Maximization Of The Capacity Of Flood Control Dam For Raw Water Reserve In Sampang City

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Abstract: The soil in Sampang Regency has low water absorption capacity. This is due to the topsoil is dominated by clay soil, while the subsoil is weathered from limestone. As a result, rainwater tends to be surface runoff and difficult to absorb into the ground, thus the flood discharge is high. This condition makes Sampang Regency experience limited groundwater resources, so that raw water needs are more dependent on the river water (flood water). Samiran river, with its dam, is one of the major sources of raw water for the fulfillment of irrigation water, and for drinking water as well. The topography around the dam location makes the Samiran river potential for flood water reservoir. This study aimed to analyze the water quality in Samiran dam, as well as the volume of flood water that can be used as raw water. In general, the results of this study show that the water quality of Samiran dam was in accordance with the standards for raw water. In addition, the potential for flood water that can be used as raw water was 50 l/sec, to support water needs for 344 days.

Index Terms: River water, surface water reservoir, raw water.

1. INTRODUCTION

The development and changes of environmental conditions resulted in a considerably large differences in river discharge, ie between the rainy season and the dry season. Therefore, flooding and sedimentation have always been one of the consequences that can ultimately reduce the potential for discharge and the capacity and function of existing water structures. Sampang Regency has the main potential of water resources (SDA) in the form of flood water or river water. Clean water services in the Sampang Regency region receive considerable attention, because residents are not easy to utilize shallow ground water. This is common in soils formed from limestone, which generally have a high level of porosity with high physical spatial variants of the soil. Sampang Regency has an upper layer of land dominated by clay soil, while the underground layer is weathered from limestone. As a result, rainwater tends to be surface runoff and difficult to absorb into the ground, so that flood discharge is high and bottom flow is low. This condition makes Sampang Regency experience limited groundwater resources, so that raw water needs are more dependent on river water (flood water). Samiran river, which is complete with dams, is one of the sources of raw water for the fulfillment of irrigation water, and even for drinking water. The topography around the dam location makes the Samiran river very potential for flood storage facilities. The condition of the samiran river during the study, as well as the location of the flood overflow plan, is shown in Figure 1. The storage of flood water that will be used for raw water is carried out to the left of Samiran Dam.

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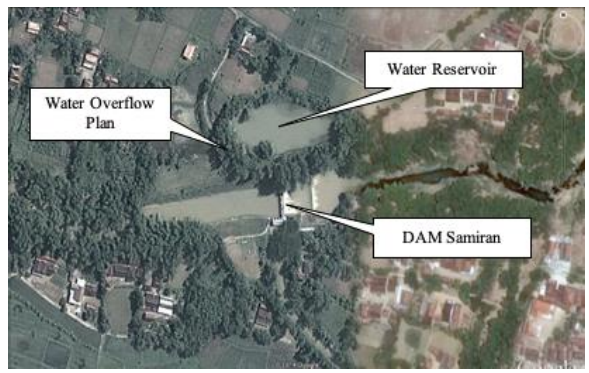

Figure 1. *The site of flood control dam*

Efforts to meet the need for clean water for residents of the City of Sampang must be accompanied by a policy to increase the capacity of the water supply system from the PDAM. Efforts to increase the supply capacity of raw water sources by utilizing the potential of Samiran flood dam water require in-depth analysis, especially related to the available dam storage capacity. However, the first step that must be done is to do a water quality analysis. Water quality analysis is very important to be done to ensure that river water used as raw water has a standard quality that is not polluted. This is important to ensure the safety of the community in using water, ie there are no adverse impacts on health. One study on water quality that can be used as an illustration is Sheftiana et al. (2017) who conducted research on the Gelis River in Kudus Regency, Central Java. The results of his research showed that river water quality was included in the medium polluted category. This condition is certainly not expected to occur in Samiran river water, considering that Sampang Regency is in dire need of river water as raw water for various purposes.

