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DESIGN OF WATER DISTRIBUTION SYSTEM USING EPANET SOFTWARE

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Abstract: A well-planned network of pipes must provide an adequate and consistent supply of water to meet the growing population's water demands. The Department of Jevan Pradhikaran, Jalgaon, gave the information, which has been followed. Information about the primary water sources, the population in the area, the amount of water required, the need for pumps, the distribution network, and general features of the area such water tanks are all necessary for the efficient design of a water distribution system.

As to the Maharashtra government, an individual's daily water usage is 70 liters, and the infrastructure has been planned appropriately. Using all of this data, this paper clarifies the process of developing a water supply system for the area. Using "EPANET" software; the water supply plan for that area was designed. Software from EPANET is easy to use. Many computer tools were created to guarantee that different parts of society had an appropriate supply of high-quality water in accordance with demand; of all the tools available, EPANET became the most well-liked and practical for efficient complex design. network of pipes. This study emphasizes how pipes can be efficiently designed and distributed using the EPANET tool.

***Index Terms* – Water Supply Model, Analysis, Design, Distribution Network, Hydraulic Modeling, EPANET Software.**

I. INTRODUCTION

A hydraulic infrastructure made up of parts including pipelines, tanks, reservoirs, pumps, valves, and so on is called a water distribution system. Ensuring that end users have access to drinkable water is crucial. As such, developing new water distribution networks or expanding current ones requires an efficient water supply. The computation of pressures and flows in intricate networks is a significant challenge to those involved in the planning, building, and upkeep of public water distribution systems. A relatively hard topic is the analysis and design of a pipe network, particularly when the network is made up of several pipes, as is often the case with big metropolitan water distribution systems. The steady state sequence, which is a minor but crucial component in determining the network's suitability, can be used to predict the network's behavior in the absence of appreciable fluid acceleration.

I.1 About EPANET

An extended-term simulation of hydraulic and water quality behavior in pressure-only pipe networks is carried out by the computer program EPANET. Pipes, valves, most pumps, nodes (pipe junctions), storage tanks, and reservoirs are all parts of a network. Many time steps of the concentration of material species throughout the network are included in a simulation period since EPANET monitors the water flow for every pipe, the pressure in every node, and the water level in every tank. It is possible to replicate not just the kinds of chemicals present in the water, but also its age and source.

I.2 Objective

1) The distribution system's goal is to provide water to every home and public area.
2) Finishing the carefully designed distribution system that will transport water from a water tank to each individual home.
3) The primary goal of distribution systems is to provide sufficient water pressure at several locations, such as consumer taps, and to choose the distribution's height in relation to the position of the water tank.
4) Gathering information for the creation of a water distribution network model, such as plan layout and topographical studies.
5) To determine the best network model and assess the two primary limitations (allowable pressure and effective diameter).

I.3 Study Area

Water provision in the city is the responsibility of Jalgaon Municipal Corporation. The two water filtering facilities are owned by JCMC and are called Girna and Dapora, respectively. The British constructed the Dapora natural water filtration facility in 1985, whereas the Girna artificial water filtration plant dates back to 1927.

The majority of Jalgaon City's land is level. The Girna River flows south-north along Jalgaon City's western border, close to Nimkhedi Village, with a general slope to the north. In the city, there are four or five main drains that go from south to north. There are a few low-lying places and some steep sections in the city. The city has unique terrain in several areas, with some wards having a high population density and others having a low population density. Because of this attractive topography, our priority zone is 9, i.e. The region covered by Girna Kol contributing wards 53(P), 42, 43, 51(P), 49, 50, and 44 is included in Girna Tank Zone 9. Zone 9 encompasses 332.68 hectares in total. The mill tank has a 3.5 million liter capacity.

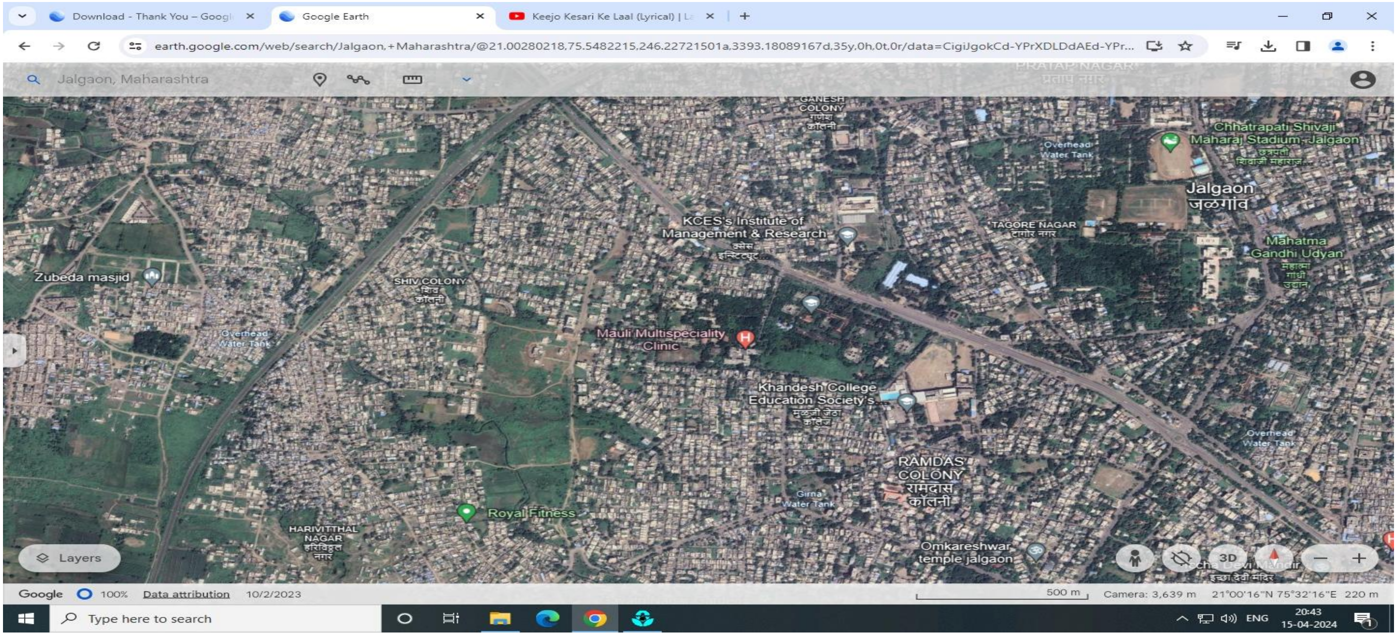


Fig.1 Study Area

II. LITERATURE REVIEW :

[1] G. Anisha et al. (2016) conducted an analysis and design of a water distribution network using EPANET for Chirala Municipality in the Prakasam District of Andhra Pradesh:-

The Chirala Municipality currently uses an inconsistent supply system and a dead-end network for its network. The Chirala municipality's water delivery system might or might not be dependable in the years to come.

