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# Analysis of Existing Water Distribution Network, To Investigate Its Adequacy in Performances of Its Function. A Case Study of: Badarawa/Malali Distribution Network

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## Abstract

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, 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. In this paper it was used to analyze the existing water distribution network in order to investigate its adequacy in performance of its function, the results obtained from this study revealed a lot of deficiencies in its design implementation and usage.

## Introduction

A water distribution network is a system containing pipes, reservoir, pumps and valves of different types, which are connected to each other to provide water to consumers. It is a vital component of the urban infrastructure and required significant investment. A water distribution system typically falls into one of two categories: (1) New design or (2) Rehabilitation of an existing works. A new design problem consists of a network layout where all pipes have to be assigned a diameter (i.e. The location of all pipes is given). A rehabilitation problem contain an existing network that requires an increase in its hydraulic capacity (e.g. via replacement, cleaning, or parallization of existing pipes) and/or provision of water to new consumers (e.g. via expansion within pipes). Effective water supply system is of paramount importance in designing a new water distribution network or in expanding the existing one. It is essential to investigate and establish a reliable network ensuring adequate head

Optimizing the performance of water distribution network can take many forms, and are comprised of many components and have many different performance criteria, for example, the decision variable within the optimization problem could involve the selection of diameter sizes for all the pipes, the sizes and location of tanks, valves, pressure setting and valve location and pump types and locations. In addition to these, the demand in the system could involve a range of demand cases including peak hours, fire loading and extended period of simulation,

There is extensive literature on application of computer software's in finding different solution to water distribution network. Researchers have been investigating effectiveness in performance of water distribution network with various approaches using different computer software's, such as optiga, epanet and opti designer.

Alperovits and Shamir (1977) presented a research on checking the performance of a water distribution network using a popular software known as opti designer. The length of pipe with differential diameter was used as decision making variable. The LPG method was later further improved by Kessler and Shamir (1989), for example. Kessler and Shamir (1989)presented two stages LPG method. In the first stage, parts of the variables are kept constant while other variables are solved separately in order to obtain a good network performances. In the second step, search for identifying the good network performance is conducted based on the gradient of the objective function. Flows are modified according to gradient of the objective functions. Eiger et al. (1994) used the same formulation of Kessler and Shamir (1989) and solved a given problem. Savic and Walters (1997) also determined deficiencies in performance in a given water distribution network in conjunction with EPANET network solver.

` However, the optimal network design is quite complicated due to nonlinear relationship between flow and head loss and the presence of discrete variables, such as market pipe sizes (Kessler and Shamir, (1989); Eiger et al. (1994); Dandy et at. (1996)). In addition, the pipe length, with their various diameters represents the cost of the network, is also nonlinear and causes great difficulty in the design of the network. Researchers in recent years have focused on probabilistic approach to overcome these difficulties (Savic and Walters, (1997); Abebeand Solomatine, (1998); Cunha and Sousa, (1999); Eusuff and Lansey, (2003) considering a combination of random and deterministic steps.

Other Previous works performed using "EPANET" includes the work by TospornSampon et al (2007) to solve a problem of split-pipe design of water distribution network. As mentioned earlier, the network simulation model used is EPANET, Roesman (2000)calculates nodal heads and flow in pipelines, storage in each tank, and concentration of substance throughout the system, and water age and source tracing both as strategic and dynamic loading conditions. Hazen Williams equation is used due to its wide applicability in water supply.

The main focus of this research is to model the existing water distribution network in order to investigate its adequacy in performance of its function, at the same time to identify all the deficiencies in its design implementation and usage.

## Study Area

Our study area is Badarawa and Malali that fall under Kaduna North Local Government. It lies on the latitude $10^0$ -$31^1$ and longitude $7^{0--}27^1$ (source: Kaduna State Environmental Protection Authority)]. The topography of the area is a differential one, i.e. one side of the area is relatively flat , while the other side is slightly elevated (see figure 1, below).