Other research related to analyzing the potential of rivers to support water needs is Priambodo et al. (2015) who examined the Lingseng river in Cemoro Village, Temanggung Regency, Central Java. The results show that there is a deficit of 27,140.23 m3, so it has the potential to reduce agricultural productivity. Thus, to overcome the water balance deficit, a dam was designed with a minimum capacity of 27,140.23 m3 and a total capacity of 30,653.45 m3. The elevation of the overflow lighthouse is +1.542 m, with an elevation elevation of +1.545.5 m. In addition, Susanto and Yedida's research (2017) related to the reliability of the Molintogupo reservoir reservoir (Bone Bolango Regency, Gorontalo Province) for raw water needs using the F.J Mock method showed a water shortage of 1,555,200 liters. In addition, it is known that the reservoir storage capacity that meets the raw water needs is 3,874.95 m3, so it requires a spillway height of 5 m and a water level elevation of + 183.5 m. This study aims to analyze the quality of Samiran dam water, the potential for flood discharge that can be used for raw water reserves, as well as the capacity of flood water reservoirs that must be provided. The results of this study are expected to be the basis for the development of the Samiran dam and its maintenance in order to always meet the water needs of the people of Sampang Regency.

2. METHOD

2.1 Water Quality Standard

River water that will be used as a raw water source plan to meet drinking water needs must be adjusted to the existing quality standards. In this study, the standard water quality standard used was Minister of Health Regulation No. 492 / MENKES / PER / IV / 2010 concerning Drinking Water Quality Requirements.

2.2 Prediction of Discharge Potential

In this study, prediction of the potential for large base flow discharges was made by considering rainfall and watershed conditions, namely the NRECA and F.J methods. Mock The data needed in the mainstay discharge analysis using the NRECA method is 10 daily rainfall, evapotranspiration (calculated using temperature data), relative humidity, wind speed and length of solar radiation. Initial moisture storage and initial groundwater storage values are obtained by try and error. Furthermore, as a control at the end of the calculation, the value of the initial humidity pool (period I January) must approach the final settlement capacity (period III December). In the FJ-Mock method, the monthly discharge calculation is done with the assumption that the rain falling in the catchment area is partially lost through evapotranspiration, partly seeping into the ground (infiltration) and the rest will be runoff. The F.J.Mock method has 2 principles for calculating surface runoff that occur in rivers, namely the water balance under the ground which are all based on rain, climate and soil conditions.

2.3 Prediction of discharge of the flood water

Flood discharge prediction is based on design rain and base flow discharge using the Synthetic Unit Hydrograph (Nakayasu) method. The use of this method is due to the absence of simultaneous hourly rain and discharge data, so modeling must be made. In addition, because the watershed studied has a distinctive character in hilly areas.

3. RESULT AND DISCUSSION

3.1 Water Quality

The results of water quality analysis in the Samiran watershed are shown in Table 1. Water quality analysis was carried out at the Water Quality Monitoring Laboratory, Pamekasan District Health Office.

Table 1. *The result of water quality analysis*

No.	Parameters	Unit	Result	Standard*
	PHYSICAL			
1	Odor	-	Odorless	Odorless
2	Total Dissolved Solids (TDS)	mg/L	329	1500
3	Turbidity	NTU	0.99	25
4	Taste	-	Tasteless	Tasteless
5	Color	-	Colorless	Colorless
6	Temperature	°C	30	± 30
	CHEMICAL			
7	Iron (Fe)	mg/L	0.05	1.0
8	Mangan (Mn)	mg/L	0.03	0.4
9	Nitrate as N	mg/L	10	10
10	Nitrite as N	mg/L	0.05	1.0
11	pH	-	7.3	6.5-9.0
12	Chloride (Cl)	mg/L	40	600
13	Hardness as CaCo3	mg/L	303	500

*Regulation of the Health Minister, Republic of Indonesia No. 416/MENKES/PER/IX/1990

Source : Research data (Laboratory of water quality control, Health Department of Pamekasan Regency)

Based on the results of laboratory tests, it can be stated that the quality of the Samiran dam water is proven to meet the standards and can be utilized for drinking water needs. However, water treatment needs to be done first to ensure that the water is completely clean of all pollutants. Quality river water that has been confirmed can be channeled to the community through pipes. If the raw water has been treated in drinking water treatment, then the community can get safe drinking water to be used as raw material for drinking water or for other purposes.

