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ANALYSIS OF SHALLOW GROUND WATER CAPACITY TESTING WITH PUMPING TEST METHOD

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ABSTRACT

This thesis discusses about testing of the shallow groundwater capacity using the pumping test method in the North Loktabat of Banjarbaru area. This thesis aims to determine the groundwater level, analyze the value of transmissivity and storativity using the Cooper Jacob method and the effect of water extraction on wells.

The pumping test is carried out in two stages. First, the production well pumping test process to observe a decrease due to the pumping process and the second is the recovery test which is carried out to observe the refilling process of the production well being pumped.

Based on results, the deep groundwater level varies over time. The groundwater level increased and peaked on 23 October 2019 and decreased again due to the rainy season. The data analysis method used is the Cooper Jacob method (straight line method). Thus, the transmissivity value (T) is affected by the drawdown valuation and the longer stable time, makes smaller the transmissivity value and the storativity value (S) growing the transmissivity value as big as storativity value, because transmissivity is the ability to transmit water to deliver water to storage. The residual drawdown ability of water returns to the water level before pumping, but in October on 9, 16 and 23 the water does not return to the water level before pumping, as well as in well B (monitoring well), the conditions apply same. The effect of water withdrawal on the surrounding wells with a distance of 9m is relatively small and the distance of 15m has no effect.

Keyword: Pumping test, drawdown, residual drawdown,aquifer, Cooper Jacob

1. INTRODUCTION

Groundwater (Kodotie, 2012) is the part of water in nature that is below the ground surface. The formation of groundwater follows the cycle of water circulation on earth called the hydrologica lcycle, which is a natural process that takes place in water in nature which changes places sequentially and continuously. Ground water is a very important component for life on earth, because all living aspect need water as daily basis. In recent months, Indonesia would face the dry season that is drier than normal, South Kalimantan Province is the one of region that included (BMKG, 2019). Either, decreasing of the groundwater capacity become the impactsof the long dry season.

North Loktabat is one of the sub-district that part of Banjarbaru city. This area which is precisely located on Jalan Kartika has many vegetable farmers who grow variety of vegetables. Vegetable farmers themselves need a lot of groundwater for watering and washing vegetables, so they want to know the water capacity and whether or not they will take a lot of water from the surrounding wellspring or just called well. Farmers usually water their vegetables twice a day, morning and evening when the dry season and rainy season vegetable farmers do not water their vegetables, farmers watering their vegetables using the sprinkel method, within area around 320m which spend 600 liters of water a day according to the information of small farmer community union. Thus, in this final research we will analyze the shallow groundwater capacity test in North Loktabat.

The Cooper-Jacob method (KrusemanandDeRidder, 1991) is one of many methods that used to determine the transmissivity value and storativity coefficient of the groundwater wellspring or water resource over unsteady-state flow. The Cooper-Jacob method is also known as the straight-line method. This method can be used as an estimate to tested aquifer which is a aquifer pressure, a homogeneous and or isotropic aquifer, the aquifer is pumped with a constant flow for the well spring which is unstable. Floating method and any measuring gauge could become an intrument method for any moving water source. This is due to the compatibility and ease of implementation factors. Unlike the case with motionless water sources, the most suitable measurement of the flow of still water sources is to use the pumping test.

The pumpingtest (Harjito, 2014) is a method of measuring water discharge, the idea of which is obtained from observing the continuity of water sources and the reachable of water from the source itself. The essence of this pumping test is the comparison between the decrease in the water level at the time of pumping to the increase in thewater level during recovery at the same time.

Formulation of the problem

The problems to be discussed can be formulated as follows:

1. How the level of condition of the groundwater for different variations each time?
2. How to analyze the transmissivity value to testing the wells using the Cooper Jacob method?
3. How is the groundwater storage capacity?
4. How is the abilityof the residual drawdown of the aquifer to refill after the well has been pumped?
5. How does pumping up groundwater will affect the level of the wells around it?

Research Objectives

The objectives of this study are as follows:

1. To determine the condition of the ground water level at different time variations.
2. To analyze the transmissivity value of the tested well spring using the Cooper Jacob method.
3. To determine the storage capacity of thegroundwater.
4. To determine the ability of the residual drawdown aquifer to replenish after the tested wellspring is pumped.
5. To determine the effect of water level of the wells around after groundwater pumped.

