

Analysis of Clean Water Distribution System in Nuruwe Village, West Kairatu District, Seram West Regency using Epanet Software 2.0

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Keywords— *Water, Hydrolysis, Epanet, Feasibility.*

Abstract— *Water is one of the natural elements that more or less influences every important role in the life of humans and other creatures in this nature which is a basic need for humans so that it becomes the main thing if the clean water sector gets priority in handling and fulfilling it. Water demand is the amount of water needed for household, industrial and other needs. Population Projection is a scientific calculation of population in the future based on assumptions about the components of population growth at a certain level, the results of which will show the characteristics of the population, births, deaths and migration. EPANET is a computer program that provides hydraulic simulations and trends in the quality of water flowing in pipelines. The network itself consists of Pipes, The method of data collection and analysis used in this study was to conduct a survey at the research location to review and see directly the conditions of the research location, then create a piping system that is suitable for the research location, after that calculate the projected population and clean water distribution system in Nuruwe village by using the Epanet 2.0 Software to analyze the feasibility of the piping system based on the number of residents and water needs it can be concluded that the clean water requirement needed by the residents of Nuruwe Village is 2.44 liters/second, with this amount of water demand, a network system distribution model is made piping using Epanet 2.0 software, and the results obtained are Run Successful, which means the distribution of the piping system runs 100%.*

I. INTRODUCTION

Water is one of the natural elements that more or less influences every important role in the life of humans and other creatures in this nature which is a basic need for humans so that it becomes the main thing if the clean water sector gets priority in handling and fulfilling it. It is expected to be able to distribute and meet the community's clean water needs properly and evenly, with the existing pipe distribution system. If the distribution system that occurs is not good, it will cause various kinds of problems

including a lack of water pressure so that the water flow is not distributed evenly, with the existing pipe distribution system. (Rusdina, 2015)

The clean water supply system that is implemented in the PAMSIMAS program in obtaining clean water will produce better quality and quantity of services different from one city/regency to another. This is also the case in West Seram District, Maluku Province, where the distribution of clean water from this program has not been maximized in each area. If the distribution system that

occurs is not good, it will cause various kinds of problems including lack of water pressure so that the water flow is not distributed evenly. One of the villages in West Seram Regency which is also affected by the less than optimal distribution of water is Nuruwe Village, Kairatu Barat District. This area also experiences the same thing, where water distribution is not optimal even though there is already a pipe network system in this area (batosamma, 2018).

Thus, to anticipate the clean water problem in Nuruwe Village, West Kairatu District, it is necessary to review it so that the clean water problem in the village can be properly resolved. In this study the authors propose an alternative solution to clean water problems by re-analyzing the clean water distribution system assisted by Epanet 2.0 software. The distribution system will be modeled in EPANET 2.0 software to find out whether water sources can meet community needs in a sustainable manner until the planned year.

With this the author conducts research on the Analysis of the Clean Water Distribution System in Nuruwe Village, Kairatu Barat District, West Seram Regency Using Epanet 2.0 Software

II. LITERATURE REVIEW

2.1 Definition of Water

Water is a natural resource that is absolutely used for life and human life and in the environmental management system, water is an element of the environment.

Clean water is water that is used for daily needs and will become drinking water after being boiled first. As a limit, clean water is water that meets the requirements for a drinking water supply system. The requirements in question are requirements in terms of water quality which include physical, chemical, biological and radiological quality, so that when consumed it does not cause side effects (General Provisions of Permenkes no. 416/Menkes/PER/IX/1990). In the General Description Module of Drinking Water Provision and Treatment, March 2003 Edition, p. 3 of 41 (Makawimbang et al., 2017).

2.2 Water Needs

Water demand is the amount of water needed for household, industrial and other needs. The priority of water needs includes domestic, industrial, and public service water needs (Pramono & Andana, 2019). The water requirement determines the size of the system and is determined based on water usage

1. Clean Water Requirements Standard

Water needs will be categorized into domestic and non-domestic water needs. Domestic water needs are water

needs that are used for household needs, namely for drinking, cooking, bathing, washing clothes and other needs, while non-domestic water needs are used for commercial activities such as industry, offices, and social activities such as schools, hospitals, places of worship and commerce. (Suheri et al., 2019). The average water consumption unit for non-domestic facilities and infrastructure in the evaluation is adjusted to the DPU standards of the Directorate General of Cipta Karya, 1996 in Table.1 and also domestic facilities and infrastructure are listed in Table.2 as follows:

Table.1: Non-domestic water needs

No.	Sarana dan prasarana	UnitKebutuhanKonsumsiAir (liter/hari)
1	masjid	30 untuk100 orang
2	gereja	10 untuk100 orang
3	toko	10 untuk20 orang
4	pasar	10 untuk20 orang
5	hotel	25 untuk300 tempat tidur
6	rumah makan	2000 untuk1 rumah makan
7	industri	2000 untuk1 industr
8	rumah sakit	240 untuk300
9	puskesmas	25 untuk10 orang
10	apotek	10 untuk20 orang
11	sekolah	25 untuk250 orang
12	kantor	30 untuk25 orang
13	bioskop	25 untuk200 tempat duduk

Table.2: Domestic water demand

URAIAN	KATEGORI KOTA BERDASARKAN JUMLAH PENDUDUK (JIWA)				
	> 1.000.000	500.000 s/d 1.000.000	100.000 s/d 500.000	20.000 s/d 100.000	< 20.000
	Kota Metropolitan	Kota Besar	Kota Sedang	Kota Kecil	Desa
1	2	3	4	5	6
1. Konsumsi Unit Sambungan Rumah (SR) (liter/kg/hari)	> 150	150 - 120	90 - 120	80 - 120	60 - 80
2. Konsumsi Unit Bidang (HU) (liter/kg/hari)	20 - 40	20 - 40	20 - 40	20 - 40	20 - 40
3. Konsumsi unit non domestik					
a. Niaga Kecil (liter/m ² /hari)	600 - 900	600 - 900		600	
b. Niaga Besar (liter/m ² /hari)	1000 - 5000	1000 - 5000		1500	
c. Industri Besar (liter/m ² /hari)	0.2 - 0.8	0.2 - 0.8		0.2 - 0.8	
d. Pariwisata (liter/m ² /hari)	0.1 - 0.3	0.1 - 0.3		0.1 - 0.3	
4. Kehilangan Air (%)	20 - 30	20 - 30	20 - 30	20 - 30	20 - 30
5. Faktor Hari Malam	1.15 - 1.25	1.15 - 1.25	1.15 - 1.25	1.15 - 1.25	1.15 - 1.25
	* harian	* harian	* harian	* harian	* harian
6. Faktor Jam Puncak	1.75 - 2.0	1.75 - 2.0	1.75 - 2.0	1.75	1.75
	* hari maks	* hari maks	* hari maks	* hari maks	* hari maks
7. Jumlah Jiwa Per SR (Jiwa)	5	5	5	5	5
8. Jumlah Jiwa Per HU (Jiwa)	100	100	100	100 - 200	200
9. Sisa Tekan Di penyediaan Distribusi (Meter)	10	10	10	10	10
10. Jam Operasi (jam)	24	24	24	24	24
11. Volume Reservoir (% Max Day Demand)	15 - 25	15 - 25	15 - 25	15 - 25	15 - 25
12. SR - HU	50 : 50 s/d 80 : 20	50 : 50 s/d 80 : 20	80 : 20	70 : 30	70 : 30
13. Cakupan Pelayanan (%)	90	90	90	90	70

Information :

*) depending on the socio-economic survey

**) 60 % piping, 30 % non piping

***) 25 % piping, 45 % non piping

The feasibility standard for clean water needs is 49.5 is 2.5 liters per day. Standard water requirements in humans usually follow the formula of 30 cc per kilogram of body weight per day. That is, if someone with a body weight of 60 kg, then the need for water per day is 1,800 cc or 1.8 liters. The UNESCO world body itself in 2002 has established the basic human right to water, which is 60 ltr/person/day. The Directorate General of Human Settlement, Ministry of Public Works, subdivides the standards for drinking water according to regional locations as follows:

- 1) Rural areas with a need of 60 liters / per capita / day
- 2) Small City with a need of 90 liters / per capita / day.
- 3) Medium City with a need of 110 liters / per capita / day.
- 4) Metropolitan City with a need of 130 liters / per capita / day.

