Water Distribution System Modeling by Using EPANET Software

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PROJECT REPORT
APPROVAL

The thesis titled "Water distribution system modeling using EPANET software" submitted by Montasir Maruf, Rifat Al Muzaddid, Mohammad Abrar Arif Chowdhury St. No. 115401, 11540, 115425 has been found as satisfactory and accepted as partial fulfillment of the requirement for the Degree Bachelor of Science in Civil Engineering.

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DEDICATION

We dedicate our thesis work to our family. A special feeling of gratitude to our loving parents.

We also dedicate this thesis to our many friends who have supported us throughout the process. We will always appreciate all they have done.

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"*In the name of Allah, Most Gracious, Most Merciful*"

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ABSTRACT

Keywords: EPA-NET software, integrated behavior of the system, pressure head, velocity head, water distribution system modeling, average daily demand, maximum daily demand, fire demand.

Sustainable development is a prime concern now a days. A good water infrastructure plays a key role for any kind development for a city. Here in this study, capital city of Bangladesh, Dhaka has been focused for analysis purpose. Although the average condition of the municipals water infrastructure systems are poor and deteriorating fast. Supply water distribution network of Banani area was selected for detail analysis. The area has been modeled using EPA-NET software on the basis of data surveyed by Dhaka WASA. An efficient water distribution system depends on adequate pressure head, velocity and flow rate. Ensuring all of this is a challenging task. Calculation of required pressure head, velocity coverage, flow rate, chlorine dosage has been done. Fire demand coverage has been analyzed for Banani area. Fire demand analysis gives the full overview of the system in the emergency condition. In water supply system chlorine is used for neutralize bacteria and make the water pure. The modelling of chlorine residual in water supply systems is of great importance in managing disinfectant concentrations throughout the network. EPANET brought enhanced capabilities for the simulation of

chlorine residuals in water supply systems. Here chlorine dose analysis has also been performed. A simulation on chlorine dose has been run to calculate the amount of chlorine that will be needed for the whole system. It will increase the efficiency of the system. Two types of scenarios has been simulated. Like, reducing the diameter of the pipes and using a multiple factor of 1.1. These scenarios indicates how will the system behave in case of failure condition. Finally, this study offers a modeling strategy of water distribution system of Banani area which will also help to overcome the possible risks & uncertainties. It will also improve the efficiency and performance of the network.

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Chapter 1 Introduction

1.1 Background:

Water distribution networks play an important role in modern societies being its proper operation directly related to the population's well-being. However, water supply activities tend to be many problems, so to guarantee good service levels in a sustainable way the water supply systems performance must be evaluated. The incorporation of performance assessment methodologies in the management practices creates competitiveness mechanisms that lead to the culture of efficiency and the pursuit of continuous improvement. The desired sustainability involves both water services and water infrastructures. The optimal management of urban water infrastructures is an unavoidable issue that needs to be addressed given their intrinsic value (water infrastructures represent an important portion of the municipal public infrastructures) and the potential consequences of the service disruption. The performance assessment is the key towards sustainability, where performance assessment can be defined as "*any approach that allows for the evaluation of the efficiency or the effectiveness of a process or activity through the production of performance measures*". Performance assessment is currently a well-established practice in the water sector. At the same time it should be ensured to supply sufficient quantity of good quality of water, it becomes almost imperative in a modern society, to plan and build suitable water supply schemes which may provide potable water to the various section of the community in accordance with their demand and requirements. Maintaining these two sections is really a challenging task. Due to the advent of some computer based software it possible to visualize, and model the entire cycle of water supply network from source to household. The network system must be modeled, analyzed, and its performance is evaluated under the various physical and hydraulic parameters or conditions. This process is called as “Simulation’. EPANET is a computer program that performs extended period simulation of hydraulic and water quality behavior within pressurized pipe networks. EPANET tracks the flow of water in each pipe, the pressure at each node, the height of water in each tank, and the concentration of a chemical species throughout the network during a simulation period comprised of multiple time steps.

Through EPANET it is possible to represent configuration of distribution system and pipe network where detailed information about the pipe like “Diameter, Length, Pipe material etc.” and devices like “Nodes, Valves etc.” are given. EPANET is such a computer based program that performs extended period simulation of hydraulic and water quality behavior within pressurized pipe networks. Through this software the daily demand of people of a certain area, fire demand, pressure head etc. can be calculated. Not only that by running for preliminary test it can be realized whether any reservoir or pump is needed to meet the demand of population. Pressure at nodes, height of tanks, and concentration of chemical species.

In Dhaka where there live a huge number of people, is very imperative in modern society to insure the availability of potable water and to plan and design for a sustainable economic suitable pipe network system or water supply schemes. To maintain and fulfill the demand of the huge population is big challenge. In this study water distribution network of Banani area which is a part of Dhaka city has been modeled through EPANET. The network has been simulated for extended period of time in different scenarios. Pressure head, velocity, flow rate, fire demand has been calculated.

1.2 OBJECTIVE:

a) To check whether is it possible to model a water distribution network with EPANET.

b) To calculate pressure head, velocity and flow rate of the network.

c) Design of pipe network to withstand any failure condition.

d) Design of pipe network system for fire demand.

e) To find alternative alignments for main pipe line from source.

f) Simulation of the water distribution network system for various hydraulic parameters.

g) Find out the Chlorine Dosage.

h) Measure the head loss.

i) Average water demand and maximum water demand can be calculated.

j) Network Analysis (Sensitivity Analysis, Dead end pipe Analysis)

1.3 Significance:

a) As EPANET is a free software so if this is possible to model the network with EPANET efficiently then it would a great help for the developed country like Bangladesh.

b) Adequate quantity of potable water can be supplied.

c) Excess amount of water to meet the fire demand can be supplied.

d) As through this software concentration of chemical species throughout the network can be calculated so potable water can be supplied.

e) As average water demand and maximum water demand is known through this software, so it will be easy to control pressure.

f) Water with desirable pressure can be supplied.

g) Through this software economic and suitable pipe material can be chosen.

Chapter 2 Literature review

In order to construct water distribution model and simulate the model many researchers tried to find some parameters that affect the simulation and play an important role to maintain the distribution system properly. Some of these parameters and their studies are discussed in this literature review.

2.1 Present demand:

The objective of any water distribution modeling system is to meet the present demand of the locality. A study led by J Muranho (2014) [2] checked the distribution system through EPANET that if the system is able to meet the present demand. The also analyzed the consequence of a pipe burst in terms of the difference between the demand required and the demand satisfied.

Another study led by Dr. H. Ramesh, L. Santhosh (2012) [1] also checked the present demand through traditional formula and then simulate the model through EPANET. They found that the result is almost same.

In another study led by Giulia Farina (2012) [5], they compared simulated result with two other methods. In first approach the total water demand associated with each pipe was divided into equal parts between the end nodes of the pipe. And in second approach the pipe is divided into two sub-reaches of equal length, which are ascribed to the respective end nodes of the pipe; the water demand in each half is computed and the result is assigned to the end nodes accordingly. Then result of these two approach were compared with EPANET simulation model. They took into account the real positions of users along pipes. They found almost similar results. Slight variations are found due to pipe resistance correction. Simplification of network has also an effect in result.

2.2 Future demand:

Future demand is one of the top concern in any water distribution system. A water distribution system should be able to meet the demand in future. So a simulation is necessary for this reason. In a study led by Dr. H. Ramesh, L. Santhosh (2012) [1] future demand had been calculated and simulated in EPANET. In that study the used a formula of

Arithmetic Increase Method : P_n= [P0+n. x*]

Geometric Increase Method : P_n= P0 (1+r/100) n

Incremental Increase Method : P_n= {P0 + n. x*+ [n (n+1)/2] y*}

Where P_n = Prospective or forecasted population; n =Number of decades;

r = Assumed growth rate in % ; x* = Average increase of population of known decades;

y* = Average of incremental increase of the population of known decades.

Though these formula they calculated future population. Then they ran a simulation in EPANET.

2.3 Pressure head:

Pressure head is another important issue for water distribution system modeling. Low pressure head causes supply deficit. In a study led by Dr. H. Ramesh, L. Santhosh (2012) [1] pressure head is calculated through traditional equation. Then they pick four nodes and ran simulation in EPANET. The results from EPANET are almost equal with the results they got from traditional equation. The results of the simulations are checked using hydraulic equations. This showed that the results are correct and can be used for modeling water supply system.

Another study led by J Muranho (2014) [2] evaluated the technical performance of a distribution system network on the basis of pressure head and showed a simulated map. It also proves that performance doesn't only depend on pressure it also depends on height of the node.

2.4 Velocity head:

Velocity head is another parameter of a good water distribution modeling system. A study led by Dr. H. Ramesh, L. Santhosh (2012) [1] calculated velocity head of different nodes through the equation of $v^2/2g$. Then simulated the model through EPANET. They compared the two results and found almost same.

Another study led by J Muranho (2014) [2] analyzed the maximum and minimum velocity head. The maximum allowed velocity is calculated by the formula $V(D) = 0.127 \cdot D0.4$, with D in millimeters and V in m/s. After that system model was simulated by EPANET.

2.5 Variable speed pump efficiency:

One of the possible for saving energy in water distribution systems is the introduction of variable speed pumps (VSPs). However, to assess the cost effectiveness of using VSPs, a correct estimate of VSP energy consumption, and therefore efficiency, is essential. This task involves estimating the efficiency of various components: pump, motor, and variable speed drive. Hydraulic solvers, which are used to check the hydraulics of the system, usually use of the affinity laws to describe the pump behavior in a VSP pumping system. A study led by Angela Marchi (2013) [3] demonstrates the inaccuracy of the popular hydraulic solver EPANET 2, which does not properly take into account the affinity laws in the efficiency computation when the speed changes for VSP operations. Instead, the software uses the original efficiency curve at the nominal speed. Therefore, the pump power and the energy consumption retrieved, which are inversely proportional to the efficiency, are incorrect.

2.6 Limitations of EPANET:

Nodal outflows in a pressure deficient water distribution network depend on available nodal heads. Thus, node-head flow relationship exists at each node which are solved along with other appropriate equations for simulation. A study led by M. A. H. Abdy Sayyed (2014) [4] showed that while using EPANET for such simulation, source code needs to be modified to obtain direct solution.

2.7 Simulation for system considering normal pressure & pressure deficient scenarios:

A study led by J Muranho (2014) [5] ran a water distribution system through EPANET considering both normal pressure & pressure deficient scenarios. The analysis found that the pressure deficient condition must be supported by tools that can compute the available demand as a function of the pressure condition. This requirement has led to the development of pressure demand and pressure-leakage relationship to model the available nodal demand

and pipe leakage. It is also focused on the behavior of the pressure driven simulation and address the need to report more data about the internal state of the system mainly when pressure is positive but insufficient to fulfill the demand. Also attention is given to consumption of water losses through pipe leakage.

2.8 Analysis of water distribution system in rural areas using EPANET 2:

In the study led by Dr. G. Venkata Ramana, Ch. V. S. S. Sudheer , B.Rajasekhar (2015) [6] it has been shown that EPANET 2 is successfully used in analyzing and modeling of rural water distribution system. They selected the area of Kadapa District of Andhra Pradesh, India. A water distribution model has been prepared in EPANET and ran simulation. It checked the present demand, future demand and the pressure in the nodes. They also checked the head vs. flow. All the results are satisfactory. And the concluded that EPANET 2 can be successfully used in analyzing complex type of network.

2.9 Modeling of chlorine decay:

Chlorine is used worldwide as a disinfectant residual to counteract microbial contamination and proliferation in drinking water supply systems. The management of chlorine residual concentration within defined limits in drinking water systems is a major concern for utilities. Hence the modelling of chlorine residual in water supply systems is of great importance in managing disinfectant concentrations throughout the network. First order decay kinetics are currently often used to describe both bulk and wall chlorine consumption. Water quality models that simulate chlorine decay are valuable tools for the management of chlorine residual. Such models are currently used for dosage optimization, chlorination facilities siting and prediction of critical locations where chlorine may decay to ineffective levels. EPANET brought enhanced capabilities for the simulation of chlorine residuals in water supply systems.

A study led by L.Monteiro, D.Figueiredo, S.Dias, R.Freitas, D.Covas, J.Menaia, S.T.Coelho. [7] The case study was carried out in a sector of the drinking water transmission system that supplies eastern Algarve, Portugal. It shows that 2R model conceptually approaches better the processes involved in bulk chlorine consumption in supply systems, namely by incorporating fast and slow decay terms, and depending less on wall decay calibration, similarly satisfactory descriptions of chlorine decay were produced with the 1st and nth order models. Hence, 2R and 1st and nth order less complex models may be successfully used for simulating chlorine decay in supply systems, provided that a sound calibration of wall reaction rate coefficient is performed. It also shows that EPANET 2 is more advantageous than other simulation software for modeling of chlorine decay.

Another study led by F. Nejjari, V. Puig, R.Pérez, J. Quevedo, M.A. Cugueró, G. Sanz, J.M. Mirats, 2013. [8] Their study area was water distribution system of southern part of Barcelona. A simulation has been run and they checked the chlorine concentration over time. They also compared different zone approach. This paper shows that single zone, double zone and three zone combined model reduce the model error and it helps to calibrate the model. It also shows that this chlorine analysis data can be used for commercial uses.

2.10 Observations from literature review:

1. Present demand and future demand can be calculated through EPANET. It gives an accurate result and it can be used for commercial uses.
2. Pressure head and velocity head can also be calculated through EPANET. There is no variations between the traditional formula results and simulated results.
3. EPANET 2 does not properly take into account the affinity laws in the efficiency computation when the speed changes for VSP operations. Instead, the software uses the original efficiency curve at the nominal speed. So it doesn't give accurate results.
4. In a pressure deficient water distribution network nodal outflows depend on available nodal heads. So in this case source code needs to be modified.
5. Chlorine concentration and decay can be successfully analyzed and simulated through EPANET. For accurate results wall coefficient and bulk coefficient need to be modified.

Chapter 3 Description of EPANET

3.1 General:

EPANET is a computer program that performs extended period simulation of hydraulic and water quality behavior within pressurized pipe networks. A network consists of pipes, nodes (pipe junctions), pumps, valves and storage tanks or reservoirs. EPANET tracks the flow of water in each pipe, the pressure at each node, the height of water in each tank, and the concentration of a chemical species throughout the network during a simulation period comprised of multiple time steps. In addition to chemical species, water age and source tracing can also be simulated. EPANET is designed to be a research tool for improving our understanding of the movement and fate of drinking water constituents within distribution systems. It can be used for many different kinds of applications in distribution systems analysis.

Sampling program design, hydraulic model calibration, chlorine residual analysis, and consumer exposure assessment are some examples. EPANET can help assess alternative management strategies for improving water quality throughout a system.

These can include:

- Altering source utilization within multiple source systems,
- Altering pumping and tank filling/emptying schedules,
- Use of satellite treatment, such as re-chlorination at storage tanks,
- Targeted pipe cleaning and replacement.

Running under Windows, EPANET provides an integrated environment for editing network input data, 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.

3.2 Hydraulic Modeling Capabilities:

Full-featured and accurate hydraulic modeling is a prerequisite for doing effective water quality modeling. EPANET contains a state-of-the-art hydraulic analysis engine that includes the following capabilities:

- Places no limit on the size of the network that can be analyzed
- Computes friction head loss using the Hazen-Williams, Darcy-
- Weisbach, or Chezy-Manning formulas
- Includes minor head losses for bends, fittings, etc.
- Models constant or variable speed pumps
- Computes pumping energy and cost.
- Models various types of valves including shutoff, check, pressure
- Regulating, and flow control valves
- Allows storage tanks to have any shape (i.e., diameter can vary with
- height)
- Considers multiple demand categories at nodes, each with its own
- Pattern of time variation
- Models pressure-dependent flow issuing from emitters (sprinkler heads)

- Can base system operation on both simple tank level or timer controls and on complex rule-based controls.

3.3 Water Quality Modeling Capabilities:

In addition to hydraulic modeling, EPANET provides the following water quality modeling capabilities:

- Models the movement of a non-reactive tracer material through the network over time.
- Models the movement and fate of a reactive material as it grows (e.g., a disinfection by-product) or decays (e.g., chlorine residual) with time
- Models the age of water throughout a network
- Tracks the percent of flow from a given node reaching all other nodes over time
- Models reactions both in the bulk flow and at the pipe wall
- Uses n-th order kinetics to model reactions in the bulk flow
- Uses zero or first order kinetics to model reactions at the pipe wall
- Accounts for mass transfer limitations when modeling pipe wall reactions
- Allows growth or decay reactions to proceed up to a limiting concentration
- Employs global reaction rate coefficients that can be modified on a pipe-by-pipe basis
- Allows wall reaction rate coefficients to be correlated to pipe roughness
- Allows for time-varying concentration or mass inputs at any location in the network
- Models storage tanks as being either complete mix, plug flow, or two-compartment reactors.

3.4 Steps in Using EPANET:

One typically carries out the following steps when using EPANET to model a water distribution system:

- Draw a network representation of your distribution system or import a basic description of the network placed in a text file.
- Edit the properties of the objects that make up the system.
- Describe how the system is operated.
- Select a set of analysis options.
- Run a hydraulic/water quality analysis.
- View the results of the analysis.

3.5 Limitations:

There are some limitations of EPANET. Here it is described in detail.

- For multiple demand conditions/ planning/scenarios/various methods of integrating with other data sources an agency may already have in place not supported in EPANET such as GIS.
- It is not very User friendly while selecting & deselecting.
- Files cannot be exported directly from Microsoft Excel.

Chapter 4 Location & Working procedure

This chapter is about details description of project location and working procedure. Here details about the location, data collections, data sorting and the working procedure has been discussed. Two types of models has been formed. This models helped to achieve the study objective.

4.1 Location:

As a project location the southern part of Banani area has been chosen which is under District Meter Area 502 (DMA-502). It is started from Kamal Ataturk Avenue and ended to Uttara Airport Road along Korail slum area. Some parts of Gulshan are also included to our project location. But the project location mainly includes Banani Road no. #6, #7, #8 & #11. There are 2 super markets, some commercial buildings, residential houses and restaurants are included in Banani region.

Fig 4.1 is the Google earth view of Banani area.

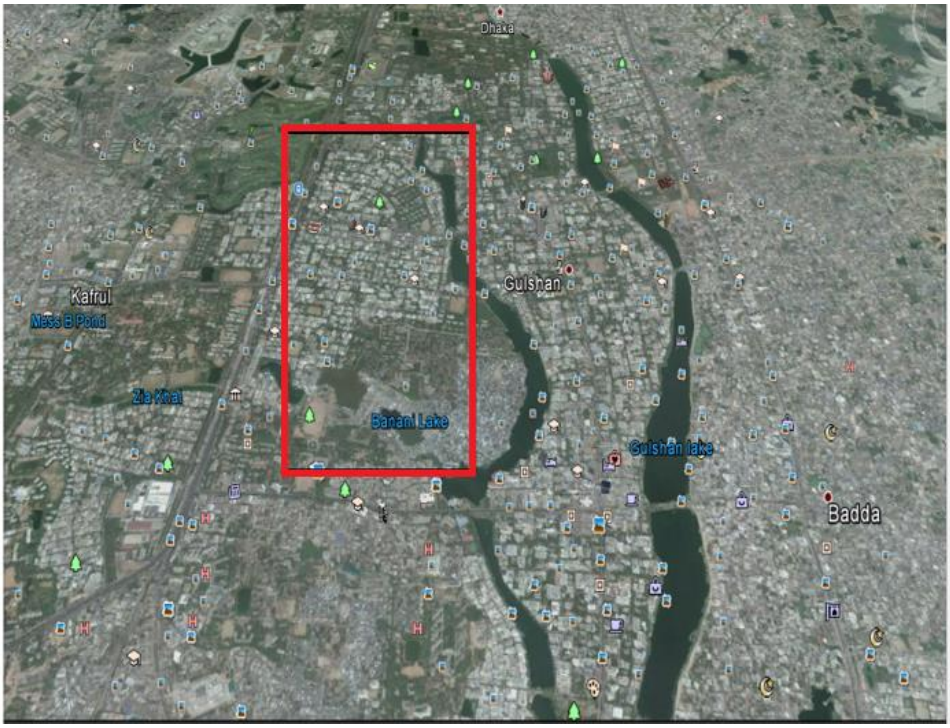

Fig: 4.1, Google Earth View of project

As in this area a huge number of people live so the utilization of water is also huge. To perform a better pipe-line distribution 195 nodes, 245 pipes, 99 open valves and 3 pumps are used.

