TECHNICAL FEASIBILITY ANALYSIS OF MAIN DISTRIBUTION NETWORK IN THE DEVELOPMENT OF PARAKU DRINKING WATER SUPPLY SYSTEM, PADANG CITY, INDONESIA

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ABSTRACT

Purpose: The purpose of this study is to assess the technical viability of the main distribution network (MDN) of the Paraku Drinking Water Supply System in Padang City, Indonesia.

Theoretical Framework: A water distribution system is a component of a WSS that delivers treated water from a water treatment facility to consumers (residential, commercial, industrial, and firefighting requirements). The main distribution network’s dimensions are determined using MDN pipe specifications based on Indonesian National Standard 7509: 2011.


Results and conclusion: The feasibility study considers the technical provisions of the MDN pipeline based on SK SNI 2005, where the pipeline is as short as possible and avoids difficult and expensive construction. There were two potential MDNs, and Line 2 was chosen as the alternative. The pressure and flow velocity in the pipe were then checked to see if Line 2 was technically feasible using Epanet 2.0 software. The Epanet 2.0 calculation results demonstrate that the flow of raw water from a water treatment plant with a capacity of 50 L/second can be flowed by gravity and sufficient pressure to the point of connection on the By-Pass Road. The route is completed at the pipe connection on By-Pass Road Padang (0°57’52.0’S 100°24’12.7’E) at an elevation of 30.86 meters.

Research implications: Understanding the technological viability of the MDN line in developing Paraku DWSS that complies with statutory laws.


Keywords: Main Distribution Network, Paraku, Pipeline, Technical Viability, Water Supply Systems.

ANÁLISE DE VIABILIDADE TÉCNICA DA PRINCIPAL REDE DE DISTRIBUIÇÃO NO DESENVOLVIMENTO DO SISTEMA DE ABASTECIMENTO DE ÁGUA POTÁVEL DE PARAKU, CIDADE DE PADANG, INDONÉSIA

RESUMO

Objetivo: O objetivo deste estudo é avaliar a viabilidade técnica da principal rede de distribuição (MDN) do Sistema de Abastecimento de Água Potável Paraku na cidade de Padang, na Indonésia.

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1 INTRODUCTION

The demand for drinking water rises as the population grows (Fikri et al., 2023). Humans use rivers as a supply of raw water, which then undergoes treatment into drinking water (Jamwal, 2019). Water sources used for drinking water have an impact on the health of humans (Karimi Alavijeh et al., 2021). As a result, water sources must meet physical, chemical, and biological requirements before being processed into drinking water (Chhabra, 2017; Luby et al., 2018; Muharemi et al., 2019; Nur et al., 2023). Some diseases can be transferred by water if the water used as a source of drinking water is contaminated (Cifuentes et al., 2002; Nafi’u & TK, 2016; Njiru et al., 2016; Nyagwencha et al., 2013).

Regional Drinking Water Company in Padang City, as the operator of the drinking water supplier in the City of Padang, Indonesia, keeps trying to meet the drinking water demands to the people of the City of Padang. Water consumption includes residence needs such as washing and cooking (Haghiabi et al., 2018), public use in metropolitan areas (Kondo et al., 2019), and industrial demands (Raux-Defossez et al., 2018). The development of the Paraku Drinking Water Supply System (DWSS) is one of the development programs that will be carried out by the Padang City Water Supply Perumda to address the demands of the community in Padang City's southern sector (Southern Service Area). The development of the Paraku SPAM is a part of the investment strategy for the southern region's Perumda Water Drinking City of Padang’s service area, which will include the construction of the main distribution pipeline network.

So far, the federal government has been primarily responsible for the establishment of drinking water distribution systems; however, in line with efforts to adopt decentralization and
internal socio-political processes, the provision of DWSS has become a mandatory authority of regional governments. The central government's funding contribution for DWSS development remains low. Furthermore, the company's low financial capability prevents it from funding all development operations. To counter this, different finance sources to meet development needs must be explored.

The Paraku DWSS development program will be financed through the Banking Program with a total capacity to be utilized of 50 liters/second. The source of the water used comes from the Lubuk Peraku River which is located in the Bandar Create Village, Lubuk Kilangan District. This additional capacity is mainly carried out to improve services in the Southern Region. The Development Program is in the form of a complete WTP development plan with a capacity of 50 L/second and the main IPA main distribution pipeline for the service area of Perunda Water Drinking in Padang City in the southern region. It is essential to conduct comprehensive research described in the feasibility study of DWSS Paraku in order for the development plan to be executed in accordance with the expected aims and objectives.

2 THEORETICAL FRAMEWORK

Water Supply Systems (WSS) are designed to provide drinking water of the desired quality to the final consumers at the required pressure and flow (USEPA, 2023). A water distribution system is a component of a WSS that delivers treated water from a water treatment facility to consumers (residential, commercial, industrial, and firefighting requirements). The distribution layout design is dependent on the topographical conditions of the service area and the street layout. Layout planning of distribution pipelines is determined based on the following considerations; a) the situation of the road network in the service area; b) consumer density; c) topography and natural boundaries of the service area and, d) land use service area. Main Distribution Network (MDN) is a series of distribution pipes that form a distribution zone within a WSS service area. Therefore, anticipated future changes in population, socioeconomic developments, hydraulic infrastructure capacity, and water pollution from domestic and industrial sources are crucial factors influencing the WTP (Almheiri et al., 2021).

