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JENV adalah jurnal yang mengkaji berbagai masalah/persoalan terkini yang bersifat mendasar atau terapan yang berhubungan dengan bidang teknik dan pengelolaan lingkungan serta pengelolaan limbah dengan frekuensi penerbitan dua kali setahun pada April dan Oktober. Kelayakan pemuatan dipertimbangkan oleh penilai dengan *double blind review* berdasarkan keaslian dan keabsahan ilmiah.

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EDITORIAL

Pembaca yang terhormat, Jurnal Teknik Lingkungan dan Pengelolaan Limbah (JENV) yang terbit bulan April 2023 ini merupakan jurnal edisi kedelapan nomor 1 yang diterbitkan oleh Universitas Presiden. Dengan tujuan untuk berkontribusi secara nyata di bidang Teknik Lingkungan berdasarkan ilmu pengetahuan, manajemen dan teknologi yang terkini, kehadiran jurnal ini diharapkan mampu memberikan inspirasi terhadap solusi masalah-masalah lingkungan yang semakin memerlukan perhatian yang memadai.

Pada edisi kedelapan nomor 1 Jurnal JENV ini terdapat satu makalah di bidang pencemaran udara: Palm Oil Mill Effluent as an Environmental Pollutant: Indonesia Palm Oil Industry; empat makalah mengenai pengolahan limbah: The Study of Eco Enzymes Application For Decoloring Textile Industry Wastewater Following by pH Value Analysis; The Study of Rainwater Harvesting System For Supporting Green Campus; Priorities in the Phasing Design of Rangkasbitung Sub-District Sewerage System; Reduksi Tingkat Kekeruhan dan Total Partikel Tersuspensi melalui Proses Sentrifugasi pada Air Limbah Wudu; satu makalah di bidang manajemen lingkungan: Analisis Daya Dukung untuk Mendukung Swasembada Pangan di Provinsi Kalimantan Utara.

Semua tulisan ilmiah yang dipublikasikan telah melalui proses seleksi dengan metoda *blind review* oleh dewan redaksi dan mitra bestari.

Pada kesempatan ini kami mengucapkan terimakasih kepada dewan pengarah, dewan redaksi, editor pelaksana, tim sekretariat, dan para penulis yang telah memberikan peran secara aktif sehingga penerbitan Jurnal JENV ini dapat terlaksana dengan baik. Kami berharap Jurnal JENV volume 8 nomor 1 bulan April 2023 ini dapat bermanfaat bagi perkembangan ilmu dan pendidikan di Indonesia, khususnya di bidang Lingkungan Hidup.

Ketua Dewan Editor

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PRIORITIES IN THE PHASING DESIGN OF RANGKASBITUNG SUB-DISTRICT SEWERAGE SYSTEM

Lani Oktaviani, Ramadhani Yanidar, Lailatus Siami

ABSTRACT

Rangkasbitung Sub-district (105 25' – 106 30' EL and 6 18' – 7 00' SL) is the capital city of Lebak Regency which has an area of 7,252 Ha. Based on the Master Plan of Lebak Regency 2014 – 2034, It will be built the toll roads and industrial areas in Nameng Village, Citeras Village, and Mekarsari Village. Therefore the Rangkasbitung will become a rapidly growing urban area**.** The sanitation services are still 60,63%. To achieve the Goal 6 of SDGs, then this paper aims to design an analytical technique the sewerage system in order to achieve sanitation for all, and to recommend the planning phases in order to be effective and efficient sewerage system until the end of the 2040. The Sewerage system design has anticipated the Ciujung River and Ciberang River with seven (7) tributaries that pass through this sub-district. The location of the Waste Water Treatment Plant (WWTP) is designed at a low elevation, namely in Kolelet Wetan, Nameng, and Mekarsari Village by considering the flood-free areas and topography. The recommendations for the construction phases are based on population density and the service area of the WWTP location. The total wastewater discharge is designed as 510.367 L/sec, which will be implemented into two phases. The first phase will build WWTP A = 208.937 L/sec and WWTP B = 275.188 L/sec, then WWTP C = 26.242 L/sec in the second phase. The design of the trunk sewer has a total 24,556 m length, of which 19,043 m will be in the first phase and 5,513 m will be in the second phase. The diameter of the trunk sewer ranges from 300 mm to 1,000 mm. The

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first phase indicated depth by diameter (d/D) ratio in the range of 55% - 78%, and the velocity range of 0.68 – 2.24 m/sec. The final phase indicated 61% - 75% and the velocity range of 0.69 – 2.24 m/sec.

