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Availability Analysis of Lematang Watersheed as Raw Water in the Muara Enim District

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Abstract
Water availability in a watershed includes rainwater that seeps into the ground and the rest will flow as runoff to the surface. Lematang Watershed is located in South Sumatra Province that crosses Lahat Regency starting from Pagar Alam and finished into the Enim River in Muara Enim Regency. Lematang Watershed has an area of 8773 km^2. The purpose of this study was to determine the availability of water in the Lematang Watershed using the Mock method and to calculate the mainstay discharge in the Lematang Watershed using the basic planning month method.
This study aims to analyze the amount of water availability Qs (retention capacity) with various return periods of Q_5; Q_{10}; Q_{25}; Q_{50} and Q_{100}, Obtain the amount of reliable capacity (Q_{80}) needed for clean water with various return periods of Q_5; Q_{10}; Q_{25}; Q_{50} and Q_{100} and to analyze the water balance between water needs compared to water availability in the Lematangwatersheed in 2020, 2025 and 2035.
The conclusion of the study is water availability Qs (storage capacity) with various return periods, each Q_5 is 124,066 m^3/sec; Q_{10} is 143,228 m^3/sec; Q_{25} is 173,203 m^3/sec; Q_{50} is 199,947 m^3/sec and Q_{100} is 230,834 m^3/sec and reliable capacity (Q_{80}) required for clean water with various return periods, each Q_5 is 99,252 m^3/sec; Q_{10} is 114,582 m^3/sec; Q_{25} is 138,563 m^3/sec; Q_{50} is 159,958 m^3/sec and Q_{100} is 184,667 m^3/sec and the water balance in the Lematangwatersheed in 2020 of 371,507.88 m^3 is still smaller than the water availability of 1,444,659.58 m^3; likewise in 2025 where the water requirement of 728,241.53 m^3 is still smaller than the water availability of 1,444,659.58 m^3 but In 2035 there was a water imbalance, where the water requirement of 2,518,551.29 m^3 was greater than the water availability of 1,444,659.58 m^3.

***Keywords**: Lematang river, storage capacity, water availability, water balance*

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I. INTRODUCTION

Lematang Watershed has an area of 8773 km2. The purpose of this study was to determine the availability of water in Lematang Watershed using the Mock method and to calculate the mainstay discharge in Lematang Watershed using the basic planning month method. From the results of the calculation of water availability, the minimum discharge in July 2008 was 21.44 m3/sec and the maximum discharge in December 2007 was 1144.77 m3/sec. For irrigation, drinking water, industry, the smallest mainstay discharge occurred in July, namely irrigation of 32.82 m3/sec, drinking water of 5.73 m3/sec and industry of 13.69 m3/sec and the largest mainstay discharge for irrigation occurred in January of 181.80 m3/sec, for drinking water in November of 85.50 m3/sec, and for industry in November of 113.85 m3/sec. Keywords: Water availability, River basin (DAS), surface runoff (Inneke Widyasari, et al., 2010).

In order to meet the needs of drinking water facilities for the community, the Muara Enim Regency Government, in this case PDAM LematangEnim Muara Enim Regency collaborates with all stakeholders including the Drinking Water work unit, the Public Works and Spatial Planning Service of Muara Enim Regency, trying to build drinking water facilities and infrastructure in order to meet the needs of sufficient drinking water for the local community. The availability of drinking water is the task and responsibility of the Regional Government, especially in this case it is applied in the program for the construction of clean water reservoirs and connecting water network installations to housing and settlements. (PDAM Kab. Muara Enim, 2023).

Lematang Enim Regional Drinking Water Company (PDAM) is a Government-owned Business Entity of Muara Enim Regency (BUMD) which was established based on Regional Regulation Number 4 of 1986 dated May 9, 1986, which is domiciled and headquartered in Muara Enim City. To carry out activities in providing clean water, PDAM LematangEnim Muara Enim Regency has water management installations (IPA) in 5 (five) Branches, namely: Muara Enim Branch, Tanjung Enim Branch, Ujan Mas Branch, TelukLubuk Branch and Gelumbang Branch, with a total installed capacity of 757.5 liters/second and a total real production capacity of 730 liters/second. The current water loss rate is 28.62%, this figure is still above the average recommended water loss rate of 20%. (PDAM Muara Enim, 2023)

Based on the data on the number of existing connections currently where the number of customers is 35,677 units/customers consisting of 763 inactive units/customers and 34,914 active customers/units, assuming 1 (one) SR consists of 5 people, it can be seen that the total service coverage of piped drinking water managed by PDAM Muara Enim Regency currently only serves around 174,570 people or 52.20% of the total population of the service area, namely 511,971 people (Muara Enim in Figures, 2025).