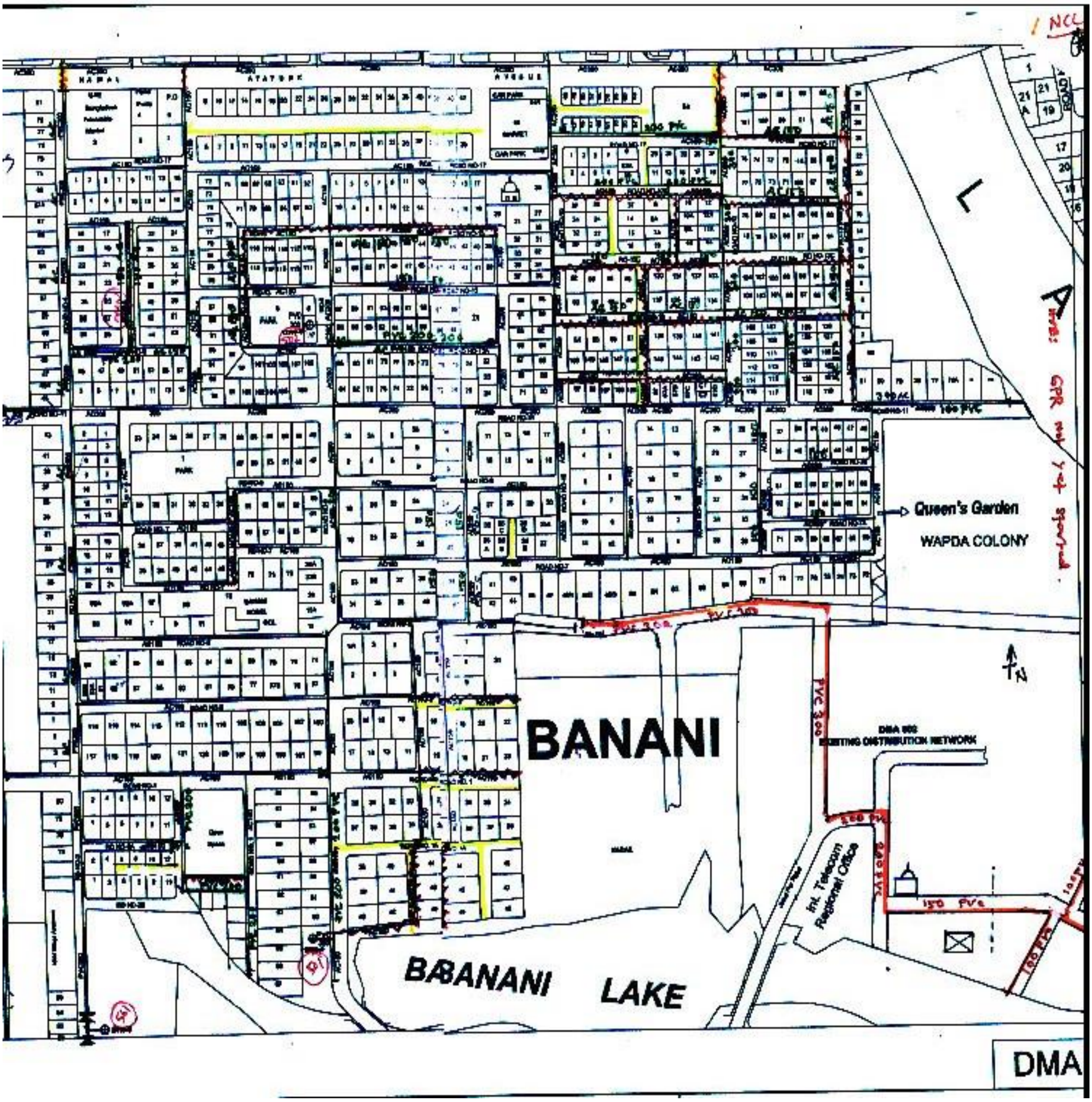

Fig: 4.2, Project View

Fig: 4.2 shows the water supply pipe outline of the Banani area. It is formed by DWASA. It shows the pipe, nodes, tanks and pump.

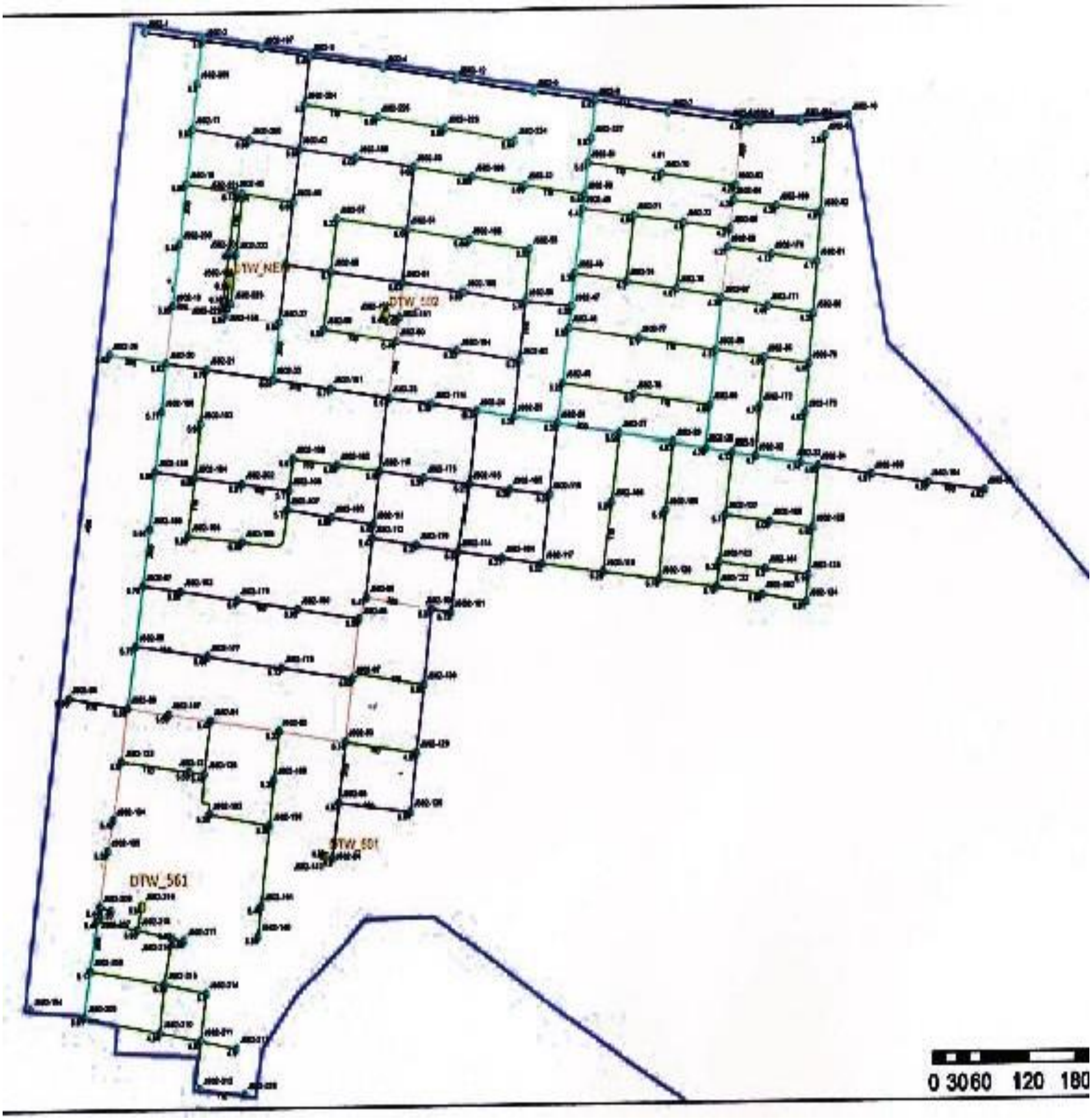

Fig: 4.3, Pipe-line distribution of project

All these maps or drawings are given by DWASA (Dhaka water supply & sewerage authority).

4.2 Working Procedure:

At first data is collected from the source in this case it was collected from DWASA (Dhaka water supply & sewerage authority). And according to that data a draft design is drawn, in this draft design all the detailed data is included and this draft drawing is drawn into A3 size paper. All the nodes, pipes and other necessary objects are identified in the draft map. Then the background of the design outline is prepared in AutoCAD according the draft map.

Fig: 4.4 shows the background prepared by AutoCAD.

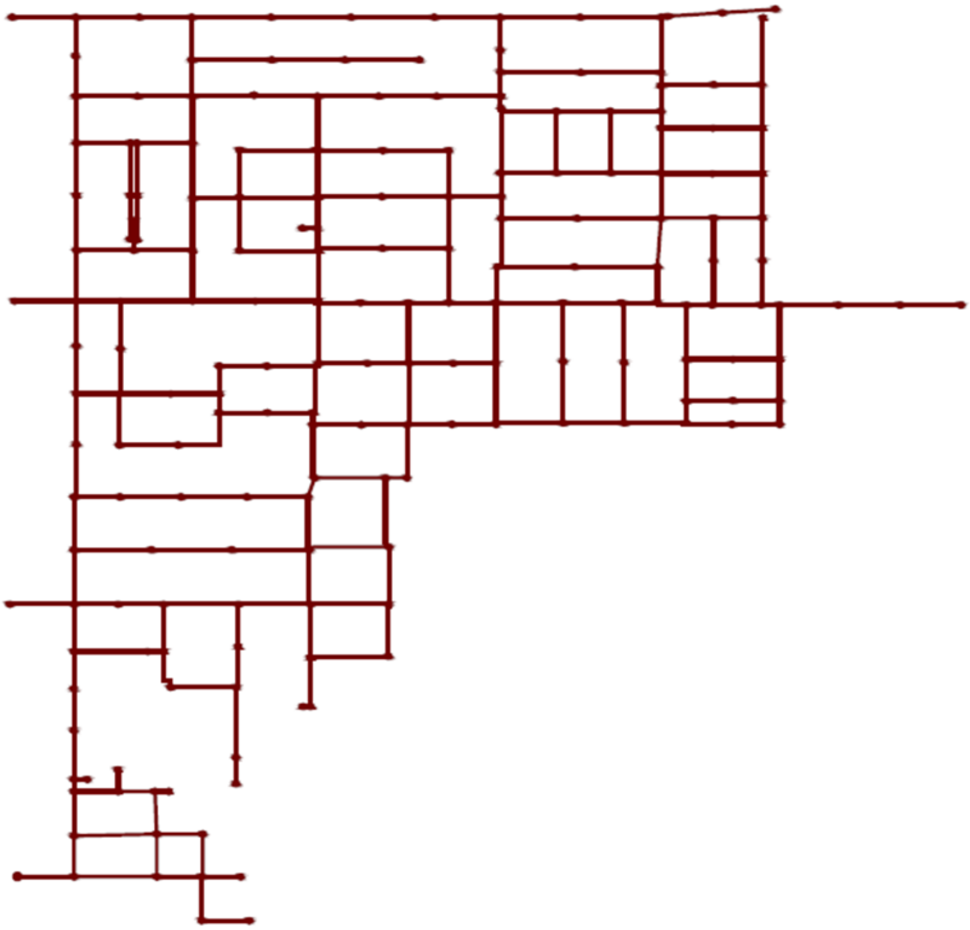

Fig: 4.4

There may be some errors in this background. So to resolve these errors and to increase the accuracy several cross checking is done. After completing the cross checking the raw file of AutoCAD is prepared completely and then the raw file is exported to EPA-NET. Then nodes, pipes, pumps and tanks are added to the main network with EPANET tools. Pumps were also added with Standard Pump Curves.

Imaginary tanks are added to calibrate the pressure with DWASA data.

Thus the model has been established and after the necessary adjustments the final results were generated. There are some errors, those are solved instantly.

Fig: 4.5 shows the final model prepared by EPANET.

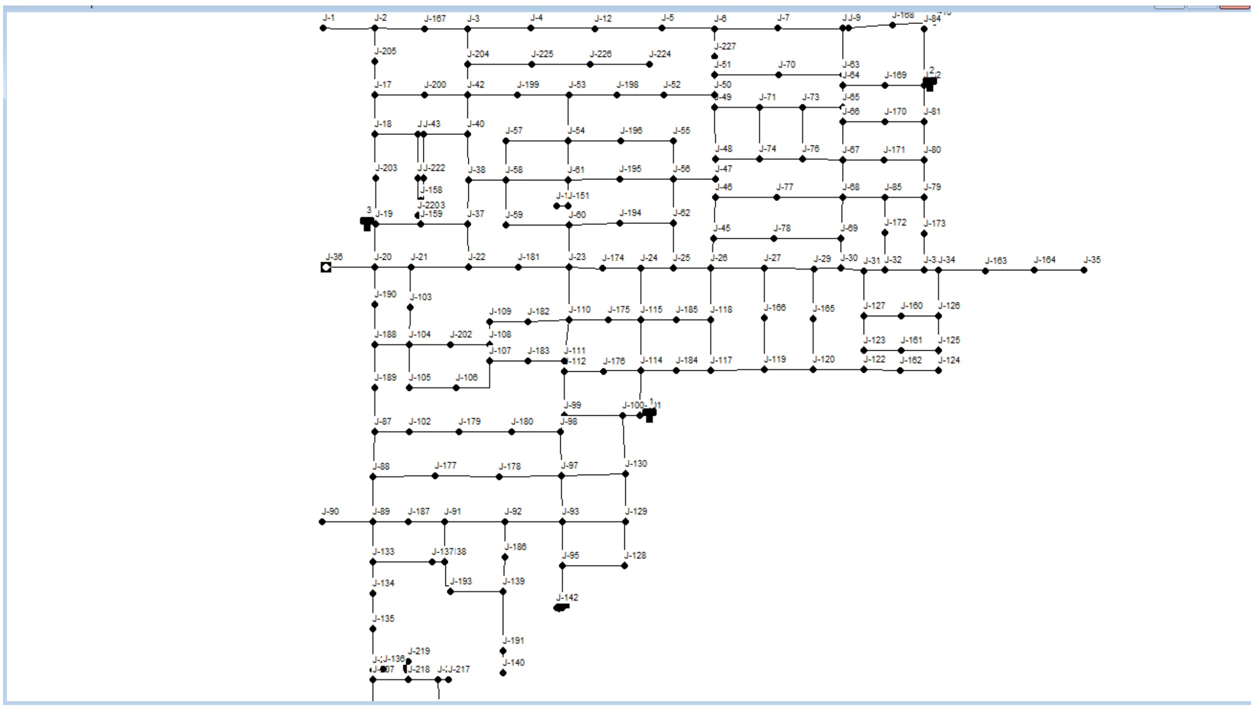

Fig: 4.5

4.2.1 Assigning data in nodes:

First the data from DWASA (Dhaka water supply & sewerage authority) was taken and then each and every nodes are labeled. The label was assigned as J-[XYZ]. After labelling individual ID was given to each nodes. Elevation of each nodes are given and these are added through the data of DWASA (Dhaka water supply & sewerage authority). Demand on each nodes are assigned on the whole model. Base demand and the junction ID are assigned in nodes input.

4.2.2 Assigning data on pipes:

According to data pipes are also labeled and after labelling individual ID are given to each and every pipe. Here pipes are assigned as P-[XYZ]. Layout has been maintained according to "START NODE" and "END NODE" from the source data. Length of each pipes are assigned on whole model. Diameter of every pipe is assigned according to DWASA-data.

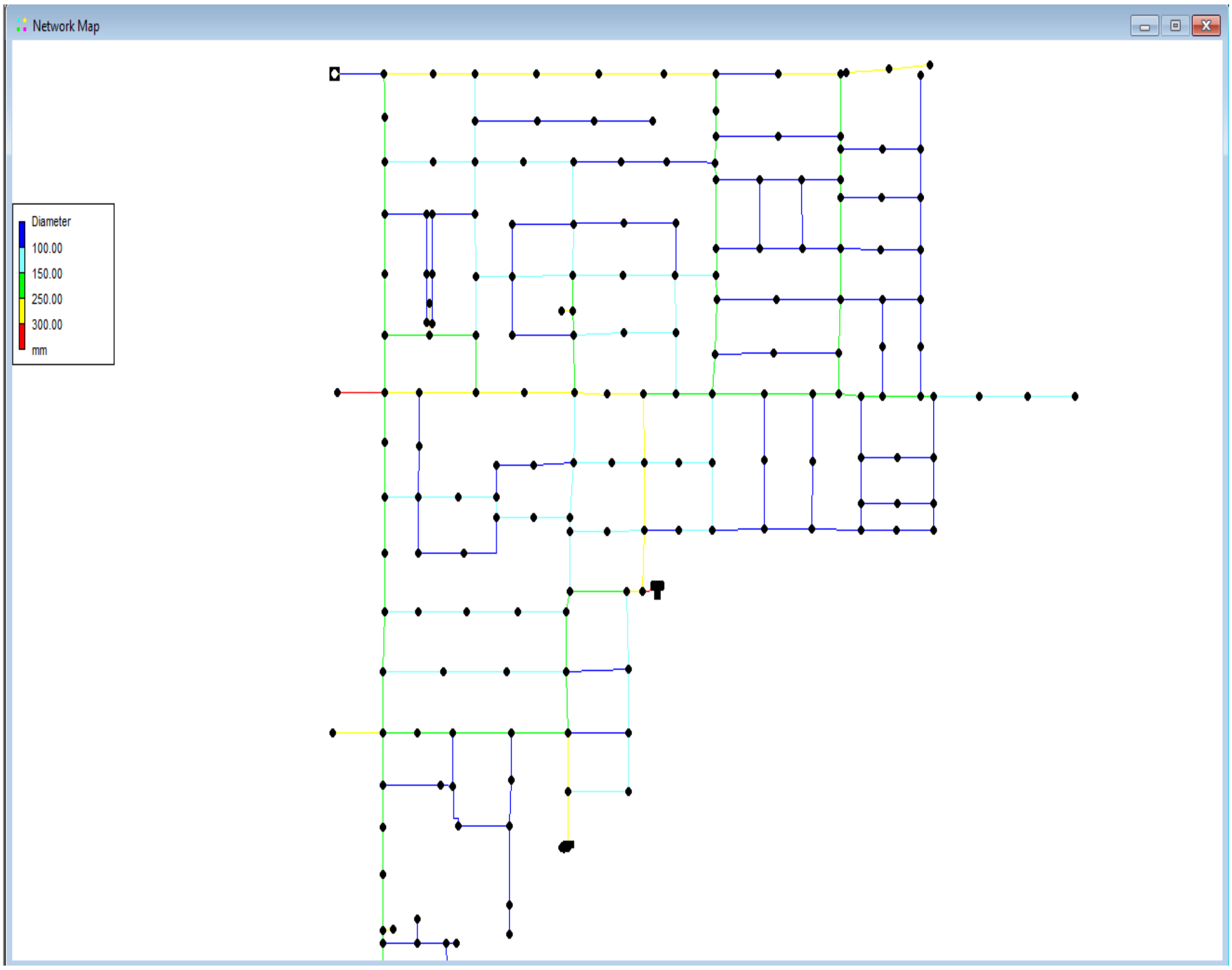

Fig: 4.6

This figure (Fig: 3.6) indicates the diameter of each pipe on model. The deep blue indicates diameter of less than 100 mm. pipe. Sky-blue indicates diameter of 100mm. to 150mm. Green one indicates diameter of 200 mm. to 250 mm. pipes. Yellow color indicates the pipe diameter between 250 mm. to 300mm. and the red one indicates the pipes' diameter more than 300mm. overall 4- types Pipes have been used having diameter (6", 7", 9"&11"). "Hazen-Williams" coefficient -"C" value was assigned as a value of 110 in each pipe. Pipe diameter, pipe length, Hazen-Williams coefficient are the input of pipe section.

4.2.3 Assign values on Valves:

The Valves which are designed all through the model maintain Open Gate Valve properties. A value of 0.02 as a “loss coefficient” in every valves was included in the Pipes. According to the Data every Valves are operable.

4.3 Calibration:

The purpose of calibration is to get a proper result and reduce the chance of wrong output. Here all the data (pressure, flow, velocity) are calibrated with DWASA data. For the purpose of calibration imaginary tanks were used. Otherwise EPANET does not support to run the model without tank.

4.4 Assumptions:

There are few assumptions that are used for simulation.

- Hazen-Williams coefficient ‘C’ value is used as 110. It can be also said ‘Roughness coefficient’.
- Here in the model open gate valves are used. So as friction factor 0.02 has been used.
- There are ‘Standard tee flow through branch’ and ‘Standard tee flow through run’ in the network. For ‘Standard tee flow through branch’ loss coefficient 1.8 has been used and ‘Standard tee flow through run’ loss coefficient 0.6 has been used.

Chapter 5 Result & Discussion

The topic of this chapter is to discuss about the results and understand the behavior of the network in different scenarios. Here network has been analyzed in five different scenarios. The scenarios are ADD (Average Daily Demand), MDD (Maximum Daily Demand), FD (Fire demand), Sensitivity analysis (Reduction of diameter of pipe and use of multiple factor 1.1). More ever Dead End Pipe Analysis and Chlorine Doses Analysis have been done.

5.1 ADD (Average Daily Demand):

DWASA served the demand data which is basically MDD. So all the MDD have been divided by 1.8 to get ADD. After giving the input of ADD result of pressure and total head of every node and flow and velocity of every pipe are displayed. Fig:

5.1 shows the information of node and Fig: 5.2 shows the information of pipe.