KEYWORDS

Design; Rangkasbitung Sub-district; Sewerage System.

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Priorities in The Phasing Design of the Rangkasbitung Sub-District Sewerage System

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Abstract. Rangkasbitung Sub-district (105 25' – 106 30' EL and 6 18' – 7 00' SL) is the capital city of Lebak Regency which has an area of 7,252 Ha. Based on the Master Plan of Lebak Regency 2014 – 2034, It will be built the toll roads and industrial areas in Nameng Village, Citeras Village, and Mekarsari Village. Therefore the Rangkasbitung will become a rapidly growing urban area. The sanitation services are still 60,63%. To achieve Goal 6 of SDGs, this paper aims to design an analytical technique for the sewerage system to achieve sanitation for all, and to recommend the planning phases to be an effective and efficient sewerage system until the end of 2040. The Sewerage system design has anticipated the Ciujung River and Ciberang River with seven (7) tributaries that pass through this sub-district. The location of the Waste Water Treatment Plant (WWTP) is designed at a low elevation, namely in Kolelet Wetan, Nameng, and Mekarsari Village by considering the flood-free areas and topography. The recommendations for the construction phases are based on population density and the service area of the WWTP location. The total wastewater discharge is designed as 510.367 L/sec, which will be implemented into two phases. The first phase will build WWTP A = 208.937 L/sec and WWTP B = 275.188 L/sec, then WWTP C = 26.242 L/sec in the second phase. The design of the trunk sewer has a total of 24,556 m in length, of which 19,043 m will be in the first phase and 5,513 m will be in the second phase. The diameter of the trunk sewer ranges from 300 mm to 1,000 mm. The first phase indicated depth by diameter (d/D) ratio in the range of 55% - 78%, and the velocity range of 0.68 – 2.24 m/sec. The final phase indicated 61% - 75% and the velocity range of 0.69 – 2.24 m/sec.

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1 Introduction

Rangkasbitung Sub-District, Lebak Regency is the city center of Lebak Regency which has an area of 7,252 Ha. Rangkasbitung Sub-District is one of the Sub-Districts in Lebak Regency which has an area of 7,252 Ha or 72.52 km^2, consisting of eleven (11) villages and five (5) urban villages. Wastewater management in this area is still using an on-site system and has access to safe sanitation using a septic tank. In 2019, sanitation services in Rangkasbitung Sub-District were still 60.63% [2]. To realize access to sanitation for the entire population, a sewerage system is planned in Rangkasbitung Sub-District, Lebak Regency. The sewerage system will be designed to serve 100% of the population until the end of the planning year in 2040.

The sewerage system design in Rangkasbitung Sub-District aims to build the optimal, effective, and efficient sewerage system from several alternative pipeline routes that will drain the sewage to Waste Water Treatment Plant (WWTP) until the 2040 year. The Waste Water Treatment Plant (WWTP) location will be planned by considering the receiving water location, flood-free areas, and topography that supports the gravity flow of sewerage. Because the Rangkasbitung Sub-District is traversed by seven (7) tributaries, the trunk sewer design will drain to three WWTPs. The location of WWTPs is planned at Kolelet Wetan Village, Nameng Village, and Mekarsari Village which are in low-elevation areas. Rangkasbitung Sub-District is traversed by many tributaries so the most effective route is planned that drains wastewater to 3 WWTPs.