2. Clean Water Requirements

In planning a clean water distribution system, of course there are water requirements (Boekoesoe, 2010). these are:

1) Quantity

The quantity requirement in the supply of clean water is in terms of the amount of raw water available. This means that raw water can be used to meet regional needs and the number of people to be served.

2) Continuity

Raw water for clean water must be taken continuously with relatively constant debit fluctuations, both during the dry and rainy seasons. Continuity can also mean that clean water must be available 24 hours per day, or whenever needed, water needs are available. However, these ideal conditions can hardly be met in every region in Indonesia, so to determine the level of continuity of water use can be done by approaching consumer activities towards priority water use. The priority for water use is for a minimum of 12 hours per day, namely during the hours of life activities, namely at 06.00 – 18.00.

2.3 Population Projection

Predictions of population in the future are based on the rate of urban development and trends, land use directions and the availability of land to accommodate population growth. It is necessary to know the prediction of the population in the 20-year planning period to determine the clean water needs of the planning area (Asrurudin, 2020). By taking into account the rate of development of the population in the past, the statistical method is the closest method for estimating the population in the future. The method used is:

• **Geometric Method**

This method is considered good for a short period of time equal to the period of data acquisition. The equation used is:

$$P_n = P_o (1 + r)^n \dots\dots\dots (2.1)$$

With :

- P_n = Number of Population in Year n
- P_o = Total population in the base year
- r = Population Growth Ratio
- n = Year Projection

2.4 Hydraulic Analysis

Flow in a pipe or flow in which the entire pipe section is filled with water. If water flows in a pipe but there is a free water surface in the pipe, then the flow is not included in the definition of flow in a pipe (Amin, 2011).

1) Main Energy Loss (major)

There are several empirical equations that are used each with its own advantages and disadvantages. The Darcy Weisbach equation is most widely used in fluid flow in general. For flows with relatively unchanged viscosity, the Hazen Williams equation is used. The following shows the following two equations:

a) Darcy Weisbach equation

Darcy Weisbach's mathematical equation is:

$$H_f = (L.v^2 / D.2g) \dots\dots\dots (2.2)$$

With :

- h_f = loss of energy or pressure (major or main)(m)
- v = discharge of water in the pipe (m³/s)
- f = friction coefficient (DarcyWeisbach)
- L = pipe length (m)
- D = pipe diameter (m)
- g = acceleration due to gravity (m/s²)

b) The Hazen Williams equation

The Hazen-William equation is the most commonly used, this equation is more suitable for calculating pressure loss for pipes with large diameters, namely above 100 mm.

In addition, this formula is often used because it is easy to use. The Hazen Williams equation empirically states that the discharge flowing in the pipe is proportional to the pipe diameter.

$$S = hS/L \dots\dots\dots (2.3)$$

With :

- S = hydraulic tilt
- h_L = pressure loss
- L = pipe length

Besides that there is a factor C which describes the physical condition of the pipe such as the smoothness

of the inner wall of the pipe which describes the type of pipe and its age.

In general Hazen William's formula is as follows:

$$Q = 0.2785 \cdot C \cdot d^{2.63} \cdot S^{0.54} \dots\dots\dots(2.4)$$

With :

- Q = water discharge in the pipe (m³/s)
- C = pipe roughness
- d = pipe diameter
- S = hydraulic tilt

If the pressure loss or hL is to be calculated then:

$$h_l = (Q / (0.2785 \cdot C \cdot d^{2.63})) L \dots\dots\dots (2.5)$$

With :

- Q = water discharge in the pipe (m³/s)
- C = pipe roughness
- d = pipe diameter
- L = is the length of the pipe from node 1 to node 2

C is (Hazen William coefficient) different for various types of pipes while for High Density Poly Ethylene (HDPE) pipes the value of C (Hazen William coefficient) is 130. The following is C in Hazen William which can be seen in Table .3.

Table.3: Hazen William's C Score (DPU Directorate General of Cipta Karya)

Pipe Type	Grade C Planning
Asbestos Cement (ACP)	120
UPVC	120
Medium DPE	130
High HDPE	130
Ductile (DCIP)	110
Cast iron (CIP)	110
GIP	110
Steel	110
Pre-streams (PSC)	120

2) Secondary Energy Loss

Local energy loss due to cross-section enlargement, cross-section reduction, diaphragms and pipe bends. Minor energy loss in mathematical language is written as follows:

$$h_f = k (v^2 / 2g) \dots\dots\dots (2.7)$$

With :

- k = loss of energy
- k = coefficient of minor loss
- v = speed
- g = gravity

In general, this pressure loss is much smaller than the loss due to friction in the pipe, therefore this pressure loss is commonly referred to as a minor loss or minor loss. (Dharmasetiawan, 2004: page II-12).

2.5 Water Pressure Requirements

According to the DPU (Department of Public Works) standards, water that is channeled to consumers through transmission and distribution pipes is designed to be able to serve consumers to the farthest with a drinking water pressure of 10 mka or 1 atm. This pressure figure must be maintained, ideally evenly distributed on each distribution pipe. If the pressure is too high, it will cause the pipe to burst and damage the plumbing tools. The pressure is also kept not too low, because if the pressure is too low it will cause water contamination during flow in the distribution pipe (Mahardhika, 2018).

1) Brocaptering (Spring Catcher Tub)

Protecting and capturing water from springs to be collected and channeled using transmission pipes to reservoirs.

2) Reservoir (Reservoir) The function of the reservoir is:

- As a reserve of clean water in the event of damage or repair of the distribution network.
- As a reserve to meet usage fluctuations.
- Can function as a pressure relief tub.
- As a water reserve for fire fighting.

The dimensions of the power depending on the service reservoir generally range between 17.5% - 20% of the average daily water demand. The greater the tamping capacity of the service reservoir, the safer the system is against system damage/repair and fire fighting.

2.6 Epanet 2.0 application

1) **Introduction to EPANET 2.0 Software**

Epanet is a computer program which describes the hydraulic simulation and the trend of the quality of water flowing in the pipeline. The network itself consists of Pipes, Nodes (pipe connection points), pumps, valves, and water tanks or reservoirs. EPANET tracks the flow of water in each pipe, the condition of the water pressure at each point and the condition of the concentration of chemicals flowing in the pipe during the flow period. In addition, water age and source tracking can also be simulated (Safitri et al., 2021).

EPANet can assist in setting strategies to realize water quality in a system. These include:

- 1) Alternative use of sources in various sources in one system.
- 2) Alternative pumping in scheduling filling or tank filling.
- 3) Use of treatment, for example chlorination in storage tanks.
- 4) Targeting pipe cleaning and replacement.