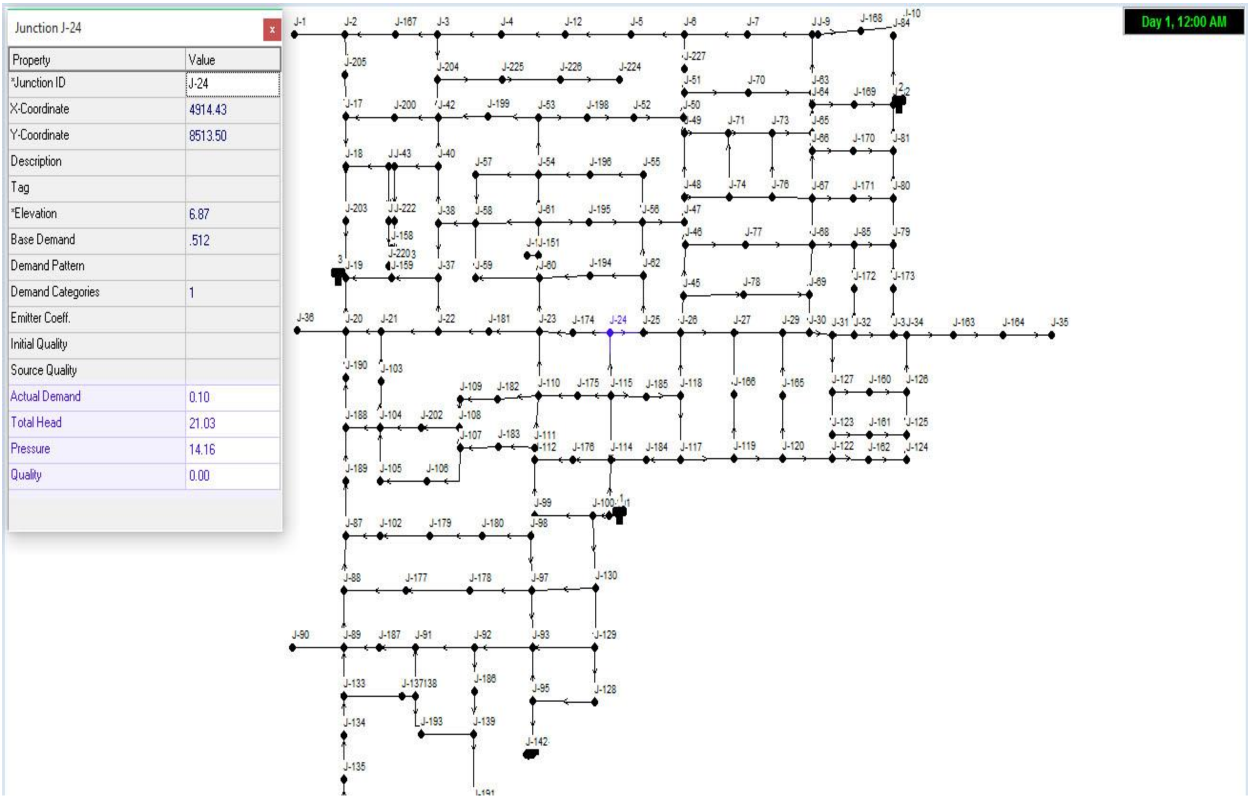
Junction J-24
Property | Value
*Junction ID | J-24
X-Coordinate | 4914.43
Y-Coordinate | 8513.50
Description
Tag
*Elevation | 6.87
Base Demand | .512
Demand Pattern
Demand Categories | 1
Emitter Coeff.
Initial Quality
Source Quality
Actual Demand | 0.10
Total Head | 21.03
Pressure | 14.16
Quality | 0.00
Day 1, 12:00 AM

Fig: 5.1

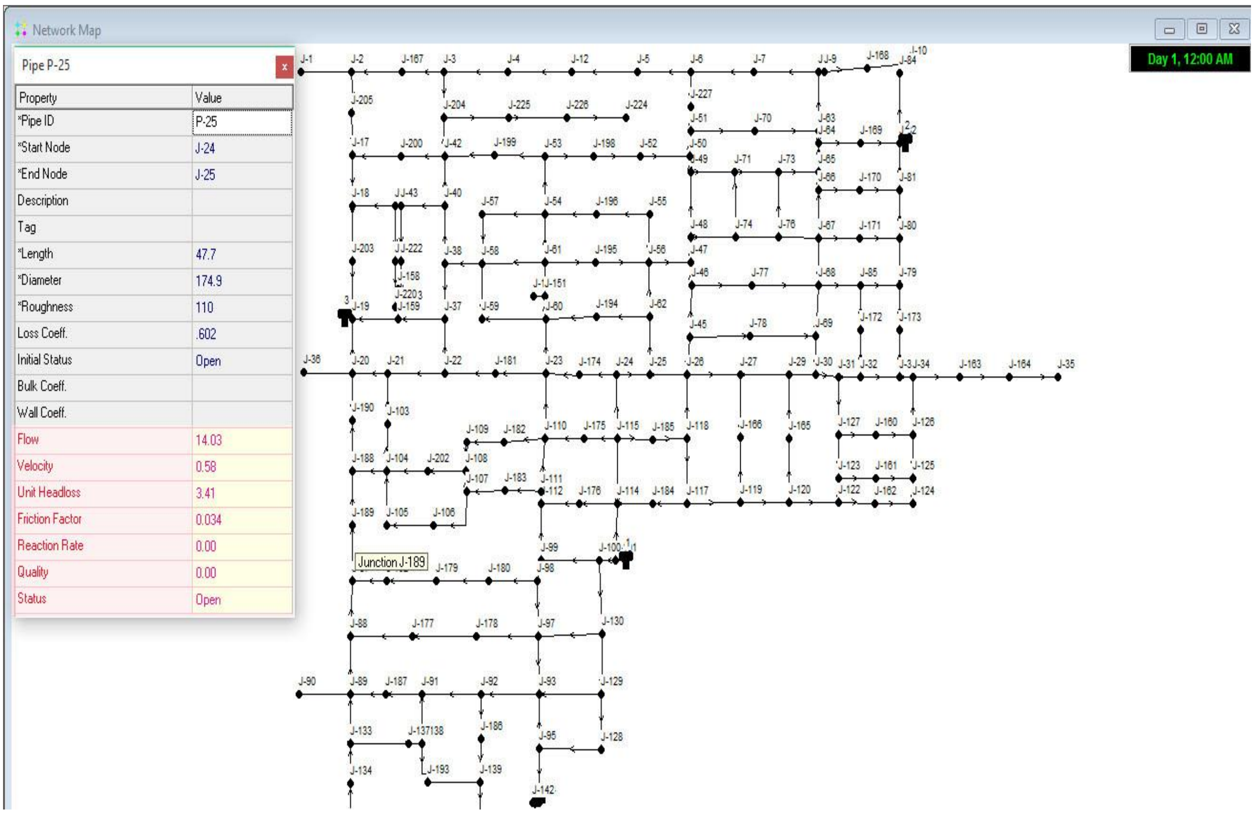
Network Map
Pipe P-25
Property | Value
*Pipe ID | P-25
*Start Node | J-24
*End Node | J-25
Description
Tag
*Length | 47.7
*Diameter | 174.9
*Roughness | 110
Loss Coeff. | .602
Initial Status | Open
Bulk Coeff.
Wall Coeff.
Flow | 14.03
Velocity | 0.58
Unit Headloss | 3.41
Friction Factor | 0.034
Reaction Rate | 0.00
Quality | 0.00
Status | Open
Junction J-189
Day 1, 12:00 AM

Fig: 5.2

Pressure of every node have been analyzed individually. The normal range of pressure for node is 10-15m. Here we can see in Fig: 5.3 that almost in every node the value of pressure is within 12-13m. So the limit is normal. Only in node J-225 the value of pressure is 15.84m. High pressure cause pipe bursting. But here pressure is normal. So there is no chance of pipe bursting.

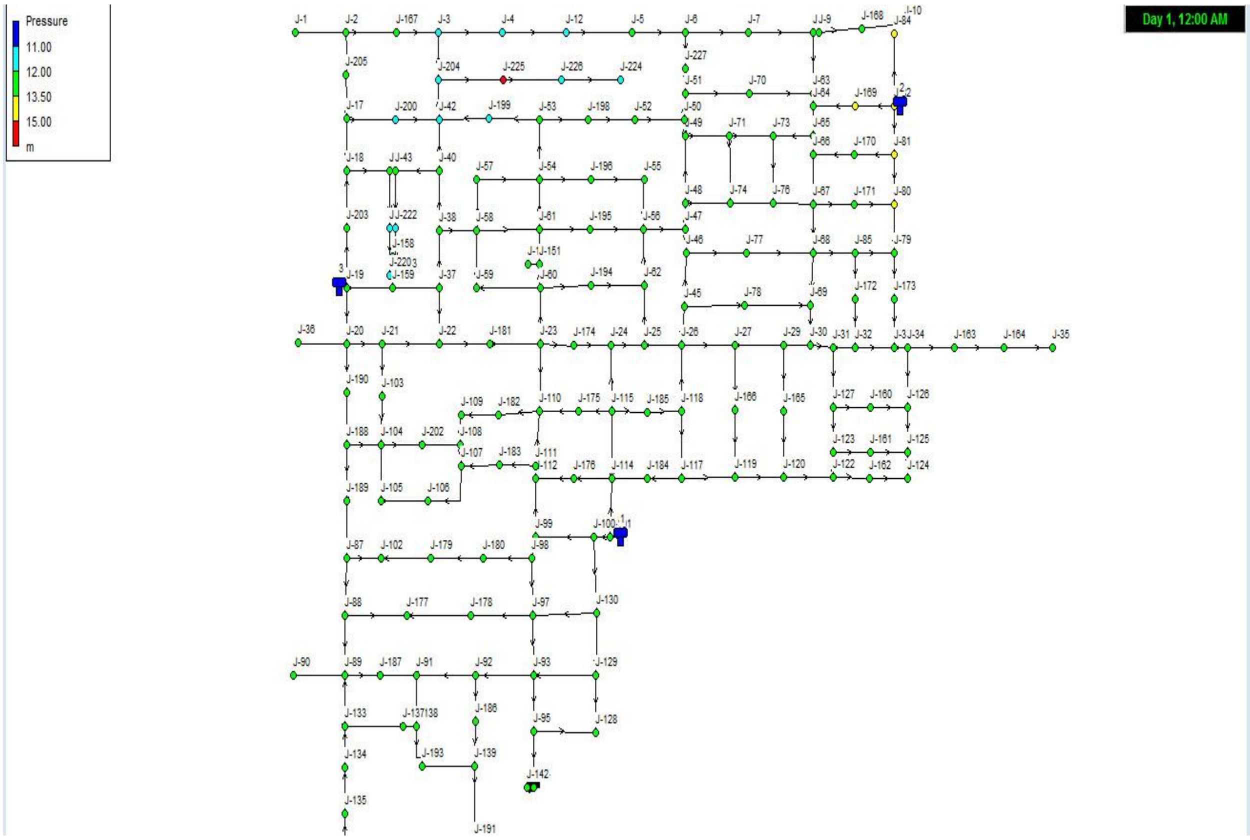

Fig: 5.3

Fig: 5.4 shows the head loss in nodes. Here the value of head loss in all nodes are within 20-25m. Acceptable limit of head loss is 20-25m. So head loss is within acceptable limit.

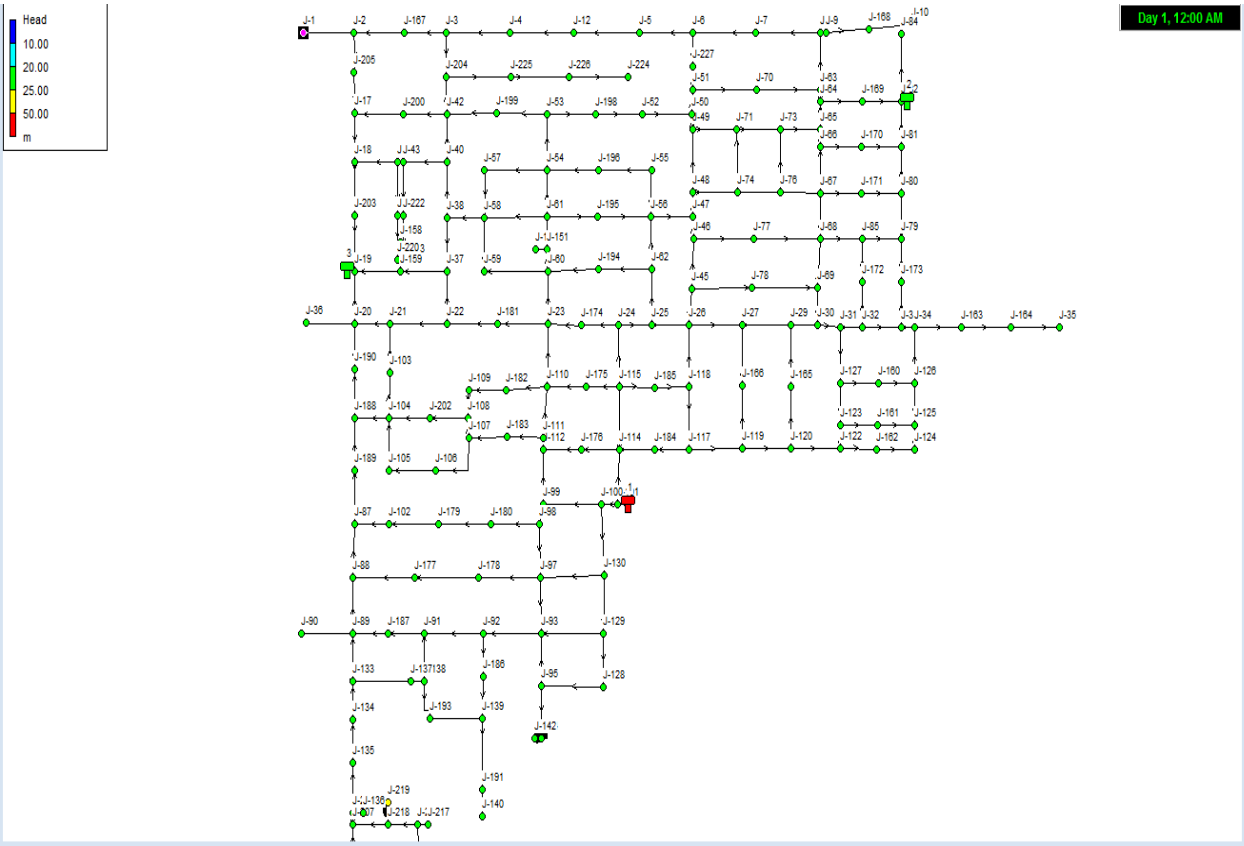

Fig: 5.4

Fig: 5.5 shows the flow variation. Maximum flows of the pipes are within 1-20 lps. Few pipes are below 1lps and one pipe is above 20lps.

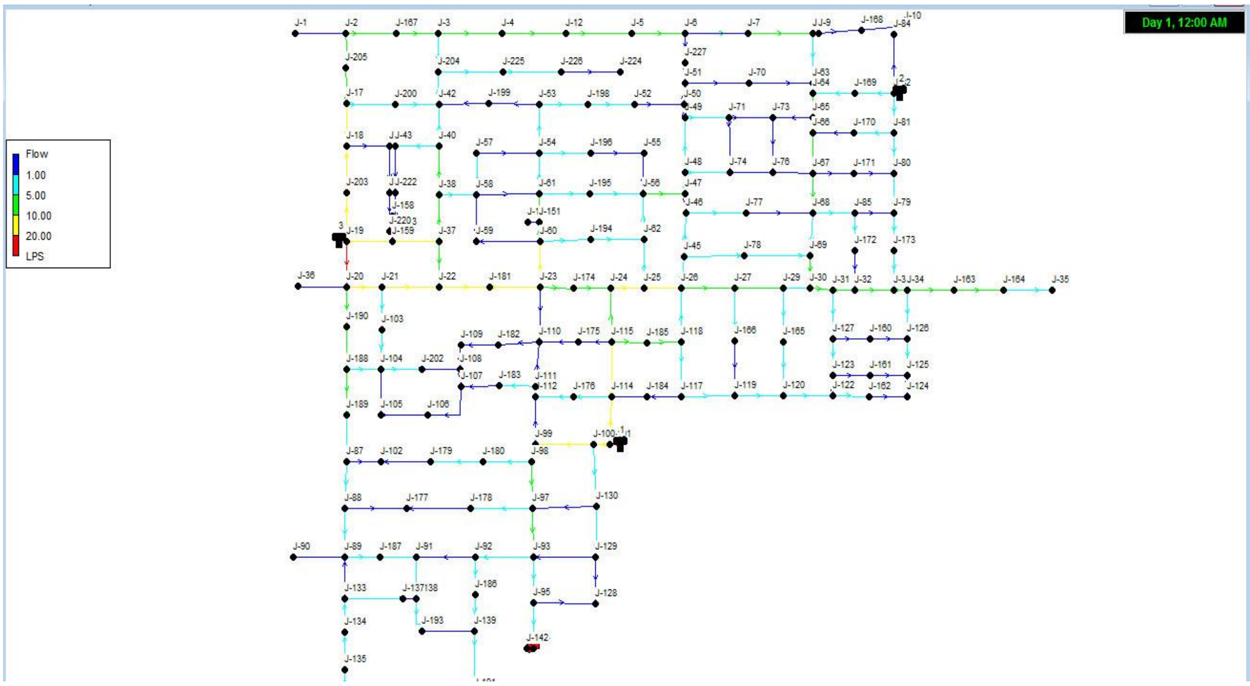

Fig: 5.5

Fig: 5.6 shows the velocity variation. Here velocity are between 0.01-1.00 m/s. The velocity variation is high. But velocities are within the limit.

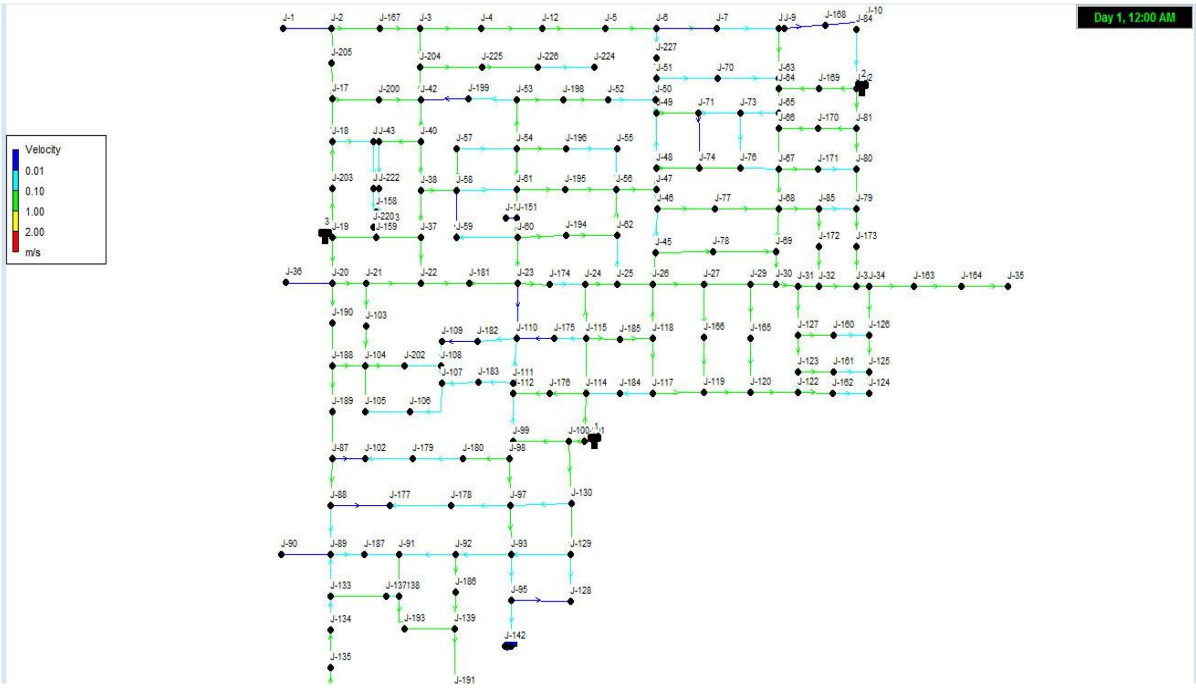

Fig: 5.6

Chlorine dose analysis has also been done. It appears that 1mg/L chlorine dose in every tank is enough for covering the whole network. Fig: 5.7, 5.8 & 5.9 show the three hours simulation results of chlorine dose.