[2] Montasir Maruf, et.al conducted a Water Distribution System Modeling using EPANET Software, (2015):-

An effective water infrastructure is crucial to a city's development in many respects. For analytical purposes, this study concentrates on Dhaka, the capital city of Bangladesh. Municipal water infrastructure is generally in bad shape, but it is deteriorating quickly.

[3] Bharanidharan B et.al (2015) made a design of water distribution system using epanet:-

A well-planned network of pipes must provide an adequate and consistent supply of water to meet the growing population's water demands. The information supplied by the Indore, Himachal Pradesh, IPH (Irrigation and Public Health Department) is used for this purpose.

[4] Research on the Water Distribution System by Ishani Gupta, Dr. Shakti Kumar and Dr. R.K. Khitoliya using EPANET:-

Based on observations taken in April 2013, an attempt has been made to recreate the water distribution network of a city in Urban Settlement, Punjab, India. A municipal corporation that serves the study region is reliant on groundwater supplies.

III. METHODOLOGY:

3.1. Population Forecasting:

A city or town's predicted population over the duration of the design process is the basis for designing the water supply and sanitation system. Any undervaluation will render the system unsuitable for its intended use, and an overestimation will render it expensive. The population of the city changes with time, thus the system should be developed with the population at the end of the design era in mind. The following factors influence population changes:

a) Increase from births

b) Decrease from deaths

c) Migration-related increase or decline

d) Annexation-related increase.

A population history and present of a city can be found in the census's population records. Following the collection of these demographic data, the population at the conclusion of the design period is estimated using a variety of techniques appropriate for that city while taking the city's development pattern into consideration.

The following techniques form the basis of population estimation:

a) Logistic Curve Method
b) Master Plan Method
c) Incremental Method
d) Graphical Method
e) Comparative Graphical Method
f) Arithmetical Increase Method
g) Geometrical Increase Method

3.2. Distribution System:-

3.2.1 Methods of Distribution:

Every customer must receive water at the flow rate necessary for effective delivery. As a result, the pipe lines need to be under some pressure in order to force the water to reach each site. The following categories apply to distribution systems, based on how they are delivered:

i. Pumping system
ii. Dual system
iii. Gravity system

3.2.2 Layouts of Distribution System:

In practical use, four distinct distribution system types are typically employed. They are divided into the following categories based on how they are arranged and supplied:

i. A tree structure or dead end
ii. The grid iron system
iii. A ring or circular system
iv. The radial system

3.2.3 Systems of Supply:

Water might be delivered constantly for the whole day or sporadically only during the morning and evening peak hours. Because users may use less water and experience occasional short-term losses, intermittent supply systems may result in some water consumption reductions. In India, intermittent supply systems are commonly used.

3.3. EPANET Overview:

The input data file and the EPANET computer program make up the two components of the EPANET computer model that is used for water distribution network analysis. In a pipe network, a data file describes the properties of the pipes, nodes (pipe ends), and control components (such pumps and valves). For pressures at nodes and flow rates in pipes, a computer program solves linear mass equations and nonlinear energy equations. Input data file required is the area image, created using GOOGLE EARTH software.

3.4. Data Collection:

a) **Distribution Network Diagram:** The Municipal Corporation provided a copy of the most recent distribution system diagram. The distribution of mains and sub-mains, their movement around the region, the existence of dead ends, etc., are all made clearer by the graphic.
b) **Source information:** The primary water supply is the water tank. It's a raised storage facility next to Zone 9.The Municipal Corporation provided the water head and other pertinent information about the water tank.

c) **Topography:** The necessary data was derived from the elevation of the area occupied by the municipal office.

d) **Population Statistics:** The Municipal Corporation has information on the entire population. The first duty after completing all data collection is to create the computer-aided model. EPANET software was used to build the model.

e) **Distribution System:** Transmission mains, distribution pipelines, and pumping stations make up the intricate network that is the distribution system. House connection pipes are smaller and the dimensions of the main and sub main pipes are 200 mm, 150 mm, and 100 mm.

3.5. Phases of using EPANET:

These actions are usually taken while modeling water distribution with EPANET.

1) Sketch up your distribution system as a network.

2) Modify the attributes of the system's constituent components.
3) Explain the workings of the system.
4) Choose a group of choices for examination.
5) Conduct a water quality and hydraulic examination.
6) Examine the analysis's findings.

3.6. Installing EPANET:

EPANET Version 2.2 is intended to operate on Intel-compatible personal computers running Windows 7/8/10. **Epanet2.2_setup.exe** is the only installation file that is provided with it.

1) Choose Run from the Windows Start menu to install EPANET.
2) To find the epanet2.2_setup.exe file on your computer, either type its complete path and name or use the Browse option.
3) Select the OK button type to start the configuration procedure.

You will be prompted by the setup program to select the location (directory) in which the EPANET files should be stored. To start, **open c:\Program Files (x86)\.EPANET Version 2.2.**: EPANET 2.2 will appear as a new item in your Start Menu once the files have been installed. Just choose this item from the Start Menu, then choose EPANET 2.2 from the pop-up submenu to start EPANET. (EPANET2w.exe is the name of the executable file that runs EPANET under Windows.)

If you would like to uninstall EPANET from your computer, follow these steps:

1) Slide the Control Panel open.
2) Double-click the application item to uninstall or add/remove programs.
3) From the list of programs that displays, choose EPANET 2.2.
4) Either select uninstall with a right-click or click the Add/Remove option.