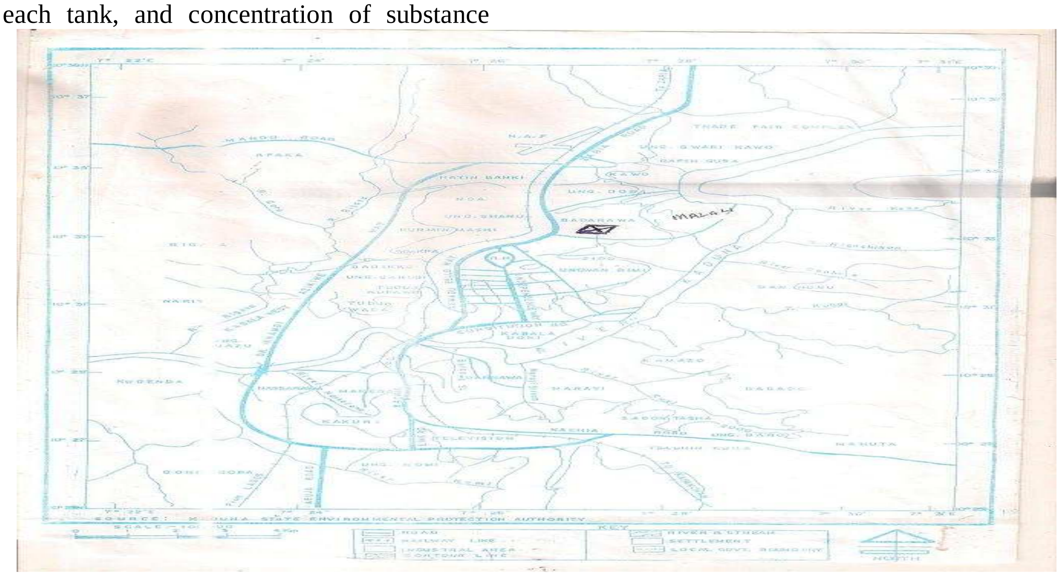


**Fig 1:⊠-The Study Area**

## Methodology

### Materials

The materials used includes: topographical map, water demand, population, distribution network parameters such as: elevations, pipe diameter, pipe length and pipe material. Finally the EPANET software.

### Method of Data Collection

The topographical map of Badarawa / Malali study area, was produced by using GIS software, after obtaining the map, the existing water network for the study area was drawn on the map, together with the junctions and their elevations. This was done with the help of experienced water board personnel, after proper editing, the full water supply network of the area was produced on the recent topographical map, and later transferredinto the Epanet software work space using a process called map transport. The demand was obtain after surveying the network in the area, average of 25 to 30 houses were connected to each individual node/Junction also the study area falls under the category of urban settlement, as a result of this development, the standard from the Federal Ministry of Water Resources manual on water demand was used, for this research 180 L/C/D was considered with an average of nine (9) persons in each house. We obtained a demand at particular junction by multiplying (number of houses at junction by number of people in the house by 180L/C/D).

In this research the existing distribution network of Badarawa/ Malali was studied and analyzed. It consists of 145 pipes of different materials 120 junctions, two tanks, and a source reservoir (i.e treatment plant) from which water is pumped through a pumping main to the overhead reservoir and later distributed to the network by gravity, as shown below:

## Analysis/Result

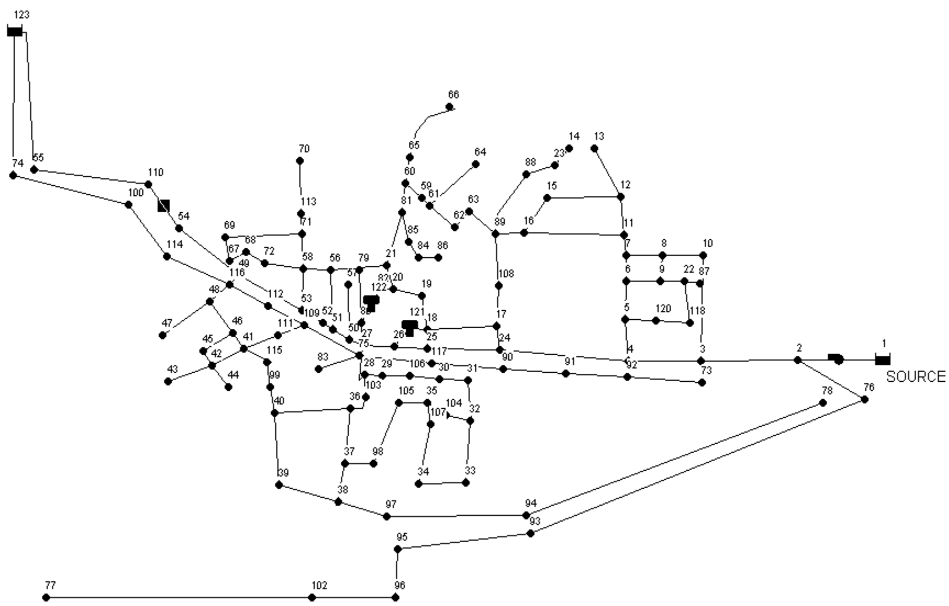
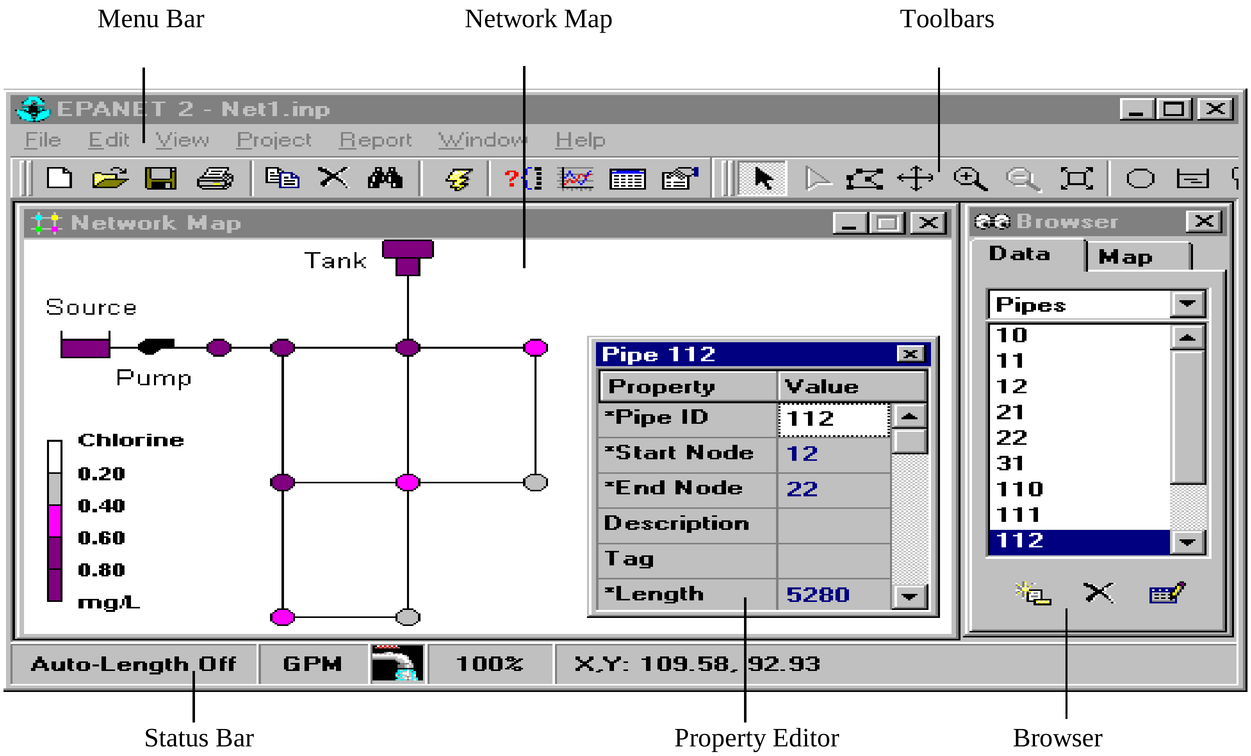



**FiG 2: Badarawa /Malali existing Water Supply network.**

As earlier mentioned epanet software was used to carry out the analysis for the above network, 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, it provides an integrated environment for editing network input data, running hydraulic and water quality simulations, and viewing the results in a variety of formats.

## EPANET'S workspace

The basic EPANET workspace is pictured below. It consists of the following userinterface elements: a Menu Bar, two Toolbars, a Status Bar, the Network Mapwindow, a Browser window, and a Property Editor window.




## Steps in Using EPANET

The following steps were carried out using EPANET to model the existing network for Badarawa/ Malali water distribution network:

1. Draw a network representation of your distribution system or import a basic description of the network. (In this research GIS packages were used to draw the network , and imported to the epanet)
2. Edit the properties of the objects that make up the system
3. Select a set of analysis options
4. Run a hydraulic/water quality analysis

The analysis of any water distribution network includes determining quantities of flow and head losses in the various pipe lines, and resulting residual pressure at various demands in the network junctions .The results obtain for the existing network for badarawa/malali area, are described below**:**