The population and water demand prediction are important in determining wastewater discharge [9]. Population growth per urban village/village in Rangkasbitung Sub-District is different because it is influenced by the conditions of each urban village/village. Population growth in Rangkasbitung Sub-District varies by the urban village. Nameng Village, Citeras Village, and Mekarsari Village have a population growth rate of 2.8% based on the 2014-2034 Lebak Regency Master Plan [7]. Those villages are planned to become industrial areas, and as a result, residential areas will grow. The majority of Pasir Tanjung and Cimangeunteung villages are designated for dry land agriculture and plantations, therefore their population growth rates are low, at 0.92% and 0.90%, respectively.

Rangkasbitung Sub-District is located in Lebak Regency with an altitude range from 25 to 62.5 meters. Rangkasbitung Sub-District is crossed by rivers and its many tributaries, namely the Ciujung River, the Ciberang River, and seven (7) tributaries. Ciujung River has headwater in Bogor and downstream in Serang Regency. The tributaries pass through some flood-prone areas.

The growth of cities is thought to be significantly influenced by transportation routes and node sites, according to Cooley and Weber [11]. Tanah Abang – Rangkasbitung and Rangkasbitung – Merak are two electric train commuter lines in Rangkasbitung Sub-District. Serang – Panimbang Toll Road is another toll road under construction that is a part of the National Strategy Project. Based on the Master Plan of Lebak Regency in 2014 – 2034, an industrial area will be constructed encompassing many villages in Rangkasbitung Sub-District, including Nameng Village, Citeras Village, Mekarsari Village. This demonstrates that Rangkasbitung Sub-District is an essential link on the Java – Sumatra Island route and has the potential to grow. **Table 1** are shown the land use of Rangkasbitung Sub-District.

Table 1. Land Use Rangkasbitung Sub-district.

No	Land Use	Currently (Ha)	Master Plan* (Ha) 2034
1.	Residential Land	955	2,686
2.	Plantation Land	3,749	1.082
3.	Industrial Land	-	760
4.	Others	2,548	2,724

*Source: Lebak Regency Master Plan 2014 – 2034

2 Method

2.1 Data Collection

Figure 1 provides a detailed view of the flowchart of the planning method as the foundation for the sewerage system design.

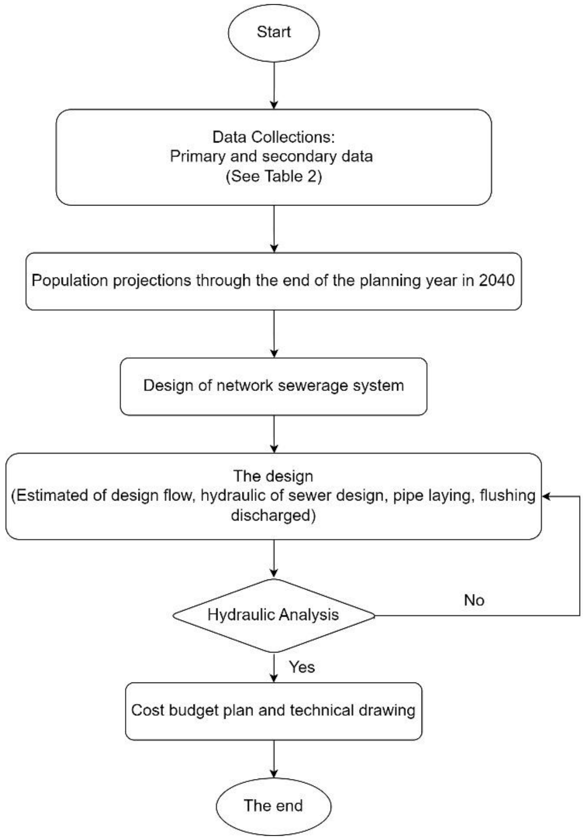

Figure 1. Flowchart of the Planning Method

According to the flowchart above, data collection is the first step in this planning. This phase involves gathering data from the source in the form of primary and secondary data, which are shown in more detail in **Table 2**.

