference, 2017.

[34] P Ingeduld , "real-time forecasting with EPANET 2.0", World Environmental and Water Resources Congress ASCE, PH(420), 2007.

[35] Dipali B Paneria and Bhaskar vijaykumar bhatt, "Modernization in Water Distribution System", NHCE, 2017.

[36] Pankaj Kumar Roy, Ankita Konar, Gourab Banerjee, Somnath Paul,Asis Mazumdar And Ronjon Chkraborty, "DEVELOPMENT AND HYDRAULIC ANALYSIS OF A PROPOSED DRINKING WATER DISTRIBUTION NETWORK USING WATERGEMS AND GIS", ISSN 0257–8050, pp 371-379, 2015.

[37] Baiyi Jiang, F. Z., "Building water distribution network hydraulic model by using WaterGEMS",American Society of Civil Engineers, 2013.

[38] Wagner, E.G. and Lanoix, J.N., " Water supply for rural areas and small communities, Geneva" (World Health Organization: Monograph Series, No. 42), Columbia University Press, New York., pp 194-223, 1959.

[39] Mohapatra S., Kamble S., Sargaonkar A., Labhasetwar P.K., Sridevi. H. and Watpade S.R., " Efficiency Study of a Pilot Water Distribution System Using EPANET and ArcGIS10", A Report prepared by National Environmental Engineering Research Institute, Nagpur, India, 2013.

 DOI : 10.35291/2454-9150.2019.0060