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## **Design development alternatives for Alubijid Municipal water system in Misamis oriental, Philippines using EPANET**

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**Abstract**---Providing safe and clean water is a concern and responsibility of the local government unit (LGU) in the Philippines. However, this is a great challenge to the LGU because of several factors such as availability of water supply, increasing population, low or no maintenance of existing water systems, and lack of engineering expertise. The general objective of this study is to come up with design development alternatives for Alubijid municipal water supply system in Misamis Oriental using EPANET. This study consists of two major stages, namely: the modelling stage and the design stage. The former includes modeling the physical features of the existing water supply system to EPANET. The design stage focused on the evaluation of the different sustainable alternatives available. The sources of potable water include groundwater through deepwell and surface water collected from springs. The design displays information on the projected population, supply-demand analysis, hydraulic design and analysis, and alternative network design for the area. With the results from the simulation, it is concluded that the existing water supply system cannot withstand the demand of the municipality in the year 2040 though a long-distance water supply system with a flow rate of 10 liters per second will be installed. This is due to the demand which is way larger than the supply. Thus, the design helps the municipality carry out improvement in the existing water distribution network to cater the future demand of the area.

**Keywords**---EPANET software, hydraulic design, water demand, water distribution network.

## **Introduction**

Water is a basic human need. The Right to Water, as proclaimed by [1] in 2010 is said to be "indispensable for leading a life in human dignity" and "a prerequisite for the realization of other human rights". Providing safe and clean water is a concern and responsibility of the local government unit in the Philippines. However, this is a great challenge to the local government unit because of several factors such as availability of water supply, increasing population, low or no maintenance of existing water systems, and lack of engineering expertise. Water distribution networks are considered as one of the most significant urban infrastructures. Their proper performance leads to an increase in the level of water supply services and also customer's satisfaction [2].

EPANET Software is a useful tool for extended period simulation which should be embraced by water utilities, especially in the developing countries, to simulate and predict hydraulic parameters thereby manage efficiently the water distribution networks [3]. Different scenarios can be modeled by using the EPANET tool and more descriptions of this can be found in some previous studies. These include the study of [4] in evaluating the practical impact of the zero minimum pressure head assumption under pressure-deficient condition in water distribution networks considering pipe isolation, fire demand, and altering total reservoir heads; [5] in simulating of steady state and extended-period analysis, single- and multi-species simulation plus demand- and pressure- driven analysis by integration of hydraulic and water quality modelling in distribution networks; [6] in Uncertainty analysis of looped water distribution networks; [7] in noniterative modelling for pressure-deficient modelling of water distribution systems; [8] in simulating pressure variations in the distribution system and compare with measured data in the field; and [9] in calibrating methodology to estimate the pipe background leakage parameters; and among others.

Alubijid is one of the local governments experiencing problems with their water supply system. Alubijid is a 4th class municipality situated in the western part of Misamis Oriental, 25 kilometers west of Cagayan de Oro City and 67 kilometers East of Iligan City. In 2008, Alubijid constructed a water system financed by the Asian Development Bank worth 24 million pesos. This consists of a production well, 2 reservoirs, 2 booster pump stations, transmission lines and distributions lines. Unfortunately, the said system did not function well as planned. One of the reservoirs and its booster pump stations has not been used since its construction. From time to time during peak hours, certain areas experience low pressures and sometimes no flow at all. The local government has asked the technical assistance of the Mindanao University of Science and Technology. In response, this study is made to investigate the existing water system and provide a technical evaluation on the current system.

## **Methods**

This study consists of two major stages, namely: modelling stage and design stage. The former includes modeling the physical features of the existing water supply system to EPANET. This model needs to be calibrated using the ground data such as actual pressure and discharge at critical points in the system. This

data was obtained by conducting physical tests in peak hours where the system is at stress. The design stage focused on the evaluation of the different sustainable alternatives available.

### **Study Area**

Alubijid is located AT 8° 24'30" - 8°35'36" north latitude and 124°21'30" - 124°30'30" east longitude. It is bounded on the north by macajalar bay; on the east by the municipality of el salvador; on the south by the municipality of manticao; and on the west by the municipalities of laguindingan, gitagum, libertad, initao and naawan. The municipality is situated in the western part of misamis oriental, 25 kilometers west of cagayan de oro city and 67 kilometers east of iligan city.