## Network Table - Links (pipes)

| Link ID | Flow | Velocity | Unit Head loss | Friction Factor |
|---|---|---|---|---|
| | LPS) | (m/s) | (m/km) | |
| Pipe 2 | -281.44 | 2.24 | 116.65 | 0.183 |
| Pipe 3 | -251.16 | 2.00 | 92.90 | 0.183 |
| Pipe 4 | 38.58 | 0.79 | 33.74 | 0.268 |
| Pipe 6 | -30.99 | 0.44 | 7.48 | 0.229 |
| Pipe 11 | -1.73 | 0.35 | 85.61 | 1.129 |
| Pipe 12 | 0.81 | 0.18 | 28.99 | 1.280 |

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| | | | | |
|---|---|---|---|---|
| Pipe 13 | 0.73 | 0.17 | 23.83 | 1.281 |
| Pipe 14 | -0.68 | 0.15 | 20.85 | 1.281 |
| Pipe 15 | -1.53 | 0.35 | 103.67 | 1.277 |
| Pipe 19 | 16.31 | 0.33 | 6.04 | 0.268 |
| Pipe 20 | 5.27 | 0.67 | 177.67 | 0.776 |
| Pipe 21 | 4.56 | 0.58 | 133.43 | 0.776 |
| Pipe 22 | -6.37 | 0.81 | 260.19 | 0.775 |
| Pipe 23 | -290.52 | 2.31 | 124.30 | 0.183 |
| Pipe 24 | -317.792.53 | 148.72 | 0.183 | |
| Pipe 25 | 7.72 | 0.98 | 381.51 | 0.775 |
| Pipe 26 | -326.27 | 2.60 | 156.76 | 0.183 |
| Pipe 27 | 11.85 | 0.67 | 69.05 | 0.452 |
| Pipe 28 | 3.18 | 0.63 | 288.02 | 1.128 |
| Pipe 30 | 1.02 | 0.20 | 29.55 | 1.131 |
| Pipe 32 | -0.21 | 0.01 | 0.00 | 0.034 |
| Pipe 36 | 6.07 | 0.34 | 18.13 | 0.452 |
| Pipe 37 | -0.45 | 0.03 | 0.10 | 0.440 |
| Pipe 39 | -3.43 | 0.19 | 5.79 | 0.453 |
| Pipe 40 | -4.13 | 0.23 | 8.41 | 0.453 |
| Pipe 41 | -0.24 | 0.01 | 0.00 | 0.032 |
| Pipe 43 | 1.31 | 0.03 | 0.04 | 0.274 |
| Pipe 44 | 0.70 | 0.04 | 0.25 | 0.458 |
| Pipe 45 | 0.67 | 0.04 | 0.23 | 0.459 |
| Pipe 8 | -9.08 | 0.18 | 1.87 | 0.269 |
| Pipe 46 | -11.54 | 0.24 | 3.02 | 0.268 |
| Pipe 47 | -1.67 | 0.03 | 0.06 | 0.270 |
| Pipe 48 | 0.67 | 0.09 | 2.94 | 0.782 |
| Pipe 50 | -378.78 | 3.01 | 211.28 | 0.183 |
| Pipe 53 | 12.95 | 1.65 | 1072.85 | 0.775 |

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|---|---|---|---|---|
| Pipe 55 | 8.70 | 1.11 | 485.06 | 0.775 |
| Pipe 56 | 0.82 | 0.10 | 4.29 | 0.781 |
| Pipe 57 | -14.41 | 0.11 | 0.31 | 0.183 |
| Pipe 58 | -6.40 | 0.05 | 0.06 | 0.185 |
| Pipe 59 | 12.62 | 1.61 | 1019.04 | 0.775 |
| Pipe 62 | -2.10 | 0.42 | 125.07 | 1.129 |
| Pipe 63 | -1.42 | 0.28 | 57.57 | 1.130 |
| Pipe 64 | 0.15 | 0.03 | 0.08 | 0.135 |
| Pipe 66 | 0.94 | 0.19 | 25.24 | 1.132 |
| Pipe 67 | 0.82 | 0.05 | 0.33 | 0.457 |
| Pipe 68 | 1.55 | 0.20 | 15.37 | 0.778 |
| Pipe 69 | 0.70 | 0.09 | 3.19 | 0.781 |
| Pipe 70 | 0.30 | 0.02 | 0.03 | 0.266 |
| Pipe 72 | -0.51 | 0.03 | 0.03 | 0.110 |
| Pipe 73 | -1.03 | 0.01 | 0.00 | 0.215 |
| Pipe 74 | 2.50 | 0.02 | 0.01 | 0.186 |
| Pipe 75 | 1.79 | 0.01 | 0.00 | 0.179 |
| Pipe 76 | 9.51 | 0.13 | 0.71 | 0.230 |
| Pipe 80 | 26.56 | 0.54 | 16.00 | 0.268 |
| Pipe 81 | 0.82 | 0.01 | 0.00 | 0.051 |
| Pipe 83 | 10.26 | 1.31 | 674.19 | 0.775 |
| Pipe 84 | 9.56 | 1.22 | 585.02 | 0.775 |
| Pipe 82 | 0.76 | 0.10 | 3.72 | 0.781 |
| Pipe 85 | -0.73 | 0.09 | 3.45 | 0.781 |
| Pipe 86 | -18.06 | 2.30 | 2087.11 | 0.775 |
| Pipe 87 | -0.91 | 0.12 | 5.38 | 0.780 |
| Pipe 88 | 0.76 | 0.04 | 0.29 | 0.456 |
| Pipe 91 | 0.82 | 0.16 | 18.99 | 1.133 |
| Pipe 92 | -0.69 | 0.16 | 21.38 | 1.281 |