Muara Enim City is flanked by 2 large rivers, to the west of Muara Enim City flows the Lematang River where the upstream of the Lematang River is in Lahat Regency, while in the middle of the city flows the Enim River where the upstream of the Enim River is in OKU Regency. The capacity of the Lematang River in the dry season is 10-20 m3/second, while the Enim River in the dry season is 60-65 m3/second. (BBWSS VIII, 2025)

The need for clean water in Muara Enim Regency, as in other areas, is a basic need that is very important for daily life, especially for household needs such as drinking, cooking, bathing, and other needs. In general, the need for clean water per person per day ranges from 70 to 150 liters, depending on the type of activity and individual needs.

II. MATERIAL AND METHODS

The location and scope of the research is the LematangWatersheed, Muara Enim Regency (Figure 1).

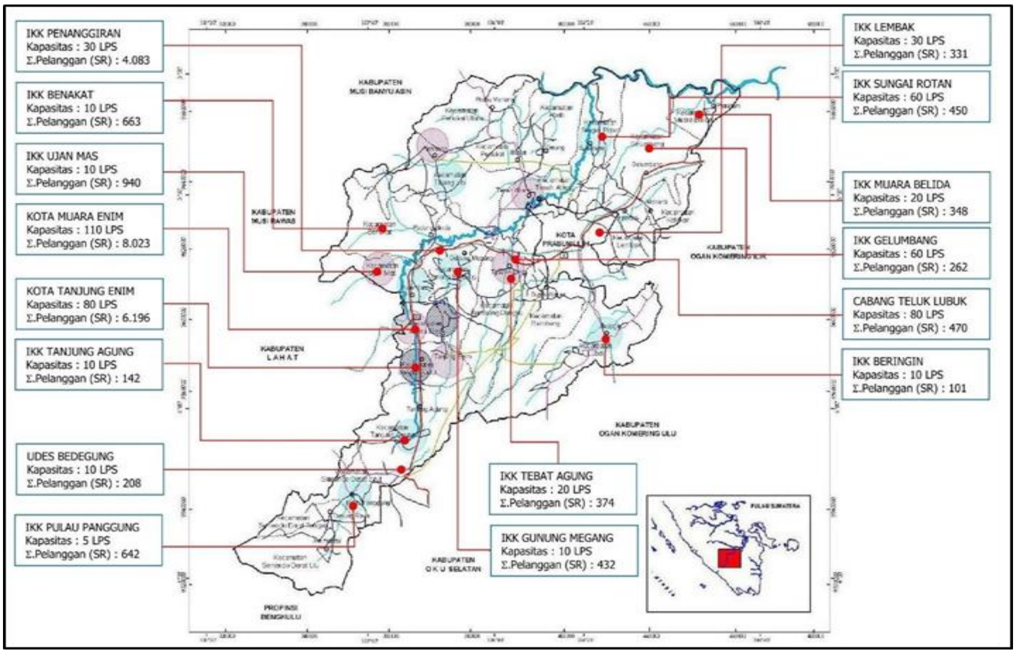


Figure 1: Research location

2.1. Research type and Data Sources

2.2.1. Research Type

The research approach is carried out using qualitative and empirical analysis methods.

2.2.2. Data Sources

This study will use two data sources, namely:

1. Primary data, namely data obtained directly from the research location, including conducting topographic surveys, taking hydrometric data on the flow of the Lematang River in Muara Enim City.
2. Secondary data, namely data obtained from reference data literature from related agencies (BBWSS-8; local BMKG; PUPR and Spatial Planning Office of Muara Enim Regency; BPS of Muara Enim Regency and Muara Enim Regency in Figures) as well as existing research results that have been carried out in other places related to the research.

