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Intake Planning in Loma River, Tolikara Regency

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ABSTRACT

The provision of clean water in Karubaga City has been hampered by inadequate piping distribution networks, forcing reliance on drilled wells in villages. This study aims to address the problem of inadequate clean water facilities by planning an effective water intake system for the Loma River in Tolikara Regency. Using a combination of quantitative and qualitative methods, the research analyzed hydrological data, intake hydraulics, and the structural stability of intake buildings. Results indicate that the Loma Intake requires significant rehabilitation due to sediment deposition, while the Palagi Intake needs an evaluation of the pipeline network to improve flow pressure and distribution. The study concludes that redesigning and constructing efficient water intake systems is crucial to meeting the community's clean water needs while mitigating health risks from water pollution.

Keywords: Raw Water; River; Intake Building

Introduction

Human life is inseparable from the need for water (Kılıç, 2020). Water is needed to meet various needs, especially clean water or drinking water that is needed to ensure human survival. Therefore, the provision of clean water needs to be sought both by the government and the community itself. The clean water used must meet the requirements both in terms of quantity and quality (WHO, 2022). Various technologies have been used to provide and treat raw water in such a way that it meets the requirements of clean water and drinking water (Darmasetiawan, 2004; Gabrielle et al., 2021). Law No. 7 of 2004 article 40 paragraph 1 states that the need for raw water for household drinking water is carried out by developing a drinking water supply system (Pemerintah Pusat, 2004).

The need for clean water in the Mountainous Papua Province, especially Tolikara Regency, continues to increase annually, driven by the rapid development of the region (BPS Papua, 2021). To meet the clean water needs of residents in Tolikara Regency, various water sources are currently utilized, including river water, shallow groundwater (dug wells), deep groundwater (drilled wells), and rainwater (Direktorat Jenderal Sumber

Daya Air, 2013). The Loma River is one of the water sources relied upon by the community for daily needs. However, a critical requirement for the community is a clean water network. The raw water facilities and infrastructure in Tolikara Regency remain incomplete; some installed systems face issues preventing them from adequately meeting community needs (Aboagye et al., 2022; Gupta et al., 2021; Setyaninditha et al., 2021). In addition, many water sources remain unutilized due to their remote locations, the absence of pipeline networks, and the lack of water intake buildings. A raw water intake building, constructed at a water source such as rivers, springs, or groundwater, is designed to capture and provide water for drinking purposes. Given these challenges, conducting an intake planning study is crucial to identify the optimal intake location.

This research addresses the critical problem of providing sustainable and efficient clean water infrastructure in Tolikara Regency, with a focus on intake planning for the Loma River. The existing intake facilities in the region are either damaged or insufficient, such as the Loma Intake, which is buried in sediment and requires major rehabilitation. Moreover, the current water distribution systems fail to adequately serve urban populations, highlighting the need for comprehensive evaluation and redesign.

The importance of this research lies in its potential to significantly improve the quality of life for the Tolikara community by ensuring access to clean and safe water. By employing both quantitative and qualitative methods, this study analyzes hydrology, intake hydraulics, and intake structure stability to propose innovative and effective solutions. The novelty of this research lies in its focus on designing a tailored water intake system that addresses the specific challenges of the region, considering its geographical, environmental, and socio-economic factors.

The purpose of this study is to make a raw water intake plan to overcome the problem of clean water in the Tolikara Regency community.

Methods

This research is located in Tolikara Regency, Karubaga District. The district is geographically located at 138° 00'00"- 139o 00'00" East Longitude and o00'00" - 4o00'00" South Latitude. Administratively, Tolikara Regency is administratively bordered by Mamberamo Raya and Sarmi Regency to the North, Bordered by Jayawijaya Regency to the South, Bordered by Jayawijaya Regency to the East, and Bordered by Puncak Jaya Regency to the West.

The methods that will be used in this study are quantitative and qualitative methods. Quantitative is intended to provide explanation, assessment and analysis using measurable quantities, expressed in numbers. A quantitative approach is used to analyze hydrology to obtain the design flood discharge and mainstay discharge, intake hydraulics to obtain the intake dimension size and intake stability to control the safety of the designed intake building. The data taken are primary data and secondary data.