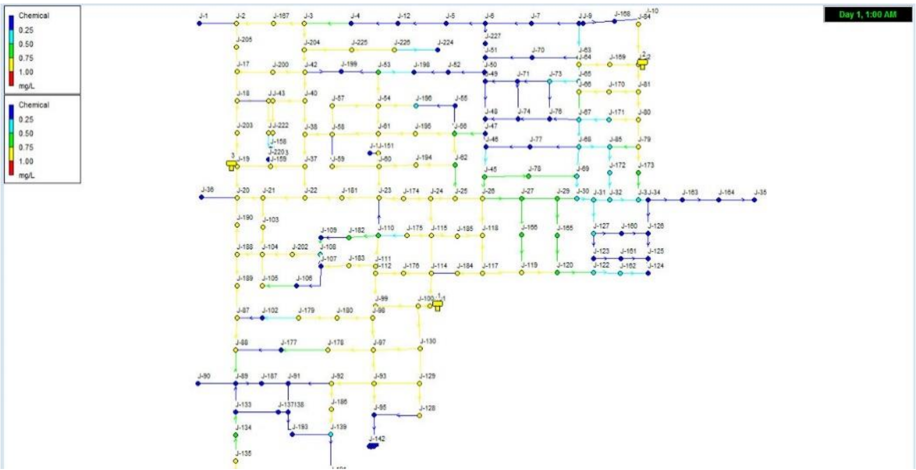

Fig: 5.7

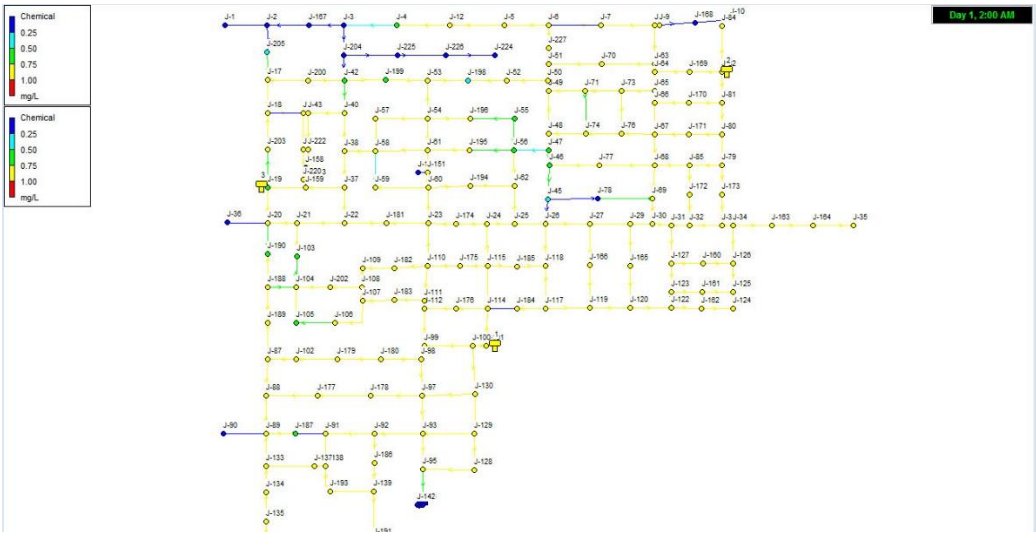
Chemical
0.25
0.50
0.75
1.00
mg/L
Chemical
0.25
0.50
0.75
1.00
mg/L
Day 1, 2:00 AM

Fig: 5.8

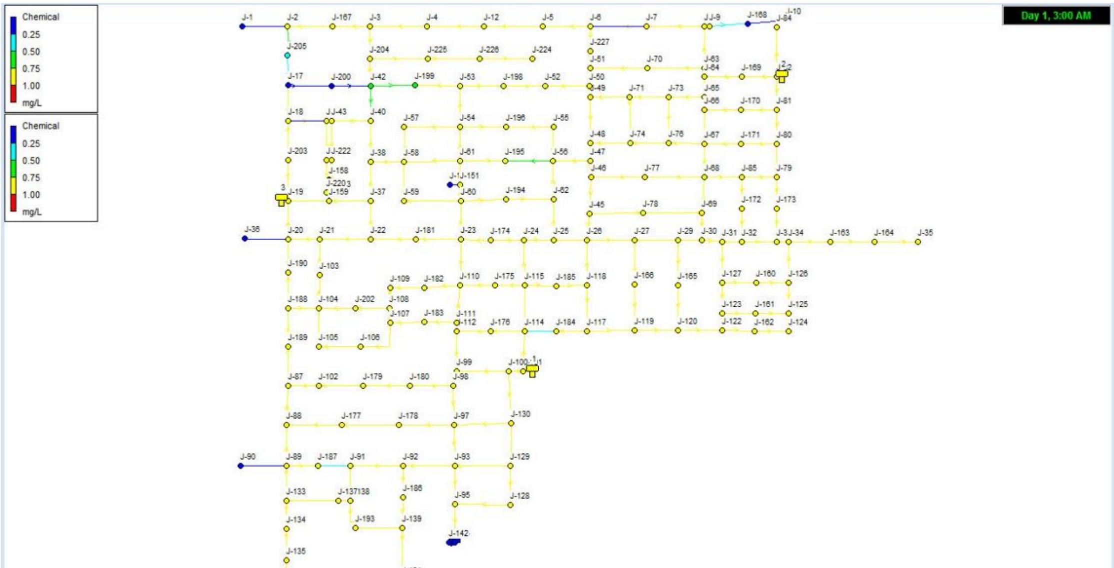
Chemical
0.25
0.50
0.75
1.00
mg/L
Chemical
0.25
0.50
0.75
1.00
mg/L
Day 1, 3:00 AM

Fig: 5.9

So from the analysis of ADD it can be concluded that there are no high or low pressure nodes, high or low flow rate and no high or low velocity.

5.2 MDD (Maximum Daily Demand):

DWASA served the MDD data. After giving the input EPANET analyzed the data and all the necessary results are displayed. MDD result of pressure and total head of every node and flow and velocity of every pipe are displayed. Fig: 5.10 shows the information of node and Fig: 5.11 shows the information of pipe.

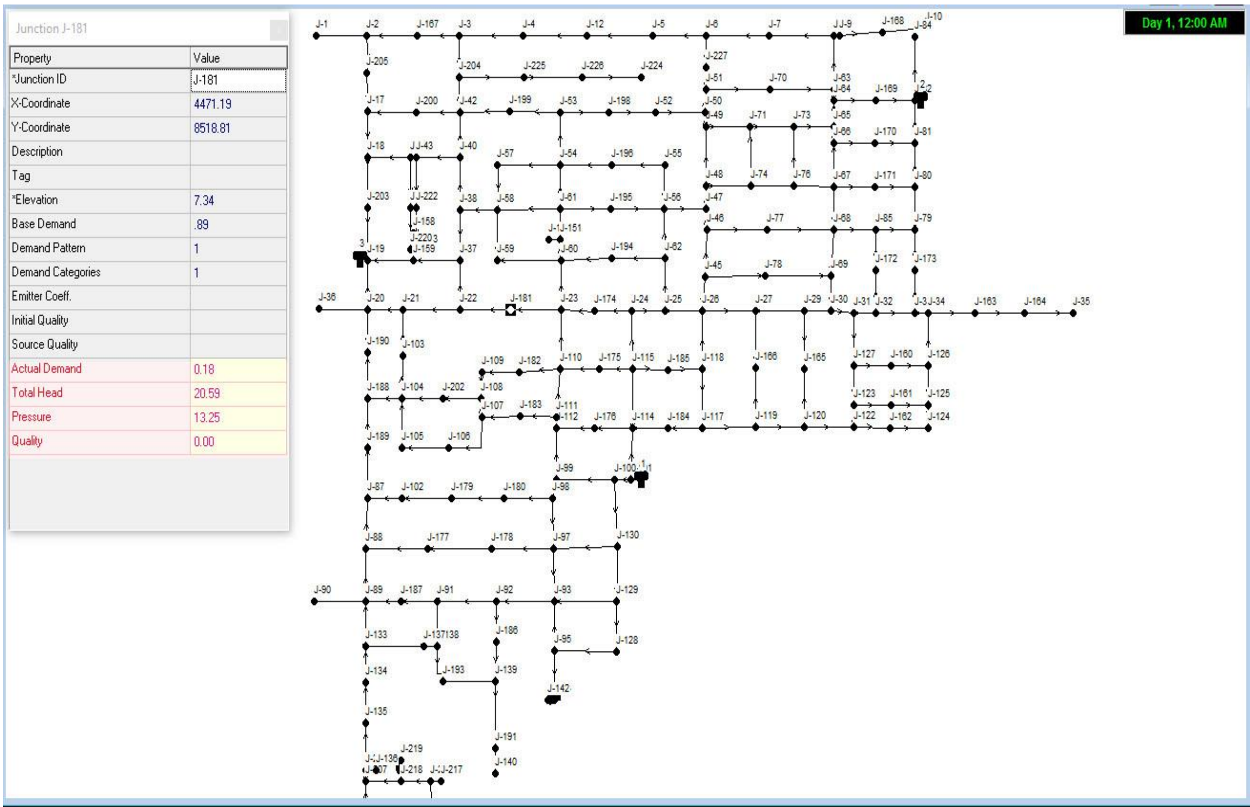

Fig: 5.10

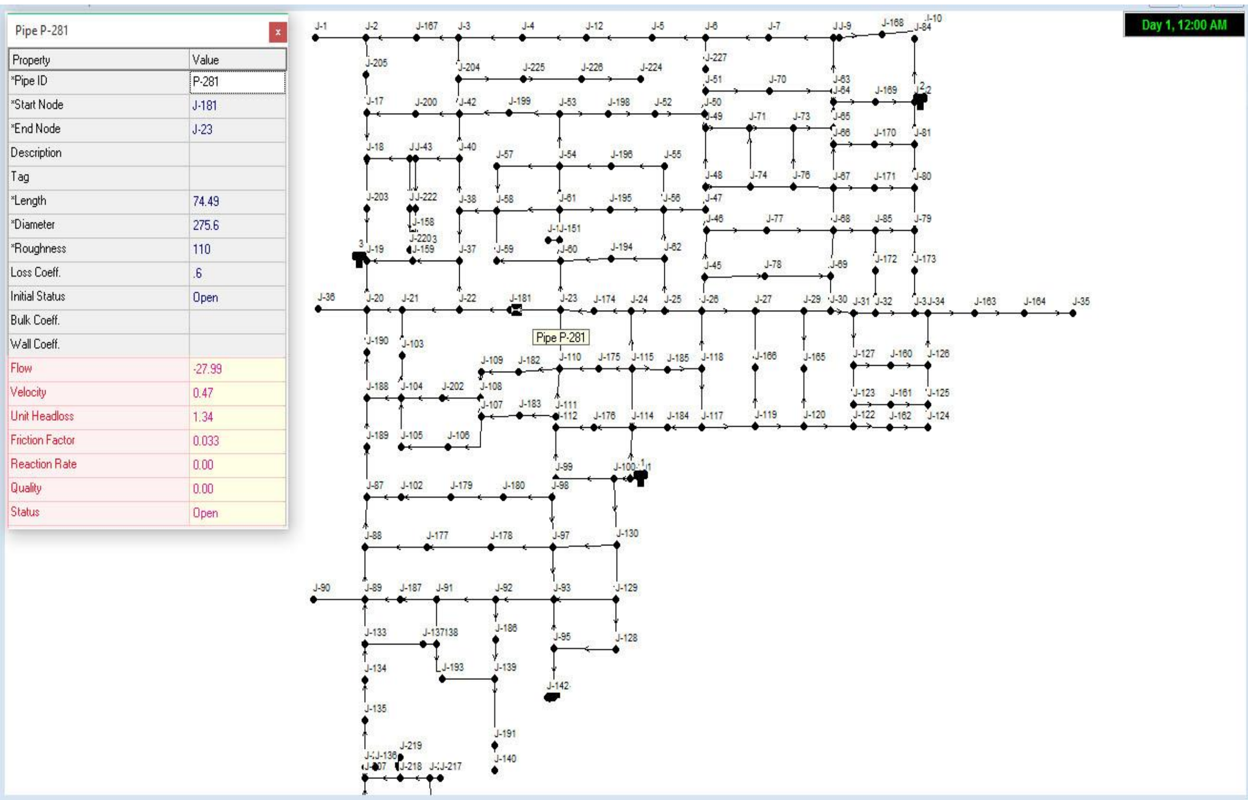

Fig: 5.11

Pressure of every node have been analyzed individually. The normal range of pressure for node is 10-15m. Here we can see in Fig: 5.12 that almost in every node the value of pressure is within 12-13m. So the limit is normal. Pressure of some nodes of southern zone are above 15m. High pressure cause pipe bursting. But no nodes contain pressure above 25m. So these nodes are slightly vulnerable to pipe bursting.

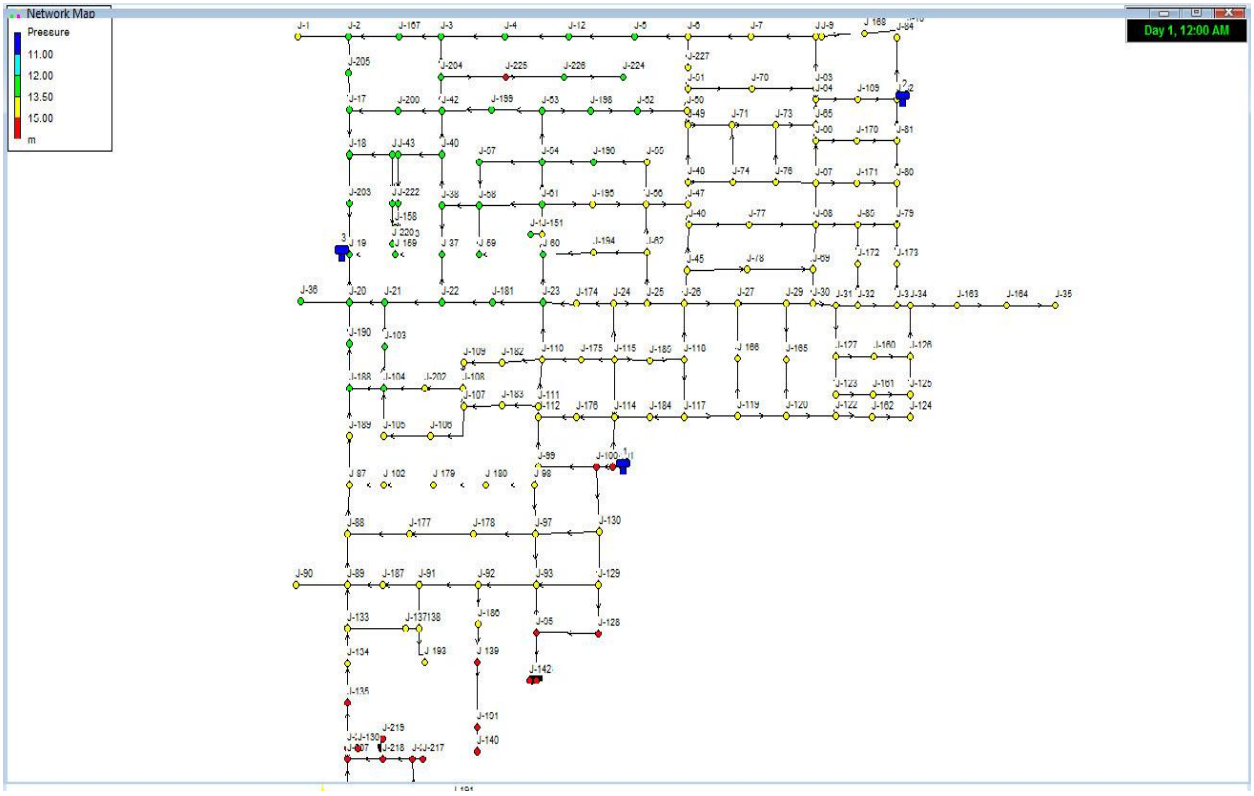

Fig: 5.12

Fig: 5.13 shows the head loss in nodes. Here the value of head loss in all nodes are within 20-25m. Acceptable limit of head loss is 20-25m. So head loss is within acceptable limit.

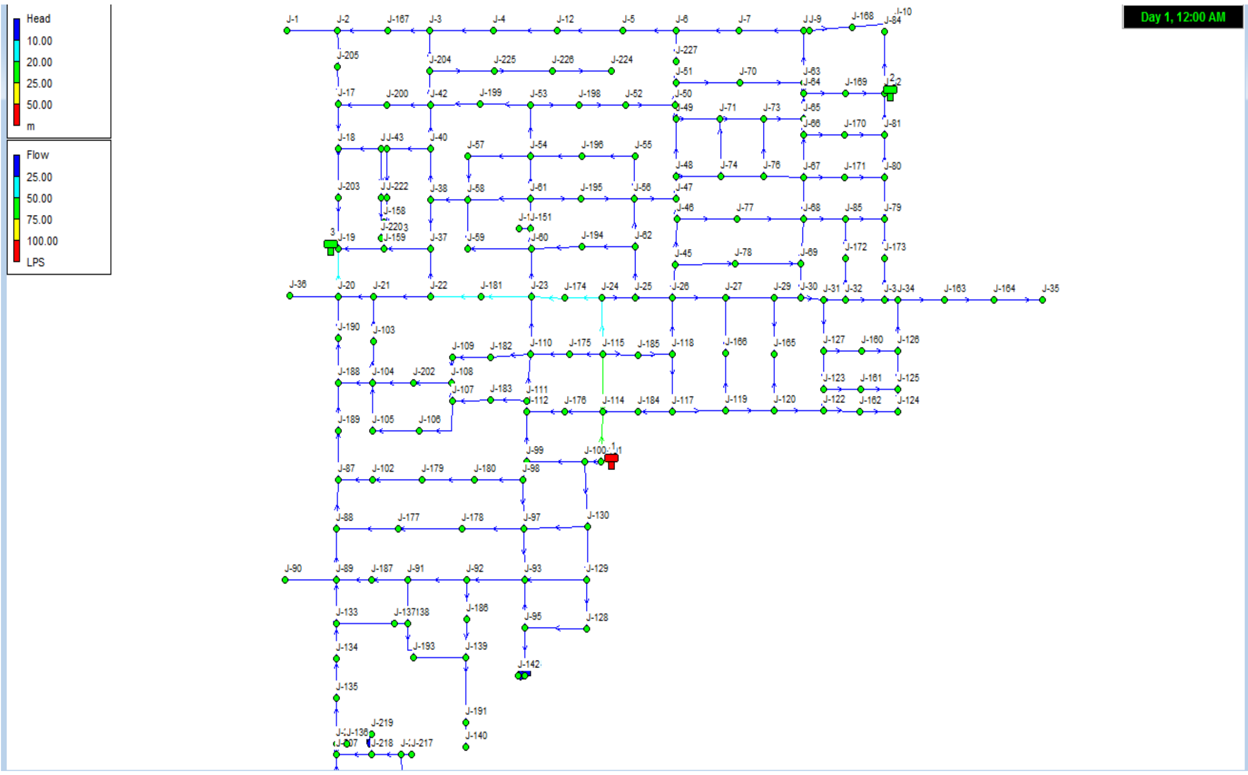

Fig: 5.13

Fig: 5.14 shows the flow variation. Maximum flows of the pipes are within 1-20 lps. Few pipes are below 1lps and one pipe is above 20lps. There is no negative flow and flows in every pipe are within reasonable value.

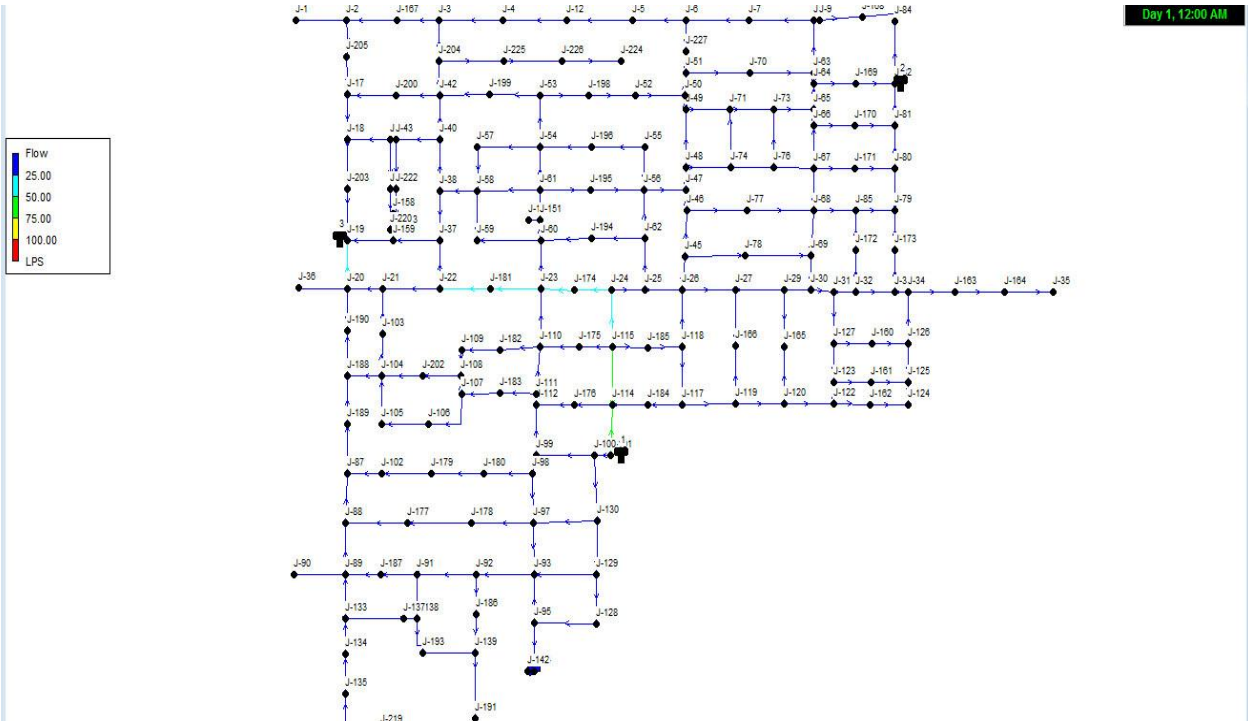

Fig: 5.14

Fig: 5.15 shows the MDD velocity variation. Here velocity are between 0.01-1.00 m/s. The velocity variation is high. But velocities are within the limit.