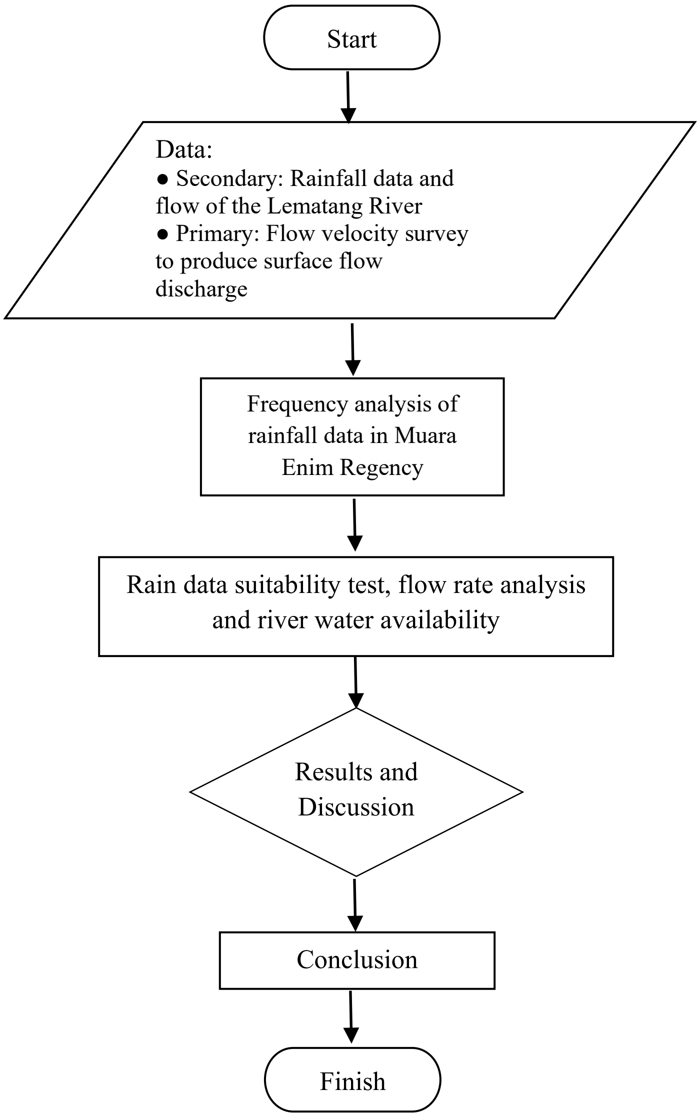


Figure 2: The flowchart of the methodology

III. RESULTSAND DISCUSSION

3.1. Selection of Return Period

Determination of return period based on the method:

1. Empirical Method

Past event observation data to predict future events with the same magnitude. The probability of extreme events in "N" years will recur in the next "n" years is expressed as:

$P (N,n) = n / N + n$ .... (1)

2. Risk Analysis

The risk of failure of the planned building is a risk analysis expressed in the equation:

$R = 1 - 1 - 1/T\ n$ .... (2)

with:

R = Probability where Q Qt occurs at least once in n years.

3.2. Hydrology Analysis

Considering the availability of hydrometric data is not yet available properly, rainfall data is used as the basis for hydrological calculations. The rainfall data used is rainfall data recorded by several stations in the planning area and has quite long data, namely from 2011 to 2021 and the average rainfall value is taken from the maximum monthly rainfall data.

For the planned rainfall estimate, frequency analysis is used by reviewing the commonly used distribution:

1. Planned Rain Estimate

a. For Return Periods above 1 year

The planned rainfall estimate is carried out by analyzing the frequency of the annual maximum rainfall data (annual series). There are several distributions in statistics and those commonly used in frequency analysis are 4 (four) types, namely:

1). Normal
2). Gumbel type I
3). Log normal 2 parameters
4). Pearson type III log

Each distribution has its own statistical properties. By calculating the statistical parameters of the analyzed data series, it can be estimated which distribution is appropriate for the data series. The statistical parameters in question are as follows:

$$X = \frac{\Sigma xi}{n} \qquad \text{(3)}$$

$$S = \sqrt{\frac{(xi - xr)^2}{(n-1)}} \qquad \text{(4)}$$

$$Cs = \frac{n}{(n-1)(n-2)S^3} \sum (xi - xr)3 \qquad \text{(5)}$$

$$Ck = \frac{n}{(n-1)(n-2)(n-3)S^4} \sum (xi - xr)4 \qquad \text{(6)}$$

with:
xr = Mean value
S = Standard deviation
Cs = Skewness coefficient
Ck = Curtosis coefficient
xi = rainfall data
n = amount of data

The typical statistical properties of each distribution can be explained as follows:

1). Normal Distribution: Cs = O
Typical characteristics: Cs = 0
Probability P (x-S) = 15.87%
P (x) = 50.00%
P(x+s) = 84.14%
The possibility of a variable in the interval x – S and X + S = 68.27% and in the interval X – 2S and X + 2S = 95.44%.