3.7. Drawing the Network:

With our mouse and the buttons on the Map Toolbar displayed below, we can now start sketching our network. (Click View >> Toolbars >> Map if the toolbar is not visible)

1. We'll add the reservoir first. Press the Reservoir icon. Next, point the mouse cursor at the reservoir's location (which is someplace to the left of the map).
2. We'll add the junction nodes after that. After selecting the Junction option, click the map where required nodes are located.
3. Lastly, add the tank by selecting the Tank option and then the location on the map..
4. Next we will add the pipes. First click the Pipe button on the Toolbar. Then click the mouse on a first node on the map and then on other node. Note how an outline of the pipe is drawn as you move the mouse from nodes. Repeat this procedure for all the pipes.
5. Finally we will add the pump. Click the Pump button and add it wherever required.

We have now finished drawing the example network. The network map in Figure 2 should be the same as yours. You can reposition the nodes if they are not in the correct place by first selecting it with the mouse and then dragging it to the new location while holding down the left mouse button. Take note of how the node moves with the pipes that are attached to it. It is possible to rearrange the labels in a comparable way.

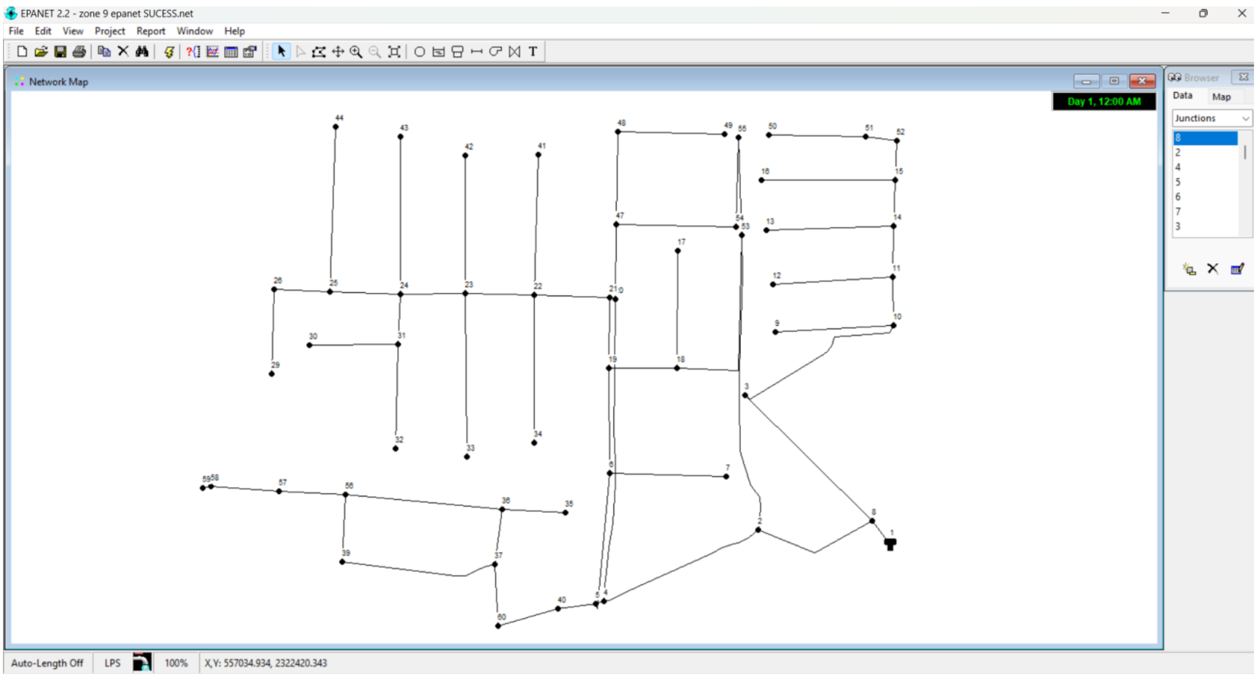
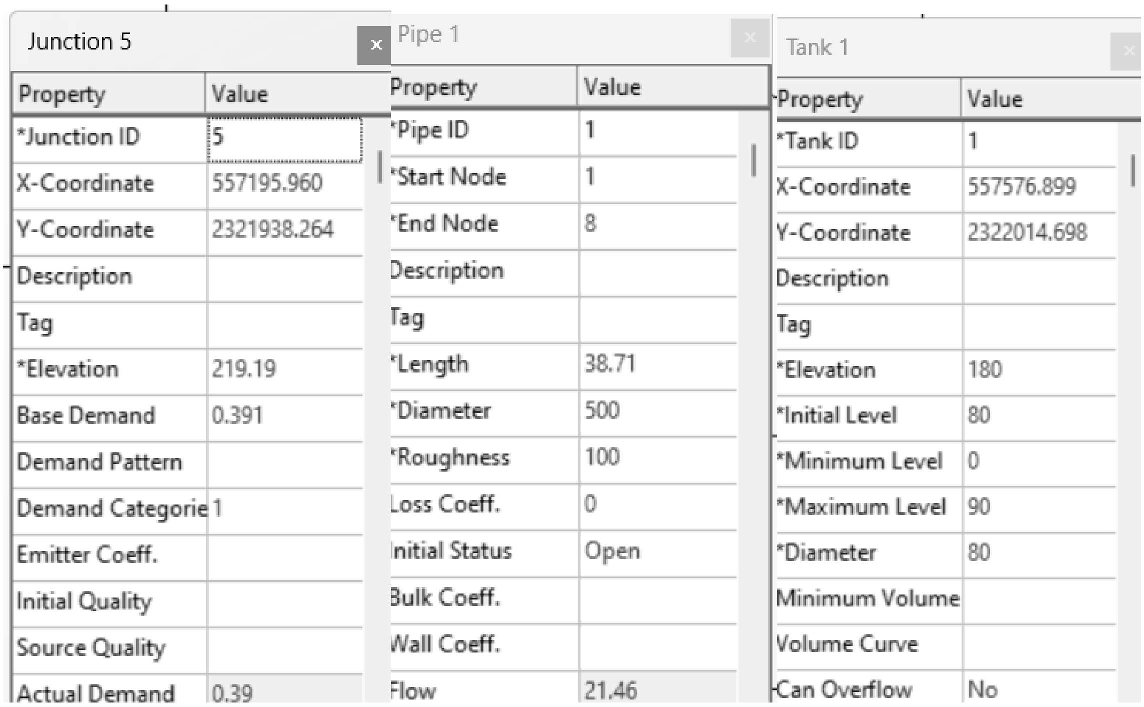


Fig 2 : Network Of The System

3. 8. Setting Object Properties:

When an object is introduced to a project, it is given a default collection of properties. Hence new properties from the collected data should be added to it. Follow the following steps to access it :

1. Click and hold the object twice on the map.
2. To access Properties, right-click on the object and choose it from the pop-up menu that displays.
3. Click the Edit button in the browser window after selecting the object from the Data page.
4. You can get more detailed descriptions of the properties listed by pressing the F1 key whenever the Property Editor is in focus.