3.2 Potential Discharge

The results of the calculation of base flowrate using the F.J Mock method are shown in Table 2.

Table 2. *Potential discharge from 2004 to 2013*

Month	Discharge (m3/sec)									
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Jan	8.8324	1.1365	5.7144	1.5731	4.8210	5.4476	5.7575	7.0664	7.7445	5.5306
Feb	8.7766	3.4438	4.3916	7.2495	6.9479	5.2356	4.4315	3.0002	10.163	6.9498

									1	
Mar	5.9105	4.1998	3.8865	5.7898	6.1554	3.2273	10.6563	6.6005	6.6832	11.4398
Apr	2.4673	2.6217	3.2833	5.9771	3.5771	3.1399	12.4948	9.7722	4.9727	10.5669
May	2.5038	1.0545	5.0684	2.6077	1.4981	5.4759	9.6529	7.2991	3.6451	12.0043
Jun	1.6309	2.2804	1.8297	2.0332	1.7090	1.9417	6.6507	2.9421	1.5387	9.7180
Jul	0.6715	0.7675	0.8853	0.8333	0.6460	0.9395	4.5944	1.4236	0.7445	3.6956
Aug	0.3357	0.3838	0.4427	0.4167	0.3230	0.4698	3.0666	0.7118	0.3723	1.8478
Sep	0.1735	0.1983	0.2287	0.2153	0.1669	0.2427	4.5437	0.3678	0.1923	0.9547
Oct	0.0839	0.5129	0.1107	0.9404	1.2031	0.1174	5.0162	0.1779	0.0931	0.4619
Nov	0.0434	0.1788	0.0572	2.9419	6.8809	0.0607	5.6912	8.3779	4.2581	0.2387
Dec	0.0210	6.3905	0.0277	6.3985	7.6754	1.9890	8.4872	7.2804	6.0517	0.1155
Min.	0.0210	0.1788	0.0277	0.2153	0.1669	0.0607	3.0666	0.1779	0.0931	0.1155
Ave.	2.6209	1.9307	2.1605	3.0814	3.4670	2.3573	6.7536	4.5850	3.8716	5.2936
Max.	8.8324	6.3905	5.7144	7.2495	7.6754	5.4759	12.4948	9.7722	10.1631	12.0043

Furthermore, from the calculation of the mainstay debit, the mainstay debit obtained 80% in the 2009 basic planning year as follows:

Table 3. *Potential discharge 80% of Samiran watershed, planning year2009*

Month	Number of days	Discharge (m3/sec)	Volume (m3)
Jan	31.0	5.4476	14,590,898.58
Feb	29.0	5.2356	13,118,307.83
Mar	31.0	3.2273	8,643,896.35
Apr	30.0	3.1399	8,138,546.40
May	31.0	5.4759	14,666,745.57
Jun	30.0	1.9417	5,032,879.69
Jul	31.0	0.9395	2,516,439.84
Aug	31.0	0.4698	1,258,219.92
Sep	30.0	0.2427	629,109.96
Oct	31.0	0.1174	314,554.98
Nov	30.0	0.0607	157,277.49
Dec	31.0	1.9890	5,327,334.67
Total		28.2871	74,394,211.284
Average		2.3573	6,199,517.607

3.3 Discharge Of The Flood

The results of the unit discharge hydrograph analysis at the Samiran DAM Location using the Nakayasu HSS method are explained as follows:

