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Evaluation of the Primary Pipe Network at Banua Anyar Booster Pump as an Effort to Reduce Water Loss in the Service area of Northern Banjarmasin, South Kalimantan

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ABSTRACT

Recorded as the best PDAM in South Kalimantan in Banjarmasin City. PT. Bandarmasih Perseroda Drinking Water (PAM Bandarmasih) is still facing the problem of high water loss rates of 29.07% in 2022, which is still far above the National Medium Term Development Plan (RPJMN) target with a minimum water loss value of 20%. One of the ways PDAM can reduce water loss is by evaluating the pipe network in a District Meter Area (DMA). This research focuses on evaluating the primary pipe network in the area served by the Banua Anyar booster which serves 18 DMAs. Network evaluation using EPANET 2.0 software. The evaluation results show that the diameter of the primary pipe from the booster pump to the Banua Anyar pipe bridge has quite high unit-head loss and flow velocity values due to flow friction with the pipe surface. It is necessary to change the diameter of the primary pipe used in the Banua Anyar booster network from a diameter of 400 mm to 600 mm which can reduce the rate of water loss by 6.3%. In the future, it is hoped that the value of water loss at PDAM Banjarmasin City can be reduced and the affordability of drinking water services for the people of Banjarmasin City can increase.

KeyWords: Banua Anyar, Pipe, Water, Banjarmasin.

INTRODUCTION

PT. Air Minum Bandarmasih (Perseroda) (PAM Bandarmasih) is currently grappling with a significant water loss issue, reaching 29.07% in 2022 in Banjarmasin City, South Kalimantan (2022 BUMD WATER PERFORMANCE BOOK, 2022). Typically, Public Water Utilities (PDAMs) facing high levels of water loss struggle to meet customer water demand (Al-Hanif & Rezagama, 2016). This situation contradicts the objectives outlined in the Medium-Term Development Plan (RPJMN) established by the Indonesian Government for providing drinking water services to the community (Erianik et al., 2020).

Given the population growth in Banjarmasin City, the demand for clean water has escalated. As the operator of the Drinking Water Supply System (SPAM), the Regional Drinking Water Company (PDAM) must monitor and evaluate its management through a measure of success. The success of SPAM management by PDAM can be assessed through a performance evaluation (Rozaq & Iqbal, 2018).

One strategy to mitigate water loss is to address the physical water loss level (Munis et al., 2021). At PAM Bandarmasih, the high water loss is still influenced by the diameter of pipes installed in the Banjarmasin City pipe network. Many zones with pipe networks have outdated infrastructure with limited discharge capacities. As the Banjarmasin City community expands, the water supply to customers increases. However, the existing pipe diameters are insufficient for handling large discharges, resulting in elevated pipe friction and head loss. Customers served by PAM Bandarmasih, particularly those farthest from the service source, often experience water shortages during peak usage hours (06:00 WITA – 08:00 WITA).

This research aims to evaluate primary and secondary pipe networks, focusing on the Banua Anyar booster, through a case study at PAM Bandarmasih in Banjarmasin City. The Banua Anyar booster caters to customers in 16 DMA in the North Banjarmasin area. The evaluation of pipe networks utilizes EPANET 2.0 software. EPANET 2.0, applied to existing data, assesses the condition of the pipe network, allowing for a comparison with ideal conditions (Widyanto et al., 2021). The evaluation results serve as recommendations for PDAM in efforts to reduce the water loss levels at PAM Bandarmasih.

METHODS

The research was conducted at the PAM Bandarmasih office in Banjarmasin City from February to May 2023. The research methodology involved collecting both secondary and primary data. Secondary data included existing pipe diameters, pipe network locations, QGIS maps, and other technical information necessary for evaluating pipe network designs. Primary data, on the other hand, was obtained through the analysis of pipe network data using EPANET 2.0 software, incorporating input data for pressure and discharge required at each junction. The research scale involves calculating the effective primary and secondary pipe diameters within the drinking water distribution network of the Banua Anyar booster. The efficacy of these pipe diameter calculations is determined by evaluating the results of headloss calculations within the pipes, which are performed using the Hazen Williams formula.

$$H_f = \frac{10{,}583 * Q^{1{,}85}}{C^{1{,}85} * d^{4{,}87}} * L$$

Additionally, calculations are conducted, taking into consideration the flow velocity within the water pipes. The water flow speed adheres to Indonesian standards outlined in Minister of Public Works Regulation No. 18/PRT/M/2007 regarding the Implementation of Drinking Water Supply System Development. According to these standards, the permissible flow speed in drinking water pipe networks falls within the range of 0.3 – 2.5 m/s, with a minimum pressure of 0.7 bar or 7 meters. An optimal pipe diameter results in a calculated water flow velocity within the pipe that aligns with the permitted range while minimizing headloss.