1. Data Primer

Primary data is all data obtained directly from the field survey process. The data data is searched and collected by researchers from their observation objects using measurement tools, survey forms, and celebration lists (questionnaires). The primary data in question are:

a. Topography
b. Hydrology
c. Hydrica
d. Geology
e. Socio-Economic and environmental circumstances

2. Data Seconds

Secondary data is data or information obtained in a structured data format and sourced from government and private agencies that are relevant to the objectives of this research such as:

a. Rainfall data
b. Data Climatology
c. Topographic map data.

Results and Discussion

1. Population Projections

The rate of population growth is calculated from the population growth data of all Tolikara Regency as seen in Table 1.

Table 1. Population Growth Rate

It	Regency/City	District	Total Population in 2022 (Persons)	Population Growth Ratio (%)
1	Tolikara	Karubaga	18003	1.85

Source: BPS Papua Province, 2021

a. Geometric Method

From the results of the calculation of population growth using the Geometric Method, the number of population can be projected up to 25 years and can be seen in the following table:

Table 2. Recapitulation of the 25-Year Population Projection of Mountainous Papua Province

Year	n	Jumlah Penduduk (Jiwa)							
		Wamena	Tiom	Karubaga	Kobakma	Elelim	Dekai	Oksibil	Kenyam
2020	0	65766	11013	17676	13504	16675	17316	6408	6157
2025	5	72079	11899	19373	14369	18276	18978	6576	6712
2030	10	78997	12857	21232	15290	20030	20800	6749	7316
2035	15	86580	13891	23270	16270	21952	22796	6926	7975
2040	20	94890	15009	25502	17313	24059	24984	7108	8694
2045	25	103999	16217	27952	18422	26369	27383	7295	9477

Source: Calculation Results, 2024

2. Projected Water Needs

In accordance with the Framework of Reference, water demand projections are carried out for the next 25 years (Müller Schmied et al., 2021). By taking 2020-2022 as the beginning of the plan, water demand in Tolikara Regency is projected with an interval of 5 years until 2045. The results of water needs in Tolikara Regency (Karubaga) are attached in Table 3.

Table 3. Projected Water Needs of Tolikara Regency (Karubaga) until 2045

It	Description / Criteria		Unit	Projected Year					
				2020	2025	2030	2035	2040	2045
1	Household Needs (Domestic)								
	-	Population	(soul)	17676	19373	21232	23270	25504	27952
	-	Number of Population Served	(soul)	10606	12592	14863	17453	20403	23759
	-	Served with SR	(soul)	6363	7870	9661	11781	14282	17225
	-	Served through HU	(soul)	4242	4722	5202	5672	6121	6534
	-	SR Needs	(m3/day)	636	826	1063	1355	1714	2153
	-	HU Needs	(m3/day)	127	142	156	170	184	196
	-	Number of household needs	(m3/day)	764	968	1219	1525	1897	2349
2	Non-Domestic Needs		(m3/day)	191	281	406	578	813	1007
3	Total (1+2)		(m3/day)	955	1249	1625	2103	2711	3356
4	Water Loss		(m3/day)	191	250	325	421	542	671
5	Average Daily Needs			1145	1499	1950	2524	3253	4027
6	Maximum Daily Needs		(m3/day)	1260	1649	2145	2776	3578	4430
			(lt/sec)	14.58	19.08	24.83	32.13	41.41	51.27
			(m3/s)	0.01	0.02	0.02	0.03	0.04	0.05
			(lt/day)	1,259,945	1,648,769	2,144,958	2,776,412	3,578,108	4,429,872
7	Peak Hour Needs		(m3/day)	1890	2473	3217	4165	5367	6645
			(lt/sec)	21.87	28.62	37.24	48.20	62.12	76.91

(Source: Calculation Results, 2024)

3. Reliable Discharge and Water Balance

The results of the calculation of discharge with 80% reliability (Q80) in all rivers in Tolikara Regency are shown in order in the following Table 4.

