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DESALINATION REJECT WATER UTILIZATION for REVERSE OSMOSIS PLANT RAW WATER

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ABSTRACT

Desalination plant serves to treat seawater into raw water through the evaporation process. In Muara Tawar power plant, desalination plant commonly used to supply raw water for combined cycle power plant. Distillate water from desalination plant must have certain criteria (conductivity <20 µs/cm). Distillate water with conductivity higher than 20 µs/cm will be removed. Reverse osmosis (RO) plant in block 5 in Muara Tawar power plant need raw water with conductivity <32000 µs/cm so that dump water from block 1 can be utilized. Desalination dump water can be utilized as a raw water for RO plant block 5. By utilizing dump water from block 1 to raw water block 5 there are several financial benefits. Until December 2017 saving by using dump water is IDR 586,587,603, - and saving from electricity is IDR 4,069,531, -.

KEYWORDS: Desalination, Reverse Osmosis, Water

1. INTRODUCTION

Water in electric generation is an essential material [1]. Water supply in Muara Tawar power produeced by desalination plant. Desalination plant serves to treat seawater into raw water through the evaporation process. Seawater evaporation occurs by conditioning the temperature and pressure on the evaporator modules. Sea water vapor is filtered by demister and the salts will be left in the demister. The vapor will be flowed through the distillate tray into desalination products. Desalination plant obtained energy from steam supplied by auxiliary boiler, while the water pressure is obtained from the desalination sea water supply pump. To obtain the standard water quality, the chemical injection system for anti foam and anti scale) were added. Operation of combined cycle power plant (CCPP) requires amount of water to producing steam with certain quality and quantity [2]. When the conductivity value of the treated seawater is less than the standard conductivity value (<20µS/cm), the water will be transferred into the raw water tank. In Muara Tawar power plant, desalination plant commonlyis used to supply raw water for combined cycle power plant. Distillate water from desalination plant must have certain criteria such as conductivity <20 µs/cm. Conductivity is an intrinsic property of a solution, the ion-facilitated electron flow through it [3]. Distillate water with conductivity higher than 20 µs/cm will be removed.

Reverse osmosis (RO) plant in block 5 Muara Tawar power plant require raw water with conductivity <32000 µs/cm, hence, the dump water from block 1 can be utilized. Desalination dump water can be utilized as a raw water for RO plant block 5. At the RO Plant operation process in Block 5, there are two membrane filtration processes, i.e. by the SWRO (Sea Water Reverse Osmosis) membrane and BWRO (Brackish Water Reverse Osmosis) membrane, we will find that the output water of the membrane SWRO has a conductivity of 200 - 600 µS. That is, the water dump of block 1 desalination having a conductivity of 20 µS - 400 µS can be utilized in RO Plant Block 5. In this research, the utilization reduction of distillate water for RO plant was proposed and can be minimized by utilizing water from desalination plant.

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2. REVIEW

Reverse Osmosis

Reverse osmosis (RO) is currently the most important desalination technology and it is experiencing significant growth [4]. Reverse osmosis is a method of cleaning through a semi permeable membrane. In the membrane process, the separation of water from the impurities is based on a molecular-scale filtration process. High pressure is applied and forcing water through the reverse osmosis process from high-density to the low-density fluids. During the process, dirt and hazardous materials will be disposed as contaminated water (waste). Water molecules and micro materials smaller than reverse osmosis pores will be filtered through the membrane. Reverse osmosis system consists of 4 main processes, namely pretreatment, pressurization, membrane separation, and post treatment stabilization [5]. Figure 1. shows reverse osmosis process in a plant.