RESULTS

The pipe distribution network modeling in the booster using EPANET 2.0 software is described in terms of existing conditions. This includes primary pipes with the largest diameters of 400 mm and 300 mm, and secondary pipes with diameters of 200 mm, 150 mm, and 75 mm. The junction elevation is set at 0 (zero), aligning with the land contour of Banjarmasin City, which is at 0.16 Meters Above Sea Level (MASL). The EPANET modeling is visually presented in Fig 1 below.

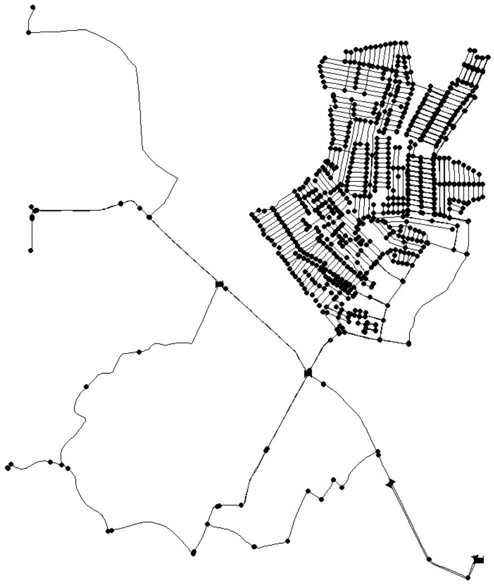

Fig 1. EPANET Modeling Banua Anyar Booster

Water requirements are adjusted according to the specific needs of each DMA served by the Banua Anyar booster, and these adjustments are incorporated into the base demand for each junction, as illustrated in Table 1 below.

Table 1. Flow Rate and Pipe Pressure in DMAs Served by Banua Anyar Booster

DMA	Pipe Diameter (mm)	Flowrate (LPS)	Pipe Tapping Diameter (mm)	Pressure on Tapping (m)
401A	100	7,07	300	5,94
401B	100	7,07	200	5,58
401C	100	7,07	200	6,44
401D	150	7,07	400	6,17
402A	150	6,50	200	5,63
403	100	5,47	300	5,59
405A	100	8,59	200	6,45
405B	150	8,59	200	7,43
406A	100	10,69	200	5,53
406B	150	10,69	200	5,67
409A	150	13,66	250	7,57
409B	100	13,66	300	5,57
410	150	30,20	300	8,13
412	150	18,36	400	6,77
414	100	3,98	250	5,94
415	150	20,00	200	0,50
416	200	13,95	300	1,29
418	150	9,46	200	6,45

Table 1 presents the ideal conditions of the Banua Anyar booster pipe network in the EPANET software. However, these conditions do not align with the field conditions. The water loss rate in the DMA served by the Banua Anyar booster reached 39.9% in January 2023. Additionally, the water pressure received by customers at the furthest points in DMA

415 and 416 (Sungai Andai area) is very low. Instantaneous pressure measurements during the nighttime minimum hours show a value of 0.5 bar and no flow during peak daytime hours. Several factors contribute to these conditions, including high headloss due to excessive water velocity in the pipes, pipe congestion due to high cavitation in the pipes, and physical losses resulting from pipe leaks. The Billing Statement (Daftar Rekening Ditagih/DRD) indicates that with a customer count of 27,573 Service Connections (SR) in the area served by the Banua Anyar booster, the water loss still stands at 39.9% in January 2023 and increases to 43.29% in February 2023, as shown in Table 2 below.

Table 2. Billing Statement (DRD) for PAM Bandarmasih January – February 2023

Description	Januari 2023	Februari 2023
Number of Customer	27.573	27.597
Total Water Usage (m3)	454.401	463.933
Average Water Usage/Customer	16,48	15,83
Water Loss	39,9%	43,29%

The solution to reducing water loss at PAM Bandarmasih begins with the evaluation of water velocity in the primary pipe network with a diameter of 400 mm. The pipe network is assessed to identify the highest headloss value in the primary pipe network. EPANET 2.0 modeling indicates that high headloss occurs along the Banua Anyar booster pump to the end of the Banua Anyar bridge. The modeling results for headloss and velocity in the primary pipe can be observed in Table 3 below.