Table 4. *The result of HSS Nakayasu of Samiran watershed*

No	Time	t/Tp	(t-Tp)/T0,3	(t - Tp + 0,5. T0,3)/ 1,5 T0,3	(t - Tp + 1,5. T0,3)/2 T0,3	UH
1	0	0.00	-0.69	-0.12	0.41	0.000
2	1	0.47	-0.36	0.09	0.57	7.459
3	2	0.95	-0.03	0.31	0.73	39.367
4	3	1.42	0.29	0.53	0.90	31.441
5	4	1.90	0.62	0.74	1.06	21.246
6	5	2.37	0.94	0.96	1.22	14.357
7	6	2.85	1.27	1.18	1.38	10.800
8	7	3.32	1.59	1.40	1.55	8.317
9	8	3.80	1.92	1.61	1.71	6.404
10	9	4.27	2.24	1.83	1.87	4.932
11	10	4.75	2.57	2.05	2.03	3.851
12	11	5.22	2.90	2.26	2.20	3.166
13	12	5.70	3.22	2.48	2.36	2.602
14	13	6.17	3.55	2.70	2.52	2.139
15	14	6.64	3.87	2.91	2.69	1.758
16	15	7.12	4.20	3.13	2.85	1.446
17	16	7.59	4.52	3.35	3.01	1.188
18	17	8.07	4.85	3.57	3.17	0.977
19	18	8.54	5.17	3.78	3.34	0.803
20	19	9.02	5.50	4.00	3.50	0.660
21	20	9.49	5.82	4.22	3.66	0.543
22	21	9.97	6.15	4.43	3.83	0.446

No	Time	t/Tp	(t-Tp)/T0,3	(t - Tp + 0,5. T0,3)/ 1,5 T0,3	(t - Tp + 1,5. T0,3)/2 T0,3	UH
23	22	10.44	6.48	4.65	3.99	0.367
24	23	10.92	6.80	4.87	4.15	0.301
25	24	11.39	7.13	5.08	4.31	0.248

Furthermore, the flood hydrograph based on the Nakayasu HSS and the hourly rain above can be determined as follows:

Tabel 5. *Hydrograph of the flood in Samiran watershed*

No.	T (hour)	Discharge						
		UH (m3/sec/mm)	Q2 (m3/sec)	Q5 (m3/sec)	Q10 (m3/sec)	Q25 (m3/sec)	Q50 (m3/sec)	Q100 (m3/sec)
1	0	0.000	10.00	10.00	10.00	10.00	10.00	10.00
2	1	7.459	31.66	32.79	33.11	33.30	33.36	33.40
3	2	39.367	128.01	134.28	136.04	137.08	137.46	137.65
4	3	31.441	123.37	129.90	131.74	132.82	133.21	133.42
5	4	21.246	102.94	108.65	110.26	111.21	111.55	111.73
6	5	14.357	85.71	90.60	91.98	92.79	93.08	93.23
7	6	10.800	75.21	79.55	80.77	81.49	81.74	81.88
8	7	8.317	67.05	70.93	72.03	72.67	72.90	73.02
9	8	6.404	58.94	62.34	63.29	63.86	64.06	64.16
10	9	4.932	46.75	49.29	50.01	50.43	50.58	50.66
11	10	3.851	37.45	39.33	39.86	40.17	40.29	40.34
12	11	3.166	31.33	32.78	33.18	33.42	33.51	33.56
13	12	2.602	26.97	28.12	28.44	28.63	28.70	28.74
14	13	2.139	23.63	24.54	24.80	24.95	25.01	25.04
15	14	1.758	21.01	21.75	21.95	22.08	22.12	22.14
16	15	1.446	18.95	19.55	19.71	19.81	19.85	19.87
17	16	1.188	17.32	17.81	17.95	18.03	18.06	18.07
18	17	0.977	16.02	16.42	16.53	16.60	16.62	16.63
19	18	0.803	14.95	15.28	15.37	15.42	15.44	15.45
20	19	0.660	14.07	14.34	14.41	14.46	14.47	14.48
21	20	0.543	13.34	13.57	13.63	13.66	13.68	13.69
22	21	0.446	12.75	12.93	12.98	13.01	13.02	13.03
23	22	0.367	12.26	12.41	12.45	12.48	12.49	12.49
24	23	0.301	11.86	11.98	12.02	12.04	12.04	12.05
25	24	0.248	11.53	11.63	11.66	11.67	11.66	11.68
Q Maksimum '(m3/dt)			128.01	134.28	136.04	137.08	137.46	137.65