Table 2. Primary Data and Secondary Data

No	Name of Data	Kind of Data		Source
		Primary	Secondary	
1.	Existing Contour Map		√	Geospatial Agency, Development Planning Agency at Sub-National Level Lebak Regency
2.	Land Use Map		√	Geospatial Agency, Development Planning Agency at Sub-National Level Lebak Regency

No	Name of Data	Kind of Data		Source
		Primary	Secondary	
3.	The Planning Area Conditions	√	√	Field Survey, Development Planning Agency at Sub-National Level Lebak Regency
4.	Road Network Map		√	Geospatial Agency, Development Planning Agency at Sub-National Level Lebak Regency
5.	Overview of The Planning Area		√	Development Planning Agency at Sub-National Level Lebak Regency
6.	Location of Receiving Waters	√	√	Field Survey, Development Planning Agency at Sub-National Level Lebak Regency
7.	Location determination of WWTP	√	√	Field Survey, Development Planning Agency at Sub-National Level Lebak Regency
8.	Total Population		√	Central Agency Lebak Regency
9.	Data on Clean Water Usage		√	Municipal Waterworks Lebak Regency
10.	Data of Wastewater Percentage		√	Undergraduate Thesis
11.	Lebak Regency Master Plan 2014 – 2034		√	Development Planning Agency at Sub-National Level Lebak Regency

2.2 Data Analysis Method

Data analysis is the processing of data that will be analyzed to obtain decisions that will be used as the basis for planning for sewerage which includes: Data on the number of residents per urban village/village from the last ten years will obtain the percent population growth rate to calculate population projections up to end of the planning year.

Data on clean water usage is needed in finding domestic clean water needs (L/person/day) based on household groups and the percentage of non-domestic clean water needs to domestic needs in Rangkasbitung Sub-District. In addition, the factor maximum day value can be found using clean water usage data by comparing the maximum discharge and the average discharge of drinking water needs for one year. In calculating the need for clean water for non-domestic industrial areas, a value of 0.4 L/Ha/sec is used in the range of 0.2 – 0.8 L/Ha/sec [4]. In industrial areas, it is assumed that 20% of the total industrial area per village is the area of settlements for residents who live or work around industrial areas. Data for domestic and non-domestic clean water needs in one year is obtained from Municipal Waterworks Tirta Multatuli, Lebak Regency (data for 2018 – 2020).

The percentage value of wastewater discharge to clean water discharge is obtained from the Tanah Tinggi WWTP, Tangerang City which is contained in 3 Undergraduate Thesis references and the amount of data is 8 data [3] [6] [8]. While the infiltration discharge uses an infiltration coefficient (Cr) of 0.2 and a channel infiltration discharge of 2 L/sec/1,000 people with consideration of adjusting the conditions in Indonesia.

The sewerage system design has several steps, including planning the sewerage route by taking into the topography, receiving water, and land use. Wastewater discharge will design until the end of the planning year (2040, by calculating the wastewater discharge, the average wastewater discharge (qr), equivalent population (PE), minimum discharge (Qmin), and peak discharge (Qpeak) that can be seen below [1].

$$\text{qr} = \frac{\text{Qdom}+\text{Qnon dom}}{\Sigma\text{population}/1.000\text{jiwa}} \quad (1)$$

Description:

qr = Average discharge of wastewater (L/sec/1,000 people)

Qdom = Domestic wastewater discharge (L/sec)

Qnon dom = Non-domestic wastewater discharge (L/sec)

$$\text{PE}/1{,}000 = \frac{\text{Qdom (L/second)}+ \text{Qnon domestik (L/second)}}{\text{qr}} \quad (2)$$

Description:

PE/1,000 = Equivalent population per 1,000 people (people)

qr = Average discharge of wastewater (L/sec/1,000 people)

$$\text{Qmin} = \frac{1}{5} \text{ x } (\Sigma\text{PE}/1.000)^{1,2} \text{ x qr} \quad (3)$$

Description:

Qmin = Minimum wastewater discharge (L/sec)

PE/1,000 = Equivalent population (people/1,000)

qr = Average wastewater discharge (L/sec/1,000 people)

$$\text{Qpeak} = \text{Qmd} + \text{Qinf.surface} + \text{Qinf.channel} \quad (4)$$

Description:

Qpeak = Peak discharge (L/sec)
Qinf.surface = Surface infiltration discharge (L/sec)
Qinf.channel = Channel infiltration discharge (L/sec)