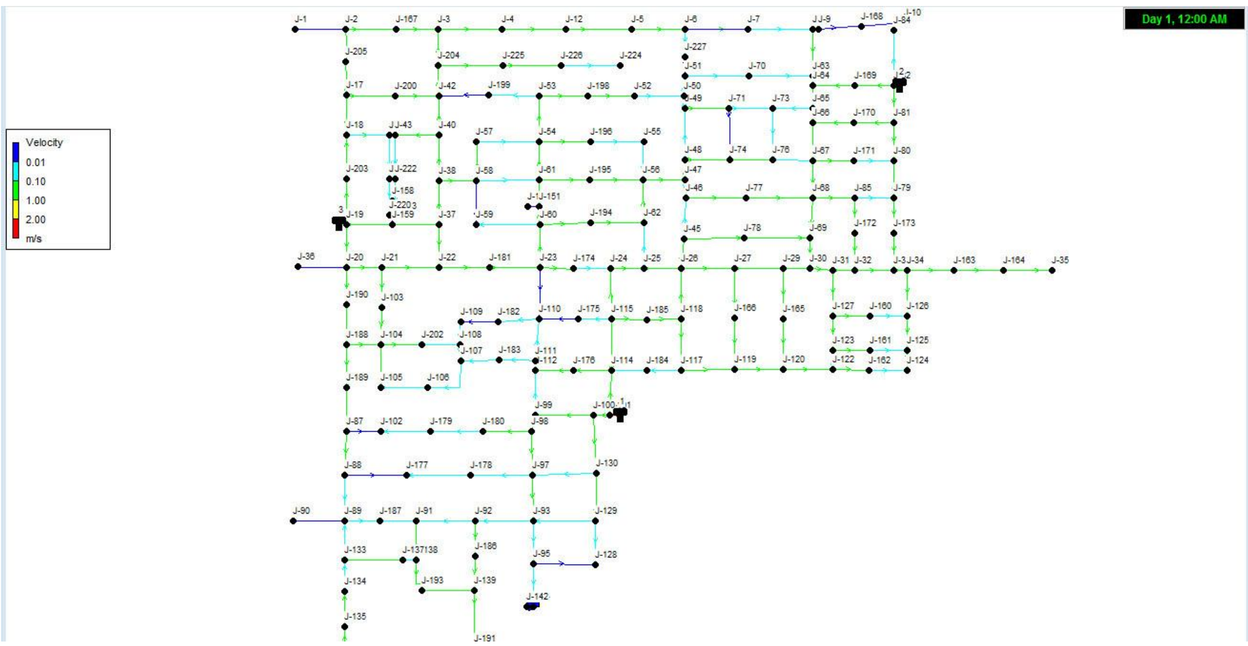

Fig: 5.15

Chlorine dose analysis has also been done. It appears that 1mg/L chlorine dose in every tank is enough for covering the whole network. Fig: 5.16, 5.17 & 5.18 show the three hours simulation results of chlorine dose.

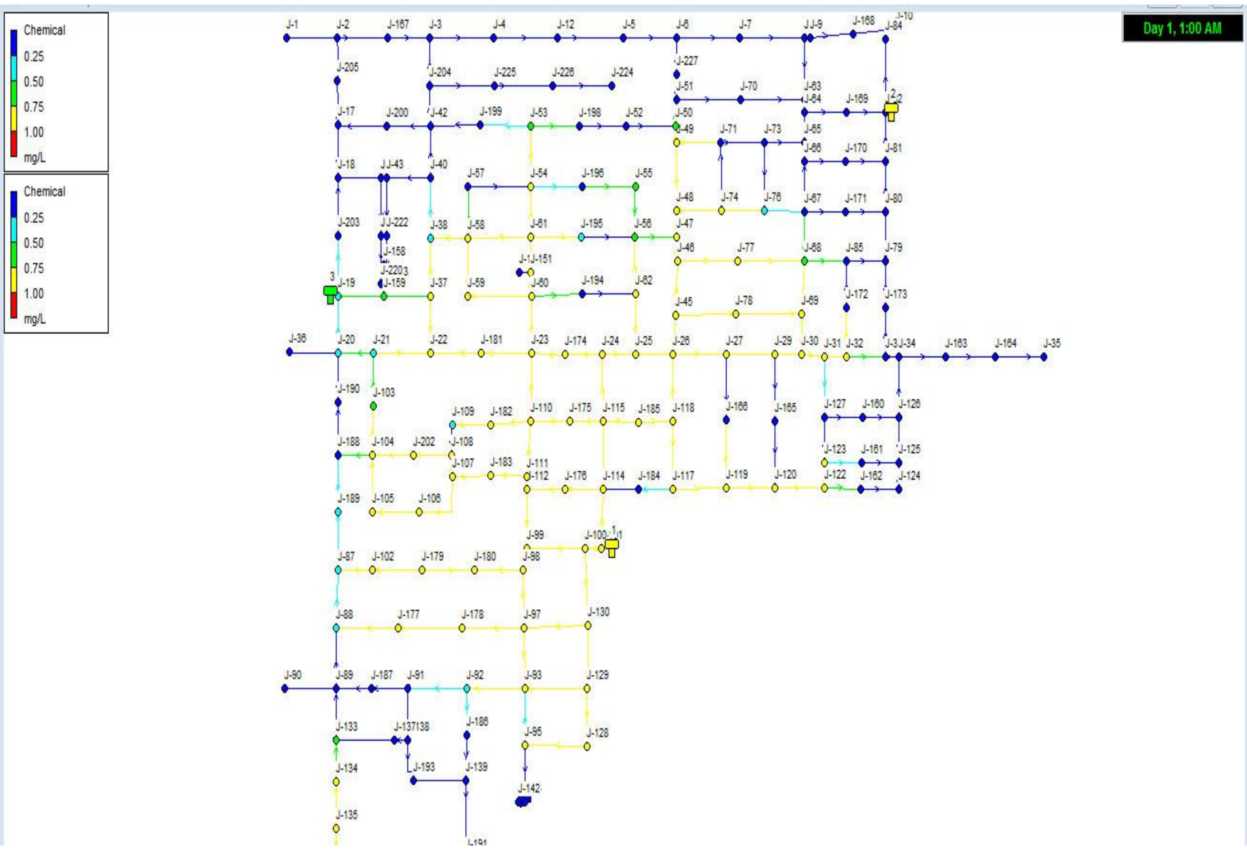

Fig: 5.16

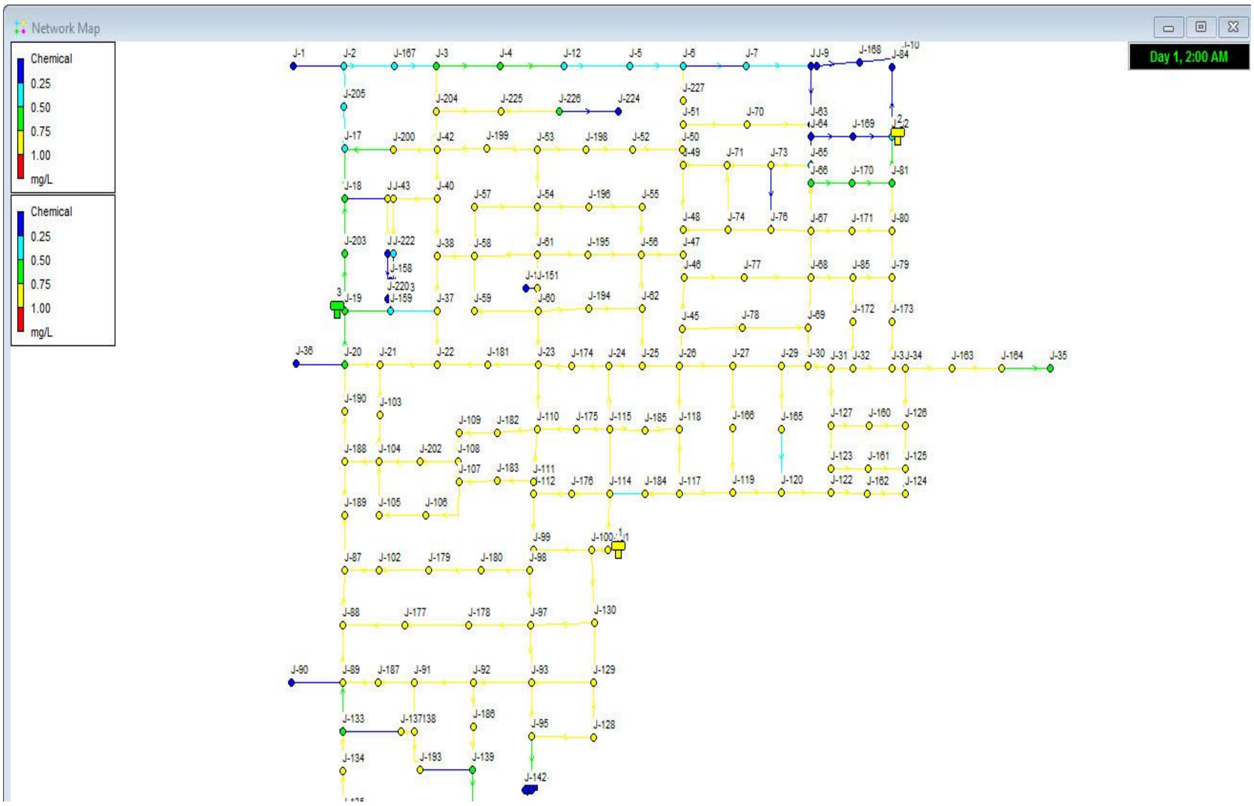

Fig: 5.17

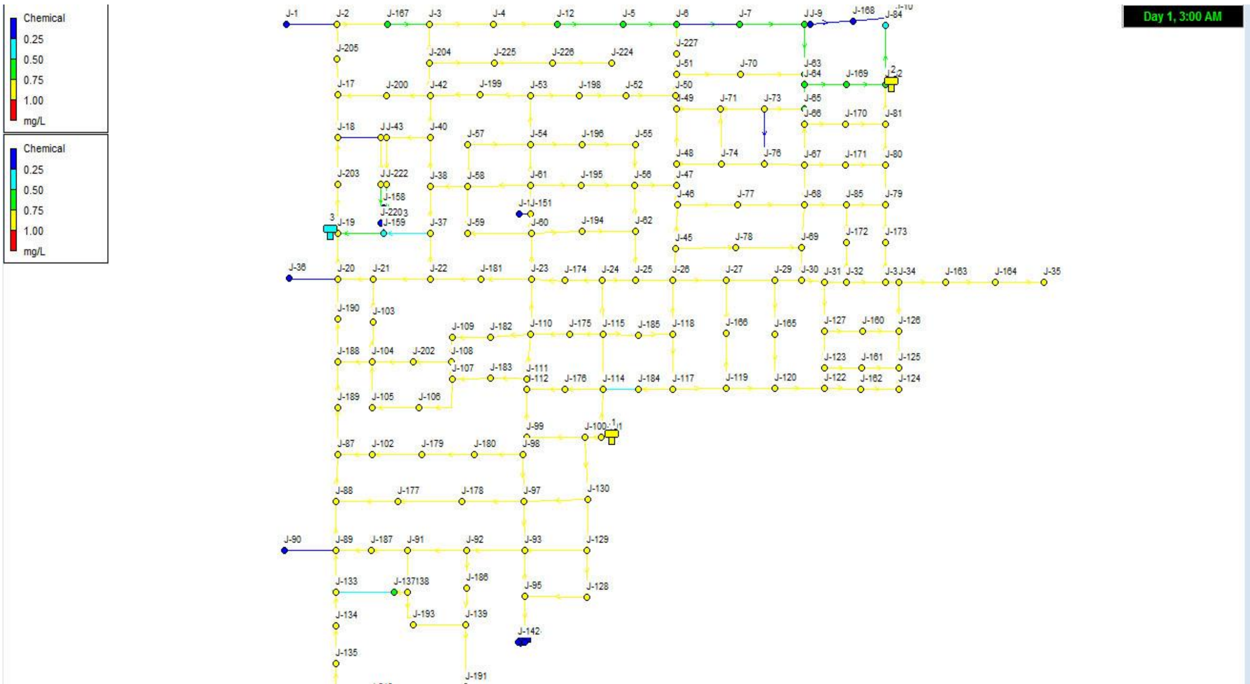

Fig: 5.18

Table 5.1 shows the summary of information of nodes and pipes for MDD

Pressure		Flow		Velocity	
High pressure node	Low pressure node	High flow rate	Low flow rate	High velocity	Low velocity
19	0	0	6	0	0

Table: 5.1

5.3 FD (Fire Demand):

Fire demand coverage has also been checked. The purpose of Fire demand analysis is to check whether the present system is capable to supply water for fire emergency or not. And is there any necessity of extra tank or pump.

After giving the input EPANET analyzed the data and all the necessary results are displayed. FD result of pressure and total head of every node and flow and velocity of every pipe are displayed. Fig: 5.19 shows the information of node and Fig: 4.20 shows the information of pipe.

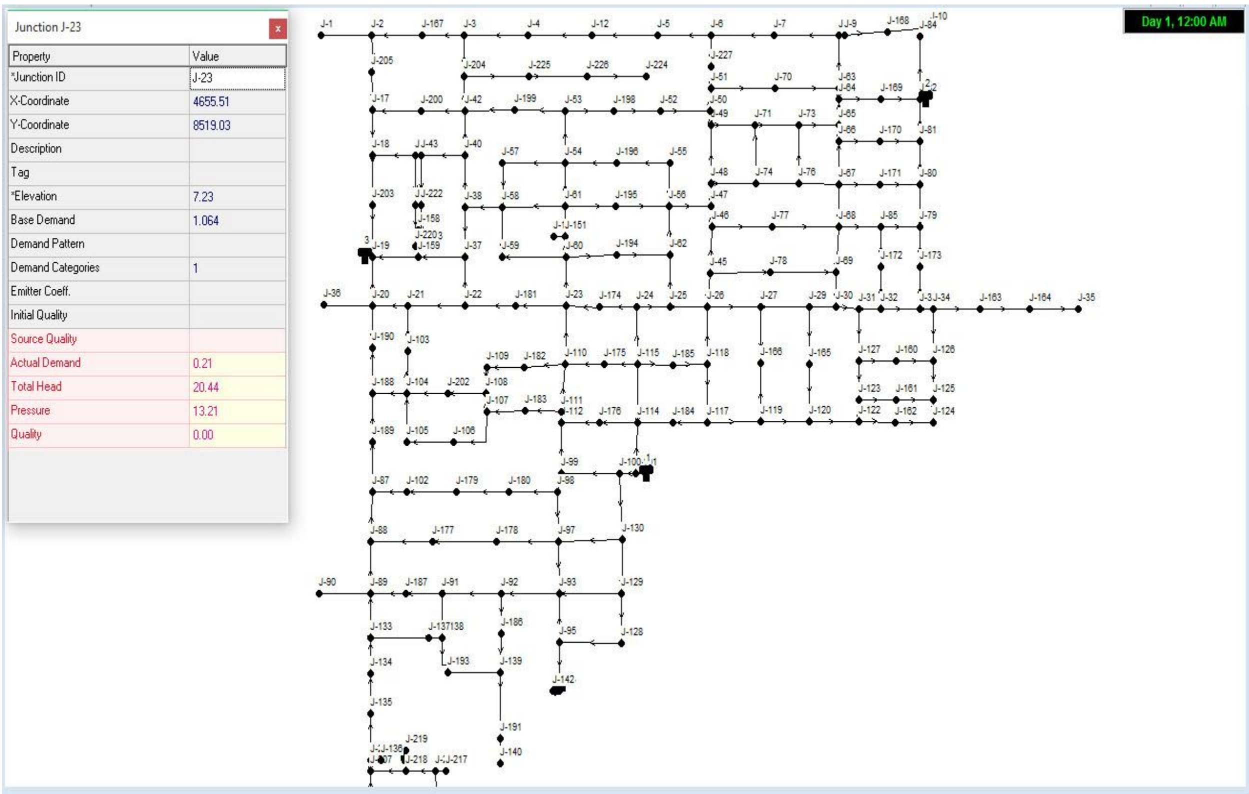

Fig: 5.19

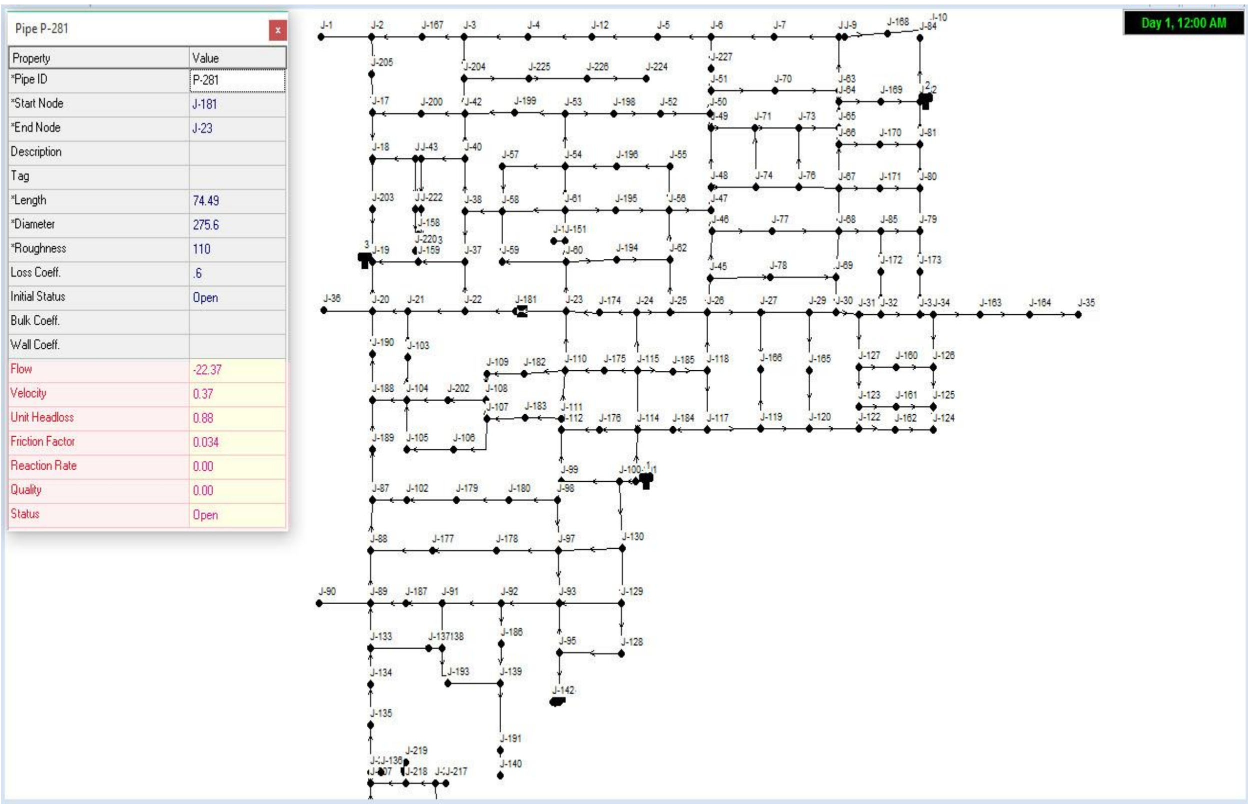

Fig: 5.20

Pressure of every node have been analyzed individually. The normal range of pressure for node is 10-15m. Here we can see in Fig: 5.21 that almost in every node the value of pressure are below 10m. So the pressure is low. There are no chance of pipe bursting and low pressure creates supply deficiency.