Based on Table 5, the resulting flood hydrograph image is as follows:

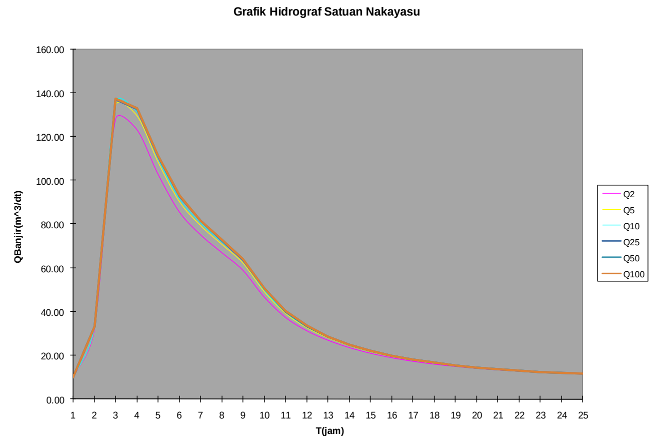

Figure 1. *Hydrograph of water discharge in Samiran watershed*

3.4 Potential Capacity of Samiran Watershed

The intake of raw water is done by channeling water to the reservoir using an overflow building by utilizing the high water level of the flood that is on the Samiran River. The overflow also functions as a takeaway structure placed at the upstream of the Samiran Dam. In order not to disturb the irrigation water supply and minimize incoming sediment, the overflow height is placed parallel to the height of the lighthouse. The maximum flood discharge in the Samiran River can be seen in the following table:

Table 6. *Maximum flood discharge in Samiran watershed*

Annual repetition	Discharge (m3/sec)
2	128.01
5	134.28
10	136.04
25	137.08
50	137.46
100	137.65

Based on the calculation, the flood plan discharge that will be used to be accommodated as a source of raw water is taken at the time of 2.5, and 10 years. Based on the results of calculations, floods obtained at flood waters and at normal water levels are as high as the Samiran Dam lighthouse. After that, the potential for taking is based on flood level and normal water level (see figure 2).

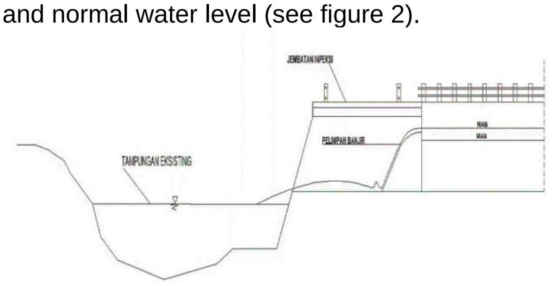

Figure 2. *Concept of water distribution system*

Based on the calculation, the flood plan discharge that will be used to be accommodated as a source of raw water is taken at the time of 2.5, and 10 years. Based on the results of calculations, floods obtained at flood waters and at normal water levels are as high as the Samiran Dam lighthouse. After that, the potential for taking is based on flood level and normal water level (see figure 2).

Table 7. *Calculation of curve rate*

Elevation M.A (m)	H (m)	A (m2)	P (m)	R (m)	V (m/sec)	Q (m3/sec)
19.00	0	0.00	21.00	0.00	0.00	0.00
20.00	1	21.25	23.06	0.92	0.82	17.43
20.50	1.5	32.06	24.09	1.33	1.05	33.59
21.00	2	43.00	25.12	1.71	1.24	53.28
21.50	2.5	54.06	26.15	2.07	1.41	75.97
22.00	3	65.25	27.18	2.40	1.55	101.30
22.50	3.5	76.56	28.22	2.71	1.68	128.99
23.00	4	88.00	29.25	3.01	1.80	158.84
23.50	4.5	99.56	30.28	3.29	1.92	190.67
24.00	5	111.25	31.31	3.55	2.02	224.35
24.50	5.5	123.06	32.34	3.81	2.11	259.77
25.00	6	135.00	33.37	4.05	2.20	296.84
25.50	6.5	147.06	34.40	4.28	2.28	335.48