To determine the pipe dimensions, the Nomograph for Design of Main Sewers chart (Graphic Hydraulic Elements of Circular Sewers Running Partly Full Manning Formula) was used (**Figure 2**). In calculating the dimensions of the pipe, the Manning equation is used which refers to equation (5) [1].

$$v = \frac{1}{n} \times R^{2/3} \times S^{1/2} \quad (5)$$

Description:
R = Hydraulic radius (m)
S = Pipe slope
n = Manning roughness coefficient

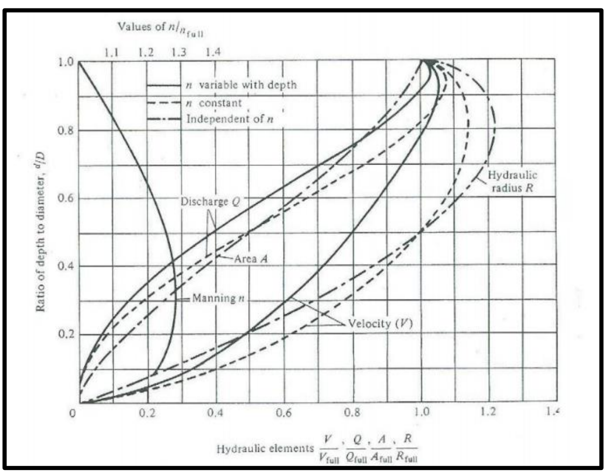

Figure 2. Hydraulic Elements of Circular Sections
(Source: Babbitt, 1922)

The sewer was designed by fulfilling the following criteria that are a maximum of 18 hours to reach WWTP with self-cleaning velocity; preferably using the gravity flow except the topography conditions do not support hence it will use pumping flow, and even in a minimum velocity condition, the material must be able to carry. [10].

3 Results and Discussion

3.1 Wastewater Main Pipeline

Wastewater will be directed to three WWTPs, which are situated in the villages of Citeras Village, Nameng Village, and Kolelet Wetan Village. To split the flow of wastewater and prevent pipelines from crossing rivers, tributaries, and flood-prone areas, wastewater drainage is divided into three WWTPs. Given that Kolelet Wetan Village and Nameng Village are located close to one another and are divided by tributaries, WWTP A and WWTP C are designed to serve areas with residential land use for both urban and rural people. Due there is urban development for industrial areas, WWTP B is proposed to be built in Citeras Village and will serve areas with residential land use and industrial areas. **Figure 3** shows the map of the land use plan for the planning area (Rangkasbitung Sub-District) in 2034 [5]. **Figures 4** and **Figure 5** show the primary pipeline maps for the wastewater network's phases I and II, respectively, while Section 3.3 explains the wastewater network's phasing.