Table 4. Results of Calculation of Reliable Discharge on the Loma River

No	Moon	Water Availability, Q80 (m3/s)
		S. Loma
1	Jan	0.4332
2	Feb	0.4347
3	Mar	0.4344
4	Apr	0.4346
5	May	0.4336
6	Jun	0.4338
7	Jul	0.4336
8	Aug	0.4334
9	Sep	0.4336
10	Oct	0.4336
11	Nov	0.4337
12	Some	0.4326

(Source: Calculation Results, 2024)

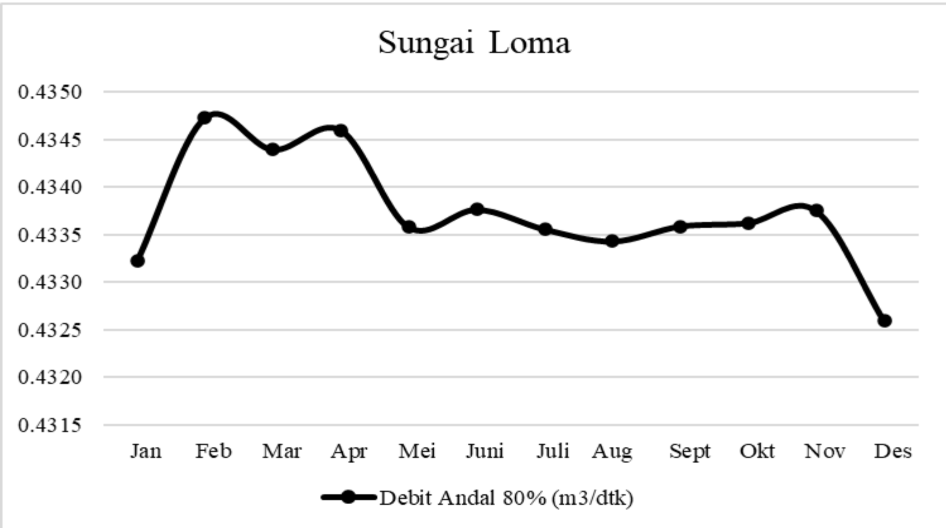


Figure 1. Reliable Discharge (Q80) of Loma River

The results of the water demand projection show a comparison between water demand and water availability in Tolikara Regency.

Table 5. Results of Calculation of Reliable Discharge of Loma River

No	Moon	Water Availability, Q80 (m3/s)	Water Requirement (m3/s)	Surplus (m3/s)
1	Jan	0.4332	0.02	0.4127

No	Moon	Water Availability, Q80 (m3/s)	Water Requirement (m3/s)	Surplus (m3/s)
2	Feb	0.4347	0.02	0.4142
3	Mar	0.4344	0.02	0.4139
4	Apr	0.4346	0.02	0.4141
5	May	0.4336	0.02	0.4131
6	Jun	0.4338	0.02	0.4133
7	Jul	0.4336	0.02	0.4130
8	Aug	0.4334	0.02	0.4129
9	Sep	0.4336	0.02	0.4131
10	Oct	0.4336	0.02	0.4131
11	Nov	0.4337	0.02	0.4132
12	Some	0.4326	0.02	0.4121

(Source: Calculation Results, 2024)

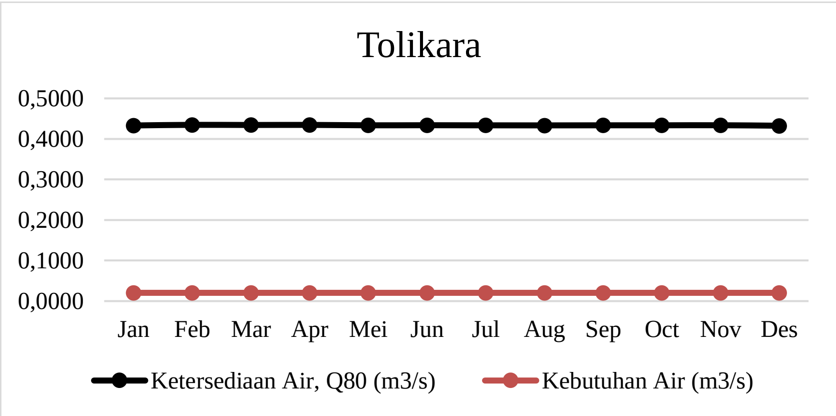


Figure 2. Comparison of Water Availability and Water Needs of Tolikara

4. Flood Discharge Plan

Table 6. Recapitulation of the results of the Tolikara Distribution Conformity test