Junction 5

Property	Value
*Junction ID	5
X-Coordinate	557195.960
Y-Coordinate	2321938.264
Description	
Tag	
*Elevation	219.19
Base Demand	0.391
Demand Pattern	
Demand Categorie	1
Emitter Coeff.	
Initial Quality	
Source Quality	
Actual Demand	0.39

Pipe 1

Property	Value
*Pipe ID	1
*Start Node	1
*End Node	8
Description	
Tag	
*Length	38.71
*Diameter	500
*Roughness	100
Loss Coeff.	0
Initial Status	Open
Bulk Coeff.	
Wall Coeff.	
Flow	21.46

Tank 1

Property	Value
*Tank ID	1
X-Coordinate	557576.899
Y-Coordinate	2322014.698
Description	
Tag	
*Elevation	180
*Initial Level	80
*Minimum Level	0
*Maximum Level	90
*Diameter	80
Minimum Volume	
Volume Curve	
Can Overflow	No

Fig 3: Properties Of Junction, Pipe,Tank

3.9. Running an Analysis:

With the data we currently have, we can perform a hydraulic analysis on our example network for a single period, or snapshot. Either choose Project >> Run Analysis or press the Run button located on the Standard Toolbar to initiate the analysis. (Select View >> Toolbars >> Standard from the menu bar if the toolbar is not visible.)

The result is displayed as shown in figure 4.

In the event that the run fails, a Status Report window will open and explain the issue. You have several options for viewing the computed results if it completed successfully.

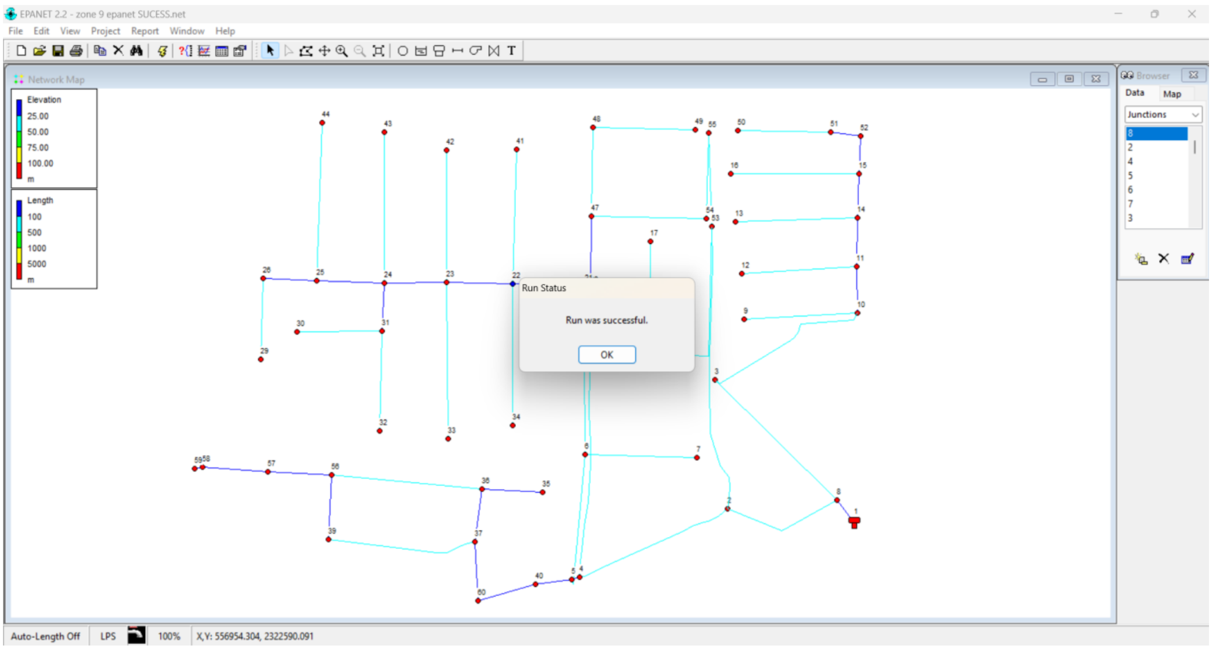


Fig 4: Run Successful

3.10. Viewing the Results in Tables

Choose Table from the toolbar. The desired information can then be chosen. The press OK as shown in fig 5 , which provides with a table of the required information. The middle tab on the active window can be used to select which columns to print. the outcomes for the pipelines and junctions.

