The impact of building development and renovation towards the hydrological condition in Java Heritage Hotel Purwokerto

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Abstract. The development at the Java Heritage Hotel Purwokerto will have a direct impact on the hotel's water use. Because it results in reduce water catchment areas. Considering that the water source in this hotel uses groundwater from deep wells, the expansion of the built-up area this hotel will make the groundwater level decreases. The objective of this study was to investigate the effect of the development of this hotel on the local drop in groundwater levels and to propose solution for the area's hydrological circumstance. To overcome the predicted increase in flooding and restore the groundwater level, water conservation measures are required, one of which is infiltration well technique. According to the result of the calculation, the calculate design rainfall for the 5 year return period is 68.66 milimeter per hour. Using the design of infiltration wells with a depth of 3 m and a diameter of 1 m, 162 infiltration wells for absorb roof runoff, 63 infiltration wells for absorb parking a lot runoff, 178 of infiltration well for absorb half the channel capacity and 356 wells for absorbing the total channel capacity. Meanwhile, pumping activities at the this hotel will result in a drawdown of 14 cm, and to return the groundwater level to its original state, a pumping time lag of 2.7 hours is required.

1 INTRODUCTION

Hotel Java Heritage Purwokerto is one of the star hotels in the heart of Purwokerto, Central Java which is ready to accept MICE on a national scale. For this reasons PT. Panorama Semesta as the owner has obtained a principle permit for activities to expand the Java Heritage Hotel building with a floor area of 35,000 m^2. It is hoped that after renovation and development, the Java Heritage Purwokerto Hotel will further strengthen its existence in the tourism world of Banyumas Regency. This renovation and development activity is carried out by adding facilities, rooms, buildings, and so on.

The addition of rooms and buildings will of course affect the amount of water required for each room, considering that the hotel's water source uses groundwater from deep wells, there is a lot of waste water that must be disposed of and rainwater runoff will be channeled into the drainage channel.

This results in increasingly critical water catchment areas, so there is less opportunity for rain to enter the bowels of the earth. Meanwhile, groundwater use through pumping is increasing day by day. As a result, there is a groundwater deficit, which is characterized by the deepening of the groundwater level. So water conservation is needed as an effort to increase groundwater and prevent or minimize water loss as surface flow and storage as much as possible into the earth. One effort that can be done is to build infiltration wells around buildings [1,2,3].

Based on complaints from residents around the hotel, their wells experienced a decrease in water level. There are many opinions that the decline was caused by pumping from the Java Heritage hotel. As a result of renovations and additional rooms, water demand has increased so that pumping from wells is higher than before. From this opinion, action is needed to increase the quantity of groundwater as a community need. One possible measure is to control the runoff of rainwater that falls in the catchment area, namely the Java Heritage Purwokerto Hotel.

In this research, we will analyze how large the capacity of infiltration wells is and the number of infiltration wells needed to control water runoff that occurs as well as the effect of using wells at the Java Heritage Purwokerto Hotel on the surrounding groundwater level.

The expected benefits of this research are to determine the impact of changes in hydrological characteristics due to the development of the Java Heritage Hotel, to design infiltration wells to reduce changes in hydrological characteristics, especially surface flow around the study area and to find out the extent of the impact of water extraction in the Java Heritage Hotel's wells on the ground water level. surrounding.

To limit the research object and provide good results, this research is limited by the following things:

a. The hydrological conditions reviewed in the research are runoff.

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b. The planned infiltration well construction is of circular cross-section with impermeable walls (concrete walls) and a porous base.
c. Permeability testing using a single ring infiltrometer test.
d. Rainfall data is daily rainfall for 14 years.

2 THEORETICAL AND BASIS

2.1 Factors that influence the decline in ground water levels

a. *Drawdown (s)*
Drawdown or loss component in the aquifer is the loss of head in the aquifer where the flow is laminar [4]

$$S = \frac{Q}{4\pi T} w(u) \quad (1)$$

$$u = \frac{r^2 S}{4Tt} \quad (2)$$

where ;
S = drawdown (m)
Q = discharge (m3/minute)
T = transmsivitas (m^2/minutet)
T = long pumping time (minute)

b. *Residual Drawdown*
The decline in the groundwater level after pumping is stopped, where the water level rises again to approach the original groundwater level (recovery period). This principle assumes that after the cessation of pumping, the well continues to be pumped at the same rate as before, and an imaginary charge, equal to the pumping rate, is injected into the well. The taking and filling discharges then cancel each other out [4]
$With$;
s'(r,t) = residual drawdown (m)
u' = r^2S / (4Tt')
S' = storativity during recovery
t' = the time pumping stopped

2.2 Rain

Rain is an important input component in the hydrological process, the characteristics of rain include intensity, duration, depth and frequency. Rainwater that falls to the ground surface does not completely enter the ground. Some will flow through drainage channels. High intensity rain causes flooding, coupled with the long duration of the rain. So this needs to be considered so that groundwater conservation can be effective.

a. Rain Intensity Analysis
Talbot Metode
If there is hourly rainfall data, the rainfall intensity is calculated using the following equation:

$$I = \frac{a}{t+b} \quad (3)$$

I = Rainfall Intensity (mm/hour)
t = duration of rain (hour)
a dan b = A constant that depends on the duration of the rain

- Sherman and Ishoguro Metode
If in the field the rainfall period is more than 2 hours, then the rainfall intensity can be calculated using the following equation:

$$I = \frac{a}{t^n}$$

where,
I = rainfall Intensity (mm/hour)
t = duration of rain (hour)
n = a constanta