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|---|---|---|---|---|
| Pipe 65 | 1.46 | 0.33 | 95.04 | 1.277 |
| Pipe 93 | 2.17 | 0.49 | 208.17 | 1.276 |
| Pipe 94 | 1.73 | 0.39 | 132.63 | 1.276 |
| Pipe 16 | -380.24 | 3.03 | 212.91 | 0.183 |
| Pipe 1 | -471.68 | 3.75 | 327.61 | 0.183 |
| Pipe 60 | 8.75 | 0.12 | 0.60 | 0.230 |
| Pipe 77 | 8.05 | 0.11 | 0.51 | 0.230 |
| Pipe 95 | 7.34 | 0.10 | 0.42 | 0.230 |
| Pipe 96 | 6.61 | 0.09 | 0.34 | 0.230 |
| Pipe 97 | 5.91 | 0.08 | 0.27 | 0.230 |
| Pipe 98 | 5.12 | 0.07 | 0.21 | 0.231 |
| Pipe 99 | 3.63 | 0.05 | 0.10 | 0.231 |
| Pipe 100 | 2.92 | 0.04 | 0.07 | 0.231 |
| Pipe 101 | 2.22 | 0.03 | 0.04 | 0.230 |
| Pipe 102 | 1.52 | 0.02 | 0.02 | 0.237 |
| Pipe 103 | 0.76 | 0.01 | 0.00 | 0.165 |
| Pipe 104 | 3.66 | 0.01 | 0.00 | 0.125 |
| Pipe 105 | 3.66 | 0.01 | 0.00 | 0.136 |
| Pipe 106 | 2.95 | 0.01 | 0.00 | 0.122 |
| Pipe 107 | 2.11 | 0.01 | 0.00 | 0.136 |
| Pipe 108 | 1.43 | 0.00 | 0.00 | 0.074 |
| Pipe 109 | 0.70 | 0.00 | 0.00 | 0.000 |
| Pipe 34 | -1.02 | 0.06 | 0.51 | 0.456 |
| Pipe 78 | -1.78 | 0.10 | 1.56 | 0.454 |
| Pipe 110 | -4.27 | 0.54 | 116.77 | 0.776 |
| Pipe 111 | -5.06 | 0.64 | 163.79 | 0.776 |
| Pipe 112 | -5.82 | 0.74 | 216.62 | 0.775 |
| Pipe 113 | 1.68 | 0.09 | 1.39 | 0.454 |
| Pipe 114 | 0.97 | 0.06 | 0.47 | 0.456 |
| Pipe 115 | 0.31 | 0.02 | 0.01 | 0.125 |