Running in a windows environment, Epanet can be integrated to perform editing in data entry, running simulations and viewing running results in various formats. It also includes color codes on maps, data tables, graphs, and contour images.

For example for designing, calibrating hydraulic models, residual chlorine analysis, and customer analysis. EPANET can assist in managing strategies for realizing water quality in a system.

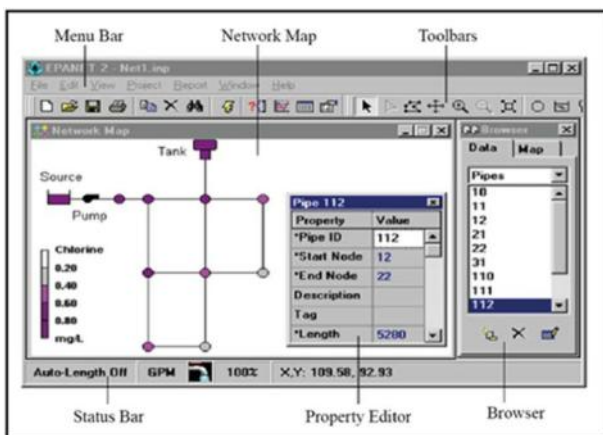


Fig.1: Display (source: Epanet 2.0 Application)

The use of software tools makes it easier to analyze the condition of the existing clean water pipelines so that it helps in rearranging the existing clean water pipelines.

2) How to use Epanet 2.0 Software

▪ Installing Apps

EPANET version 2.0 is designed for a Windows 95/98/NT operating system environment that is compatible with IBM/Intel PCs (Asrorudin, 2020). It consists of one file, en2setup.exe, which contains the self-extraction setup program. To install Epanet:

- Select Run from the Windows Start menu.
- Enter the full path and file name en2setup.exe or click the browse button to locate it on your computer.
- click the OK button to start the process.

The Setup Program will ask for the choice of the folder (directory) where the Epanet files will be placed. The default folder is c:\program files\Epanet 2.0. After the file is installed, the Start Menu will have a new Epanet 2.0 menu. To easily log out of Epanet, select the inactive item on the Star Menu, then select Epanet 2.0 from the submenu that appears. (The executable file name of Epanet under windows is epanet2w.exe)

Likewise, if you want to remove Epanet from your computer, you can follow the following procedure:

- Select Settings from the Start Menu

- Select Control Panel from the Settings menu
- Double click on the add/remove programs item
- Select Epanet 2.0 from the list of programs that appears
- Click the Add/Remove button

▪ Bar Menu

The menu bar located at the top of the EPANET work area contains a group of menus used to control EPANET programs consisting of:

a) File Menu

The file menu contains commands for opening and saving data files and for printing.

b) Edit Menu

The Edit menu contains commands for editing and copying.

c) View Menu

On the View Menu there are commands to control the display of the network map.

d) Project Menu

Project Menu in it there are commands related to the analysis being carried out on the project menu.

e) Menu Reports

The Report menu has commands that are used to display analysis data in different formats.

f) Window Menus

The menu window contains commands Rearranges all the smaller windows to match the main window

g) Help Menu

The Help Menu contains commands for getting help in using EPANET. Help can also be obtained by pressing the F1 function key.

3) Open Program and Program Settings

- Run the epanet program Start – Program – Epanet 2.0
- After the Epanet program appears, then click File then click New or click Open then double click the file name if the file already exists.
- Create an image file for the base map that will be made into the existing pipeline with a "BMP" file (if it is still in JPG format, it must be converted to BMP) which will be made to load the image on epanet.
- Enter the map image in BMP form, namely click View – Backdroop – Load – press the plan drawing file

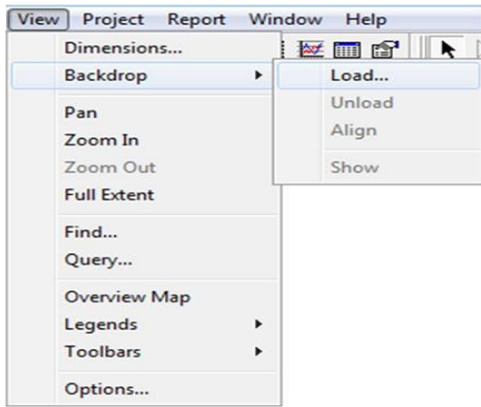


Fig.2: Display BMP file creation

e) Before creating a system network, first equalize the size of the discharge unit and determine the head loss formula, namely click on the Browser Toolbar:

➤ Hydraulic Data

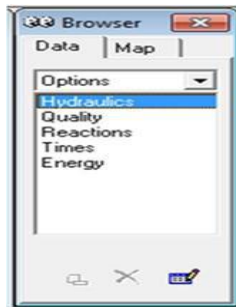


Fig.3: View Data generation

➤ Flow unit (LPS) head loss

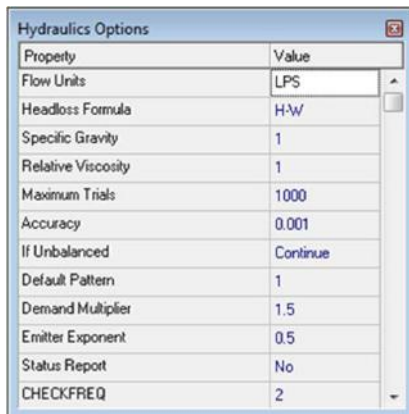


Fig.4: Display of making a headloss flow unit

➤ Data Options time

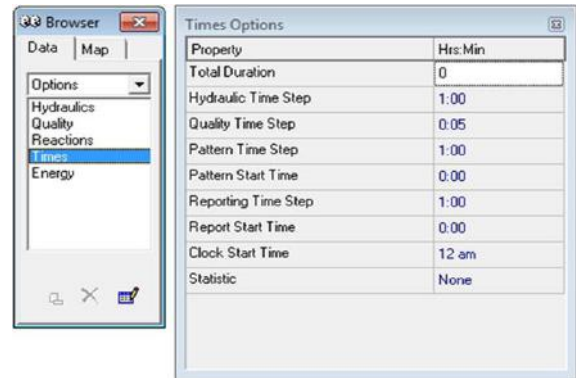


Fig.5: Display of making total duration data

4) **Create a Network Model Drawing**

Create a distribution system network according to the existing system, using the Toolbars Map available in the epanet program (SIREGAR, 2021).

- ❖ Click the Reservoir Toolbar and place it on the plans.
- ❖ Click the Node/Junction Toolbar and place it on the plans.
- ❖ Click Pipe Toolbar connect between junctions (press junctions for nodes then place them on the plan drawing).
- ❖ Then forwarded to Tank , Valves , Pump , etc.

5) **Enter Data**

- ❖ After creating the system network, then filling in each data on junctions, pipes, reservoirs, pumps, tanks, etc. The data is filled according to the existing system.
- ❖ Create Time Patterns. The time pattern contains the peak hour factor for fluctuations in water usage per hour.

Data – Patterns – Add

In the patterns editor, the data that must be filled in includes:

- a) Pattern Name (Pattern ID) → eg 1
- b) The multiplier is filled with the peak hour factor. Peak hour factor (peak factor) is filled based on fluctuations in water usage.