No	Distribution Type	Condition	Calculation Results	Conclusion
1	Normal	Cs= 0	Cs= 0.46	Not Compliant
		Ck = 3	Ck= -0.682	
2	Log Normal	Cs= 0.453	Cs= -0.116	Not meeting
		Ck= 3.368	Ck = -0.815	
3	Gumbel	Cs= 1.1396	Cs= 0.46	Not Compliant
		Ck= 5.4002	Ck= -0.682	

(Source: Calculation Results, 2024)

Of the three types of distributions, none has the same skewness and kurtosis coefficient values as the data. Therefore, the distribution that matches the data is the Pearson III Log.

Table 1. Recapitulation of Rainfall Calculation Results of Tolikara Design

Probabilities in order (P=1/T)	Anniversary Period (Years)	Distribution			
		Normal (mm)	Log Normal (mm)	Gumbel (mm)	Log Pearson III (mm)
50%	2	62.482	62.482	58.907	59.202
20%	5	80.751	62.584	78.138	65.375
10%	10	90.321	62.637	90.870	68.870
4%	25	100.543	62.694	106.957	72.995
2%	50	107.068	62.730	118.891	75.177
1%	100	112.941	62.763	130.738	77.479

(Source: Calculation Results, 2024)

1) Flood Discharge Analysis

The design discharge is needed as input data in the analysis of the maximum water level on alternative intake locations in all rivers in Tolikara Regency (Ehalt Macedo et al., 2022; Medina et al., 2022). The method used to analyze the design discharge in this study is the Nakayasu Synthetic Unit Hydrograph Method.

Table 2. River Data in Tolikara Regency

River Data				
Regency	**River Flow**	**Long**	**Elv Hulu**	**Elv Hilir**
A	B	C	D	And
Tolikara	Holiday	339.0048	1919.238	1989.2461

(Source: Calculation Results, 2024)

a) Nakayasu Unit Hydrograph Method

Table 3. Recapitulation of Loma River Flood Discharge Calculation

No	Re-Period (Year)	Method HSS Nakayasu (m3/it)
1	2	5.642
2	5	6.230
3	10	6.563
4	25	6.956
5	50	7.164
6	100	7.384

(Source: Calculation Results, 2024)