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|---|---|---|---|---|
| *Pipe 116* | *0.55* | *0.03* | *0.15* | *0.460* |
| *Pipe 117* | *-1.75* | *0.35* | *87.07* | *1.129* |
| *Pipe 118* | *-2.48* | *0.49* | *174.92* | *1.128* |
| *Pipe 119* | *-7.04* | *0.40* | *24.37* | *0.452* |
| *Pipe 120* | *-7.86* | *0.44* | *30.34* | *0.452* |
| *Pipe 123* | *-4.08* | *0.81* | *472.36* | *1.127* |
| *Pipe 124* | *-8.81* | *0.18* | *1.77* | *0.269* |
| *Pipe 125* | *-9.52* | *0.19* | *2.06* | *0.269* |
| *Pipe 126* | *-379.56* | *3.02* | *212.15* | *0.183* |
| *Pipe 127* | *-380.24* | *3.03* | *212.91* | *0.183* |
| *Pipe 128* | *0.03* | *0.28* | *615.20* | *1.891* |
| *Pipe 129* | *-0.78* | *0.10* | *3.97* | *0.781* |
| *Pipe 131* | *2.96* | *0.02* | *0.01* | *0.190* |
| *Pipe 132* | *1.66* | *0.01* | *0.00* | *0.201* |
| *Pipe 133* | *0.82* | *0.01* | *0.00* | *0.000* |
| *Pipe 134* | *6.17* | *0.13* | *0.87* | *0.269* |
| *Pipe 135* | *5.39* | *0.11* | *0.66* | *0.269* |
| *Pipe 136* | *4.68* | *0.10* | *0.50* | *0.269* |
| *Pipe 137* | *1.57* | *0.36* | *109.33* | *1.277* |
| *Pipe 138* | *0.78* | *0.18* | *27.19* | *1.280* |
| *Pipe 139* | *-0.03* | *0.01* | *0.00* | *0.108* |
| *Pipe 140* | *36.31* | *0.74* | *29.89* | *0.268* |
| *Pipe 141* | *33.85* | *0.69* | *25.97* | *0.268* |
| *Pipe 142* | *-0.17* | *0.00* | *0.00* | *0.309* |
| *Pipe 143* | *-0.70* | *0.04* | *0.25* | *0.458* |
| *Pipe 144* | *-1.52* | *0.09* | *1.14* | *0.455* |
| *Pipe 145* | *-2.22* | *0.13* | *2.44* | *0.454* |
| *Pipe 5* | *-339.75* | *2.70* | *169.99* | *0.183* |
| *Pipe 10* | *-341.36* | *2.72* | *171.60* | *0.183* |
| *Pipe 18* | *-350.88* | *2.79* | *181.30* | *0.183* |

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| | | | | |
|---|---|---|---|---|
| Pipe 29 | -351.72 | 2.80 | 182.17 | 0.183 |
| Pipe 31 | -365.07 | 2.91 | 196.26 | 0.183 |
| Pipe 33 | -1.67 | 0.33 | 78.96 | 1.129 |
| Pipe 35 | -1.70 | 0.34 | 82.67 | 1.129 |
| Pipe 38 | -31.69 | 0.45 | 7.82 | 0.229 |
| Pipe 42 | -33.23 | 0.68 | 25.03 | 0.268 |
| Pipe 49 | 7.27 | 0.41 | 26.00 | 0.452 |
| Pipe 51 | 4.37 | 0.25 | 9.42 | 0.453 |
| Pipe 54 | 0.70 | 0.14 | 14.13 | 1.134 |
| Pipe 61 | 2.22 | 0.44 | 140.40 | 1.128 |
| Pipe 71 | 1.43 | 0.29 | 58.58 | 1.130 |
| Pipe 7 | 0.73 | 0.17 | 23.83 | 1.281 |
| Pump 52 | 193.89 | 0.00 | -72.15 | 0.000 |

## Network Table – Nodes (Junctions)

| Node ID | Demand | Head | Pressure |
|---|---|---|---|
| | (LPS) | (M) | M) |
| Junc 2 | 0.00 | 654.15 | 69.15 |
| Junc 3 | 0.70 | 695.02 | 106.02 |
| Junc 4 | 0.79 | 715.35 | 125.35 |
| Junc 5 | 0.70 | 711.29 | 122.29 |
| Junc 6 | 0.76 | 707.69 | 98.69 |
| Junc 7 | 0.79 | 704.83 | 92.83 |
| Junc 8 | 0.84 | 701.06 | 89.06 |
| Junc 9 | 0.73 | 698.95 | 89.95 |