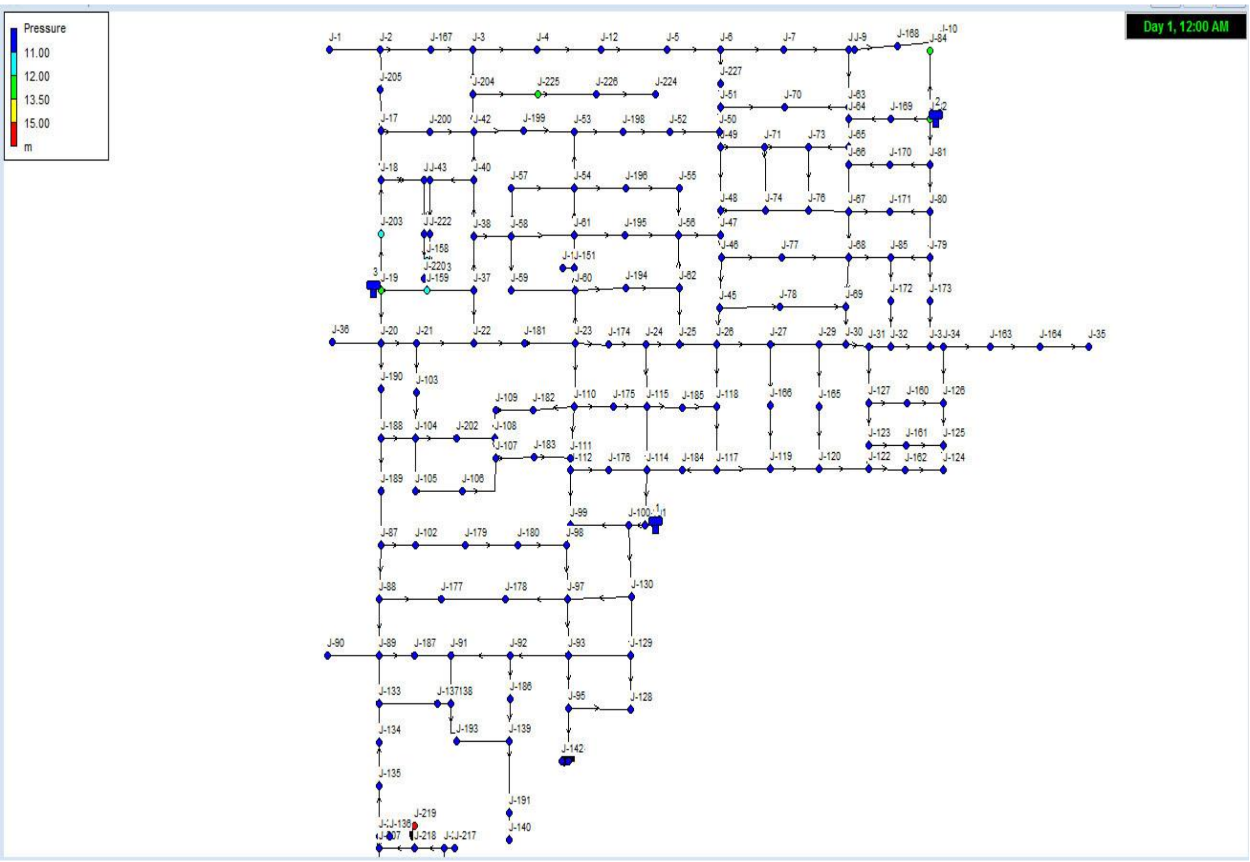

Fig: 5.21

Fig: 5.22 shows the head loss in nodes. Here the value of head loss in all nodes are within 20-25m. Acceptable limit of head loss is 20-25m. So head loss is within acceptable limit. But in node number J-219 the head loss is little bit higher. The value of the head loss is 31m.

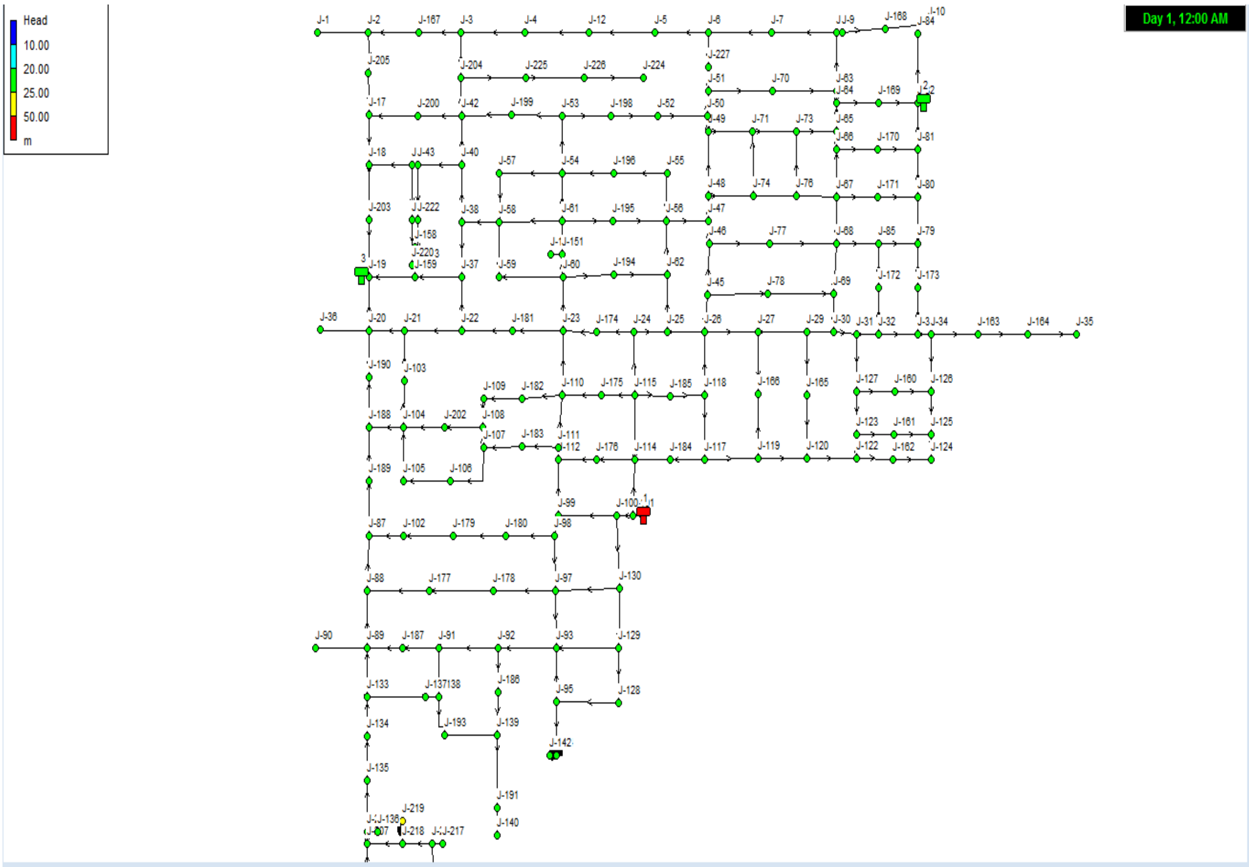

Fig: 5.22

Fig: 5.23 shows the flow variation. Maximum flows of the pipes are within 1-5 lps. Few pipes are below 1lps and one pipe is above 20lps. There is no negative flow and flows in every pipe are within reasonable value. The flow rate is low comparison to the ADD and MDD.

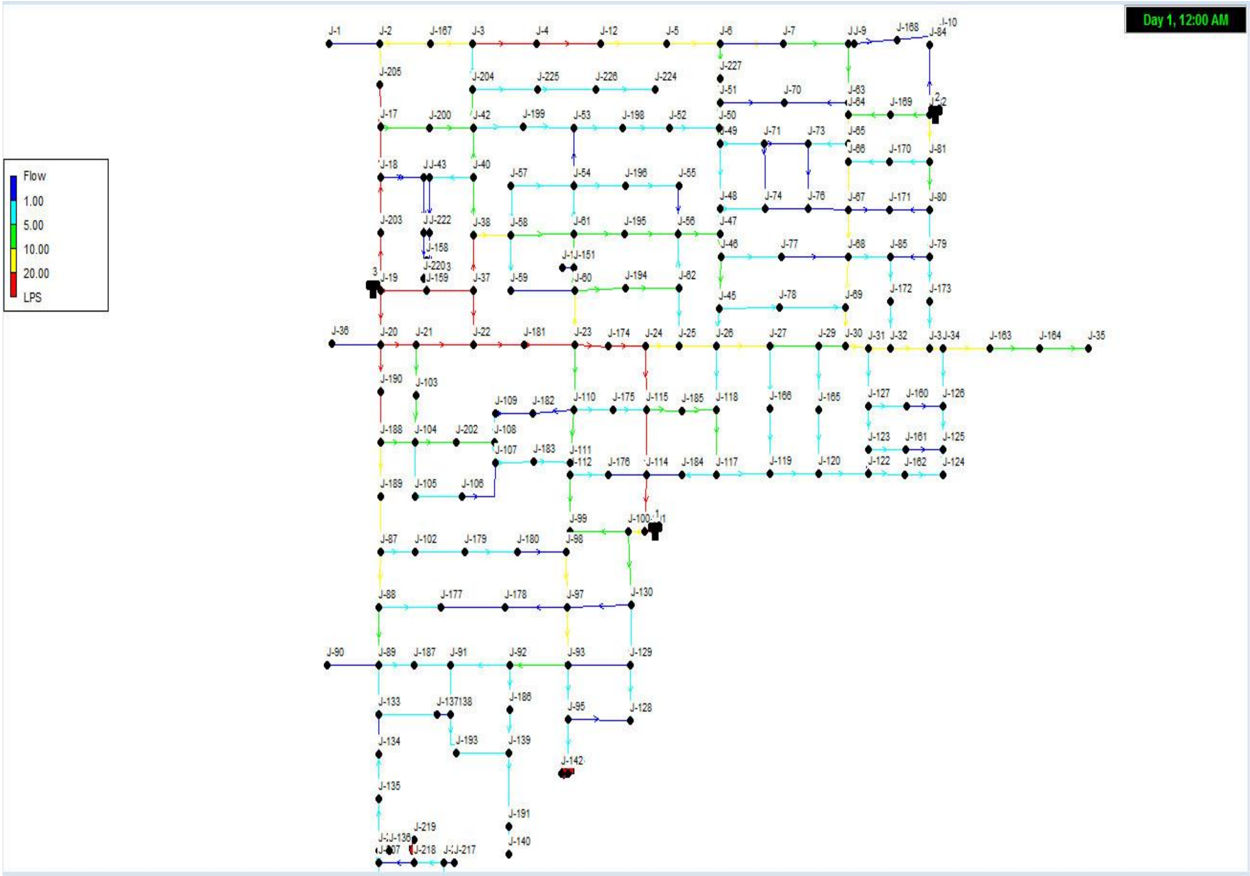

Fig: 5.23

Fig: 5.24 shows the MDD velocity variation. Here velocity are between 0.01-1.00 m/s. The velocity variation is high. But velocities are within the limit.

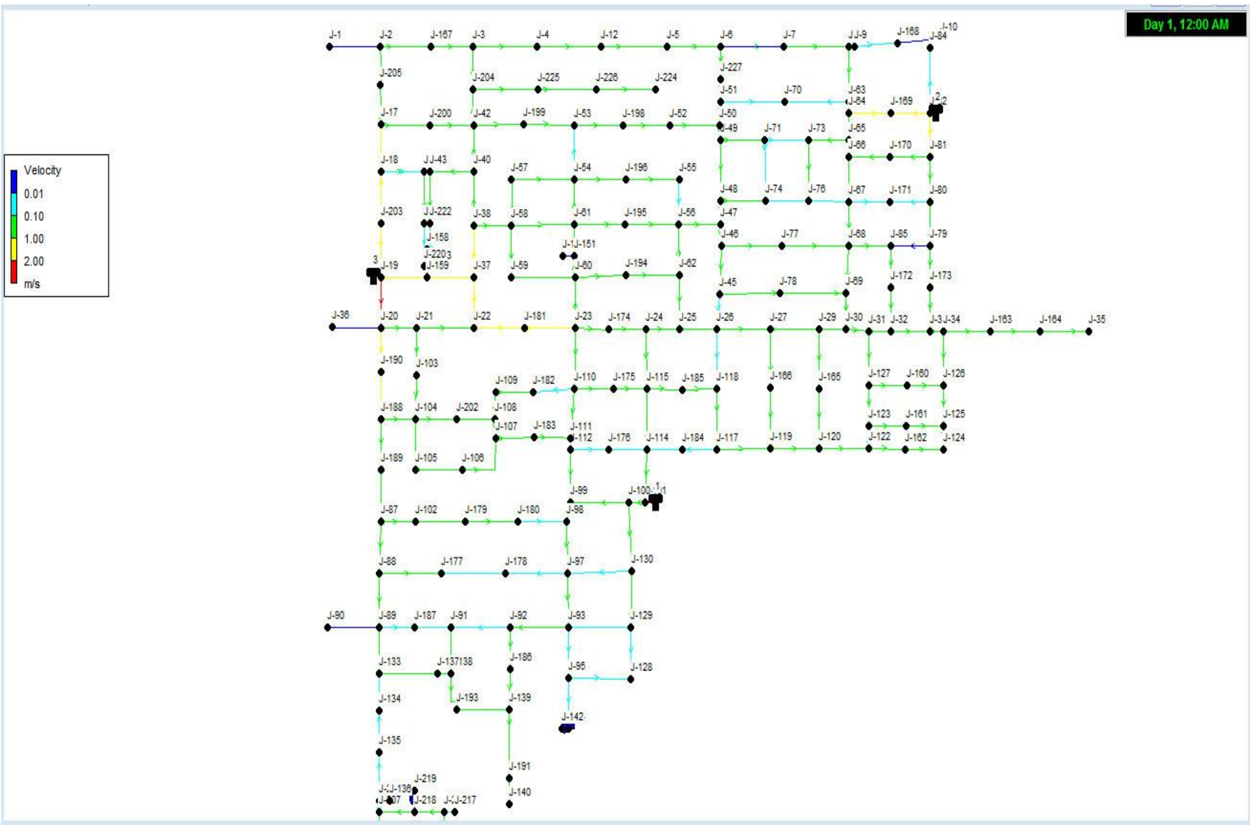

Fig: 5.24

Table 5.2 shows the summary of information of nodes and pipes for FD

Pressure		Flow		Velocity	
High pressure node	Low pressure node	High flow rate	Low flow rate	High velocity	Low velocity
0	188	0	30	0	0

Table: 5.2

So, from above discussion it can be observed that a reservoir/tank is needed to cover the fire demand of Banani area. Otherwise present system has pressure deficit and low flow rate.

5.4 Sensitivity Analysis:

Two types of sensitivity analysis has been done. One is using a multiple factor of 1.1 with the base demand another is diameter of pipes are reduced to the value of 25mm.

5.4.1 Using multiple factor 1.1:

A multiple factor of 1.1 has been used with the base demand to check any failure scenario. Here details of sensitivity analysis has been discussed.

Pressure of every node have been analyzed individually. The normal range of pressure for node is 10-15m. Here we can see in Fig: 5.25 that almost in every node the value of pressure is within 12-15m. So the limit is normal. High pressure cause pipe bursting. But no nodes contain pressure above 16m. So there is no chance of pipe bursting.

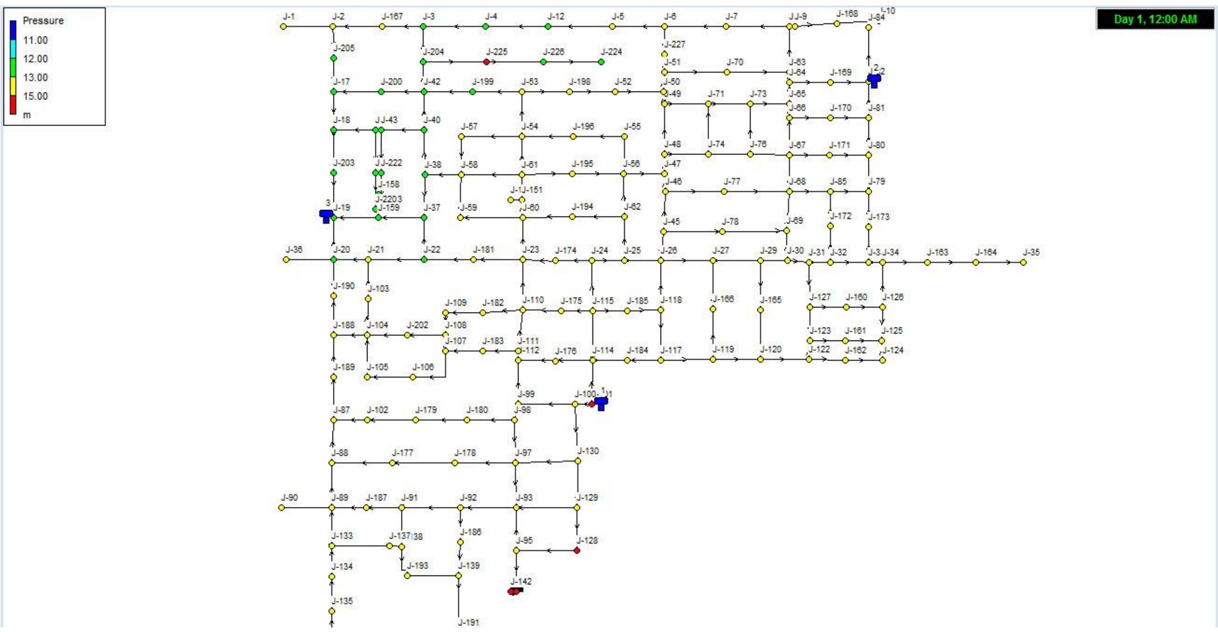

Fig: 5.25

Fig: 5.26 shows the head loss in nodes. Here the value of head loss in all nodes are within 20-25m. Acceptable limit of head loss is 20-25m. So head loss is within acceptable limit.

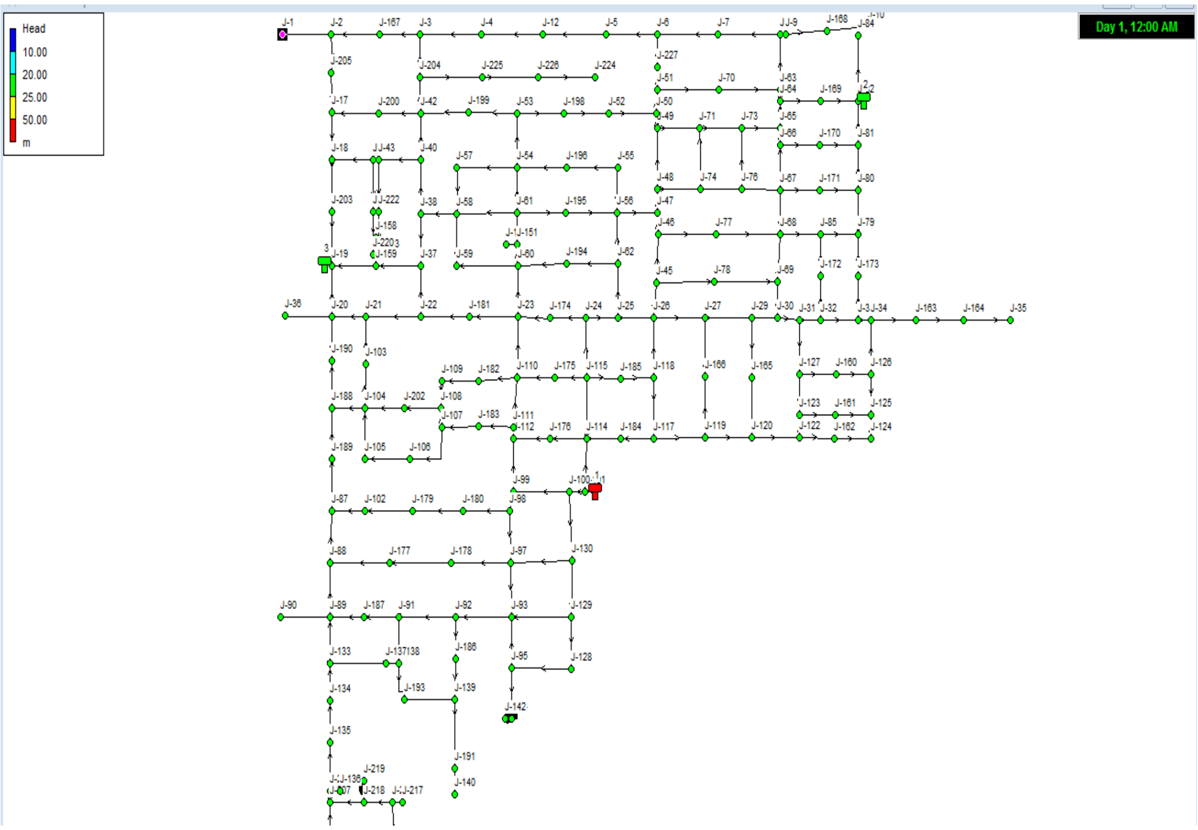

Fig: 5.26

Fig: 5.27 shows the flow variation. Maximum flows of the pipes are within 1-20 lps. Few pipes are below 1lps and one pipe is above 20lps. There is no negative flow and flows in every pipe are within reasonable value.