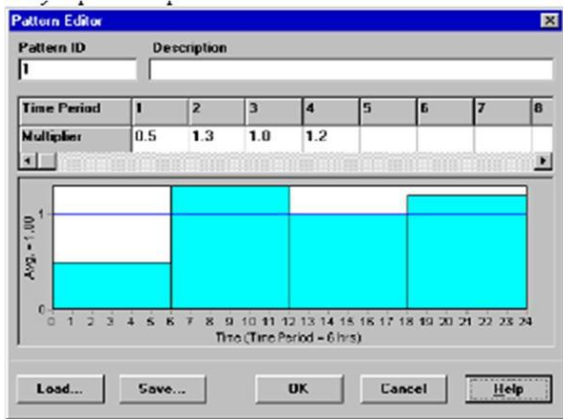


Fig.6: Data entry display (Pattern Editor)

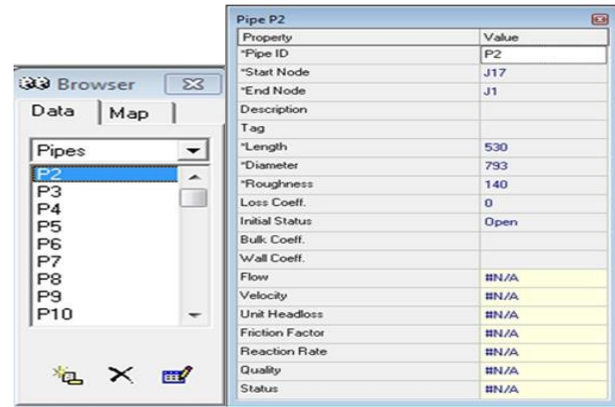


Fig.8 Display Pipe Id

Apart from using the time pattern, the peak factor/peak hour factor can also be entered in the Demand Multiplier. Option – Hydraulic Option – Demand Multiplier (peak hour factor 1.5 – 1.75).

- ❖ Fill in Junctions data. In the Junction properties that must be filled include:
 - a) Junction Name (Junction ID)
 - b) Elevation (Elevation) → in meters
 - c) Debit (Base Demand) → in L/s
 - d) Demand pattern → Fill in the name of the pattern that has been made, for example 1

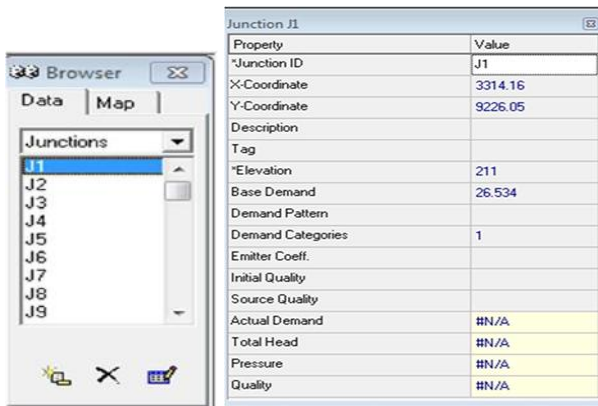


Fig.7: Display Junction Id

- ❖ Fill in Pipe data. The Pipe properties that must be filled include:
 - a) Pipe name (Pipe ID) → eg P-1
 - b) Pipe length (Length) → in meters
 - c) Pipe diameter → in mm
 - d) Pipe roughness coefficient (roughness) → 110 – 120 for plastic

- ❖ Fill Reservoir data. The Reservoirs properties that must be filled include:
 - a) Reservoir Name (Reservoir ID) → eg R-1
 - b) Head Total (Total Head) → in

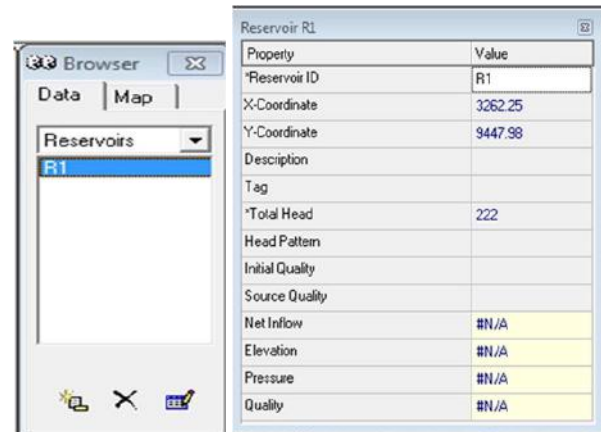


Fig.9: Reservoir filling display Id

- ❖ If pumping is required in a system, before filling in the pump data, first make a pump curve.

Data – Curves – Add In the Curve editor fill in:

 - a) Curve Name (Curve ID) → eg p-1
 - b) The type of curve that will be made, because it makes a pump curve, then fill in the pump type (curve type: pump)
 - c) Fill in the discharge (flow) with L/s and pressure in meters
 - d) Click OK

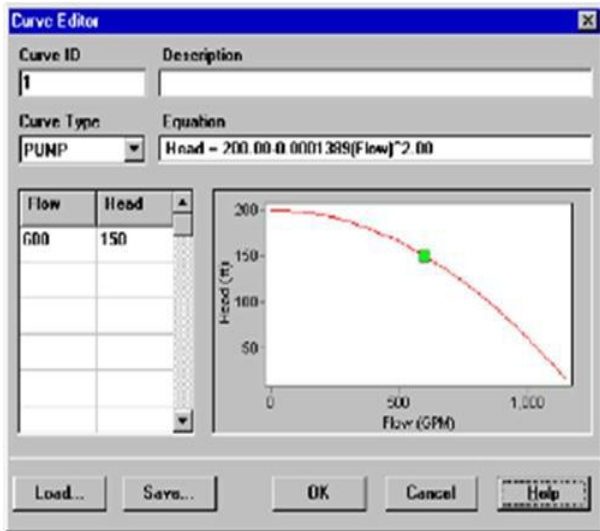


Fig.10: Display of the pump editor Curve

Fill in the data Pump (Pump). The Pump properties that must be filled include:

- a) Pump Name (Pump ID) → eg Pump-1
- b) Pump curve (Pump curve) → filled in accordance with the pump curve that has been made, for example p-1

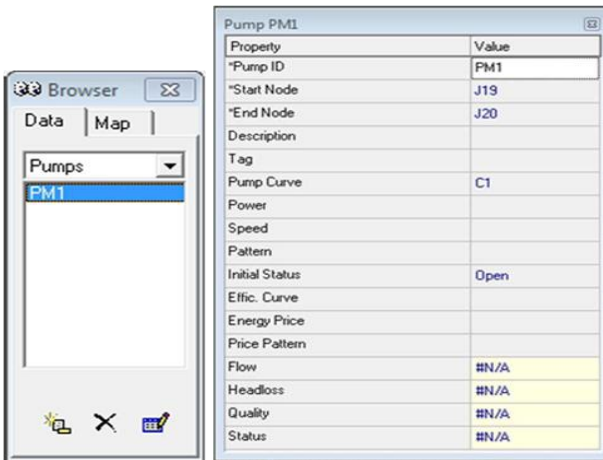


Fig.11: Display Pump Id

6) Run Data and Models

- a) After all done press Run (shape of lightning)
- b) If RUN is SUCCESSFULL then proceed with the appearance of the data and checking the data whether it is in accordance with the standards set.
- c) Display of entry results in tabular form.