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|---|---|---|---|
| *Junc 10* | *0.70* | *699.88* | *87.88* |
| *Junc 11* | *0.76* | *704.83* | *90.83* |
| *Junc 12* | *0.76* | *701.33* | *85.33* |
| *Junc 13* | *0.73* | *695.37* | *78.37* |
| *Junc 14* | *0.73* | *694.98* | *74.98* |
| *Junc 15* | *0.84* | *708.64* | *93.64* |
| *Junc 16* | *0.82* | *732.50* | *118.50* |
| *Junc 17* | *0.73* | *780.94* | *175.94* |
| *Junc 18* | *0.70* | *778.59* | *173.59* |
| *Junc 19* | *0.70* | *752.71* | *155.71* |
| *Junc 20* | *0.67* | *738.00* | *140.00* |
| *Junc 21* | *0.76* | *777.38* | *163.38* |
| *Junc 22* | *0.82* | *691.04* | *83.04* |
| *Junc 23* | *0.73* | *697.42* | *79.42* |
| *Junc 24* | *0.70* | *782.54* | *182.54* |
| *Junc 25* | *0.76* | *816.83* | *212.83* |
| *Junc 26* | *0.73* | *619.62* | *15.62* |
| *Junc 27* | *0.82* | *848.56* | *246.56* |
| *Junc 28* | *0.82* | *840.23* | *238.23* |
| *Junc 29* | *0.70* | *809.19* | *207.19* |

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|---|---|---|---|
| *Junc 30* | *0.73* | *761.11* | *162.11* |
| *Junc 31* | *0.70* | *758.06* | *161.06* |
| *Junc 32* | *0.79* | *758.05* | *165.05* |
| *Junc 33* | *0.76* | *758.02* | *148.02* |
| *Junc 34* | *0.76* | *758.03* | *148.03* |
| *Junc 35* | *0.82* | *758.36* | *148.36* |
| *Junc 36* | *0.73* | *833.72* | *223.72* |
| *Junc 37* | *0.70* | *829.90* | *216.90* |
| *Junc 38* | *0.76* | *829.92* | *215.92* |
| *Junc 39* | *0.70* | *831.19* | *217.19* |
| *Junc 40* | *0.79* | *833.72* | *222.72* |
| *Junc 41* | *0.82* | *834.05* | *224.05* |
| *Junc 42* | *0.84* | *834.05* | *225.05* |
| *Junc 43* | *0.70* | *834.00* | *217.00* |
| *Junc 44* | *0.67* | *834.02* | *221.02* |
| *Junc 45* | *0.76* | *834.28* | *223.28* |
| *Junc 46* | *0.79* | *834.28* | *227.28* |
| *Junc 47* | *0.67* | *835.39* | *774.39* |
| *Junc 48* | *0.73* | *835.91* | *227.91* |
| *Junc 49* | *0.76* | *954.38* | *345.38* |

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| | | | |
|---|---|---|---|
| Junc 50 | 0.79 | 860.50 | 255.50 |
| Junc 51 | 0.82 | 874.25 | 263.25 |
| Junc 52 | 0.84 | 887.00 | 277.00 |
| Junc 53 | 0.73 | 905.25 | 294.25 |
| Junc 54 | 0.79 | 992.46 | 381.46 |
| Junc 55 | 0.00 | 1151.93 | 520.93 |
| Junc 56 | 0.70 | 777.45 | 171.45 |
| Junc 57 | 0.82 | 859.66 | 248.66 |
| Junc 58 | 0.76 | 777.46 | 169.46 |
| Junc 59 | 0.67 | 755.22 | 138.22 |
| Junc 60 | 0.73 | 770.95 | 151.95 |
| Junc 61 | 0.76 | 750.87 | 133.87 |
| Junc 62 | 0.79 | 750.89 | 134.89 |
| Junc 63 | 0.79 | 753.45 | 138.45 |
| Junc 64 | 0.82 | 750.78 | 132.78 |
| Junc 65 | 0.84 | 769.37 | 149.37 |
| Junc 66 | 0.70 | 768.45 | 146.45 |
| Junc 67 | 0.73 | 777.46 | 168.46 |
| Junc 68 | 0.76 | 777.46 | 167.46 |
| Junc 69 | 0.82 | 777.45 | 167.45 |

ISSN: 2277-9655
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| | | | |
|---|---|---|---|
| *Junc 70* | *0.82* | *777.46* | *159.46* |
| *Junc 71* | *0.79* | *777.46* | *168.46* |
| *Junc 72* | *0.70* | *777.46* | *169.46* |
| *Junc 73* | *0.76* | *1448.04* | *858.04* |
| *Junc 74* | *0.76* | *1449.05* | *818.05* |
| *Junc 75* | *0.73* | *1448.09* | *845.09* |
| *Junc 76* | *0.00* | *654.15* | *73.15* |
| *Junc 77* | *0.70* | *654.15* | *44.15* |
| *Junc 78* | *0.70* | *828.40* | *237.40* |
| *Junc 79* | *0.82* | *848.56* | *235.56* |
| *Junc 80* | *0.76* | *624.70* | *23.70* |
| *Junc 81* | *0.67* | *771.89* | *153.89* |
| *Junc 82* | *0.70* | *677.78* | *74.78* |
| *Junc 83* | *0.76* | *1448.05* | *840.05* |
| *Junc 84* | *0.73* | *754.03* | *140.03* |
| *Junc 85* | *0.79* | *757.81* | *143.81* |
| *Junc 86* | *0.70* | *753.32* | *139.32* |
| *Junc 87* | *0.82* | *690.07* | *81.07* |
| *Junc 88* | *0.70* | *716.67* | *109.67* |
| *Junc 89* | *0.84* | *780.00* | *173.00* |