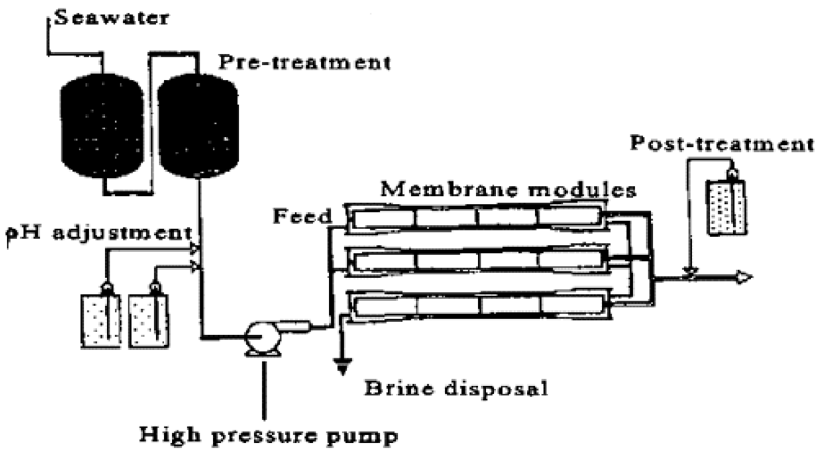

Figure 1. Reverse Osmosis Process Diagram

The feed water at the pretreatment stage is treated to the membrane by separating suspended solids, adjusting pH, and adding inhibitors to control scaling that can be caused by certain compounds, such as calcium sulfate. In pressurization phase, the pump will increase the feed pressure through the pretreatment process to the operating pressure corresponding to the membrane and salinity of the feed water.

The permeable membrane will block the flow of the dissolved salt, while the membrane will allow the water of desalinated products to pass through them. The membrane permeability will effect to the result of the presence of two stream i.e. the flow rate of clean water products and concentrated brine flow rate. Since there is no perfect membrane in this separation process, a small amount of salt can flow through the membrane and remain on the product water.
The water from the membrane separation product usually requires a pH adjustment before being delivered to the distribution system to be used as raw water. The product flows through the aeration column where the pH will be neutralized from about 5 to 7. Pretreatment systems based on reverse osmosis systems generally consist of mixing tanks, rapid sand filters, iron and manganese filters and the last is a color removal system.

Multistage Flash Desalination Plant

Desalination plant is a operation unit to convert sea water into distillate water by evaporation. The seawater conductivity from higher than 100 µs/cm is reduced into distillate water with conductivity lower than 20 µs/cm through a heat exchanger. Figure 2 shows a common desalination plant.

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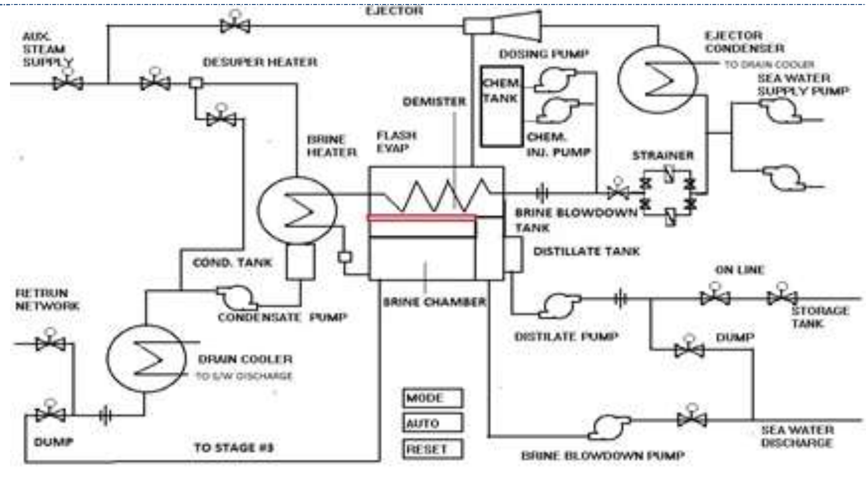

Figure 2. Desalination Plant Schematic Diagram

The seawater from the Water Intake is pumped with a pressure of 5-6 bar, then filtered by a strainer. Seawater filtered by prefilter entering flash chamber through condenser flash evaporator tube then injected anti scale and anti foam chemical solution. A small amount of sea water is used for cooling on ejector condenser and drain cooler.

The seawater is flown from tube condenser evaporator at stage 20 into condenser evaporator at stage 1 then transferred into brine heater to be heated with latent vapor (dry vapor). The seawater enter the first stage evaporator up to the last stage evaporator. Some of sea water will evaporate and the vapor is filtered by demister. Steam that contains lots of salt / mineral (not yawning) will fall into the brine chamber and continued until last brine chamber. Steam containing a small amount of salt/minerals will be distilled by the condenser evaporator tubes into distillate water. The distillate water is collected by distillate tray and then flows to distillate tank (raw water tank) using distillate pump (pressure ± 4.5 bar) under conductivity level <20 μs/cm. If the water conductivity higher or equal 20 μs / cm, it will be flowed to sea water discharge by distillate level online dump valve. High concentrated/saline-rich sea water in the brine chamber will be accommodated into the brine blowdown and then pumped to sea water discharge.