III. METHODOLOGY

Research Flow Chart

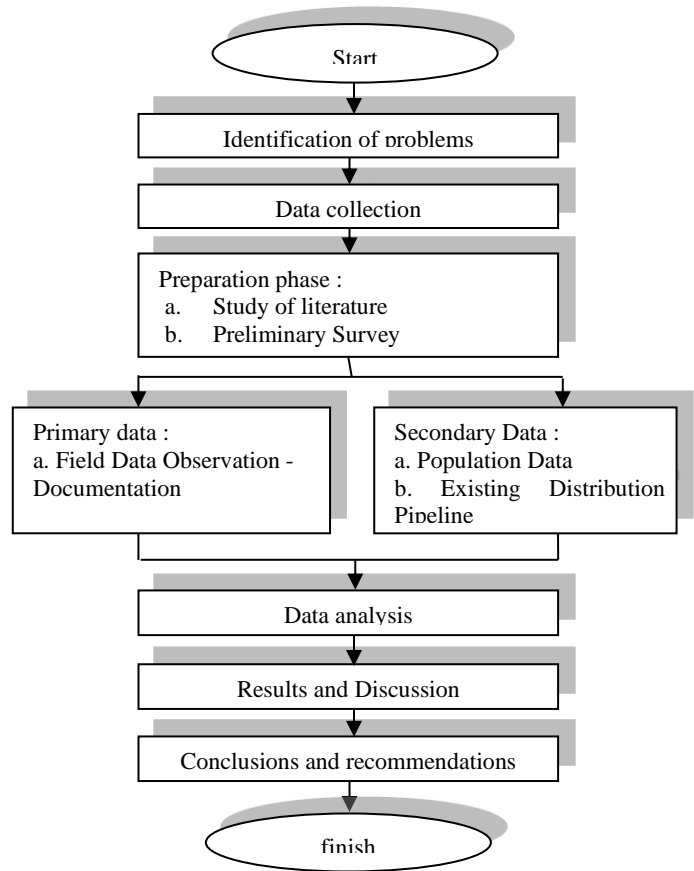


Fig.12: Research Flowchart

3.1. Research sites

In the research conducted by the author, the location was in Nuruwe Village, Kairatu Barat District, West Seram Regency.



Fig.13: Research Locations

3.2. Tools and Materials

Materials used to meet the needs of this research include: research permits, maps of research locations, and pictures of village maps

The tools used in this research are: Camera. Stationery, and Meter rolls

3.3. Data collection technique

The data collection method used for this purpose includes two parts, namely:

- 1) Primary data collection, which consists of:
Observation, namely data collection by observing the research location directly. Data taken directly at the research location, among others, Existing Pipeline data.
- 2) Secondary data collection, which consists of:
Secondary data, namely data obtained at the village office in the form of population data for the last five years, village maps and other data that supports the research process.

3.4. Data Analysis Techniques

Data analysis was carried out by utilizing methods obtained from literature studies. The steps taken are as follows:

- 1) Process population data.
- 2) Analyze the large demand for clean water that must be met by springs in the next 15 years.
- 3) Calculating the existing water needs
- 4) After the necessary data has been collected, we can perform the analysis. This analysis was performed with Epanet 2.0.

3.5. Epanet 2.0 Analysis Flowchart

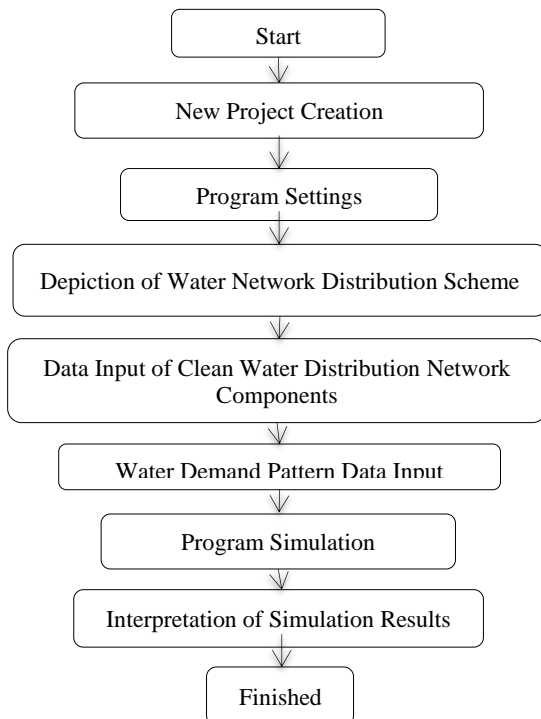


Fig.14: EPANET 2.0 Analysis Flowchart

IV. ANALYSIS AND DISCUSSION

4.1 Pipeline Network Map

Piping Network Is a map of the pipeline network carrying water from the reservoir reservoir to the service network. The following is a map of the pipeline network from Nuruwe Village, Kairatu Barat District, West Seram Regency.

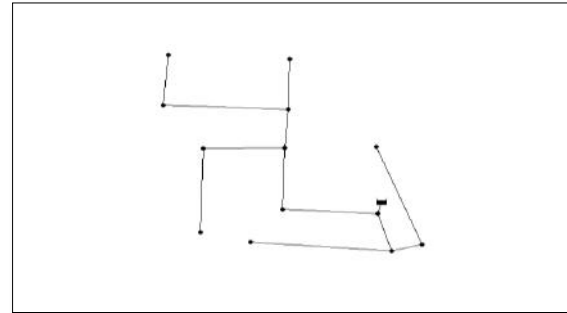


Fig.15: Pipeline Network Map of Nuruwe Village

As seen in Figure 15 above the piping network system in Waisamu Village has 2 piping network systems namely, the one in red is the old piping network, while the one in yellow and blue is a piping network system that has been added recently .

4.2 Water Demand Analysis

Water requirements for socio-economic facilities must be differentiated according to PDAM regulations and taking into account the production capacity of existing sources, level of leakage and service. The main factor in the water demand analysis is the population in the study area. To analyze projections for the following years, Arithmetic and Geometric methods can be used. From this projection, the amount of water demand from the domestic and non-domestic sectors is calculated based on the criteria of the 1996 Directorate General of Cipta Karya.

4.3 Population Projection

The method used to calculate the projected population for the next 15 years uses the geometric method. The geometric method formula is as follows:

The geometric method formula

$$Mr = Po (1 + r)n$$

Information :

Po = Total Population Served (Soul)

r = Population Growth Ratio (2 % = 0.02)

n = Design Period (15 Years)

Table.4: Population Data for 2016 – 2021

No	Year	Number of Souls	Number of families
1	2016	1533	348
2	2017	1564	355
3	2018	1569	357
4	2019	1628	370
5	2020	1661	378
6	2021	1730	393

Table.5: Population Growth Projections for 5, 10, and 15 Years

No	Point	Population Projection			
		P0(1+r)^n			
		Year 2021	5 years	10 years	15 years
1	MA.A - DE	526	581	641	708
2	A.A1 - A.A4	407	449	496	548

3	C.C1 - C.C2	361	399	440	486
4	D.D1 - D.D2	445	491	542	599
5	Amount	1739	1920	2120	2340

Example of Calculation of Population Needs Projection 5, 10, and 15 Years of Nuruwe Village using the geometric method:

Line No. 1. Example of Calculation of Population Growth Projection for 5 Years MA.A – DE Pipeline

$$P_n = P_0 \times (1 + r)^n$$

$$P_n = 526 \times (1 + 0.02)^5$$

$$P_n = 581$$

Line No. 1. Example of Calculation of Population Growth Projection for 10 Years MA.A – DE Pipeline

$$P_n = P_0 \times (1 + r)^n$$

$$P_n = 526 \times (1 + 0.02)^{10}$$

$$P_n = 641$$

Line No. 1. Example of Calculation of Population Growth Projection for 15 Years MA.A – DE Pipeline

$$P_n = P_0 \times (1 + r)^n$$

$$P_n = 526 \times (1 + 0.02)^{15}$$

$$P_n = 708$$

Table.6: 15 Year Population Calculation Projection Nuruwe Village for Each Pipeline and Node

No	Track Pipe	nodes	Number of population served (soul)	Population Projection 15 yrs (soul)
		MA		
1	MA-A	A	0	0
2	AB	B	67	90
3	BC	C	89	120
4	CD	D	156	210
5	DE	E	214	288
			Total = 526	Total = 708
		A		
1	A-A1	A1	41	55
2	A1-A2	A2	52	70
3	A-A3	A3	79	106
4	A-A4	A4	235	316
			Total = 407	Total = 548
		C		
1	C-C1	C1	127	171

2	C1-C2	C2	234	315
			Total = 361	Total = 486
		D		
1	D-D1	D1	256	345
2	D1-D2	D2	189	254
			445	599
			Total Number = 1739	Total Number = 2340

Line No 1. Example of calculating the projected population for 15 years: Pipeline MA – A, Pipeline A

$$P_n = P_o (1 + r)^n$$

$$P_n = 67 (1 + 0.02)^{15}$$

$$P_n = 90$$

So the population increase for the MA-A pipeline, Pipe A is 90 people

4.4 Calculation of Water Needs

Water demand is the amount of water needed for household, industrial and other needs. Priority water

needs include domestic water needs, industry, public services. Water demand is the amount of water that is reasonably needed for basic human (domestic) activities and other activities that require water. The water requirement determines the size of the system and is determined based on water usage.

In calculating the demand for domestic and non-domestic water, peak hour water demand, and the planned volume of the reservoir for the 15th year, you can see the calculation example below:

Table.7: Calculation of Projection of Clean Water Needs in Nuruwe Village

No	Uraian	Satuan	Tahun 2021	5 Tahun (2026)	10 tahun (2031)	15 Tahun (2036)	Analisa Perhitungan		Keterangan
							Kode	Cara Hitung	
1	Jumlah penduduk	jiwa	1.739	1.920	2.120	2.340	1		rata2 kenaikan 2% pertahun
	Pelayanan penduduk	%	100	100	100	100	2		juklak 100% pelayanan
		jiwa	1.739	1.920	2.120	2.340	3		
2	Pelayanan SR	%	90	100	100	100	4		juklak / survei
		jiwa	1.565	1.920	2.120	2.340	5	(5)= ((4)*(3))/100	
		jiwa/sb	5	5	5	5	6		juklak
		Jmlh. Sb	313	384	424	468	7	(7)= (5) / (6)	
	Pemakaian Air	Lt/org/hr	90	90	90	90	8		juklak
		Lt/sb/hr	450	450	450	450	9	(9)= (8) x (6)	
		Lt/det	1,63	2,00	2,21	2,44	10	(10)=(5)x(8)/86400	
3	Pelayanan KU / HU	%	10	-	-	-	11	(11)= 100 - (4)	
		jiwa	174	-	-	-	12	(12)=(11)/100*(3)	
		jiwa/HU	100	100	100	100	13		juklak
		Jmlh. HU	2	-	-	-	14	(14)=(12)/(13)	
	Pemakaian Air	Lt/org/hr	60	60	60	60	15		juklak
		Lt/HU/hr	6.000	6.000	6.000	6.000	16	(16)=(13)*(15)	
		Lt/det	0,12	-	-	-	17	(17)=(12)*(15)/86400	
4	Total Domestik	Lt/det	1,75	2,00	2,21	2,44	18	(18)=(10)+(17)	
5	Total Non Domestik	%	0	0	0	0	19		
		Lt/det	-	-	-	-	20		
6	Total Kebutuhan Air	Lt/det	1,75	2,00	2,21	2,44	21	(21)=(18) + (20)	
7	Kehilangan Air	%	20	20	20	20	22		juklak
		Lt/det	0,39	0,44	0,49	0,54	23	(23)=(21)*(22)/90	
8	Kebutuhan Air								
	- Rata-rata	Lt/det	2,14	2,44	2,70	2,98	24	(24)=(21)+ 23)	
	- Harian Puncak	Faktor	1,1	1,1	1,1	1,1	25		juklak
		Lt/det	2,35	2,69	2,97	3,28	26	(26)=(24)* (25)	
		M ³ /hari	8,48	9,68	10,69	11,80	27	(27)=(26)x3600/1000	
		M ³ /hari	203,41	232,32	256,50	283,20	28	(28)=(27)*24	
	- Jam Puncak	Faktor	1,5	1,5	1,5	1,5	29		juklak (minimum)
		Lt/det	3,21	3,67	4,05	4,47	30	(30)=(24)*(27)	
9	Kebutuhan Air Baku	Faktor	3,0	3,0	3,0	3,0	31		faktor keamanan
		Lt/det	7,06	8,07	8,91	9,83	32	(32)=(26)*(31)	Besarnya debit perencanaan
									3X kebutuhan air baku
10	Volume Reservoir	M ³	40,68	46,46	51,30	56,64	33	(30)=(0,2)*(28)	Minimum 20% harian Maks Kriteria perencanaan

Example of Calculation: Calculation of Water Needs in Nuruwe Village Pipeline D – E, Node E for Year 0 and Year 15

Column. 5 Row 10.

An example of calculating the water demand for year 0 Pipeline D – E, Node E

Water requirement = $(90 \times 214) / 86400$

Water requirement = 0.22 liter/sec

Information :

Average water requirement = 90lt/Org/sec

Number of people served = 214 souls

1 day = 86400 seconds

Column.7 Row 10.

An example of calculating the water demand for the 15th year Pipeline D – E, Node E

Water requirement = $(90 \times 288) / 86400$

Water requirement = 0.30 lt/sec

Information :

Average water requirement = 90l/Org/sec The number of people served = 288 souls

1 day = 86400 seconds

For the calculation of other pipelines can be seen in Table.16 below.

Table.16: Water Needs in Nuruwe Village

No	Track Pipe	nodes	NODE LOAD			
			Number of population served	Water Needs	Total population 15 yr projection	Water Needs Projection 15 yrs
			(soul)	(lt/d)	(soul)	(lt/s)
		MA				
1	MA-A	A	0	0.00	0	0.00
2	AB	B	67	0.07	90	0.09
3	BC	C	89	0.09	120	0.12
4	CD	D	156	0.16	210	0.22
5	DE	E	214	0.22	288	0.30
			Total = 526		Total = 708	0.74
		A				
1	A-A1	A1	41	0.04	55	0.06
2	A1-A2	A2	52	0.05	70	0.07
3	A-A3	A3	79	0.08	106	0.11
4	A-A4	A4	235	0.24	316	0.33
			Total = 407		Total = 548	0.57
		C				
1	C-C1	C1	127	0.13	171	0.18
2	C1-C2	C2	234	0.24	315	0.33
			Total = 361		Total = 486	0.51
		D				
1	D-D1	D1	256	0.27	345	0.36
2	D1-D2	D2	189	0.20	254	0.26
			Total = 445		Total = 599	0.62
			Total Number = 1739	Total Number = 1.81	Total Number = 2340	Total Number = 2.44

4.5 Hydrolysis Calculation

Hydraulic calculations in this case calculate node loads, pipe loads, and head loss calculations in the Nuruwe Village piping system.