Problem Limitation

As for the limitation of the problem in this study are:

1. The study onlytested 3 wells as watersource.
2. The 0.0 elevation is at ground level.
3. In this study using the Cooper Jacob method
4. The shallow water wellspring tested
5. The data took on September, October and November 2019
6. The location of this research is located on Kartika Street, Loktabat Utara Village, which is a part of Banjarbaru Utara Sub-district in Banjarbaru City, South Kalimantan Province. Geographically the location of the pumping test research is located at position 3 ° 26'43.1 "SL - 114 ° 48'11.2" WL.

Research Advantage

The benefit of this research is to provide information about the effect of water extraction from nearby wells,therefore it provides information for vegetable farmers about the water balance between existing capacity requirements.

Research Location Map

Below is a map of the pumping test research location which is located on Jalan Kartika Loktabat Utara Banjarbaru as follows:

Picture 1 Research Location Map

2. REVIEW OF THE PROBLEM

Pumping Test

The pumping test is also known as the aquifer test. The purpose of this aquifer test is to determine the constancy of the aquifer such as transmissivity and storage coefficient. This aquifer test is very important for planning and control of water source. This method used Cooper Jacob method or also called the straight line to calculate the parameters such as transmissivity and storativity, which is influenced by the time concept which is done graphically.

The stages of aquifer testing are often referred to aspumping stage, namely:

1. Continuous Pumping, Continuous pumping test is carried out continuously with a stable rate. This test is performed to observe the decrease in the ground water level and if a drastic drop in the water level is found and affects other existing well springs, the pumping test is carried out with a decrease in the discharge. (Susiloputri& Farida, 2011).
2. The recovery test is carried out after the continuous test is done, at the recovery test stage the pump is turned off and an increase in groundwater (recharge) is observed after pumping is stopped. At this stage, it can be seen whether the groundwater is replenished or not. (Susiloputri& Farida, 2011).

Wellsprings Characteristics

To find out the amount of pump discharge produced by one of the well, it is done by means of the pumping test / aquifer test. Pumping is carried out by pumping groundwater from the tested well at a constant flow rate. In this test, the aquifer parameters discovered, in the form of the transmissivity coefficient (T) and the storage coefficient (S).

Accordingto Jacob (Susiloputri& Farida, 2011), if the relationship between the time period (t) since pumping started and the drop in water level (s) in the test / observation well is roughly a straight line, then:

$$T = \frac{2{,}3 \times Q}{4 \times \pi \times \Delta s}$$

$$S = \frac{2{,}25 \times T \times t_0}{r^2}$$

Which is:

T = Transmissivity Coefficient (m^2/day)

S = Storativity Coefficient

Q = large pumping discharge (m^3/day)

Δs = The differencein s in one logarithmic cycle in t

to = time for s = 0 (day)

r = Distance between pumping wells and test wells/observation (m)

If the calculation is based on the recovery of the water surface, if the pumping rate is constant Q, the time since the start of pumping t, the time after pumping has stopped t ', the difference between the original surface of water and the recovery of the water level s' and if the relationship between s' and log (t / t ') is drawn closer to the straight line through the origin, then the following formula can be determined:

$$T = \frac{0{,}183\ Q}{s} \log \frac{t}{t'} ..$$

In a logarithmic cycle, log (t / t ') = 1 and the difference in water surface Δs, then:

$$T = \frac{0{,}183\ Q}{\Delta s}$$

3. RESEARCH METHOD

Location

The location of this research is located on Jalan Kartika, Loktabat Utara sub-district, which is one part of the Banjarbaru Utara district in Banjarbaru City, South Kalimantan Province. Geographically, the pumping test research location is in coordinate possition of 3°26’43.1”SL - 114°48’11.2”WL.

Research Equipment

The equipment used in this research are:

1. Monitoring theWells

   Monitor wells are wells whose groundwater level fluctuation is measured when production wells are pumped.

2. Observation theWells

   Production wells are wells to be pumped, where before pumping a groundwater level is measured. This measurement aims to determine whether the pumping of production wells has an effect on the groundwater level around the well.

3. Water Pump

   The pump used during the pumping process (pumping test) in the production well is the Shimizu pump.

4. Measuring Tape

The measuring tape is used to measure the depth of the water level or well manually. Measuring tapes are also used to measure the distance between production wells and observation wells.