The following is a hydrographic chart of the Loma river

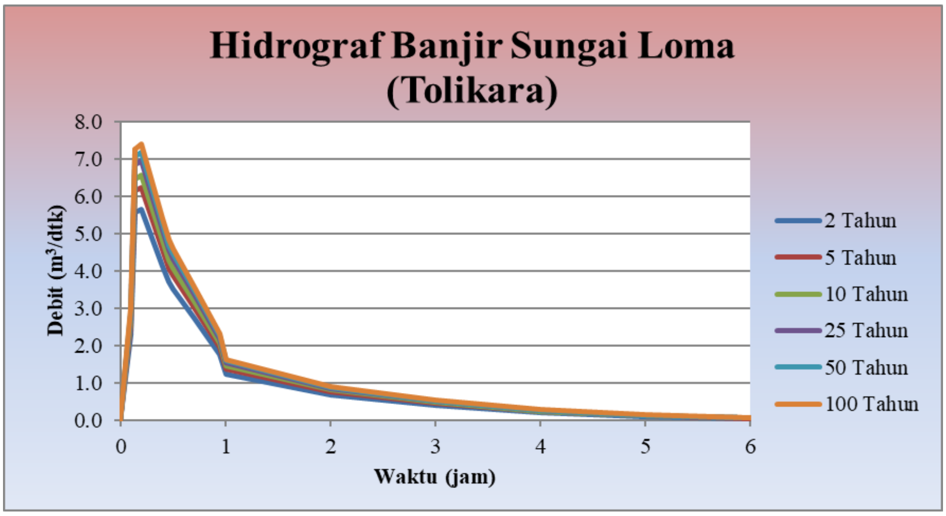
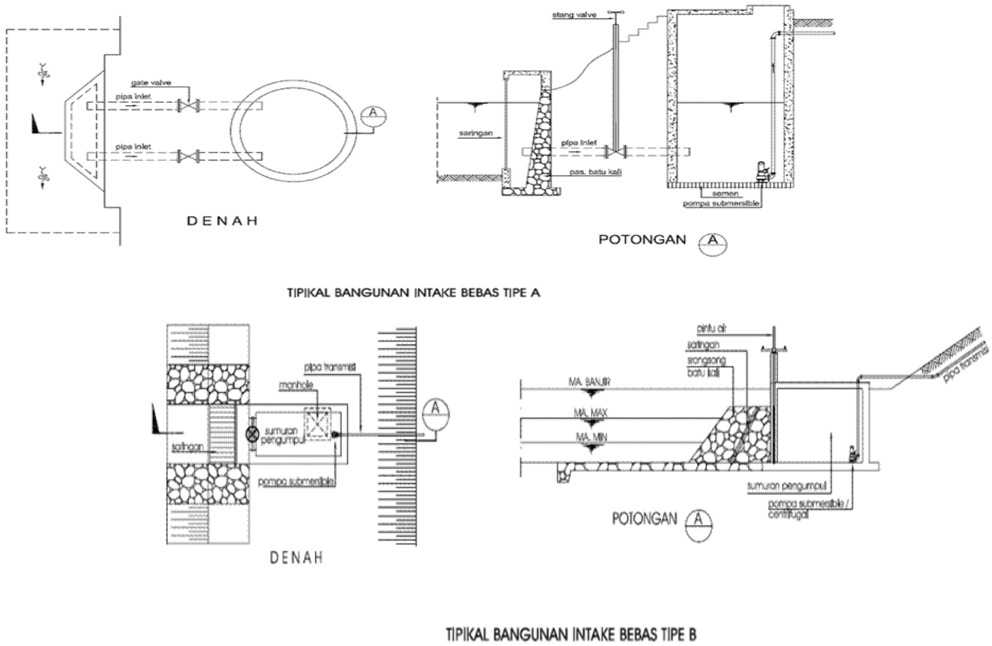


Figure 3. Flood Hydrograph for the Loma Tolikara River Intake

5. Intake Planning

a. Intake Alternatives

With several considerations, especially because the river channel is used as a transportation channel and the cross-sectional geometry of the river is relatively deep, the type of intake that is suitable for use in the Loma River is *free intake*. Alternative types of *free intake* that can be considered are shown in the following figure.