Unmarinated seawater (brine water) on 1st Stage will be forwarded to the next stage by brine orifice. At brine orifice the pressure will be increased. This is performed to keep the enthalpy down due to the loss of energy (internal energy) through the evaporation process. Since the enthalpy increases, the temperature will also increase. Brine water that flowed to brine orifice will be flashing, hence brine water will have a larger heat transfer surface. Lower pressure operating condition on each stage, flashing on brine water, enthalpy recovery, and the evaporation process at each stage will continue even as brine's water temperature is drops. In addition, sea water on the condenser evaporator tube will carry out the latent heat of the distilled brine vapor on each stage. Chamber temperature at each Stage will be maintained. If the temperature is not maintained well and the brine chamber temperature increases, it will tend to rapid scaling or fouling. This will reduce the overall heat transfer coefficient (U) and increase pressure drop in the brine chamber. In other words, desalination plant will become inefficient. Hot steam will be condensed into condensate water and flowed to condensate tank. The water will be pumped by condensate pump with pressure ± 4 bar via drain cooler and then back to ST 14/Aux. Boiler (closed cycle).

3. METHOD

Operation Studies

During the operation process, desalination plant will begin to produce distillate water when vacuum evaporator module pressure reach -0.88 bar, and sea water temperature reach 101 °C according to operational requirements.The early production, first distillate water produced may not in good quality such as the conductivity value is still around 400 μS for 3.05 hours at Block 1 and it will reduce over the time. Reverse osmosis plant operation in Block 5, where there are two filtration processes by the membrane i.e. by the membrane SWRO (Sea Water Reverse Osmosis) and BWRO

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(Brackish Water Reverse Osmosis) membrane. The water at the membrane SWRO outlet has a conductivity of 200 - 600 µS. However, the water dump of Block 1 desalination have a conductivity of 20 µS - 400 µS that it can be utilized in RO Plant Block 5.

Utilization of Water Dump Desalination Block 1

Figure 3 and 4 show new line for water dump desalination can be utilized for this purpose, in the WWTP at Block 1, sludge tank as the desalination water dump reservoir can be used because this sludge tank has enough volume capacity. After the water dump is collected, the desalination water dump is ready to utilized. The operating procedure can be describe as follow. Water flowed to permeate tank Block 5 (reservoir after SWRO) if water dump has conductivity <500 µS. It will be used as raw water for BWRO membrane. Desalination water dump temperature should be at 36 ^{o}C corresponding to operational limitation of BWRO membrane is smaller than 45^{o}C. If the water dump temperature is more than 45 ^{o}C or has conductivity more than 500 µS, it is used as a supply for sea water holding tank, where the sea water holding tank is not required maximum water dump temperature. Utilized for water sprinkling plants, water for washing and so on.