Column. 8 Rows. 9

An example of calculating the number of people supplied by the MA – A Pipeline, Node A:

Total population supplied = total population served by points MA - A, D - E – total population of MA - A

Number of population supplied = 526 – 0

Number of population in supply = 526

Column.10 Row.9

An example of calculating the projected number of people supplied for 15 years in the MA – A Pipeline, Node A:

$$P_n = P_o (1 + r)^n$$

$$P_n = 526 (1 + (0.02))^{15}$$

$$P_n = 708 \text{ souls}$$

Column.11 Row.9

Example of calculation of Flow projection on MA – A Pipeline, Node A:

Flow = (15 year population projection x average water demand) / 86400

$$\text{Flow} = (708 \times 90) / 86400$$

$$\text{Flow} = 0.74 \text{ liter/sec}$$

Column.12 Row.9

An example of calculating peak flow hour projections on the MA – A Pipeline, Node A:

Peak hour flow = Flow x peak hour factor

$$\text{Peak hour flow} = 0.74 \times 1.5$$

$$\text{Peak flow hour} = 1.11 \text{ lt/sec}$$

Column.18 Row.3

An example of calculating the theoretical pipe diameter in the MA – A Pipeline, Node A:

$$D. \text{ Theoretical Pipeline} = (3.59 \times \text{Peak hour flow} \times 106) / (\text{Slope} 0.54 \times \text{HW Coefficient}) 0.38$$

$$D. \text{ Theoretical Pipe} = (3.59 \times 1.11 \times 106) / (35,290,54 \times 120) 0.38$$

$$D. \text{ Theoretical Pipe} = 25.11 \text{ mm} = 63.00 \text{ (Design pipe diameter)}$$

Columns.20 Rows.3

Example of calculating head loss per 100 m on the MA – A Pipeline, Node A:

$$H. \text{loss} = (3.59 \times \text{Peak hour flow} \times 106) / (\text{Design pipe } D. 2.63 \times \text{HW coefficient}) 1.85$$

$$H. \text{loss} = (3.59 \times 1.07 \times 106) / (63.00 \times 2.63 \times 120) 1.85$$

$$H. \text{loss} = 0.38 \text{ m}$$

Columns.20 Rows.3

Example of calculating Total Head loss + 10% minor in the MA – A Pipeline, Node A:

$$\text{Total H.loss} + 10\% = H. \text{loss} \times (\text{pipe length}/100) \times (1 + (\text{minor loss}/100))$$

$$\text{Total H.loss} + 10\% = 0.38 \times (17/100) \times (1 + (10/100))$$

$$\text{Total H.loss} + 10\% = 0.07 \text{ m}$$

Column.21 Row.3

Example of calculating HGL on the MA–A Pipeline, Node A:

$$\text{HGL} = \text{Reservoir elevation} - \text{Total H.loss} + 10\%$$

$$\text{HGL} = 12 - 0.07$$

$$\text{HL} = 11.93$$

Column.22 Row.3

Example of calculating the Residual Pressure in the MA – A Pipeline, Node A:

$$\text{Residual Pressure} = \text{Reservoir Elevation} - \text{Total H.loss} + 10\%$$

$$\text{Residual Pressure} = 12 - 0.07$$

$$\text{Residual Pressure} = 11.93 \text{ m}$$

Column.23 Row.3

Example of calculating Flow Velocity (V) in the MA – A Pipeline, Node A:

$$V = ((4 \times \text{Peak hour flow}) / 1000) / (((3.14 \times D. \text{ design pipe}) / 1000)^2)$$

$$V = ((4 \times 1.07) / 1000) / (((3.14 \times 63.00) / 1000)^2)$$

$$V = 0.34 \text{ m/s}$$

Table.17: Hydraulic Calculation of Pipe Load, Headloss, Residual Pressure, Nuruwe Village

BEBAN NODE					BEBAN PIPA				Koeff HW	PERHITUNGAN HEAD LOSS					
Jmlh. Pddk yg dilayani	Kebutuhan Air	Jmlh. Pddk Proy 15 thn	Kebut. Air Proy 15 thn	Kebut air jam puncak	Jmlh. Pddk yg disuplai	Jmlh. Pddk Proy 15 thn	Flow	Flow Jam Puncak		Diam. Pipa D teoritis	Diam. Pipa D desain	Hloss per 100 m	Total Hloss (+10% minor)	HGL	Sisa Tekan
(jwa)	(lt/d)	(jwa)	(lt/dt)	(lt/dt)	(jwa)	(jwa)	(lt/dt)	(lt/dt)	C	(mm)	(mm)	(m)	(m)	(m)	(m)
															12.00
0	0.00	0	0.00	0.00	526	684	0.71	1.07	120	24.78	63.00	0.38	0.07	11.93	11.93
67	0.07	90	0.09	0.14	459	597	0.62	0.93	120	50.76	63.00	0.29	0.39	11.54	11.54
89	0.09	120	0.12	0.19	437	568	0.59	0.89	120	47.49	63.00	0.27	0.28	11.26	11.26
156	0.16	210	0.22	0.33	370	481	0.50	0.75	120	40.84	63.00	0.20	0.13	11.12	11.12
214	0.22	288	0.30	0.45	312	406	0.42	0.63	120	40.13	50.00	0.44	0.38	10.74	10.74
526		708	0.74	1.11											
															11.54
41	0.04	55	0.06	0.09	366	476	0.50	0.74	130	39.19	63.00	0.17	0.11	11.43	7.43
52	0.05	70	0.07	0.11	355	462	0.48	0.72	130	35.65	50.00	0.49	0.21	11.22	6.22
79	0.08	106	0.11	0.17	328	426	0.44	0.67	130	46.09	50.00	0.42	0.75	10.47	6.47
235	0.24	316	0.33	0.49	172	224	0.23	0.35	130	36.73	50.00	0.13	0.25	10.22	7.22
407		548	0.57												
															11.54
127	0.13	171	0.18	0.27	234	304	0.32	0.48	130	36.94	63.00	0.07	0.08	11.46	8.46
234	0.24	315	0.33	0.49	127	165	0.17	0.26	130	30.72	50.00	0.07	0.10	11.35	7.35
361		486	0.51												
256	0.27	345	0.36	0.54	189	246	0.26	0.38	130	37.24	63.00	0.05	0.09	11.27	9.27
189	0.20	254	0.26	0.40	256	333	0.35	0.52	130	36.29	50.00	0.27	0.23	11.03	10.03
445		599	0.62												
1739	1.81	2340	2.44	4.76											

4.6 Piping Network Modeling With E-PANET 2.0 Software

The output generated from the EPANET program includes debit flowing in the pipe (lt/s), water pressure from each point/node/junction which can be used as an analysis in determining installation, pump and reservoir operations.