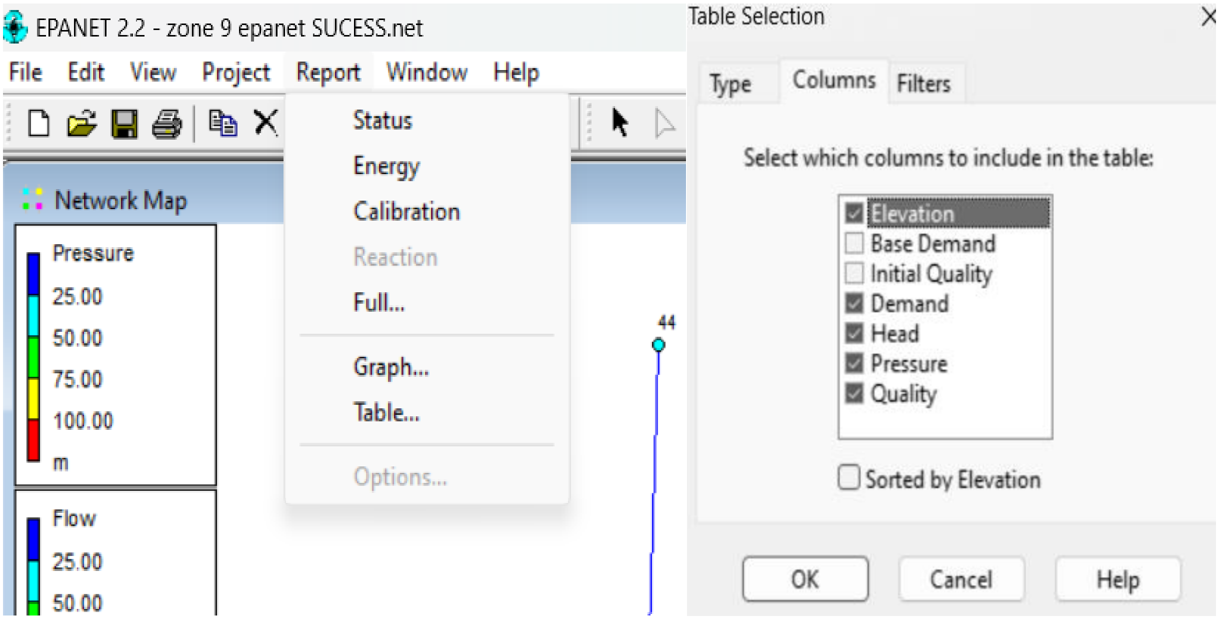


Fig 5: Steps of Viewing Results

IV. RESULTS AND DISCUSSION

- This chapter discusses the findings of the pipe network analysis conducted on the pipes and junctions in Zone IX Girna Tank, Jalgaon city.
- The results for all of the junctions in the chosen Zone IX area are shown in Table 1 and Table 2 displays the results for all of the pipes. Every junction has pressures that are kept at roughly 20.
- The table displays the outcomes for each pipe line in the network. It is possible to operate this EPANET program with pipe sizes as little as 120 mm and as large as 500 mm.
- We have created the following EPANET network using a variety of data that we obtained from Jalgaon Jevan Pradhikaran Department regarding Nodes, Joints, Junctions, Discharges, and Pipe Diameter.(displayed Fig. 6)

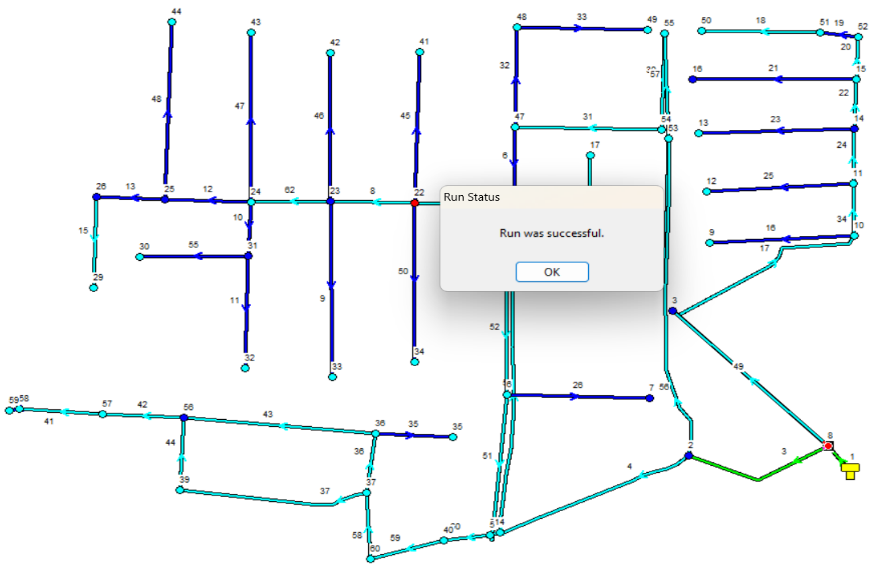


Fig 6: Final Network

Table 1: The input values for node

EPANET 2.2 - zone 9 epanet SUCESS.net - [Network Table - Nodes]

File Edit View Project Report Window Help

Node ID	Elevation m	Demand LPS	Head m	Pressure m	Quality
Junc 8	230.29	0.43	260.00	29.71	0.00
Junc 2	237.95	0.41	259.98	22.03	0.00
Junc 4	225.67	0.27	259.98	34.31	0.00
Junc 5	219.19	0.39	259.96	40.77	0.00
Junc 6	221.07	0.20	259.96	38.89	0.00
Junc 7	237.06	0.48	259.96	22.90	0.00
Junc 3	237.42	0.46	260.00	22.58	0.00
Junc 9	226.88	0.32	260.00	33.12	0.00
Junc 10	231.10	0.33	260.00	28.90	0.00
Junc 11	227.37	0.30	260.00	32.63	0.00
Junc 12	227.43	0.17	260.00	32.57	0.00
Junc 13	221.63	0.16	260.00	38.37	0.00

Table.2: The input values for pipes.

EPANET 2.2 - zone 9 epanet SUCESS.net - [Network Table - Links]

File Edit View Project Report Window Help

Link ID	Length m	Diameter mm	Roughness	Flow LPS	Velocity m/s	Unit Headloss m/km	Status
Pipe 1	38.71	500	100	21.46	0.11	0.05	Open
Pipe 2	231.01	400	100	1.79	0.01	0.00	Open
Pipe 3	162.94	400	100	17.46	0.14	0.10	Open
Pipe 4	221.12	400	100	7.87	0.06	0.02	Open
Pipe 5	391.71	400	100	7.59	0.06	0.02	Open
Pipe 6	96.17	400	100	-1.21	0.01	0.00	Open
Pipe 7	97.46	400	100	4.24	0.03	0.01	Open
Pipe 8	90.03	400	100	3.46	0.03	0.01	Open
Pipe 9	212.06	400	100	0.45	0.00	0.00	Open
Pipe 10	65.39	400	100	1.01	0.01	0.00	Open
Pipe 11	134.43	400	100	0.32	0.00	0.00	Open
Pipe 12	91.26	400	100	1.11	0.01	0.00	Open
Pipe 13	71.60	400	100	0.50	0.00	0.00	Open
Pipe 15	109.78	120	100	0.35	0.03	0.03	Open
Pipe 16	153.11	400	100	-0.32	0.00	0.00	Open

4.1. Description of Graphs

Numerous correlations between elevation, velocity, flow, pressure, head, demand, contour, etc. are investigated using EPANET. Plotting the graphs will help you understand these correlations.