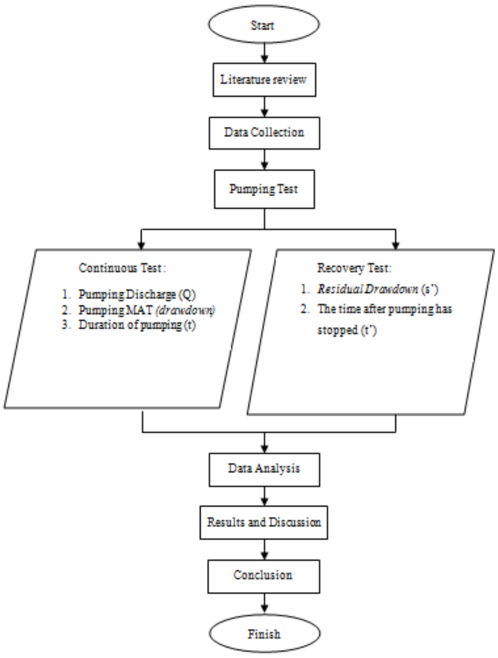
5. Stopwatch

   The stopwatch is used to calculate the time of lowering the groundwater level during pumping or when pumping is stopped (recovery test).

Research procedure

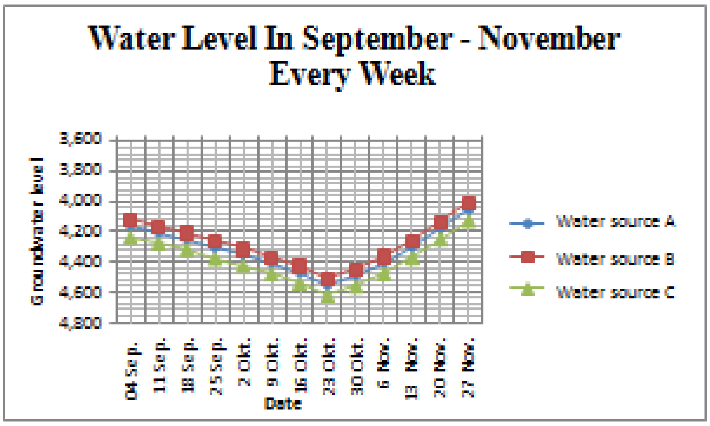
The steps taken in the pumping test process are as follows:

1. Determine monitoring wells that the water level will be measured in when pumping production wells.
2. Record the location or distance from the monitoring well to the observation well
3. Measure the water level of each well before pumping is carried out
4. Prepare a measuring tape to find out the water level.
5. Record the groundwater level in the monitoring well at the specified time when pumping is carried out in the production well.
6. Stop the pump after the specified pumping time has been completed.
7. Reviewing of the monitoring well’s data when the pump is turned off.
8. Analyze the data that been obtained from testing.



4. RESULTS AND DISCUSSION

From observations of groundwater level conditions takes three months (September, Octoberand November), the groundwater levels in the wells A, B, and C have the same trendline. Well C has the highest groundwater level and varies over time. The increase in groundwater level peaked on 23 October 2019 and decreased again as the rainy season progressed. Well B as a monitoring well has the lowest water level and well A as a production well is between wells B and C. The effect of seasonality has an effect on variations in groundwater level. Can be seen at the image below:



Picture 2 Water Level In September-November Every Week

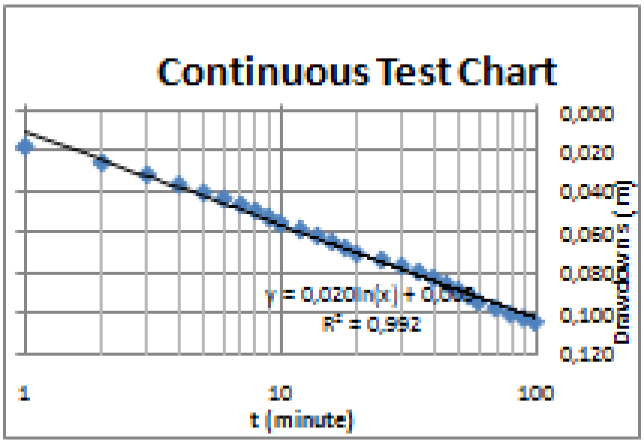
Calculation

Value of transmissivity with the Cooper Jacob Method in Continuous Test

Table of Decrease the water level of the wells observation in September 4 September 2019 as follows:

T (Minute)	S (m)
0	0
1	0,018
2	0,026
3	0,032
4	0,036
5	0,040
6	0,043
7	0,046
8	0,049
9	0,052
10	0,055
12	0,058
14	0,061
16	0,064
18	0,067
20	0,070
25	0,073
30	0,076
35	0,079
40	0,082
45	0,085
50	0,088
55	0,091
60	0,094
70	0,097
80	0,099
90	0,101
100	0,102

From the field results in the table above, the values of t and s are obtained, when t= 100 minutes and the value of s = 0.102 m. The graph below shows shifting drawdown value during the experiment on 4 September.