- Mononobe Metode
If short-term rain data is not available, only daily rain data is available, then the rain intensity can be calculated using the following equation:

$$I = \frac{R_{24}}{24}\left(\frac{24}{t}\right)^{2/3} \quad (4)$$

$With$;
I = rainfall Intensity (mm/hour)
t = duration of rain (hour)
R24 = maximum 24-hour rainfall (mm)

b. Frequency Analysis
The aim of frequency analysis is to find the relationship between the magnitude of extreme events and the frequency of events using a probability distribution [5,6]. The distributions commonly used for frequency analysis are:

- Normal Distribution

$$z = \frac{x-\mu}{\sigma} \quad (5)$$

$With$;
z = standard unit
X = random variable
σ = standard deviation
μ = mean

- Log Normal Distribution

$$Cs = Cv^3 + 3C_v \quad (6)$$

$$C_k = Cv^8 + 6Cv^6 + 15C_v^4 + 16Cv^2 + 3 \quad (7)$$

To determine the depth of rain in making probability graphs, the rain data value is changed to the equation:

$$y = ln\, P \quad (8)$$

- Gumbel Distribution

$$C_s \approx 1{,}396 \quad (9)$$

$$C_s \approx 1{,}396 \quad (10)$$

The equation used for flood frequency analysis is:

$$x_t = x_{rt} + k^* \quad (11)$$

$$k = \frac{Y_t - Y_n}{s_n} \quad (12)$$

$$Y_t = -\ln\left[\ln\left(\frac{T}{T-1}\right)\right] \quad (13)$$

with,
Xt = planned debit for the birthday period t years (m3/sec)
Xrt = average discharge (m3/sec)
k = frequency factor
S = standard deviation
Yt = reduce variable
Yn = reduced mean
Sn = reduce standard deviation
n = number of years of observation
T = return period

- Log Pearson III Distribution

$$L_n x_t = L_n x_{rt} + k * S \quad (14)$$

where
Xt = planned flood discharge (m3/sec)
Xrt = average discharge (m3/sec)
k = frequency factor
S = standard deviation

Table 1. Distribution type and criteria

Distribution Type	Criteria
Normal	$(X_{rt} \pm s) = 68{,}27\%$ $(X_{rt} \pm 2s) = 95{,}44\%$ $C_s \approx 0$ $C_k \approx 3$
Log Normal	$C_s = 3C_v + C_v^3$ $C_v \approx 0{,}06$ $C_k = C_v^8 + 6C_v^6 + 15C_v^4 + 16C_v^2 + 3$
Gumbel	$C_s = 1{,}139$ $C_k = 5{,}400$
Log Pearson Type III	except values above

c. Alignment Test
To determine the distribution pattern and average discharge that best suits several statistical distribution methods that have been carried out, a concordance test is carried out. In this test, what is usually observed is the expected calculation result [7]. There are two types of goodness of fit tests that are usually carried out, namely:Smirnov Kolomogrof . The test is carried out by looking for the probability difference value for each variable Xi according to the empirical and theoretical distribution, which is symbolized by Δ. The price Δi max must be smaller than Δcrit.

- Chi Square (Chi-kuadrat)

$$x^2 = \sum_{i=1}^{k} \left[\frac{(E_f - O_f)^2}{E_f}\right] \quad (15)$$

$With$;
X2 = calculated Chi – squared value
Ef = expected frequency for class i
Of = frequency read in class i
K = number of classes

The value of X2 must be smaller than the critical value of X2 for a certain real degree (a) and a certain degree of freedom (DK). Generally, a real degree of 5% is used and for the Chi Square distribution, the DK value can be used by the following formula:

$$DK = K - (P + 1) \quad (16)$$

$$K = 1 + 3{,}22 \log n \quad (17)$$

$With$;
DK = Degrees of freedom
K = Many classes
P = Number of attachments

2.3 Infiltration Well

The working principle of infiltration wells is to channel and collect rainwater into holes or wells so that the water can have a longer stay on the ground surface, so that little by little the water can seep into the ground.

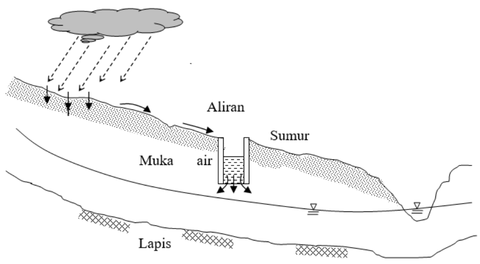


Fig 1. Working principle of infiltration wells

a. Design of Infiltration Wells

The basic concept of an infiltration well is essentially to provide an opportunity and a way for rainwater that falls on impermeable land to seep into the ground by storing the water in an infiltration system. The size or dimensions of the infiltration well required for a piece of land depends on several factors as follows [11,14].
1. The surface area to be drained, namely the land where the water will be collected in absorption wells, in this case the road pavement.
2. Rain characteristics, including rain intensity, rain duration, rain interval. In general, it can be said that the higher the rainfall, the longer the rain lasts, the larger the volume of infiltration wells required. Meanwhile, large rain intervals can reduce the required well volume.
3. Soil permeability coefficient, namely the ability of the soil to pass water per unit time. Sandy soil has a higher permeability coefficient than clay soil.
Planning for infiltration wells can be done using the formula proposed by Sunjoto [6]. Theoretically, the volume and efficiency of an infiltration well can be calculated based on the balance of water entering the well and water seeping into the ground and can be written as follows:

$$H = \frac{Q}{Fk}\left[1 - e^{\frac{-FkT}{\pi R^2}}\right] \quad (18)$$

$With$;
H = water level height in the well (m)
F = geometric factor (m)
Q = incoming water flow (m^3/sec)
T = flow time (seconds)
K = soil permeability coefficient (m/sec)
R = well radius (m)