The stages of piping network modeling with EPANET 2.0 software are:

1. Open the Google Earth Pro software to draw a piping system. Place the location point first to determine the coordinate point.
2. Take a picture of the piping network from Google Earth Pro then input it in Ms. Visio, then cut the image and adjust it according to the workbook in Ms. Visio.
3. After successfully getting the image that has been cropped on Ms. Visio, then open the EPANET software then enter the image by pressing the file menu at the top left of the display then pressing the open file menu and entering the image that has been cut from Ms. Visio into the EPANET software .
4. Enter the previously recorded Coordinate Points into the EPANET software in order to minimize distance errors in the EPANET software by pressing the view menu then selecting a dimension and then entering the coordinates in the four dimension columns, namely X and Y.
5. After entering the coordinates, then determine the location of the reservoir according to the piping system data or the piping system plan that has been determined by pressing the add reservoir menu.
6. After entering the coordinates, then in the top center menu you will see the add junction menu, circular shape, press the menu then mark each point of the pipeline using the menu.
7. Then connect each of these junctions by pressing the add pipe menu, which is shaped like an inverted capital I to connect each junction point that has been previously marked.
8. After connecting each piping system using the add pipe menu, then placing the elevation of each location point at each junction point by pressing the junction point and entering the elevation according to the elevation on google earth pro at each junction point,

for example the elevation of point E on goggle earth pro by 4 m then enter the same elevation at point E in the EPANET software. Do the same thing at each junction point as in method no.8 to be able to provide elevation at each junction point of the piping network.

9. After that, enter the previously calculated water requirement at each piping junction point by pressing the piping junction point where you want to enter the water requirement, then enter the water requirement in the base demand section according to the calculation. For example, at the junction point of pipe E, enter the water requirement based on the calculation results.
10. Do the same for all existing junction points so that all junction points in the piping system have the required amount of water according to the calculation results.
11. After that, enter the design pipe diameter for each pipe connection, and also input the roughness value according to the calculation results according to the calculation results obtained. For example, in the D - E pipe connection, the design pipe diameter is 50 mm with a roughness value of 120.
12. After all the values have been entered, the next step is to see whether the water flow system is running smoothly or not, by clicking the Run menu on the top left of the EPANET display menu in the form of a lightning bolt. ⚡ to see whether the water flow in the piping system runs smoothly or not.
13. If the EPANET menu display after finishing Run shows the Run Successful display, then it indicates that the drainage system in the piping network is flowing 100%.
14. After the Successful Run, it is continued by displaying data in the form of Network Link data, Network Nodes data that has been obtained in the EPANET software by pressing the table menu at the top left of the EPANET software display.
15. Display the data that has been obtained for later and then the data (Network Link, Network Nodes data) is entered on the Ms.Excel display for further input into

the results that have been obtained from the EPANET Software.

16. Then look at the graphical display recorded in the EPANET software by pressing the Graph menu at the top left of the EPANET Software display menu, and then pressing the Frequency plot on the Graph Type and pressing Links on the Object Type, then selecting Parameters to display on the graph.

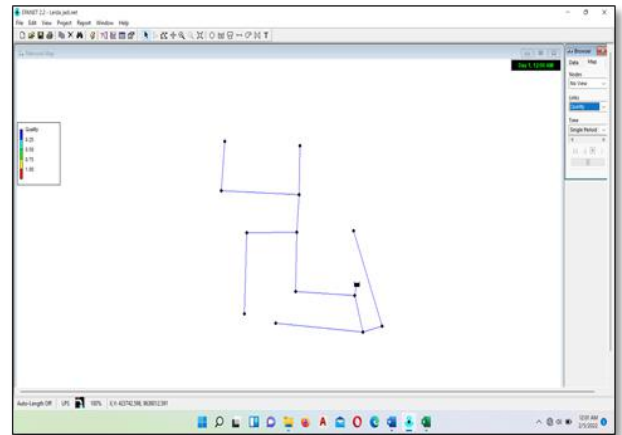


Fig.8: EPANET Menu Display

17. To view the Flow, Velocity, Unit HeadLoss, and Friction Factor graphs, select the Parameters section of the Graph Selection menu display in the Graph Menu.
18. Then look for the browser menu at the top right of the EPANET Software display with the browser name and select the Map menu to display directly the state of the existing piping system by pressing on Nodes and Links to select what parameters you want to display.
19. From the data that has been obtained, then enter these data into Ms. Excel to be the resulting data from EPANET Software.
20. From the data that has been obtained, then enter these data into Ms. Excel to be the resulting data from EPANET Software.

Table.18: Network Table Links

Network Table – Nodes							
ID nodes	elevation	Base Demand	Initial Quality	Requests	heads	pressure	Quality
	m	LPS		LPS	m	m	
Pipe Junctions 2	0	2.44	0	2.44	10.99	10.99	0
Pipe Junctions3	6	0.14	0	0.14	8.8	2.8	0
Pipe Junctions4	4	0.51	0	0.51	7.19	3.19	0
Pipe Junctions 5	3	0.62	0	0.62	6.78	3.78	0
Pipe Junctions 6	4	0.43	0	0.43	6.68	2.68	0

Pipe Junctions7	4	0.08	0	0.08	10.92	6.92	0
Pipe Junctions8	5	0.11	0	0.11	10.9	5.9	0
Pipe Junctions 9	4	0.16	0	0.16	10.87	6.87	0
Pipe Junctions10	3	0.48	0	0.48	10.68	7.68	0
Pipe Junctions11	3	0.26	0	0.26	7.09	4.09	0
Pipe Junctions12	4	0.48	0	0.48	6.92	2.92	0
Pipe Junctions13	2	0.52	0	0.52	6.56	4.56	0
Pipe Junctions14	1	0.38	0	0.38	6.49	5.49	0
Pipe Reservoir1	12	#N/A	0	-6.61	12	0	0

Table.19: Network Table Nodes

1												
ID link	Length	Diameter	Roughness	Bulk Coef.	Wall Coef.	Flow	Velocity	Head loss units	Friction Factor	Reaction Rate	Quality	Status
	m	mm				LPS	m/s	m/km		mg/l/d		
Pipes Pipes1	12.01	63	130	0	0	6.61	2.12	84.03	0.023	0	0	open
Pipes Pipes 2	79.56	63	120	0	0	3.34	1.07	27.53	0.03	0	0	open
Pipes Pipes3	63.35	63	120	0	0	3.2	1.03	25.43	0.03	0	0	open
Pipes Pipes4	40.19	63	120	0	0	1.95	0.63	10.16	0.032	0	0	open
Pipes Pipes5	52.1	50	120	0	0	0.43	0.22	1.9	0.039	0	0	open
Pipes Pipes6	40.32	63	130	0	0	0.83	0.27	1.8	0.031	0	0	open
Pipes Pipes7	26.53	50	130	0	0	0.27	0.14	0.69	0.036	0	0	open
Pipes Pipes8	108.62	50	130	0	0	0.16	0.08	0.26	0.039	0	0	open
Pipes Pipes9	117.89	50	130	0	0	0.48	0.24	2.01	0.033	0	0	open
Pipes Pipes10	68	63	130	0	0	0.74	0.24	1.46	0.032	0	0	open
Pipes Pipes11	86.78	50	130	0	0	0.48	0.24	2.01	0.033	0	0	open
Pipes Pipes12	104.89	63	130	0	0	0.9	0.29	2.09	0.031	0	0	open
Pipes Pipes13	52.53	50	130	0	0	0.38	0.19	1.31	0.034	0	0	open

From the results of the analysis of the distribution of piping networks using EPANET 2.0 software, the result is that the distribution of piping networks gets 100% results.

V. CONCLUSION

1. The need for clean water needed by the residents of Nuruwe Village, West Kairatu District, West Seram Regency is 2.44 liters/second
2. The distribution of the piping system has been able to meet the needs of clean water in Nuruwe Village, Kairatu Barat District, West Seram Regency because it has met the water needs of the residents of Nuruwe Village.

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