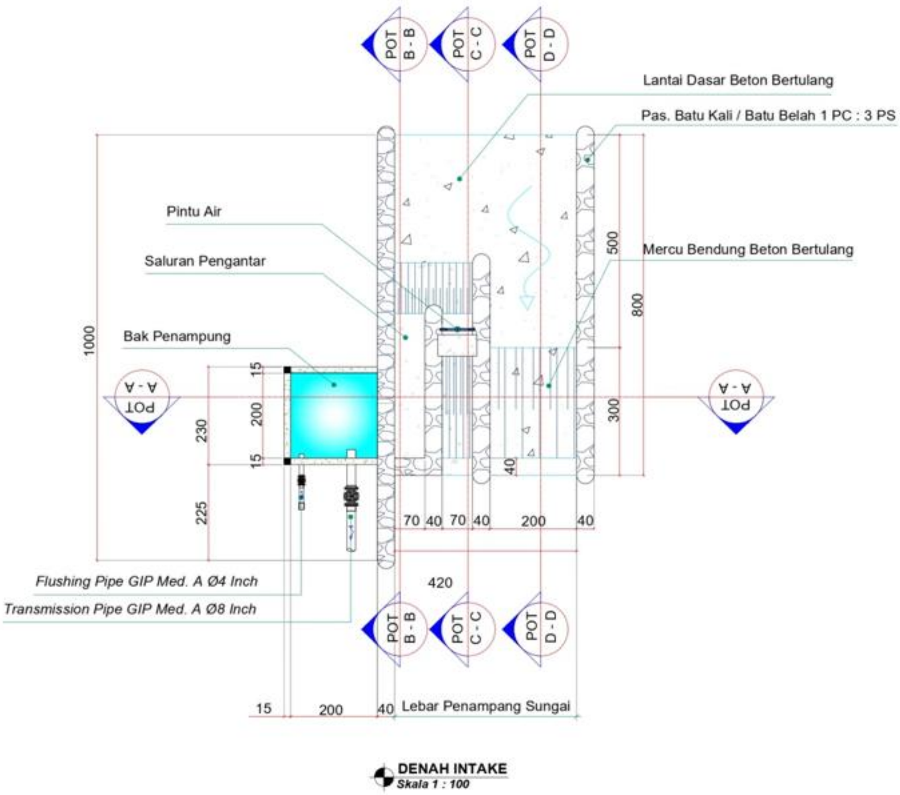


(c) Intake Eksisting

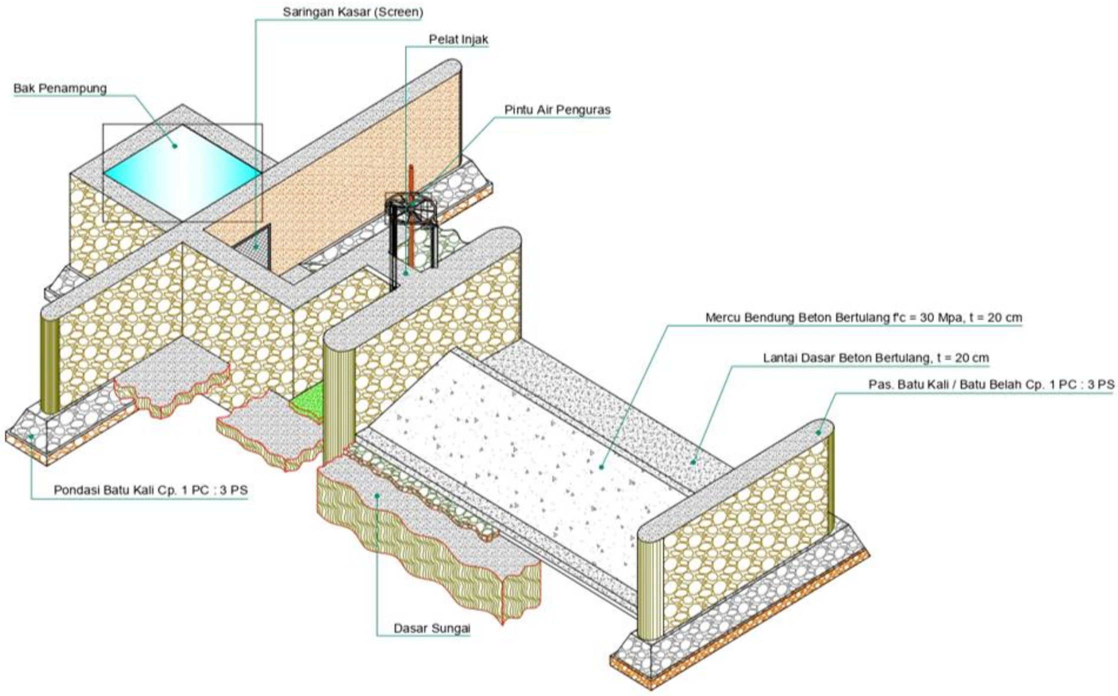
Figure 4. Alternative Free Intake Type

Table 4. Clean Water Discharge Capacity in Tolikara Regency

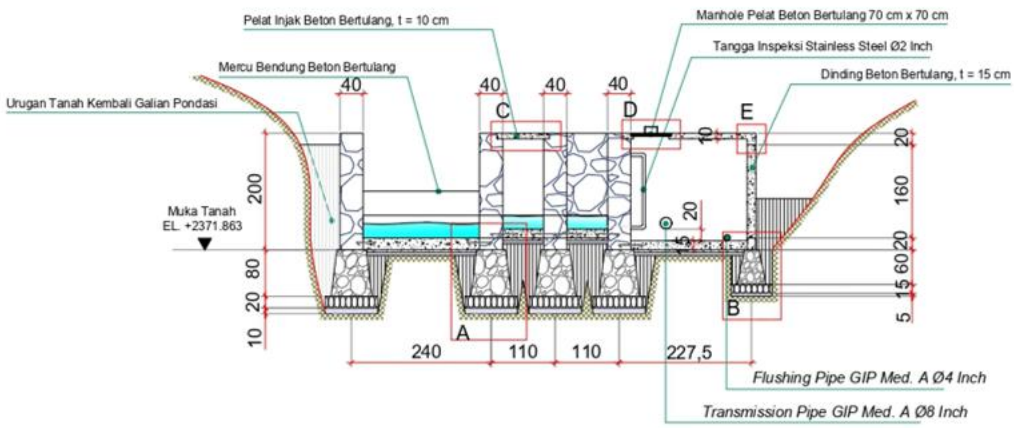