2). Log normal distribution (2 parameters)
Characteristics: Cs = 3 Cv
Cs is always positive
Probability line equation: x(t) = x + K

With x(t) = rainfall depth with recurrence period t (years) K = Frequency factor

3). Gumbel distribution type I

Characteristics: Cs = 1.3960 cv and Ck = 5.4002

Probability line equation:

$$X(t) = x + \frac{\sigma}{\sigma n}(y - yn) \qquad \text{(7)}$$

with: Y = reduced variated

yn and n = Mean value and standard deviation of reduced variated.

4). Pearson Log Distribution type III

The statistical data does not approach the characteristics of the three previous distributions. The rainfall data is transformed into its natural logarithm value so that the xi values change to ln xi. Then the average value, standard deviation and skewness coefficient are calculated as follows:

$$\overline{ln \frac{\sum_{i=1}^{n} ln\, xi}{n}} \qquad \text{(8)}$$

$$S = \sqrt{\frac{\sum_{i=1}^{n}(ln\, xi - \overline{ln}\quad x)^2}{(n-1)}} \qquad \text{(9)}$$

$$Cs = \frac{n}{(n-1)(n-2)S^3}\sum_{i=1}^{n}(\ln xi - \overline{\ln}\, x)^3 \qquad \text{(10)}$$

Probability line equation:

$$\ln x(t) = \overline{\ln}\, x + K\, S \qquad \text{(11)}$$

K is the frequency factor. based on the Cs value calculated in equation 11, the depth of rainfall with a return period of t years is obtained by finding the antilogarithm of the ln (t) value.

To find out whether the existing data is in accordance with the selected theoretical distribution, a goodness of fit test is carried out using the Smirnov Kolmogorov and chi-square tests.

a. For Return Period Less than 1 year

The estimated planned rainfall with a return period of less than 1 year cannot be done using the frequency analysis above. Determining the depth of rainfall with a probability of being equaled or exceeded one or more times in a year can be done using the approach below.

1. The length of the rainfall data series is determined (for example n years).
2. Data in each year is broken down from large to small.
3. In each year, the data is taken (k + 1) largest data, where k is the number of events equaled or exceeded in the desired year. So that during n years n x (k + 1) data are obtained.
4. This new data series is sorted from large to small.
5. Rainfall with a probability of being equaled or exceeded k times in a year is data in the order (n x k + 10).

Table 1: Chi-Square and Smirnov-Kolmogorov Goodness-of-Fit Tests

Frequency Distribution	**Goodness-of-Fit Tests**			
	Chi-Square test		**Smirnov-Kolmogorov test**	
	$\sum X^2$	X^2 critic	Δ_{max}	Δ_{critic}
Normal	17,16	14,07	0,6278	0,3380
Log-Normal	12,80	14,07	0,8804	0,3380
Log-PearsonTipe III	10,98	14,07	0,9031	0,3380
Gumbel	17,16	14,07	0,7220	0,3380

(Source: Analysis result, 2025)

Based on the results of the rainfall frequency analysis, the ones that meet the design rainfall are based on Gumbel distribution with return periods of 5, 10, 25, 50 and 100 years respectively.

By using the Mononobe formula and design rainfall with Gumbel Distribution, the rainfall intensity is obtained as in table 2.

Table 2: Rainfall intensity with various return periods

T (Year)	R_{24} (mm)	I (mm/jam)
5	95,89	35,86
10	110,70	41,40
25	133,87	50,06
50	154,55	57,80
100	178,42	66,72

(Sources: Analysis result, 2025)

The intensity calculation for return periods of 5, 10, 25, 50 and 100 years in a time span of 10 minutes can be seen in Table 3 below:

Table 3: Rainfall Intensity with Rain Recurrence Period and Duration

T		Return period				
Minute	**Hour**	**5**	**10**	**25**	**50**	**100**
5	0.083	174.258	201,170	243,272	280,843	324,216
10	0.167	109.776	126,729	153,252	176,920	204,243
20	0.333	69.154	79,834	96,543	111,453	128,665
30	0.500	52.775	60,925	73,676	85,054	98,190
40	0.667	43.565	50,292	60,818	70,211	81,054
50	0.833	37.543	43,341	52,411	60,506	69,850
60	1.000	33.246	38,380	46,413	53,581	61,856
70	1.167	29.999	34,632	41,880	48,348	55,815
80	1.333	27.444	31,682	38,313	44,230	51,061
90	1.500	25.371	29,290	35,420	40,890	47,205
100	1.667	23.650	27,303	33,017	38,116	44,003
110	1.833	22.194	25,622	30,985	35,770	41,294
120	2.000	20.944	24,178	29,238	33,754	38,967
130	2.167	19.855	22,922	27,719	32,000	36,942
140	2.333	18.898	21,817	26,383	30,457	35,161
150	2.500	18.049	20,836	25,197	29,088	33,580
160	2.667	17.289	19,959	24,136	27,863	32,166
170	2.833	16.604	19,168	23,180	26,760	30,892
180	3.000	15.983	18,451	22,313	25,759	29,737
190	3.167	15.417	17,798	21,523	24,847	28,684
200	3.333	14.899	17,200	20,800	24,012	27,720
210	3.500	14.422	16,649	20,134	23,243	26,833
220	3.667	13.982	16,141	19,519	22,534	26,014
230	3.833	13.573	15,670	18,949	21,876	25,254
240	4.000	13.194	15,231	18,419	21,264	24,547
250	4.167	12.839	14,822	17,924	20,693	23,888

260	4.333	12.508	14,440	17,462	20,159	23,272
270	4.500	12.197	14,081	17,028	19,658	22,694
280	4.667	11.905	13,744	16,620	19,187	22,150
290	4.833	11.630	13,426	16,236	18,743	21,638
300	5.000	11.370	13,126	15,873	18,324	21,154
310	5.167	11.124	12,842	15,530	17,928	20,697
320	5.333	10.891	12,573	15,205	17,553	20,264
330	5.500	10.670	12,318	14,896	17,196	19,852
340	5.667	10.460	12,075	14,602	16,857	19,461
350	5.833	10.260	11,844	14,323	16,535	19,088
360	6.000	10.069	11,624	14,056	16,227	18,733

(Sources: Analysis result, 2025)

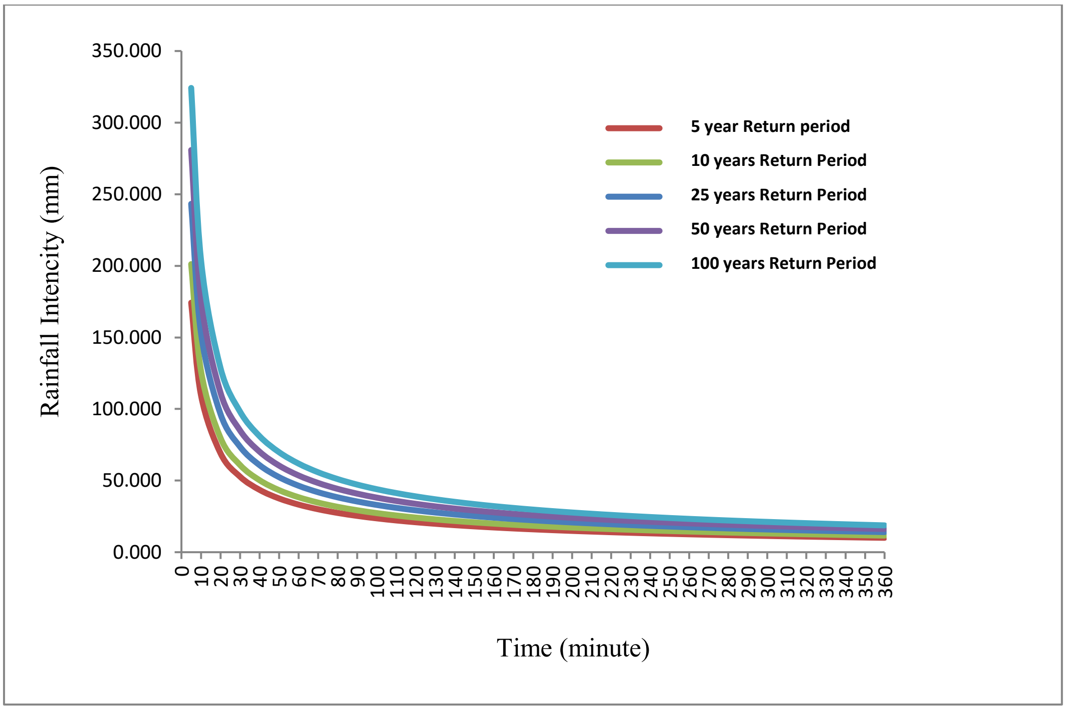


Figure 3: *Intencity Duration Frequency* (IDF) Curve

3.3. Flow Discharge (Q)

Q = 0.2778 C I A
with:
Q = Peak discharge (m^3/sec)
C = Runoff coefficient
I = Rain intensity with duration equal to flood concentration time (mm/hour)
A = Catchment area (km^2)