1) Distribution of Pressure Velocity

It is a graph that illustrates the variation in velocity across several pipes in relation to the pressure applied to a specific pipe line. Figure 7 also shows various pressure and velocity numbers.

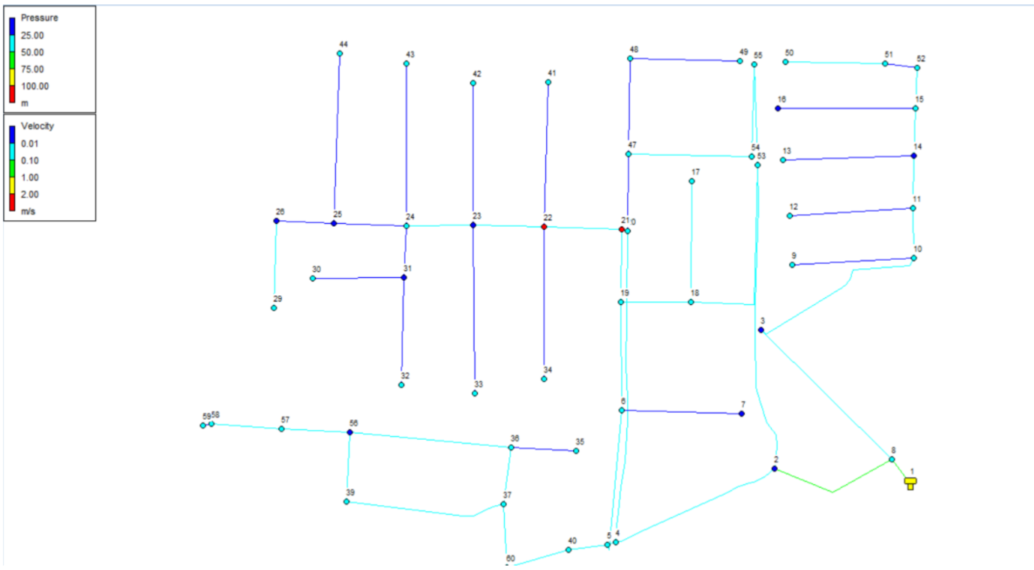


Fig 7. Pressure Vs Velocity Distribution

2) Contour Plot of Elevation

As shown in figure 8, this map displays the contour level in relation to the Elevation of pipe lines at various levels, which are further identified by the use of different colors.

Fig 8. Contour Plot Of Elevation

3) Contour Plot of Demand

The contour of various demand levels, measured in liters per meter at various sites, is displayed on this map. These can be identified by their distinct colors, as shown in Figure 9.

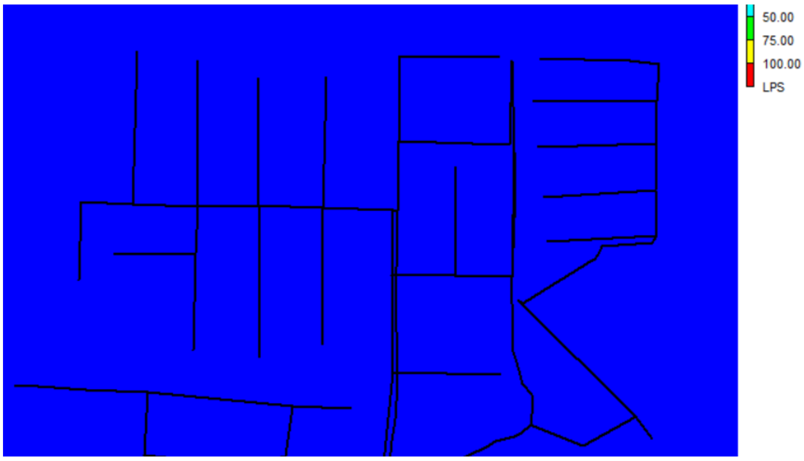


Fig 9. Contour Plot Of Demand

4) Contour of Plot Pressure

With the aid of colors, this map also displays contour levels of various pressures at various nodes, as shown in figure 10.

Fig 10. Contour Plot Of Pressure

5) Elevation-Diameter Distribution

As shown in Figure 11, this graph displays the fluctuation in diameter and height with various color schemes.