Regency City	Maximum Daily Needs (2045)	Water Availability (Q80)	Existing Capacity of the System (2022)	Additional Capacity
	LTR/s			
Karubaga	51.272	433.734	0.000	51.272



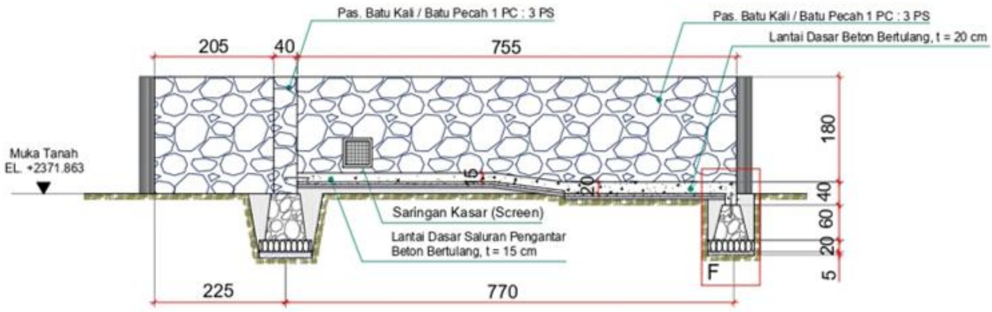
Picture of the Loma River Intake Plan, Tolikara Regency