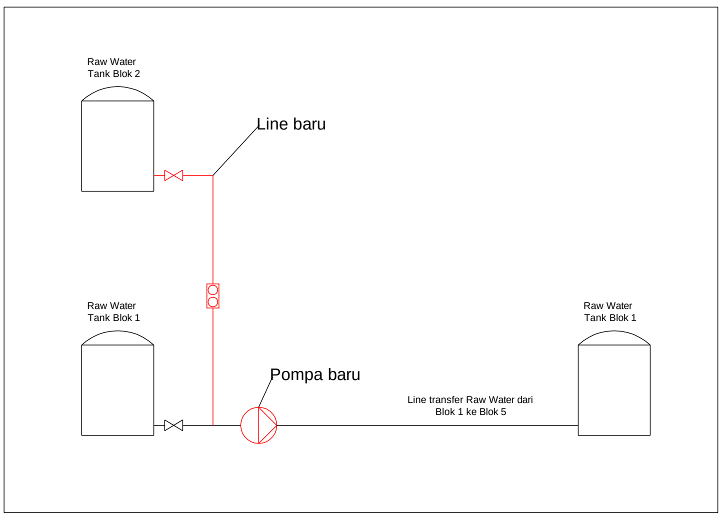

Figure 3. Additional distillate line

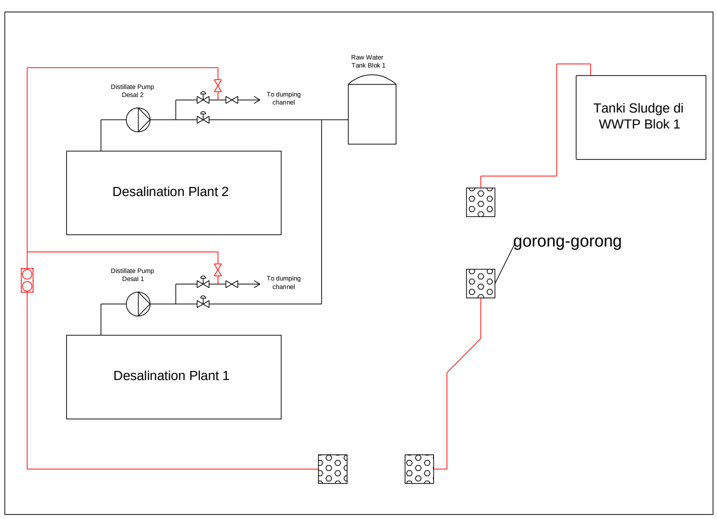

Figure 4. Additional line to the conservation tub

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Realization of Implementation.

From the engineering view of points, it can be concluded that water dump blow Block 1 can be utilized in permeate tank/sea water holding tank at Block 5 or for other purposes such as water sprinkling plants or washing water to be accommodated in sludge tanks WWTP Block 1. To realize the advantage of water dump desalination, it is required the additional line from desalination to sludge tank and continued to permeate tank / sea water holding tank Block 5.

4. RESULTS AND DISCUSSION

In order to evaluate the performance of the proposed innovation the plant data were collected as follows:

Table 1. Test Results

PJB UP MUARA TAWAR			
	INTEGRATED MANAGEMENT SYSTEM	No. Dok.	
	ISO 9001:2008 - ISO 14001:2004 - OHSAS 18001:2007 , PASS 55, MALCOLM BALDRIGE, 5S	No. Revisi	2
		Tgl. Berlaku	8 Maret 2017
	DOKUMEN LEVEL IV : FORMULIR PEMANTAUAN KUALITAS PRETREATMENT RO BLOK 5 SAAT COMBINE DARI STORAGE TANK BLOK 1	Halaman	1 dari 1

AREA	NO URUT	SAMPLE	PARAMETER	SATUAN	TANGGAL : 13 SEPTEMBER 2017 KONDISI NORMAL	KONDISI SAAT COMBINE					BATASAN
				Pukul :	14.19	15.10	16.10	17.00	18.00	19.10	
BOP Blok 5	1	Sludge Storage Tank Blok 1 [Hasil Dump Desal MSF]	SC	µs/cm	3537						Max 62 mS/cm
			pH	-	8,33						6-8
			Tubidity	NTU	1,8						Max 6
			Counter Inlet	m^3							
			Counter outlet	m^3							
		Holding Tank	SC	µs/cm	32370	28,27	2988	29,470	29870	30,570	Max 62 mS/cm
			pH	-	7,99	7,84	8,13	8,23	8,19	8,25	6-8
			Turbidity	NTU	5,88	3,73	2,91	2,54	2,66	3,16	Max 6
	2	MMF A	SC	µs/cm							
			pH	-							
			Turbidity	NTU							Max 1
		MMF B	SC	µs/cm		30,58	29,46	29000	28600	29320	
			pH	-		7.98	8.11	8.20	7,96	7,65	
			Turbidity	NTU		1,34	1,48	1,25	1,76	1,52	Max 1
		Filtered Tank	SC	µs/cm		30,44	28,79	28580	2800	2900	
			pH	-		7,93	8,15	8,25	8,20	8.12	
			Turbidity	NTU		1,26	1,25	1,24	1,37	1,18	Max 1
		Catridge Filter	Turbidity	NTU					27630	2831	
			SDI	-							< 3
			Temp	°C							Max 45

KETERANGAN :
1. Pengukuran parameter urut dari sample yang termurni hingga sample terkontaminan (No 1 s.d 2), & semua batasan di dasarkan dari manual book
2. Catat parameter dari yang beroperasi saja

PENYELIAAN LAPORAN ANALISA:

MENGETAHUI NAMA & TANDA TANGAN	
PENYELIA LABORATORIUM	SUPERVISOR PRODUKSI BLOK 5
Erlangga.	Komang Gede N. U.