The rational method is used to determine peak discharge values, especially in relatively small irrigation areas. The rational method can be applied to areas that have a maximum area of 5000 ha. The rational method is written as follows:

$$Q = 0{,}778CIA \quad (19)$$

$With$,
Q = discharge / runoff (m^3/sec)
C = runoff coefficient
I = rainwater intensity (mm/hour)
A = drainage area (km^2)

In drainage planning, the flow concentration time is the same as the duration of the rain. In drainage planning we can take a return period of 5 or 10 years. Concentration time can be calculated with the following equation:

$$T_c = t_0 + t_d \quad (20)$$

$$t_d = \frac{L}{v} \quad (21)$$

$$t_0 = 0{,}0195\left(\frac{L_o}{So^{0,5}}\right)^{0,77} \quad (22)$$

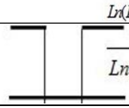
With ,
Tc = concentration time (hours)
td = flow time (minutes)
So = slope of land
Lo = length of the furthest point perpendicular to the channel (m)

Table 2. Runoff Coefisient

Surface Type	Runoff Coefisient (C)
1. Bussines	
City Area	0,70 – 0,95
Suburban Area	0,50 – 0,70
2. Housing Area	
Single Family Area	0,30 – 0,50
Separated Multiunit	0,40 – 0,60
Closed Multiunit	0,60 – 0,75
Sub Urban	0,25 – 0,40
Home Area	0,50 – 0,70
3. Industrial Area	
Light industrial area	0,50 – 0,80
Heavy industrial area	0,60 – 0,90
4. Roof	0,75 – 0,95
5. Garden, grave	0,10 – 0,25
6. Road	
Asphalt	0,75 – 0,95
Concrete	0,80 – 0,95
Rock	0,70 – 0, 85
7. Dirt road	0,10 – 0,50

b. Faktor Geometrik

Table 3. The geometric factor of the infiltration well building

No	Model Type/Geometric Coefisien t(f)	Researcher
1.	 5.5 R 2 π R	Hvorslev; 1951 Taylor; 1938 Sunjoto; 1989
2.	 $\frac{2\pi L}{Ln(L/R+\sqrt{(L/R)^2+1}}$ $\frac{2\pi(L+2/3R)}{Ln(L+2R)/R+\sqrt{(L/R)^2+1}}$	Dachler; 1936 Sunjoto; 1989
3.	 $\frac{2\pi L}{Ln(L/2R+\sqrt{(L/2R)^2+1}}$ $\frac{2\pi(L+2/3R)}{Ln(L+2R)/2R+\sqrt{(L/2R)^2+1}}$	Dachler; 1936 Sunjoto; 1989
4.	 $\frac{\pi(ho+hw)}{Ln(hw/R+\sqrt{(hw/R)^2+1}}$	Sunjoto; 1989

In this study, type 1 infiltration wells were used, the geometric factors formulated by Sunjoto [5], namely:

$$f = 2\pi R \quad (23)$$

c. Infiltration Well Requirements

Even though infiltration wells bring many benefits, their construction must pay attention to the conditions necessary to obtain optimal results, the general requirements are [11,12,13]:

- Rainwater absorption wells are built on land that is water-free and landslide-resistant,
- rainwater absorption wells must be free of waste contamination/contamination,
- the water that enters the infiltration well is rainwater,
- for areas with poor environmental sanitation, rainwater absorption wells only collect rainwater from the roof and channel it through gutters, and
- consider hydrogeological, geological and hydrological aspects.

d. Pemeability

The permeability coefficient price for each soil is different. Some soil permeability coefficient values are given in the following table [14].

Table 4. Soil Permeability Coefficient Value

No.	Type of soil	Permeability Coefisient (m/dt)
1.	Clay	$> 10^{-9}$
2.	Sandy Loam	10^{-9} - 10^{-8}
3.	Silty Clay	10^{-8} - 10^{-7}
4.	Silt	10^{-7} - 10^{-6}
5.	Very Fine Sand	10^{-6}- 10^{-5}
6.	Fine Sand	10^{-5} - 10^{-4}
7.	Rough Sand	10^{-4} - 10^{-3}
8.	Gravel Sand	10^{-3} - 10^{-2}
9.	Gravel	$>10^{-2}$

Soil permeability values are divided into 3 types of permeability, namely:

- medium soil permeability (loam/silt, 2.0 – 6.5 cm/hour),
- soil permeability is rather fast (fine sand, 6.5-12.5 cm/hour), and
- fast soil permeability (coarse sand, > 12.5 cm/hour).

Table 5. Minimum distance of infiltration wells from buildings

No	Building or object	Distance (m)
1	Building/ Hous	3
2	Land/ Plt ownership limit	1,5
3	Drinking water well	10
4	Septick tank	10
5	River	30
6	Drinking water pipe	3
7	Public road	1,5
8	Big Tree	3

When placing infiltration wells, you must pay attention to the layout of their placement, so that they do not have a negative impact or damage the surrounding environment. The following table provides the minimum distance for infiltration wells from other buildings.

e. Infiltration Well Construction
Basically, infiltration wells can be made from various materials available at the location, but still pay attention to existing requirements. As depicted in Figure 2, the walls and bottom of the absorption well are porous.