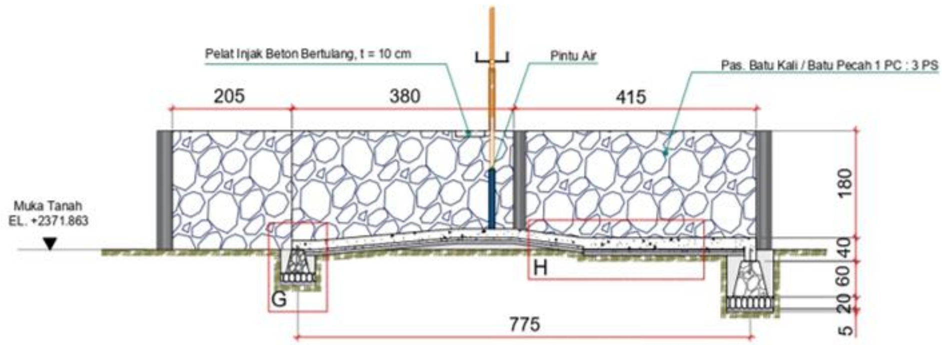
PERSPEKTIF INTAKE
Skala 1 : 100



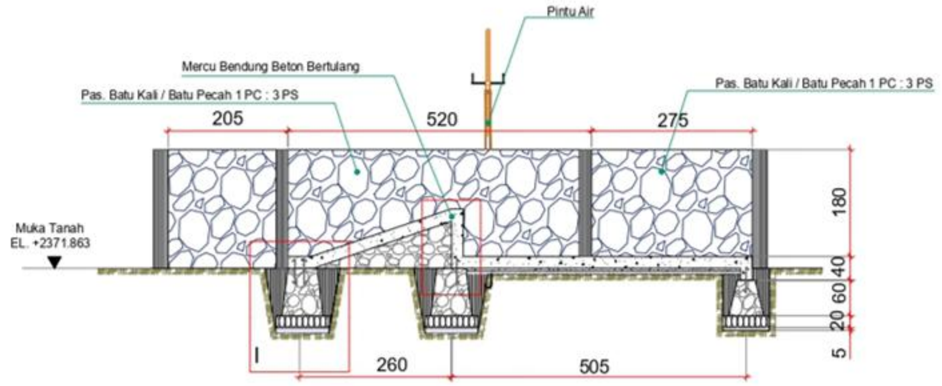
POTONGAN A - A
Skala 1 : 75



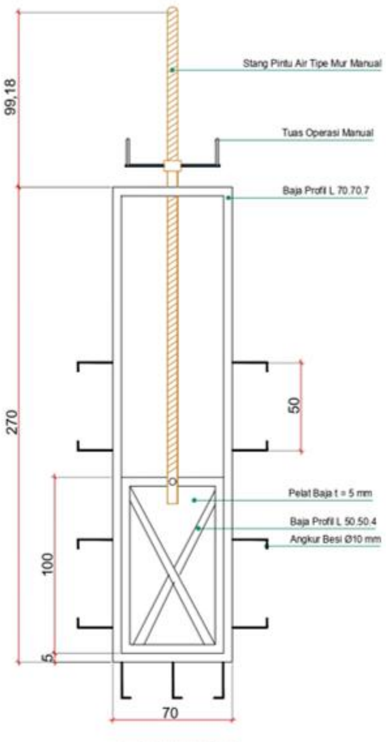
POTONGAN B - B
Skala 1 : 75



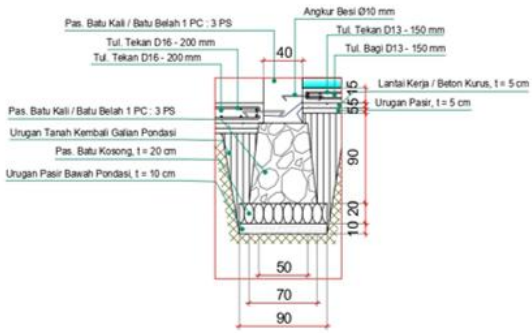
POTONGAN C - C
Skala 1 : 75



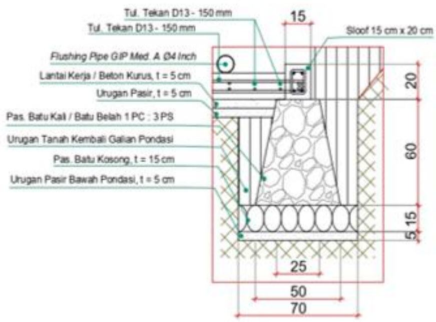
POTONGAN D - D
Skala 1 : 75



DETAIL PINTU AIR
Skala 1 : 20



DETAIL A
Skala 1 : 35



DETAIL B
Skala 1 : 20

Conclusion

Based on the description above, it can be concluded that the Intake Planning in the Loma River, Tolikara Regency is as follows: 1) The discharge of water availability in the Loma river, Tolikara Regency is 0.4332 m3/s. 2) The water demand in Tolikara Regency, especially in Karubaga District, is 51,272 liters/second (0.05 m3/s), for which it is necessary to build an intake in the Loma River in order to be able to drain water for the needs of the community. 3) The intake plan that will be built on the Loma river, Tolikara Regency, is to have a 2 x 2 x 2 meter reservoir.

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