The main distribution network's dimensions are determined using MDN pipe specifications based on Indonesian National Standard 7509: 2011. The following requirements are pipelines should be kept as short as possible, avoiding routes that require complicated and expensive construction, having a minimum pipe hydraulic height of 5 meters above the pipe, which is sufficient to ensure the operation of the air valve, and avoiding elevation differences that are excessive to avoid pipe class differences. Hydraulic simulation WSS evaluation using the EPANET version 2.0 application. The model outcomes of EPANET 2.0 would encourage better water distribution network management techniques (Dabedo et al., 2023).

3 METHODOLOGY

3.1 Field Observation

The task required determining the Main Distribution Network (MDN) site's status, road accessibility, measuring distances, and the existing state of affairs in the region the MDN pipeline crosses, such as site status.

3.2 Data Analysis Methods

The Paraku main distribution pipeline plan was chosen in order to carry out two alternatives and take into consideration the scenario that was observed during field inspections.
Evaluation of probable MDN locations based on environmental and practical considerations, including site characteristics, access to roads and pipelines, and land status and replacement. The selected route was determined by the advantages and disadvantages of each alternative.

3.3 Software Epanet 2.0

EPANET 2.0 was used to conduct a technical feasibility investigation of MDN. EPANET 2.0 is made up of computer programs developed by the United States Environmental Protection Agency. The flow or discharge of each pipe, the pressure at each node, the water level in the reservoir, and changes in the concentration of chemical compounds supplied to the network in a distribution during the simulation period may all be tracked using EPANET 2.0 (Rossman, 2000). In order to analyze the drinking water distribution network system, it is required to understand the data that must be entered (input) and the data that will be created (output). Epanet 2.0 requires a network map, nodes/junctions/points of distribution components, elevation, distribution pipe length, pipe inner diameter, the sort of pipe used, and type of source (springs, drilled wells, Water Treatment Plant, etc.) as inputs. Each point's hydraulic head, pressure, and speed are the outputs.

4 RESULTS AND DISCUSSION

4.1 Paraku DWSS Development Scheme

The development of the Padang City DWSS to improve services in the Southern Region includes the development of some of the existing service areas and some of the new service areas. The addition of the service area covers most of the southern service area, including Lubuk Begalung and Kuranji, as well as parts of the central service area which includes South Padang, and East Padang (Figure 1). The additional capacity for this development is 50 L/second. The source of water comes from the Lubuk Paraku River which is located in the Village of Bandar Create, Lubuk Kilangan District.

The development scheme for the 50 L/second Paraku DWSS can be seen in Figure 2. The development includes the construction of a complete Water Treatment Plant (WTP) with a capacity of 50 L/second and the main WTP main distribution pipeline for the Regional Drinking Water Company in the Padang City service area in the southern region. Raw water from the Lubuk Paraku River (intake) is gravity-fed into the WTP through a raw water transmission pipe that is 4,885 meters long and made of Galvanized Iron (GI). Treated water from the WTP is then stored in a reservoir and gravity-fed to the new service area via a 400 mm diameter HDPE main distribution pipe. The MDN construction site, which crosses community land, will also undergo land replacement. The following is a recapitulation of the development of Paraku SPAM with a capacity of 50 L/second:

I. Water Treatment Plant
   1. Procurement/Construction of Complete WTP capacity of 50 L/second
   2. Procurement/Construction of a Reservoir with a capacity of 1000 m$^3$
   3. Land Procurement for Reservoir Buildings

II. Main Distribution Network (MDN)
   1. Procurement/Installation of HDPE Type Pipe Dia. 400mm
   2. Land Compensation
4.2 The Selection of the Paraku DWSS Main Distribution Line

The Teluk Bayur industrial region in Padang City is the primary target for services provided by the 50 L/second Paraku SPAM. The result of this addition is that there will be more house connections. PT. Padang Raya Cakrawala and PT. Wilmar, both companies in the palm oil sector, are potential clients for this business. From IPA Paraku to this southern service region, a Main Distribution Line (MDL) will be constructed. Peraku DWSS offers potential industrial clients (PT. Padang Raya Cakrawala 15 L/second and PT. Wilmar 5 L/second), regular clients (8 L/second), and Low-income society 16 L/second to the South Service Area. Table 1 below shows the prospective clients that DWSS Paraku hopes to serve and their needs for clean water.