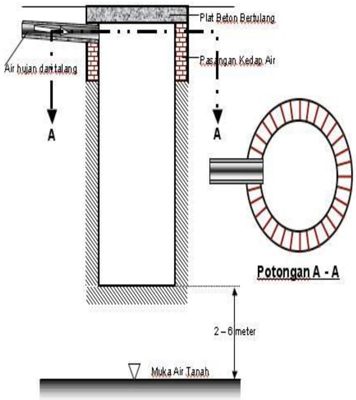


Fig 2. Infilltration Well

What needs to be noted is that for safety, absorption wells need to be equipped with walls. The materials needed for an infiltration well include:

1. Inlet/outlet channels can use iron pipes, paralon pipes, concrete buisses, clay pipes, or stone masonry.
2. The walls of the well can use woven bamboo, used drums, fiberglass tanks, brick masonry, or concrete buis.
3. The bottom of the well and the gaps between the excavation and the wall where the water seeps can be filled with palm fiber or gravel.

3 METHODS

This research was carried out at the Java Heritage Hotel Purwokerto, in this hotel there is no infiltration well to absorb rainwater into the ground. There are changes and additions to the building at this hotel. The water level is ± 4m from the ground surface in the dry season.

Primary data consists of groundwater depth, soil permeability values and situation maps. Secondary data includes daily rainfall data for the last 14 years, hydrogeological maps, and deep well drilling data at the Java Heritage Purwokerto Hotel as well as channel slope and flow discharge.

4 RESULTS AND ANALYSIS

4.1 Well Depth

Field surveys were carried out to obtain data ongroundwater depth and elevation from dug wells in several residents' houses around the Horizon Purwokerto Hotel. To determine the ordinates and elevation of each well, GPS is used.

Fig. 3. Data Collection Location

The ordinate data that has been obtained is then converted into UTM which will later be used to create contours of the research location. Below is a table of groundwater depth data and the ordinates of wells around the Hotel.

Table 6. Well ordinate and depth data

No	Ordinat		Ordinat UTM		Depth (m)	Ground Level Elev. (m)	Ground Water Level Elev. (m))
1	S	7.41563	Northing	9179918	3.55	126	122.45
	E	109.2368	Easting	305400			
2	S	7.41555	Northing	9179927	2.425	126	123.575
	E	109.2369	Easting	305413			
3	S	7.41556	Northing	9179926	3.13	126	122.87
	E	109.237	Easting	305423			
4	S	7.41653	Northing	9179818	4.326	122	117.674
	E	109.2363	Easting	305344			
5	S	7.41456	Northing	9180037	2.08	128	125.92
	E	109.2379	Easting	305526			
6	S	7.41412	Northing	9180085	2.67	128	125.33
	E	109.2378	Easting	305504			
7	S	7.41484	Northing	9180006	2.79	127	124.21
	E	109.238	Easting	305529			
8	S	7.4147	Northing	9180021	2.94	129	126.06
	E	109.2377	Easting	305501			

4.2 Soil Permeability

To obtain soil permeability values, soil samples were taken in the field using single ring infiltration. Then the samples were taken to the Agricultural Soil Laboratory to be tested for permeability values. From laboratory tests, the permeability (K) value of the Horison Hotel soil is 0.00021286 m/sec. This value shows that the soil permeability coefficient at the Java Heritage Purwokerto Hotel is very fast.

4.3 Channel Dimensions

Channel dimensions are used to determine the capacity of the channel and the runoff discharge that occurs. To obtain the dimensions of the channel, measurements are made directly on the channel with a tool in the form of a meter. From the measurement results, it was found that the dimensions of the channel were square with a height = 1.12 m; width = 0.4 m; S value = 0.00857. Because the channel surface is concrete, the value of n = 0.017. From the previous data, it can be seen that the value of Q = 0.7477 m3/second.

4.4 Hydrological Analysis

The rain data obtained from the Purwokerto Water Resources and Highways Service is daily rain data which is then selected to become the annual maximum rain (annual maximum series). The rain data used comes from Kranji Station, Purwokerto from 1996 to 2011. The rain data used in the frequency analysis is the maximum daily rainfall data each year for 14 years.

Table 7. Kranji Station Average Rain Data

Year	P (mm)
1996	190
1997	88
1998	196
1999	180
2000	133
2002	48
2003	184
2004	120
2005	112
2006	82
2007	60
2008	120
2010	153
2011	350

4.5 Calculation of Statistical Parameters

Below is a table of statistical parameter calculation results for the normal distribution, log normal distribution, log Pearson distribution, and Gumbel distribution.

Table 8. Calculation of Statistical Parameters

Parameter Statistik	x	Y=ln x
Average	144	4.847
Standard Deviation (s)	75.35	0.2512
Skewness Coefisient (C_s)	1.439	-0.1374
Kurtosis Coefisient (C_k)	3.282	0.177
Variansi Coefisient (C_v)	0.530	0.1075

Selection of Distribution Type

Table 9. Distribution selection parameters

Distribution Type	Criteria	Result
Normal	$(X_{rt} \pm s)$ = 68,27%	79,00%
	$(X_{rt} \pm 2s)$ = 95,44%	93,00%
	$C_s \approx 0$	1,44
	$C_k \approx 3$	6,648
Log Normal	$C_S = 3C_V + C_V^3 = -0,1374$	0,324
	$C_V \approx 0,06$	0,1705
	$C_K = C_V^8 + 6C_V^6 + 15C_V^4 + 16C_V^2 + 3 = 3.749$	3,187
Gumbel	$C_S = 1,1396$	1.439
	$C_k = 5,4002$	6.648
Log pearson Type III	Except for conditions above	OK

4.6 Distribution Alignment Testing

Table 10. Chi – Square Test & Smirnov Kolmogorov Test Results

No	Distribution	Chi-Kuadrat			Smirnov Kolmogorov		
		X	X_{kritik}	Syarat	Δ_{maks}	Δ_{kritik}	Syarat
1	Normal	3.857	5.991	Ok !	0.1146	0.34	Ok !
2	Log Normal	4.571	5.991	Ok !	0.0801	0.34	Ok !
3	Log Pearson III	4.571	5.991	Ok !	0.0739	0.34	Ok !
4	Gumbel	3.143	5.991	Ok !	0.8947	0.34	No!