From the Table 1, the conductivity of sea water in the holding tank can be shown in Figure 5.

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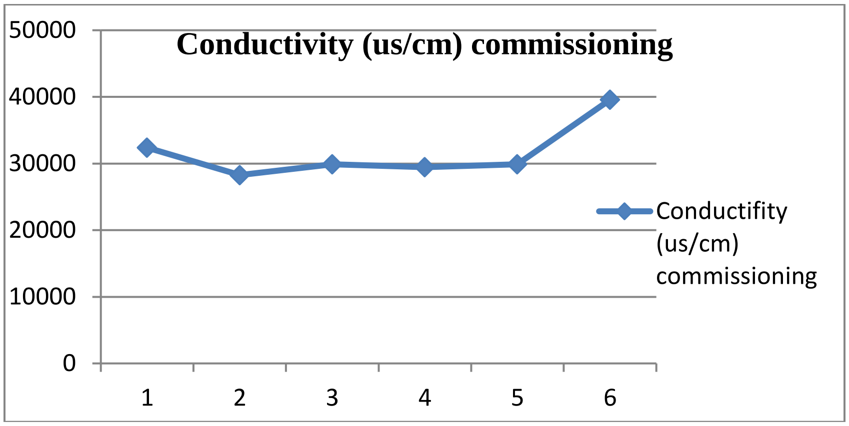

Figure 5. Graph of change of conductivity of sea water holding tank.

From Figure 5. the effect of water transfer from sludge storage tank to conductivity at sea water holding is not significant due to the large volume of required water to decrease the conductivity.

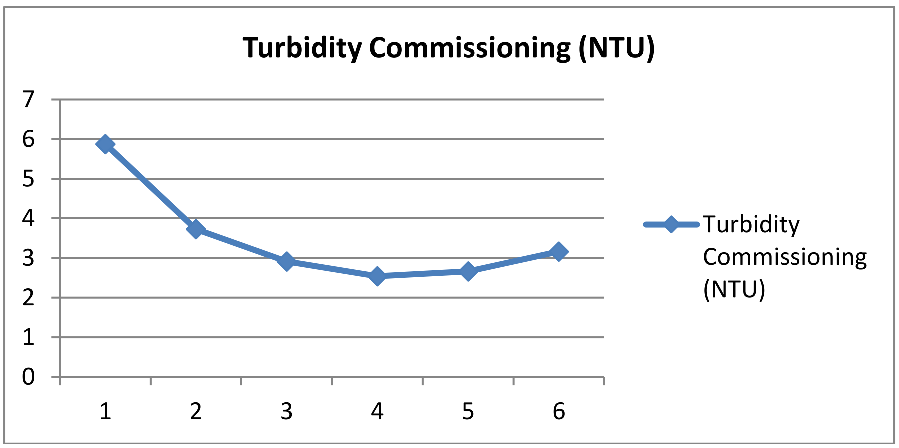

Figure 6. Graph of change Turbidity sea water holding tank.

Figure 6 shows the effect of water transfer from sludge storage tank to turbidity is very significant because the water in sludge storage tank has turbidity 1.8. Therefore the effect of water from sludge storage tank to conductivity of sea water holding tank is 9,92% and effectiveness to turbidity is 49.66%, as shown in Table 2.

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Table 2. Water effectiveness Sludge storage tanks

No.	Holding tank			
	SC (us/cm)	% (change)	Turbidity (NTU)	% (change)
1	32370		5.88	
2	28270	12.67%	3.73	36.56%
3	29880	8.81%	2.91	50.51%
4	29470	9.71%	2.54	56.80%
5	29870	8.48%	2.66	54.76%
6	39570		3.16	
Average		9.92%		49.66%

Sludge storage tank capacity is 150 m³ and sea water holding tank is 15 m³, Transfer pump have flow capacity of 25 m³/h. The water transfer pump fills the sea water holding tank block 5 and SWSP (sea water supply pump). The pump will be off if the sea water holding high level. Logic of SWSP can be seen in Figure 7.