### **Data Collection**

The existing and potential water sources and their hydraulic properties were determined from the field and from secondary sources. The hydraulic conditions of the existing network were assessed and evaluated to determine the capacity and capability of the system to support the water needs of the community for the next 15-20 years. Possible design of the network was developed and analyzed for the projected water demand. The analysis of the new system is necessary, and, if the head at each node becomes inadequate, there is an inefficiency of the whole system and the impossibility to deliver the requested nodal demand to all users. Secondary data were obtained from the municipality of Alubijid and validated through ocular visit to the identified water sources. From the data gathered, hydraulic properties of existing and potential waters sources were then assessed. Data for newly installed components like pumps, reservoir, and pipelines were readily available from the as-built plan. Data from the old reservoir and new wells were manually obtained through the conduct of actual engineering survey activity.

Out of 16 barangays of Alubijid, eight (8) barangays had their own barangay water system. Due to problems of nonpayment and deficiency of water being supplied in each barangay, the municipal administrators took charge in the implementation of the water distribution system. There sources of potable water for Alubijid includes groundwater and surface water. Groundwater are being drilled through deepwells while surface water is being collected from springs. Also, there is a problem of the quality of water, and that there is a high presence of e-coli and fecal coliform. The water from the existing river in Alubijid supplied the treatment facility. Through chlorination, the water is treated before it is supplied to the community as potable water.

There were 20 reservoir tanks from Barangay Lagtang, Poblacion, Lumbo, Lanao, Sampatulog, Tugason, Calatcat, Talaba, and Lourdes. From the GPS, the geographical data of the different locations were collected and viewed in Google Earth. These data were then used for the location of the existing water-related structure on the area. Surveying works were conducted for determining potential wells and existing tanks in the area. The population data of Municipality of Alubijid, Misamis Oriental included records from 1990, 1995, 2000, and 2015.

The total population of Alubijid based on 2015 record is 29,724 with an average household size of 4.82. Based from the recorded population data, there is a historical growth of population with an average increase of 2.10 as of 2015. Projecting the population of the municipality by 2030, Alubijid will have a total population of 40,597 people.

## Results

### Model Building in EPANET

Elevations and pipe diameter of the existing water system is shown on Fig. 1. For old or existing water system, the roughness coefficient used for plastic pipes is  $C = 120$ . The existing tank is given as shown in the CAD file from the LGU office which had an equivalent of 100 cubic meter. There was a long distance water supply which has a 3-meter diameter and 10-meter height (equivalent to 70 cu.m.). The existing CAD file of the water distribution model was transformed into an EPANET ready file.

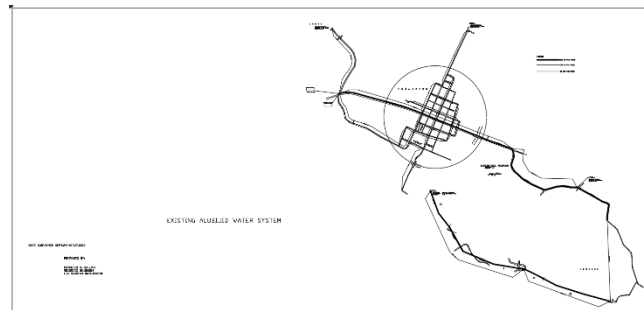


Fig.1. Existing Water Distribution System in Alubijid, Misamis Oriental

### Water Consumption Criteria

Level II Public Faucets: 50 - 60 lpcd  
 (Each public faucet should serve 4 - 6 households)  
 Level III House Connections: 80 - 100 lpcd  
 Institutional Connections; 1.0 m<sup>3</sup>/d  
 Commercial Connections: 0.8 m<sup>3</sup>/d

From Fire Code of the Philippines, Section 10.5.7.1 Clause C, all reservoirs must provide 60 cu.m. fire reserve for storage. Non-Revenue water (NRW) are unaccounted volume due to leakage of the supply pipe network. Since the system is existing, 20% was used as the NRW factor. The demand pattern with minimum and maximum factor used is 0.3 and 2.5, as shown in Fig. 2.

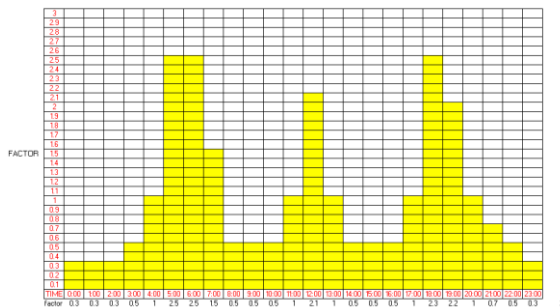


Fig. 2. Demand Pattern

**Pressure and Discharge Test**

There was already information on the existing discharge of the supply reservoirs in the area. The data collected from the Engineering Office of LGU-Alubijid was used to determine the pump capacity of the wells in the area.