4.7 Peak Discharge

To get rain, the plan is to use the Mononobe method, which will then get the peak discharge at the research location.

Tablel 11. IDF rain intensity value

t	Return Period (year)				
	2	5	10	25	50
5	234.16	359.86	447.46	405.59	649.16
10	147.51	226.70	281.88	255.51	408.94
15	112.57	173.00	215.12	194.99	312.08
20	92.93	142.81	177.58	160.96	257.62
45	54.12	83.17	103.42	93.74	150.03
60	44.67	68.66	85.37	77.38	123.85
120	28.14	43.25	53.78	48.75	78.02
180	21.48	33.01	41.04	37.20	59.54
240	17.73	27.25	33.88	30.71	49.15
300	15.28	23.48	29.20	26.46	42.36

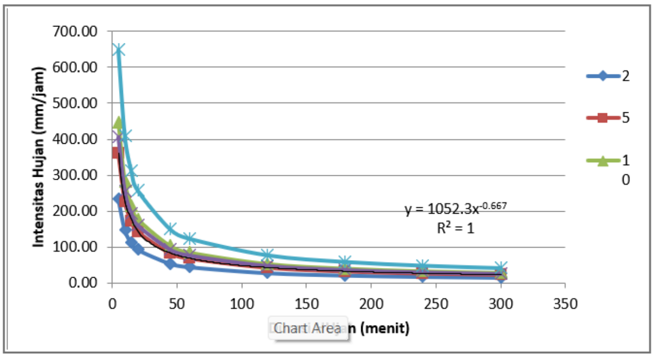


Fig. 4. IDF Curve

With a planned return period of 5 years and dominant duration = 60 minutes, the rain intensity (I) = 68.66 mm/hour.

5 Infiltration Well Design

In planning this infiltration well, type 1 well is used and the diameter of the infiltration well used (D) = 1 m. So the geometric factor value (f) = 3.14 m. To calculate runoff discharge, a dominant rain duration of 60 minutes is used, with a C value from the roof of 0.95. By using the rational equation Q = 0.278 CIA, we get the runoff shown in table 12 below

Table 12. Runoff discharge from the Java Heritage Purwokerto Hotel building

No	Building Code	Area (m^2)	Q (m^3/sec)
1	A	207.6	0.00376
2	B	207.6	0.00376
3	C	207.6	0.00376
4	D	207.6	0.00376
5	E	551.04	0.00999
6	F	110	0.00199
7	G	293.2	0.00532
8	H	293.2	0.00532
9	I	207.74	0.00377
10	J	263.9	0.00479
11	K	263.9	0.00479
12	L	263.9	0.00479
13	M	329.94	0.00598
14	N	362.7	0.00658
15	O	119.34	0.00216
16	P	1590	0.02883
17	Q	1114	0.02020
18	R	1051	0.01906
19	S	718.2	0.01302
20	T	4047.2	0.07339
21	U	762	0.01382
22	V	21	0.00038
23	W	5318.6	0.09644

Meanwhile, to calculate the runoff discharge from the parking lot to determine the concentration time, use equation 2.31 with a value of So = 0.00857 and a C value for paving blocks of 0.9. From these data, runoff discharge can be generated for each parking lot which is presented in table 13.

Table 13. Runoff discharge from the Java Heritage Purwokerto hotel parking lot

Blok	Area (m^2)	Lo (m)	to (min)	L (m)	td (min)	Tc (min)	I (mm/hour)	Q (m^3/sec)
P1	461.44	5.75	1.593	153.17	91.766	93.359	52.688	0.0061
P2	533.585	6.5	1.750	78.40	46.970	48.721	80.933	0.0108
P3	84.5	44.35	7.679	142.80	85.553	93.232	52.735	0.0011
P4	518	12.4	2.878	142.80	85.553	88.432	54.608	0.0071
P5	1822	26.53	5.170	142.80	85.553	90.723	53.694	0.0245
P6	240	6	1.646	142.80	85.553	87.199	55.116	0.0033
P7	2478	58.42	9.494	142.80	85.553	95.047	52.069	0.0323
P8	800	15	3.333	78.40	46.970	50.303	79.243	0.0159
P9	940	30.66	5.779	56.69	33.964	39.743	92.578	0.0218

In planning infiltration wells, a soil permeability value (K) is needed, from laboratory results the soil permeability value at the Java Heritage Purwokerto Hotel is 0.000213 m/second and the drainage time (T) is 3600 seconds. By using equation 21, you will get the capacity of one infiltration well to reduce rainwater.

$$H = \frac{Q}{Fk}\left[1 - e^{\frac{-FkT}{\pi R^2}}\right]$$

With ; H = 3 m; F = 3,14 m; D = 1 m ; T = 3600 sec

From the data and equations above, the resulting capacity of one infiltration well is 0.002103 m3/second.