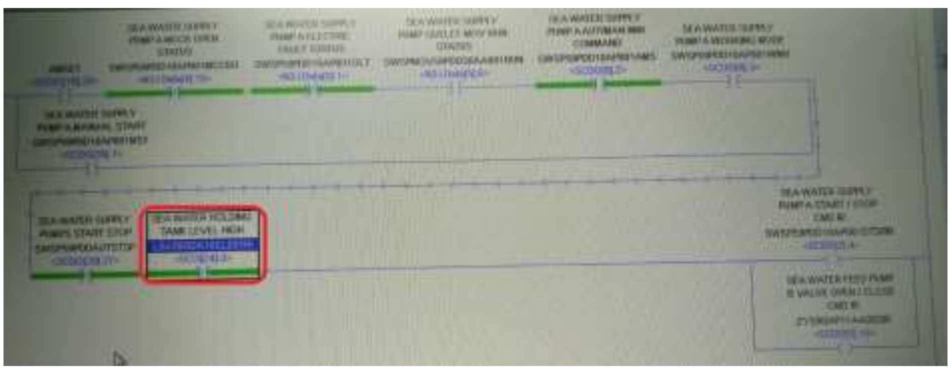

Figure 7. Logic of SWSP Auto Operation.

Since there is a difference in pump power between the SWSP and the transfer pump, there is a saving of electrical energy from each water transferred to RO plant block 5 as shown in Table 3.

Table 3. Difference in use of electrical energy.

No.	Pump	Power (kW)
1	Sea Water Supply Water Pump	20
2	Transfer Sludge Storage Pump	7.5
	Total	12.5
	Electricity Price (IDR/kWh)	1,302
	(IDR/hour)	16,275
	For 6 hours (Rp)	97,650

The difference of electricity usage is 12.5 kW. If the price of electrical energy is IDR. 1,302,-/kWh, hence the savings is IDR. 97,650,- for 6 hours. During 2017 the distillate water in the container and transferred to block 5 can be seen in the Table 4:

Table 4. Difference in electricity usage.

	Distilate input	Distilate output
February	169.1	135.7
March	469.6	246.2
April	194.6	160.4
May	409.8	282
June	498.7	465.8
July	594.8	412.8
August	95.6	0
September	2607.1	2242.2
October	1973.9	2205.2
November	62.8	100.9
December	30.5	0
Total	7,107	6,251

The main purpose of this innovation is to utilize desalination water dump which still qualifies as raw water reverse osmosis plant block 5. Dump valve in desalination will open at start time because its conductivity still not fulfill raw water quality that is <20 µS cm. The dump valve will also open when desalination is in operation if the distillation conductivity is >20 µS/cm.
Until December 2017, the desalination dump water entering the conservation basin is 7107 m^3 and the salinity to RO plant block 5 is 6251 m^3. If the cost to produce distillate water is IDR 93.836, - then the the saving is IDR 586,587,603, -.
In terms of self-saving, we can comparing the transfer kw (kW) power from the sludge tank with power (kW) of equipment in the reverse osmosis plant which is not operable if the holding tank is filled by the transfer pump from the desalination water dump reservoir.
Self-use savings can be calculated using the difference between the pump power between the SWSP and the transfer pump of each water transferred to the reverse osmosis plant block 5. SWSP power = 25 kWh and transfer pump = 7.5 kWh. Therefore, the difference is 12.5 kWh with the pump capacity 25 m^3/h. During 2017 the water has been transferred to block 5 is 6251.2 m. For the electricity savings is = 3125.6 kWh or equivalent to IDR 4,069,531, -.

5. CONCLUSION

Water desalination dump is used as raw water RO plant block 5. The desalination water dump which is collected first in conservation block 1, can improve the raw water quality of reverse osmosis plant block 5. Periodic monitoring of water conductivity in sludge tanks is necessary. If the conductivity is <400 µS then water from the sludge tank is passed to the permeate tank, if conductivity> 400 µS then the water from the sludge tank is supplied to the holding tank. By implement this research there are several financial benefits. Until December 2017 saving by using dump water is IDR 586,587,603, - and saving from electricity is IDR 4,069,531, -.

6. ACKNOWLEDGEMENTS

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