ISSN: 2277-9655
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|---|---|---|---|
| *Junc 100* | *0.70* | *1448.78* | *830.78* |
| *Junc 102* | *0.73* | *654.15* | *51.15* |
| *Junc 103* | *0.82* | *836.89* | *225.89* |
| *Junc 104* | *0.76* | *758.12* | *153.12* |
| *Junc 105* | *0.79* | *774.38* | *171.38* |
| *Junc 106* | *0.73* | *782.89* | *175.89* |
| *Junc 107* | *0.70* | *758.19* | *152.19* |
| *Junc 108* | *0.70* | *780.53* | *173.53* |
| *Junc 109* | *0.76* | *1448.14* | *831.14* |
| *Junc 110* | *0.67* | *1066.74* | *446.74* |
| *Junc 111* | *0.82* | *832.94* | *221.94* |
| *Junc 112* | *0.70* | *1448.19* | *841.19* |
| *Junc 113* | *0.84* | *777.46* | *165.46* |
| *Junc 114* | *0.70* | *1448.65* | *836.65* |
| *Junc 115* | *0.79* | *833.91* | *220.91* |
| *Junc 116* | *0.73* | *1448.53* | *838.53* |
| *Junc 117* | *0.70* | *1448.06* | *845.06* |
| *Junc 118* | *0.82* | *691.04* | *91.04* |
| *Junc 120* | *0.79* | *696.49* | *96.49* |
| *Junc 90* | *0.70* | *1448.05* | *850.05* |

| | | | |
|---|---|---|---|
| *Junc 91* | *0.70* | *1448.05* | *849.05* |
| *Junc 92* | *0.76* | *1448.04* | *850.04* |
| *Junc 93* | *0.70* | *654.15* | *50.15* |
| *Junc 94* | *0.82* | *829.04* | *224.04* |
| *Junc 95* | *0.84* | *654.15* | *51.15* |
| *Junc 96* | *0.67* | *654.15* | *51.15* |
| *Junc 97* | *0.70* | *829.38* | *226.38* |
| *Junc 98* | *0.76* | *803.88* | *201.88* |
| *Junc 99* | *0.70* | *833.80* | *229.80* |
| *Resvr 123* | *-389.75* | *1450.00* | *0.00* |
| *Resvr 1* | *277.78* | *582.00* | *0.00* |
| *Tank 122* | *8.80* | *625.00* | *10.00* |
| *Tank 121* | *17.33* | *620.00* | *10.00* |

## Conclusion

The main focused of this researchisto analyze the existing water distribution network in order to investigate its adequacy in performance of its function, implementation and its usage. At the end of the analysis theresults revealed the following deficiencies on the existing pipe line network:

(1) A situation encountered in the studied water distribution network is that of improper connections on the pumping main which supplies water to the reservoir, this may cause a problem to the reservoir of not getting to full designed capacity.

(2) Also the result obtained revealed a problem of low pressure in some portion of the network; this may point toward the likelihood of a closed valve in the area, or as result of several factors such as: illegal connections, leakages and extension of water services to other areas without improving the designed water supply demand from the treatment plant.

(3) It was observed that the existing network on the recent topographical map does not have a wider coverage of water distribution to some parts of the area; this is as a result of rapid residential expansion in the area.

## Recommendations

The foregoing deficiencies are enough to cause water crisis in the study area, having obtained these, it is recommended to:

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(a) Use one of the optimization techniques to optimize the network in order to resolve the observed deficiencies.
(b)-Use one of the optimization software to develop a model of the new design /expansion, and then simulate flow characteristics and capacities for optimum distribution of water in the area.
(c)-Use the outcome to inform the concerned government agency on what should be done to ensure adequate water supply to various consumers who reside in Badarawa and Malali area.

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