In planning the infiltration well at Hotel Java Heritage Purwokerto, it is divided into several scenarios which can later be used by Hotel Java Heritage Purwokerto, namely:

1. Infiltration wells only absorb runoff from the roof.

To calculate the number of infiltration wells, divide the runoff discharge by the reduction capacity of the infiltration wells.

Table 14. Results of calculating the need for infiltration wells for each building

No	Building Code	Area (m^2)	Q (m/sec)	Q Well	∑ Well	∑ Well
1	A	207.6	0.0038	0.00210	1.7897	2
2	B	207.6	0.0038		1.7897	2
3	C	207.6	0.0038		1.7897	2
4	D	207.6	0.0038		1.7897	2
5	E	551.04	0.0100		4.7506	5
6	F	110	0.0020		0.9483	1
7	M	329.94	0.0060		2.8444	3
8	G	293.2	0.0053		2.5277	3
9	H	293.2	0.0053		2.5277	3
10	I	207.74	0.0038		1.7909	2
11	J	263.9	0.0048		2.2751	3
12	K	263.9	0.0048		2.2751	3
13	L	263.9	0.0048		2.2751	3
14	R	1051	0.0191		9.0607	9
15	Q	1114	0.0202		9.6039	10
16	N	362.7	0.0066		3.1269	4
17	O	119.34	0.0022		1.0288	1
18	P	1590	0.0288		13.7075	14
19	S	718.2	0.0130		6.1917	6
20	T	4047.2	0.0734		34.8912	35
21	U	762	0.0138		6.5693	7
22	V	21	0.0004		0.1810	1
23	W	5318.6	0.0964		45.8520	46
∑					159.5869	167

2. The infiltration well only absorbs runoff from the parking lot.

Table 15. Results of calculating the need for infiltration wells for each parking lot.

No	Block	Area (m^2)	Q (m3/det)	Q well	∑well	∑well
1	P1	461.44	0.006083	0.002103	2.892519	3
2	P2	533.585	0.010805		5.13778	6
3	P3	84.5	0.001115		0.53016	1
4	P4	518	0.007077		3.365368	4
5	P5	1822	0.024477		11.63907	12
6	P6	240	0.00331		1.573754	2
7	P7	2478	0.032282		15.3506	16
8	P8	800	0.015861		7.542262	8
9	P9	940	0.021773		10.35338	11
∑					58.3849	63

3. Of the total canal capacity, half is drained by canals and half is absorbed by infiltration wells.
   Q channel = 0.7477 m^3/sec
   Q infiltration well = 0.002103 m3/sec
   $$well\ needs = \frac{(0{,}7477\ /\ 2)}{0{,}0021013} = 177{,}765$$
   From the calculation above, it is found that the need for infiltration wells is 177,765 ≈ 178 infiltration wells.
4. Infiltration wells absorb the entire capacity of the channel.
   Q channel = 0.7477 m3/sec
   Q infiltration well = 0.002103 m^3/sec
   $$well\ needs = \frac{0{,}7477}{0{,}0021013} = 355{,}53$$

From the calculation above, it is found that the need for infiltration wells is 355.53 ≈ 356 infiltration wells.

5. The entire area of the Java Heritage Purwokerto Hotel is divided into 2 blocks. From each block, the inundation that occurs is calculated by reducing the amount of runoff by the channel capacity. Table 16 shows the results of inundation calculations for each block. From these calculations it can be seen that the number of puddles in each block has a negative value. So it can be concluded that these blocks do not have ponds, so there is no need for absorption wells.

Table 16. Flooding in each block

Building Code	Area (m^2)	Q Channel (m^3/sec)	Q Max (m^3/sec)	∑Q Max (m^3/sec)	Q flood (m^3/sec)
A	207.6		0.003764271		
B	207.6		0.003764271		
C	207.6		0.003764271		
D	207.6		0.003764271		
E	551.04		0.009991638		
F	110		0.001994556		
G	293.2		0.005316398		
H	293.2		0.005316398		
I	207.74		0.00376681		
J	263.9		0.004785121		
K	263.9	0.74777157	0.004785121	0.153903924	- 0.593867642
L	263.9		0.004785121		
M	329.94		0.00598258		
Q	1114		0.0201994		
R	1051		0.0190571		
P 1	461.44		0.006082968		
P 2	533.585		0.010804752		
P 3	84.5		0.001114927		
P 4	518		0.00707737		
P 5	1822		0.024476974		
P 6	240		0.003309606		
N	362.7		0.00598258		
O	119.34		0.002163912		
P	1590		0.0288304		
S	718.2		0.013022637		
T	4047.2		0.073385155		
U	762	0.74777157	0.013816833	0.303937735	-0.44383383
V	21		0.000380779		
W	5318.6		0.096438596		
Hal 7	2478		0.032282308		
Hal 8	800		0.015861377		
Hal 9	940		0.021773158		

6. The entire area of the Java Heritage Purwokerto Hotel is divided into 2 blocks. From each block, the inundation that occurs is calculated by reducing the amount of runoff with the channel capacity of the channel height reduced by a free board of 0.45 m. So the channel capacity becomes 0.447328 m3/second.