Picture 3 Continuous Test Chart

Pumping carried out on the well causes a decrease in the water table from the above curve. From the curve above, the comparison of the drawdown and t values obtained t = 100 minutes already in a steady state and s = 0.102 m.

From the curve above it can be concluded that:

The equation for the line of descent: s = 0,020 ln(t) + 0,009

$$0 = 0{,}020 \ln(t) + 0{,}009$$

$$\ln(t) = -\frac{0{,}009}{0{,}020}$$

$$= -0{,}45$$

$$t_0 = e^{-0{,}45}$$

$$t_0 = 0{,}637 \text{ minutes}$$

Q = 1000 liter = 1 m^3

Δs with value $t_2 = 10 \,.\, t_1$

$t_1 = 1$

$t_2 = 1 \,.\, 10$

= 10 minutes

for t_1 :

$s_1 = 0{,}020 \ln(t_1) + 0{,}009$

$= 0{,}020 \ln(1) + 0{,}009$

$= 0{,}009$

for t_2 :

$s_2 = 0{,}020 \ln(t_2) + 0{,}009$

$= 0{,}020 \ln(10) + 0{,}009$

$= 0{,}055$

$\Delta s = s_2 - s_1$

$= 0{,}055 - 0{,}009$

$= 0{,}046$

The slope of the line (m) ⟶ $\Delta s = 0{,}046$

$$T = \frac{2{,}3\, Q}{4\pi . \Delta s}$$

$$= \frac{2{,}3 \times 1}{(4 \times 3{,}14 \times 0{,}046)}$$

$$= \frac{2{,}3}{0{,}57776}$$

= 3,981 m^2/day

= 0,00276 m^2/minute

On September 4, 2019, the groundwater wells studied at the research location were obtained with Q = 1 m^3, Δs = 0.046, the transmissivity (T) value during pumping was 3.981 m^2 / day = 0.002796 m^2 / minute.

Calculation of Storativity Value (S) using the Cooper Jacob Method

Storativity is the volume of water released or stored per unit cross-sectional area perpendicular to the aquifer surface at each hydraulic head difference on that surface. Storativity is a unitless quantity involving the volume of water in an aquifer

$S = 2,25\ T.\ t_0/r^2$

$= \frac{2,25\ T \times t_0}{r^2}$

$= \frac{2,25 \times 0,00276 \times 0,637}{(9)^2}$

$= \frac{0,00395}{81}$

$= 0,0000487$

On September 4, 2019, the groundwater wells studied at the research location were obtained with Q = 1 m3, r = 9 m, t_0 = 0.637 minutes and the value of transmissivity (T) when pumping was 3.981 m^2 / day = 0.002796 m^2 / minutes get the value of Storativity (S) of 0.0000487 = 4.87 x 10^{-5}.

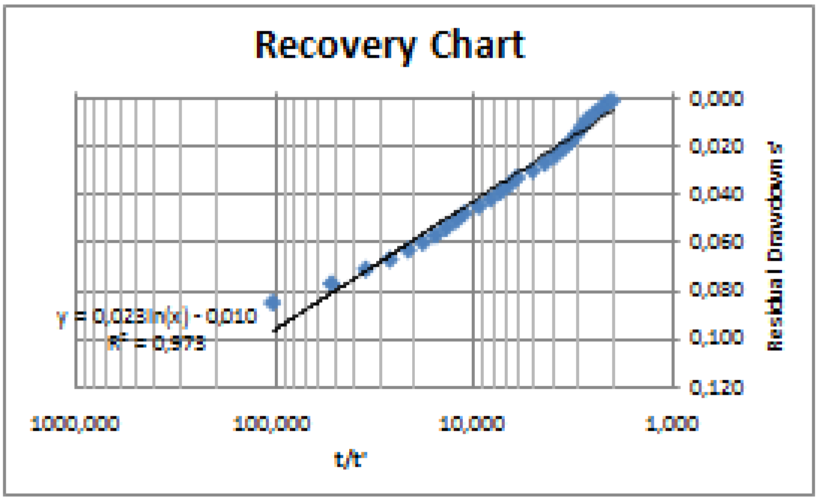
The Transmissivity with the Cooper Jacob Method valuation on the Recovery Test

The recovery test done when the pump is stopped after the pumping test, the water level in the well will start to rise. This increase of water depth is known as a residual drawdown, s'. This occur the difference between the original water level depth before the start of pumping and the measured water level depth at a time after cessation of pumping.