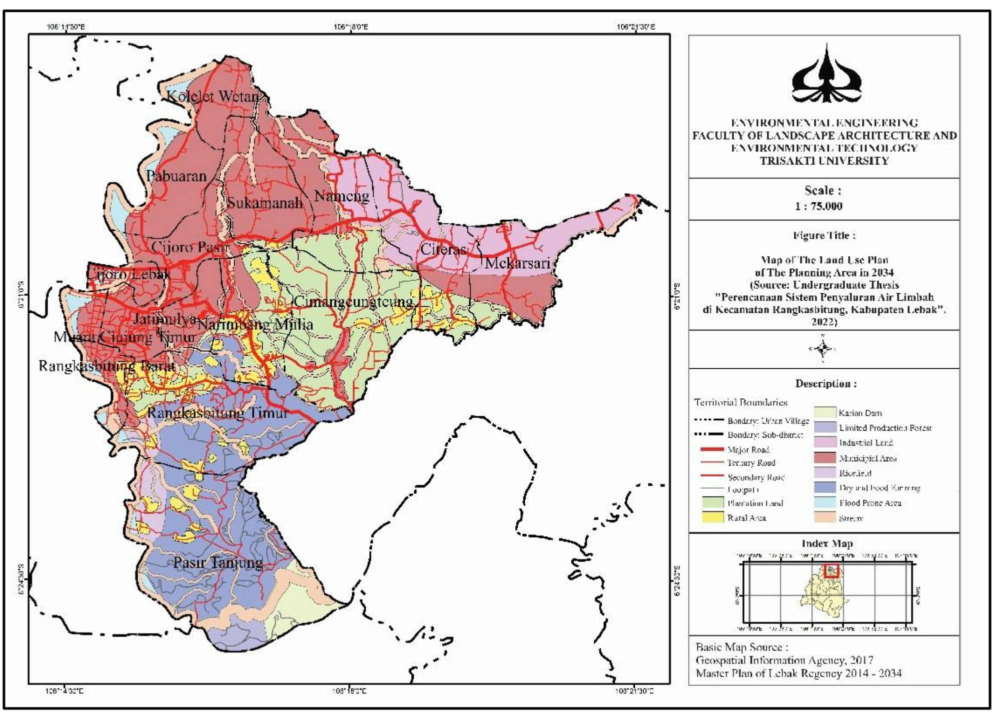

Figure 3. Map of The Land Use Plan of The Planning Area (Rangkasbitung Sub-District) Year 2034