Table 17. Flooding in each block

Building Code	Area (m^2)	Q Channel (m^3/sec)	Q Max (m^3/sec)	∑Q Max (m^3/sec)	Q flood (m^3/sec)
A	207.6		0.003764271		
B	207.6		0.003764271		
C	207.6		0.003764271		
D	207.6		0.003764271		
E	551.04	0.447328	0.009991638	0.153903924	- 0.293424076
F	110		0.001994556		
G	293.2		0.005316398		
H	293.2		0.005316398		
I	207.74		0.00376681		
J	263.9		0.004785121		
K	263.9		0.004785121		
L	263.9		0.004785121		
M	329.94		0.00598258		
Q	1114		0.0201994		
R	1051		0.0190571		
P 1	461.44		0.006082968		
P 2	533.585		0.010804752		
P 3	84.5		0.001114927		
P 4	518		0.00707737		
P 5	1822		0.024476974		
P 6	240		0.003309606		
N	362.7		0.00598258		
O	119.34		0.002163912		
P	1590		0.0288304		
S	718.2		0.013022637		
T	4047.2		0.073385155		
U	762	0.447328	0.013816833	0.303937735	- 0.143390265
V	21		0.000380779		
W	5318.6		0.096438596		
Hal 7	2478		0.032282308		
Hal 8	800		0.015861377		
Hal 9	940		0.021773158		

From the table above it can be concluded that each block does not produce flooding, so there is no need for absorption wells.

6 Groundwater Analysis

6.1. Flow Pattern

From the results of the well survey around the Java Heritage Hotel, the coordinates and height of the ground water level were obtained. The coordinates and elevation of the groundwater level are used to determine the direction of groundwater flow at the research location. To obtain contours at the research location, Surfer software was used. The coordinates that have been obtained are converted into UTM with South Latitude coordinates as the X axis, East Longitude coordinates as the Y axis and ground water level elevation as the Z axis.

Table 18. Well Coordinates and Elevation

X	Y	Z
305400	9179918	122.45
305413	9179927	123.575
305423	9179926	122.87
305344	9179818	117.674
305526	9180037	125.92
305504	9180085	125.33
305529	9180006	124.21
305501	9180021	126.06

From the table data above, a contour map will be obtained. From these contours, the direction of groundwater flow at the research location can be seen as shown in the image below. Points 1, 2, 3, 4, 5, 6, 7, 8 with circle symbols indicate data collection points. Meanwhile, the square symbol shows the well at the Java Heritage Hotel Purwokerto

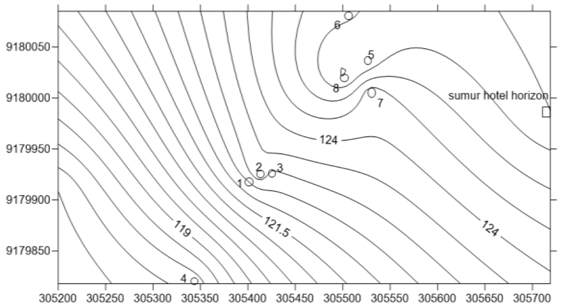


Fig. 5. Contour of the Java Heritage Purwokerto Hotel area

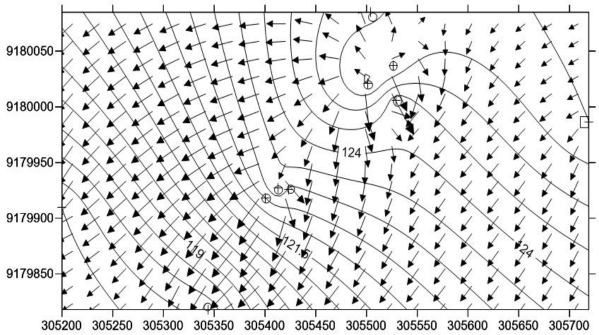


Fig. 6. Groundwater Flow Patterns

From the contours and flow patterns above and then compared with the flow patterns on the hydrogeological map in the Purwokerto area around the Horizon Hotel from the Department of Energy and Mineral Resources, it can be concluded that the flow patterns are the same [15].

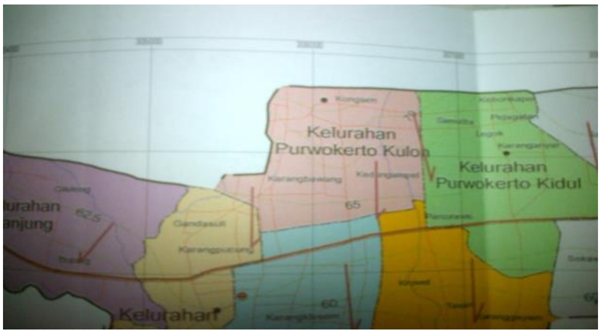


Fig. 7. Groundwater Flow Patterns at the Research Location

a. Drowdown

To determine the decline in ground water levels at each point, Pumping Test data is needed at the research location. From this data, Transmissivity (T) and Storativity (S) values can be obtained at the research location. Data obtained from the Water Resources, Mining and Energy Service shows the T value = 570.15 m^2/day while the S value = 1.11 x 10^{-3}. By using equation 1 you can obtain the drowdown for each well as shown in the following table.

Table 19. Drowdown on residents' wells

No	Sumur	r (m)	u	W(u)	S (m)
1	Mushola Al Azkha	326	0.413808	0.679797	0.061514
2	Ms. Mingan	311	0.376604	0.743275	0.067258
3	Ms. Mukidi	301	0.352774	0.788673	0.071366
4	Mr. Rohadi	411	0.65773	0.4053	0.036675
5	Mr. Kasim	199	0.154195	1.440787	0.130375
6	Ms. Iin Endarti	236	0.216864	1.156935	0.10469
7	Mr. Paryoto	191	0.142047	1.511558	0.13678
8	Mr. Sugeng	282	0.309644	0.882364	0.079844

From the table above, it can be seen that the decrease due to the use of drilled wells at the Java Heritage Purwokerto Hotel did not result in a large decrease in ground water levels. The largest decline occurred in Mr Paryoto's well, namely 13.7 cm.

b. Residual Drawdown

To find out how much time it takes to restore the groundwater level to the level before pumping, use equation 4. With a value of s' = 0.9 s, the groundwater level time for recovery will be known in table 20.