**Model Calibration**

The model was calibrated incorporating other information such as the location of the residential households.

**Model Verification**

The information collected on the water consumers inventory and consumption was used to verify the existing nodes of the water distribution system. The whole system was checked, calibrated, and verified if the discharge and pressure rates were at minimum and maximum. Reservoirs initially created in EPANET were verified if its capacity would accommodate the demand volume. Scenario 1 is simulated considering the existing water distribution system in the area. The simulation shows negative pressures in certain nodes. Negative pressure exists in the nodes during peak hours and the unit head loss was over the limits. It means the supply cannot cater the demand of the municipality in year 2040.

Scenario 2 considered a long-distance water supply with a discharge of 10 lps, 8 kms from the existing steel reservoir. Negative pressure still exists in the nodes during peak hours and the unit head loss was over the limits. Even with the long-distance water supply system, it cannot supply the whole municipality in year 2040. With the results from the simulation, it is can be observed that the existing water supply system cannot withstand the demand of the municipality in year 2040. Even if there will be a long-distance water supply system with a flow rate of 10 liters per second, it still cannot suffice due to the demand which is way larger than the supply of water in the area. If the pump will not be used, the required supply discharge is found to be 52.9 lps. If the pump operates 12 hours per day, there is a need to supply 43.9 lps. Adding another 10 lps from a source, there is a need to pump for at least 23 hours every day.

The supply should be greater than the demand for water, however, it is not the case for the water supply in Alubijid as shown in Fig. 3. By the theory of flow-in is

equal to flow-out, the excess water of the Day 1 should be greater or equal to the initial volume of the reservoirs. The reservoir has a critical role during the peak hours and the fire demand reservation should be considered. The waste in the system should be zero or minimal. It will be useless if the system keeps on pumping water to the tanks yet there is no space to store it.

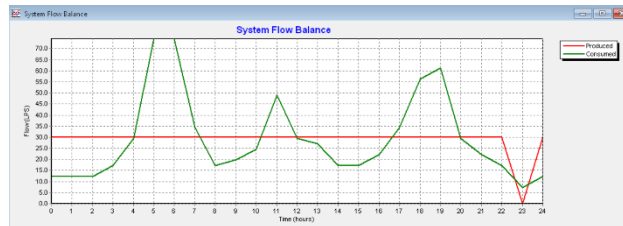


Fig. 3. System Flow Balance

### Supply-demand Analysis

A supply-demand analysis was conducted comparing the actual and the proposed design of the water distribution as shown in Fig. 4. It is proposed to have an additional source in the area to deliver the needed demand. However, it is hard to find a source which is 43.9 lps or 52.9 lps. It is recommended to find another source with at least 10 lps and with pump operation of 23 hours. Since 23 hours is not advisable for an operation of the pump in any system, there should be another pump wherein each pump should operate only in a maximum of 12 hrs. A reservoir should be constructed with a diameter of 5.4m and a height of 10m. Aside from that, resizing of pipes is needed to improve the efficiency of the system. Although it can sustain with no negative pressures but the unit head loss exceeds 10 m/km, especially during the fire incident.

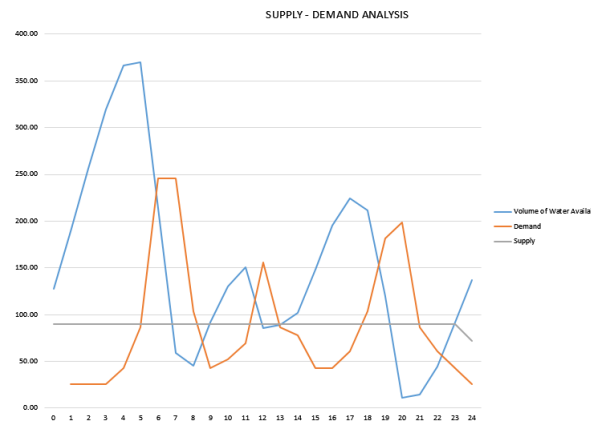


Fig. 4. Supply-demand Analysis

### Conclusion

With the results from the simulation, it is concluded that the existing water supply system cannot withstand the demand of the municipality in year 2040.

Even if a long-distance water supply system will be installed with a flow rate of 10 liters per second, it still cannot suffice. It is due to the demand which is way larger than the supply. To ensure sufficient pressures on the critical points, it requires pipe improvements on the Poblacion area to avoid head losses. Thus, pipe diameter on some pipelines at Poblacion area should be increased.

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