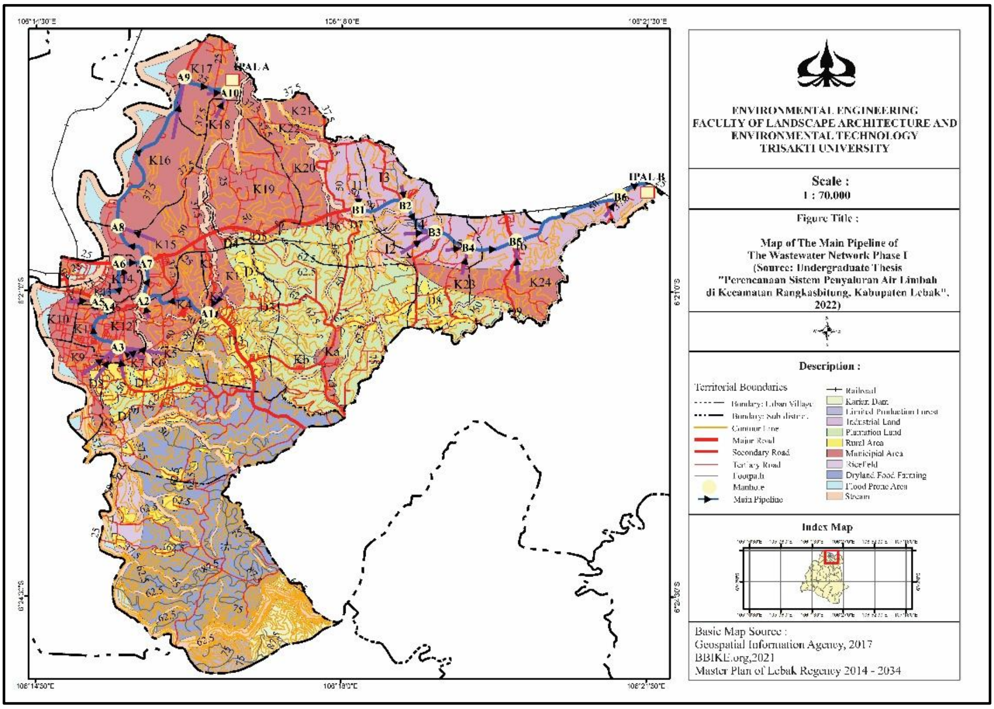

Figure 4. Map of The Main Pipeline of The Wastewater Network Phase I

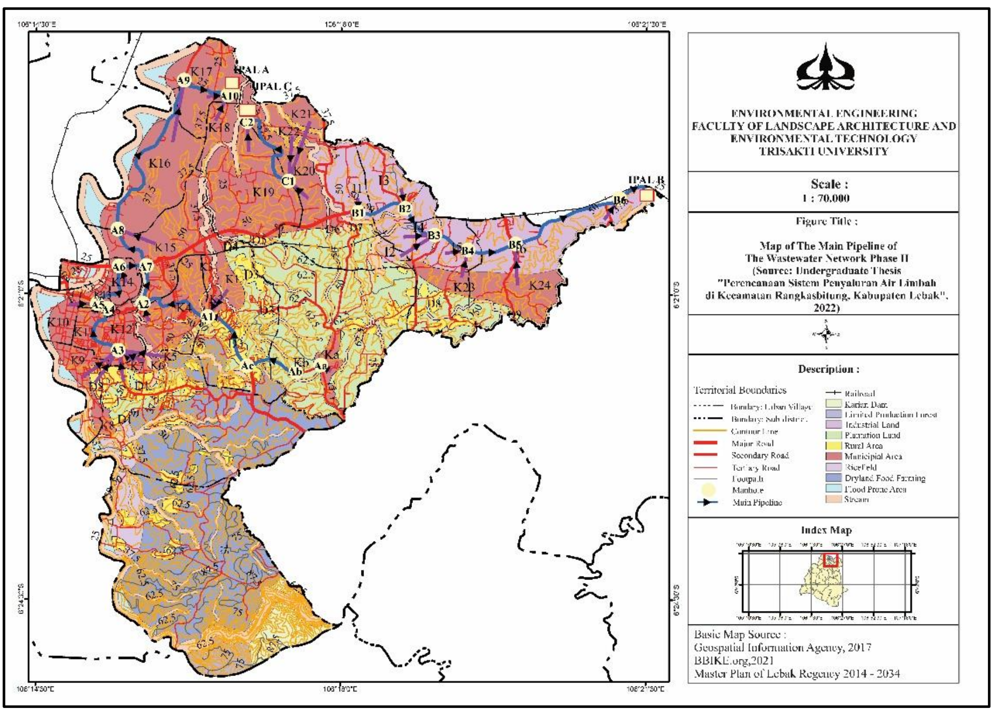

Figure 5. Map of The Main Pipeline of The Wastewater Network Phase II

3.2 Planning Basis

The results of the data analysis which includes data on population, clean water demand, and the percentage of wastewater will be used as the basis for planning the sewerage system in Rangkasbitung Sub-District. The planning basis that has been obtained can be continued in calculating the average wastewater discharge and wastewater discharge per WWTP until the end of the planning year.

The prediction of the population until the end of planning is calculated using the population growth rate. The population in 2020 is 128,250 and the estimated population for 2030 and 2040 is approximately 157,553 and 194,832, respectively.

Based on the results of the analysis of clean water data in 2018 – 2020 using statistical tests, the amount of domestic clean water needed in Luxury Households is 166.83 L/person/day; in Medium Household is 158.38 L/person/day, and in Simple Household is 114.89 L/person/day. In addition to clean water data based on household groups, the factor maximum day value (Fmd) is 1.89.

Based on the results of the analysis of clean water data in 2018 – 2020 using statistical tests, the percentage of non-domestic clean water needs to domestic clean water needs is 4.498%. The percentage of wastewater used is the result of data analysis using statistical tests with a 95% confidence level of 79.49%.

Based on the main pipeline and the results of data analysis, the results of the calculation of the average discharge of wastewater for each WWTP, WWTP A are 1.507 L/sec/1,000 people; WWTP B of 10.991 L/sec/1,000 people; WWTP C is 1.493 L/sec/1,000 people. Meanwhile, the wastewater discharge until the end of the planning year (2040) is different for each WWTP, WWTP A is 208.937 L/sec; WWTP B of 275.188 L/sec; and WWTP C of 26.242 L/sec.

3.3 Sewerage Planning Phases

The planning of the sewerage system is divided into two phases that take into consideration the population density and the distance from the service area to the WWTP. Construction of WWTP A (without pipeline Aa-A1) and WWTP B is designed in phase I (2030). Twenty-two residential blocks are served by WWTP A, while four residential blocks and 6 industrial blocks are served by WWTP B. The construction of the Aa-A1 pipeline, which will drain to WWTP A and WWTP C, is designed for phase II (2040). In phase II, WWTP C will service seven residential blocks while WWTP A will serve twenty-four blocks. By 2030, it will serve both urban and rural areas with a high population density in phase I.