Table 20. Recovery Time

Sumur	r (m)	u'	W'(u)	S'(m)	t' (minute)
Mushola Al Azkha	326	0.414207	0.679159	5.77E-05	161.8438
Ms. Mingan	311	0.377026	0.742506	6.96E-05	161.8186
Ms. Mukidi	301	0.353207	0.787811	7.8E-05	161.8014
Mr. Rohadi	411	0.663043	0.40114	0.000377	160.7019
Mr. Kasim	199	0.154547	1.43883	0.000177	161.6306
Ms. Iin Endarti	236	0.21728	1.155391	0.00014	161.6896
Mr. Paryoto	191	0.142382	1.509513	0.000185	161.6186
Mr. Sugeng	282	0.310087	0.881315	9.5E-05	161.7684

From the results of the calculations above, it can be seen that the recommended time to pause pumping is 161.8438 minutes or 2.7 hours.

7 Conclusion

From the results and discussion several conclusions were obtained, namely as follows.

1. Maximum daily rainfall depth data at the Java Heritage Purwokerto Hotel for 14 years follows the Log Pearson III distribution.
2. The permeability value of the research location's soil is 2.13 x 10-4 m/sec, which includes soil with very fast permeability.
3. Using the Mononobe Method rain intensity, the infiltration well that has been determined has impermeable walls and a porous bottom, a diameter of 1 m and a well depth of 3.00 m. With several calculation scenarios, the number of infiltration wells is obtained as follows;
   a. The absorption wells only absorb runoff from the roof, resulting in 167 absorption wells.
   b. The infiltration wells only absorb runoff from the parking lot, resulting in 63 infiltration wells.
   c. Of the total canal capacity, half is drained by canals and half is absorbed by infiltration wells. From the calculations, 178 absorption wells were produced.
   d. Infiltration wells absorb the entire capacity of the channel, from calculations the resulting infiltration wells are 356 infiltration wells.
   e. The entire area of the Java Heritage Hotel is divided into 2 blocks. From each block, the inundation that occurs is calculated by reducing

the amount of runoff by the channel capacity. From the calculations it was concluded that these blocks do not have ponds, so there is no need for absorption wells.

f. The entire area of the Java Heritage Hotel is divided into 2 blocks. From each block, the inundation that occurs is calculated by reducing the amount of runoff with the channel capacity of the channel height reduced by a free board of 0.45 m. So the channel capacity becomes 0.447328 m3/second. From the calculation results, these blocks do not produce inundation so they do not require absorption wells.

4. The decline in groundwater levels in the wells around the hotel was 14 cm, so it can be concluded that pumping activities at the research location did not have much effect on the decline in groundwater levels in the surrounding area.
5. To ensure the groundwater level does not decrease, pumping can be carried out for 3 hours, then the pump operation is stopped for 2.7 hours to return the groundwater level to normal.

Suggestion

The results of the research provided suggestions for further improvement of research on infiltration wells, including the following.

a. When planning an infiltration well, it is best to pay attention to the ability of the location's soil to pass water into the ground.
b. For locations that have moderate to low soil permeability values, it is best to consider using rainwater by creating infiltration ponds to accommodate more rainwater.
c. When choosing the type of infiltration well construction, it is best to first know the condition of the groundwater level in the area.

REFERENCES

1. *Sunjoto*. 1991. *Infiltration Well Hydraulics*. Pusat Antar Universitas Ilmu Teknik Universitas Gadjah Mada, Yogyakarta. (in Bahasa Indonesia)
2. *http://arjunawiwaha.blogspot.com*. *Infiltration Well Notes.* Diakses pada tanggal 20 Juni 2013.
3. *http://civiliana.blogspot.com*. *Planning for Making Infiltration Wells.* Diakses pada tanggal 20 Juni 2013.
4. Sterrett, Robert J. 2007. *Groundwater and Wells.* Johnson Screens a Weatherford Company.
5. Triatmodjo, Bambang. 2008. *Applied Hydrology*. Beta Offset, Yogyakarta.
6. Dewi, Sri Murni. 2009. *Planning for the Construction of Infiltration Wells.* Srikandi, Surabaya.
7. Montarcih, Lily. 2009. *Hydrology: Water Resources Engineering 1.* Penerbit Citra, Malang.
8. *Pemetaan Potensi Air Tanah Di Kecamatan Purwokerto Selatan.* 2008. Dinas Sumberdaya Air, Pertambangan dan Energi Kabupaten Banyumas.
9. Suroso. 2006. *Rainfall Analysis to Create Intensity Duration Frequency (IDF) Curve in Flood-Prone Areas, Especially DKI Jakarta.*
10. Wanielista, Martin T. 1990. *Hydrology : Water Quantity and Quality Control*. John Wiley & Sons. Inc, New York.
11. http*://repository.unib.edu*. *Groundwater Conservation*. Diakses pada tanggal 11 September 2013.
12. *http://www.scribd.com*. *Definition of groundwater.* Diakses pada tanggal 10 September 2013.
13. *sumurairhujan.blogspot.com*. Diakses pada tanggal 11 September 2013.
14. *morethangeograph.wordpress.com*. *Infiltration and Permeability.* Diakses pada tanggal 11 September 2013.
15. *www.academia.edu*. *Road Surface Drainage Planning and Design.* Diakses pada tanggal 1 Februari 2014.