Table 3. Results of Headloss and Velocity Modeling in the Primary Pipe Zone of Banua Anyar Booster

Link ID	Pipe Length (m)	Pipe Diameter (mm)	Flowrate (LPS)	Velocity (m/s)	Headloss (m)
Pipe L1287	0,55	400	215,82	1,72	8,96
Pipe L1288	2,68	400	215,82	1,72	8,96
Pipe L1182	133,52	400	187,82	1,49	12,82
Pipe L1183	271,47	400	187,82	1,49	12,82
Pipe L1184	546,02	400	187,82	1,49	12,82
Pipe L1185	192,93	400	333,28	2,65	20,04
Pipe L1186	581,30	400	252,11	2,01	11,95
Pipe L1189	792,24	400	80,10	0,64	1,43
Pipe L1190	5,79	400	54,41	0,43	0,70
Pipe L1191	620,38	400	40,18	0,32	0,40
Pipe L1192	81,15	400	40,18	0,32	0,40
Pipe L1193	142,88	400	31,35	0,25	0,25
Pipe L1194	539,54	400	31,35	0,25	0,25
Pipe L1240	117,42	400	229,16	1,82	10,02
Pipe L1242	943,86	400	13,34	0,11	0,05
Pipe L1243	2,95	400	13,34	0,11	0,05
Pipe L1252	0,71	400	127,03	1,01	3,36
Pipe L1253	3,87	400	127,03	1,01	3,36

From Table 3, the highest headloss value is observed in Pipe L1185, with a length of 192.93 m, registering a headloss value of 20.04 meters and a flow velocity of 2.65 m/s. This specific pipe is located on the Banua Anyar bridge, necessitating an increase in pipe diameter from 400 mm to 600 mm along the Banua Anyar booster to the end of the Banua Anyar bridge. This adjustment aims to mitigate the headloss level and reduce the flow velocity within the pipe. The modified pipe codes are listed in Table 4 below.

Table 3. Change of Pipe Diameter

Pipe Code	Diameter (mm)	New Diameter (mm)
Pipe L1184	400	600
Pipe L1183	400	600
Pipe L1182	400	600

With the alteration in the diameter of the primary pipes in the initial pipe network, the EPANET modeling results for each DMA are reflected as presented in Table 5 below.

Table 4. Flow Rate and Pipe Pressure in DMAs Served by Banua Anyar Booster

DMA	Diameter Pipa (mm)	Debit (l/detik)	Tapping Pipa Diameter (mm)	Pressure On Tapping (m)
401A	100	7,07	300	16,76
401B	100	7,07	200	16,40
401C	100	7,07	200	17,26
401D	150	7,07	400	16,99
402A	150	6,50	200	16,45
403	100	5,47	300	16,41
405A	100	8,59	200	17,27
405B	150	8,59	200	18,25
406A	100	10,69	200	16,36
406B	150	10,69	200	16,49
409A	150	13,66	250	18,39
409B	100	13,66	300	16,39
410	150	30,20	300	18,95
412	150	18,36	400	17,59
414	100	3,98	250	16,76
415	150	20,00	200	11,33
416	200	13,95	300	12,11
418	150	9,46	200	17,27

From Table 5, it is evident that the pressure in each DMA input has increased, especially in DMA 415 and 416, where initially there was no water flow. Now, there is pressure, to meet the requirements outlined in (PERMEN PUPR NO. 27/2016) regarding the Provision of Drinking Water Supply Systems. This regulation stipulates that the minimum pressure received by Service Connections (SR) should be at least 7 meters or 0.7 bar. Additionally, leaks in pipes throughout the area served by the Banua Anyar booster can now be identified, enabling prompt handling of pipe leak repairs. The results of the Billing Statement (DRD) after the modification of the primary pipe diameter can be seen in Table 6 below.

Table 6. Billing Statement (DRD) for PAM Bandarmasih March - April 2023

Description	Maret 2023	April 2023
Number of Customer	27.631	27.706
Total Water Usage (m^3)	403.262	451.212
Average Water Usage/Customer	14,59	16,28
Water Loss	38,90%	35,99%

In addition to the reduction in water loss in the DMA served by the Banua Anyar booster, there has been an increase in water usage by the community. Residents at critical points, who previously did not receive water before the primary pipe changes, are now served with significantly higher pressure. This is evident in the increasing average total water usage, rising from an average of 14 – 15 m3/SR month before the new primary pipe diameter operation to over 16 m3/SR month. In the future, PAM Bandarmasih can further identify opportunities by implementing various initiatives to reduce water loss values.

CONCLUSIONS

The high headloss values observed in the primary pipe network of the Banua Anyar booster occur along the pipeline route from the Banua Anyar booster to the Banua Anyar Pipe Bridge. The EPANET analysis results indicate that increasing the diameter of the primary pipe by 600 mm is necessary to reduce the flow velocity in the pipe, which contributes to the high headloss values. Following the diameter increase, the water loss decreased from 43.29% in February 2023 to 35.99% in April 2023. Additionally, the average water consumption per person rises from 15.83 m3/SR.month to 16.28 m3/SR.month. In the future, PAM Bandarmasih can take effective steps and initiatives to reduce water loss values in the DMA served by the Banua Anyar booster, such as 1) Isolating DMAs in areas that are not yet isolated; 2) Accelerating pipe leak repairs; and 3) Replacing and upgrading pipes and pipe accessories that are no longer functionally viable.

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