Table 1. The Need for Clean Water of Potential Customers DWSS Paraku

<table>
<thead>
<tr>
<th>No.</th>
<th>Potential customer</th>
<th>The Need for Clean Water (L/second)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Industries</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- PT. Padang Raya Cakrawala</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>- PT. Wilmar</td>
<td>5</td>
</tr>
<tr>
<td>2</td>
<td>Regular</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2016 – 2018) *)</td>
<td>8</td>
</tr>
<tr>
<td>3</td>
<td>Low-income society</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(2019) *)</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>46</strong></td>
</tr>
</tbody>
</table>

Note: *) Potential customer of the south services area
Source: Regional Drinking Water Company in Padang City, 2019

The MDN planning from the Paraku IPA to the service area in the Southern Region has 2 alternative routes (Figure 4.4). Selection of possible alternatives based on technical, social, environmental, and economic aspects. The selection of the MDN line starts from the Paraku Water Treatment Plant (IPA) reservoir (0°57'06.7"S 100°25'46.7"E) at an elevation of 72.8 meter and will flow by gravity to the pipe interconnection point. The interconnection will be...
carried out at the DN 300 mm plan pipe connection on Jalan By-Pass Padang to Teluk Bayur (0°57'52.0"S 100°24'12.7"E) at an elevation of 30.86 meter.

![Figure 2. Selection of the Paraku DWSS Main Distribution Line](image)

Table 2. Advantages and Disadvantages of MDN routes

<table>
<thead>
<tr>
<th>Pipeline route</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
</table>
| 1             | 1. Pipe length = 4,743 m  
2. Easy to implement  
2. Residential housing that is on the alignment plan has an effect on land acquisition costs |
| 2             | 1. Pipe length = 4,150 m, shorter than line 1.  
2. Trace has a favorable topographical elevation, and relatively flat contours.  
3. Easy to implement.  
4. High potential energy is sufficient. | 1. Passing the railroad line and not going through many residential roads.  
2. Residential housing that is on the alignment plan does not affect the cost of land acquisition much, so the cost is cheaper. |

Source: Data Analysis and Simulation Results

Based on the considerations of Table 2, the chosen alternative is route 2, because it has many technical advantages compared to route 1. This is in line with the technical provisions for MDN pipes based on Indonesian National Standard year 2005, where the pipeline is as short as possible, avoiding lines that result in difficult and expensive construction, high pipe hydraulics
a minimum of 5 m above the pipe so that it is sufficient to guarantee the operation of the air valve and avoid too large an elevation difference so that there is no difference in pipe class.

4.3 Technical Feasibility Analysis

On the selected MDN line, a technical feasibility analysis is carried out in the form of the ability to flow by gravity and pressure at the endpoint. The MDN is built from a planned WTP reservoir of 50 L/s (0°57′06.7″ S 100°25′46.7″ E) at an altitude of 72.8 m asl and will be fed by gravity to the existing MDN. The interconnection is made at the pipe connection on Jalan By Pass Padang (0°57′52.0″ S 100°24′12.7″ E) at an elevation of 30.86 meters. The planning for the MDN pipeline refers to the Regulation of the Minister of Public Works and Public Housing Number 27/PRT/M/2016). MDN uses a type of HDPE with a diameter of 400 mm and the design criteria refer to the standard distribution system planning criteria (Regulation of the Minister of Public Works and Public Housing Number 27/PRT/M/2016). MDN is calculated using the EPANET 2.0 program. to determine the pressure and flow rate. The results of calculations using the Epanet 2.0 program can be seen in Figure 3 and Figure 4. The results of Epanet 2.0 calculations show that the flow of raw water with a capacity of 50 L/second with this selected MDN can be carried out by gravity and sufficient pressure to the point of connection on the By-Pass Road.

Figure 5 shows a map of MDN and potential customers if MDN has been built from the Paraku WTP to this southern service area. Peraku DWS serves the South Service Area with potential industrial customers (PT. Padang Raya Cakrawala 15 L/second and PT. Wilmar 5 L/second), regular customers 8 L/second, and MBR 16 L/second. The discharge allocation has been calculated based on the peak factor and water leakage (Luo et al., 2018; Myronidis et al., 2018). This study is highly helpful in providing effective and sustainable drinking water (Grejo & Lunkes, 2022). Aside from that, it can be utilized as an environmental policy instrument (Silva et al., 2022).

![Figure 3: Figure elevation of selected MDN](source: Data Analysis and Simulation Results)
This study has shown the technical feasibility of MDN according to the established planning standards. This has been proven in conducting a feasibility study considering comfort and environmental aspects based on the advantages and constraints of each alternative, and supported by the use of the Epanet 2.0 application to simulate flow (velocity and pressure) in the pipe from the IPA to the interconnection point on the By-Pass Road. The goal of developing SPAM in the southern region of Padang can be reached with the MDN technical feasibility...
analysis, in accordance with the target and business plan of Regional Drinking Water Company in Padang City.

5 CONCLUSIONS

The second main distribution network alternative offers technically feasible raw water flow from the water treatment plant to the connecting point on the Bypass Road. The feasibility study takes into account the design parameters, such as the shortest pipeline possible, and steers clear of routes that would increase the difficulty and cost of construction. Using the Epanet 2.0 program demonstrates that the main distribution line, type of pipe, and chosen pipe diameter are adequate in terms of pipe speed and water pressure.

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