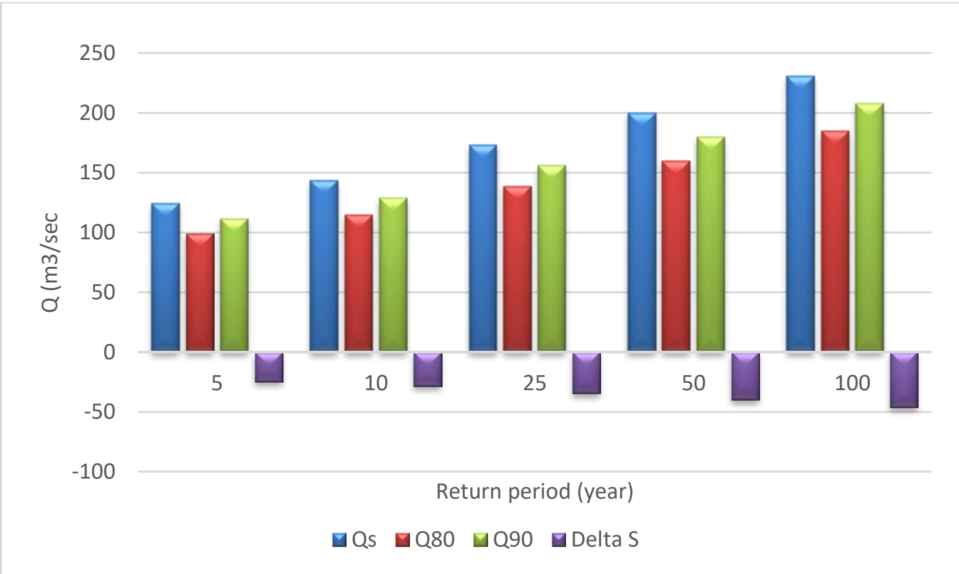
Q_5 = (0,2778) x (0,85) x (35,864 mm/jam) x (877,3 km^2)
Q_5 = 124,066 m^3/det

Table 4: The results of the recapitulation of the mainstay flow discharge (Q_{80}) and (Q_{90}) for each return period

Return Period (Years)	Qs (m^3/det)	Q_{80} (m^3/det)	Q_{90} (m^3/det)	Δs (m^3/det)
5	124,066	99,252	111,659	-24,813
10	143,228	114,582	128,905	-28,645
25	173,203	138,563	155,883	-34,640
50	199,947	159,958	179,953	-39,989
100	230,834	184,667	207,751	-46,166

(Sources: Analysis result, 2025)

The availability of water with Qs (storage capacity) (Qs) with Q80 (reliable discharge 80% and Q90 (reliable discharge 90% can be explained as in Figure.



(Sources: Analysis result, 2025)

Figure 3: Flow discharge (Qs) with mainstay Q_{80} and $Q_{90}$of Lematang watersheed

3.4. Water balance based on 80% discharge (Q_{80})

The results of the analysis of total water needs at the intake gates for the projection years 2020, 2025 and 2035. Cumulatively, the water needs in 2020 were 371,508 m3/sec. Then for 2025 it is currently 728,242 m3/sec and for 2035 it will be 2,518,551 m3/sec. Based on the results of the analysis, for 10 years (2025-2035) there will be an increase in the need for clean water in Muara Enim Regency due to the relatively increasing population growth along with the growth of residential areas spread across the regency, especially the city of Muara Enim itself.