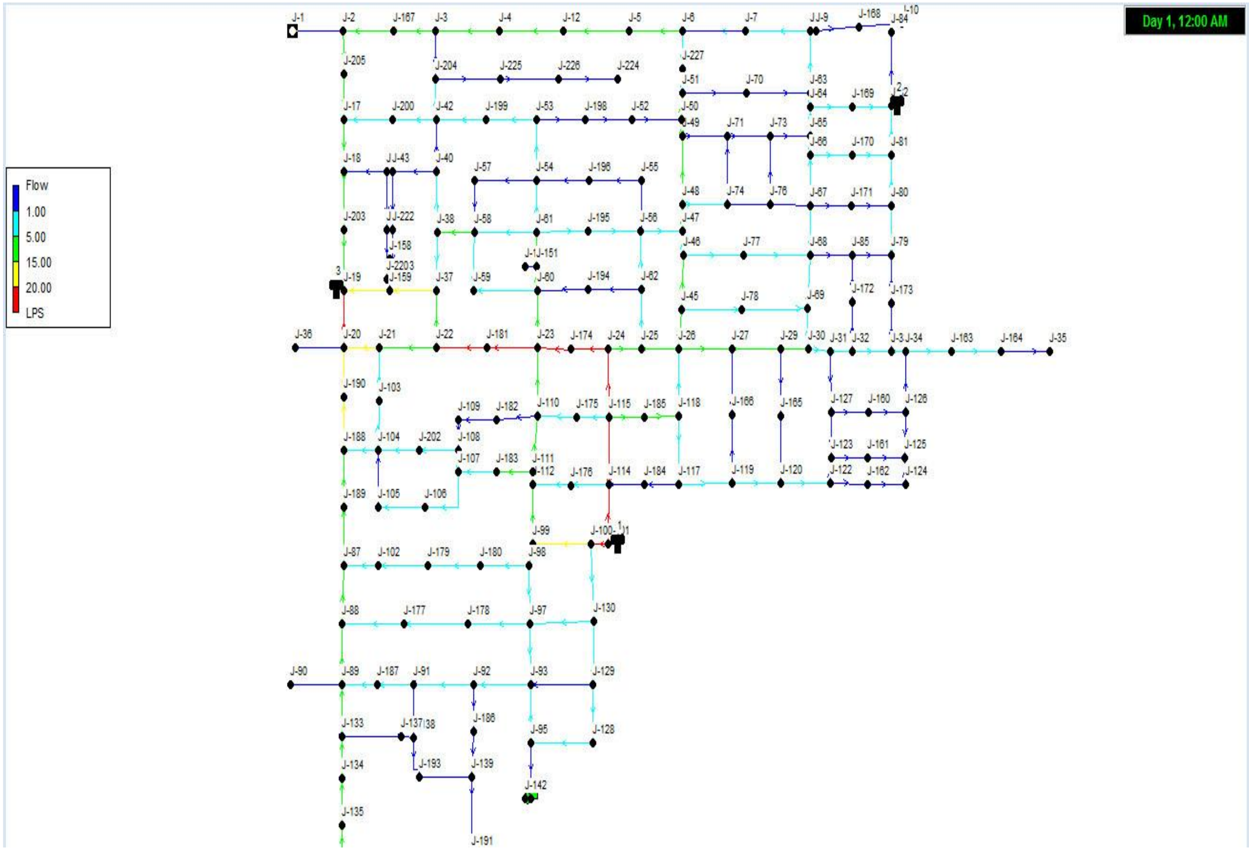

Fig: 5.27

Fig: 5.28 shows the velocity variation. Here velocity are between 0.01-1.00 m/s. The velocity variation is high. But velocities are within the limit.

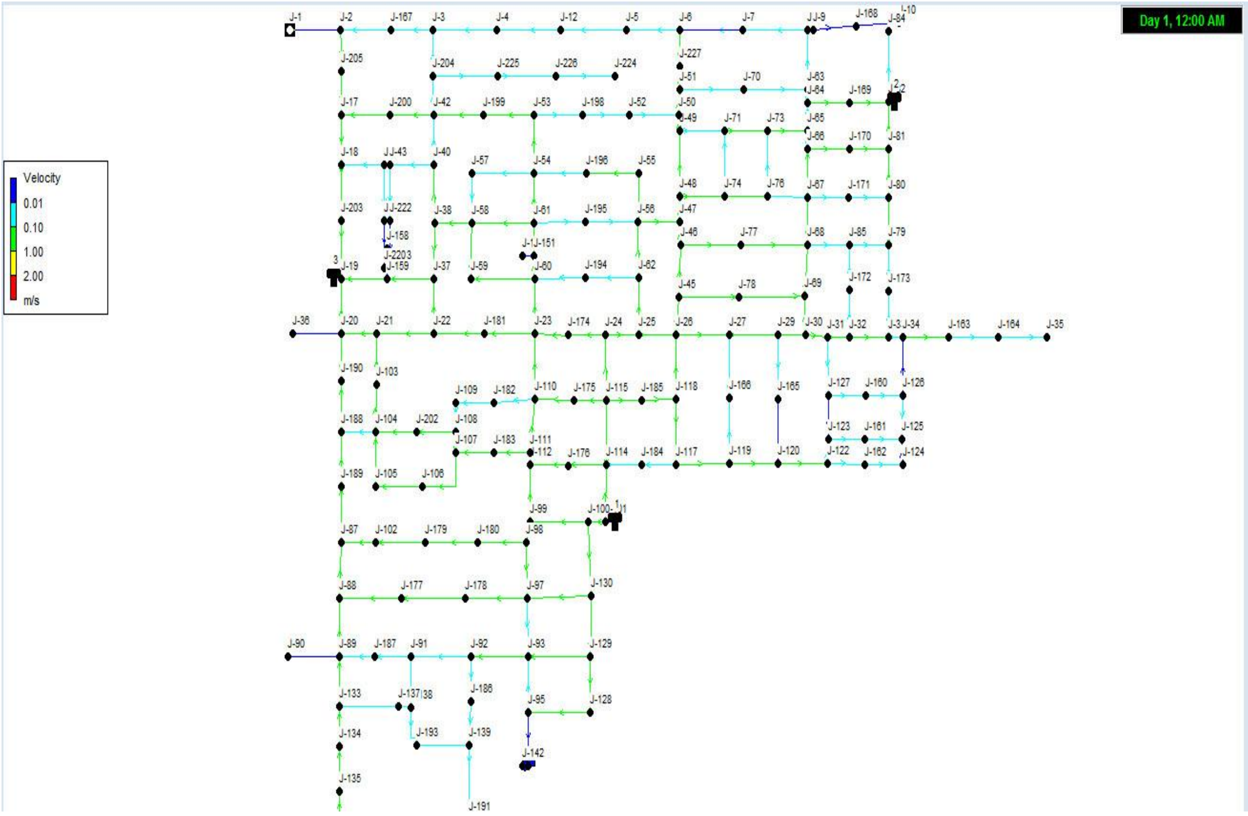

Fig: 5.28

5.4.2 Reduction pipe diameter:

Diameter of pipes are reduced to the value of 25mm. The purpose of this analysis is to check the behavior the pipe after 10/12 years. After some years dust and other particle may reduce the diameter of the pipe. So this check has been done.

Pressure of every node have been analyzed individually. The normal range of pressure for node is 10-15m. Here we can see in Fig: 5.29 that almost in every node the value of pressure is within 12-15m. So the limit is normal. Pressure of some nodes of southern zone are above 15m. High pressure cause pipe bursting. But no nodes contain pressure above 25m. So these nodes are slightly vulnerable to pipe bursting.

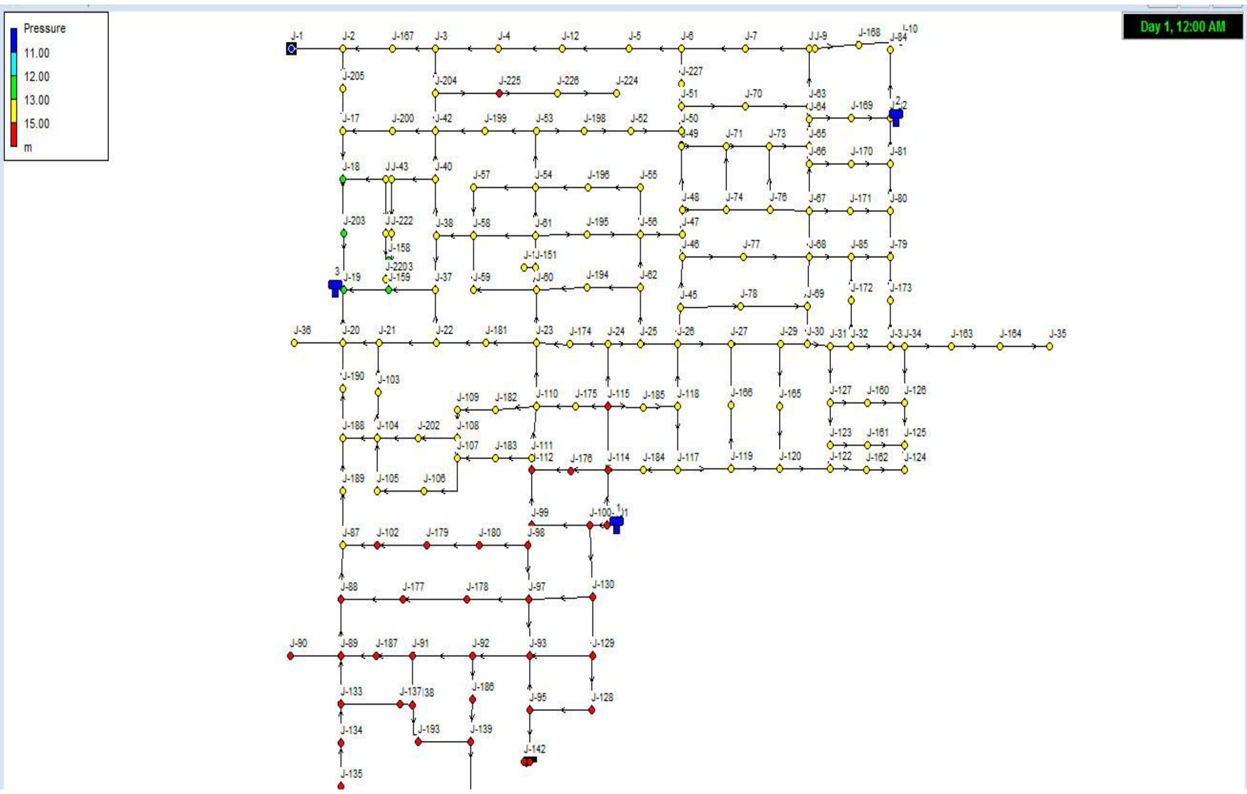

Fig: 5.29

Fig: 5.30 shows the head loss in nodes. Here the value of head loss in all nodes are within 20-25m. Acceptable limit of head loss is 20-25m. So head loss is within acceptable limit.

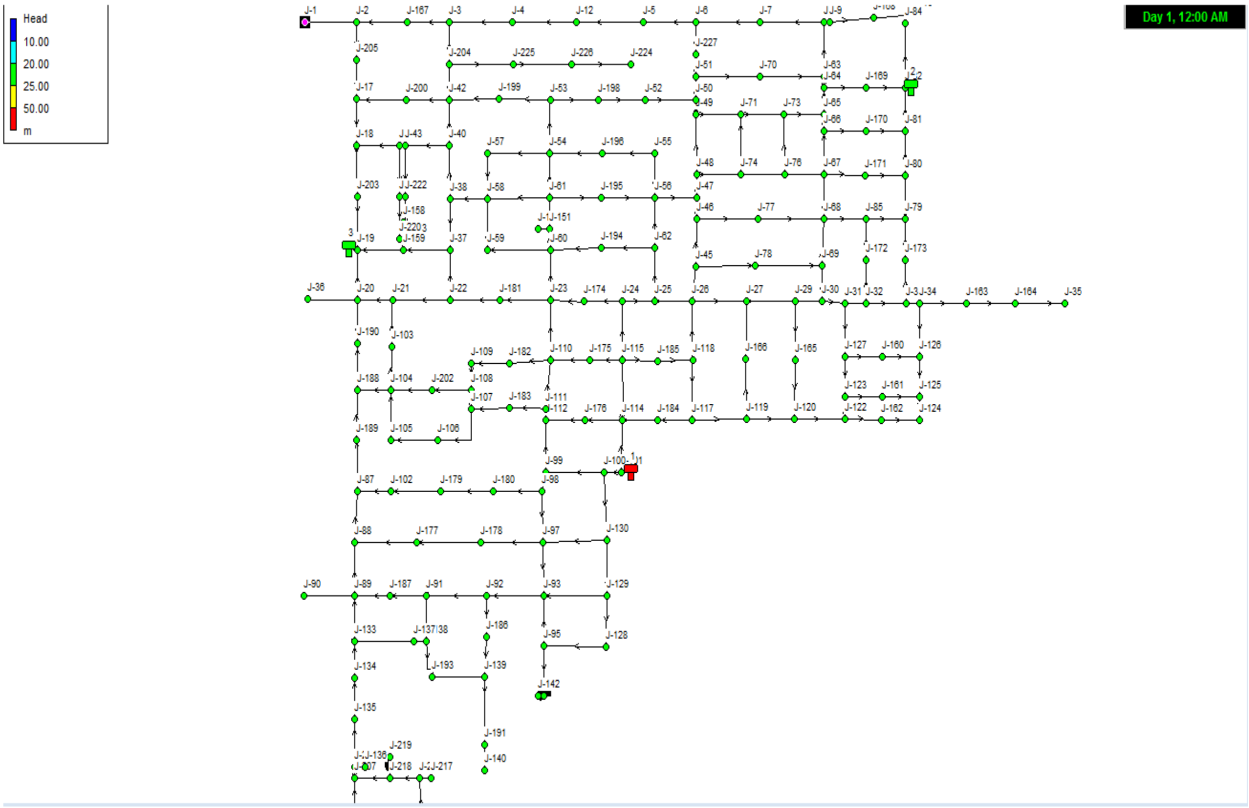

Fig: 5.30

Fig: 5.31 shows the flow variation. Maximum flows of the pipes are within 1-20 lps. Few pipes are below 1lps and one pipe is above 20lps. There is no negative flow and flows in every pipe are within reasonable value.

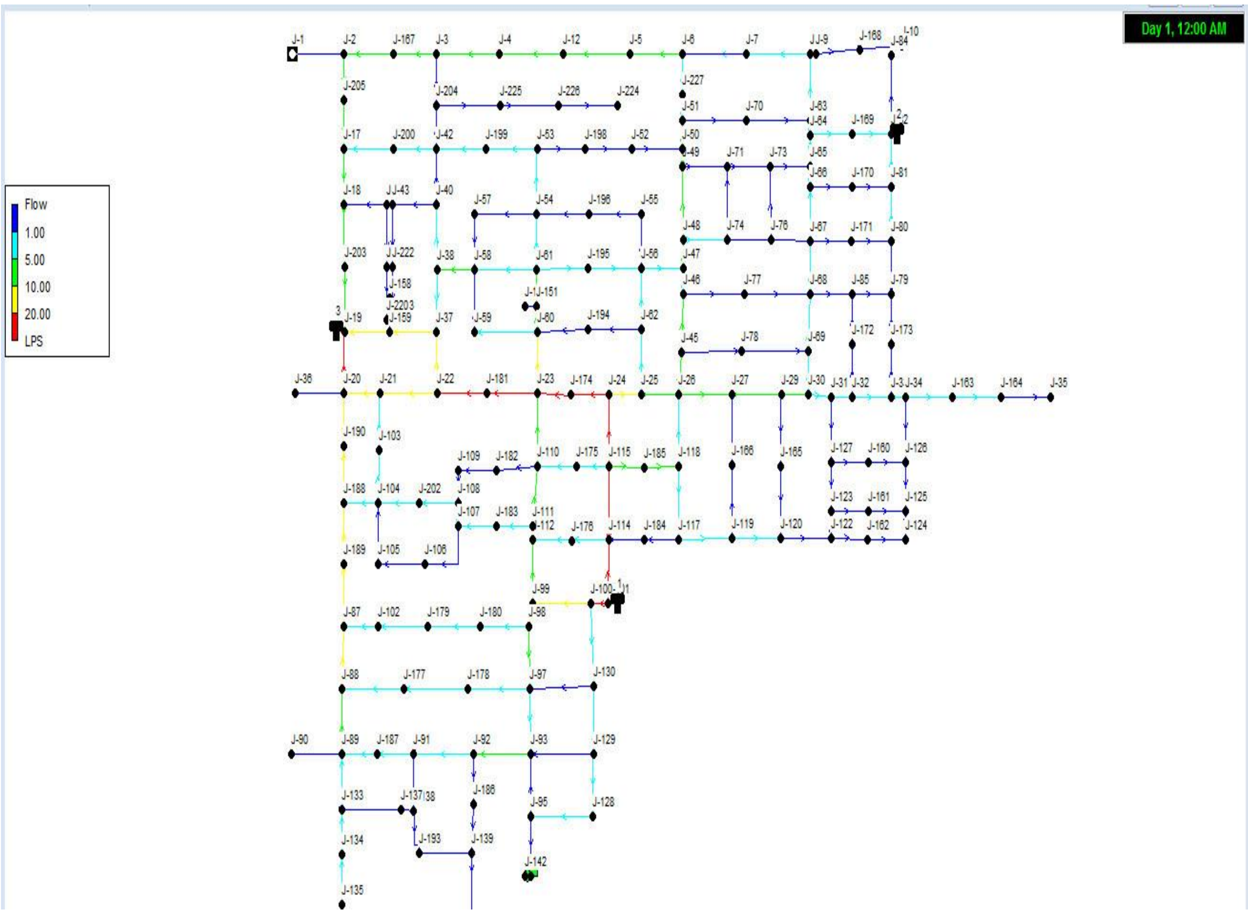

Fig: 5.31

Fig: 5.32 shows the velocity variation. Here velocity are between 0.01-1.00 m/s. The velocity variation is high. But velocities are within the limit.

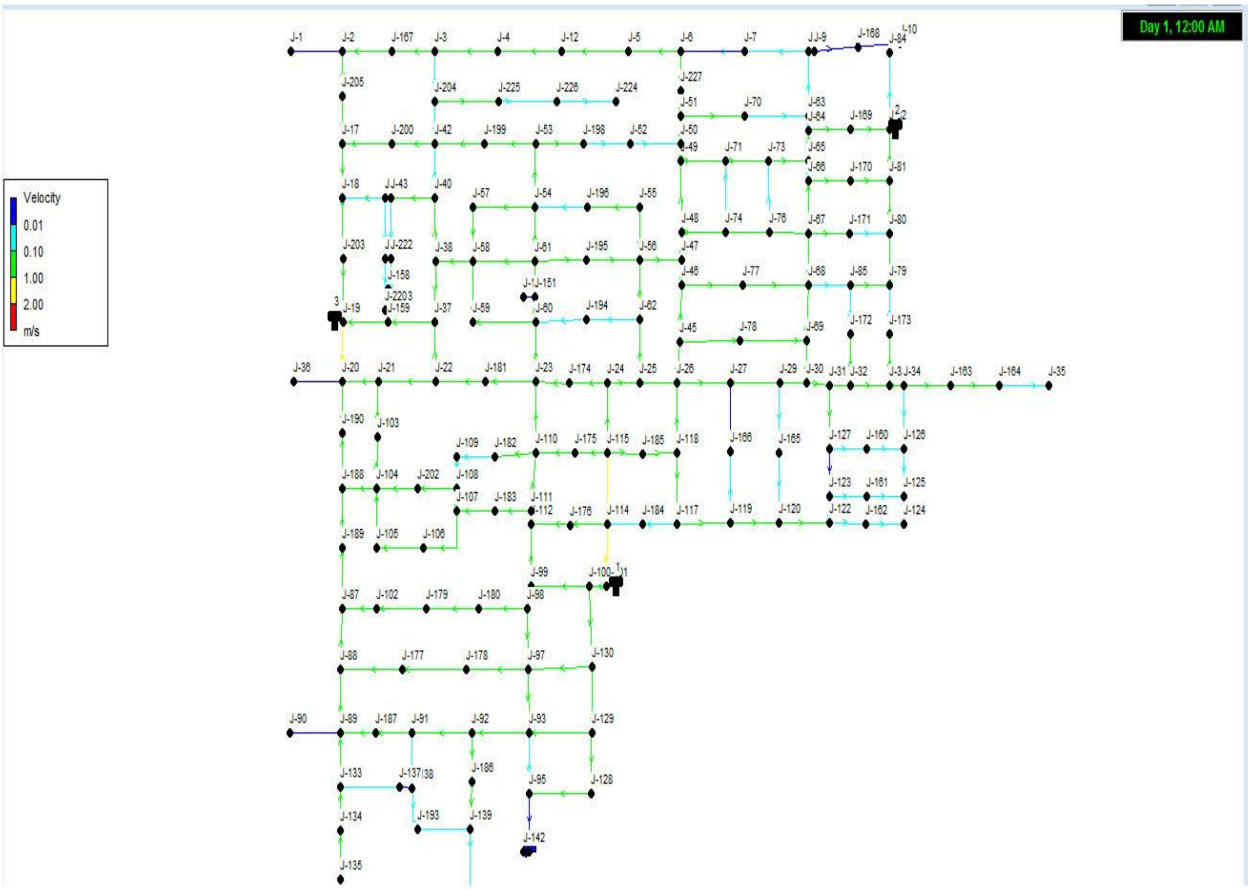

Fig: 5.32

5.5 Dead end pipe analysis:

Sometimes dead end pipes cause water stagnation and creates high pressure problem. At the dead corners of pipe there is less flow of water comparative to the other pipes. So there is chance of water stagnation. Water with a certain velocity runs through a pipe and suddenly stopped at the dead end. It results in a very high pressure and cause bursting of pipe. So to avoid it water needs to be flashed and reduce the pressure.

Here in this study dead end analysis has been performed. Models has been checked for three scenarios (ADD, MDD and FD and also the sensitivity scenarios).