Recovery Table on September 4, 2019

t (Minute)	MAT	s' (m)	t/t'	Log (t/t')
100	4,406	0,106		
101	4,388	0,088	101,000	2,0043
102	4,379	0,079	51,000	1,7076
103	4,373	0,073	34,333	1,5357
104	4,368	0,068	26,000	1,4150
105	4,364	0,064	21,000	1,3222
106	4,361	0,061	17,667	1,2472
107	4,358	0,058	15,286	1,1843
108	4,355	0,055	13,500	1,1303
109	4,352	0,052	12,111	1,0832
110	4,349	0,049	11,000	1,0414
112	4,346	0,046	9,333	0,9700
114	4,343	0,043	8,143	0,9108
116	4,340	0,040	7,250	0,8603
118	4,337	0,037	6,556	0,8166
120	4,334	0,034	6,000	0,7782
125	4,331	0,031	5,000	0,6990
130	4,328	0,028	4,333	0,6368
135	4,325	0,025	3,857	0,5863
140	4,322	0,022	3,500	0,5441
145	4,319	0,019	3,222	0,5082
150	4,316	0,016	3,000	0,4771
155	4,313	0,013	2,818	0,4500
160	4,310	0,010	2,667	0,4260
170	4,307	0,007	2,429	0,3854
180	4,304	0,004	2,250	0,3522
190	4,302	0,002	2,111	0,3245
200	4,300	0,000	2,000	0,3010

From the field results in Table 4.3, values t ', s', t / t 'and log (t / t') are obtained during the recovery test. The graph below shows the change of the residual drawdown value during the experiment on 4 September.



Picture 4 Recovery Chart

After the pumping test is carried out, the pump is stopped, the water level in the well will begin to rise (residual drawdown) can be seen in the curve above the comparison of the residual drawdown and t / t '. From the curve above the water refills in minutes t '= 200 minutes

The equation for the line of descent: s = 0,023 ln(t) + 0,010

Q = 1000 liter = 1 m^3

Δs with value $t_2 = 10 . t_1$

$t_1 = 101$

$t_2 = 101 . 10$

$= 1010$ minutes

for t_1 :

$s_1 = 0,023 \ln(t_1) + 0,010$

$= 0,023 \ln(101) + 0,010$

$= 0,0961$

for t_2 :

$s_2 = 0,023 \ln(t_2) + 0,010$

$= 0,023 \ln(1010) + 0,010$

$= 0,1491$

$\Delta s = s_2 - s_1$

$= 0,1491 - 0,0961$

$= 0,053$

The slope of the line (m) $\longrightarrow \Delta s' = 0,053$

$$T = \frac{2,30 \times Q}{(4\pi\Delta s')}$$

$$= \frac{2,30 \times 1}{(4 \times 3,14 \times 0,053)}$$

$$= \frac{2,3}{0,66568}$$

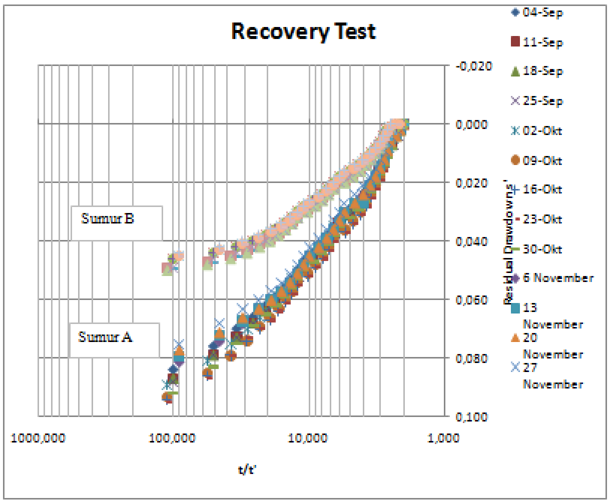
$= 3,455\ m^2/day$

$= 0,002399\ m^2/minute$

On September 4, 2019, the groundwater wells that were studied at the research location during the recovery test obtained a transmissivity (T) valueof 3.455 m^2 / day = 0.002399 m^2 / minute.

Residual Drawdown Ability of aquifers

If a well is tested for pumping during time t and then the pumping stops, there will be an increase in groundwater level during time t '. This increase in groundwater level is called a residual drawdown, namely the difference in the original water level before pumping minus the groundwater level after time t 'after the pump is turned off.