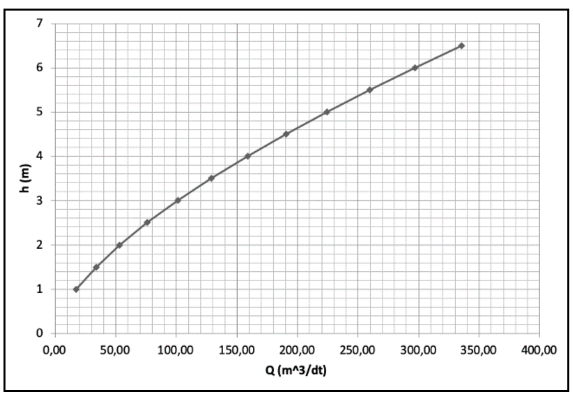

Figure 3. *Relationship of water surface and water discharge*

Based on the calculation of the relationship between water level and discharge, it is known that the water level during flood discharge with a return period of 2.5 and 10 years is as follows:

Table 8. *Water surface and flood discharge*

Annual repetition	Discharge (m3/sec)	h (m)	Elevation M.A (m)
2	128.01	3.53	22.53
5	134.28	3.60	22.60
10	136.04	3.62	22.62
25	137.08	3.66	22.66
50	137.46	3.71	22.71
100	137.65	3.78	22.78

The planned overflow is open overflow with a fixed threshold in order to be able to direct and regulate the flow and flow of water that will cross the overflow, facilitate the implementation and also for the stability of the building. The overflow dimension is planned to have a width (L) of 3.00 m and a height of 3.00 m (height of the Samiran Dam lighthouse). Thus, the results of water level elevation and overflow capacity are obtained (Table 9).

Table 9*. Elevation of water surface and distribution capacity*

Elev M.A	H	C	Leff	Q
22.00	0.00	1.600	3.00	0.00
22.10	0.10	1.609	2.98	0.15
22.20	0.20	1.618	2.95	0.43
22.30	0.30	1.627	2.93	0.78
22.40	0.40	1.636	2.90	1.20
22.50	0.50	1.645	2.88	1.67
22.60	0.60	1.653	2.86	2.19
22.70	0.70	1.662	2.83	2.76
22.80	0.80	1.670	2.81	3.36

Based on the calculation results, the maximum water discharge that can be flowed during floods is 3.36 m3 / sec. In addition, the existing storage at the work location has an area of 514.82 m2 with an exiting storage capacity of 2060 m3.

3.5 Flood Water Discharge That Can Be Used

a. Calculation of the amount of surface water runoff in the Samiran River (annually)

Q 2 = Das width (m2) x coefficient x rain intensity (mm)
= 103,378,000.00 x 0.5 x 1800/1000
= 93.040,200,00 m3

b. Potential volume after allocation of water loss in the reservoir (20%)

Volume netto= Volume – (Volume x 280%)
= 74.432.160,00m3

c. Flood water discharge that can be utilized with constant collection for 365 days

Q net = Voleme netto/(365 x 24 x 60 x 60)
= 2,36 m3/second.

4. CONCLUSION

The results of water quality analysis demonstrated that the Samiran river water met the requirements for raw water based on the Regulation of the Health Minister, Republic of Indonesia No. 416/MENKES/PER/IX/1990. Furthermore, in the calculation of flood design of the river Samiran, the peak flood discharge is in the second t (hour) with a discharge Q2 = 128 m3/sec, Q5 = 134.28 m3/sec, Q10 = 136.04 m3/sec, Q25 = 137.08 m3/sec, Q50 = 137.46 m3/sec and Q100 = 137.65 m3/sec. The collection system of the dam water can be done by using an overflow construction that is placed upstream of the weir to flow the water to the existing reservoir on the side of the Samiran dam. In this system, the height of the overflow head level is the same as the Dam height so that it does not interfere with irrigation water supply. Water dam can support the need for raw water with the dischrage of 50 l/sec, for 344 days.

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