Table 7: Total water requirement at intake

No.	Description	Unit	Projection Year		
			2020	2025	2035
1	Total Population	jiwa	24.165	47.369	163.821
	service coverage	%	65	65	65
		soul	15.707	30.790	106.484
2	domestic water needs				
	a. service target	Unit	SR & HU	SR & HU	SR & HU
	b. clean water service				
	- home connection	%	80	80	80
		soul	12.566	24.632	85.187
		ltr/day	753.948	1.477.913	5.111.215
		m3/year	275.191	539.438	1.865.594
	- public hydrant	%	20	20	20
		soul	3.141	6.158	21.297
		ltr/day	94.244	184.739	638.902
		m3/year	34.399	67.430	233.199
	c. total domestic water requirements	m3/year	309.590	606.868	2.098.793
3	Total Water Needs Service Coverage	m3/year	309.590	606.868	2.098.793
4	Water Loss to Water Needs	%	20	20	20
	(to service area)	m3/year	61.918	121.374	419.759
	Total Water Requirement at Intake	m3/year	**371.508**	**728.242**	**2.518.551**

(Sources: Analysis result, 2025)

Water balance analysis in the Lematangwatersheed includes water requirements (m^3) in 2020, 2025 and 2035, potential water availability (m^3) on average from 2020, 2025 and 2025 and water balance based on 2015, and in 2025 and 2035.

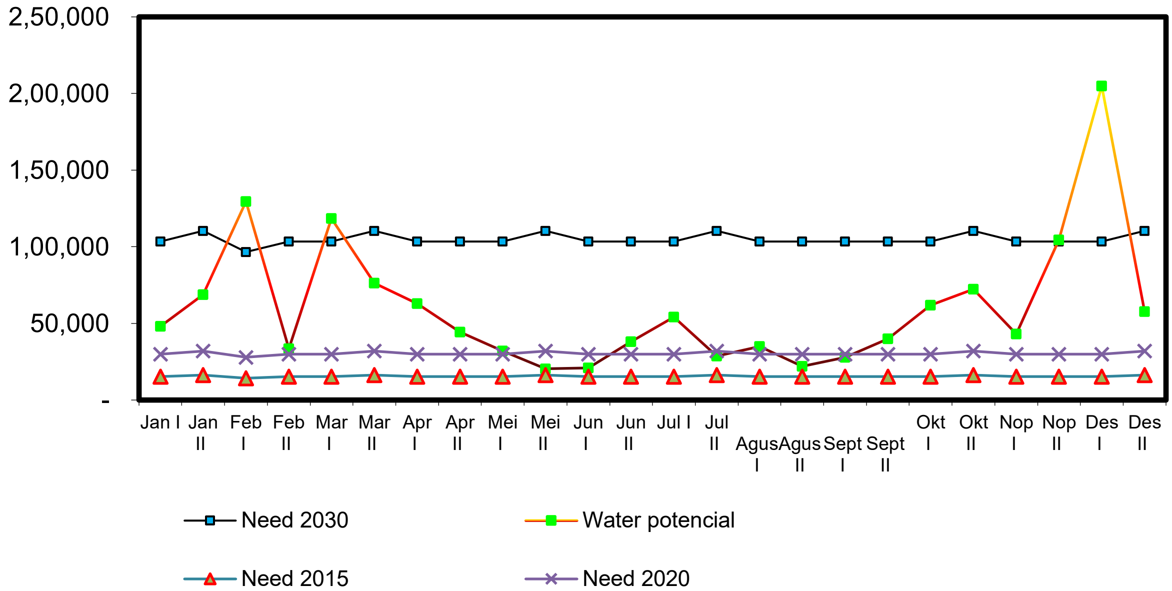


Figure 4: Lematang river water balance with a mainstay discharge of 80%

IV. CONCLUSION

This study can be concluded as follows:

1. Water availability Qs (storage capacity) with various return periods, each Q_5 is 124.066 m^3/sec; Q_{10} is 143.228 m^3/sec; Q_{25} is 173.203 m^3/sec; Q_{50} is 199.947 m^3/sec and Q_{100} is 230.834 m^3/sec.
2. The reliable capacity (Q_{80}) required for clean water with various return periods, each Q_5 is 99.252 m^3/sec; Q_{10} is 114.582 m^3/sec; Q_{25} is 138.563 m^3/sec; Q_{50} is 159.958 m^3/sec and Q_{100} is 184.667 m^3/sec.
3. The water balance in the Lematangwatersheed in 2020 of 371,507.88 m^3 is still smaller than the water availability of 1,444,659.58 m^3; likewise in 2025 where the water requirement of 728,241.53 m^3 is still smaller than the water availability of 1,444,659.58 m^3. In 2035 there was a water imbalance, where the water requirement of 2,518,551.29 m^3 was greater than the water availability of 1,444,659.58 $m^{3.}$

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