The pipeline Aa-A1 route's service area is located quite a distance from WWTP A, and according to the Master Plan, the planning area served by this route is mostly designed for plantations. Due to the low population density in the WWTP C service areas in 2030, phase II construction of the WWTP C in 2040. Pipeline C1-C2 and Line C2-WWTP are the routes that will be served by WWTP C and according to the regional Master Plan, the planning that will be served by WWTP C is mostly designed for settlements for urban populations. Following the Master Plan, the majority of the service areas that WWTP B serves industrial areas that have the potential to continue growing and have a high population density.

The dimensions of the pipe network of the sewerage system in this plan can be seen in **Table 3** and the technical comparison per Wastewater Treatment Plant (WWTP) in **Table 4**. The design of the trunk sewer has a total 24,556 m length (2040), the pipe diameter ranges from 300 to 1,000 mm, 244 manholes are needed, 44 units of the flush building, 6 siphons, and 14 pumps.

Table 3. Comparison of The Calculation Results of Pipe Dimension

Diameter(mm)	Pipe Length(m)					
	WWTP A		WWTP B		WWTP C	
	2030	2040	2030	2040	2030	2040
300	1.501	4.678	-	-	-	-
400	1.397	1.397	-	-	-	2,335
500	820	820	-	-	-	-
600	246	246	-	-	-	-
800	1,743	1,743	1990	1990	-	-
1,000	6.210	6.210	5.137	5.137	-	-
Total	**11,917**	**15,094**	**7.127**	**7.127**	**-**	**2,335**

Table 4. Comparison of Technical Aspects of Phase I and Phase II per WWTP

Description	Standard Unit	WWTP A		WWTP B		WWTP C	
		2030	2040	2030	2040	2030	2040
Total Length of Pipe	m	11,917	15,094	7.127	7.127	-	2,335
Diameter of Pipe	mm	300 – 1000	300 – 1000	800 – 1000	800 – 1000	- 19,797	400
Waste Load	L/sec	170.670	208,937	266.851	275,188	-	26,242
manhole	Unit	116	150	70	70	-	24
Flush Building	Unit	16	22	14	14	-	8
Siphon	Unit	3	4	2	2	-	-
Pump	Unit	5	5	9	9	-	-
d/D:							
Minimum		0.65	0.75	0.76	0.75	0.53	0.61
Maximum		0.71	0.75	0.78	0.75	0.53	0.61
Velocity (v_{peak}):							
Minimum	m/sec	0.68	0.69	0.76	0.76	1.20	1.27
Maximum	m/sec	2.09	2.14	2.24	2.24	1.75	1.85

The diameter and slope of the pipe must both be taken into consideration while designing the sewer line, among other factors. For wastewater to be directed to the WWTP, the planning outcomes up until the end of the planning year must have a depth by diameter (d/D) ratio ranging from 60 to 80% and a velocity (v_{peak}) ranging from 0.6 to 3 m/sec.

4 Conclusions

In designing, it is important to focus on the phases to ensure that the velocity (v_{peak}) and depth by diameter (d/D) ratio until the end of the planning fulfill the criteria. The wastewater discharge is 457.318 L/sec in the medium-term planning (in 2030) and 510.367 L/sec in the long-term (2040). The results of the identification of critical points in the sewerage network system where the velocity of self-cleaning is not attained at points C1-C2, and C2-WWTP C (from 2030 calculations). Pipeline C1-C2 with a depth by diameter (d/D) of 0.53 and velocity (v_{peak}) of 1.20 m/s, and C2-WWTP C with a depth by diameter (d/D) of 0.53 and velocity (v_{peak}) of 1.75 m/s, are the critical points in the planning phase (from 2030 calculations). In the first phase, there is a maximum flow depth of 212 mm at peak discharge and a depth by diameter (d/D) ratio of 0.53 less than 60% of the diameter, it does not fulfill the criteria, and flushing is necessary. At peak discharge, the second phase's maximum flow depth was 750 mm (d/D ratio: 0.75).

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