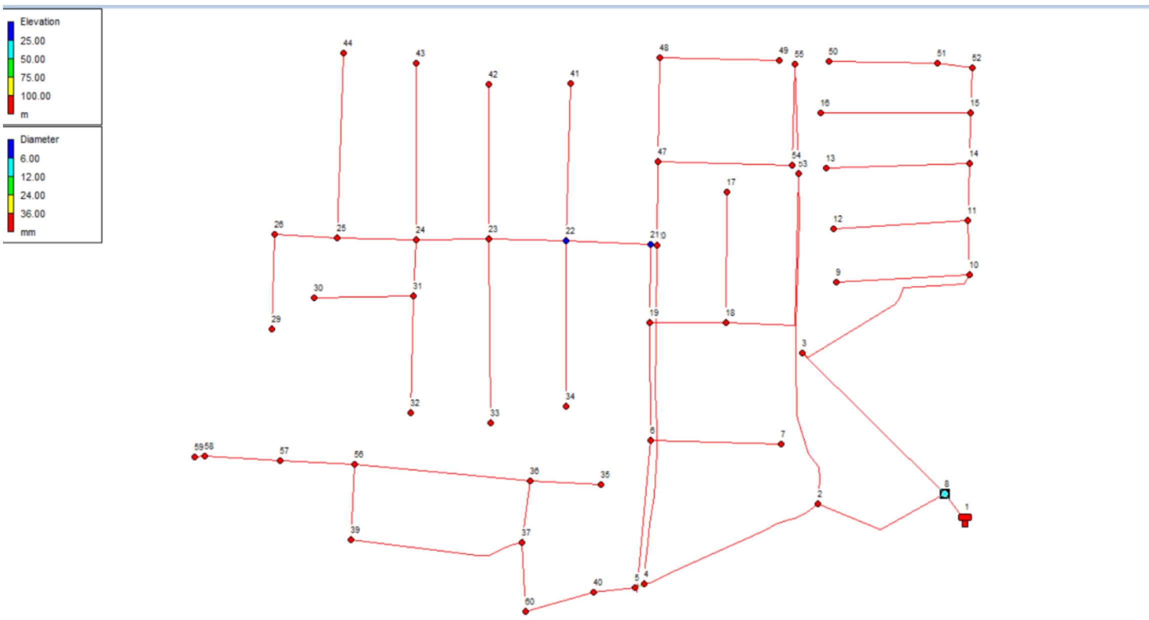


Fig 11. Elevation Vs Diameter Distribution

6) Pressure-Flow Distribution

As seen in Figure 12, this graph of pressure and flow illustrates the variation in pressure and velocity using various colors.

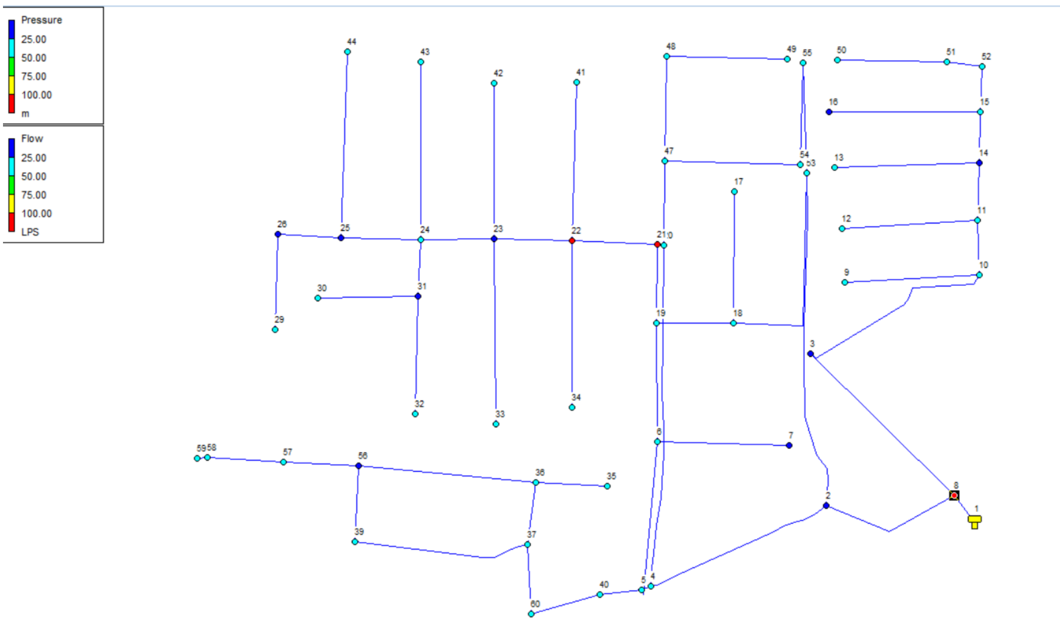


Fig 12. Pressure Vs Flow Distribution

7) Demand-Flow Distribution

Figure 13 shows about the variations in graph of water demand and flow distribution.

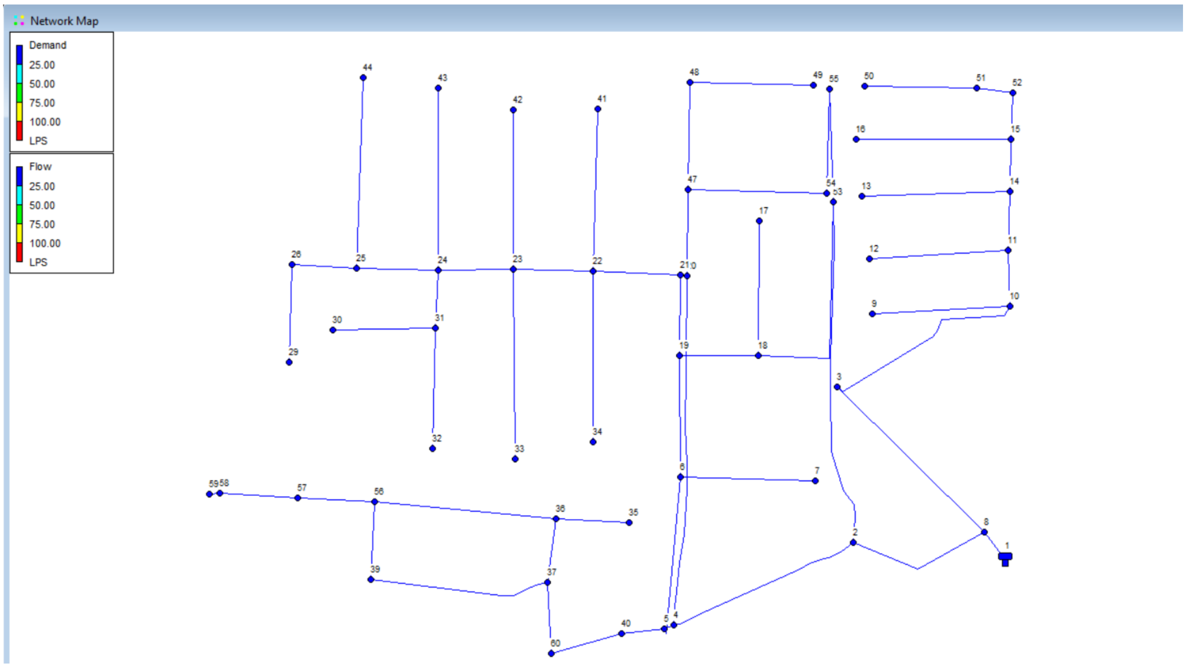


Fig 13. Demand Vs Flow Distribution

8) Pressure-Velocity Distribution

As shown in figure 14, this graph displays the variance in pressure and velocity by various values assigned by various colors.