In Fig: 5.33 it is observed that for the case of ADD pressure of the all the dead end nodes are green and yellow in color. That means that all the node's pressure are within the reasonable value.

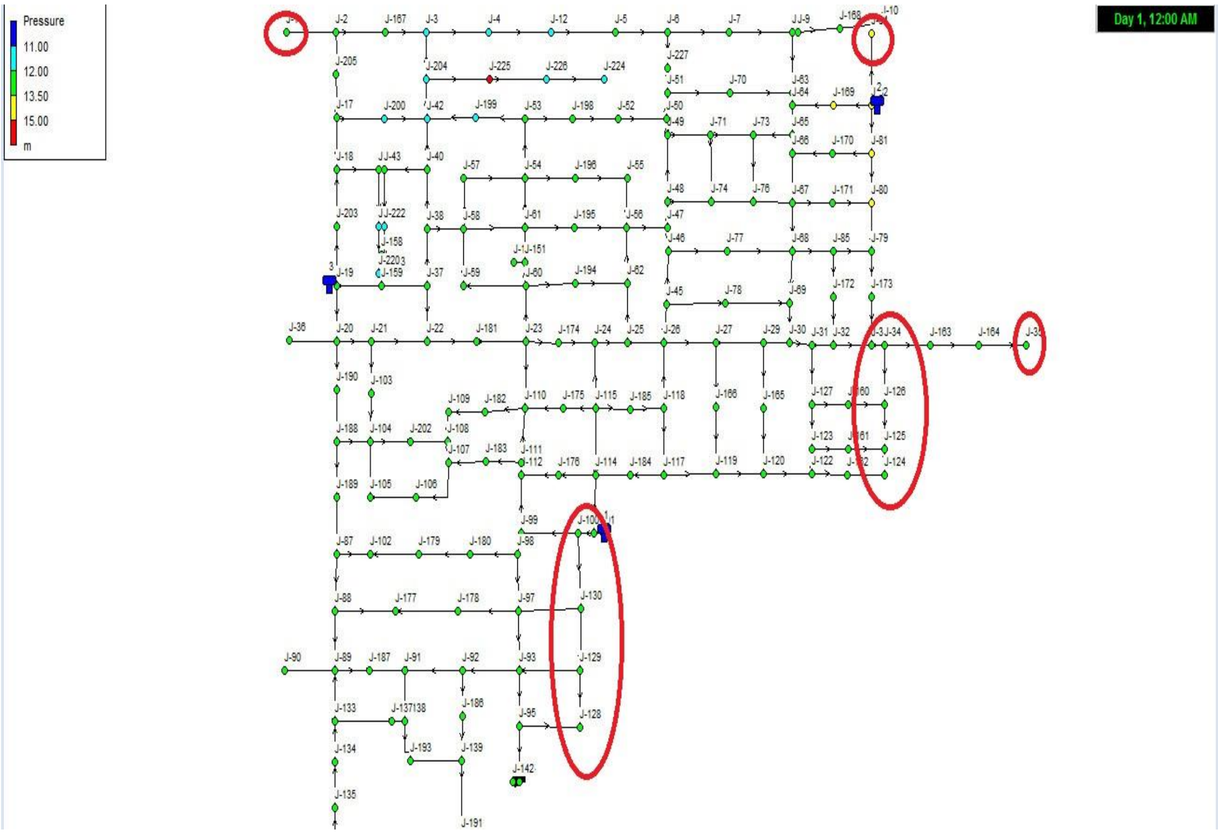

Fig: 5.33

In Fig:5.34 it is observed that for the MDD pressure of almost all the dead end nodes are 11-15m but only few are red in color. But pressure of these nodes do not cross 18m. So there are no chance of pipe bursting.

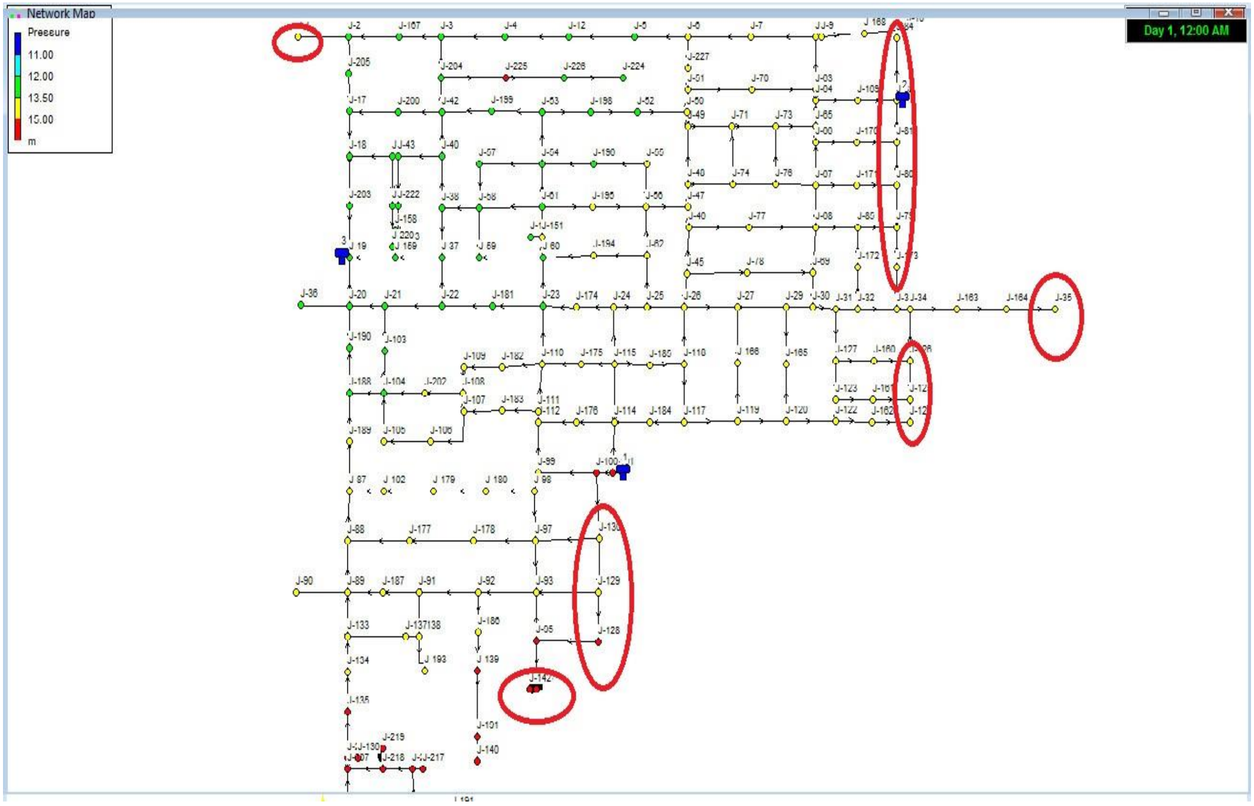

Fig: 5.34

Fig 5.35 represents the dead end pressure for FD (Fire demand). Because of high water demand for the case of fire demand and water deficiency here pressure are below 10m. From Fig 5.38 it can be concluded that here pressure of all the dead end nodes do not exceed the limit. Rather here pressure are below 11m. So there are no chance of pipe bursting.

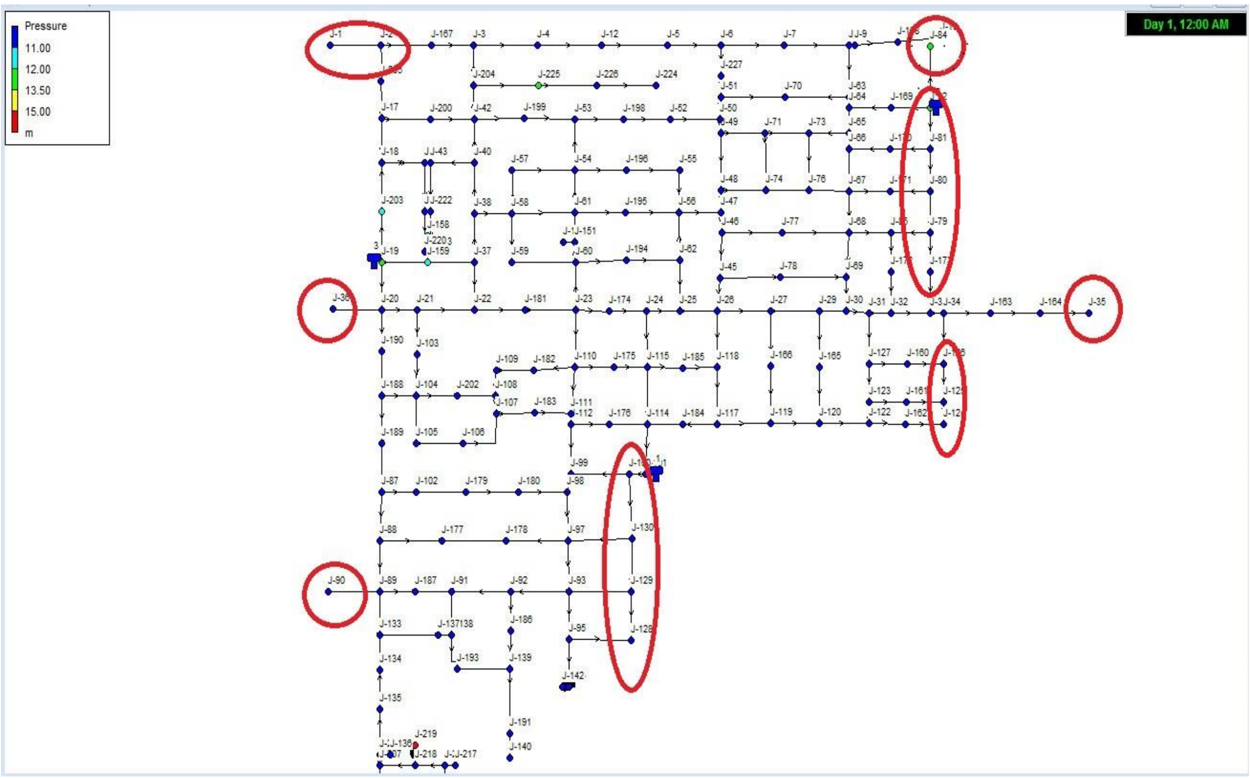

Fig: 5.35

From Fig: 5.36 it is observed that for the case of sensitivity analysis where diameter of the pipes are reduced to the value of 25mm pressure of all dead end nodes have some variations. Some node’s color are yellow and some are red. Yellow color indicates that the pressure is within 13-15m. The nodes which are red in color do not exceeds the value of 18m. So all the dead end nodes and pipes are safe.

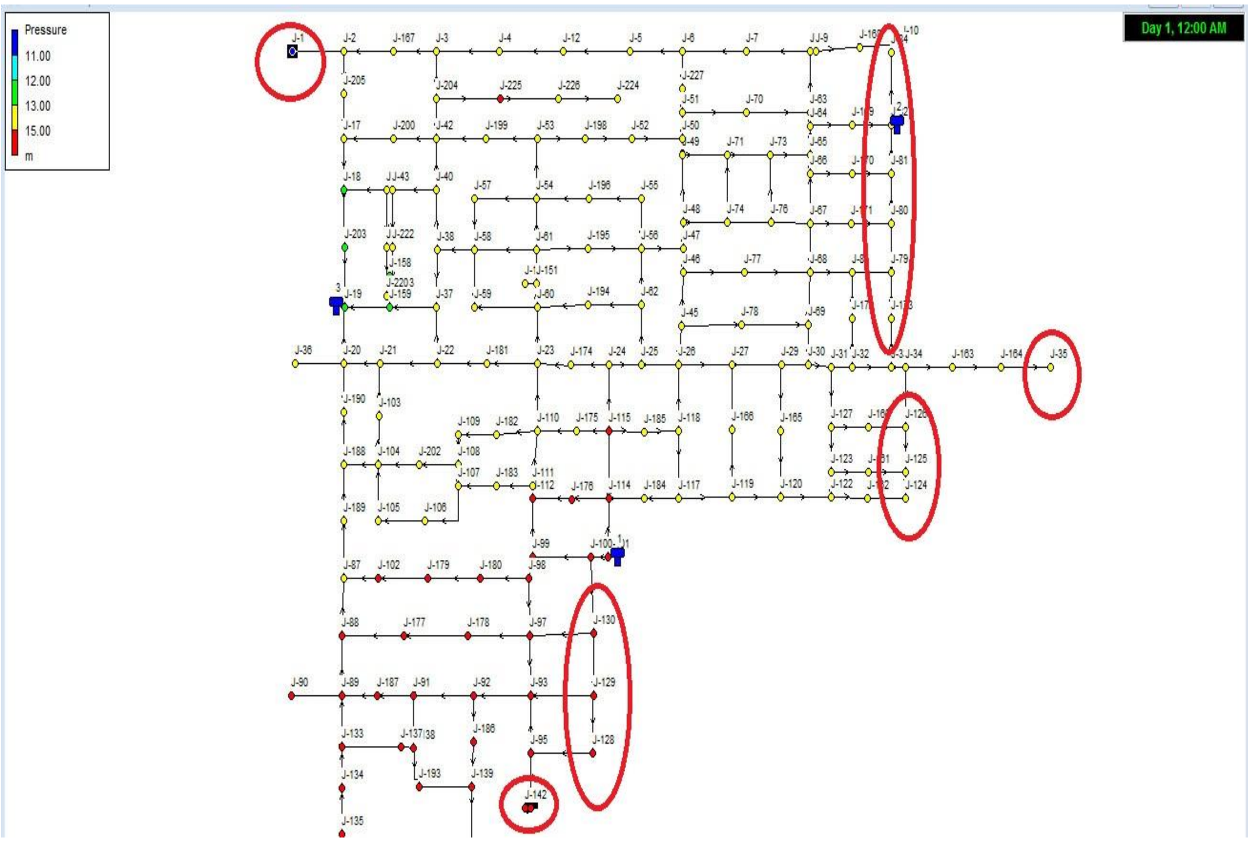

Fig: 5.36

From Fig: 5.37 it is observed that for the case of sensitivity analysis where a multiple factor 1.1 has been used color of almost all dead end nodes are yellow in color. Only one node's color is red. Yellow color indicates that the pressure is within 13-15m. The node which is red in color do not exceeds the value of 18m. So all the dead end nodes and pipes are safe.

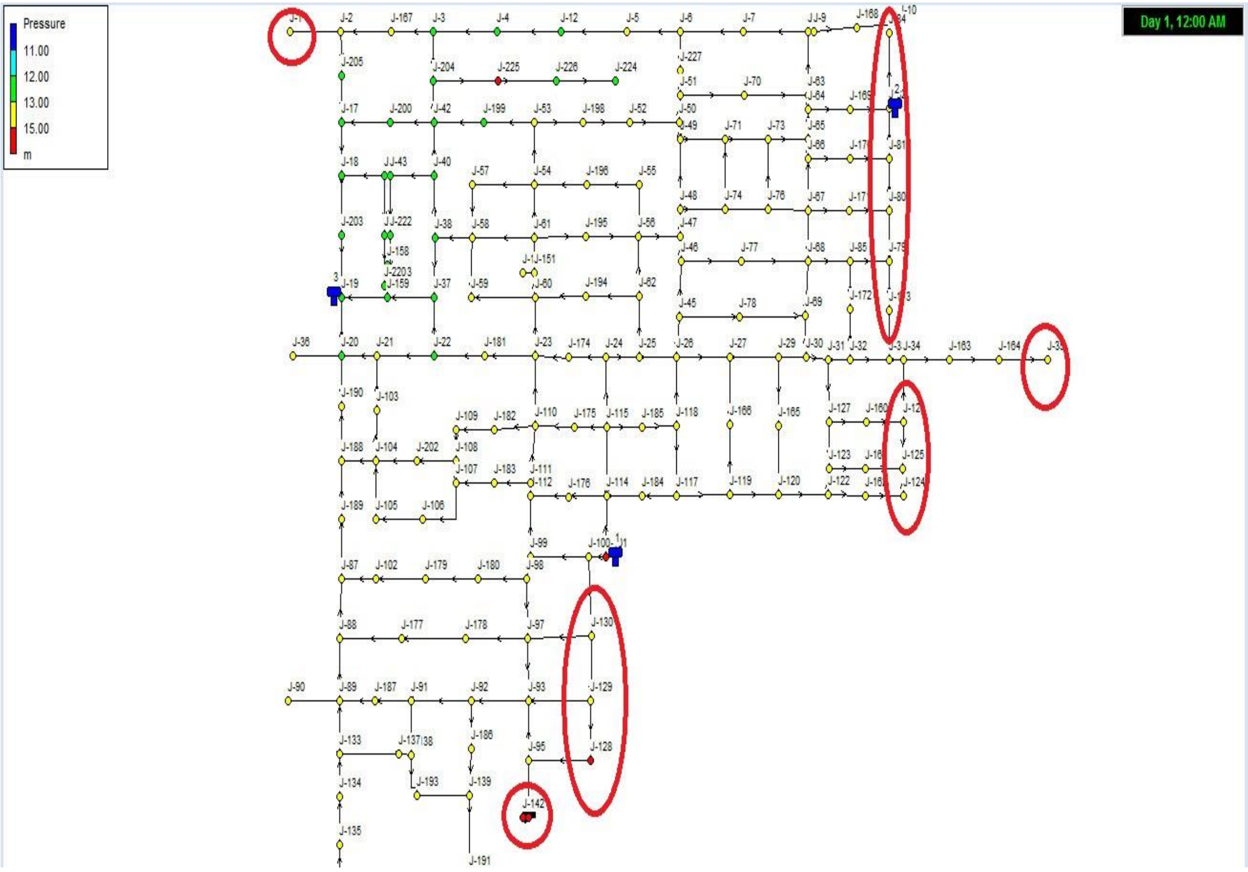

Fig: 5.37

5.6 Summary:

So from the above discussion it can be concluded that:

- Present system is capable of supplying water and meet up the ADD (Average Daily Demand).
- Present system is able to meet the MDD. But there need some modification. Such as, in some nodes the pressure is high.
- The distribution system is not capable in case of FD (Fire demand). The pressure flow rate are low.

- In the case of sensitivity where a multiple factor 1.1 has been used, it is observed that only the pressure of some nodes is little bit high otherwise flow rate, head loss, velocity are within the limit.
- And in the case of diameter reduction, only the pressure of some nodes are high and all the parameters are within reasonable value.
- From chlorine dosage analysis it has been observed that 1mg/L chlorine in every tank is sufficient to cover the system.
- From dead end pipe analysis it is clear that the pressure of that nodes are within reasonable value. So all the dead end pipes are safe and no chance of water stagnation for long time.

Chapter 6 Conclusion & Recommendations

The principal objective of this study is to build a water distribution system modeling by using EPANET software and check it under different conditions. And also to check is EPANET is a viable option for water distribution system modeling or not. To achieve this goal different conditions and parameters has been applied.

In this chapter an overview has been given about the results, findings. This is followed by recommendations to enhance the performance and sustainability of the system for the future.

6.1 Conclusions:

From the study it has been concluded that:

EPANET is viable options for water distribution system modeling in Bangladesh. As it is a free software so it can be easily used for modeling. Though there are some limitations in EPANET but it works efficiently.

Present system is capable of supplying water and meet up the ADD (Average Daily Demand). There is no need of adding valve in the pipe or any tank or pumps in the whole system.

Present system is able to meet the MDD. But there need some modification. Such as, in some nodes the pressure is high. Flow rate, velocity and head loss are within the reasonable value.

The distribution system is not capable in case of FD (Fire demand). The pressure flow rate are low. If FD is added it will not serve the purpose. It will cause the failure.

In the case of sensitivity where a multiple factor 1.1 has been used, it is observed that only the pressure of some nodes is little bit high otherwise flow rate, head loss, velocity are within the limit.

And in the case of diameter reduction, only the pressure of some nodes are high and all the parameters are within reasonable value.

Chlorine should be used to disinfect water and improve the water quality. From chlorine dosage analysis it has been observed that 1mg/L chlorine in every tank is sufficient to cover the system. So little amount of chlorine is sufficient to meet up the demand.

All the dead pipes are analyzed individually for each scenarios. And it is found that no dead end pipes are in danger of bursting.

6.2 Recommendations:

The recommendations are for enhancing the performance and sustainability of the systems. The recommendations are described below:

- In the case of MDD there is some high pressure nodes in the system. To control the high pressure open gate valve can be used. Otherwise there is a chance of pipe bursting.
- The present system is not capable of supplying water for FD (Fire Demand). So to cover the whole system another additional tank should be set up. And also to cope up the high pressure in nodes then open gate valve should be used. In some case diameter of some pipes should be enlarged to increase the flow rate.
- In the case of sensitivity analysis there is only high pressure nodes problem. To avoid that open gate valve should be used.

6.3 Limitations:

The study has been conducted considering some limitations. There are in some cases insufficient data about the system surveyed by DWASA. If more data would be available then a thorough study on the network can be conducted. Future demand forecasting is necessary for any water distribution system. Here future forecasting is not done because of insufficient data. More ever there is no scope of calibrate all the data with the DWASA surveyed data.

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