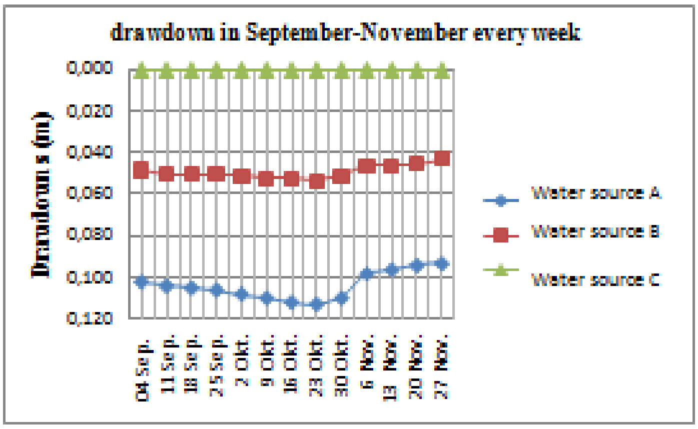


Picture 5 Recovery Test

Based on the results of the pumping test on September 4 in well A (production well) with a pumping flow of 1000 liters, the drawdown of 0.102 m for 100 minutes has reached a steady state.

Based on the results of the recovery test, it was found that the water returned to the water level before pumping, but in October on the 9th with s '= 0.015m at 4,420m groundwater level, 16 october s' = 0.016m at surface height groundwater 4.482m and 23 October s' = 0.016m at 4.564m groundwater level, the water does not return to the water level before pumping, as well as in well B (monitoring wells) the same conditions apply.

The Influence of Water Extraction on Groundwater Surface Conditions



Picture 6 Drawdown in September-November Every week

Based on the test results on 4 September in well A, production wells with a pumping flow of 1000 liters and t = 100 minutes, the drawdown was s=0.102 m, while for well B, s = 0.048 m and well C there was no decrease.

The pumping of the production wells causes a drawdown in the surrounding wells which is observed through monitoring wells, with a distance of 9m and 15m. At a distance of 9m the drawdown that occurs is relatively small, where the largest drawdown value is 0.053 m. The pumping was carried out for 110 minutes in which at 110 minutes there was no drop in the groundwater drawdown so that the pump was stopped. At a distance of 15m there is no effect on lowering the groundwater level, so in this pumping test it does not affect the surrounding wells.

5. CONCLUSION

From the description of the previous chapter, it can be derived from the results of this study as follows:

1. From the results of observations made for 3 months starting from September to November. Well A as the production well of wells B and C as a monitoring well, the ground water level conditions in wells A, B, and C havethesametrendline. Well C has the highest groundwater level and varies over time. The increase in groundwater level peaked on 23 October 2019 and decreased again as the rainy season progressed. Well B as a monitoring well has the lowest water level and well A as a production well is between wells B and C. The effect of seasonality has an effect on variations in groundwater level.
2. Based on the results of the calculation, the transmissivity (T) value is influenced by the drawdown value and pumping time so that the greater the drawdown value and the longer the stable time, the smaller the transmissivity value.

3. Based on the results of the calculation, the Storativity (S) value the greater the Tranmissivity value, the greater the Storativity value because transmissibility is the ability to transmit water to distribute water to storage.
4. Based on the results of the recovery test, the results of the residual drawdown ability of water return to the water level before pumping, but in October on the 9th with s '= 0.015m at 4,420m groundwater level, 16 October s' = 0.016 m at a groundwater level of 4.482m and 23 October s' = 0.016m at a groundwater level of 4.564m, the water does not return to the water level before pumping, as well as in well B (monitoring wells) the same conditions apply.
5. Pumping in production wells causes a drawdown in the surrounding wells which is observed through monitoring wells, with a distance of 9m and 15m. At a distance of 9m the drawdown that occurs is relatively small, where the largest drawdown value is 0.053 m. The pumping was carried out for 110 minutes in which at 110 minutes there was no drop in the groundwater drawdown so that the pump was stopped. At a distance of 15m there is no effect on lowering the groundwater level, so in this pumping test it does not affect the surrounding wells.

Suggestion

Some suggestions that can be taken into consideration for further research are:

1. Analysis of the pumping test data obtained can be done using other methods.
2. By using observations of more than 1 well.
3. Further research is needed to determine the need for groundwater extraction so that there is no deficit.

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