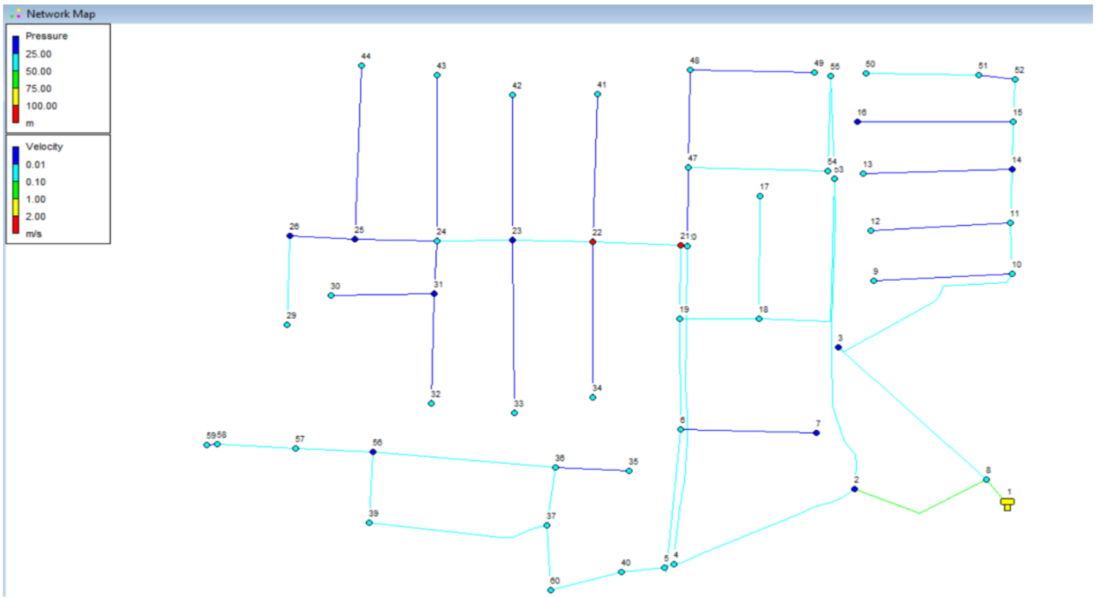


Fig 14. Pressure Vs Velocity Distribution

9) Pressure- Diameter Distribution

The pressure versus diameter graph for every pipe is displayed in Figure 15.

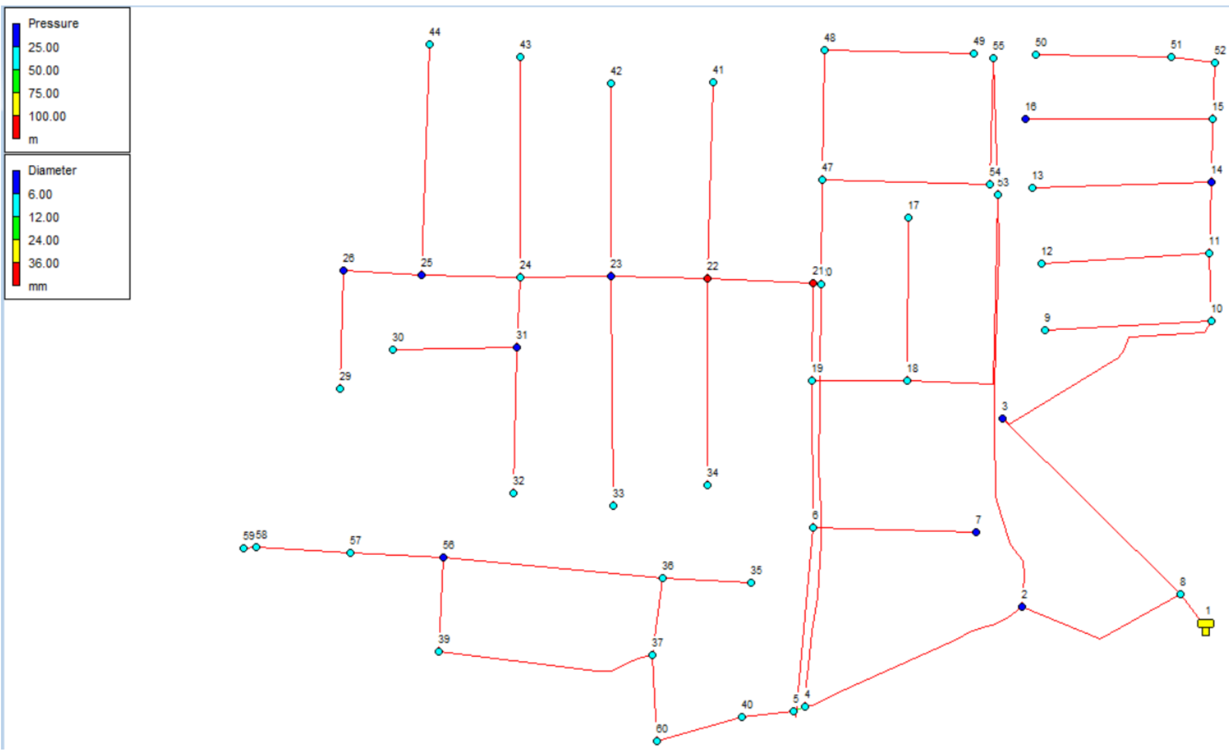


Fig 15. Pressure Vs Diameter Distribution

V. CONCLUSION

Using the nodes, elevation, number of pipes, and demand of our study region, we construct a water distribution system in this work with the use of EPANET software. In order to gather data on the area's population and per capita demand, we first conducted a survey. In light of this, we create the area's distribution system.

1. The network design for the water distribution system is the primary goal. Demand and pressure variations are displayed differently by different nodes. In this region, distribution is done using pumping systems and gravity.
2. In order to meet the water demand in a few decades, the water distribution system is planned with the future population in mind.
3. This distribution plan, which follows the zone IX layout, is a ring system. The major goal is to cost-effectively supply the general public with enough water. The system can still make significant advancements, but they will need to be achieved gradually based on resource availability.

4. A pressure of about 20 m is maintained at every junction. It is possible to operate this EPANET program with pipe sizes as little as 120 mm and as large as 500 mm.

5. Water supply engineers will benefit from this study since the procedure is simpler and quicker.

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